JEPPIAAR
INSTITUTE OF TECHNOLOGY
“Self-Belief | Self Discipline | Self Respect”

QUESTION BANK

Regulation : 2013

Year : VII

Semester : 07

Batch : 2016-2020

Academic Year : 2019-2020

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Vision of the Institution:

Jeppiaar Institute of Technology aspires to provide technical education in futuristic technologies with the perspective of innovative, industrial and social application for the betterment of humanity.

Mission of the Institution:

- To produce competent and disciplined high-quality professionals with the practical skills necessary to excel as innovative professionals and entrepreneurs for the benefit of the society.
- To improve the quality of education through excellence in teaching and learning, research, leadership and by promoting the principles of scientific analysis, and creative thinking.
- To provide excellent infrastructure, serene and stimulating environment that is most conducive to learning.
- To strive for productive partnership between the Industry and the Institute for research and development in the emerging fields and creating opportunities for employability.
- To serve the global community by instilling ethics, values and life skills among the students needed to enrich their lives.

Department Vision

To foster contemporary Skills in the field of Electrical and Electronics Engineering with innovatory Skills, Global Understanding and Nation building for the progress of Humankind.

Department Mission

- To Encompass Quality Engineers with skills as persevere to enrich the global technically.
- To engage in research activities leading to innovative application of technology with Industrial approach for the benefit of mankind.
- To provide quality structure and beneficial learning system.
- To enable them as responsible human who value Ethics and environment.

PEO's of the Department

PEO1: To provide students with the fundamental Knowledge, methodologies and use of cutting-edge Technologies.

PEO2: To provide students with an awareness and skills in lifelong learning and self-education.

PEO3: To Cultivate Teamwork, Technical writing and Oral communication skills.

PEO4: To provide students with an appreciation of engineering impact on society and the Professional responsibilities of an engineers.

Program Specific Outcomes (PSO's)

PSO1: Apply the fundamentals of mathematics, Science and Engineering knowledge to identify, formulate, design and investigate complex engineering problems of electric circuits, analog and digital electronics, electrical machines and systems.

PSO2: Apply appropriate technique and modern Engineering hardware and software tools in power systems to engage in life-long learning and to successfully adapt in multi-disciplinary environments.

PSO3: Understand the impact of Professional Engineering solutions in societal and environment context, commit to professional ethical and communicate effectively.

BLOOM’S TAXONOMY

Definition:

Bloom’s taxonomy is a classification system used to define and distinguish different levels of human cognition like thinking, learning, and understanding.

Objectives:

- To classify educational learning objectives into levels of complexity and specificity. The classification covers the learning objectives in cognitive, affective and sensory domains.
- To structure curriculum learning objectives, assessments and activities.

Levels in Bloom’s Taxonomy:

- **BTL 1 – Remember** - The learner recalls, restate and remember the learned information.
- **BTL 2 – Understand** - The learner embraces the meaning of the information by interpreting and translating what has been learned.
- **BTL 3 – Apply** - The learner makes use of the information in a context similar to the one in which it was learned.
- **BTL 4 – Analyze** - The learner breaks the learned information into its parts to understand the information better.
- **BTL 5 – Evaluate** - The learner makes decisions based on in-depth reflection, criticism and assessment.
- **BTL 6 – Create** - The learner creates new ideas and information using what has been previously learned.

TABLE OF CONTENTS

EE6008-MICROCONTROLLER BASED SYSTEM DESIGN

EE6701 **HIGH VOLTAGE ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the various types of over voltages in power system and protection methods.
- Generation of over voltages in laboratories.
- Measurement of over voltages. Nature of Breakdown mechanism in solidliquid and gaseous dielectrics.
- Testing of power apparatus and insulation coordination.

UNITI OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS 9

Causes of over voltages and its effects on power system – Lightning, switching surges and temporary over voltages, Corona and its effects – Reflection and Refraction of Travelling waves-Protection against over voltages.

UNIT II DIELECTRIC BREAKDOWN 9

Gaseous breakdown in uniform and non-uniform fields – Corona discharges – Vacuum breakdown –Conduction and breakdown in pure and commercial liquids, Maintenance of oil Quality – Breakdown mechanisms in solid and composite dielectrics.

UNIT III GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS 9

Generation of High DC, AC, impulse voltages and currents - Triggering and control of impulse generators.

UNIT IV MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS 9

High Resistance with series ammeter – Dividers, Resistance, Capacitance and Mixed dividers – Peak Voltmeter, Generating Voltmeters - Capacitance Voltage Transformers, Electrostatic Voltmeters –Sphere Gaps - High current shunts- Digital techniques in high voltage measurement.

UNIT V HIGH VOLTAGE TESTING & INSULATION COORDINATION 9

High voltage testing of electrical power apparatus as per International and Indian standards – Power frequency, impulse voltage and DC testing of Insulators, circuit breakers, bushing, isolators and transformers- Insulation Coordination.

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to understand and analyze power system operation, stability, control and protection.

TEXT BOOKS:

S.Naidu and V. Kamaraju, 'High Voltage Engineering', Tata McGraw Hill, Fifth Edition, 2013.
E. Kuffel and W.S. Zaengl, J.Kuffel, 'High voltage Engineering fundamentals', Newness Second Edition Elsevier , New Delhi, 2005.
Subir Ray,' An Introduction to High Voltage Engineering' PHI Learning Private Limited,
New Delhi, Second Edition, 2013.

REFERENCES:

L.L. Alston, 'High Voltage Technology', Oxford University Press, First Indian Edition, 2011.C.L. Wadhwa, 'High voltage engineering', New Age International Publishers, Third Edition, 2010

REGULATION: 2013 Academic Year: 2019-2020

Subject Code: EE6701 **Year/Semester: IV /07**
Subject Name: High Voltage Engineering **Subject Handler: Dr.Prajith Prabhakar**

	UNIT I OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS
	Causes of over voltages and its effects on power system – Lightning, switching surges and temporary over voltages, Corona and its effects – Reflection and Refraction of Travelling waves- Protection against over voltages.
	PART*A
1.	**What are the general applications of high voltages?**BTL1 • Cathode ray tubes • Particle accelerators • Xerography • Electrostatic Precipitators
2	**Define Isokeraunic level. (NOV/DEC 2016)(NOV/DEC 2017)**BTL1 It is defined as the number of days in a year when thunder is recorded in a particular location. Traditional method of designing thunderstorm activity by means of Isokeraunic level.
3	**What are the causes for power frequency over voltages in power system? (NOV/DEC 2017)**BTL1 Lightning and Switching surges are the Cause of over voltages
4	**What are the theories associated with the formation of charges in clouds?**BTL1 • Simpson's theory • Reynolds and mason's theory
5	**Define ground wires.** BTL1 It is used for direct stroke protection of lines for voltages of 110 kV and above and from attenuation of travelling waves in the line.
6	**What are the factors to be considered for switching over voltages in EHV and UHVSystem?**BTL1 • Interruption of low inductive currents by high speed circuit breakers • Ferro resonance condition • Interruption of fault current when the fault is cleared
7	**Mention the types of lightning strokes. (May/Jun 2013)** BTL2 • Direct stroke • Indirect stroke
8	**State the causes of overvoltage in power system.(NOV/DEC 2014)(Nov-Dec2018)** BTL2 • Sudden load rejection

- Disconnection of inductive and capacitive loads
- Ferranti effect
- Saturation in transformers
- Tap changing operation

9 **List out the various methods of protecting the power system from lightning.**BTL2

- Using Ground wires
- Using ground rods
- Using counter poise wires
- Using protective devices like rod gap, expulsion and valve type surge arrestors.

10 **Mention the sources of switching surges.(Nov-Dec 2018)** BTL2

- De-energizing of the lines, cables and shunt capacitors
- Disconnection of unloaded transformers and reactors

11 **Write down the some advantages of HVDC systems.** BTL3

- Di electric loss is less
- No charging current
- No reactive power loss

12 **Mention the different types of faults that may occur in power lines.**BTL3

- Symmetrical Faults
- Unsymmetrical Faults

13 **Write down the requirements of the lightning arrester.** BTL4

- Should not pass any current to the system component which to be protected abnormal condition.
- Should discharges the surge current without any damage

14 **Write the methods to vary the tower footing resistance.** BTL4

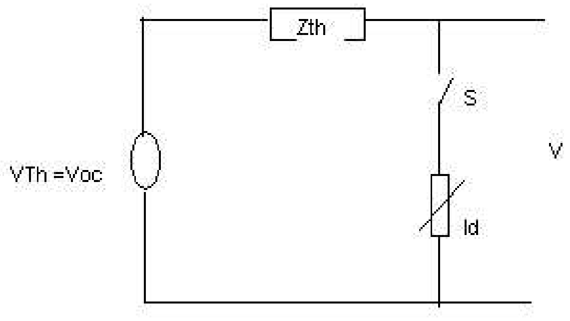
- Varying the spacing of the rod.
- Varying the number of rods

15 **Mention the five EHVAC systems in India.**BTL4

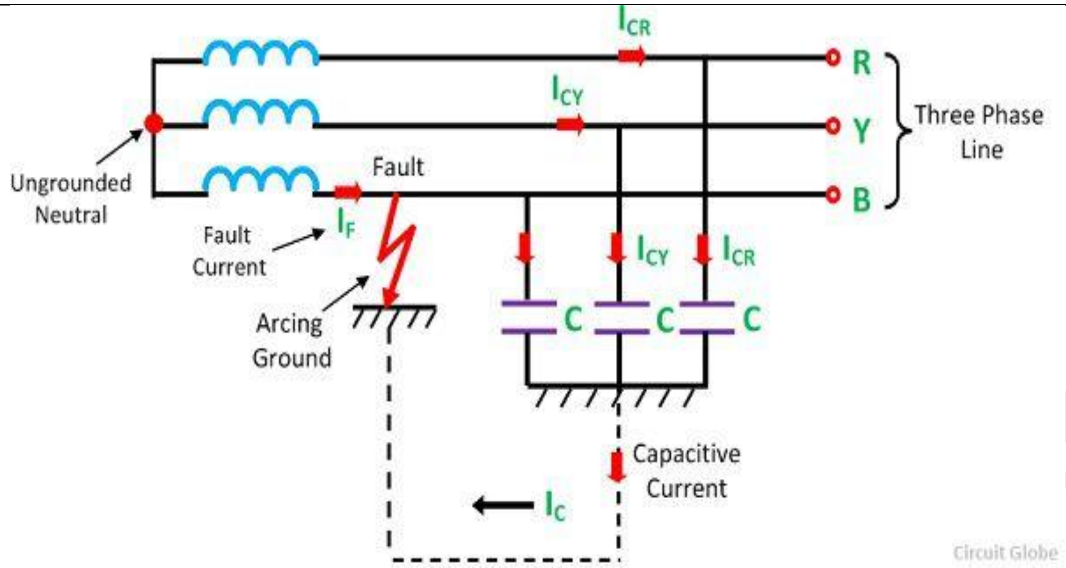
- Dehar
- Obra
- Sultanpur
- Kanpur
- Srinagar

16 **Compare the relationship between ground wires and Counterpoise wires.** BTL3

- Additional rods provided driven into the ground near the tower footing and connected to the tower footing to reduce the tower footing resistance [15 mm diameter, 3.0 m long, 10 to 16 rods].
- Horizontal wires buried at a depth of 1m in the ground, they may be parallel to the conductors or

	radial from the tower footing they are to reduce tower footing resistance.
17	**Draw the equivalent circuit of a surge diverter.**BTL3 
18	**A lightning stroke 10KA strikes a line of 400 ohms surge Impedance.** **(I) What is the over Voltage caused.** **(II) If a direct stroke occurs over the top of the unshielded $T_r$line, is the over voltage.** BTL3 **Case: I** V = Io. Z = 10KA .400 = 4000 KV **Case II** V = Io (Z/2) = (10 x 400 KV)/2 =2000KV
19	**What are disadvantages of value lightning arrester? (May/Jun 2013)**BTL1 • Expensive • Care should taken
20	**What are the disadvantages of expulsion type lightning arrestor?**BTL1 It has poor volt ampere characteristics.
21	**What are the requirements of the lightning arrestor?** BTL1 • Should not pass any current to the system component which to be protected abnormal condition. • Should discharges the surge current without any damage. • Should interrupt the power frequency follow current after the surge is discharged.
22	**What are the different types of Over Voltages?(May 2013)(May 2015).** • Lightning Overvoltages • Switching Overvoltages • Power frequency Overvoltages(Temporary Overvoltages)
23	**What is meant by back flashover?(Dec 2016).** • When a lightning strike occurs in a tower, the same has to carry large impulse currents. There will be a sudden rise in the potential, if the tower resistance is considerable. Consequently the potential may rise and sudden flashover occurs. This is called back flashover.
24	**How attenuation and distortion are caused?** • Attenuation is caused due to energy loss in the line and distortion is caused due to inductance and capacitance of the line.

	PART * B
1.	**Describe the causes for switching and power frequency over voltages.(APRIL/MAY2017) (13M)**BTL1 **Answer: Page: 1.32 - M.Jeraldin Ahila** Definition: Electromagnetically induced over voltages due to lightning discharge taking place near the line, called 'side stroke'-----(2M) • Voltages induced due to atmospheric changes along the length of the line------------(3M) • Electrostatically induced voltages due to presence of charged clouds nearby---------(3M) Explanation: This cause of over voltage in power system is the lightning strokes in the cloud.Now, how lightning strokes are produced. So when electric charges get accumulated in clouds due to thunder Strom caused due to some bad atmosphere process.---------------------------(5M)
2.	**Explain the different theories of charge formation in cloud.(APRIL/MAY 2017) (NOV/DEC 2017) (April –May 2018)(13M)** BTL1 **Answer: Page: 1.25- M.Jeraldin Ahila** Definition: First of all clouds are formed from the strong upward stream. Then, the clouds become charged by friction Potential of the cloud-----------------------(2M) Simpson's Theory---(4M) Reynolds and mason theory-------------------------------------(4M) Explanation:The energies associated with the cloud discharges can be as high as 250 kWh. It is believed that the upper regions of the cloud are usually, positively charged, whereas the lower region and the base are predominantly negative except the local region, near the base and the head, which is positive. ----(3M)
3.	**Describe the causes of arcing voltage and controlled in power systems.(13M)** BTL1 **Answer: Page:1.23 - M.Jeraldin Ahila** Definition: In an electric power system, a fault*or* fault current is any abnormal electric current. For example the area of the fault. A transient faultwill then clearand the power-line can be returned to service.---------------------------------------(2M) • Arcing ground-------------------------(2M) • Capacitive current ------------------(5M)



(4M)

4. **Explain the construction and working principle of expulsion gaps and protector tubes.(APRIL/MAY 2017) (13M)** BTL1

Answer :Page:1.40 - M.Jeraldin Ahila

- Rod gaps-----------------------------**(3M)**
- Expulsion gaps----------------------(4M)

Explanation:

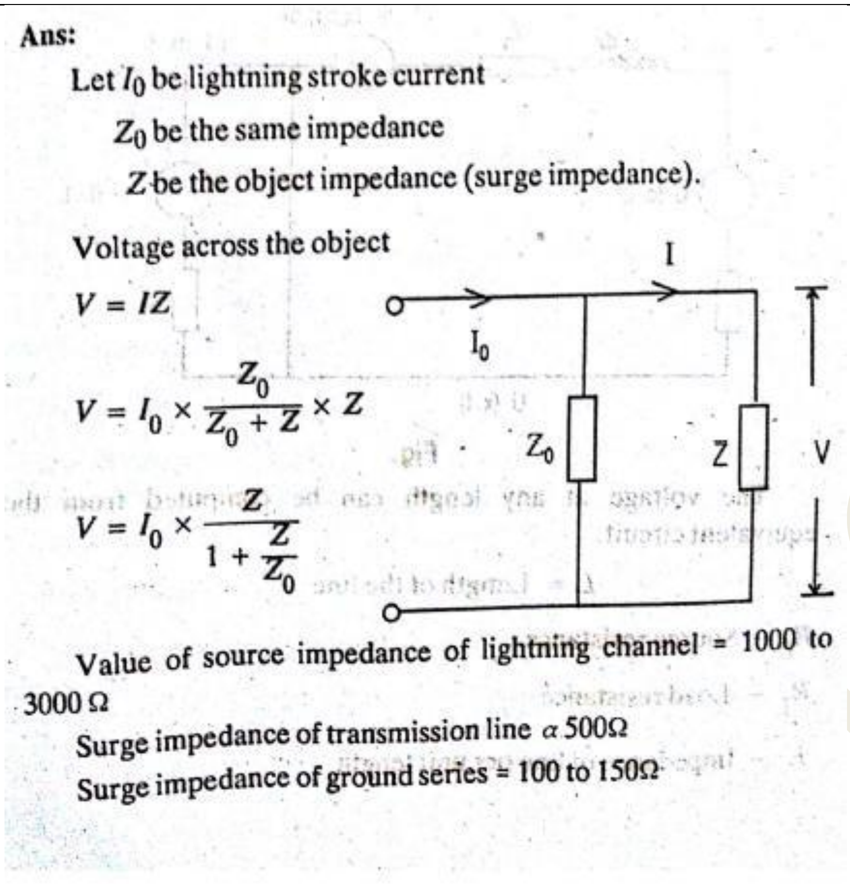
- During operation arc due to the impulse spark-over inside the fibrous tube causes some fibrous material of the tube volatized in the form of gas, which is expelled through a vent from the bottom of the tube, thus extinguishing the arc just like in circuit breakers-------(6M)

5. **Give the mathematical model for lightning discharges and explain them. (Nov/Dec 2017)**

(Nov/Dec 2016)(Nov-Dec 2018) (13M) BTL2

Answer :Page : 1.26 - M.Jeraldin Ahila

- Lightning stroke------(2M)
  The potential difference in the cloud is not much greater than that at the earth's surface, the discharge originates in the clouds. The potential gradient of the clouds is not uniform, and it is of the order of 10 – 30 KV/cm in any part of the cloud. The initial discharge which is also called pilot discharge or pilot leader moves slowly towards it from the earth-------(6M)

	 **Ans:** Let I_0 be lightning stroke current Z_0 be the same impedance Z be the object impedance (surge impedance). Voltage across the object $V = IZ$ $V = I_0 \times \frac{Z_0}{Z_0 + Z} \times Z$ $V = I_0 \times \frac{Z}{1 + \frac{Z}{Z_0}}$ Value of source impedance of lightning channel = 1000 to 3000 Ω Surge impedance of transmission line α 500Ω Surge impedance of ground series = 100 to 150Ω ---------------(5M)
6.	**Mention the operation of switching surges and discuss its advantages and disadvantages?(Nov-Dec 2018) (13M)** BTL2 **Answer:Page :1.32 - M.Jeraldin Ahila** • Switching surges ------------(2M) • As the magnetic field about the inductive conductor collapses, a brief very high voltage can be generated at that point. • This is often the case in the event of fallen tree limb or small animal causing a fault on the line. • These interruptions of power cause surges when the power is disconnected and then reconnected to the customer loads------(4M) • Power quality disturbances can be delivered during the normal operation of the electric power system. -------------------(7M)
7.	**Explain the causes of measure control over voltages due to switching and power frequently.(13M)** BTL2 **Answer:Page :1.33 - M.Jeraldin Ahila** • Saturation in transformer-----------(3M)

	• Tap changing in transformer---------(4M) • The damage caused by voltage surges can be serious enough in the home however when the effects are felt in a wider industrial scale they can even more disastrous, affecting expensive machinery and even whole sections of the power grid-----------------(6 M)
8.	**Briefly describe a method of recording the occurrence of lightning in an overhead transmission line.(APRIL/MAY 2015) (13M)** BTL3 **Answer:Page :1.34 - M.Jeraldin Ahila** • Ferranti effect------------- (3M) • Symmetrical faults--------(4M) • Un-Symmetrical faults----(3M) Faults which leads unequal currents with unequal phase shifts in a three phase system. The unsymmetrical fault occurs in a system due to presence of an open circuit or short circuit of transmission or distribution line. It can occur either by natural disturbances or by manual errors--------(3 M)
9.	**Explain about switching over voltages in EHV and UHV systems?(13M)(** BTL4) **Answer :Page :1.19 - M.Jeraldin Ahila** • Interruption of small capacitive currents, such as switching off of unloaded lines------(3M) • Capacitive current Interruption by HV air-break disconnections With high-velocity interrupt small capacitive currents • Ferro resonance condition----------------------(3M) • The most common temporary over voltages occur on the healthy phases of a system during phase-to-earth faults. The severity of the transients caused by operation of circuit-breakers strongly depends on the instant of switching-------------------(7M)
10.	**Mention about the technique of reflection of 2 substations system.(13M)** BTL5 **Answer :Page:1.57 - M.Jeraldin Ahila** • Under the influence of sufficiently strong fields, large water drops become elongated in the direction of the field and become unstable, and streamers develop at their ends.-----(3M) • A substation is a part of an electrical generation, transmission, and distribution system. • Substations transform voltage from high to low, or the reverse, or perform any of several other important functions.------------------------(6M) • Electrical substations are the interface between parts of the distribution gridand transmission systems.-----------------------------------(4M)
	PART *C
1.	**Describe about the step by step procedure for constructing bewley lattice diagram?(MAY/JUNE 2014) (15M)** BTL2 **Answer :Page: 1.54- M.Jeraldin Ahila** • Charged clouds induce charges on upstanding objects------(4M) • Stokes to phase conductor-----------(2M) • The total potential at any point, at any instant of time is the superposition of all the waves which

have arrived at that point up until that instant of time, displaced in position from each other by intervals equal to the difference in their time of arrival-------------------(2M)

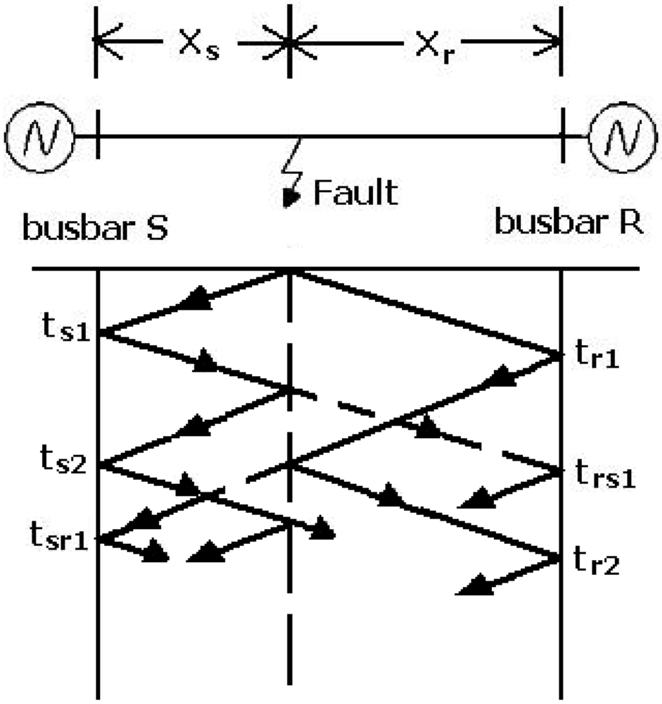


Fig. 1 Bewley's Lattice Diagram ------------------(7M)

2. **Explain the various shunt protected devices used for overhead lines against the lightning strokes?(Nov-Dec 2018)(15M)** BTL5

Answer :Page :1.40 - M.Jeraldin Ahila

- Rod gaps-------------------(3M)
- Rod GapLightning Arrester.------------(3M)
- Expulsion gaps--------------------------(3M)
- Expulsion type arrester is an improvement over the rod *gap* in that it seals the flow of power frequency follow current. Its use is normally restricted to circuits
- **Switching surge:** The over voltages produced on the power system due to switching are known as switching surge----------------------(3M)
- Insulation failure-------------------(3M)

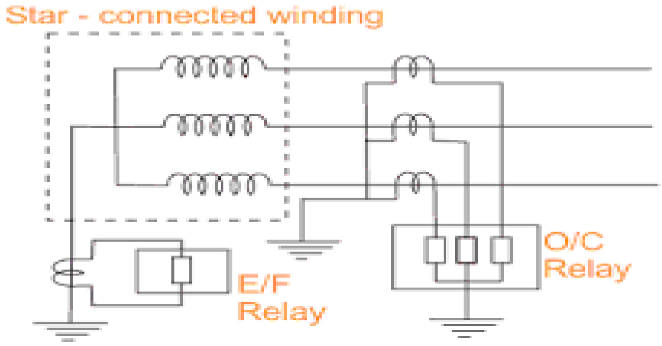
3. **Mention the various protective schemes for ground wires. (May/Jun2014) (April- May 2018)(15M)** BTL6

Answer :Page: 1.37 - M.Jeraldin Ahila

- Expulsion type--------(3M)

Counter poise wires----(3M)

- A ground fault is an inadvertent contact between an energized conductor and ground or equipment frame----------------(4M)



O/C & Unrestricted E/F Protection Scheme ----------------(5M)

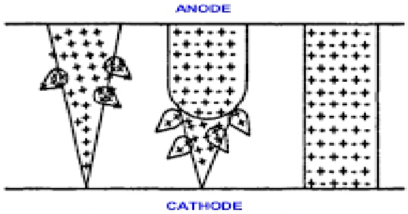
	UNIT II DIELECTRIC BREAKDOWN
	Gaseous breakdown in uniform and non-uniform fields – Corona discharges – Vacuum breakdown – Conduction and breakdown in pure and commercial liquids, Maintenance of oil Quality – Breakdown mechanisms in solid and composite dielectrics.
Q.No.	**Questions**
1.	**Define Townsend's first ionization effect.** (April/May 2017)BTL1 The average number of ionizing collisions made by an electron per centimeter travel of the electron in the direction of the field is called Town-sends ionization co-efficient .It depends on the gas pressure and E/P
2	**List the applications of Vacuum Insulators.** BTL1 • Atmospheric Pressure = 760 torr. • High Vacuum = 1 x 10-3 to 1 x 10-6 torr. • Very high Vacuum = 1 x 10-6 to 1 x 10-8 torr. • Ultra Vacuum = 10 x 10-8 torr. • For electrical Insulation purposes • Vacuum => High Vacuum • 1 x 10-3 torr to 1 x 10-6 torr.
3	**What are the characteristics of corona discharge?** BTL1 • It has bluish luminescence. • It produces hissing noise. • Air surrounding the corona becomes converted to ozone. • Creates loss of Power. • Create radio interference. • It causes deterioration of the insulation surface.
4	**Define corona inception field.** BTL1 The voltage gradient required to produce visual ac corona in air at a conductor surface is called corona inception field.
5	**What are the types of collision?**BTL1 • Elastic collision • Inelastic collision
6	**What is the use of Gas insulators?**BTL1 It is used in power transmission lines and power apparatus circuits.
7	**Define Spark voltage sparking distance.** BTL2 The voltage applied which creates the above breakdown condition is called spark voltage Vs and the corresponding gap d is called sparking distance.
	Predict the formula used by Town-sends secondary ionization co-efficient. BTL2

8	It is the net number of secondary ions produced per incident positive ion ($\gamma 1$) or photon ($\gamma 2$) or metastable particle (γ 3) $\gamma = (\gamma\ 1 + \gamma\ 2 + \gamma\ 3)$
9	**Mention the mechanisms in vacuum breakdown.** BTL2 • Particle exchange mechanism • Field emission mechanism Clump theory
10	**State Streamer theory.** BTL2 • Streamer theory considers the influence of space charge on the applied field. • Secondary avalanches are produced from the gap • Transformation from avalanche to streamer occurs when the length of avalanche exceeds a certain value. • Streamer theory overcomes the demerits of Town-sends theory.
11	**Mention the physical conditions governing ionization mechanism in gases dielectrics.** BTL3 • Pressure • Temperature • Electrode configuration • Nature of electrode surface Availability of initial conducting particles
12	**State the operation of the Spark voltage sparking distance.** BTL3 The voltage applied which creates the above breakdown condition is called spark voltage (Vs) and the corresponding gap d is called sparking distance.
13	**Define corona discharge.** BTL4 • It has bluish luminescence. • It produces hissing noise. • Air surrounding the corona becomes converted to ozone. • Creates loss of Power. • Create radio interference. • It causes deterioration of the insulation surface.
14	**Classify the various types of breakdown.** BTL4 • Chemical and Electromechanical deteriaotion and breakdown • Breakdown due to treeing and tracking
15	**Name a type of few liquid dielectrics.** BTL4 • Transformer oil • Synthetic hydro carbons – (Polyolefin's) • Chlorinated hydro carbons: P.C.B. (Toxic) • Silicone oils. Alternative to PCB
16	**Is Electronegative gas has high BD value?(Nov-Dec 2018)**BTL5

	The molecules of (SF6 gas) electro neg. gases have the property of electron attachment, (i.e., the outermost orbit of the molecules has holes) - There molecules attach the electrons in the gap to become negative ions - Negative ions have lesser mobility than electron - This attachment plays an effective role of removing electrons which otherwise have led to current growth and break down.
18	**Define Corona inspection field.** BTL2 The voltage gradient required to produce visual ac corona in air at a conductor surface is called corona inception field.
20	**State Clump mechanism.** BTL2 Loosely bounded electrode and accelerated in the gap.
21	**Define electron attachment process.** BTL1 The type of collisions in which electrons may become attached to atoms or molecules to form negative ions are called attachment collisions.
22	**What is a streamer?** BTL1 When a positive voltage pulse is applied to a point electrode, a filamentary branch is formed by ionization. This discharge is called streamer.
23	**What is called a composite dielectric?**BTL1 Different dielectric materials can be in parallel with each other or in series with one another.
24	**What is treeing?**BTL1 The spreading of spark channels during tracking, in the form of the branches of a tree is called treeing.
25	**What is tracking?** BTL1 When voltage is applied, a formation of continuous conducting paths across the surface of the insulation due to surface erosion is called tracking.
26	**What is ionization by collision? (Nov/Dec 2016)** The process of liberating an electron from a gas molecule with simultaneous production of a positive ion is called ionization. In this process, a free electron collides with a neutral gas molecule and give rise to a new electron and a positive ion.
27	**What do you meant by tracking index?** The numerical value of voltage that initiates or causes the formation of a track is called tracking index and this value is used to qualify the surface properties of dielectric materials.
	PART * B
1.	**Describe the corona formation on two conductor line. (13M)** BTL1 **Answer: Page:2.12- M.Jeraldin Ahila** - Corona is a phenomenon associated with all transmission lines--------(3M) - Corona is a luminous, audible discharge that occurs when there is an excessive localized electric field gradient upon an object that causes the ionization and possible electrical breakdown of the air adjacent to this point.-----------(4M) - In electricity, a "corona discharge" is an electrical discharge brought on by the ionization of a

	fluid or gas surrounding a conductor that is electrically charge------------- (6M)
2	**Explain the various breakdown theories involved in commercial liquid dielectrics.(NOV/DEC 2016) (13M)** BTL1 **Answer: Page: 2.27- M.Jeraldin Ahila** • Intrinsic breakdown------------------(2M) • Thermal breakdown------------------(3M) • Avalanche breakdown---------------(3M) • Dielectric discharge-----------------(2M) • Electrochemical breakdown---------(3M)
3	**Discuss the breakdown mechanism of composite Dielectrics.(NOV/DEC 2014) (April- May 2018) (Nov-Dec 2018) (13M)** BTL1 **Answer: Page: 2.29- M.Jeraldin Ahila** • Flow of a relatively large quantity of electricity, determined by the characteristics of the circuit. A bright luminous path from electrode to electrode.---------(4M) • The evolution of bubbles of gas and the formation of solid products of decomposition formation of small dielectrics In this range of vacuum, the breakdown strength is independent of the gas density and depends only on the gap length and upon the condition of electrode surface.-------------(4M) • It has been observed that for a vacuum of 10^{-6} torr, some of the metals like silver, bismuth-copper etc. attain their maximum breakdown strength when the gap is slightly less than 3 mm. • This property of vacuum switches permits the use of short gaps for fast operation. • Pits on the electrodes on anode-------------------------------- (5M)
4	**Describe clearly the breakdown in non-uniform field in corona discharge. (Nov-Dec 2018) (13M)**BTL1 **Answer :Page :2.31- M.Jeraldin Ahila** • Corona discharge is usually accompanied by a hissing or cracking audible noise, visual violet glow, production of ozone gas around the conductor, power loss and radio interference.------(6M) • The Electrical Breakdown of Gases in Non-Uniform Fields at Low Pressure.--------(4M) • Corona Inception and Electrical Breakdown *in* a Coaxial Cylindrical-----------------(3M)
5	**Explain clearly about the streamer breakdown in air at atmospheric pressure. (13M)**BTL2 **Answer: Page: 2.6- M.Jeraldin Ahila** • The mechanisms active in air at higher pressures, viz., the electron avalanche and its tip field, photo-ionization in the gas and positive streamer formation are presented. ---------(4M) • The mechanisms active in air at higher pressures, viz., the electron avalanche and its tip field, photo-ionization in the gas and positive streamer formation are presented---------- (6M) • A quantitative criterion for streamer formation is applied to give a quantitative theory for spark

	breakdown in air at atmospheric pressures.-------------------------------------(3M)
6	**Describe the various breakdown mechanisms in liquid dielectrics. (Nov/Dec 2016) (13M)**BTL2 **Answer: Page :2.21- M.Jeraldin Ahila** • Strength on electrode separation. Solid insulation forms an integral part of high voltage structures. The solid materials provide the mechanical support for conducting parts and at the same time insulate the conductors from one another.---------------------(5M) • Electromechanical breakdown occurs when the mechanical compressive stress on the dielectric caused by the electrostatic attraction of the electrodes exceeds a critical value which cannot be balanced by the dielectric's elasticity-----------------(5M) • EDM dielectric fluid serves two main purposes.------(3M)
7	**Discuss about the various mechanism of vacuum breakdown.(APR/MAY 2017) (Nov/Dec 2017) (13M)** BTL2 **Answer: Page: 2.16- M.Jeraldin Ahila** • It is regarded that the electrical break down in vacuum is initiated by particles generated on the electrode surface. -------------(4M) • Suppressing an electrical breakdown of vacuum gap is one of principal factors to achieve higher performance and reliability of advanced facilities, such as particle accelerators, space crafts, vacuum interrupters, etc.------------------(6M) • Breakdown mechanisms *of* vacuum gap*s* on the basis of particle generation on the electrode surface. Mechanism of solid, Liquid and gaseous dielectric medium--------------(3M)
8	**State and explain the Paschen's law &breakdown in non-uniform fields.(Nov-Dec 2018) (13M)** BTL3 **Answer: Page: 2.9- M.Jeraldin Ahila** • For a Uniform field gap, electric field E=V/D. **Paschen's law** Here are three equations: Breakdown voltage: breakdown = B * p * d / (C + ln(p * d))-----------------------(3M) Breakdown field strength: breakdown = p * (B / (C + ln (p * d)))-----------------------(4M) where:

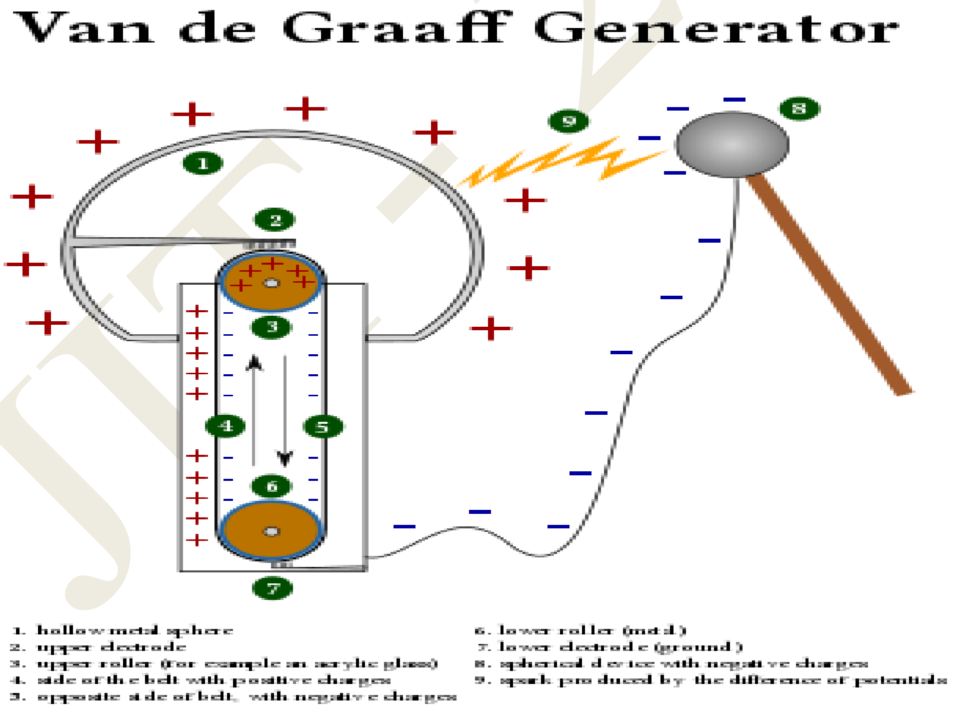
	C = A / ln (1 + 1 / gamma)--------------------------------------(3M) Temperature dependence--(3M)
9	**Explain a clear method Townsend's criterion for breakdown of Dielectric. (Nov/Dec 2016)(April- May 2018) (13M)** BTL3 **Answer: Page :2.5- M.Jeraldin Ahila** - There are always some electrons present in the atmosphere due to cosmic radiation etc. - A simple criterion for spark breakdown in the presence of a crossed magnetic field is postulated for the region around and well below the Paschen minimum-------(4M)  STREAMER BREAKDOWN ------------------(5M) - A streamer discharge, also known as filamentary discharge, is a type of transient electrical discharge. - When the line voltage is increased, the velocity of the electrons------------(3M)
10	**From the fundamental principle ,derive Townsend's Criteria for the breakdown criteria for the breakdown of gaseous dielectric medium.(NOV/DEC 2016) (13M)**BTL4 **Answer: Page:2.6- M.Jeraldin Ahila** - According to the Townsend theory, current growth occurs as a result of ionization process only Townsend mechanism when applied to breakdown at atmospheric pressure was found to have certain drawbacks.-------------------------------(4M) - The growth of charge carriers in an avalanche in a uniform field is described by $e^{\alpha d}$. This is valid only as long as the influence of the space charge due to ions field.-------------(4M) - Town sends theory says that current growth depends on ionization. But actually it depends on gas pressure and geometry of gap.----------------------------------(5M)
	PART * C
1.	**There is a gas experiment it was found steady current of 5.5*10^-8A With 0.4cm separation between the plates .For constant field, separation reduces to 0.1 cm results in a current of**

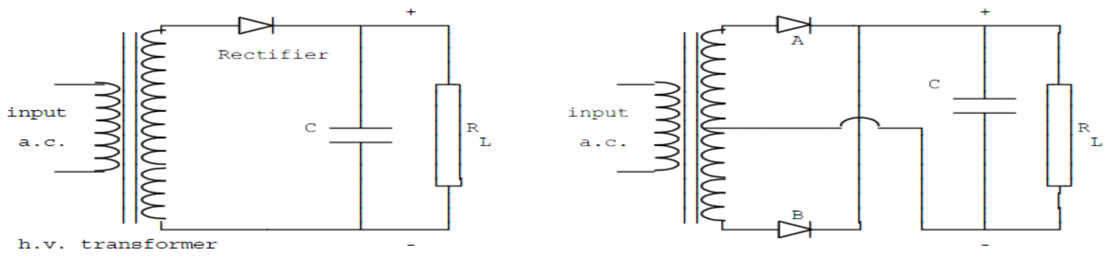
	5.5*10^-9A.Find Townsend's primary ionization coefficient.(15M) BTL2 **Answer: Page:2.40- M.Jeraldin Ahila** I=I0eαd I1=5.5*10^-8 D1=0.4cm-----------------(4M) I1/I2=eα(d1-d2)(5M) 10=eα*0.3(3M)-------------------(6M) 0.3α=ln 10(2M) A=7.676 per cm-torr. ---------------------(5M)
2	**Describe briefly of Electrochemical breakdown.(15M)** BTL5 **Answer: Page:2.33- M.Jeraldin Ahila** • Breakdown can be caused by several different processes acting singly, or together. • A number of the processes are electric, others are thermal and electromechanical, and breakdown can be promoted by internal and external gas discharges and by electrochemical processes----(4M) $F = \frac{1}{2}\varepsilon_0 \varepsilon_r \frac{V^2}{d^2}$ ------------------------------(2M) • The possibility of instability occurring for lower average field is ignored i.e., the effect of stress concentration at irregularities is not taken into account.-----------------(8M)
3	**Explain a positive plane corona.** (15M). BTL6 **Answer: Page :2.6- M.Jeraldin Ahila** • Positive and negative corona and observations at reduced pressures in the range 756- to 210-mm Hg. Oscillographic observation of corona pulses with a time resolution of the order of 10−7 second, visual and photographic observation of the corona, and current-voltage measurements have thrown new light on fundamental corona processes. ---------------------------(5M) • The negative corona revealed the fluctuations and dependence on surface conditions noted by previous workers. Current pulse shapes have been measured in negative and positive corona discharges mostly in dry air. ------------------------------------(4M)- • High-frequency instabilities of the high-pressure filamentary glow discharge, which can be responsible for the arcing from freshly polished cathodes, were observed and attributed to local positive-streamer-like breakdowns of the cathode sheath.---------------------------(6M)

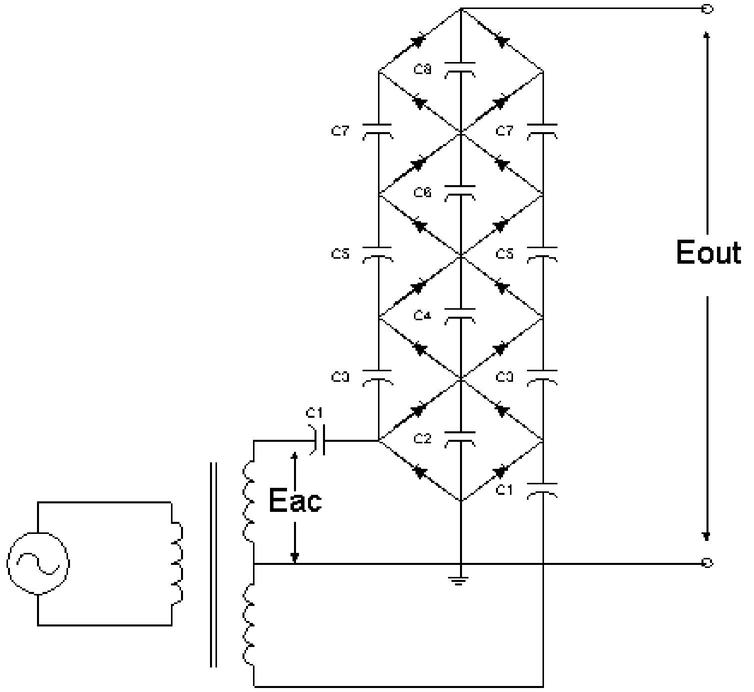
	UNIT III GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS
	Generation of High DC, AC, impulse voltages and currents - Triggering and control of impulse generators
Q.No.	**PART-A**
1.	**What are the applications of high voltages?(May/Jun 2014)** BTL1 • High DC voltages • High ac voltages of power frequency • High ac voltages of high frequency • High transient or impulse voltage of very short duration • Transient voltages of longer duration such as switching surges.
2	**What are the advantages of Van de Graff generator? (Nov/Dec 2017)** BTL1 • Very high DC voltage • Ripple free output
3	**What is the formula to determine optimum number of stages for a Cockcroft-Walton multiplier?**BTL1 Δv = 2/ ƒc [(2n3 /3) + (n2 /2) – (n/6)] Where Δv = voltage drop f = frequency c = capacitance n = number of stages
4	**Define rise time or front time.**BTL1 • It is the time required for the response to rise from 10% to 90% or 0 to 100% of the final value at the very first instant.
5	**What is Peak value?**BTL1 • The maximum positive deviation of the output with respect to its desired value is known as peak value.
6	**Define Marx circuit.**BTL1 • A bank of capacitors are charged in parallel and then discharged in series into a wave shaping network to produce a lighting impulse voltage • Double exponential fast rising & slow decaying voltage.
8	**What are the advantages of generating voltmeters?(NOV/DEC 2016)** BTL2 • It is a variable capacitance electrostatic voltage generator, generating current proportional to the applied voltage. • It does not absorb power from the voltage measuring source. • It is driven by external synchronous / constant speed motor.
9	**Distinguish between uniform field and Non-uniform field.**BTL2 • In the uniform field, increase in applied voltage produces a Breakdown in the gap in the form of a spark without any preliminary discharge. • In the non-uniform field, an increase in applied field, first cause a discharge in the gas around the

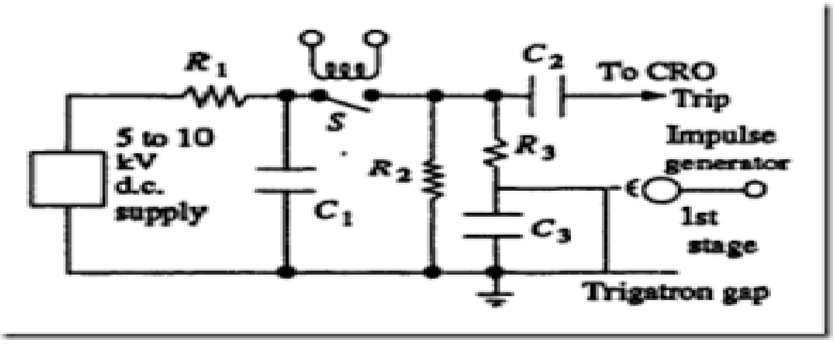
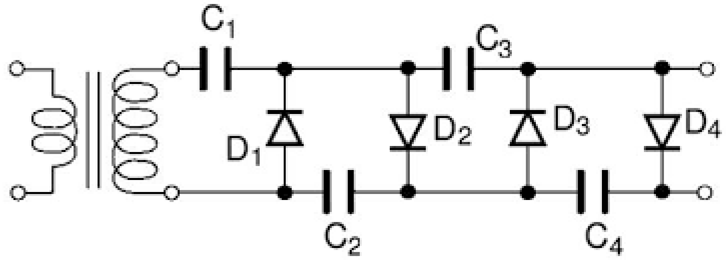
	points where the field is the highest. (Eg. Sharp Points, Curves of electrode). • This from of discharge is called corona discharge, which extends finally as the field is increased and bridges the gap between the electrodes ultimately & cause BD.
10	**Write the various methods available for generating High DC voltage.**BTL2 • Half & full wave rectifiers • Voltage multiplier circuits
11	**State principle of Electrostatic machines.** BTL3 • In electrostatic machines, current carrying conductors are moved in a magnetic field • The mechanical energy is converted into electrical energy.
12	**Write the general concept of multistages impulse generators.**BTL3 • DC charging set • Charging resistor • Generator capacitor or spark gap • Wave shaping resistors and capacitors • Triggering system • Voltage dividers
13	**Write the lighting over voltage in exponential form.** BTL4 • $V = V0 [e-\alpha t- e- \beta\tau]$ • $\alpha=1,\beta=100,\tau=50$
14	**Define Specialty of high voltage / current measurement.** BTL4 • Safety of men & materials. • Accuracy • Induction of over voltage, due to stray coupling. • Proper location. • Linear extrapolation not valid. • Electromagnetic interference.
15	**State the performance of a potential Divider and a generating Voltmeter for measurement of DC Voltages.** BTL4 **Potential Dividers** • Direct contact with HV • Source loading • Power dissipation. • They require calibration **Generating Voltmeter** • Does not absorb power from voltage measuring source • Scale is linear & extension range easy. • They require calibration
16	**Mention the different devices used for High DC voltages.**BTL5

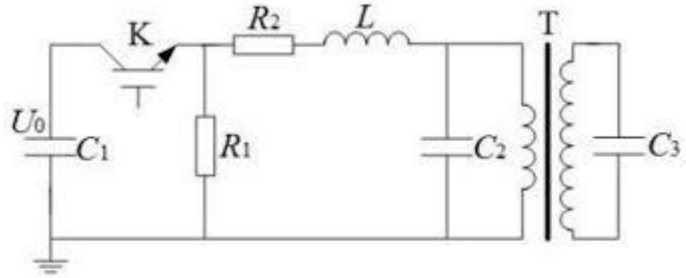
	• Series resistance micro ammeter. • Resistance potential dividers • Generating of Voltmeters • Sphere gap & Spark gaps.
17	**Mention the various methods available for measurement of High Impulse currents or High frequency ac or fast rising ac.**BTL5 1. Resistive shunts 2. Magnetic pot cut meter.
18	**Define surge diverter.** BTL1 • When the line voltage is less than the limiting value the leakage current should be zero. • When the line voltage exceeds the limit, it should offer zero impedance irrespective of the wave shape, so that the surge voltage is by passed.
19	**Write the basic principle of Electrostatic machines.** BTL4 In electrostatic machines, current carrying conductors are moved in a magnetic field, so that the mechanical energy is converted into electrical energy.
20	**What are the advantages of using cascade transformer units for HVAC generation? (NOV/DEC 2014).** BTL1 • Natural cooling is sufficient. • Transformer are compact in size • Constructional is identical • Three phase connection in star or delta is possible
21	**What is peak value?**BTL1 The maximum positive deviation of the output with respect to its desired value is known as peak value.
22	**What are the limitations of Van de Graff generator?** BTL1 • Low current output. • Belt velocity due to vibration. • It is difficult to have an accurate grading of electric fields
23	**Discuss the Disadvantages of a half wave rectifier circuit? (Nov 2013)** • Low DC output and low efficiency. • Higher ripple factor in output voltages and currents. • Low transformer utilization factor.
24	**Mention the specifications of standard impulse waves. (May 2013) (Nov 2015)(Nov-Dec 2018)** By definition the rise of front time and tail time 1.2/ 1.5 micro sec, 1000 kV(standard value), fall time of 50 % of 50 micro sec.
25	**Mention the advantages of high frequency transformers**. Saving in cost and size, pure sine wave output, uniform distribution of voltage across the winding coils due to subdivision of coil stack into number of units.
26	**What is transient voltage?** It is an oscillatory wave or a damped oscillatory wave of frequency ranging for few Hundred hertz to few kilohertz.

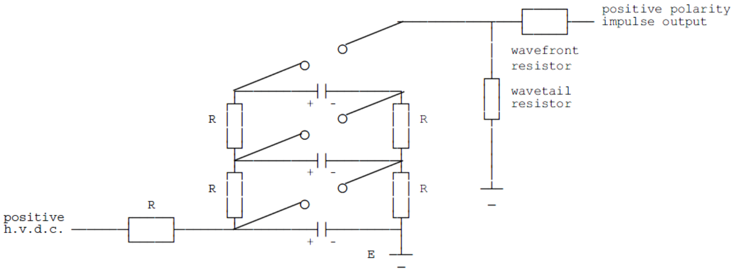
27	**What are the components of a multistage impulse generator?** Dc charging unit, charging resistors, generator capacitors and spark gaps, wave shaping resistors and capacitors, triggering system, voltage dividers and gas insulated impulse generators.
28	**Explain Delbarton circuit. (Dec 2012, Dec 2016)** A combination of Cockcroft Walton type voltage multiplier with cascaded transformer dc rectifier is developed for very high voltages but limited output currents having high stability, small ripple factor and fast regulation. This type of circuit is called Delbarton circuit
29	**Give any two methods of switching surge generation in laboratory. (May 2013)** ☐ By changing the tail time constants of impulse generator. ☐ By connecting primary and secondary windings of power transformer in series
	PART-B
1.	**Describe with a neat sketch the working of Vande Graff Generator. What are the factors that limit the maximum voltage obtained?(Nov/Dec 2017)(APR/MAY 2017)(Nov-Dec 2018) (13M)** BTL3 **Answer: Page: 3.16 - M.Jeraldin Ahila** - Electrostatic generators using the principle of charge transfer can give very high direct voltages. -------------------------------(4M) - A Van de Graff generator is an electrostatic generator which uses a moving belt to accumulate electric charge on a hollow metal globe on the top.  -----------(6M) - Generally used for scientific experiments, the generated charges are used to speed particles such as ions.-----------------------------------(3M)
2	**Explain the generation of high direct voltages and voltage multiplier circuits. (13M)**BTL1

	Answer: Page:3.19 - M.Jeraldin Ahila • The advantage of *"Voltage Multiplier Circuits*" is that it allows *higher voltages* to be created from a low voltage power source without a need for an expensive-------(4M) • A voltage multiplier is an electrical circuit that converts AC electrical power from a lower • Higher DC voltage, typically using a network of capacitors and diodes.-----------(3M) **Rectifier circuits**  (a) half-wave rectifier (b) full-wave rectifier Figure 7.7 - Half-wave and full-wave rectifier circuits (6M)
3	**Describe the construction and principle of operation multistage Marx Generator.(APRIL/MAY 2017) (April May 2018) (13M)(** BTL1) **Answer: Page:3.19 - M.Jeraldin Ahila** • A Marx generator is an electrical circuit first described by Erwin Otto Marx in 1924. Its purpose is to generate a high-voltage pulse from a low-voltage DC supply. --------------(7M) • This Marx generator is normally connected to a single output transmission line. • Surges caused in them during operation, it is necessary to test this equipment with voltages of the form likely to be met in service---(6M)
4	**Describe the working principle of a Cockcroft-Walton voltage multiplier circuit. (May/Jun 2014) (13M)(** BTL1) **Answer: Page:3.7 - M.Jeraldin Ahila** • Positive and negative half cycles • TheCockcroft–Walton *(CW) generator*, *or* multiplier,is an electric *circuit*that generates ahigh *DC voltage*from a low-*voltage AC* or pulsing *DC* input.----------------(6M)

	 --------------------------------(7M)
5	**Discuss with diagram the operation of resonant transformer. (13M)** (BTL2) **Answer: Page:3.22- M.Jeraldin Ahila** • Equivalent Primary and secondary winding • The voltage present at the secondary winding is the same as the voltage that is applied at the primary winding. These are used when it is desirable to galvanic ally isolate the primary from the secondary.----------------------------(7M) • LV winding is *placed* nearer to *core* as the amount of *insulation* required to a liquid which acts as insulatingand heat transfer medium.--------*(6M)*
6	**Describe the multistage impulse current generator circuit .Explain its operation and applications.(13M)**(BTL2) **Answer: Page : 3.42 - M.Jeraldin Ahila** • Generation of high dc voltage, Voltage Multiplier Circuits and Ripple Minimization. Sources of over voltages and Standard Lightning and Switching wave shapes. Impulse Voltage Generator, Analysis of Single Stage Circuit. Multistage Impulse Generator and their Triggering Methods.---------------------------------------(7M) • A new high-*voltage* multi-stage impulse generator circuit is described. The circuit is based on conventional multi-stage impulse generator circuits but trigatrons are used in each stage in place of the *sphere gaps* used in conventional circuits.---------(6M)
7	**Discuss briefly about Tripping and control of impulse generators. (13M)** (BTL2) **Answer: Page:3.58 - M.Jeraldin Ahila**

	- In large impulse generators, the spark gaps are generally sphere gaps or gaps formed by hemispherical electrodes. --(4M)  0 (5M) - The gaps are arranged such that sparking of one gap results in automatic sparking of other gaps as overvoltage is impressed on the other. ----------------------(3M)
8	**Solve the n-stage Voltage multiplier circuits and hence deduce the condition of n-stages. (May/June2014)(13M)**(BTL3) **Answer: Page: 3.7 - M.Jeraldin Ahila** - The CW multiplier has the disadvantage of having very poor voltage regulation. - The voltage drops rapidly as a function the output current. In some applications, this is an advantage.------------------------ (6M) - A *Voltage* Multiplier Circuit is a special type of diode voltage double circuit ... C1 to Vp and *on* the positive half-cycle D2 adds the AC peak voltage to Vp*on*C1 and ... single diode-capacitor stage to the half-wave *voltage* doubler circuit above  - ---------------------------(7M)
9	**A Cockcroft-walton type voltage multiplier has eight stages with Capacitances all equal to 0.05µF.The supply transformer secondary voltage in 125Kv at frequency is 150Hz and load current is 5Ma.Find the optimum number of stages for minimum voltage regulation.(13M)(April/May 2015)** BLT3 **Answer: Page.:3.37 - M.Jeraldin Ahila** Finding a Frequency:3 Optimum number of stages:10 V max=125KV Frequency=150Hz Current I=5Ma=$5*10^{-3}$--------------------------(7M)

	C=0.05µF (6M) Optimum number of stages=$125*10^{3}*150*0.05*10^{-5}/(5*10^{-3)}$ Stages=12 ---(6M)
10.	**Explain about the Marx generator.(13M)(MAY 2018)** BTL4 **Answer: Page.:3.68 - M.Jeraldin Ahila** • A Marx generator is an electrical circuit its purpose is to generate a high-voltage pulse *from* a low-voltage DC supply --(7M) • The period of discharge of the Marx discharging into a short *circuit* is given ... *having* 7 *stages*, each stage with two 0.15µF, 50Kv----------------------------(6M)
11	**A 100KVA,250/200V testing transformer has 1% and5%leakage reactance on 400KVA base .A cable has to be tested at 600Kv Using the above transformer as a resonant transformer at 50 Hz. Charging current of cable at 400Kv is. Determine the input voltage of the transformer neglecting dielectric loss of a cable.(13M)(** BTL4) **Answer: Page: 3.25- M.Jeraldin Ahila** Determination of input transformer:5 Neglecting loss transformer:6 Secondary voltage=200KV Voltage of the cable=400KV -----------------------(7M) Charging current=KVA/KV=$100*10^{3/}200*10^{3}$ I=0.5Amp Excitation Voltage on Secondary side transformer=I*R=$0.5*10^{3}*8$=4Kv. Input voltage =$4*10^{3*}250/200*10^{3}$=5Volt -------------------(6M)
1.	**Design and explain the circuit's gas insulated impulse generators. (15M)** (BTL2) **Answer: Page:3.45- M.Jeraldin Ahila** • High-Voltage ImpulseTesting evaluates the ability of Electrical *Insulation* Systems to withstand ... *Impulse* testing can also be performed on motors, *generators*. • *Insulation* Test *Generator*. The 1.2/50µs Lightning *impulse* forms the basis for a variety of *insulation* test applications.---(8M)  • ---------------- **(4M)**

	 Figure 8.17 - Marx Impulse generator circuit -------------------------------(3M)
2	**Examine Cascade transformer Unit with isolating Transformer for Excitation. (15M)** BTL6 **Answer: Page.:3.27- M.Jeraldin Ahila** • Cascading primary and secondary winding • A high-voltage source consisting of a limited number of step-up **transformers** with their secondary's in series, the primary of each after the first being supplied from a pair of taps on the secondary of the preceding.------------------(8M) • Excitation in different cores • There -are *several* variables which affect the performance of such *cores* with respect to *core* loss and *exciting* current.--------------------------(7M)
3	**A six stage impulse generator has 0.06µ F, the wave front and wave tail resistances connected are 500Ω and 4000 Ω and output voltage 550 kV respectively. If the load Capacitance is 1200pf determine the front time and tail time of the impulse generator.**(APR/MAY 2015) **(15M)** BTL5 **Answer: Page: 3.42- M.Jeraldin Ahila** Front time:8 Tail time:7 Number of stages=8 Capacitance is 0.01875 µ F Load capacitance=1200pf=0.0012 µ F------------------------ (8M) Front time=$3R_1$(C1C2/C1+C2)=3*500(0.01875*10^{-6}*0.0012*10^{-6}) FT=1.69 µsec T2=62.84 µsec --- (7M)

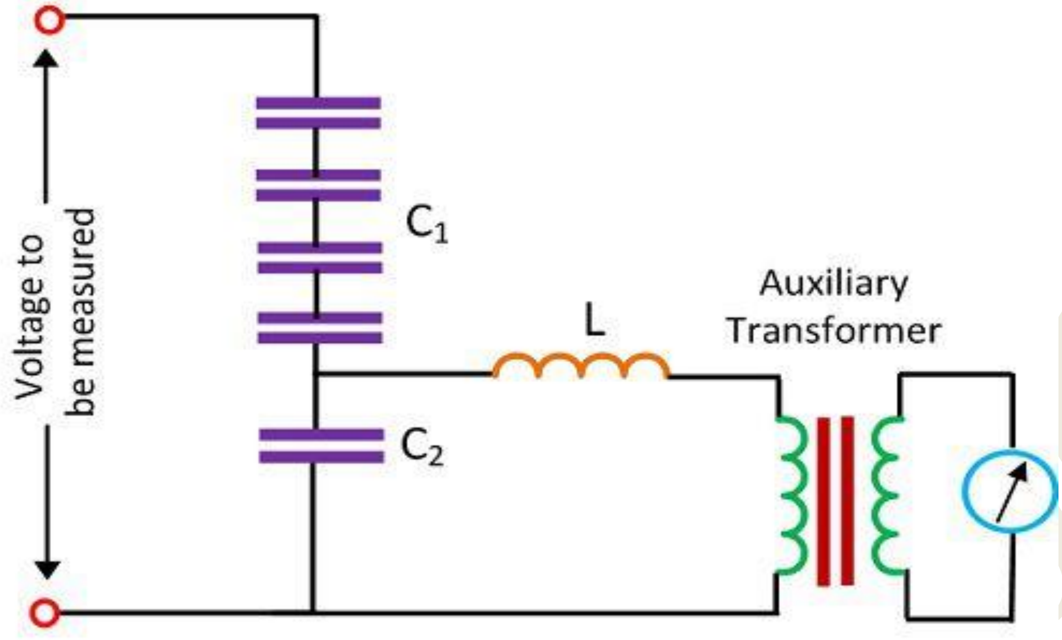
4	**Design a impulse Voltage Generator circuits. (15M)** BTL6 **Answer: Page:3.33- M.Jeraldin Ahila** • The higher voltage of the upper electrode arises from the fact that for the same charge, a smaller capacitance gives a larger voltage. • Very short pulse high-voltage or high-current surges can be produced by an electrical apparatus known as impulse generator. --------------------------(8M) • High impulse voltages are used to test the durability of electric power equipment against lightning and switching surges. • The Marx Impulse generator is used to generate such high impulse voltages. • The upper electrode has a smaller capacitance to earth on account of the larger spacing involved.--(7M)

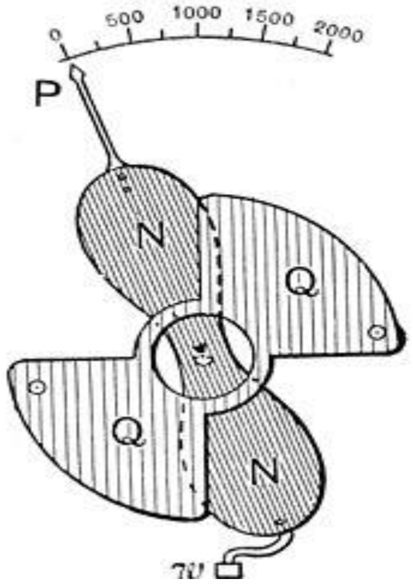
	UNIT IV MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS
	High Resistance with series ammeter – Dividers, Resistance, Capacitance and Mixed dividers – Peak Voltmeter, Generating Voltmeters - Capacitance Voltage Transformers, Electrostatic Voltmeters –Sphere Gaps - High current shunts- Digital techniques in high voltage measurement.
Q.No.	**PART*A**
1.	**Define Generating voltmeter.(Nov/Dec 2016)** BTL1 A generating voltmeter is a variable capacitor electrostatic voltage generator which generates current proportional to the applied external voltage.
2	**List the various devices used for High DC voltages.**BTL1 • Series resistance micro ammeter. • Resistance potential dividers • Generating of Voltmeters • Sphere gap & Spark gaps.
3	**What are the various methods used for measurement of power frequency AC voltages?**BTL1 • Potential dividers, resistance or capacitive Type. • Potential Transformers electromagnetic or C. V. T. • Electrostatic voltmeters.
4	**Define 'Sphere gap' for measurement of High voltages.** BTL1 • A uniform field sphere gap will always have a spark over voltage within known tolerance under constant atmospheric conditions. • Hence it can be used for measurement of peak value of the voltage. It is independent of the voltage wave form and hence suitable for all types of wave forms, from DC to DC.

5	**What are the factors influencing the spark over voltage of a sphere gap?(Nov/Dec 2014)**BTL1 • Nearby earthed object • Atmospheric conditions and humidity • Irradiation • Polarity and rise time of voltage wave forms.
6	**What principle does Rogowski Coil works?(Nov-Dec 2018)** BTL1 If a coil is placed surrounding a current carrying conductor, the voltage signal induced in the coil.
7	**State the principle is used in electrostatic voltmeter.**BTL2 • If the electric field is produced by the voltage between a pair of parallel plate disc electrodes, the Force F on an area A of the electrode, for which the field gradient E is the same across the area and perpendicular to the surface.
8	**State the qualities of a CRO used for measurement of impulse voltage measurements.**BTL2 • Sealed tube, hot cathode Type • Photo graphic arrangements for recording wave forms. • Input voltage range from 5mv/cm to 20v/cm.
9	**Mention the limitations in the series resistance design.**BTL2 • Power dissipation and source loading • Temperature effects and longtime stability • Voltage dependence of resistive elements • Sensitivity to mechanical stresses
10	**Mention the merits of faraday generator.**BTL2 • When a linearly polarized light beam passes through a transparent crystal in the presence of a magnetic field, the plane of polarization of the light beam undergoes rotation. • These rotations of polarization are proportional to the current.
11	**State the use of Rod to Rod**.BTL3 • Breakdown voltage higher when is negative • Breakdown voltage depends on humidity of air. • The field is highly non uniform.
12	**Mention the principle of Regowski Coil.**BTL3 **Voltage developed** • $V2(t) = M\ d/dt\ (I(t))$ • When V2(t) is passed through an Integrating network then • $Vm\ (t) = M\ (1/RC)\int dI(t)/dt = M\ I\ (t)/RC$ When R & C are those of the Integrating circuits. • i.e. $Vm(t) = K\ I\ (t)$ • Thus by measuring Vm (t), we can calculate I(t), the current.
13	**State the factors of influencing the spark over voltage of a sphere gap.**BTL4 • Nearby earthed object • Atmospheric conditions and humidity • irradiation

	• Polarity and rise time of voltage wave forms.
14	**Mention the methods available for measurement of High alternating current.** BTL4 • Resistive shunts with milli ammeters • Electromagnetic current Transformers.
15	**Mention the types of peak reading AC voltmeters.** BTL4 • Series capacitor peak voltmeter • Digital peak voltmeter • Peak voltmeter with potential dividers
16	**Define Specialty of high voltage / current measurement.**BTL5 • Safety of men & materials. • Accuracy
17	**State the performance of a potential Divider and a generating Voltmeter for measurement of DC Voltages.**BTL5 **Potential Dividers** • Direct contact with HV • Source loading • Power dissipation. • They require calibration **Generating Voltmeter** • No direct contact • Does not absorb power from voltage measuring source • Scale is linear & extension range easy. • They require calibration • Careful construction necessary • Disturbance in mounting make calibration invalid.
18	**Mention the function of a delay cable in the HV measurements using a CRO.** BTL6 • With rapidly changing signals, the CRO time base should be started before the original signal reaches the CRO y plates otherwise, the signed may be missed by the CRO. • Therefore while measurement, using a CRO, the Triggering of the CRO time base is done directly (X plate) immediately and the signal proportional to voltage /current to be measured is sent through a delay cable to the vertical (Y) plates so that the required delay is obtained. • Delay cable may be a long inter connecting cable 20 to 50m long.
19	**What principle is used for the Faraday generator in measurement of high current?** BTL6 • $\alpha = V B. l$ • Where • α = Rotation of the plane • V = Constant • B = Magnetic Field • l = Length of the crystal • Where • B is made to be produced by the current to be measured I (t). $\alpha = K I (t)$

20	**Mention the criteria required to assess the potential dividers used for High Impulse voltages.**BTL6 • The shape of the voltage in the test arrangement should be transferred without any distortion to the LV side. • Simple determination of the transfer function is to be ensured.
21	**What are the methods to measure high frequency ac voltages and impulse voltages?** BTL1 • Potential divider with a CRO. • Peak voltmeters
22	**Define Generating voltmeter.** BTL1 A generating voltmeter is a variable capacitor electrostatic voltage generator which generates current proportional to the applied external voltage.
23	**What are the disadvantages of CVT?** BTL1 • Voltage ratio is susceptible to temperature variations. • In the presence of capacitance and choke, the problem of ferro-resonance occurs in power system
24	**What are the types of peak reading AC voltmeters?** BTL1 • Series capacitor peak voltmeter. • Digital peak voltmeter • Peak voltmeter with potential dividers
25	**Define Hall effect.** BTL1 • Whenever an electric current flows through a metal plate in a magnetic field perpendicular to it, Lorenz force will detect the electrons in the metal plate in a direction perpendicular to both the magnetic field and the flow of current. • The change in displacement generates an emf called the Hall Effect.
	PART B
1.	**What is CVT? Explain how CVT can be used for high voltage AC measurement.(NOV/DEC 2016) (13M)** BTL1 **Answer: Page :4.28 - M.Jeraldin Ahila** • The capacitive voltage transformer step-down the high voltage input signals and provide the low voltage signals which can easily measure through the measuring instrument. • The Capacitive voltage transformer (CVT) is also called capacitive potential transformer • The capacitive potential divider, inductive element and the auxiliary transformer are the three main parts of the capacitive potential transformer. ---------------------------------------(4M)

	 Capacitive Potential Transformer Circuit Globe ----------------(3M) • For measuring high voltage (above 100kV) the high insulated transformer is required. • The highly insulated transformer is quite expensive as compared to the normal transformer----------------(6M)
2	**Describe the compare the performance of resistance capacitance and mixed RC potential dividers for measurement of impulse Voltages.(May/Jun 2014)(13M)** BTL1 **Answer: Page:4.35- M.Jeraldin Ahila** • A resistor–capacitor circuit (RC circuit), or RC filter or RC network, is an electric circuit composed of resistors and capacitors driven by a voltage or current source.--------------------------------(3M) • The equivalent circuit of such a construction is shown in Fig. 7.34. Such dividers are made up to 5 MV with response times less than 30 n s.----------------------------------- (4M) • Voltage dividers used for measuring more than one million volts attenuate the criteria required to assess the dividers.--(6M)
3	**Describe Electrostatic Voltmeter and list it advantages over it.(13M) (**Nov/Dec 2017).BTL3 **Answer: Page:4.14- M.Jeraldin Ahila** • Electrostatic voltmeter can refer to an electrostatic charge meter, known also as surface DC voltmeter, or to a voltmeter to measure large electrical potentials, traditionally called electrostatic voltmeter.------(4M)

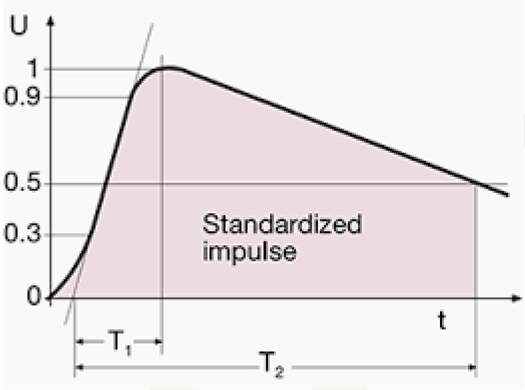


(9M)

4 **How the instruments used for the measurements of impulse voltage and current? (13M).**BTL1

Answer: Page:4.54 -M.Jeraldin Ahila

- An impulse generator is an electrical apparatus which produces very short high-voltage or high-current surges.
- The impulse generator design is based on the Marx circuit.----------(4M)



-----------------------------(3M)

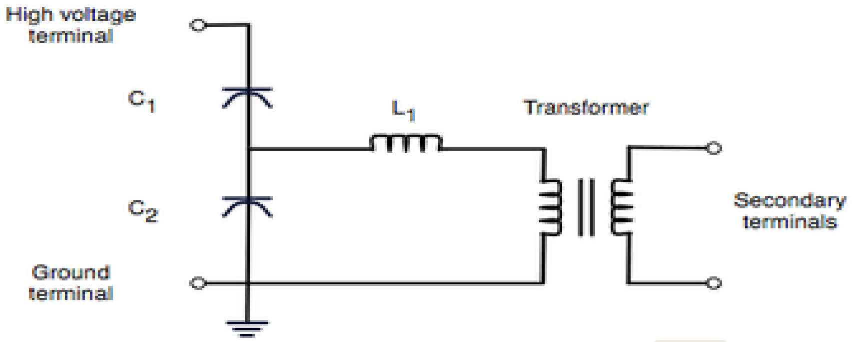
- The purpose of the impulse test is to determine the ability of the transformer insulation to withstand the transient voltages due to lightning.
- It is well known that power system components are subjected to severe over voltage due to internal switching or external lightning surges. --------------------- ------ (4M)

5 **Explain about the CVT.(13M)**BTL2

Answer: Page:4.12 -M.Jeraldin Ahila

- A capacitor voltage transformer (CVT or CCVT), is a transformer used in power systems to step down extra high voltage signals and provide a low voltage signal, for metering or operating a protective relay.

- With the popularization of PCs, the constant voltage transformers (CVTs) have also become equally popular.
- The CVT is simply a magnetic transformer of a special construction that has a capacitor connected across the secondary winding of the transformer.--------------------------------------(5M)
- The voltage regulation possible in a CVT also is good.-------------------------(4M)
- The input voltage ranges 170 to 260 V and output regulation is 230 ± 2 % at no load to full-load. Distortion-approximately 5% under full-load conditions. Rating of 50, 150, 250, 350, 500, 750, 1000, 2000 VA.



(4M)

6 **Explain the principle and construction of generating voltmeter for the measurement of high DC voltages. List out its advantages and disadvantages.(April/May 2017) (Nov-Dec 2018)(13M)**BTL2

Answer: Page: 4.4 M.Jeraldin Ahila

- A Generating Voltmeter Principle and Construction is a variable capacitor electrostatic voltage generator which generates current proportional to the applied external voltage.
- The device is driven by an external synchronous or constant speed motor and does not absorb power or energy from the voltage measuring source.------------------ (4M)

Principle of Operation

The charge stored in a capacitor of capacitance C is given by q = CV. If the capacitance of the capacitor varies with time when connected to the source of voltage V, the current through the capacitor,

$$i = \frac{dq}{dt} = V\frac{dC}{dt} + C\frac{dV}{dt} \qquad (7.1)$$

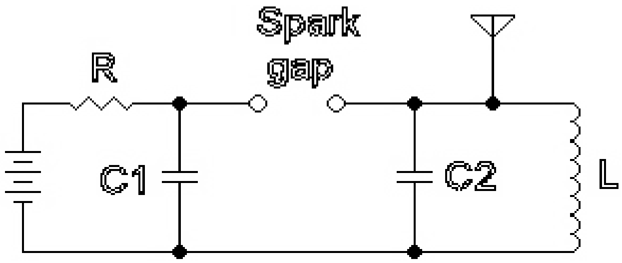
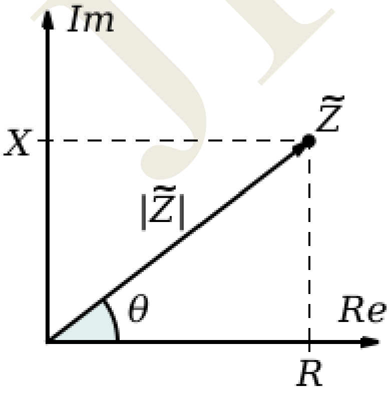
--------------------(3M)

For d.c. voltages dV/dt = 0. Hence,

$$i = \frac{dq}{dt} = V\frac{dC}{dt} \qquad (7.2)$$

------------------------(3M)

If the capacitance C varies between the limits C_0 and $(C_0 + C_m)$ sinusoidally as

	$C = C_0 + C_m \sin \omega t$ the current i is $i = i_m \cos \omega t$ $i_m = V C_m \omega$ --(3M)
7	**Explain how a sphere gap can be used to measure the peak value of voltages? Also discuss the parameters and factors that influence such voltage measurement?** (Nov/Dec 2016) (13M)BTL3 **Answer: Page :4.21 M.Jeraldin Ahila** - A spark gap consists of an arrangement of two conducting electrodes separated by a gap usually filled with a gas such as air, designed to allow an electric spark to pass between the conductors. ------------- (5M) - A spark gap consists of an arrangement of two conducting electrodes separated by a gap usually filled with a gas such as air, designed to allow an electric spark to pass between the conductors.----------------(2M)  (6M)
8	**Explain with diagram the extended series impedance for high resistance for high voltage measurements. (13M)**BTL3 **Answer: Page :4.8 M.Jeraldin Ahila** - Electrical impedance is the measure of the opposition that a circuit presents to a current when a voltage is applied. --(4M)  - ----------------(5M)

Most ohmmeters of the design shown in the previous section utilize a battery of relatively low voltage, usually nine volts or less. ------------------------------(4M)

9 **Explain in detail the operation of faraday generator. (13M) (** BTL4)

Answer: Page :4.40 M.Jeraldin Ahila

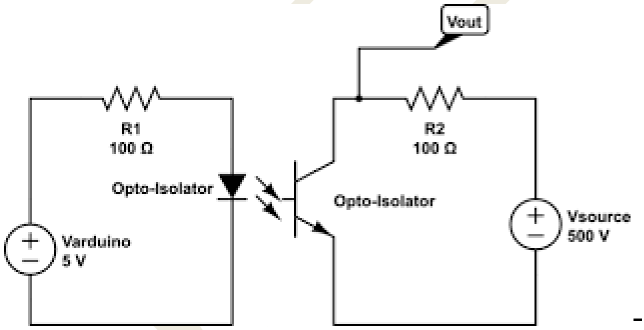
- An electric generator is a device that converts mechanical energy obtained from an external source into electrical energy as the output. ... Faraday discovered that the above flow of electric charges could be induced by moving an electrical conductor, such as a wire that contains electric charges, in a magnetic field.--(4M)

- **Disadvantage**—for power transmission, DC voltage from a **generator** is more difficult to step up or down.
- In DC System, The Value of charging current is quite **low**, therefore, the length DC Transmission lines is greater than AC lines. --(6M)
- Voltage induced in the armature of the DC generator is AC, but that is converted to the Dc form through the Commutator. (3M)

10. **Explain in detail the various techniques for the measurement of High DC voltages.(MAY/JUNE 2015) (13M)** BTL4)

Answer: Page :4.39- M.Jeraldin Ahila

- Electrostatic or high impedance voltmeter: to measure DC voltage across R2. Where V2 is the DC voltage across the low voltage arm R2.
- Potential dividers are made with 0.05% accuracy up to 100 kV, with 0.1% accuracy up to 300 kV, and with better than 0.5% accuracy for 500 kV.-----------------------------------(6M)
- It is also possible to measure the magnetic field generated by the current to be measured, or to measure the force between conductors.--(4M)
-



- ------ ----- (3M)

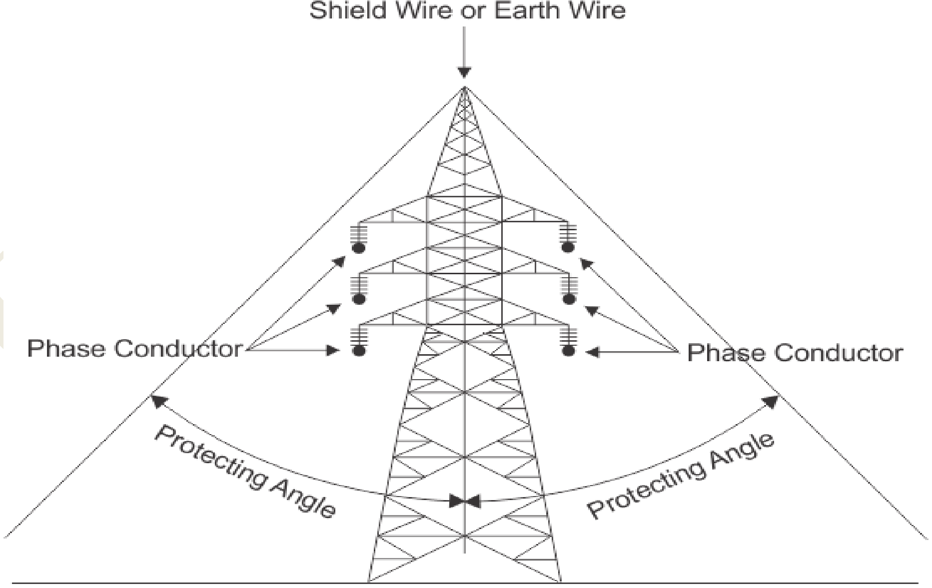
PART C

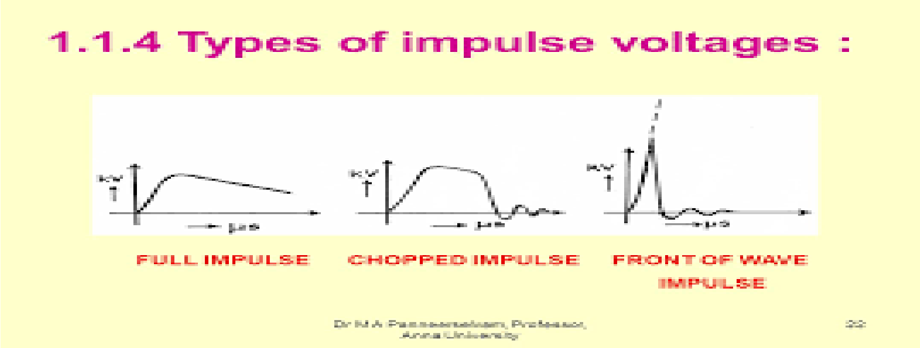
1.	**A Rogoswki coil is required to measure impulse current of 8KA having rate of change of current is 10^10A/sec. The voltmeter is connected across the integrating circuit which reads 8Volts for full scale deflection. The input to integrating circuits is from Rogoswki coil .Determine the mutual inductance of coil, R and C for the integrating circuits. (15M)** (BTL2) **Answer: Page:4.56 -M.Jeraldin Ahila** $i(t)=RC/M\ V_0(t)$ $8*10^3=RC/M*8$------------- (2M) $RC/M=8*10^{3/8}=10^3$ Time taken to reach peak value$^{=}8*10^3/10^{10}=8*10^{-7}$secs--------- (3M) $T=8*10^{-7}/1/4=32*10^{-7}$ Frequency=32 Hz.------------------(6M) proper integration1/CR=f/5=107/32*5=106/16-------------------(4M)_
2	**Discuss the hall generator method for DC measurements.(15M)**(BTL3) **Answer: Page:4.58 -M.Jeraldin Ahila** • A Hall generator is a solid state sensor which provides an output voltage proportional to magnetic flux density. --(4M) • The Hall Effect is the development of a voltage across a sheet of conductor when current is flowing and the conductor is placed in a magnetic field----------(4M) • Hall generators are also used in instruments that measure linear or angular displacements, magnetic-field gradients, magnetic flux densities, or the output of electric motors, as well as in contactless inverters and in playback heads of sound-recording systems.------------------- (7M)
3	**Discuss and compare the performance of resistance capacitance and mixed RC potential dividers for measurement of impulse voltages.(MAY/JUNE 2014)(15M)**BTL3 **Answer: Page:4.68- M.Jeraldin Ahila** • Resistor in series. When resistors are connected in series, the current through each resistor is the same. In other words, the current is the same at all points in a series circuit.------------(4M) • The same current flows through each part of a series circuit. The total resistance of a series circuit is equal to the sum of individual resistances. Voltage applied to a series circuit is equal to the sum of the individual voltage drops.-------------------------------------(6M) • This sensor detects the mechanical strain of the transducer on which a foil strain gauge is cemented. Tests ascertained that the strain was directly proportional to the voltage measured, with errors less than 2 % for voltages up to 26,000 V. -------------------------------(5M)

	UNIT V HIGH VOLTAGE TESTING & INSULATION COORDINATION
	High voltage testing of electrical power apparatus as per International and Indian standards – Power frequency, impulse voltage and DC testing of Insulators, circuit breakers, bushing, isolators and transformers- Insulation Coordination.
Q.No.	**PART*A**
1.	**Mention the necessities of High voltage testing.**BTL1 • To check whether they are as per the design and as per specifications and standards. • To ensure that the HV equipment is able to withstand over voltages produced naturally or within the system.
2	**What is the specialty of HV Testing?** BTL1 • The H.V. lab requires higher space. • Special equipment's are required. • Special Techniques are required.
3	List **standards for HV Testing.** BTL1 • B I S - Bureau of Indian Standards. • I E C - International Electro Tech. Commission. • B S I - British Standard Institution.
4	**Define Creep age distance.**BTL1 It is the shortest distance on the contour of the external surface of the insulator unit or between two metal fittings on the insulator.
5	**What are self-restoring and Non self-restoring insulation?**BTL1 • Insulation which completely regains its dielectric strength after a disruptive Discharge is called a self-restoring insulation. • Insulation which does not regain its insulating property after a disruptive discharge is a Non self-restoring insulation.
6	**Define the Disruptive dis charge voltage.(Nov/Dec 2017)**BTL1 • The Voltage that produces loss of dielectric strength of equipment is called disruptive discharge voltage. In solid-it is called puncture. • In liquid or air-it is called Flashover.
7	**State flashover and puncture.(May/June 2014)**BTL2 • When a loss of dielectric strength occurs inside a liquid or gaseous insulation or along the surface of a solid Insulation, it is called flashover. • When a loss of dielectric strength occurs inside a solid it is called puncture.

8	**Define type test.**BTL2 - Whenever a new brand is introduced and a new design is adopted. - Whenever the quality of the individual equipment is to be established say at the time of purchase. - Periodically the dielectric breakdown will be occur.
9	**State power frequency Test. May/June 2014)** (BTL2) - Power factor Test - Partial Discharge Test - 1 Minute W.S. Test - Visible discharge Test - Impulse with stand Test – Full wave (Positive & Negative Polarity) - Impulse with stand Test – Chopped wave (Positive & Negative polarity) - Switching surge Flashover Test - Impulse Flash over Test under oil.
10	**State AC Test Voltage and Impulse voltage**.BTL2 - Alternating current voltage of frequency 40 to 60 Hz, approximately sinusoidal (7% deviation is permitted) is called AC Test voltage. - It is a fast rising slow decaying voltage, characterized by its peak value, time to front and time to half value. - Standard Impulse Voltage - Peak : Tolerance ±3% - Time to Front : T_f 1.2µsec ±30% - Time to half value : T_t 50µsec ±20%
11	**State atmospheric correction with reference to High Voltage Testing.**BTL3 - Normally HV Tests are done under Normal Temperature, pressure & humidity conditions and then the values are corrected to the following conditions. - Temp : 27^0C - Pressure : 1013 Milli-bar 760 torr - Absolute humidity : 17gram/m3 - This is done by applying the following correction factors. h = humidity correction factor - d = air density correction factor
13	**Define Insulation coordination. (Nov/Dec 2014)(May 2018)(Nov-Dec 2018)** BTL4 - The selection of suitable values for the insulation levels of the various components in any electrical system and their arrangement in a rational manner is called insulation coordination.
14	**What is meant by Flashover voltage?(Nov/Dec 2016)** BTL4 - The Test voltage which has 50% probability for flashover is called 50% flashover voltage.

	• The test voltage which causes flashover of the test object at each of its application
15	**What is insulation level of an apparatus?** BTL1 It is defined as that combination of voltage values which characteristics its insulation with regards to its capability of withstanding the dielectric stresses.
16	**What is the necessity for measurement of RIV?**BTL5 • Sometimes electrical equipment like power Transformer, conductors, rotating machines etc. produce unwanted electrical signals in the radio frequency range of 150k Hz to 30 M Hz, whereas the power frequency being 50 Hz. • These signals affect the communication systems & should be prevented. Hence RIV measurement is necessary.
17	**Mention the system protection level and its selection depends on what factors.** BTL6 In the power system, system protection level is established considering the, • Location of the station • Protection level of arrester • Line shielding
18	**State system protection level.**BTL6 • Atmospheric Condition • Station Location • Protection level of arresters.
19	**Define BIL.(April/May 2015)** BTL6 • The basic insulation levels are reference levels fixed by standards for each voltage levels. • Basic impulse levels are reference levels expressed in terms of impulse crest voltage(V_p) with a standard lightning impulse voltage(1.2/50 micro seconds wave) for any apparatus the insulation level as demonstrated by suitable tests should be greater than or equal to the BIL
20	**Define withstand voltage.**BTL1 The voltage which has to be applied to a test object under specific condition in a withstand test is called withstand voltage.
	PART* B
1.	**Explain the direct and synthetic testing of isolators and circuit breakers in detail. (13M)**BTL1 **(Nov/Dec 2017)(May 2018) (Nov-Dec 2018)** **Answer: Page :5.40 - M.Jeraldin Ahila** • A circuit breaker “trips” or shuts off the electrical flow to protect the circuit from overheating and causing damage--even possibly an electrical fire.-------------(4M) • It should have a high dielectric strength to withstand operating and flashover voltages. Also, an insulator must be free from pores or voids, which may damage it.------------------(3M)

	 • If during this process insulator may not damage or punctuated then it test is ok. Is there are two flash over occur from five times then insulator test is failed----------------------.(6M)
2	**Explain in detail about Insulation Coordination. (NOV/DEC 2017)(Nov-Dec 2018)(13M)** BTL4 **Answer: Page :5.23 - M.Jeraldin Ahila** • Probability of failure of insulation is high at the weakest insulation point nearest to the source of over voltage---------------------------(3M) • In insulation coordination method, the insulation of the various parts of the system must be so graded that flash over if occurs it must be at intended points. ------ (4M)  • Overhead earth wire or ground wire or shield wire is also used to over the electrical substation to protect different electrical equipment from lightning strokes.(6M)
3	**Describe about the tests performed on bushings. (13M) (APRIL/MAY 2015)(May 2018)** BTL1

	Answer: Page :5.21 - M.Jeraldin Ahila • A bushing is used to bring high voltage conductors through the grounded tank or body of the electrical equipment without excessive potential gradients between the conductor and the edge of the hole in the body.-------------------------------------- (6M) • The bushing is either immersed fully in oil or is installed as in service condition. This test is carried out to ascertain that the internal breakdown strength of the bushing is 15% more than the power frequency momentary dry withstand test value.-----------------(4M) • Bushing may refer to: Bushing (bearing), a type of plain bearing. Bushing (electrical), an insulated device that allows a conductor to pass through a grounded conducting barrier. Bushing (isolator), a mechanical device used to reduce vibrations. (3M)
4	**Write the flash over voltage with stand high voltages impulse voltages Creep-age distance. (13M) (APRIL/MAY 2017)** BTL1 **Answer: Page :5.5 - M.Jeraldin Ahila** • Impulse testing systems are designed to generate impulse voltages that simulate lightning strikes and switching surges.----------------- (6M) • The complete test system consists of a charging rectifier, impulse stages according to the "Marx Circuit", an impulse voltage divider and impulse voltage measurement system. • The purpose of the impulse voltage test is to secure that the transformer insulation withstand the lightning overvoltage which may occur in service. ----------------------(4M) 1.1.4 Types of impulse voltages : -------------------(3M)
5	**Discuss the various tests carried out in a circuit breaker at HV labs. (13M)(NOV/DEC 2016)** BTL2 **Answer: Page :5.5 - M.Jeraldin Ahila** • It is used to detect failures and encapsulates the logic of preventing a failure from constantly recurring, during maintenance, temporary external system failure or unexpected system difficulties.-- (4M) • **Mechanical Test** -A circuit breaker must open and close at the correct speed and perform its designated duty and operation without mechanical failure.---------------(6M) • Making and breaking currents, both symmetrical and asymmetrical restriking voltages, and

switchgear is sometimes tested at rated conditions. ------------------------(3M)

6 **Discuss the method of tests on transformers.(13M) (APRIL/MAY 2015)** (BTL2)

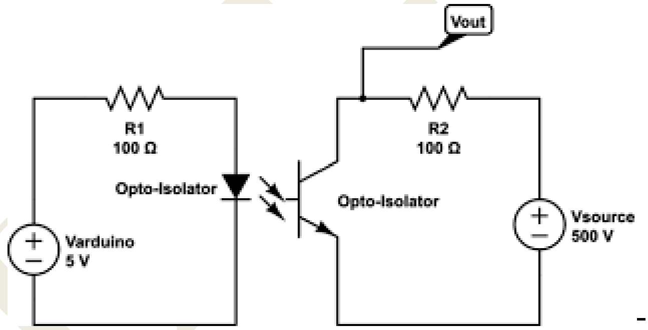
Answer: Page:5.12 - M.Jeraldin Ahila

- Insulation resistance Test-------------------------(2M)
- Winding resistance Test---------------------------(3M)
- Turns Ration / Voltage ratio Test.
- Polarity / Vector group Test.
- No-load losses and current Test.---------------------(4M)
- Short-circuit impedance and load loss Test.
- Continuity Test.
- Magnetizing Current Test. --------------------- (4M)
- The methodology used to check ratio includes the Voltage method and the transformer Turns Ratio (TTR) test set.

7 **Describe about the Isolator switches and reduces it overcome.(13M)** (BTL2)

Answer: Page:5.8 - M.Jeraldin Ahila

- Circuit breaker always trip the circuit but open contacts of breaker cannot be visible physically from outside of the breaker and that is why it is recommended not to touch any electrical circuit just by switching off the circuit breaker.--------------------------(3M)
- Isolators are used to open a circuit under no load. Its main purpose is to isolate one portion of the circuit from the other and is not intended to be opened while current is flowing in the line.-- (4M)



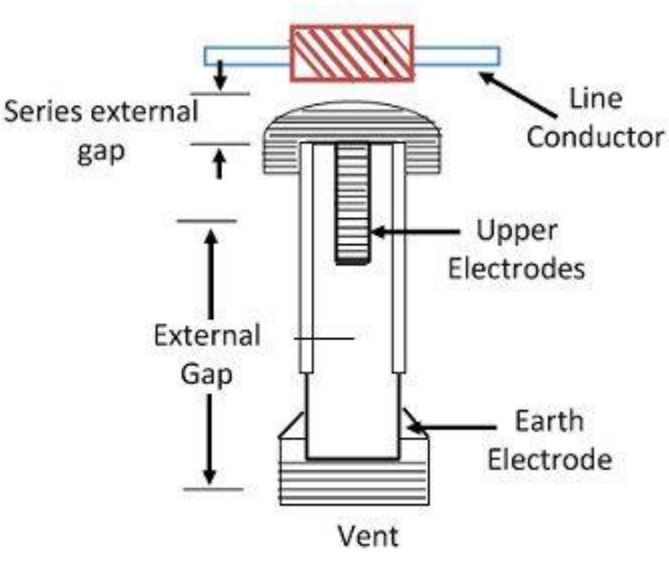
-------------------------------------(3M)

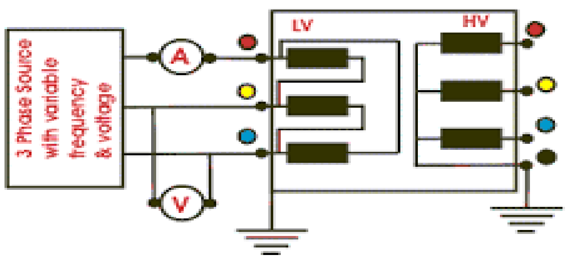
Counter rotation of both post insulators stacks open the contact arm and isolator becomes in off condition. --- (3M)

8 **Apply the necessity of the insulation coordination and insulations problem over the transmission line.(13M)**BTL3

Answer: Page:5.24 - M.Jeraldin Ahila

- Insulation Coordination is a series of steps used to select the dielectric strength of equipment in relation to the operating voltages and transient over voltages which can appear on the system for which the equipment is intended.----------------(4M)

	• This minimum voltage rating is defined as BIL or basic insulation level of electrical equipment. ---(6M) • The purpose of insulation is to slow the rate of heat transfer. This is true in both hot and cold climates. --(3M)
9	**What are the factors considered for selection of surge diverters? (13M)** BTL2 **Answer: Page:5.14 - M.Jeraldin Ahila** • A surge protector (or surge suppressor or surge diverter) is an appliance or device designed to protect electrical devices from voltage spikes. --------------------------(4M) • Overload protection is a protection against a running overcurrent that would cause overheating of the protected equipment.-------------------------------------(4M)  Expulsion-type Surge Diverter Circuit Globe -- (5M)
	PART C
1.	**State the relationship among impulse voltage tests and power frequency tests. (15M) (Nov/Dec 2017)**BTL2 **Answer: Page:5.6- M.Jeraldin Ahila** • Impulse voltage test systems are used for impulse voltage testing of transformers, cables, gas-insulated switchgears (GIS), arresters, and other high-voltage devices. ---------(4M) • During switching impulse voltage test, the insulation between windings and between winding and earth and withstand between different terminals is checked. • An impulse generator is an electrical apparatus which produces very short high-voltage or high-current surges. ------------------------------------(5M)



Induced AC voltage test connection diagram

(6M)

2

Explain with a neat diagram of synthetic testing of circuit breakers. Why is synthetic testing advantages over direct method for short circuit test.(15M) (NOV/DEC 2017) BTL6

Answer: Page :5.3- M.Jeraldin Ahila

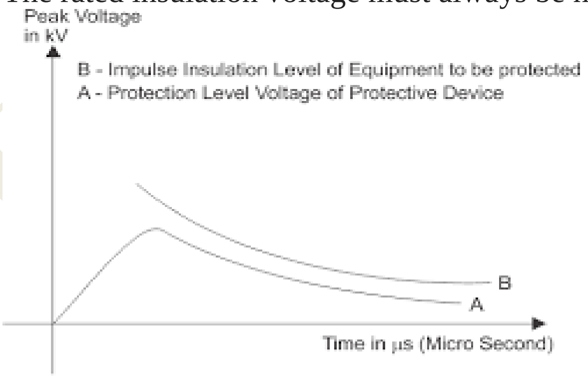
- The term insulator is also used more specifically to refer toinsulating supports used to attach electric power distribution or transmission lines to utility poles and transmission towers.--- (6M)
- Trapping air is also the principle in all highly insulatingclothing materials such as wool, down feathers and fleece.-------------------------(4M)
- The paper cup is a lot like the Styrofoam cup I mentioned above, with the dry wood fibers trapping air.----------------------------------- (5M)

3

Explain how insulation coordination design problems in EHV and UHV systems.(May/June 2014) (15M)BTL3

Answer: Page:5.28- M.Jeraldin Ahila

- Insulation Coordination is the process of determining the proper insulation levels of various components in a power system as well as their arrangements.--------------------------(5M)
- The rated insulation voltage must always be higher than the rated operating voltage.



Voltage - Time Curved Used for Insulation Coordination ------------------------------------(5M)

- An analytical method is proposed for evaluating the effect of TS forced outages on reliability of IPS using Loss of Load Probability and Lost Energy.
- When comparing alternatives, this method makes it possible to determine the extra amount of Present worth Cost connected with Forced Outages of TS and required to ensure equal

	reliability level in each variant.---(5M)

EE6702 PROTECTION AND SWITCHGEAR

OBJECTIVES:

- To educate the causes of abnormal operating conditions (faults, lightning and switching surges) of the apparatus and system.
- To introduce the characteristics and functions of relays and protection schemes.
- To impart knowledge on apparatus protection
- To introduce static and numerical relays
- To impart knowledge on functioning of circuit breakers

UNIT I PROTECTION SCHEMES 9

Principles and need for protective schemes – nature and causes of faults – types of faults – fault current calculation using symmetrical components – Methods of Neutral grounding – Zones of protection and essential qualities of protection – Protection schemes

UNIT II ELECTROMAGNETIC RELAYS 9

Operating principles of relays - the Universal relay – Torque equation – R-X diagram – Electromagnetic Relays – Overcurrent, Directional, Distance, Differential, Negative sequence and Under frequency relays.

UNIT III APPARATUS PROTECTION 9

Current transformers and Potential transformers and their applications in protection schemes - Protection of transformer, generator, motor, busbars and transmission line.

UNIT IV STATIC RELAYS AND NUMERICAL PROTECTION 9

Static relays – Phase, Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Overcurrent protection, transformer differential protection, distant protection of transmission lines.

UNIT V CIRCUIT BREAKERS 9

Physics of arcing phenomenon and arc interruption - DC and AC circuit breaking – re-striking voltage and recovery voltage - rate of rise of recovery voltage - resistance switching - current chopping - interruption of capacitive current - Types of circuit breakers – air blast, air break, oil, SF6 and vacuum circuit breakers – comparison of different circuit breakers – Rating and selection of Circuit breakers.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to understanding and analyzing power system operation, stability, control and protection.

TEXT BOOKS:

1. Sunil S.Rao, ‘Switchgear and Protection’, Khanna Publishers, New Delhi, 2008.
2. B.Rabindranath and N.Chander, ‘Power System Protection and Switchgear’, New Age International (P) Ltd., First Edition 2011.
3. M.L.Soni, P.V.Gupta, U.S.Bhatnagar, A.Chakrabarti, ‘A Text Book on Power System Engineering’, Dhanpat Rai & Co.,1998.

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2. Y.G.Paithankar and S.R.Bhide, ‘Fundamentals of power system protection’, Second Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2010.
3. C.L.Wadhwa, ‘Electrical Power Systems’, 6th Edition, New Age International (P) Ltd., 2010
4. Ravindra P.Singh, ‘ Switchgear and Power System Protection’, PHI Learning Private Ltd., New Delhi, 2009.
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Subject Code:EE6702 **Year/Semester: II/07**
Subject Name: Protection And Switchgear **Subject Handler: Mrs.L.Pattathurani**

UNIT I - PROTECTION SCHEMES

Principles and need for protective schemes – nature and causes of faults – types of faults – fault current calculation using symmetrical components – Methods of Neutral grounding – Zones of protection and essential qualities of protection – Protection schemes.

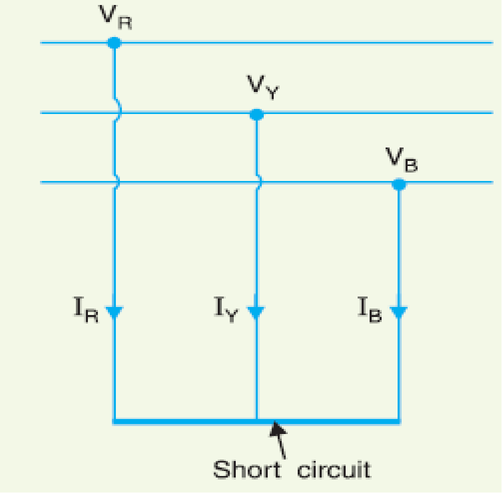
PART * A

Q.No	Questions
1	**State any four functions of protective relaying. (MAY -20 15)** BTL2 ➢ To disconnect the abnormally operating part so as to avoid the damage within effective operation of the rest of the system. ➢ To prevent the subsequent faults arising due to the primary fault. ➢ To disconnect the faulty part as quickly as possible so as to minimize the damage to the faulty part itself. ➢ To improve system performance, reliability and service continuity.
2	**Give the consequences of short circuit.(April/May 2019)** BTL2 Whenever a short-circuit occurs, the current flowing through the coil increases to an enormous value. If protective relays are present , a heavy current also flows through the relay coil, causing it to operate by closing its contacts. The trip circuit is then closed , the circuit breaker opens and the fault is isolated from the rest of the system. Also, a low voltage may be created which may damage systems connected to the supply.
3	**What is protective zone? (MAY -20 15) (April/May 2019)** BTL1 A protective zone is a separate zone which is established around each element of power system remains unprotected. The area of a power system which remains unprotected such that any fault occurring in that area would not be cleared at all is called dead spot or blind spot of a power system.
4	**What are unit system and non unit system?** BTL1 A unit protective system is one in which only faults occurring within its protected zone are isolated.Faults occurring elsewhere in the system have no influence on the operation of a unit system.A non unit system is a protective system which is activated even when the faults are external to its protected zone.
5	**List the basic requirements or essential qualities of protective relaying. (DEC-2008)** BTL1 (i)Reliability (ii) selectivity and discrimination (iii) speed and time (iv)sensitivity (v) stability (vi) adequateness (vii) simplicity and economy.
6	**What is primary protection?** BTL1 Is the protection in which the fault occurring in a line will be cleared by its own relay and circuit breaker. It serves as the first line of defense.
7	**What is back up protection?** BTL1 Is the second line of defense, which operates if the primary protection fails to activate within a definite time delay.
8	**Define energizing quantity.** BTL1 It :s to the current or voltage which is used to activate the relay into operation.
9	**Define operating time of a relay.** BTL1

	It is defined as the time period extended from the occurrence of the fault through the relay detecting the fault to the operation of the relay.
10	**Define resetting time of a relay.** BTL1 It is defined as the time taken by the relay from the instant of isolating the fault to the moment when the fault is removed and the relay can be reset.
11	**What are over and under current relays?** BTL1 Overcurrent relays are those that operate when the current in a line exceeds a predetermined value. (eg: Induction type non-directional/directional overcurrent relay, differential overcurrent relay)whereas undercurrent relays are those which operate whenever the current in a circuit/line drops below a predetermined value.(eg: differential over-voltage relay)
12	**Mention any two applications of differential relay.** BTL2 Protection of generator & generator transformer unit; protection of large motors and busbars.
13	**What is biased differential bus zone reduction?** BTL2 The biased beam relay is designed to respond to the differential current in terms of its fractional relation to the current flowing through the protected zone. It is essentially an over-current balanced beam relay type with an additional restraining coil. The restraining coil produces a bias force in the opposite direction to the operating force.
14	**Define pickup value and plug setting multiplier.(DEC -201 0)** BTL2 Pickup value: it is the minimum value of an actuating quantity at which relay starts operating. In most of the relays actuating quantity is current in the relay coil and pickup value of current is indicated along with the relay. Plug setting multiplier: the ratio of actual fault current in the relay coil to the pickup current is called plug setting multiplier(P.S.M.).
15	**Why the secondary of the C.T. should not be open?(MAY-2 01 5)** BTL2 If the secondary of the C.T. is kept open then current through the secondary becomes zero hence the ampere turns produced by secondary which generally oppose primary ampere turns becomes zero. As there is no counter m.m.f., unopposed primary m.m.f. produce high flux in the core. This produces excessive core loss heating the core. It also produces heavy e.m.f. on primary and secondary side which may damage the insulation of the winding. This is dangerous from the operator point of view as well. Hence the secondary of C.T. should not be open.
16	**What is pickup current? (DEC -201 4)** BTL1 The minimum value of the actuating current at which the relay starts operating is called pickup current of the relay.
17	**What are the different types of faults in a power system? (May 17) (MAY-2014)** BTL1 Symmetrical faults: the fault which gives rise to equal fault currents in all the lines with displacement of 120° between them. The example is line to line fault i.e. shorting of all three lines. Unsymmetrical faults: The fault which gives rise to unequal fault currents in all the lines with unequal displacement between them. The example is line ground, line to line, line to line to ground faults.
18	**What are the causes of faults in a power system? (DEC -201 3)** BTL2 The various causes are failure of insulation of conductor at one or more places, conducting objects comes in contact with the live part of the system, mechanical failure, excessive internal and external stress, over voltages due to switching surges, lightning strokes, heavy winds and storms, falling of trees on the lines, accidents of vehicles with the towers or poles,

	perching of birds on the lines, accidental short circuits due to snakes, kites, strings etc.
19	**What are the various methods of earthing in substations? (MAY -20 15)** BTL1 ➢ Solid or effective grounding ➢ Resistance grounding ➢ Reactance grounding ➢ Resonant grounding
20	**Why earth wire is provided in overhead transmission lines? (DEC -201 5)** BTL2 ➢ To protect the line conductors from direct lightning strokes. ➢ To reduce the line outages ➢ To reduce the interference on neighbouring installations. ➢ To transmit telecommunication signals.
21	**What is the difference between a short circuit and an overload? (DEC-2015)** BTL2 When there is a short circuit, the impedance at the fault point is almost zero and the voltage at the fault point is zero. The short circuit current is very high. While an overload means the load is higher than the rated load which is specified as the safe load. Thus the current is also higher than the safe load. The overload does not causes damage instantly but if persists for long time, can cause damage to the system.
22	**Differentiate between a fuse and a circuit breaker.** BTL2 Fuse is a low current interrupting device. It is a copper or an aluminium wire. Circuit breaker is a high current interrupting device and it act as a switch under normal operating conditions.
23	**Define auto re-closing.** BTL1 Auto recloser, is a circuit breaker equipped with a mechanism that can automatically close the breaker after it has been opened due to a fault.
24	**Summarize the functions of isolating switch**. BTL5 In sub-stations, it is often desired to disconnect a part of the system for general maintenance and repairs. This is accomplished by an isolating switch or isolator. An isolator is essentially a knife switch and is designed to open a circuit under *no load.* In other words, isolator switches are operated only when the lines in which they are connected carry no current.
25	**Explain surge absorber. Differentiate it from surge diverter.** BTL4 A **surge absorber** is a protective device which reduces the steepness of wave front of a surge by absorbing surge energy. Although both surge diverter and surge absorber eliminate the surge, the manner in which it is done is different in the two devices. The surge diverter diverts the surge to earth but the surge absorber absorbs the surge energy.
	PART * B
1.	(i) **Describe the Essential Qualities of Protective Relaying. (8 M) (MAY-2014) .(April/May 2019)** BTL 2 **Answer: Page: 1.2 - Thiagarajan** **Three main functions/duties:** 1. Safeguard the entire system to maintain continuity of supply 2. Minimize damage and repair costs where it senses fault 3. Ensure safety of personnel. (2 M) **Necessity:** Necessary for early detection and localization of faults, prompt removal of faulty equipment from service. ➢ **Selectivity**: detect, isolate, the faulty item. ➢ **Stability**: leave all healthy circuits, intact to ensure continuity or supply.

	➢ **Sensitivity**: Detect even the smallest fault, current or system abnormalities and operate correctly at its setting before the fault, irreparable damage. ➢ **Speed**: operate speedily, when it is called upon to do so, minimizing damage to the surroundings and ensuring safety to personnel. ➢ meet all of the above requirements, protection must be reliable. ➢ **Dependable**: must trip when called upon to do so. ➢ **Secure**: must not trip when it is not supposed to. (6 M) **(ii) Discuss the Nature and Causes of Faults in a power system. (7M) (DEC-2007)** BTL3 **Answer :Page 1.5 – Thiagarajan** **Various causes of faults**: ➢ Breaking of conductors or failure of insulation. (1 M) ➢ Mechanical failure, accidents, excessive internal and external stresses, affects the supply to the neighbouring zone.(1 M) ➢ The maximum possibility of fault occurrence, transmission lines, greater lengths, exposure to atmospheric conditions. (1 M) ➢ Deterioration of insulation, perching of birds, accidental short circuiting by snakes, kite strings, three branches etc. (1 M) ➢ Switching surges or surges caused by lighting.(1 M) ➢ Fire which destroys the equipment, spreads up in the system and causes total failure.(1 M)
2.	**Explain the overlapping of protective zones with neat sketch. (13M) (DEC -201 5) (April/May 2019)** BTL2 **Answer :Page 1.11- Thiagarajan** **Protective Zones**: Protective relaying scheme, the circuit breakers , appropriate points, power system can be disconnected for repairing work, usual operation and maintenance requirements, under abnormal conditions like short circuits. ➢ overlapped, no chance of existence of a dead spot in a system. No part of the system is left unprotected. (3 M) ➢ **Primary and Backup Protection**: ➢ The backup protection, main protection can fail, reasons : Failure in circuit breaker, Failure in protective relay, Failure in tripping circuit, Failure in d.c tripping voltage.(5 M) ➢ Diagram: (3 M) **Various components in protective zone:** Generators, transformers, transmission lines, bus bars, cables, capacitors etc. (2 M)
3.	**Classify and analyse the different faults in power system. Which of these are more frequent? (13M) (April/May 2019)** BTL 4 **Answer :Page 1.8 - Thiagarajan** ➢ **Types of faults**: Symmetrical and unsymmetrical faults, Open circuited phases, winding faults, simultaneous faults, cross country earth fault.(3 M) ➢ **Symmetrical faults** Gives rise to symmetrical fault currents, also known as balanced faults, two types: line to line to line to ground (L-L-L-G) and line to line to line (L-L-L). (3 M)



- **Unsymmetrical faults:** gives rise to unsymmetrical currents, the magnitude of fault currents in the three lines are different having unequal phase displacement.

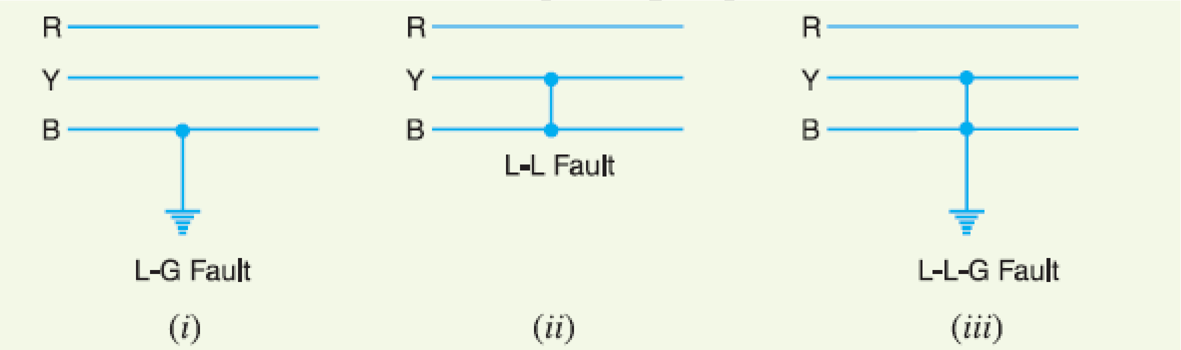
Very common and less severe than symmetrical faults. (7 M)

Three types: Line to ground (L-G), line to line (L-L) and double line to ground (LL-G) faults.

(*i*) Single line-to-ground fault (*L* — *G*): Between a line and ground. Most common type of fault.

(*ii*) Line-to-line fault (*L* — *L*): Between two lines

(*iii*) Doube line-to-ground fault (*L* — *L* — *G*): Between two lines and ground.



4. **Explain the fault current calculation using symmetrical components.(13M)** BTL3

Answer :Page 423 - V.K.Mehta

Symmetrical components:

The positive, negative and zero phase sequence components are called the symmetrical components of the original unbalanced system (Definition- 2 M)

Operator 'a':

The operator 'a' is one, which when multiplied to a vector rotates the vector through 120° in the anticlockwise direction. (operator 'a' explanation- 3 M)

	$\overrightarrow{I_R} = \overrightarrow{I_{R1}} + \overrightarrow{I_{R2}} + \overrightarrow{I_{R0}}$ $\overrightarrow{I_Y} = \overrightarrow{I_{Y1}} + \overrightarrow{I_{Y2}} + \overrightarrow{I_{Y0}}$ $= a^2\,\overrightarrow{I_{R1}} + a\,\overrightarrow{I_{R2}} + \overrightarrow{I_{R0}}$ $\overrightarrow{I_B} = \overrightarrow{I_{B1}} + \overrightarrow{I_{B2}} + \overrightarrow{I_{B0}}$ $= a\,\overrightarrow{I_{R1}} + a^2\,\overrightarrow{I_{R2}} + \overrightarrow{I_{R0}}$ (8 M)
5.	**Define the terms pick-up current, Plug setting multiplier and auto reclosure. (6M)** BTL1 **Pick up current:** The deflecting force, controlling force, the moving parts, initiate to move, to change the position of the contacts in the relay. The current which the relay initiates its operation.(2 M) **Plug setting multiplier:** Ratio of fault current in the relay to its pick up current. $PSM = \frac{Fault\ current\ in\ relay\ coil}{Pick\ up\ current}$ $= \frac{Fault\ current\ in\ relay\ coil}{Rated\ CT\ secondary\ current\ \times\ Current\ setting}$ (2 M) **Auto reclosure:** Relay receives the fault initiation from the protection relay, triggers the auto reclose function. After tripping the circuit breaker (CB), the Auto reclose function reclose the CB.(2 M)
6.	**Explain in detail about surge absorbers. (13M)** BTL2 **Answer :Page 3.38- Bakshi** **Surge absorber:** Reduce the steepness of wave front, absorbs energy containing in travelling wave. Eliminate the surge, Surge diverter- diverts the surge to earth. (3 M) Surge absorber using capacitor: Impedance of capacitor inversely proportional to frequency. Used for protection of transformer winding, free from very high stresses. Series combination of resistor and capacitor. Diagram. (4 M) Parallel combination of resistance and inductance. Ferranti surge absorber: Inductive coil magnetically coupled, not electrically to a metal shield and steel tank containing it. Filter effect, high frequency currents, prevented from passing freely through the absorber. Energy transferred through mutual induction, heat dissipation. Diagram. (4 M) Field of application: Near rotating machines or switchgear, across series reactors. (2 M)
	PART*C
1.	**Explain the various methods of earthing the neutral point of the power system. (15 M) (DEC-2015) (May 2017) (April/May 2019)** BTL 2 **Answer :Page 1.15- Thiagarajan** **Grounding:** ➢ Connecting the metallic frame of electrical equipment or some electrical part of the system (e.g. neutral point in a star-connected system) to earth (i.e. soil) (2 M) **Classifications: (*i*)** Equipment grounding **(*ii*)** System grounding. **Equipment Grounding:**

Connecting non-current-carrying metal parts (i.e. metallic enclosure) of the electrical equipment to earth (i.e. soil) ,insulation failure, the enclosure remains at earth potential. (1 M)

System grounding:

Connecting some electrical part of the power system (e.g. neutral point of a star connected system, one conductor of the secondary of a transformer etc.) to earth (i.e. soil)(1 M)

Advantages of Neutral Grounding: (3 M)

(*i*) Voltages of the healthy phases do not exceed line to ground voltages *i.e.* they remain nearly constant.

(*ii*) The high voltages due to arcing grounds are eliminated.

(*iii*) The protective relays can be used to provide protection against earth faults. In case earth fault occurs on any line, the protective relay will operate to isolate the faulty line.

(*iv*) The overvoltages due to lightning are discharged to earth.

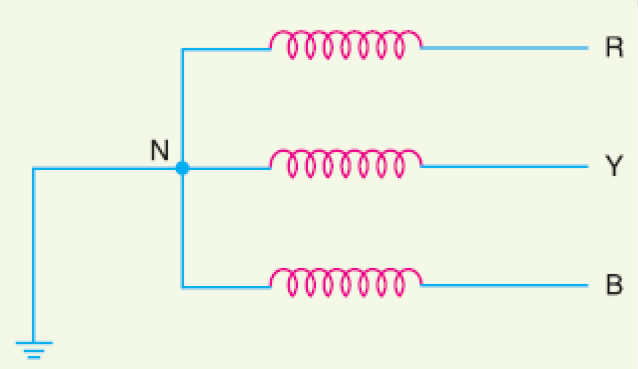
(*v*) Provides greater safety to personnel and equipment.

(*vi*) Provides improved service reliability.

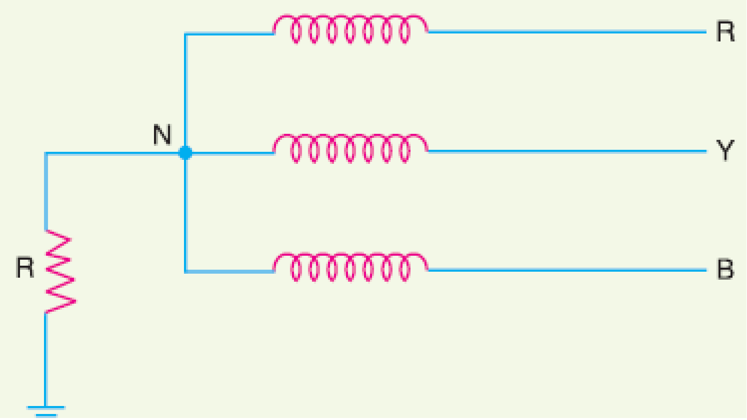
(*vii*) Operating and maintenance expenditures are reduced.

➢ **Methods of Neutral Grounding**

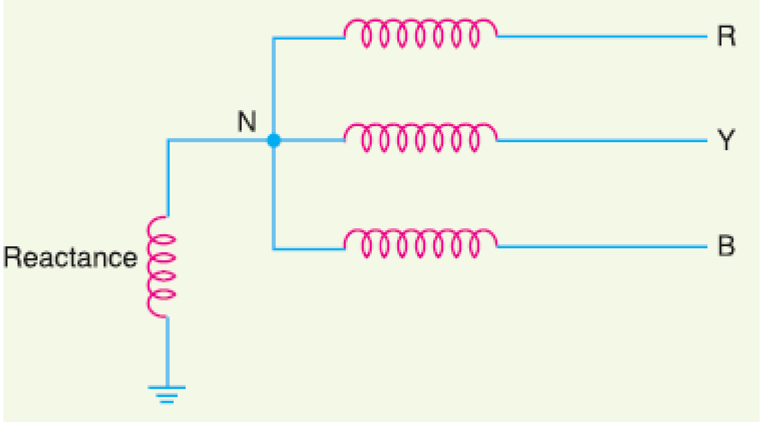
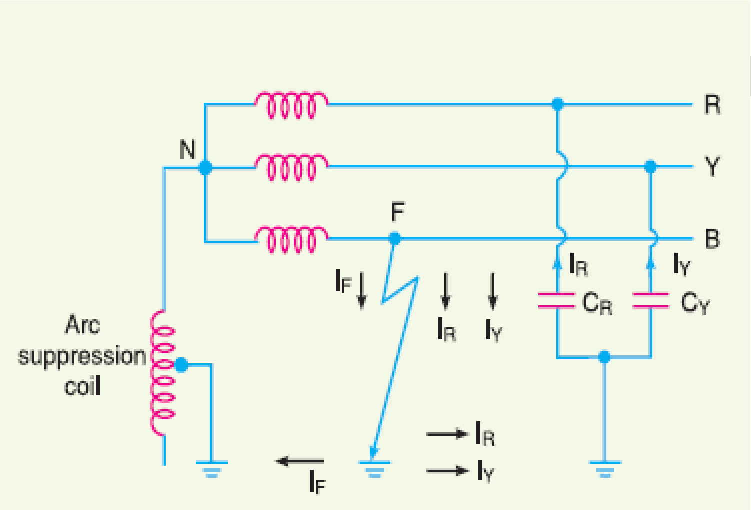
- **Solid Grounding:** When the neutral point of a 3-phase system (e.g. 3- phase generator, 3-phase transformer etc.) is directly connected to earth (i.e. soil) through a wire of negligible resistance and reactance, it is called solid grounding or effective grounding. (2 M)

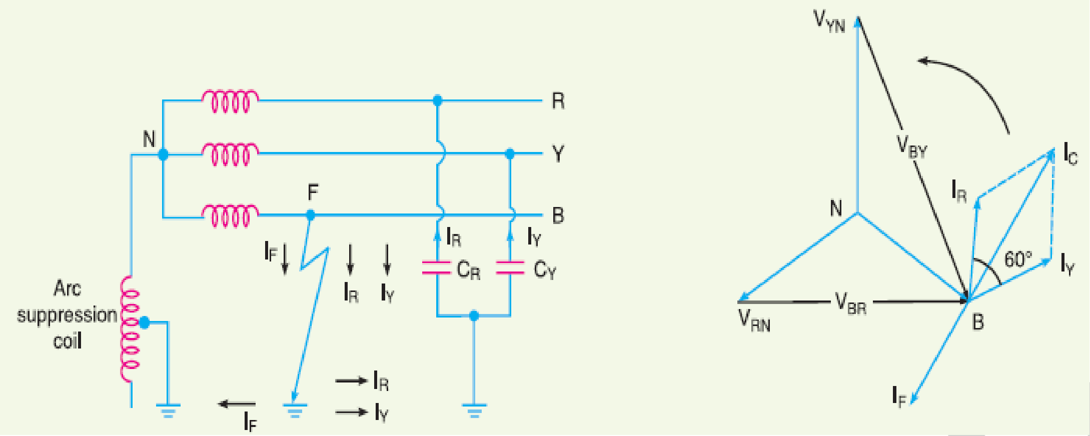


- **Resistance Grounding:** When the neutral point of a 3-phase system (e.g. 3-phase generator, 3-phase transformer etc.) is connected to earth (i.e. soil) through a resistor, it is called resistance grounding. (2 M)



- **Reactance Grounding:**In this system, a reactance is inserted between the neutral and ground. (2 M)

	 - **Resonant Groundings/Peterson coil Groundings** When the value of L of arc suppression coil is such that the fault current I_F exactly balances the capacitive current I_C, it is called resonant grounding. (2 M) 
2.	**Write a note on RESONANT GROUNDING (OR) ARC SUPPRESSION COIL GROUNDING (OR) PETERSON COIL (8 M) (May 2017) (MAY -20 15)** BTL3 **Answer :Page: 1.21 - Thiagarajan** ➢ Capacitive currents, responsible for producing arcing grounds, capacitive currents flow, capacitance exists between each line and earth (3 M) ➢ value of L of arc suppression coil ,fault current I_f exactly balances the capacitive current IC, resonant grounding. $L = \frac{1}{3\omega^2 C}$ (Derivation: 3 M)



Advantages:

i. The Peterson coil has the advantages of ungrounded neutral system.

ii. The Peterson coil is completely effective in preventing any damage by an arcing ground.

Disadvantages.

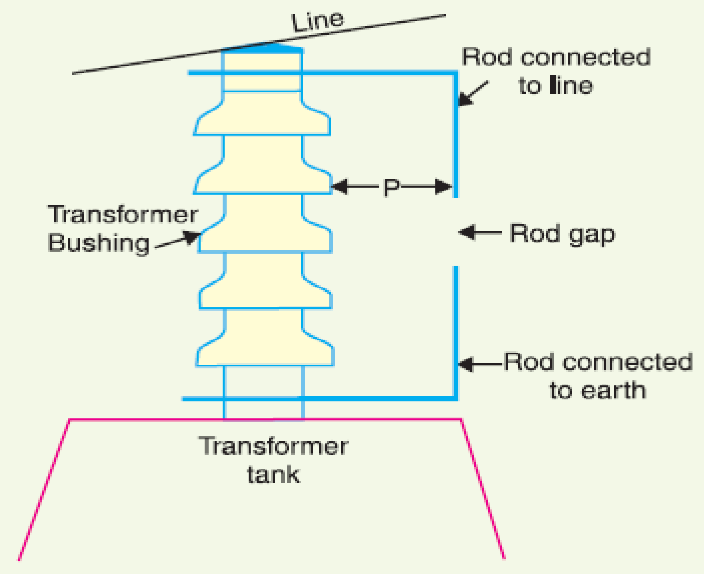
(*i*) Due to varying operational conditions, the capacitance of the network changes from time to time. Therefore, inductance *L* of Peterson coil requires readjustment.

(*ii*) The lines should be transposed. (2 M)

3. **Analyse the various types of lightning arrestors and working Principle of Lightning arresters. (15 M) (May 2017)** BTL4

Answer :Page: 560 - V.K.Mehta

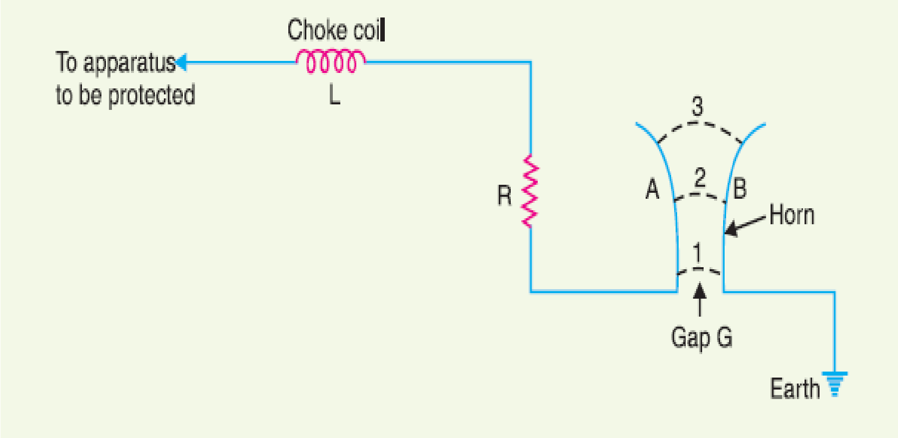
- A lightning arrester or a surge diverted is a protective device, which conducts the high voltage surges on the power system to the ground. (2 M)
- **Rod arrester** : Under normal operating conditions, the gap remains non-conducting. On the occurrence of a high voltage surge on the line, the gap sparks over and the surge current is conducted to earth. In this way, excess charge on the line due to the surge is harmlessly conducted to earth. (2 M)



(1 M)

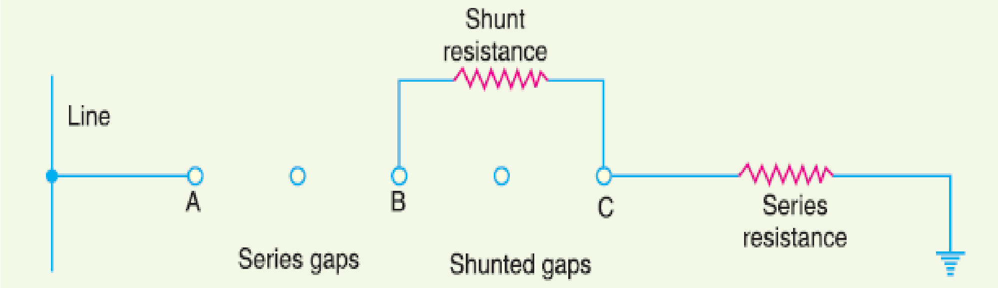
- **Horn gap arrester:** Two horn shaped metal rods *A* and *B* separated by a small air gap. One end of horn is connected to the line through a resistance *R* and choke coil

L while the other end is effectively grounded. (2 M)



(1 M)

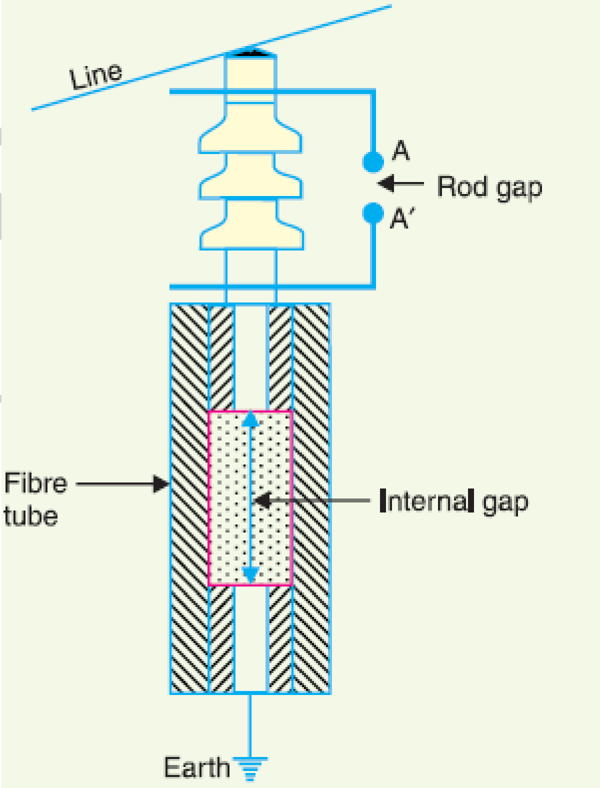
- **Multi gap arrester**



(1 M)

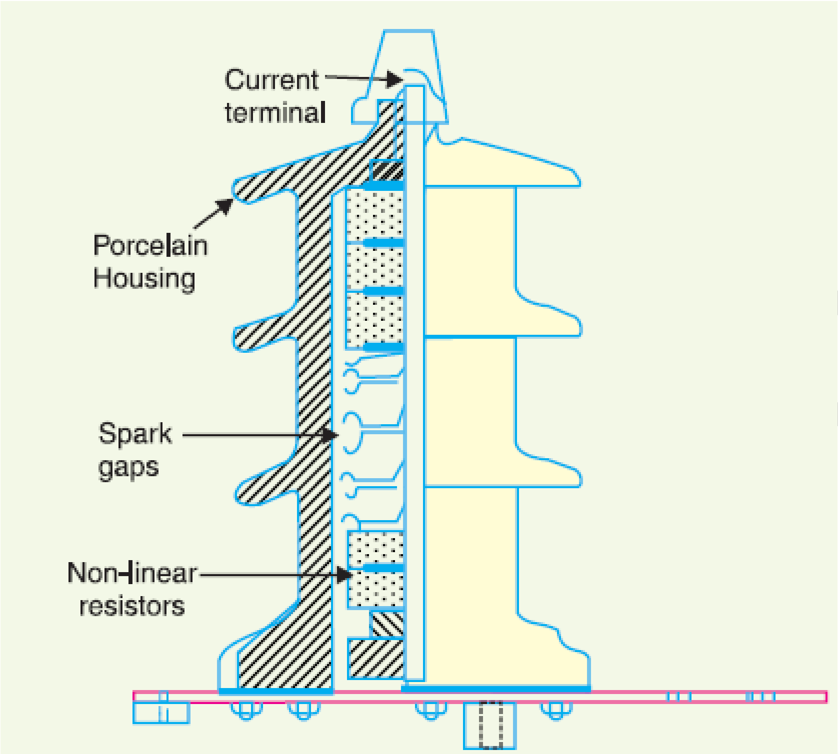
Employed where system voltage does not exceed 33 kV.(2 M)

- **Expulsion type lightning arrester**



(1 M)

- **Valve type lightning arrester:** Two assemblies (*i*) series spark gaps and (*ii*) non-

	linear resistor discs (made of material such as thyrite or metrosil) in series. The non-linear elements are connected in series with the spark gaps.(2 M) 
4.	**A balanced 3 phase star connected load is supplied from 3 phase unbalanced supply with negligible internal impedance. Three identical star connected resistors rated for 3300 V, 500 KVA are used as a three phase load. The neutral point is not available. The line voltages of supply are E_R= 3960<0^0 V, E_Y= 3300<-138.6^0 V, E_R= 2640<124.2^0 V. Find the current in R line by the method of symmetrical components. (15 M)** BTL3 **Answer :Page 2.23- Bakshi** E_{R1}= 3252.48<-5.05^0V (2 M) E_{R2}= 774.18<21.674^0 V(2 M) Converting all line to phase components- (2 M) R= 21.78 Ω (3M) I_R= 68.5119<-102.879^0 V (6 M)

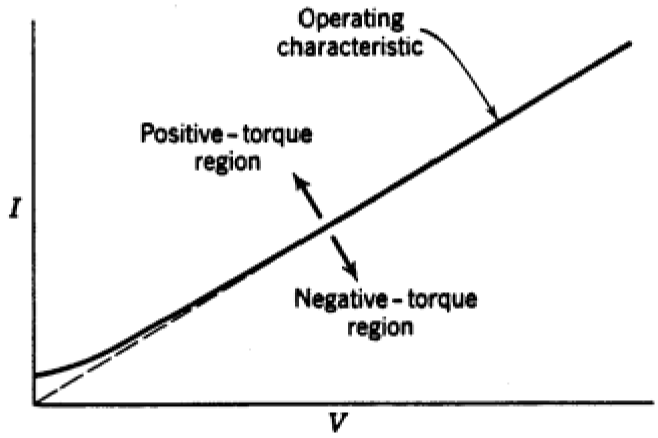
UNIT II ELECTROMAGNETIC RELAY

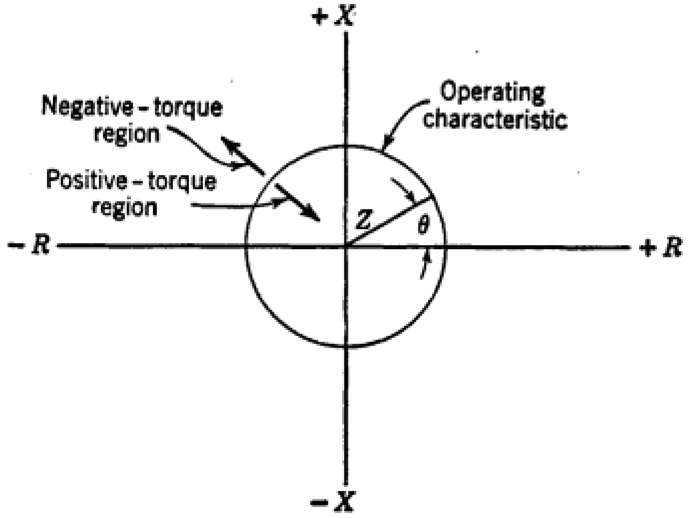
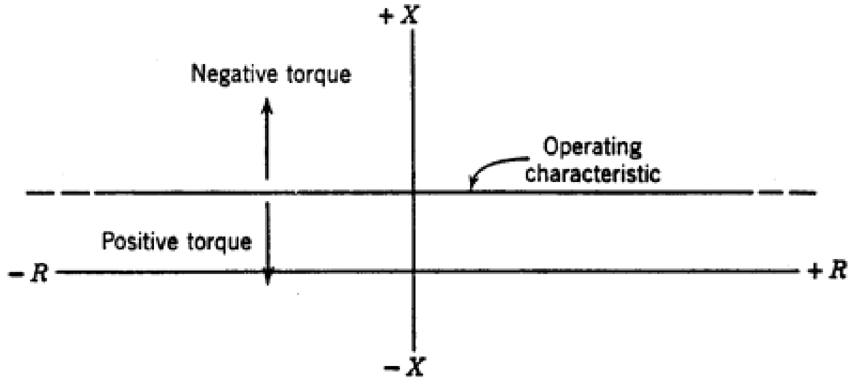
Operating principles of relays - the Universal relay – Torque equation – R-X diagram – Electromagnetic Relays – Over current, Directional, Distance, Differential, Negative sequence and Under frequency relays.

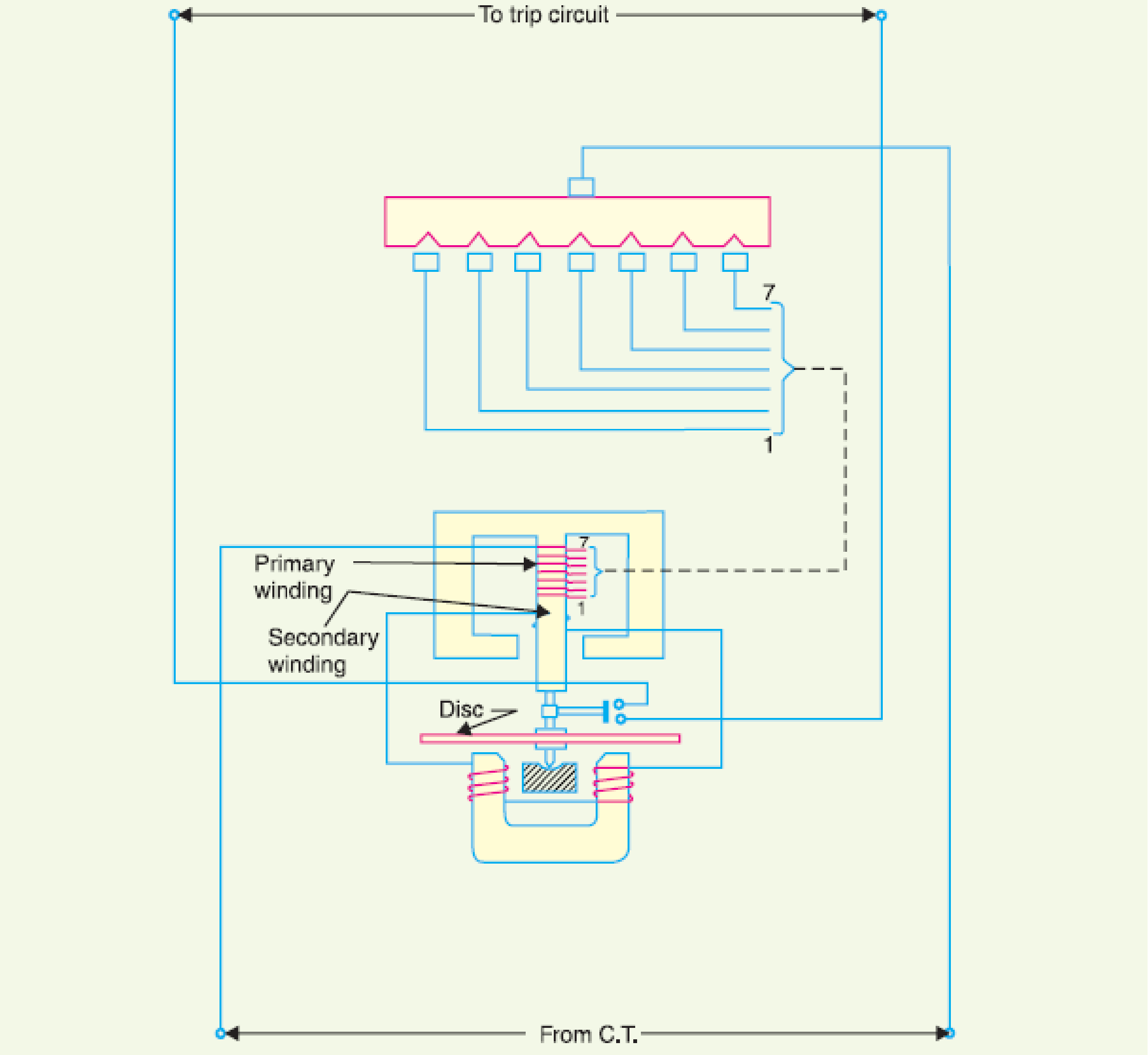
PART * A

Q.No.	Questions
1	**Identify the need of relay coordination.** BTL2 The operation of a relay should be fast and selective, ie, it should isolate the fault in the shortest possible time causing minimum disturbance to the system. Also, if a relay fails to operate, there should be sufficiently quick backup protection so that the rest of the system is protected. By coordinating relays, faults can always be isolated quickly without serious disturbance to the rest of the system.
2	**Mention the short comings of Merz Price scheme of protection applied to apower transformer.** BTL2 In a power transformer, currents in the primary and secondary are to be compared. As these two currents are usually different, the use of identical transformers will give differential current, and operate the relay under no-load condition. Also, there is usually a phase difference between the primary and secondary currents of three phase transformers. Even CT's of proper turn-ratio are used, the differential current may flow through the relay under normal condition.
3	**What are the various faults to which a turbo alternator is likely to be subjected?** BTL1 Failure of steam supply; failure of speed; over current; over voltage; unbalanced loading; stator winding fault .
4	**Define under frequency relay. (Nov/Dec 2014).(April/May 2019)** BTL1 An under frequency relay is one which operates when the frequency of the system (usually an alternator or transformer) falls below a certain value.
5	**Define the term pilot to power line protection.** BTL1 Pilot wires to the wires that connect the CT's placed at the ends of a power transmission line as part of its protection scheme. The resistance of the pilot wires is usually less than 500ohms.
6	**Mention any two disadvantage of carrier current scheme for transmission line only**. BTL1 The program time (ie, the time taken by the carrier to reach the other end-upto .1% mile); the response time of band pass filter; capacitance phase-shift of the transmission line
7	**List the features of directional relay.** BTL2 High speed operation; high sensitivity; ability to operate at low voltages; adequate short-time thermal ratio; burden must not be excessive.
8	**What are the causes of over speed and how alternators are protected fromit?** BTL2 Sudden loss of all or major part of the load causes over-speeding in alternators. Modernalternatorsareprovidedwithmechanicalcentrifugaldevicesmountedontheir driving

	shafts to trip the main valve of the prime mover when a dangerous over-speed occurs.
9	**Explain the main types of stator winding faults?** BTL1 Fault between phase and ground; fault between phases and inter-turn fault involving turns of the same phase winding.
10	**Give the limitations of Merz Price protection**. BTL2 Since neutral earthing resistances are often used to protect circuit from earth-fault currents, it becomes impossible to protect the whole of a star-connected alternator. If an earth-fault occurs near the neutral point, the voltage may be insufficient to operate the relay. Also it is extremely difficult to find two identical CT's. In addition to this, there always an inherent phase difference between the primary and the secondary quantities and a possibility of current through the relay even when there is no fault.
11	**State the uses of Buchholz's relay.** BTL1 Bucholz relay is used to give an alarm in case of incipient(slow-developing) faults in the transformer and to connect the transformer from the supply in the event of severe internal faults. It is usually used in oil immersion transformers with a rating over 750KVA.
12	**Mention any two applications of differential relay.** BTL1 Protection of generator & generator transformer unit; protection of large motors and busbars .
13	**Define differential relay. (April / May 2015)&(May / June 20 13)** BTL1 A differential relay is defined as the relay that operates when the phasor difference of two or more similar electrical quantities exceeds a predetermined value. Thus a current differential relay operates on the result of comparison between the phase angle and magnitudes of the currents entering and leaving the system to be protected.
14	**What is biased differential bus zone reduction? (April / May 2015)** BTL1 The biased beam relay is designed to respond to the differential current in terms of its fractional relation to the current flowing through the protected zone. It is essentially an over-current balanced beam relay type with an additional restraining coil. The restraining coil produces a bias force in the opposite direction to the operating force.
15	**What is meant by directional relay?(May / June 2012)** BTL1 The directional power relay is not suitable to use as a protective relay under short circuit conditions. This is because under short circuit conditions the voltage fril is drastically and such a reduced voltage may not be sufficient to produce the driving torque required for the relay operation.
16	**Describe the features of directional relay.** BTL2 High speed operation; high sensitivity; ability to operate at low voltages; adequate short-time thermal ratio; burden must not be excessive.
17	**Define Positive Sequence Components.** BTL1 Positive sequence components have three vectors equal in magnitude and displaced from each other by an angle 120˚ and having the phase sequence as original vectors.
18	**Define Negative Sequence Component. (Nov/Dec 2015)** BTL1 It has three vectors and equal in magnitude displaced from each other by an angle 120˚and the phase sequence in opposite to its original phasor.
19	**List the types of electromagnetic relay.** BTL1 Electromagnetic attraction Attracted armature type relay Solenoid type relay Balanced type relay Electromagnetic Induction

	Shaded pole struture Watt – hour meter Induction cup
20	**A relay is connected to 400/5 ratio current transformer with current setting of 150%. Formulate the Plug Setting Multiplier when circuit carries a fault current of 4000A**. BTL 3 Pick-up value = Rated secondary CT current × current setting = 5 × 1.5 = 7.5A Fault current in relay coil = 2400 x 5/ 400 = 30 A P.S.M = Fault current in relay coil / Pick up current = 30/ 7.5= 4
21	**Write down the universal torque equation of overcurrent relay.** BTL3 The universal relay torque equation can be given as $T = K_1 I^2 + K_2 V^2 + K_3 VI \cos(\phi - \tau) + \mathrm{K}$ where I = RMS value of current in current coil V = RMS value of voltage fed to the voltage coil ϕ = Electrical angle between V and I T = The maximum torque angle K_1, K_2 and K_3 = Relay constant K = Mechanical restraining torque
22	**Draw the operating characteristics of impedance relay.** BTL3 
23	**Draw the R-X diagram of impedance relay.(April/May 2019)** (BTL 3)

	
24	**Illustrate with a diagram on the operating characteristics of reactance relay** BTL3 
25	**Write down the torque equation of voltage restrained distance relay.** BTL3 $T = K_1VI \cos(\theta - \tau) - K_2V^{2} - K_3$
	PART * B
1.	**With neat Diagram explain the construction and operation of Non Directional over current relay. (13M)** BTL 2 **Answer : Page 508 - V.K.Mehta** Construction: (5 M)



- Metallic (aluminium) disc, free to rotate in between the poles of two electromagnets. The upper electromagnet, primary and a secondary winding.
- The primary connected to the secondary of a C.T. in the line to be protected, tapped at intervals. plug-setting bridge, relay operating coil, desired current setting.
- The secondary winding, energised by induction from primary series connection with winding on the lower magnet.
- The controlling torque, spiral spring, Spindle of the disc, moving contact, bridges two fixed contacts (connected to trip circuit) , disc rotates through a pre-set angle.

Working: (8 M)

- earth leakage induction type relay .

- The driving torque on the aluminium disc, induction principle.
- This torque, opposed by the restraining torque, provided by the spring.
- Under normal operating conditions, restraining torque is greater than the driving torque, the aluminium disc remains stationary.
- if the current in the protected circuit exceeds the pre-set value, the driving torque becomes greater than the restraining torque.
- The disc rotates, moving contact bridges the fixed contacts when the disc has rotated through a pre-set angle.
- The trip circuit operates the circuit breaker which isolates the faulty section.

2. **With neat Diagram explain the construction and operation of Directional over current relay. (13M) (Nov / Dec 2015) .(April/May 2019)** BTL 2

Answer : Page 2.20- V.Thiagarajan

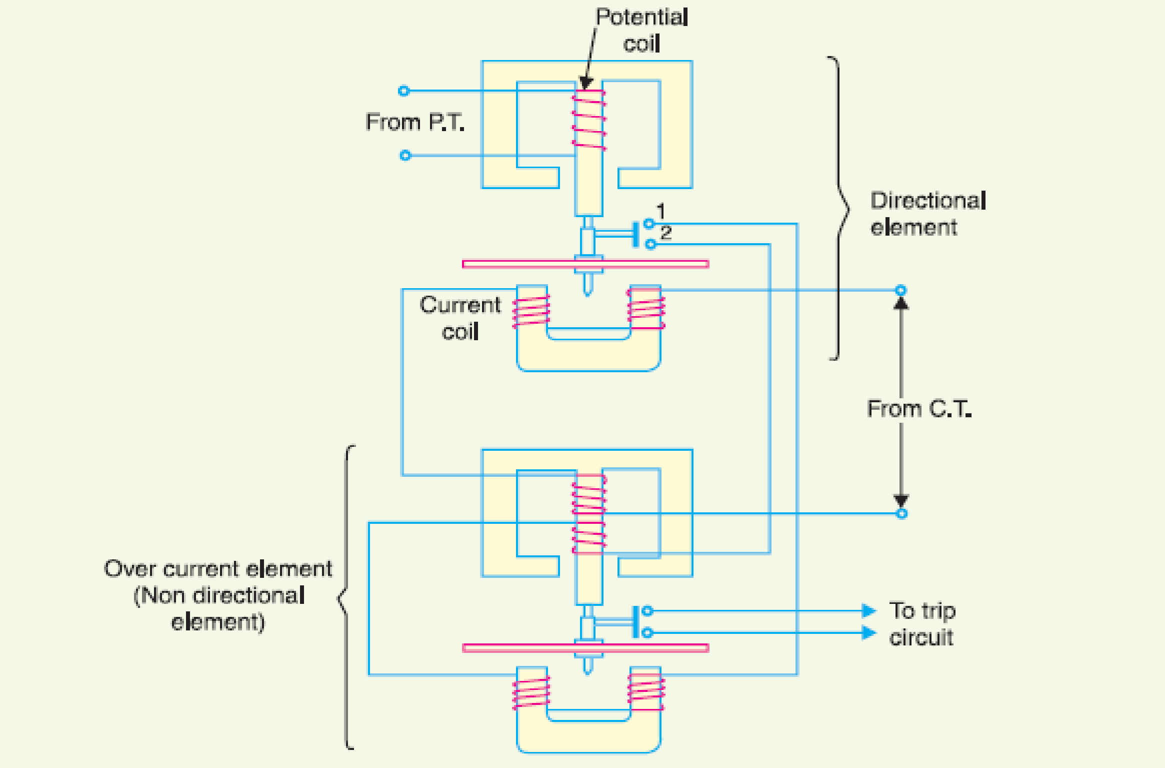


Diagram: (4 M)

Construction: (4 M)

- Independent of system voltage and power factor
- They elements are,

1. Directional element, directional power relay
2. Non directional element, non directional over current relay.

Directional element.

- Directional power relay which operates when power flows in a specific direction.
- The potential coil of this element connected through a potential transformer (P.T.) to the system voltage.
- The current coil energised through a C.T. by the circuit current.
- This winding carried over the upper magnet of the non-directional element.
- The trip contacts (1 and 2) of the directional element, series with the secondary circuit of the overcurrent element, the latter element cannot start to operate , secondary circuit is completed.

Non-directional element.

- The spindle of the disc, moving contact, closes the fixed contacts (trip circuit contacts) after the operation of directional element.
- Plug-setting bridge, relay for current setting, tappings, upper magnet of over current element, connected to the bridge.

Operation: (5 M)

- Under normal operating conditions, power flows in the normal direction directional power relay (upper element) does not operate, over current element (lower element) unenergised.
- When a short-circuit occurs, current or power flow in the reverse direction, the disc of the upper element rotates to bridge the fixed contacts 1 and 2. Completes the circuit for over current element.
- The disc of this element rotates and the moving contact attached to it closes the trip circuit. This operates the circuit breaker which isolates the faulty section.

Condition for final tripping of current:

- Current flows in a direction such as to operate the directional element.
- Current in the reverse direction exceeds the pre-set value.
- Excessive current persists for a period corresponding to the time setting of over current element.

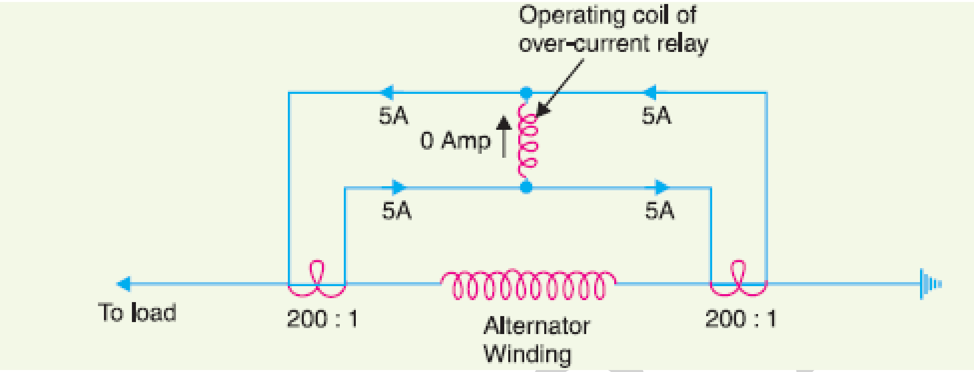
3. **Illustrate with a diagram about differential relay. (10M) (April / May 2015 & 12)** BTL 2

Answer : Page 2.40- V.Thiagarajan

- A differential relay, operates when the phasor difference of two or more similar electrical quantities exceeds a predetermined value. current differential relay operates on the result of comparison between the phase angle and magnitudes of the currents entering and leaving the system to be protected. (2 M)

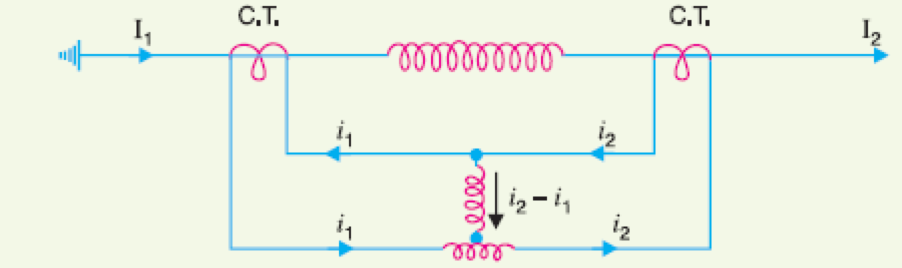
- Under normal conditions, the two currents, equal in phase and magnitude, inoperative.
- If difference current exceeds a preset value then the relay operates, opens the circuit breaker. (2 M)
- Types of Differential Relays:

Current differential relay (2 M)



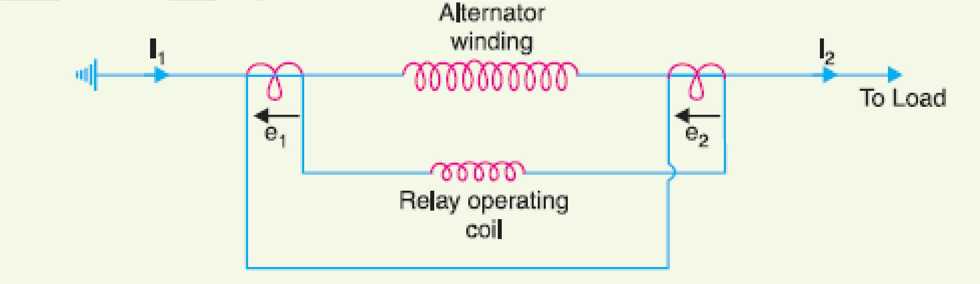
- Secondary currents of CT not equal- relay operate.

Biased beam relay or percentage differential relay (2 M)



- Operating coil proportional to $i_2 - i_1$, restraining coil proportional to (i_1+i_2)/2.
- Operating current required to trip, percentage of load current.

Voltage balance differential relay (2 M)

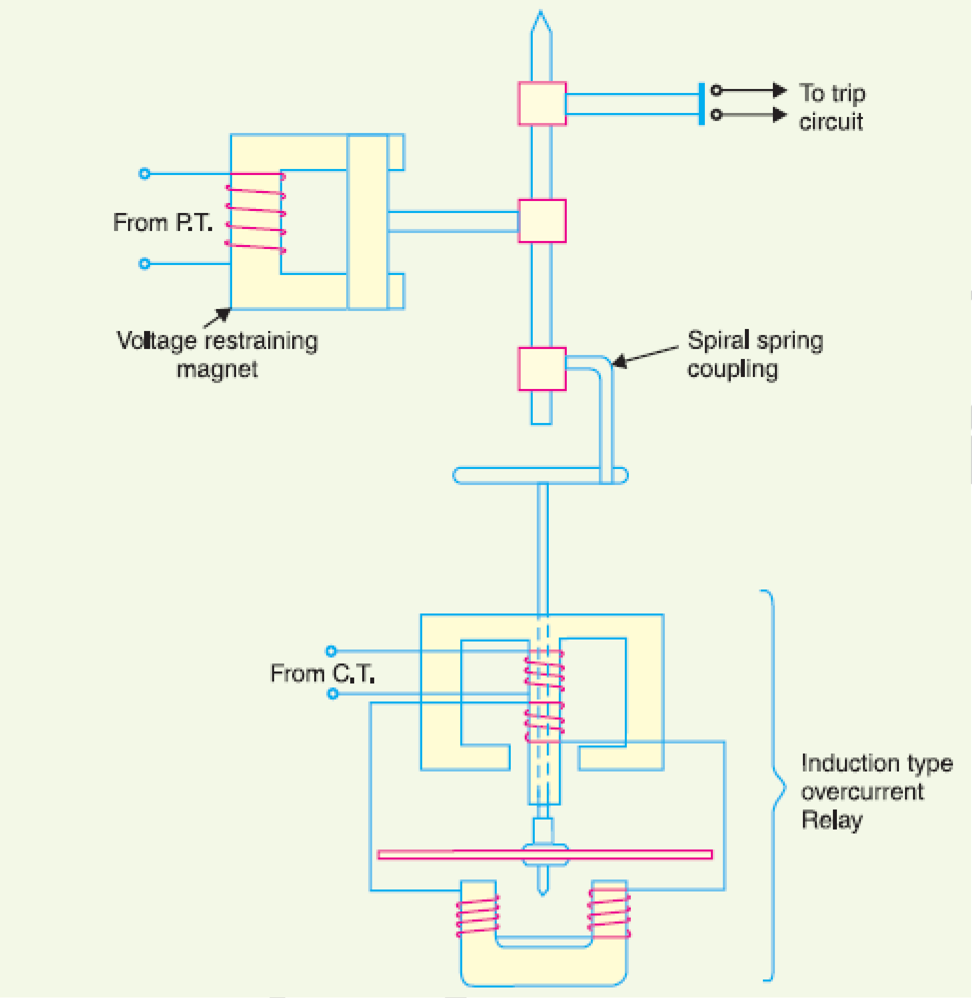


- Under normal condition, Currents equal, secondary voltage balanced
- Voltage difference, current to flow through the operating coil of the relay, closes the

	trip circuit. ➢ Translay system- modified form of voltage balance system.
4.	**Explain the working principle of under frequency relay. (8 M)** BTL 2 **Answer : Page 2.47- V.Thiagarajan** Need for Frequency relay- (2 M) Frequency Equation: $N_s = \frac{120f}{P}$: (2 M) Working principle and diagram : (4 M) ➢ The frequency of induced e.m.f. of synchronous generator, maintained constant by constant speed. ➢ Over speeding of the generator occurs due to loss of load and under speeding occurs due to increase in load. ➢ In both the cases, the frequency varies from normal value. In order to avoid damage to the generator under the above two conditions, frequency relays are used. ➢ Under frequency relay trips the feeder on load at set value of frequency, so as to give relief to the generator, thereby saving the unit. ➢ Under frequency relay thus aids load shedding programme to save the grid.
5.	**Explain the working principle of Negative sequence relay. (8M).(April/May 2019)** BTL 2 **Answer : Page 2.49- V.Thiagarajan** ➢ Negative sequence relays are used to protect electrical machines against overheating due to unbalance currents in stator. (Definition: 2 M) ➢ Working principle and diagram: (6 M) ➢ Inverse square law characteristics.
6.	**Derive the Universal relay torque equation. (5 M)** BTL 3 ➢ The universal torque equation explains the working of an electrical relay. ➢ The relay, electromagnetic. ➢ These electromagnetic consists current and voltage windings. ➢ The current through the winding produces magnetic flux. torque, produced by the interaction of the flux of the same winding or between the flux of both the windings. (2 M)

	$\text{Torque Developed by curent windings} = K_1I^2$ $\text{Torque developed by voltage winding} = K_1V^2$ $T = K_1I^2 + K_2V^2 + K_3VIcos(\theta - \tau) + K_4$ (3 M)
7.	**List the detailed classification of relays based on various parameters. (8 M)** BTL 2 **Answer : Page 2.4- V.Thiagarajan** According to construction: (2 M) ➢ Electromagnetic relays ➢ Induction relays ➢ Electrothermal relays ➢ Physico-electric relay ➢ Electro-dynamic relay ➢ Static relay ➢ Microprocessor relay According to application: (2 M) ➢ Falls below specific limit or value ➢ Directional or reverse current relay ➢ Directional or reverse power relay According to time of operation (2 M) ➢ Instantaneous relay ➢ Definite time lag relay ➢ Inverse time lag relay ➢ Inverse definite minimum time lag relay According to connectivity of circuit: (2 M) ➢ Primary relay ➢ Secondary relay ➢ Auxillary relay ➢ Back up relay

	➢ Reinforcing relay
	PART*C
1.	**Explain the working principle of impedance relays. (15 M) (April/May 13)(Nov/Dec 2012 &15)** BTL 2 **Answer : Page 2.26- V.Thiagarajan** Distance relay general definition: (3 M) Working principle of impedance relay: (5 M) ➢ Dependent on the ratio of V and I there are three types of distance relays which are, impedance relay, mho relay and reactance relay. ➢ Impedance relay which is based on measurement of impedance Torque equation: (3 M) R-X Diagram: (2 M) Explanation- (1 M)
2.	**With neat sketch, investigate how impedance relay is used as Time Distance. (13 M) (May 2017)** BTL 6 **Answer : Page 2.27- V.Thiagarajan** Operating time, $T \propto V/I$ $\propto$ Z $\propto$ distance (2 M)



(4 M)

Construction. (3 M)

- ➢ Current driven induction element, spindle carrying the disc, spiral spring coupling to a second spindle, bridging piece of the relay trip contacts.
- ➢ The bridge- open position by an armature, pole face of an electromagnet excited by the voltage of the circuit to be protected.

Operation. (4 M)

- ➢ Under normal load conditions, the pull of the armature , induction element, trip circuit contacts remain open.
- ➢ On the occurence of a short-circuit, the disc of the induction current element , rotate at a speed depending upon the operating current. the spiral spring coupling wound up till the tension of the spring , sufficient to pull the armature away from the pole face of the voltage-excited magnet.
- ➢ the spindle carrying the armature and bridging piece moves rapidly in response to the tension of the spring and trip contacts are closed.

- This opens the circuit breaker to isolate the faulty section.
- The speed of rotation of the disc proportional to the operating current,
- Neglecting the effect of control spring. time of operation of the relay , directly proportional to the pull of the voltage-excited magnet , line voltage *V* at the point where the relay is connected.
- The time of operation of relay would vary as *V/I i.e.* as *Z* or distance.

3.

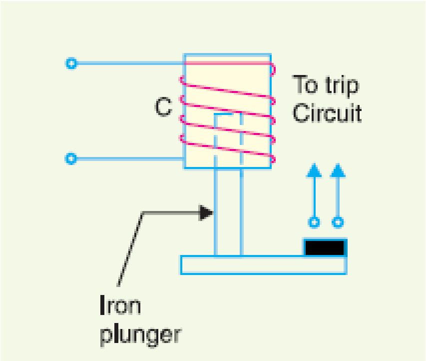
What are the Classification of Electromagnetic Relays? Explain about Electromagnetic Attraction Type Relays. (Nov2013, May2012) (May 2017) (15 M) BTL 2

Answer : Page 2.7- V.Thiagarajan

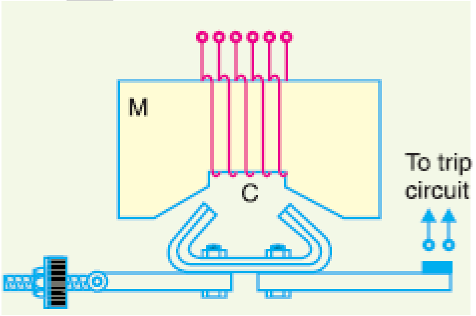
- All the relays consist of one or more elements which gets energized and actuated by the electrical quantities of the circuit.
- On-no-mechanical type which work on the principles of electromagnetic attraction and electromagnetic induction

The various types of these relays are,

- Solenoid Type



- Attracted armature type



- Balanced beam type relay:

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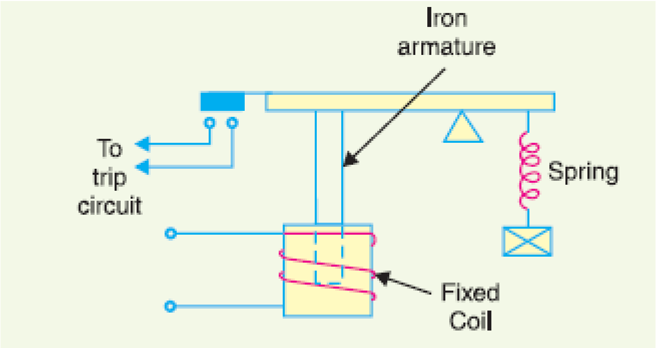

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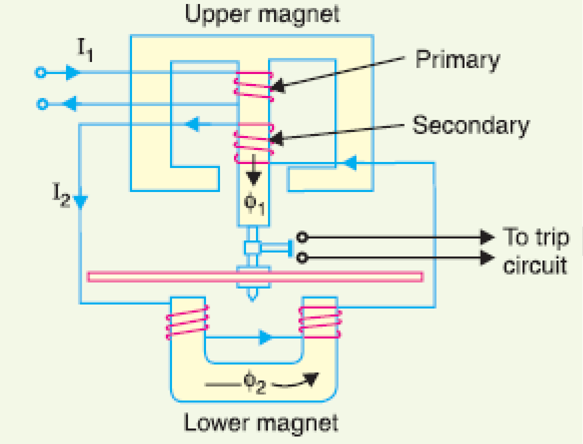
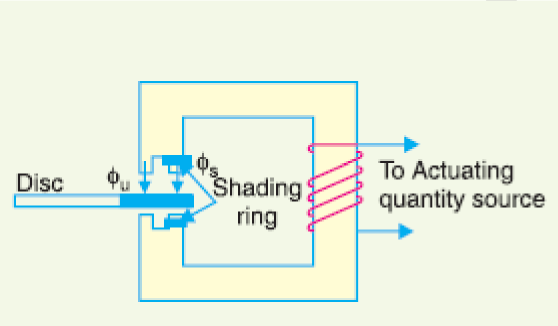
Explain the types of Electromagnetic induction type relays. (15 M) BTL 2

Answer : Page 2.15- V.Thiagarajan

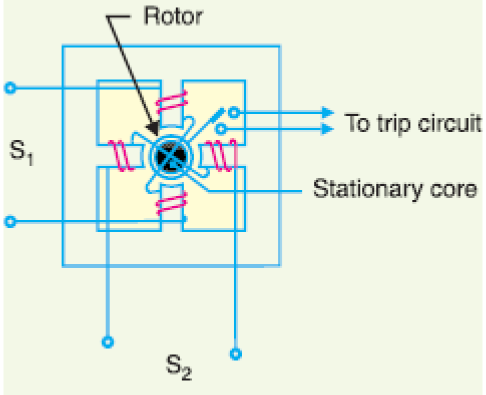
Wattmeter type: (5 M)



Shaded pole type: (5 M)



Induction cup type relay: (5 M)



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UNIT III APPARATUS PROTECTION

Current transformers and Potential transformers and their applications in protection schemes - Protection of transformer, generator, motor, busbars and transmission line.

PART * A

Q.No.	Questions
1	**What are the types of graded used in line of radial relay feeder?** BTL 2 Definite time relay and inverse-definite time relay.
2	**What are the various faults that would affect an alternator?** BTL 2 a) Stator faults 1. Phase to phase faults 2. Phase to earth faults 3. Inter turn faults b) 1. Earth faults 2. Fault between turns 3. Loss of excitation due to fuel failure c) 1. Over speed 2. Loss of drive 3. Vacuum failure resulting in condenser pressure rise, resulting in shattering of the turbine low pressure casing d) 1. Fault on lines 2. Fault on busbars
3	**Why neutral resistor is added between neutral and earth of an alternator?** BTL 2 In order to limit the flow of current through neutral and earth a resistor is introduced between them.
4	**What is the backup protection available for an alternator?** BTL 1 Over current and earth fault protection is the backup protections.
5	**What are faults associated with an alternator?** BTL 1 External fault or through fault Internal fault 1, Short circuit in transformer winding and connection 2, Incipient or slow developing faults
6	**What are the main safety devices available with transformer?** BTL 1 Oil level guage, sudden pressure delay, oil temperature indicator, winding temperature indicator .
7	**What are the limitations of Buchholz relay?** BTL 2 Only fault below the oil level are detected. Mercury switch setting should be very accurate, otherwise even for vibration, there can be a false operation. The relay is of slow operating type, which is unsatisfactory.
8	**What are the problems arising in differential protection in power transformer and how are they overcome?** BTL 2 Difference in lengths of pilot wires on either sides of the relay. This is overcome by connecting adjustable resistors to pilot wires to get equipotential points on the pilot wires. Difference in CT ratio error difference at high values of short circuit currents that makes the relay to operate even for external or through faults. This is overcome by introducing bias coil. Tap changing alters the ratio of voltage and currents between HV and LV sides and the relay will sense this and act. Bias coil will solve this. Magnetizing inrush current appears wherever a transformer is energized on its primary side producing harmonics. No current will be seen by the secondary. CT's as there is no load in the circuit. This difference in current will actuate the differential relay. A harmonic restraining unit is added to the relay which will block it when the

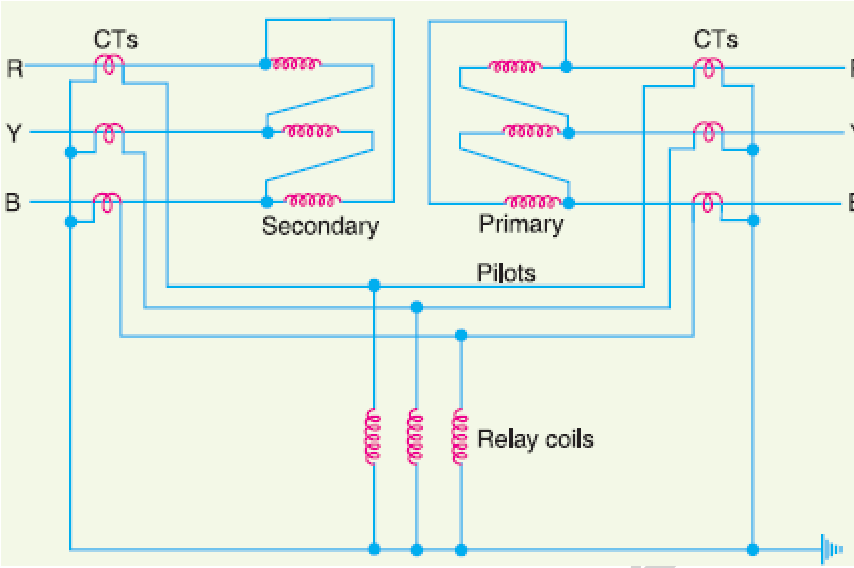
	transformer is energized.
9	**What is REF relay?** BTL 1 It is restricted earth fault relay. When the fault occurs very near to the neutral point of the transformer, the voltage available to drive the earth circuit is very small, which may not be sufficient to activate the relay, unless the relay is set for a very low current. Hence the zone of protection in the winding of the transformer is restricted to cover only around 85%. Hence the relay is called REF relay.
10	**What is over fluxing protection in transformer?** BTL 1 If the turns ratio of the transformer is more than 1:1, there will be higher core loss and the capability of the transformer to withstand this is limited to a few minutes only. This phenomenon is called over fluxing.
11	**What are the uses of Buchholz's relay?** BTL 1 Buchholz relay is used to give an alarm in case of incipient(slow-developing) faults in the transformer and to connect the transformer from the supply in the event of severe internal faults. It is usually used in oil immersion transformers with a rating over 750KVA.
12	**Why busbar protection is needed?.(April/May 2019)** BTL 2 Fault level at busbar is high b) The stability of the system is affected by the faults in the bus zone. (c) A fault in the bus bar causes interruption of supply to a large portion of the system network.
13	**What are the merits of carrier current protection?** BTL 2 Fast operation, auto re-closing possible, easy discrimination of simultaneous faults .
14	**What is field suppression?** BTL 2 When a fault occurs in an alternator winding even though the generator circuit breaker is tripped, the fault continues to fed because EMF is induced in the generator itself. Hence the field circuit breaker is opened and stored energy in the field winding is discharged through another resistor. This method is known as field suppression.
15	**What are the causes of bus zone faults?** BTL 2 Failure of support insulator resulting in earth fault Flashover across support insulator during over voltage Heavily polluted insulator causing flashover Earthquake, mechanical damage etc.
16	**What are the problems in bus zone differential protection?** BTL 2 Large number of circuits, different current levels for different circuits for external faults. Saturation of CT cores due to dc component and ac component in short circuit currents. The saturation introduces ratio error. Sectionalizing of the bus makes circuit complicated. Setting of relays need a change with large load changes.
17	**What is meant by relay operating time?(Nov 2012)** BTL 1 It is defined as the time period extending from the occurrence of the fault through the relay detecting the fault to the operation of the relay.
18	**Give the limitations of Merz Price protection. (May 2017)** BTL 1 Since neutral earthing resistances are often used to protect circuit from earth- fault currents, it becomes impossible to protect the whole of a star-connected alternator. If an earth-fault occurs near the neutral point, the voltage may be insufficient to operate the relay. Also it is extremely difficult to find two identical CT‟s. In addition to this, there always an inherent

	phase difference between the primary and the secondary quantities and a possibility of current through the relay even when there is no fault.
19	**List the different faults that may occur in transformer.** BTL 1 External fault Internal fault Short circuit in transformer winding and connection. Incipient or slow developing fault.
20	**What are the uses of Buchholz's relay?(May 2009) (May 2017)** BTL 1 Buchholz relay is used to give an alarm in case of incipient(slow-developing) faults in the transformer and to connect the transformer from the supply in the event of severe internal faults. It is usually used in oil immersion transformers with a rating over 750KVA.
21	**Discuss the most severe fault in transmission line.** BTL 2 The most severe fault is L-L-L-G fault . (Symmetrical fault)
22	**Why secondary of CT should not be left open?** BTL 2 During normal operation of CT, the primary and secondary winding produces mmf which by lenze's law opposes each other. As the secondary mmf is slightly less than the primary mmf, the net mmf is small. This net mmf is the working / magnetizing mmf of the core of CT. Now, in case secondary winding is kept open then secondary current will be zero while the primary current of CT will remain same. Therefore the opposing mmf of secondary will no longer exist. Hence the net mmf is due to primary current only i.e. N_1I_1 which is very large. This large mmf will produce large flux in the core and will saturate the core. Again, due to large flux in the core the flux linkage of secondary winding will be large which in turn will produce a large voltage across the secondary terminals of the CT. This large voltage across the secondary terminals will be very dangerous and will lead to the insulation failure and there is a good chance that the person who is opening the CT secondary while primary is energized will die due to shock.
23	**Define the term pilot with reference to power line protection** BTL 1 Pilot wire is a communication cable between DC and primary substation, a communication cable between two relays whenever a transmission line or equipment is to be protected by using distance relay or by differential relay or price protection. A wire is connected between the CT which is located in different ends of the protection zone. This wire provides the path for the circulating current produce in abnormal condition, which is sensed by the relay and therefore is tripped.
24	**What is burden in Current Transformer?** BTL 1 The actual burden is formed by the resistance of the pilot conductors and the protection relay(s).
25	**Define feeder protection.** BTL 1 Feeder protection is defined as the protection of the feeder from the fault so that the power grid continually supply the energy. The feeder injects the electrical energy from the substation to the load end. So it is essential to protect the feeder from the various type of fault.
	PART * B
1.	**Briefly explain about transformer protection using Differential protection scheme (Merz-price protection scheme) (13M) (May june 2014, May 2017, Nov Dec 2013) .(April/May 2019)** BTL 2 **Answer: Page 3.5- Thiagarajan** ➢ **Differential protection**

Differential protection, compares currents entering and leaving the protected zone and operates when the differential current between these currents exceed a pre-determined level. (3 M)

- Under internal fault conditions (i.e. faults between the CTs) the relay operates, since both the CT secondary currents add up and pass through the relay.
- This protection is also called unit protection, as it only operates for faults on the unit it is protecting, which is situated between the CTs.

Diagram- (5 M) **and explanation-** (5 M)



- Difference in magnitude of currents in the primary and secondary of power transformer is compensated by different turns ratio of CTs.

2. **What is meant by Buchholz Relay? Explain its operation with neat sketch. (13M)** BTL 2

Answer: Page 3.36- Thiagarajan

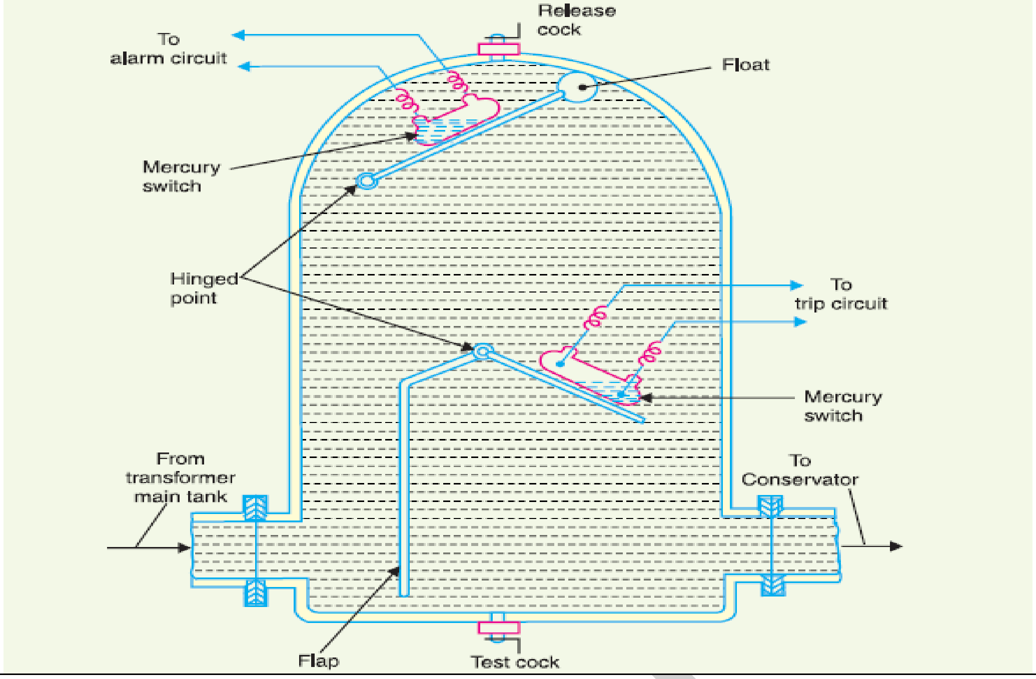
Construction: (4 M)

Alarm circuit, conservator, main tank, float, hinge, mercury switch.

Working: (5 M)

- Failure of the winding insulation will result in some form of arcing, which can decompose the oil into hydrogen, acetylene, methane, etc. Localized heating can also precipitate a breakdown of oil into gas.
- Severe arcing will cause a rapid release of a large volume of gas as well as oil vapor. The action can be so violent that the build-up of pressure can cause an oil surge from the tank to the conservator.

Diagram: (4 M)



- ➢

3. **Explain about the faults occuring in generator (13M) (Apr 2015 ,May 2014, Nov 2012)** BTL 3

Answer: Page 3.6- Thiagarajan

- ➢ The various faults which can occur associated with a generator can be classified as,
- ➢ Stator faults: The faults associated with the stator of the generator
- ➢ Rotor faults: The faults associated with the rotor of the generator.
- ➢ Abnormal running conditions: This includes number of abnormal conditions which may occur in practice, from which the generator must be protected. (3 M)
- ➢ Stator Faults

The main types of stator faults are.

Phase to phase faults

Phase to Earth Faults

Stator Inter-Turn Faults

Rotor Faults

Abnormal Running Conditions

These abnormal conditions include, I. Overloading 2. Over speeding 3. Unbalanced loading 4. Over voltage 5. Failure of prime mover (Arc of excitation (Field failure) 7. Cooling system failure (Explanation: Each 2 M)

Failure of prime-mover. Input, prime-mover fails, the alternator runs as a synchronous motor draws some current from the supply system, “inverted running”.

Failure of field: No immediate damage , permitting the alternator to run without a field for a short-period, rely on the control room attendant to disconnect the faulty alternator manually from the system bus-bars.

Over current. Due to partial breakdown of winding insulation or due to overload on the supply system. Reasons.

Over speed. Sudden loss of all or the major part of load on the alternator.

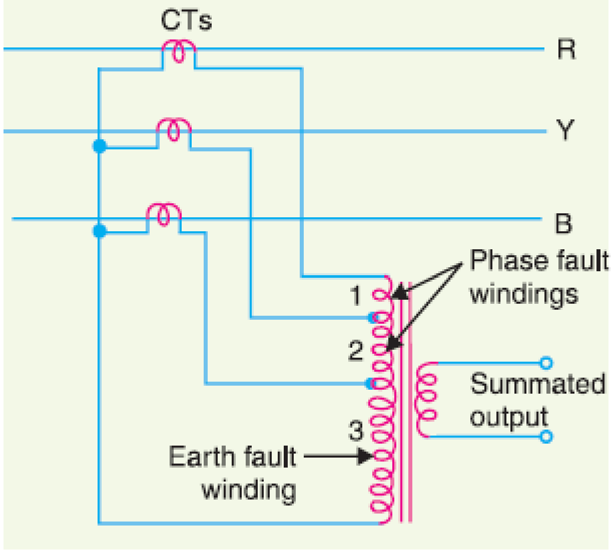
Over-voltage. Speed of the prime-mover increases due to sudden loss of the alternator load. relays are so arranged that when the generated voltage rises 20% above the normal value, they

	operate to ➢ trip the main circuit breaker to disconnect the faulty alternator from the system ➢ disconnect the alternator field circuit **Unbalanced loading.** There are different phase currents in the alternator. Unbalanced loading arises from faults to earth or faults between phases on the circuit external to the alternator. The unbalanced currents, if allowed to persist, may either severely burn the mechanical fixings of the rotor core or damage the field winding. **(*vii*) Stator winding faults.** These faults occur mainly due to the insulation failure of the stator windings. The main types of stator winding faults, in order of importance are : **(*a*)** fault between phase and ground **(*b*)** fault between phases **(*c*)** inter-turn fault involving turns of the same phase winding The stator winding faults- most dangerous- cause considerable damage to the expensive machinery. Differential method of protection (also knows as Merz-Price system)- due to its greater sensitivity and reliability.
4.	**A star-connected, 3-phase, 10-MVA, 6·6 kV alternator has a per phase reactance of 10%. It is protected by Merz-Price circulating-current principle which is set to operate for fault currents not less than 175 A. Calculate the value of earthing resistance to be provided in order to ensure that only 10% of the alternator winding remains unprotected. (10 M)** BTL 3 **Answer: Page 529- V.K. Mehta** Voltage per phase, Vph= 3810 V Full-load current, I= 875 A (2 M) Reactance per phase x = 0·436 Ω (3 M) r = 2·171Ω (5 M)
5.	**A star-connected, 3-phase, 10 MVA, 6·6 kV alternator is protected by Merz- Price circulating-current principle using 1000/5 amperes current transformers. The star point of the alternator is earthed through a resistance of 7·5 Ω . If the minimum operating current for the relay is 0·5 A, calculate the percentage of each phase of the stator winding which is unprotected against earth-faults when the machine is operating at normal voltage. (8 M)** BTL 3 **Answer: Page 530- V.K. Mehta** Voltage per phase, Vph= 3810 V Minimum fault current which will operate the relay = 1000/5 * 0.5 = 100 A (2 M) E.M.F. induced in *x*% winding = 38·1 *x* volts (2 M) 19·69% of alternator winding is left unprotected. (4 M)
6	**A 3-phase transformer of 220/11,000 line volts is connected in star/delta. The protective transformers on 220 V side have a current ratio of 600/5. What should be the CT ratio on 11,000 V side ? (8 M)** BTL 3 **Answer: Page 538- V.K. Mehta** Phase current of star connected *CT*s on 11,000 V side = 5 √3 A (2 M) Diagram: (2 M) Primary apparent power = Secondary apparent power I= 12A (2 M) Turn-ratio of *CT*s on 11000 V side= 12 : 5√ 3 = **1·385 : 1** (2 M)

7.

Explain differential pilot wire protection using translay scheme. (13 M) (BTL 3)
Answer: Page 548- V.K. Mehta

- Similar to voltage balance system except balance or opposition is between the voltages induced in the secondary windings wound on the relay magnets and not between the secondary voltages of the line current transformers.
- This permits to use current transformers of normal design and eliminates one of the most serious limitations of original voltage balance system, namely; its limitation to the system operating at voltages not exceeding 33 kV. (3 M)
- Diagram: (3 M)

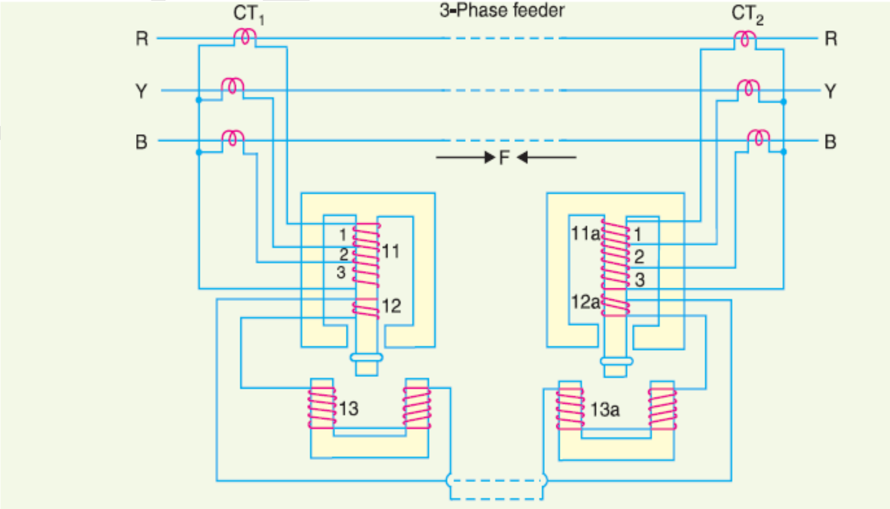


- Construction and working: (7 M)

Summation transformer, poly phase quantity into single phase quantity. Three CTs connected to tapped primary of summation transformer.

Advantages:

- primary windings 1 and 2 can be used for phase faults whereas winding 3 can be used for earth fault
- The number of pilot wires required is only two.



PART*C

1. **Breifly explain about Merz-price protection of a generator with neat sketch. (15 M)** BTL 3

Answer: Page 3.6- Thiagarajan

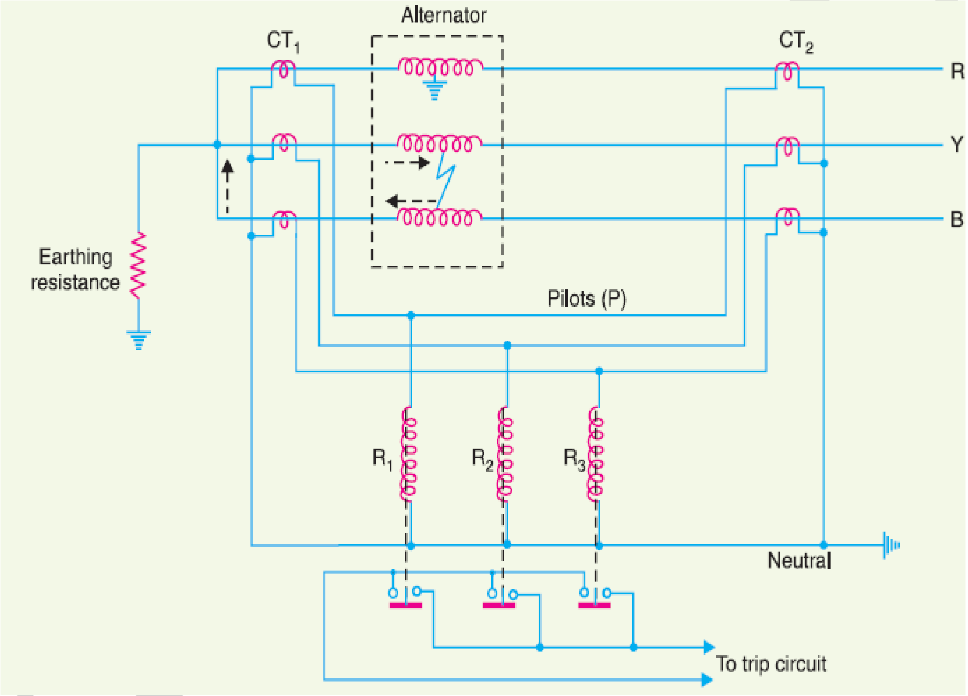
Diagram- (4 M)

Merz-price protection- (3 M)

Working: (4 M)

Advantages and disadvantages: (4 M)

- In this method, the currents at the two ends of the protected section are sensed using current transformers.
- The wires connecting relay coils to the current transformer secondary's arc called pilot wires.
- Under normal conditions, when there is no fault in the windings, the currents in the pilot wires fed C.T. secondary are equal.
- When fault occurs inside the protected section to the stator windings, the differential current I, flows through the operating coils of the relay.



2. **Explain about Motor protection (15 M)** BTL 3

Answer: Page 3.24- Thiagarajan

Ground fault protection : (8 M)

- Phase Fault Protection (**7 M)**

This protection is also called short circuit protection.

- Attracted armature type relay

Main requirements

- In the event of fault, or short circuit the breaker close to the fault should open and all other breakers are to remain in closed position, except in case of grid lines.
- In case the nearest breaker to the fault to open, back-up protection should be provided by the adjacent breakers.

- The relay operating time should be as short as possible in order to pressure system stability.
- Protection of transmission line has quite a different problem, compared to protection of generators, transformers, motors etc.

3\. **Explain transmission system protection schemes with neat sketch. (15 M) .(April/May 2019)** BTL 4

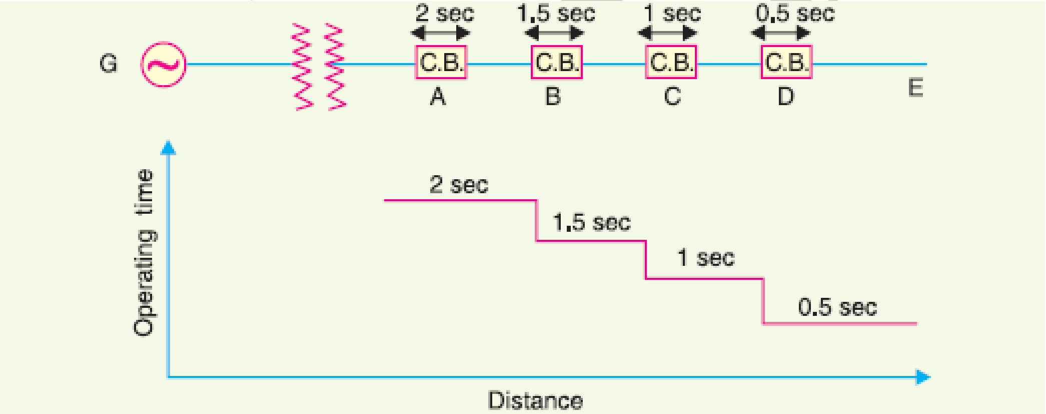
Answer: Page 3.57- Thiagarajan

- A transmission system may use one or more of the following types of protection.
- Over current protection non directional time and current graded scheme (3M)
- Directional time and current graded scheme (3M)
- Distance protection using high speed distance relays. (3M)
- Pilot wire protection (3M)
- Carrier current pilot protection
- Micro wave pilot protection
- Distance protection of lines (3M)

4\. **Discuss with neat diagram, time graded overcurrent protection and distance protection of transmission lines. (13 M)** BTL 2

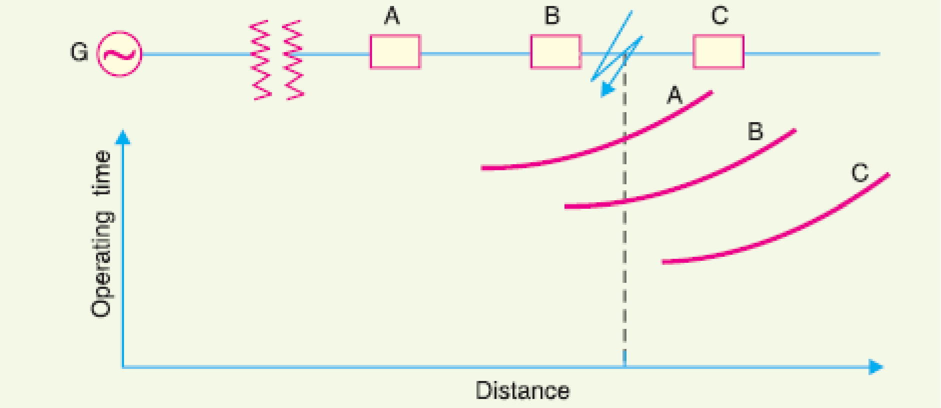
Answer: Page 544-V.K.Mehta

Definite Time relay: (4 M)



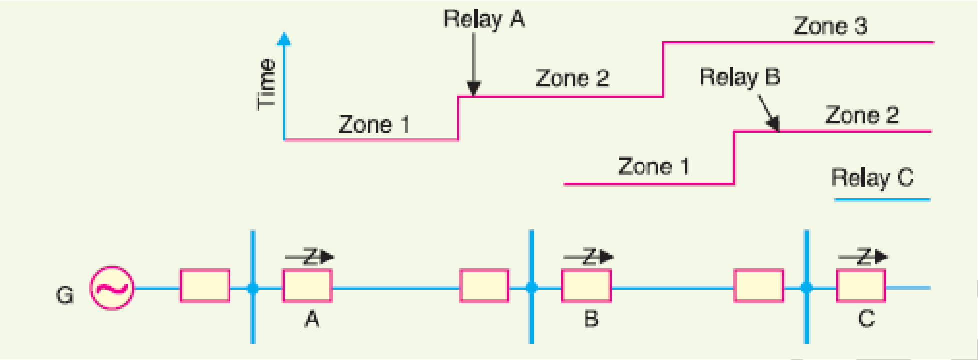
- Time of operation is fixed.
- Is independent of the operating current.
- Disadvantage: If there are a number of feeders in series, the tripping time for faults near the supply end becomes high.

Inverse Time relay: (4 M)



- Inverse time characteristics.

Distance Protection of transmission lines: (13 M)



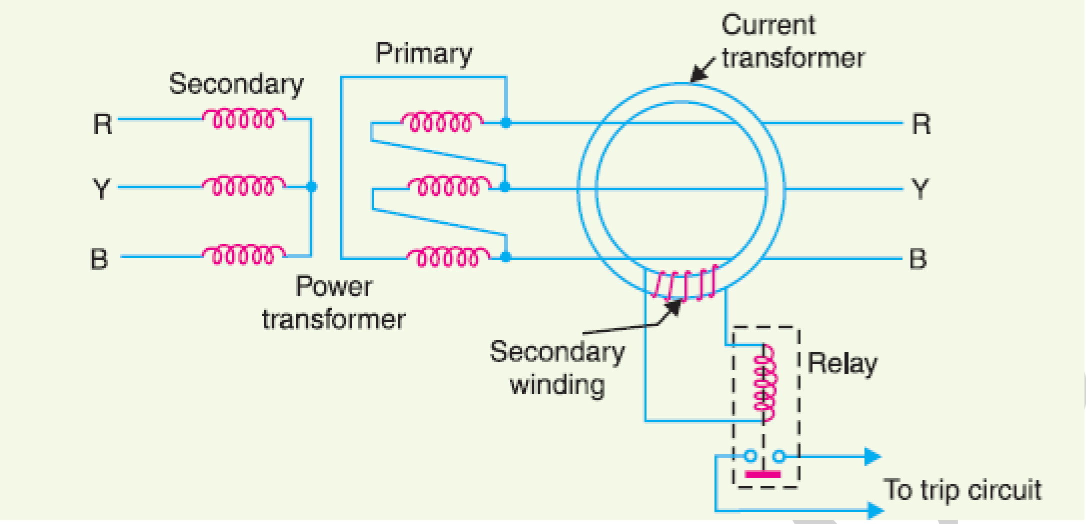
- Zone 1 covers 90% of the line and is arranged to trip instantaneously for faults in this portion.
- Zone 2 element trips the fault in the remaining 10 % of the line.
- Zone 3- back up protection.

4. **Differentiate between CT and PT. (6). (May June 2012) (May 2017)** BTL 2

S. No	Current Transformers (CT)	Potential/Voltage Transformers (PT/VT)
1	The Primary winding of a C.T have smallernumber of turns than secondary.	The Primary winding of a P.T have larger number of turns than secondary.
2	The secondary of a C.T cannot be open circuited on any circumstance when it is under service.	The secondary of a P.T can be open circuited without any damage being caused either to the operator or the transformer.
3	A CT may be considered as a series transformer.	P.T may be considered as a parallel transformer.
4	The primary current in a C.T is independent of the secondary circuit conditions (burden/load).	The primary current of a P.T depends upon the secondary circuit conditions (burden/load).
5	The primary winding of the CT is connected in series with the line carrying the current to be measured. Hence it carries of the full line current.	The primary winding P.T is connected across the line of voltage to be measured. Hence the full line voltage is impressed across its terminal.
6	With the help of CT, a 5A ammeter can be used measure a high current like 200A.	With the help of P.T, a 120V voltmeter can be used to measure very high voltages like 11KV.

5. **Explain earth fault protection of transformers. (8 M)** BTL 3

Answer: Page 535- V.K.Mehta



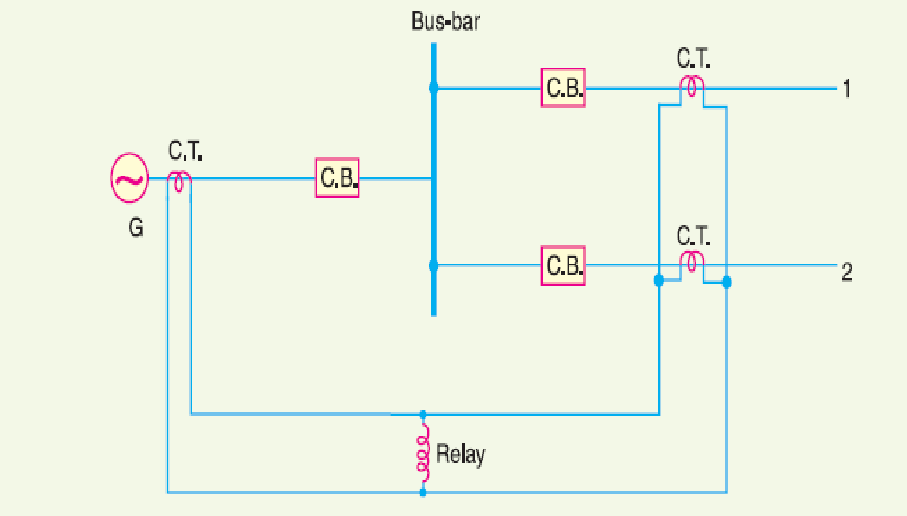
(4 M)

- ➢ The three leads of the primary winding of power transformer are taken through the core of a current transformer which carries a single secondary winding.
- ➢ The operating coil of a relay- connected to this secondary.
- ➢ Under normal conditions (i.e. no fault to earth), the vector sum of the three phase currents is zero and there is no resultant flux in the core of current transformer
- ➢ No current flows through the relay and it remains inoperative.
- ➢ Occurrence of an earth-fault, the vector sum of three phase currents - no longer zero. The resultant current sets up flux in the core of the C.T. which induces e.m.f. in the secondary winding.
- ➢ Energizes the relay to trip the circuit breaker and disconnect the faulty transformer from the system. (4 M)

6. **Briefly explain about busbar protection schemes with neat diagram. (15 M)** BTL 3

Answer: Page 542- V.K. Mehta

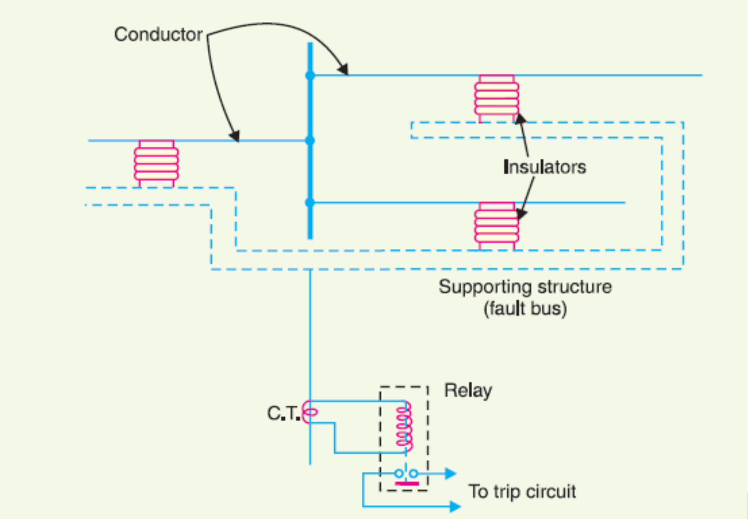
Differential Protection: (7 M)



- ➢ All CTs must be of same ratio.
- ➢ Under normal condition or during external fault condition- the sum of current entering the bus is equal to sum of current leaving it.

- Fault condition- difference current flows and cause opening of generator circuit breaker and each of the line circuit breakers.

Fault Bus Protection: (8 M)



- It is possible to design a station so that the faults that develop are mostly earth-faults.
- This can be achieved by providing earthed metal barrier (known as *fault bus*) surrounding each conductor throughout its entire length in the bus structure.
- Every fault that might occur must involve a connection between a conductor and an earthed metal part.
- By directing the flow of earth-fault current, it is possible to detect the faults and determine their location. This type of protection is known as fault bus protection.

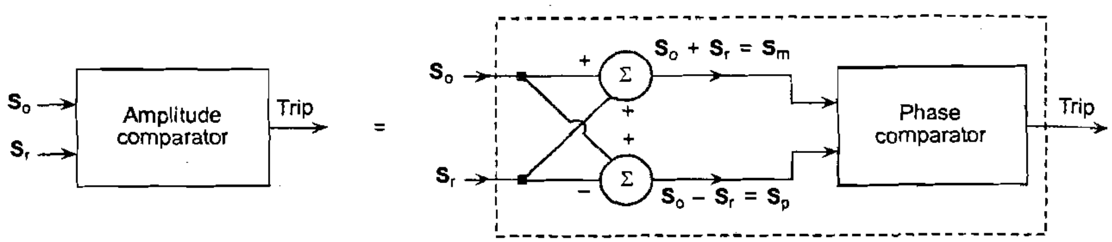
UNIT IV STATIC RELAYS AND NUMERICAL PROTECTION

Static relays – Phase, Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Over current protection, transformer differential protection, distant protection of transmission lines.

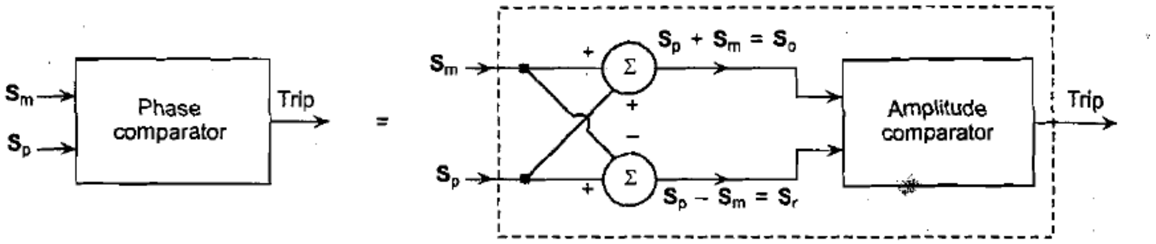
PART * A

Q.No.	Questions
1	**What is a programmable relay?** BTL 1 A static relay may have one or more programmable units such as microprocessors or microcomputers in its circuit.
2	**What is CPMC?** BTL 1 It is combined protection, monitoring and control system incorporated in the static system.
3	**What are the advantages of static relay over electromagnetic relay? (Nov 2013) .(April/May 2019)** BTL 1 Low power consumption as low as 1mW No moving contacts; hence associated problems of arcing, contact bounce, erosion, replacement of contacts No gravity effect on operation of static relays. Hence can be used in vessels i.e., ships, aircrafts etc. A single relay can perform several functions like over current, under voltage, single phasing protection by incorporating respective functional blocks. This is not possible in electromagnetic relays. Static relay is compact Superior operating characteristics and accuracy Static relay can think , programmable operation is possible with static relay Effect of vibration is nil, hence can be used in earthquake-prone areas Simplified testing and servicing. Can convert even non-electrical quantities to electrical in conjunction with transducers.
4	**Define static relay.(April/May 2019)** BTL 1 A static relays to a relay in which measurement or comparison of electrical quantities is done in a static network which is designed to give an output signal, when a threshold condition is passed, which operates a tripping device.
5	**List the types of static relays.** BTL 1 Electronic relays 2. Transducer relays 3. Rectifier bridge relays 4.Transistor relays 5. Hall effect relays 6. Guass effect relays
6	**What are the limitations of a static relay?** BTL 1 ➢ Auxiliary voltage requirement for Relay Operation. ➢ Static relays are sensitive to voltage transients which are caused by operation of breaker and isolator in the primary circuit of CTs and PTs. ➢ Serious over voltage is also caused by breaking of control circuit, relay contacts etc. ➢ Temperature dependence of static relays: The characteristics of semiconductor devices are affected by ambient temperature. Highly reliable power supply circuits

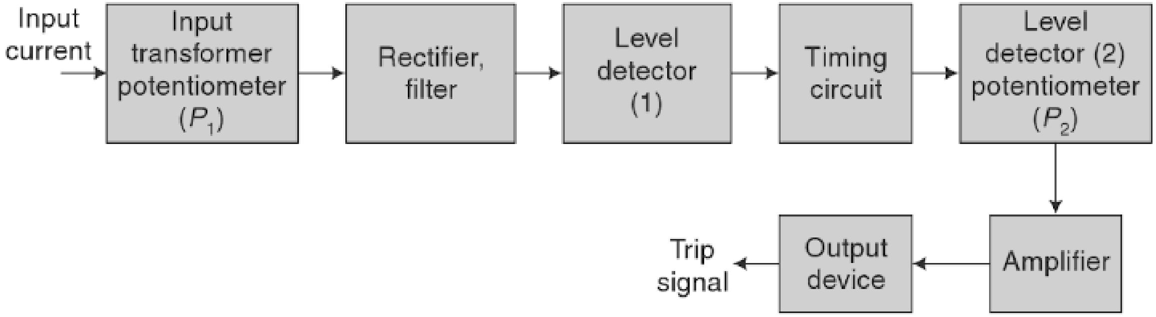
	are required.
7	**Define comparator.** BTL 3 Comparator is a part of a static relay which receives two inputs to be compared and gives output based on comparison. Types are amplitude comparator, phase comparator, Hybrid comparator.
9	**What are the types of electronic circuits used in a static protection system?** BTL 1 Analog circuits – For simple functions Digital circuits – For complex functions Hybrid circuits – For highly complex functions
10	**How does a numerical over current relay work? (May 2017)** BTL 1 Numerical over current protection algorithm first reads all the setting such as the type of characteristics to be implemented, the pickup value $I_{perunit}$, the time multiplier setting in case of inverse time over current relay or the time delay in case of DTOC relay. Using a multiplexer, the microprocessor can sense the faults currents. If fault current exceeds a pickup value, microprocessor sends a tripping signal to the C.B of the faulty circuit.
11	**Define hybrid comparator.** BTL 1 It is a comparator which compares both magnitude and phase of the input quantities. Hence amplitude and phase comparators are used. Inputs are given to phase comparator and output of phase comparator is given to amplitude comparator.
12	**What is digital filtering?** BTL 1 Digital filtering is performed using analog filters consisting of RLC circuits and active filters using operational amplifiers which is the most needed operation in numerical relaying
13	**Define sampling theorem. (May 2017)** BTL 1 It states that in order to preserve the information contained in a signal of frequency it must be sampled at a frequency at least equal to or greater than twice the signal frequency. $\varpi_{\text{sampling,min}} \geq 2\varpi\text{signal}$
14	**What are the Limitations of Numerical Relay?** BTL 1 ➢ Numerical Relay offers more functionality, and greater precision. Numerical Relay can make faster decisions. Numerical Relay protection often relies on non-proprietary software, exposing the system to potential risk of hacking. ➢ Numerical Relay protection sometimes has exposure to externally-sourced transient interference that would not affect conventional technology. ➢ Numerical Relay protection shares common functions. This means that there are common failure modes that can affect multiple elements of protection.
15	**What are the two types of Phase comparators?** BTL 1 Phase comparators are of two types: the cosine type and the sine type.
16	**What is the trip condition for Sine comparators?** BTL 1 If $0^0 < \text{Arg}\ (S_m/S_p) < 180^0$ then trip; else restrain where S_m and S_p are the inputs to the sine comparator.
17	**What is the trip condition for Cosine comparators?** BTL 1 If $-90^0 < \text{Arg}\ (S_m/S_p) < +90°$ then trip; else restrain where Sm and Sp are the inputs to the cosine comparator.
18	**Draw the duality between amplitude and phase comparators.** BTL 3



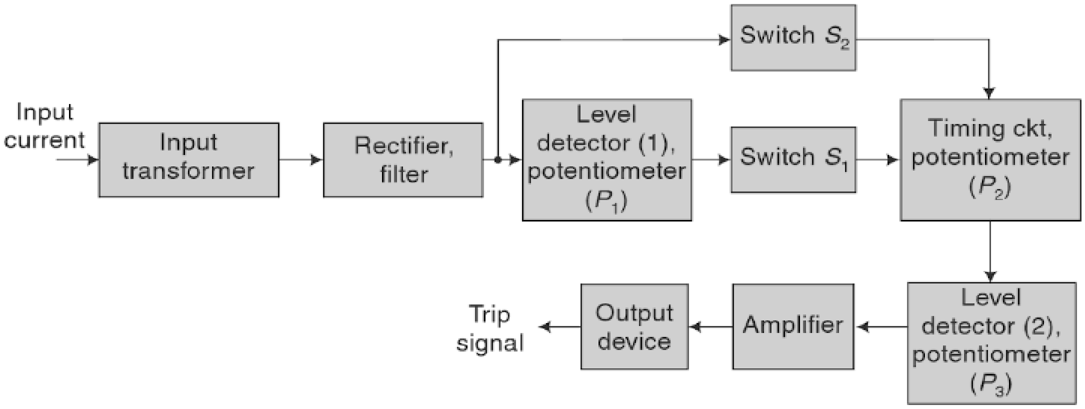
19 **Draw the duality between phase and amplitude comparators.** BTL 3



20 **Draw the block diagram of static instantaneous over current relay.** BTL 3

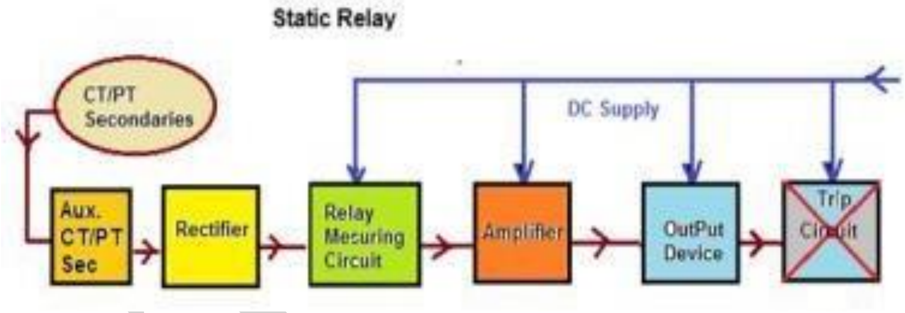


21 **Draw the block diagram of static inverse time over current relay.** BTL 3



22 **What are the types of Numerical Over current relays?** BTL 1

- Microprocessor based over current relays
- Microcontroller based over current relays
- Digital Signal Processor based over current relays

	➢ FPGA based over current relays ➢ ANN over current relays
23	**What is meant by under reach of distance relay?** BTL 1 A distance relay is said to under reach when the impedance seen by relay due to fault is more than the relay setting value even though the fault point is within the protected zone of line. This means that reach of relay has decreased from the setting value.
24	**What is meant by over reach of distance relay?** BTL 1 The tendency of a distance relay to operate eve when the fault is beyond its preset reach is known as over reach.
25	**State the reason for overreach of distance relays.** BTL 1 Presence of DC offset in the fault current wave.
	PART * B
1	**Explain with neat block diagram of the solid state relays. (13M)(Nov 2013)** BTL 1 **Answer: Page 98 - Notes** **Static relay introduction:** (3 M) ➢ Measurement or comparison of electrical quantities is done in a static network which is designed to give an output signal, when a threshold condition is passed, which operates a tripping device. **Block diagram:** (4 M)  **Working:** (6 M) ➢ A relay using combination of both static and electro-magnetic units is also called a static relay provided that static units accomplish the response. ➢ The performance of static relay is better than electromagnetic relays as they are fast acting and accuracy of measurement is better than electromagnetic relay. ➢ The rectified output supplied to a measuring unit comprising of comparators, level detectors, filters, logic circuits. Output - actuated when the dynamic input (i.e., the relaying quantity) attains the threshold value. ➢ This output of the measuring unit amplified by amplifier and fed to the output unit device, which is usually an electro-magnetic one. The output unit energizes the trip coil only when relay operates.

2 **Explain the block diagram of numerical relay with neat sketch. (13M) (May 2017)** BTL 1

Answer: Page: 85: Notes

Numerical relay introduction (3 M)

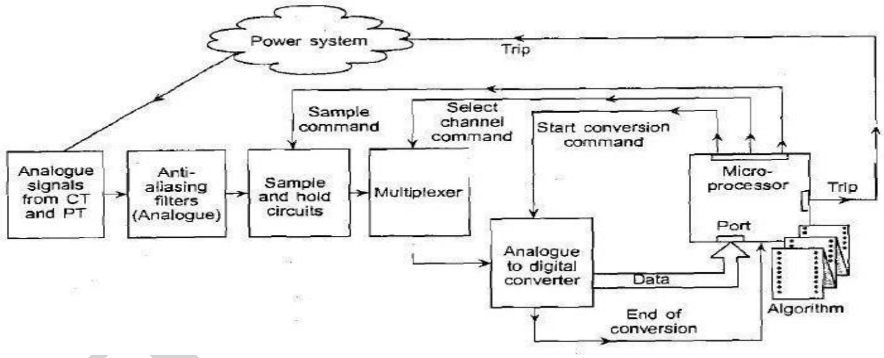
Numeric relays are programmable relays. The characteristics and behavior of the relay can be programmed.

First generation numerical relays to meet the static relay protection characteristic, modern numeric protection devices capable of providing complete protection with added functions like control and monitoring.

Numerical protection devices offer several advantages in terms of protection, reliability, and trouble shooting and fault information.

Block diagram: (4 M)

Block Diagram of Numerical Relay



Working: (6 M)

- ➢ These are microprocessor - based relays in contrast to other relays that are electromechanically controlled.
- ➢ Function of Relay: Modern power system protection devices are built with integrated functions. Multifunction like protection, control, monitoring and measuring are available today in numeric power system protection devices. Also, the communication capability of these devices facilitates remote control, monitoring and data transfer.
- ➢ Numerical protection devices are available for generation, transmission and distribution systems
- ➢ Numerical relays are micro processor based relays

- These relays provide great precision and convenience in application in the sophisticated electronic products.

Advantages of Numerical relays:

- Compact Size
- Flexibility:
- Reliability
- Multi Function Capability
- Modular frame:
- Low burden.
- Sensitivity:
- Speed & Fast Resetting

3 **Describe with neat block diagram about the working of numerical over current protection. (13M).(April/May 2019)** BTL 3

Answer: Page:89 - Notes

Diagram (5 M)

C. Block Schematic Diagram of proposed NPR for Over Current Protection

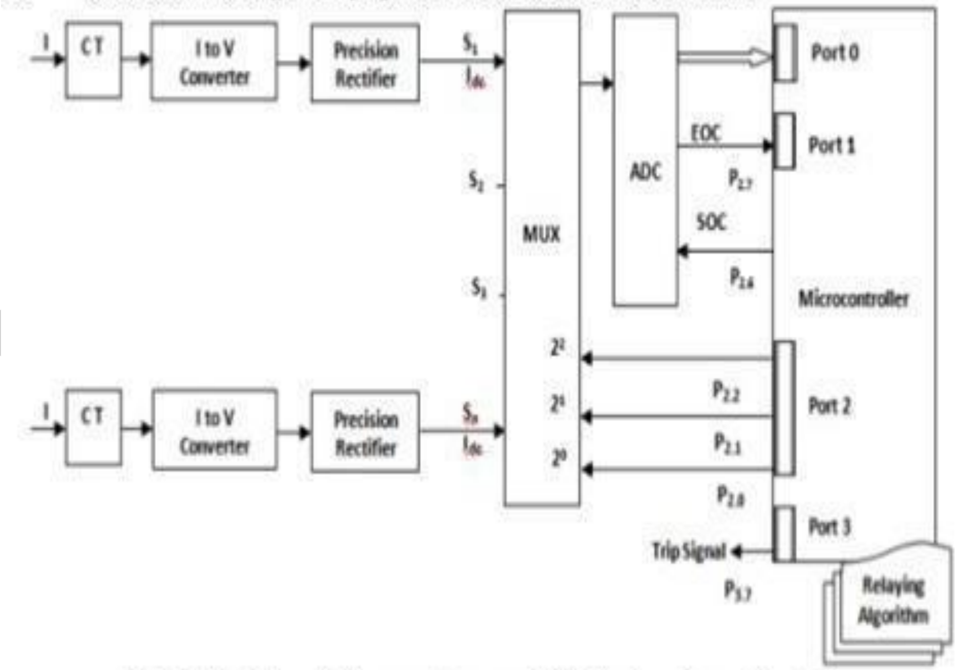


Fig.1: Block Schematic Diagram of proposed NPR for Over Current Protection

Working: **(**8 M)

	➢ The output of the rectifier fed to the multiplexer. ➢ The microcomputer sends a command to switch on desired channel of the multiplexer to obtain the rectified voltage proportional to the current in a particular circuit. ➢ The output of the multiplexer is fed to the A/D converter to obtain the signal in digital form. ➢ The A/D converter ADC 0800 has been used for this purpose. ➢ The microcomputer reads the end of conversion signal to examine whether the conversion is over or not. ➢ As soon as the conversion is over, the microcomputer reads the current signal in digital form and then compares it with the pickup value.
4	**Explain about amplitude comparators and phase comparators in detail. (13 M)** BTL 1 **Answer: Page: 96 - Notes** Amplitude comparators- (3 M) Amplitude comparator compares the magnitude of two input quantities irrespective of the angle between them. One – operating quantity, Two- restraining quantity. Amplitude of operating quantity greater than the restraining quantity, relay trips. Phase comparators- (3 M) Compares two input quantities in phase angle, irrespective of their magnitudes and operates if the phase angle between them is <=90^0 Synthesis of relays using static comparators- (7 M)
5	**Draw the flowchart for numerical over current relay. (8 M)** BTL 4 **Answer: Page 99 - Notes** **Flowchart:** (5 M)

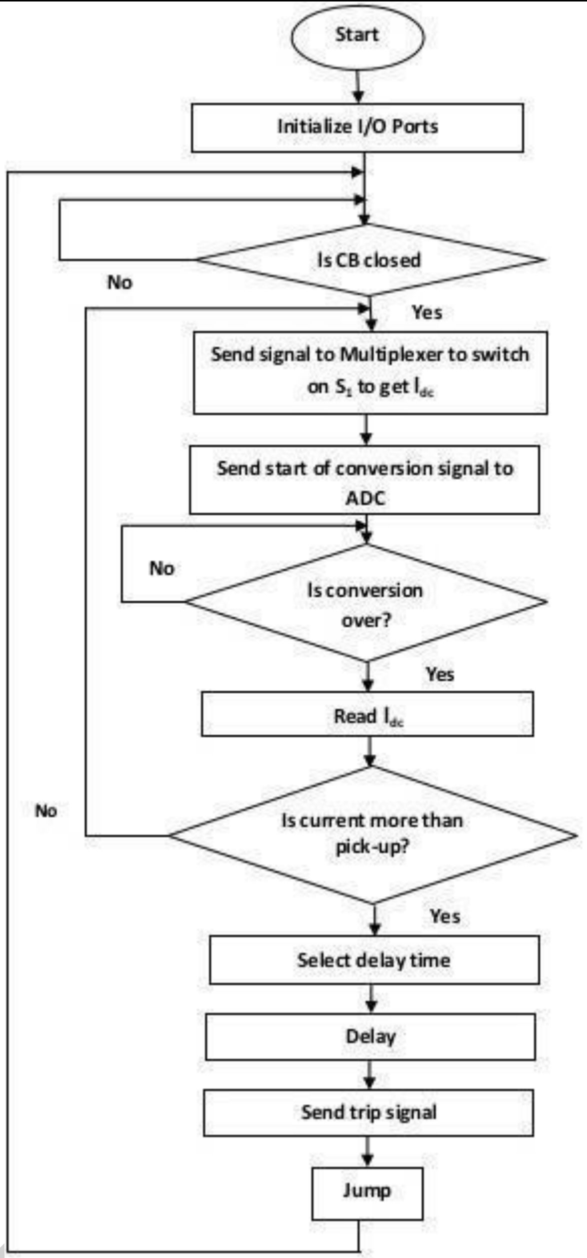


Fig.2: Flow Chart of NPR Algorithm for Over Current Protection

Explanation: (3 M)

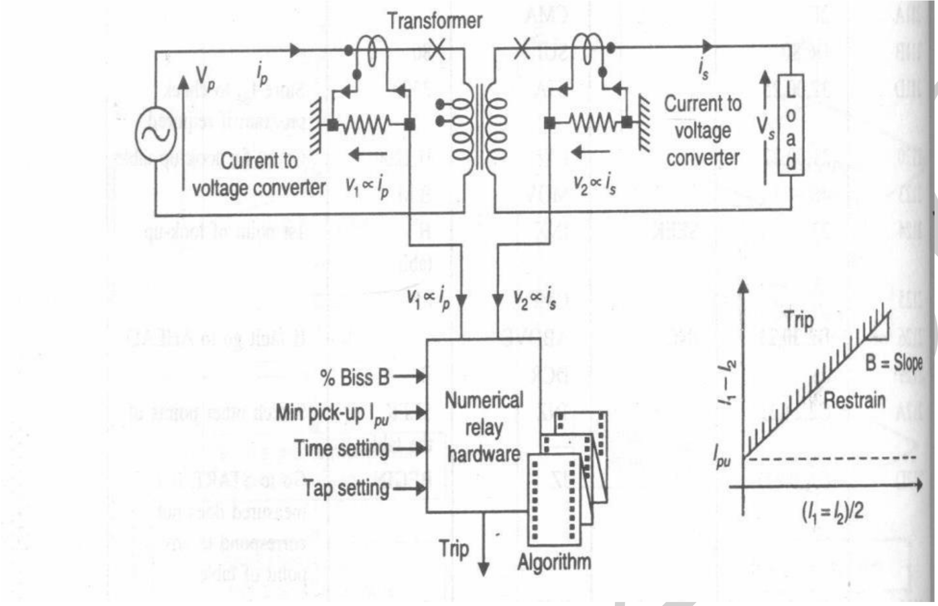
- When the fault current exceeds the pickup value, the fault current - measured once again by the microprocessor to confirm whether - fault current or transient.
- In case of any transient of short duration, the measured current above pick up value will not appear in the second measurement.
- But if there is an actual fault, it will again appear in the second measurement also and then the microprocessor will issue the tripping signal to disconnect the faulty part of the system.

PART*C

1 **Describe with neat block diagram, the working of numerical transformer differential protection. (15 M)** BTL 3

Answer: Page 102 - Notes

Diagram (5 M)



Working: (5 M)

The idea is to estimate the phasor value of the current on both sides of the transformer and find the phasor difference between the two. If magnitude of this difference -substantial, internal fault indicated and the trip signal should be issued.

Algorithm for percentage differential relay: (5 M)

- Read percentage bias B and the minimum pick up I_{pu}.
- Read i_p samples. Estimate phasor I_p using any technique.
- Read is samples. Estimate phasor Is using any technique.
- Compute spill current $I_{spill} = I_p - I_s$.
- Compute circulating current $I_{circulating} = (I_p + I_s) / 2$
- If $I_{spill} > (BI_{circulating} + I_{pu})$ then trip, else restrain.

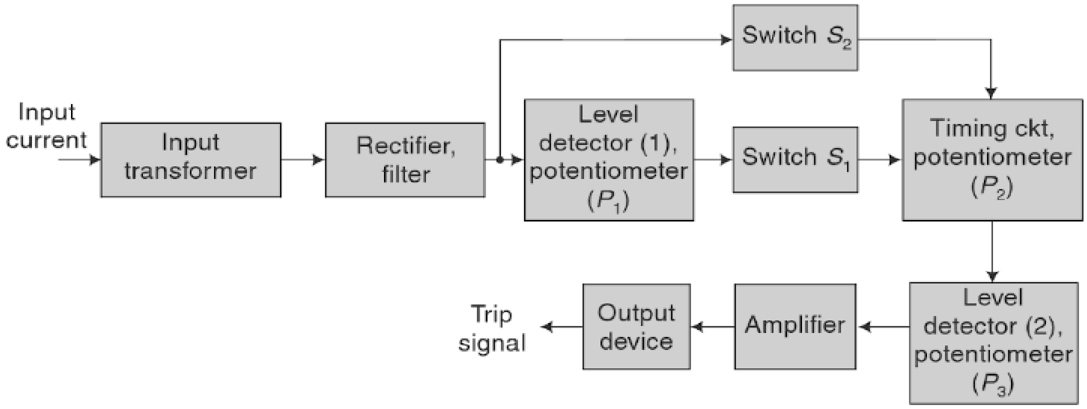
2 **Describe with neat block diagram, the working of static instantaneous over current protection relay.(15 M)** BTL 3

Answer: Page 99 - Notes

Over current relay- (3 M)

Numerical over current protection algorithm first reads all the setting such as the type of characteristics to be implemented, the pickup value $I_{perunit}$, the time multiplier setting in case of inverse time over current relay or the time delay in case of DTOC relay. Using a multiplexer,, the microprocessor can sense the faults currents. If fault current exceeds a pickup value,, microprocessor sends a tripping signal to the C.B of the faulty circuit.

Block diagram: (4 M)



Explanation: (8 M)

- The current derived from the C.T is fed to the input transformer which gives a proportional output voltage.
- The input transformer has an air gap in the iron core and is provided with tappings on its secondary winding to obtain different current settings.
- The output voltage of the transformer is rectified through a rectifier and then filtered at a single stage.
- A fixed portion of the rectified and filtered voltage (through a potential divider) is compared against a preset pick up by a level detector and if it exceeds the pickup value, a signal through an amplifier is given to the output device which issues the trip signal.
- The output may either be a static thyristor circuit or an electromagnetic slave relay.

3 **Explain the types of amplitude comparators in detail. (15 M)** BTL 3

Answer: Page: 66- Badri Ram

Types: (2 M)

- Circulating current type rectifier bridge comparators
- Phase splitting type comparators
- Sampling comparators

Circulating current type rectifier bridge comparators- used for over current and distance relay characteristics. Operating and restraining quantities are rectified and then applied to a slave relay or thyristor circuit. Two full wave rectifiers- one for operating quantity and the other for restraining quantity.

Bridges- DC polarized relay.

Operating quantity exceeds restraining quantity, relay operates. Diagram. (5 M)

Phase splitting type comparators- Input split into six components 60^0 apart, output after

	rectification smoothens within 5%, a continuous output signal is obtained. The operating time depends on the time constant. Diagram. (5 M) **Sampling comparators-** One of the inputs is rectified and it is compared with the other input at the particular moment. Diagram. (3 M)

UNIT V CIRCUIT BREAKERS

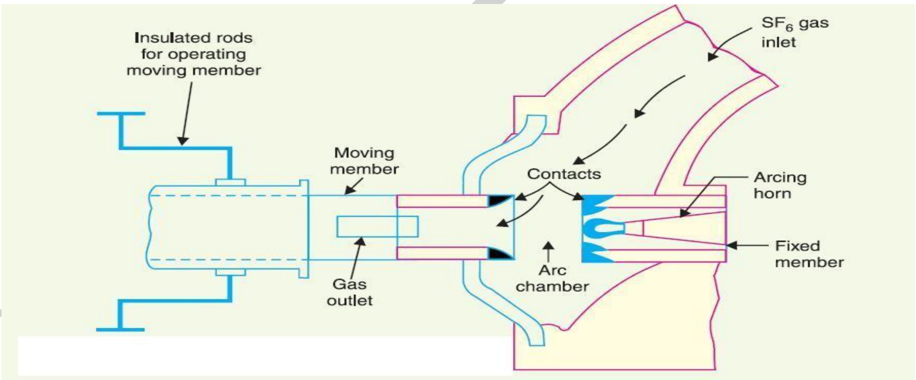
Physics of arcing phenomenon and arc interruption - DC and AC circuit breaking – re-striking voltage and recovery voltage - rate of rise of recovery voltage - resistance switching - current chopping - interruption of capacitive current - Types of circuit breakers – air blast, air break, oil, SF6 and vacuum circuit breakers – comparison of different circuit breakers – Rating and selection of Circuit breakers.

PART * A

Q.No.	Questions
1	**What is resistance switching?** BTL 2 It is the method of connecting a resistance in parallel with the contact space(arc). The resistance reduces the restriking voltage frequency and it diverts part of the arc current. It assists the circuit breaker in interrupting the magnetizing current and capacity current.
2	**What do you mean by current chopping? (April/May 2019)** BTL 2 When interrupting low inductive currents such as magnetizing currents of the transformer, shunt reactor, the rapid deionization of the contact space and blast effect may cause the current to be interrupted before the natural current zero. This phenomenon of interruption of the current before its natural zero is called current chopping.
3	**What are the methods of capacitive switching?** BTL 2 Opening of single capacitor bank Closing of one capacitor bank against another
4	**What is an arc?** BTL 1 Arc is a phenomenon occurring when the two contacts of a circuit breaker separate under heavy load or fault or short circuit condition.
5	**Give the two methods of arc interruption.** BTL 1 High resistance interruption:-the arc resistance is increased by elongating, and splitting the arc so that the arc is fully extinguished _ Current zero method:-The arc is interrupted at current zero position that occurs100 times a second in case of 50Hz power system frequency in ac.
6	**What is restriking voltage?** BTL 1 It is the transient voltage appearing across the breaker contacts at the instant of arc being extinguished.
7	**What is meant by recovery voltage?** BTL 2 The power frequency rms voltage appearing across the breaker contacts after the arc is extinguished and transient oscillations die out is called recovery voltage.
8	**What is RRRV?** BTL 2 RRRV is the rate of rise of restriking voltage, expressed in volts per microsecond. It is closely associated with natural frequency of oscillation.
9	**What is circuitbreaker?** BTL 1 Circuit breaker is a piece of equipment used to break a circuit automatically under fault conditions. It breaks a circuit either manually or by remote control under normal conditions and under fault conditions.

10	**Write the classification of circuit breakers based on the medium used for arc extinction.** BTL 1 • Air break circuit breaker • Oil circuit breaker • Minimum oil circuit breaker • Air blast circuit breaker • SF6 circuit breaker • Vacuum circuit breaker
11	**What is the main problem of the circuitbreaker?** BTL 2 When the contacts of the breaker are separated, an arc is struck between them. This arc delays the current interruption process and also generates enormous heat which may cause damage to the system or to the breaker itself. This is the main problem.
12	**Write the demerits ofMOCB.** BTL 2 • Short contact life • Frequent maintenance • Possibility of explosion • Larger arcing time for small currents • Prone to restricts
13	**What are the advantages of oil as arc quenchingmedium? (April/May 2019)** BTL 2 • It absorbs the arc energy to decompose the oil into gases, which have excellent cooling properties • It acts as an insulator and permits smaller clearance between line conductors and earthed components
14	**What are the hazards imposed by oil when it is used as an arc quenching medium?** BTL 2 There is a risk of fire since it is inflammable. It may form an explosive mixture with arc. So oil is p:red as an arc quenching medium.
15	**What are the advantages of MOCB over a bulk oil circuit breaker?** BTL 2 • It requires lesser quantity of oil • It requires smaller space • There is a reduced risk offire • Maintenance problem are reduced
16	**What are the disadvantages of MOCB over a bulk oil circuit breaker?** BTL 2 The degree of carbonization is increased due to smaller quantity of oil There is difficulty of

	removing the gases from the contact space in time The dielectric strength of the oil deteriorates rapidly due to high degree of carbonization
17	**What are the types of air blast circuit breaker?** BTL 1 Arial-blast type Cross blast Radial-blast
18	**What are the advantages of air blast circuit breaker over oil circuit breaker?** BTL 2 • The risk of fire is diminished • The arcing time is very small due to rapid buildup of dielectric strength between contacts • The arcing products are completely removed by the blast whereas oil deteriorates with successive operations.
19	**What are the demerits of using oil as an arc quenching medium?** BTL 2 • The air has relatively inferior arc quenching properties • The air blast circuit breakers are very sensitive to variations in the rate of rise of restriking voltage • Maintenance is required for the compression plant which supplies the airblast
20	**What is meant by electro negativity of SF6gas?** BTL 2 SF6 has high affinity for electrons. When a free electron comes and collides with a neutral gas molecule, the electron is absorbed by the neutral gas molecule and negative ion is formed. This is called as electro negativity of SF6 gas.
21	**What are the characteristic of SF6gas?** BTL 2 It has good dielectric strength and excellent arc quenching property. It is inert, non- toxic, noninflammable and heavy. At atmospheric pressure, its dielectric strength is 2.5 times that of air. At three times atmospheric pressure, its dielectric strength is equal to that of the transformer oil.
22	**Write the classifications of test conducted on circuitbreakers.** BTL 1 • Type test • Routine test • Reliability test • Commissioning test
23	**What are the indirect methods of circuit breaker testing?** BTL 1 • Unit test • Synthetic test • Substitution testing

	- Compensation testing - Capacitance testing
24	**What are the advantages of synthetic testing methods?** BTL 2 • The breaker can be tested for desired transient recovery voltage and RRRV. • Both test current and test voltage can be independently varied. This gives flexibility to the test • The method is simple • With this method a breaker capacity (MVA) of five time of that of the capacity of the test plant can be tested.
25	**How does the over voltage surge affect the power system?** BTL 2 The over voltage of the power system leads to insulation breakdown of the equipment's. It causes the line insulation to flash over and may also damage the nearby transformer, generators and the other equipment connected to the line.
	PART * B
1.	**Explain about the SF6 circuit breaker in detail. (13M) (Nov 2015,2014,2012)** (BTL 3) **Answer: Page 5.25- V.Thiagarajan** **Diagram: (5 M)** **Explanation: (8 M)** ➢ SF6 gas has high dielectric strength which is the most important quality of a material for use in electrical equipments and in particular for breaker it is one of the most desired properties. It has high Rate of Rise of dielectric strength after arc extinction. 
2.	**Explain about the vacuum circuit breaker in detail. (13M) (Apr 2015)** (BTL 3) **Answer: Page 5.23- V.Thiagarajan** **Diagram: (5 M)** **Explanation: (8 M)**

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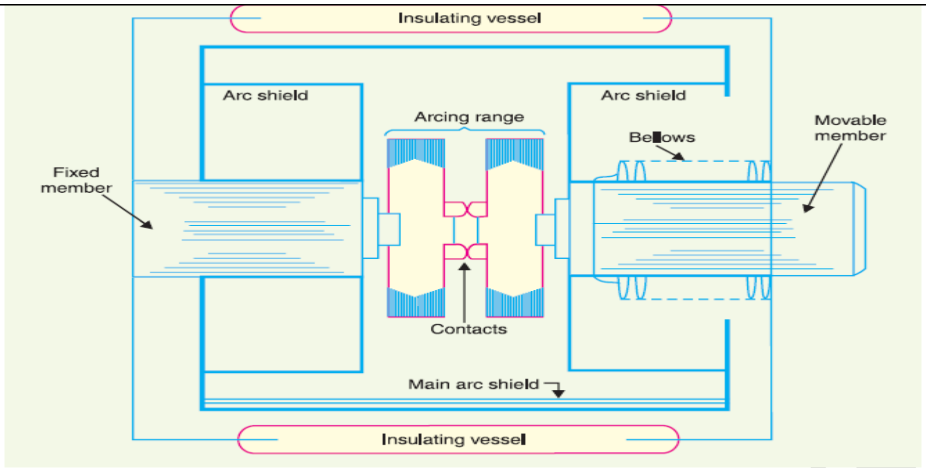
<tr><td></td><td>
Principle. The arc is quickly extinguished because the metallic vapours, electrons and ions produced during arc rapidly condense on the surfaces of the circuit breaker contacts, resulting in quick recovery of dielectric strength.</td></tr>
<tr><td>3.</td><td>Explain about the oil circuit breakers in detail.(13M)(Nov 2013,Nov 2015) (BTL 3)
Answer: Page 5.9- V.Thiagarajan
Costruction: (5 M)
There are two compartments separated from each other but both filled with oil. The upper chamber is the circuit breaking chamber while the lower one is the supporting chamber.
<i>Circuit-breaking chamber</i>. It is filled with oil and has the following parts
(<i>a</i>) upper and lower fixed contacts
(<i>b</i>) moving contact
(<i>c</i>) turbulator</td></tr>
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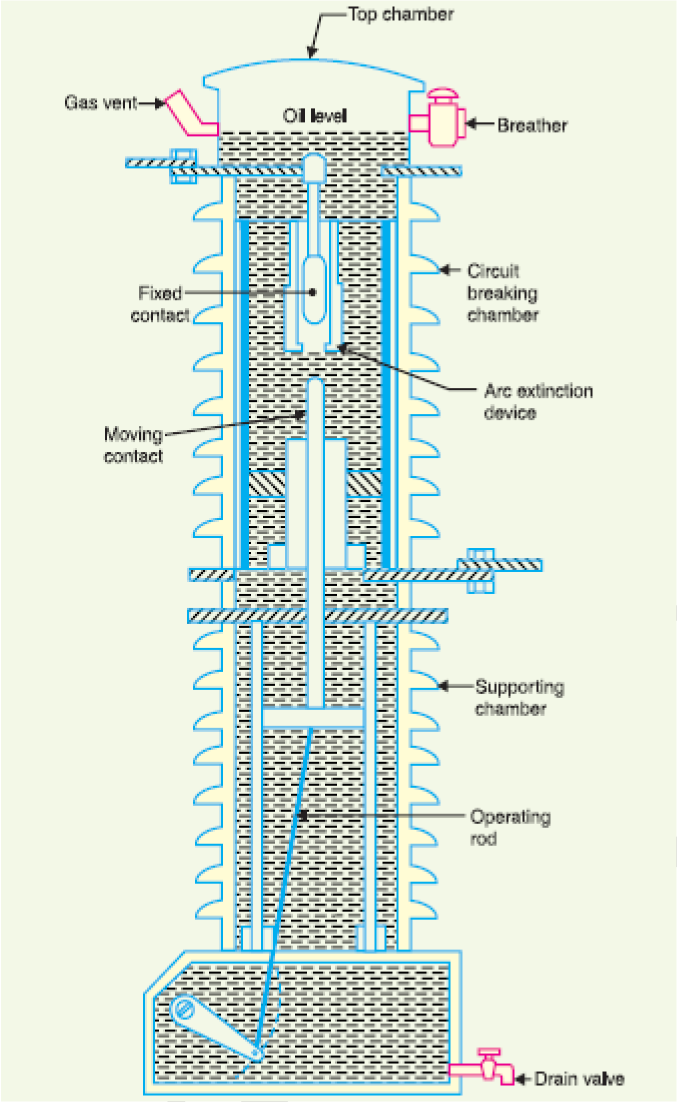


Diagram: (5 M)

Top chamber. It is a metal chamber and is mounted on the circuit-breaking chamber.

Operation: (5 M)

Under normal operating conditions, the moving contact remains engaged with the upper fixed contact. When a fault occurs, the moving contact is pulled down by the tripping springs and an arc is struck. The arc energy vaporises the oil and produces gases under high pressure.

PART*C

1. **Explain about the air blast circuit breakers in detail. (15M)(Apr 2015) (May 2017) (April/May 2019)** BTL 3

Answer: Page 5.19- V.Thiagarajan

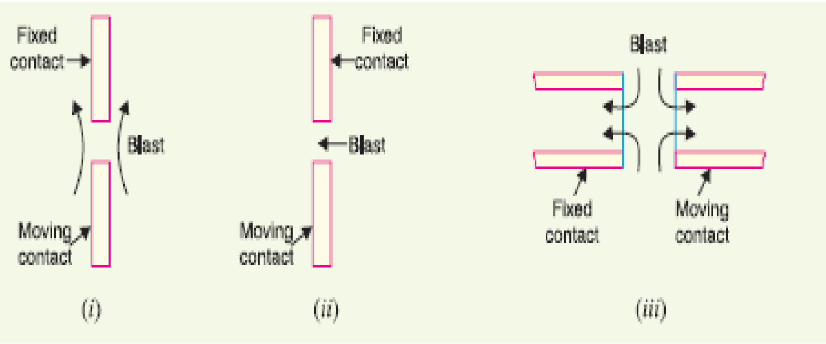
Principle: (3 M)

Construction with diagram: (7 M)

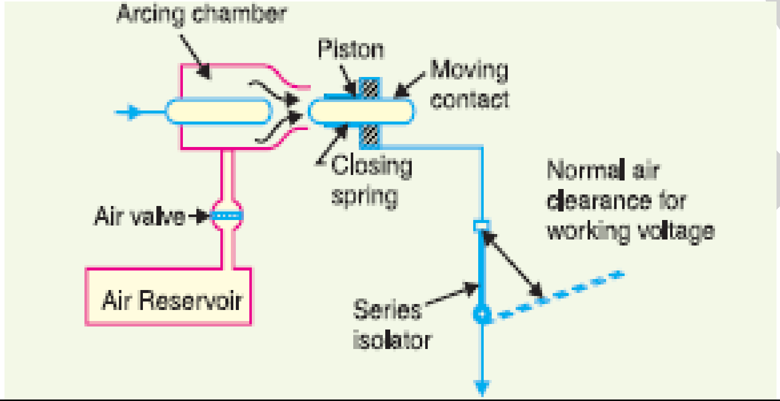
Working: (5 M)

Depending upon the direction of air-blast in relation to the arc, air-blast circuit breakers are classified into :

(*i*) Axial-blast typein which the air-blast is directed along the arc path

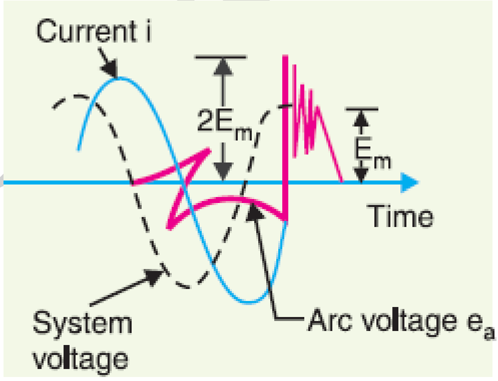


Cross-blast typein which the air-blast is directed at right angles to the arc path.
Radial-blast typein which the air-blast is directed radially.

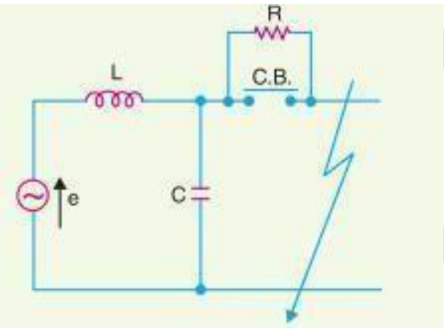


2. **Explain about Rate of rise of recovery voltage (15M)** BTL4

Answer: Page 4.17- V.Thiagarajan
Diagram: (4 M)
Explanation: (6 M)



Before current interruption, the capacitance *C* is short-circuited by the fault and the short-circui current through the breaker is limited by inductance *L* of the system only
When the contacts are opened and the arc finally extinguishes at some current zero, the generato voltage *e* is suddenly applied to the inductance and capacitance in series.
Transient frequency :$fn = 1/2\ \pi\surd\ LC$
The value of R.R.R.V. depends upon :

	(*a*) recovery voltage **(*b*)** natural frequency of oscillations **(3 M)** For a short-circuit occuring near the power station bus-bars, *C* being small, the natura frequency $f_n(= 1/ 2 \pi \sqrt{LC})$ will be high. Consequently, R.R.R.V. will attain a large value. Thus the worst condition for a circuit breaker would be that when the fault takes place near th bus-bars.
3.	**Write short notes on Resistance switching (15M) (Nov 2015,May 2013)** (BTL 4) **Answer: Page:4.22- V.Thiagarajan** **Resistance switching: (4 M)** **Diagram: (4 M)** **Derivation: (4 M)** **Explanation: (3 M)** To reduce the restriking voltage, RRRV and severity of the transient oscillations, a resistance is connected across the contacts of the circuit breaker.  This is known as resistance switching. The analysis of resistance switching can be made to find out the critical value of the shunt resistance to obtain complete damping of transient oscillations.

EE6703 SPECIAL ELECTRICAL MACHINES L T P C
3 0 0 3

OBJECTIVES:

To impart knowledge on the following Topics

- To impart knowledge on Construction, principle of operation and performance of synchronous reluctance motors.
- To impart knowledge on the Construction, principle of operation, control and performance of stepping motors.
- To impart knowledge on the Construction, principle of operation, control and performance of switched reluctance motors.
- To impart knowledge on the Construction, principle of operation, control and performance of permanent magnet brushless D.C. motors.
- To impart knowledge on the Construction, principle of operation and performance of permanent magnet synchronous motors.

UNIT I SYNCHRONOUS RELUCTANCE MOTORS 9

Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance Motors – Voltage and Torque Equations - Phasor diagram - performance characteristics – Applications.

UNIT II STEPPER MOTORS 9

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitation – Characteristics – Drive circuits – Microprocessor control of stepper motors – Closed loop control-Concept of lead angle– Applications.

UNIT III SWITCHED RELUCTANCE MOTORS (SRM) 9

Constructional features – Rotary and Linear SRM - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers –Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control – Applications.

UNIT IV PERMANENT MAGNET BRUSHLESS D.C. MOTORS 9

Permanent Magnet materials – Minor hysteresis loop and recoil line-Magnetic Characteristics – Permeance coefficient - Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation - Power Converter Circuits and their controllers – Motor characteristics and control– Applications.

UNIT V PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM) 9

Principle of operation – Ideal PMSM – EMF and Torque equations – Armature MMF – Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements– Applications.

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to model and analyze electrical apparatus and their application to power system

TEXT BOOKS:

1. K.Venkataratnam, ‘Special Electrical Machines’, Universities Press (India) Private Limited, 2008.
2. T.J.E. Miller, ‘Brushless Permanent Magnet and Reluctance Motor Drives’, Clarendon Press, Oxford, 1989.
3. T. Kenjo, ‘Stepping Motors and Their Microprocessor Controls’, Clarendon Press London, 1984.

REFERENCES:

1. R.Krishnan, ‘Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application’, CRC Press, New York, 2001.
2. P.P. Aearnley, ‘Stepping Motors – A Guide to Motor Theory and Practice’, Peter Perengrinus London, 1982.
3. T. Kenjo and S. Nagamori, ‘Permanent Magnet and Brushless DC Motors’, Clarendon Press, London, 1988.
4. E.G. Janardanan, ‘Special electrical machines’, PHI learning Private Limited, Delhi, 2014.

	Subject Code: EE6701 **Year/Semester: IV/07** **Subject Name: Special Electrical Machines** **Subject Handler: Ms.D.Thaniga**
	UNIT I - SYNCHRONOUS GENERATOR
	Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance Motors – Voltage and Torque Equations - Phasor diagram - performance characteristics – Applications.
	PART * A
Q.No	**Questions**
1	**Define SYNREL motors? (Dec 13, Dec 15)** BTL-1 Synchronous reluctance motor is similar to three–phase Synchronous motor except the rotor are demagnetized and made with saliency to increase the reluctance power. It is a motor which develops torque due to the difference in reluctance of the two axes, namely quadrature and direct axis.
2	**What is the principle of operation of reluctance machine? (Dec 14)(May 15)** BTL-1 1) In reluctance machines, torque is produced by the tendency of the rotor to move to a position where the inductance of the excited stator winding is maximized (i.e., rotor tooth aligns with active stator phase to minimize reluctance). 2) The rotor is typically constructed of soft magnetic iron shaped so as to maximize the variation of inductance with rotor position.
3	**List the properties of Reluctance motor?** BTL-1 Combined reluctance and magnet alignment torque, Field weakening capability, under excited operation for most loaded condition, High inductance, High speed capability and High temperature capability.
4	**What are the various stator current modes used in synchronous reluctance motor?** **.** BTL-1 Unipolar current modes, bipolar current modes.
5	**Mention the applications of distributed anisotropy cage rotor of synchronous reluctance motor?** BTL-1

	These rotors are used for line – start (constant voltage and frequency) applications.
6	**What is meant by reluctance torque in Synchronous Reluctance Motor?(Dec 2016) . .** BTL-1 The torque which is exhibited on the rotor due to the difference in Reluctance in the air gap (or) a function of angular position of rotor with respect to the stator coil is known as reluctance torque.
7	**List the advantages of Synchronous reluctance motor?** BTL-2 **Advantages:** Rotor is simple in construction i.e. very low inertia, Robust, Low torque, ripple, Can be operated from standard PWM AC Inverters, It can be also built with a standard induction motor, stator and windings.
8	**What are the types of Synchronous reluctance motor?(June 13,June 14)** BTL-2 Synchronous reluctance motor is classified into three types depending upon the construction of rotor. They are Salient type or Radial type rotor, Flat type or axial type rotor, Flux Barrier type or Laminated type rotor.
9	**Write the torque equation of Synchronous reluctance motor? (June 14,Dec14)** BTL-4 T = $(U^2/ 2\omega_s)\ (1/X_q - 1/X_d) \sin 2\delta$, U = Supply Voltage, I_s be the supply current which has two components I_d and I_q, I_d = Direct axis current, I_q = Quadrature axis current, ω_s =Synchronous speed in rad/sec, X_d =Direct axis reactance, X_q = Quadrature axis reactance.
10	**Skewing is required for Synchronous reluctance motor. Justify?** BTL-5 At the time of starting, reluctance motor are subjected to cogging due to the saliency of motor. This can be minimized by the skewing of the rotor parts.
11	**What are the advantages of increasing L_d / L_q ratio in Synchronous reluctance motor? .** BTL-2 Motor power factor increases, I^2R losses reduced, reduced volt – ampere ratings of the inverter driving the machine.
12	**Compare Synchronous reluctance motor and Induction motor.(Dec 15)** BTL-5

S.No.	Synchronous reluctance motor	Induction motor
1.	Torque generation due to reluctance principle	Torque generation due to Lorentz force
2.	Runs at synchronous speed	Runs at asynchronous speed
3.	Better efficiency.	Efficiency is low.
4.	Low cost.	High cost.
5.	High power factor.	Low power factor.
6.	Used for low and medium power application.	Used for high power application.

13 **Define: Magnetic flux.** BTL-1

The amount of magnetic lines of force setup in a magnetic circuit is called magnetic flux. It is analogous to electric current in electric circuit.

14 **State Reluctance.** BTL-1

The opposition offered to the magnetic flux by a magnetic circuit is called its reluctance.

15 **Define: Permeance.** BTL-1

It is a measure of the ease with which flux can be setup in a material. It is the reciprocal of the reluctance of the material.

16 **Give some potential application of synchronous reluctance machine.(Dec 12, May 15, June 2016, Dec 2016)** BTL-2

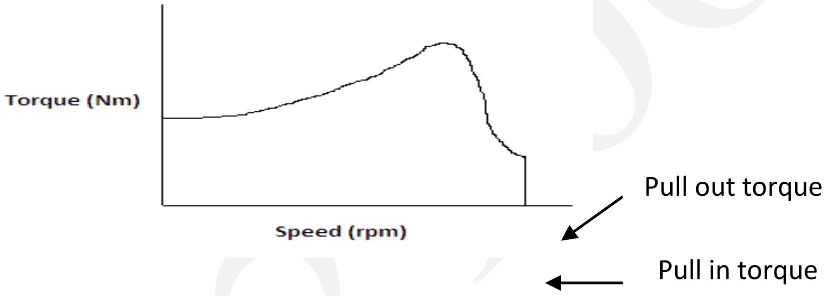
It is used for constant speed applications i.e. timing devices, signaling devices, recording instruments and phonograph, it is used in automatic processors such as in food processing and packaging industries.

Used in high speed applications, Synthetic fiber manufacturing equipment, Wrapping and folding machines, synchronized conveyors.

17 **Give the difference between synchronous reluctance motor and switched reluctance motor (June 13)** BTL-4

S.No	Synchronous reluctance	Switched reluctance motor

.	**motor**	
1.	Single salient electric motor	Doubly salient electric motor
2.	Continuous rotation	Designed for continuous rotation
3.	Controller is not necessary. Hence it is cheap.	The step pulse are given by external controller which uses rotor position sensors

18	**Draw the voltage and torque characteristics of Syrm. (May 15, June 2016)** BTL-6 
19	**Define torque angle.** BTL-1 In reluctance type synchronous motor, when the load is increased lightly, the rotor momentarily slows down, causing the salient poles of the rotor to lag the rotating field. This angle of lag is called the torque angle.
20	**When does a PM synchronous motor operate as a synchronous reluctance motor? . .** BTL-1 If the cage winding is included in the rotor and the magnets are left out or demagnetized, a PM synchronous reluctance motor.
21	**What is a Synchronous machine?** BTL-1 A machine that rotates at synchronous speed (N_s) i.e., the speed is uniquely related to supply frequency which is given by $N_s = 120f/p$.
22	**What are the disadvantages of Synchronous reluctance motor?** BTL-2 **Disadvantages:** It has poor power factor performance and therefore the efficiency is not as high as permanent magnet motor, The converter kVA requirement is high, The pull – in and pull – out torque of the motor are weak.

PART * B

1

Explain the principle of operation and constructional features of Synchronous reluctance motor.(13M) (May 12, Dec 12, Dec 13, June 14,Dec 14, Dec 2016, June 2016,may 2017) BTL-2

Answer: Page 1.3 to 1.5 – R.Srinivasan

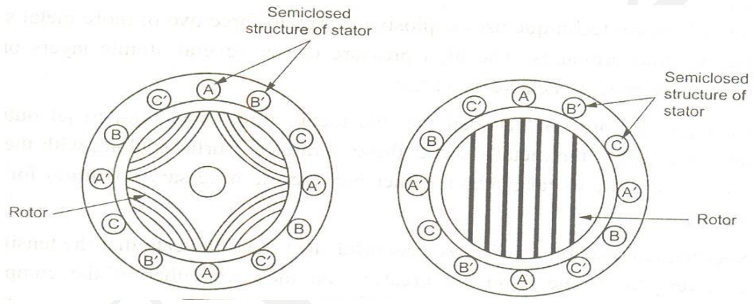
Principle:(2M)

When a piece of magnetic material is located in a magnetic field, a force acts on the material tending to bring it into the most dense portion of field. The force tends to align the specimen of material in such a way that the reluctance of the magnetic path that lies through the material will be minimum.

Constructional Features: (11M)

(a)stator

The stator has three phase symmetrical winding, which creates sinusoidal rotating magnetic field in the air gap, and the reluctance torque is developed because the induced magnetic field in the rotor has a tendency to cause the rotor to align with the stator field at a minimum reluctance position



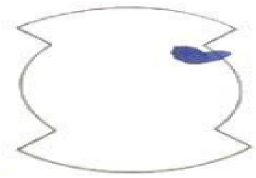
(Fig: Semi closed slot stator structures of synchronous reluctance motor.)

The rotor of the modern reluctance machine is designed with iron laminations in the axial direction separated by non-magnetic material.

The performance of the reluctance motor may approach that of induction machine. With high saliency ratio a power factor oh 0.8 can be reached.

The efficiency of a reluctance machine may be higher than an induction motor because there is no rotor copper loss.

(b)rotor

	Salient rotor shape such that the quadrature air gap is much larger than the direct air gap.  Fig. Salient rotor The low Ld. /Lq ratios are largely the result of circulating flux in the pole faces of the rotor. However the ruggedness and simplicity of the rotor structure has encouraged for high speed applications.
2	**Explain the torque – speed and torque – angle characteristics of Synchronous reluctance motor. (13M) (Dec12, Dec 13,June 14)** BTL-2 **Answer: Page 1.34 to 1.36 – R.Srinivasan** **Torque – speed characteristics (8M)** The motorstarts at anywhere from 300 to 400 percent of its full load torque (depending on the rotor position ofthe unsymmetrical rotor with respect to the field winding) as a two phase motor. As a result of the magnetic rotating field created by a starting and running winding displaced 90° in both space and time. At about ¾th of the synchronous speed a centrifugal switch opens the starting winding and the motor continues to develop a single phase torque produced by its running winding only. As it approaches synchronous speed, the reluctance torque is sufficient to pull the rotor into synchronism with the pulsating single phase field. The motor operates at constant speed up to a little over 20% of its full load torque. If it is loaded beyond the value of pull out torque, it will continue to operate as a single phase induction motor up to 500% of its rated speed. **Torque – angle characteristics (5M)**

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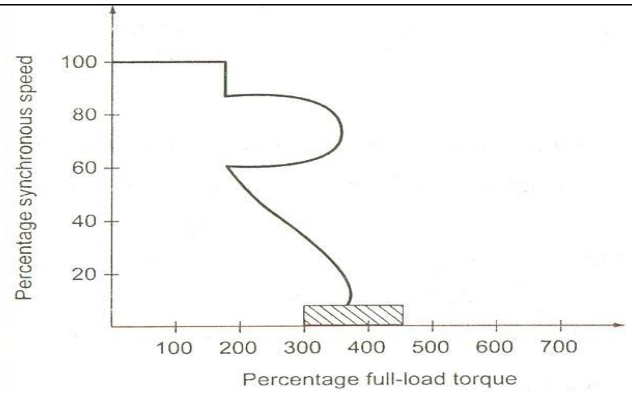
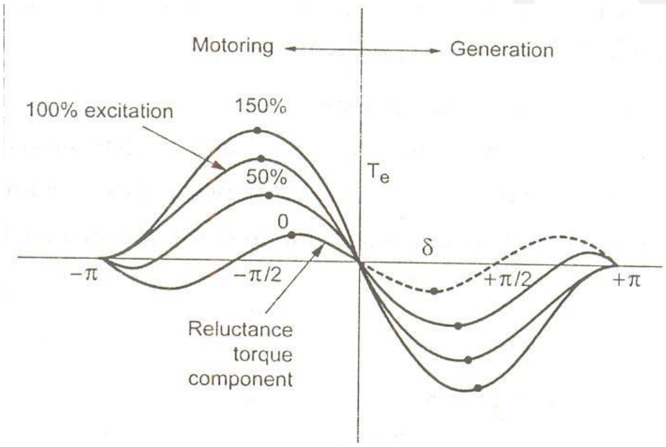


Torque – angle characteristics



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<tr><td>3.</td><td>
Draw and explain the steady state phasor diagram of Synchronous reluctance motor. (8M) (June 13,June 14,Dec 14, dec 2016, June 2016,may 2017) BTL-6

Answer: Page 1.27 to 1.34 – R.Srinivasan

The synchronous reluctance machine is considered as a balanced three phase circuit, it is sufficient to draw the phasor diagram for only one phase.

The basic voltage equation neglecting the effect of resistance is
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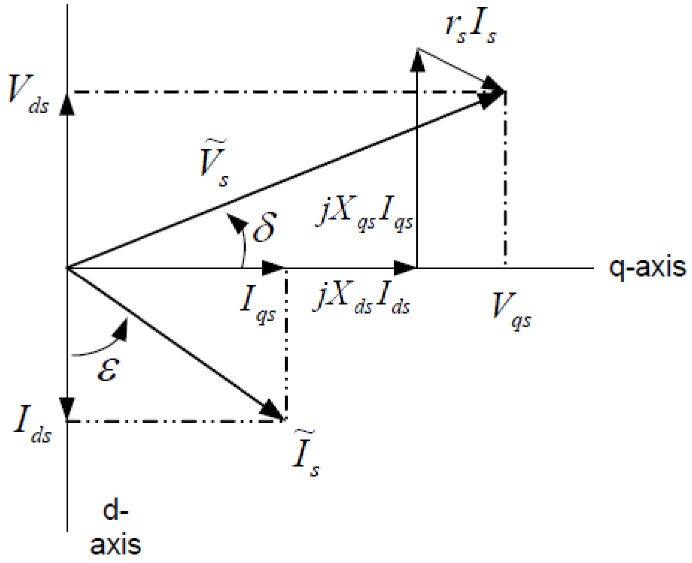


Fig. Phasor Diagram of Synchronous Reluctance Motor

V = E – j IsdXsd – j Isq Xsq …………(1.1)
V is the Supply Voltage
Is is the stator current
E is the excitation emf
8 is the load angle
Φ is the phase angle
Xsd and Xsq are the synchronous reactance of direct and quadrature axis
Isd and Isq are the direct and quadrature axis current
I = Isd + Isq……………(1.2)
Isd is in phase quadrtur with E and Isq is in phase with E.
V = E – j IsdXsd – j IsqXsq From phasor diagram
V cos8 = E + Isd Xsd ………………(1.3)
Isd = (V cos8 - E) / Xsd
IsqXsq = V sin8
Isq = V sin8 / Xsq ………………..(1.4)
Is cos Φ = Isq cos8 - Isd sin8……………(1.5)
Where
Xsd and Xsq are synchronous reactance of d and q axis.
Sub (3) and (4) in Equ (5)
Is cos Φ = (E sin8 / Xsd) + V (Xsd - Xsq) / 2 Xsd Xsq …………………(1.6)
P = 3 V Is cos Φ ………………….(1.7)
Sub equ (6) in equ (7)
Pm = T ωs
T = Pm / ωs
Sub E = 0
T = 3 / ωs V2 ((Xsd - Xsq) / 2 Xsd Xsq) sin28 --------------(1.8)

4	**A 10 HP, 4 pole, 240V, 60Hz, reluctance motor operating under rated load condition has a torque angle of 30°. Determine (a)Load torque on shaft (b)Torque angle if the voltage drops to 224V (c)For the above torque angle, will the rotor pullout of synchronism. (6M)** BTL-3 **Answer: Refer Notes** Solution: P = 7.46 kW; $\omega_s = \frac{2\pi N_s}{60}$ **;** $N_s = \frac{120*60}{4} = 1800\, rpm$ **;** $\omega_s = 188.496\, rad/\sec$ $T_L = \frac{P}{\omega_s} = 39.576\, N-m$ **;** $\delta_{rel} = 41.903°$ **;** So, the motor will not pull out of synchronism
5	**Explain the advantages and disadvantages of synchronous reluctance motor? (6M) . .** BTL-2 **Answer: Page 1.26 to 1.27 – R.Srinivasan** **Advantagess (3M)** ❖ Rotor is simple in construction i.e. very low inertia ❖ Robust ❖ Low torque, ripple ❖ Can be operated from standard PWM AC Inverters. ❖ It can be also built with a standard induction motor, stator and windings. **Disadvantages (3M)** ❖ It has poor power factor performance and therefore the efficiency is not as high as permanent magnet motor. ❖ The converter kVA requirement is high. ❖ The pull – in and pull – out torque of the motor are weak.
6	**Explain the applications and properties of synchronous reluctance motor? (6M) . .** BTL-2 **Answer: Page 1.27 – R.Srinivasan** **Applications of synchronous reluctance motor (3M)** ➢ It is used for constant speed applications i.e. timing devices, signaling devices, Recording instruments and phonograph.

- It is used in automatic processors such as in food processing and packaging industries.
- Used in high speed applications.
- Synthetic fiber manufacturing equipment
- Wrapping and folding machines.
- Synchronized conveyors.

Properties of synchronous reluctance motor (3M)

- High output power capability
- Ability of the rotor to with stand high speeds
- Negligible zero torque spinning losses
- High reliability

7

Explain the constructional features of Vernier motor. (6M) BTL-2

Answer: Page 1.39 to 1.43 – R.Srinivasan

- The stator of a vernier motor has slots and a distributed winding just like the stator of an ordinary poly phase induction motor.
- The rotor is a slotted iron core without winding. A 2 – pole machine with 12 stator slots and 10 rotor slots.

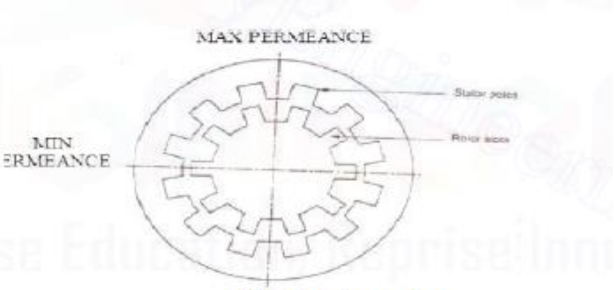


Fig. Vernier motor

- The stator and rotor teeth are facing each other in the vertical axis. The stator teeth are facing rotor slots in the horizontal axis.
- At this position therefore, the maximum permeance is along the vertical axis and the minimum permeance is along the horizontal axis.
- When then rotor is rotated one half of its slot pitch, the rotor slots will face stator teeth in the vertical axis.
- The rotor and stator teeth will face each other in the horizontal axis.

- The axis of maximum permeance is now horizontal and the axis of minimum permeance is now vertical.
- Thus the rotor movement of one –half rotor slot pitch results in a 90 degree displacement of the permeance axis.

PART * C

1

Explain the construction and operation of axial and radial flux machines. Discuss the advantages and disadvantages of each construction.(15M) BTL-5

Answer: Page 1.16 to 1.18 – R.Srinivasan

- The structure of reluctance motor is same as that of salient pole synchronous machine as shown in fig. The rotor does not have any field winding. (1M)
- The stator has three phase symmetrical winding, which creates sinusoidal rotating magnetic field in the air gap, and the reluctance torque is developed because the induced magnetic field in the rotor has a tendency to cause the rotor to align with the stator field at a minimum reluctance position (1M)

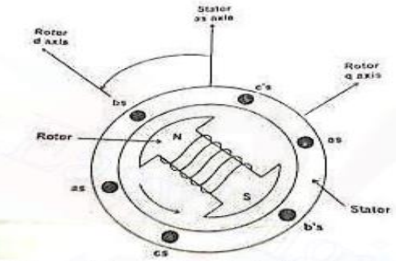


Fig. Idealized Three Phase Four Pole Synchronous Machine (Salient Pole)

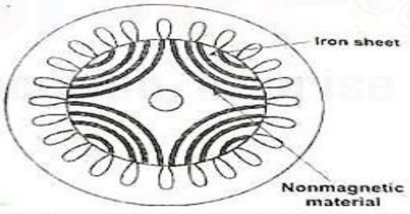


Fig . Cross Section of Synchronous Reluctance Motor.

- The synchronous reluctance motor has no synchronous starting torque and runs up from stand still by induction action. (1M)
- There is an auxiliary starting winding. (1M)
- This has increased the pull out torque, the power factor and the efficiency. (1M)
- Synchronous reluctance motor is designed for high power applications. (1M)

It can broadly be classified into

- Axially laminated (3M)
- Radially laminated.(4M)

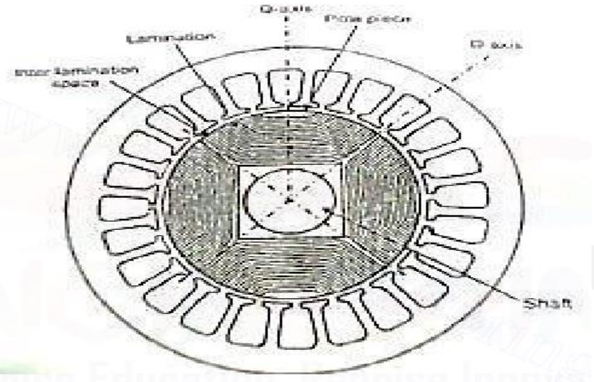


Fig. Cross section of axially laminated

- Reluctance motors can deliver very high power density at low cost, making them ideal for many applications.
- Disadvantages are high torque ripple when operated at low speed, and noise caused by torque ripple.
- Until the early twenty-first century their use was limited by the complexity of designing and controlling them.
- These challenges are being overcome by advances in the theory, by the use of sophisticated computer design tools, and by the use of low-cost embedded systems for control, typically based on microcontrollers using control algorithms and real-time computing to tailor drive waveforms according to rotor position and current or voltage feedback.

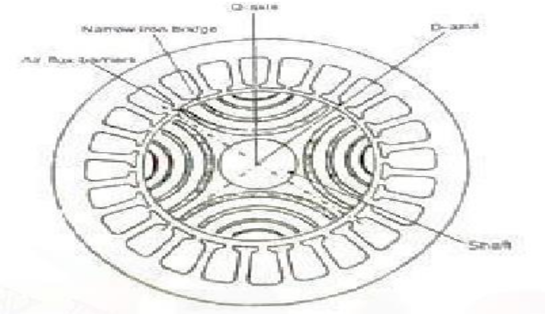


Fig. Cross section of radially laminated

- The stator consists of multiple projecting (salient) electromagnet poles, similar to a wound field brushed DC motor.
- The rotor consists of soft magnetic material, such as laminated silicon steel, which has multiple projections acting as salient magnetic poles through magnetic reluctance.
- The number of rotor poles is typically less than the number of stator poles, which minimizes torque ripple and prevents the poles from all aligning simultaneously—a

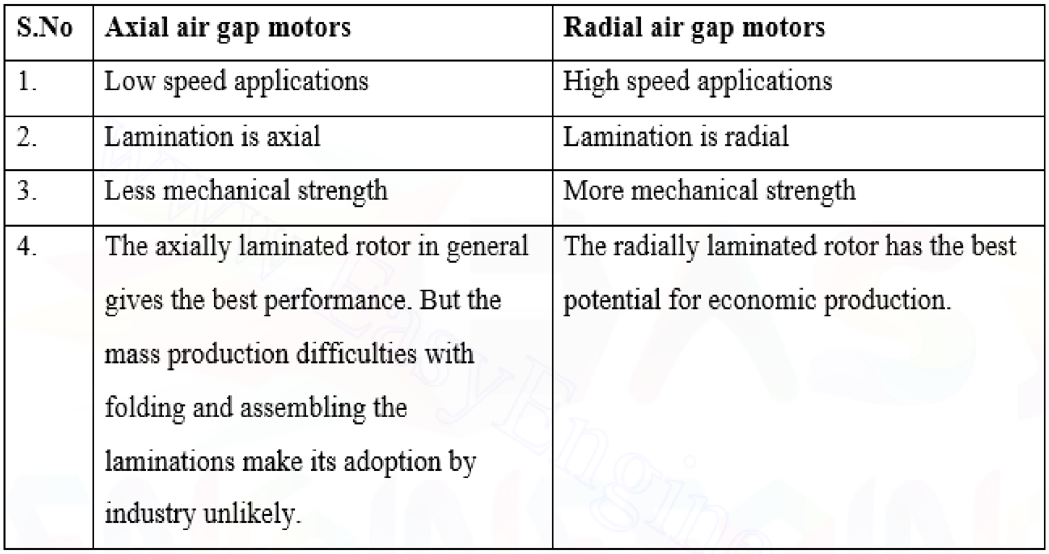
	position which cannot generate torque.
2	**Explain the constructional features of Vernier motor. (15M)** BTL-6 **Answer: Page 1.39 to 1.43 – R.Srinivasan** **Air – Gap permeance Distribution (7 M)** ➢ The permeance of air space between stator and rotor at any location is inversely proportional to the radial length of air space at that location. ➢ The stator and rotor slot depth are much larger in comparison with air gap length, the permeance of airspace can be considered as zero, where stator tooth surface is facing rotor tooth surface. ➢ The width of rectangular blocks is the widths of overlap between the stator and the rotor teeth. **Design of Vernier Motor (8M)** ➢ When the rotor rotates through an angle corresponding to one rotor slot pitch, the permeance wave rotates through an angle corresponding to one pole pitch. ➢ The pole pitch of the permeance wave is the same as the pole pitch of the stator mmf wave, because they have the same number of poles. ➢ Also in a reluctance machine, the speed of the permeance wave is the speed of rotating mmf. ➢ The rotor speed is independent of the number of poles of the machine when the speed of rotating magnetic field is reduced by increasing the number of poles of the machine.
3	**A Three Phase 400 V , 50HZ, 4 pole, stator connected synchronous reluctance motor with negligible armature resistance has Xsd=8ohm and Xsq=2ohm. For a load torque of 80 N-m, calculate a) the load angle b) the line current c) the input power factor Neglect rotational losses. (15M)** BTL-6 **Answer: Refer Notes** **a)** $w_s = \frac{4\pi f}{p}$ **(5M)** **b)** I_{sq}=$\frac{V cos\delta}{X_{sq}}$ (5M) **c)** $power = \sqrt{3}.V_L I_a$cosϕ=Tω_s (5M)

4

a) Distinguish between axial and radial air gap motors. (4M) (May/June 13) BTL-6
b) Explain the working principle of Synchronous reluctance motor. (11M) BTL-2

Answer: Page 1.39 to 1.43 – R.Srinivasan

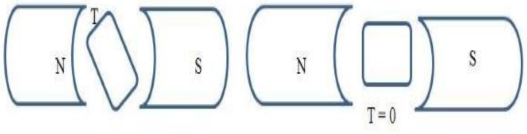
axial and radial air gap motors (4M)



S.No	Axial air gap motors	Radial air gap motors
1.	Low speed applications	High speed applications
2.	Lamination is axial	Lamination is radial
3.	Less mechanical strength	More mechanical strength
4.	The axially laminated rotor in general gives the best performance. But the mass production difficulties with folding and assembling the laminations make its adoption by industry unlikely.	The radially laminated rotor has the best potential for economic production.

WORKING OF SYNCHRONOUS RELUCTANCE MOTOR (11M)
Answer: Page 1.39 to 1.43 – R.Srinivasan

- When supply is given to the stator winding, the revolving magnetic field will exert reluctance torque on the unsymmetrical rotor tending to align the salient pole axis of the rotor with the axis of the revolving magnetic field, because in this position, the reluctance of the magnetic path would be minimum.
- If the reluctance torque is sufficient to start the motor and its load, the rotor will pull into step with the revolving field and continue to run at the speed of the revolving field.
- Actually the motor starts as an induction motor and after it has reached its maximum speed as an induction motor, the reluctance torque pulls its rotor into step with the revolving field, motor now runs as synchronous motor by virtue of its saliency.
- Reluctance motors have approximately one third the HP rating they would have as induction motors with cylindrical rotors.

	 Fig. Rotor Position due to Revolving Magnetic Field

	UNIT II - STEPPER MOTORS
	Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitation – Characteristics – Drive circuits – Microprocessor control of stepper motors – Closed loop control-Concept of lead angle– Applications.
	PART * A
Q.No	**Questions**
1	**Define: Stepper motor? (June 14)** BTL-1 Stepper motor is a motor which rotates step by step and not continuous rotation. When the stator is excited using a DC supply the rotor poles align with the stator poles in opposition such that reluctance is less.
2	**What are the advantages of Stepper motor?** BTL-2 No feedback is normally required for either position control or speed control, Positional control is non – cumulative, Stepping motor are compatible with modern digital equipment
3	**List the different types of stepper motor?** BTL-4 Variable Reluctance stepper motor (Single stack, Multi stack), Permanent magnet stepper motor, Hybrid stepper motor, Outer rotor stepper motor.
4	**Mention the features of stepper motor?(Dec 13)** BTL-4 Small step angle, High positioning accuracy, High torque inertia ratio, Stepping rate, Pulse frequency
5	**Define: Step Angle of stepper motor?(June 2013, Dec 13, June 2016)** BTL-1 A stepping motor rotates through a fixed angle for every pulse. The rated value of this angle is called the step angle and expressed in degrees.
6	**State Resolution of stepper motor?** BTL-1 It is defined as the accuracy of positioning of the rotor pole at a particular step angle with respect to stator pole.
7	**Define: Pull – in torque of stepper motor?** BTL-1 These are alternatively called the starting characteristics and refer to the range of frictional load torque at which the motor can start and stop without losing steps for various frequencies in a pulse strain.
8	**State Pull – out torque of stepper motor?** BTL-1 These are alternatively called the slewing characteristics. After the test, motor is started by a specified driver in the specified excitation mode in the self starting range; the pulse

	frequency is gradually increased; the motor will eventually run out of synchronism. The relation between the frictional load torque and the minimum pulse frequency with which the motor can synchronize is called pull – out characteristics.
9	**Define: Slewing frequency of stepper motor?** BTL-1 This is defined as the maximum frequency (stepping rate) at which the loaded motor can run without losing steps is alternatively called the maximum slewing frequency.
10	**State Stepping frequency of stepper motor?** BTL-1 The speed of rotation of a stepping motor is given in terms of the number of steps per second and the term stepping rate is often used to indicate speed.
11	**Define: Maximum starting torque of stepper motor?** BTL-1 This is alternatively called as maximum pull – in torque and is defined as the maximum frictional load with which the motor can start and synchronize with the pulse train of frequency as low as 10 Hz.
12	**Why interleaving is done in a stepper motor?** BTL-1 Interleaving is done in the stepper motor to decrease the step angle and thus increasing the resolution.
13	**Explain: VR type stepper motor?** BTL-2 It is a basic type of stepping motor in which the motor step by step rotation is achieved when the rotor teeth and stator teeth are in alignment such that the magnetic reluctance is minimized and this state provides a rest or equilibrium position.
14	**Compare closed loop control and open loop control in stepper motor.(May 12)** BTL-2 Closed loop control is more accurate, oscillatory motions are avoided for certain speed ranges, Speed remains constant for high inertial load, follows the input pulses at stepping frequency are some of the advantages over open loop control. But it is costly and complex.
15	**Define torque constant of a stepper motor.(Dec 12)** BTL-1 The torque constant of the stepper motor is defined as the initial slope of the torque current curve of the stepper motor.
16	**What is the function of driver circuit in stepper motor. (June 13)** BTL-1 The stepper motor is a digital device that needs binary signals for its operation. The power driver is essentially a current amplifier, since the sequence generator can supply only logic but not any power.

17

Give the difference between single and multi-stack stepping motors?(June 14) BTL-4

Sl.No	Single Stack Stepper Motor	Multi Stack Stepper Motor
1	The number of stator poles should be different that of the rotor poles in order to have self-starting capability and bidirectional rotation.	The stator and rotor have same number of poles and same pole pitch.
2	In single stack each and every stator pole carries a field coil.	It is used to obtain small step sizes. It consist of m identical single stack variable reluctance motor with the rotor mounts on the single shaft.

18

Distinguish the half step and full step operation of a stepper motor.(Dec 14) BTL-4

SL.NO	HALF STEP OPERATION	FULL STEP OPERATION
1	It is defined as the alternate one phase on and two phase on mode operation.	It is the one phase on mode operation .It means at that time only one winding is energized.
2	Rotor rotates on each step angle is half of the full step angle.	By energizing one stator winding the rotor rotates at some angle.it s full step operating.

19

Define the micro stepping mode of stepper motor. (May 15) BTL-1

Micro stepping means, the step angle of the VR stepper motor is very small. It is also called mini stepping. It can be achieved by two phases simultaneously as in 2 phases on mode but with two currents deliberately made unequal.

20

Name the various driver circuits used in stepper motor. (May 15, June 2016) BTL-4

Driver circuit for stepper motor are broadly classified in to Unipolar and Bipolar driver circuits. Based on the supply voltage given to stator windings they are classified as L/R driver circuit, Chopper drive circuit, H bridge drive circuit.

21	**What is the need for suppressor circuits in stepper motor? (Dec 2016)** BTL-1 The suppressor circuits are needed to ensure the fast decay of current through the winding when it is turned off
22	**Define Lead angle(Dec 2016)** BTL-1 The angle difference between the phase to be de-energized to bring the stepper motor to the position of equilibrium (stopping the motor) and energization of next phase winding to start the motor during closed loop operation is known as lead angle. The relation between the rotor's present position and the phase to be excited specified in terms of lead angle.
23	**State Holding torque and Detent torque of stepper motor? (Dec 15)** BTL-1 Holding torque is defined as the maximum static torque that can be applied to the shaft of an excited motor without causing continuous rotation. It is defined as the maximum static torque that can be applied to the shaft of an unexcited motor without causing continuous rotation.
	PART * B
1	**Explain the construction and principle of operation of Variable Reluctance Stepping motor? (13M) (May 12, Dec 12, Dec 13,June 14)(Working of Single stack type and multi stack type(June 13, June 2016))(Micro stepping Dec 13)** BTL-2 **Answer: Page 2.8 to 2.21 – R.Srinivasan** **Variable Reluctance Stepping motor:** 1. Single stack type, 2. 2.multi stack type **Construction: (6M)** ➢ The Stator is made up of silicon steel stampings with inward projected even or odd number of poles or teeth. ➢ Each and every stator poles carries a field coil an exciting coil. ➢ In case of even number of poles the exciting coils of opposite poles are connected in series. ➢ The two coils are connected such that their MMF gets added .the combination of two coils is known as phase winding

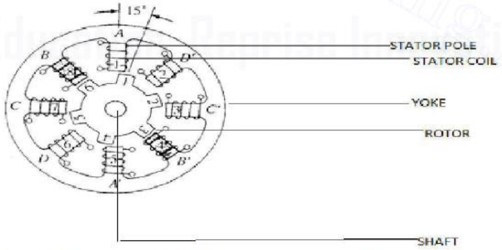
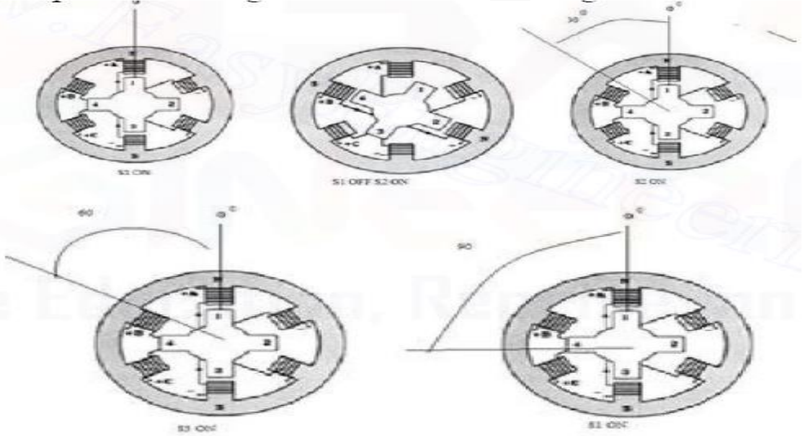


Fig. Single Stack Variable Reluctance Stepper Motor

Mode 1 : One phase ON or full step operation (3M)

- In this mode of operation of stepper motor only one phase is energized at any time.
- The axis of rotor poles 1 and 3 are in alignment with the axis of stator poles A‘ and A‘‘.
- Then angle θ = 0° the magnetic reluctance is minimized and this state provides a rest or equilibrium position to the rotor and rotor cannot move until phase a‘ is energized.
- Next phase b is energized by turning on the semiconductor switch S2 and phase a‘ is de –energized by turning off S1.
- Then the rotor poles 1 and 3 and 2 and 4 experience torques in opposite direction.

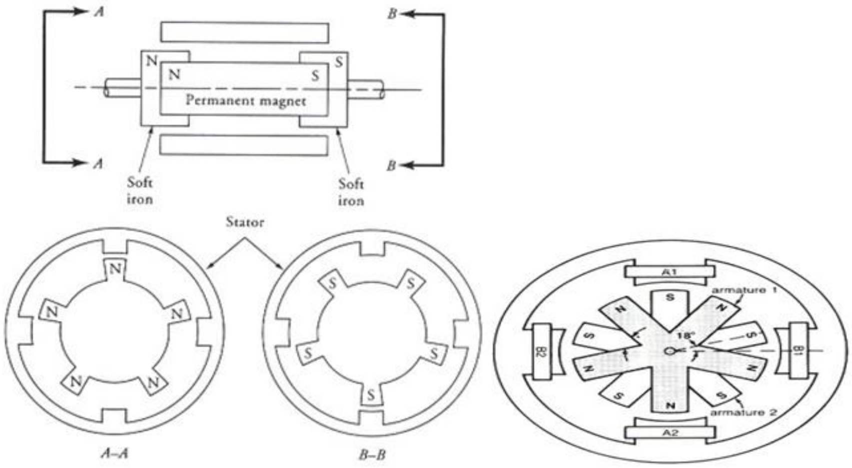


Mode II: Two Phase on Mode (2M)

- In this mode two stator phases are excited simultaneously.
- When phases a and b are energized together, the rotor experiences torque from both phases and comes to rest in a point mid-way between the two adjacent full step position.
- If the phases b and c are excited, the rotor occupies a position such that angle between AA‘ axis of stator and 1-3 axis of rotor is equal to 45°.
- To reverse the direction of rotation switching sequence is changed a and b,a and c etc.

Half step Mode (2M)

- In this type of mode of operation on phase is ON for some duration and two phases are ON during some other duration.
- The step angle can be reduced from 30° to 15° by exciting phase sequence a, a+b, b,b+c, c etc.

2	**Explain the construction and operation of hybrid Stepping motor? (8M) (Dec 14)** BTL-2 **Answer: Page 2.26 to 2.27 – R.Srinivasan** ➢ Hybrid motors combine the best characteristics of the variable reluctance and permanent magnet motors. ➢ They are constructed with multi-toothed stator poles and a permanent magnet rotor. Standard hybrid motors have 200 rotor teeth and rotate at 1.80 step angles. ➢ Other hybrid motors are available in 0.9ºand 3.6º step angle configurations. ➢ Because they exhibit high static and dynamic torque and run at very high step rates, hybrid motors are used in a wide variety of industrial applications. 
3.	**Discuss the static and dynamic characteristics of stepper motor with neat sketch? (13M) (June 14)(May 12)(June 14, Dec 2016, June 2016)** BTL-6 **Answer: Page 2.52 to 2.59 – R.Srinivasan** Stepper motor characteristics are divided into two groups ➢ Static characteristics ➢ Dynamic characteristics **Static characteristics (6M)** It is divided into two charteristics. (i)Torque Angle curve (ii)Torque current curve **(i)Torque-Angle curve** it is seen that the Torque increases almost sinusoid ally, with angle Θ from equilibrium.

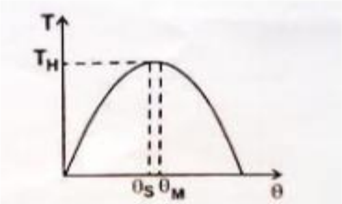


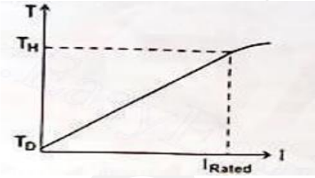
Fig. Torque Angle

Holding Torque (TH)

If the holding torque is exceeded, the motor suddenly slips from the present equilibrium position and goes to the static equilibrium position.

Detent torque (TD):

Detent torque is due to magnetism, and is therefore available only in permanent magnet and hybrid stepper motor. It is about 5-10 % of holding torque.



Torque current curve

It is seen the curve is initially linear but later on its slope progressively decreases as the magnetic circuit of the motor saturates.

Dynamic characteristics (7M)

A stepper motor is said to be operated in synchronism when there exist strictly one to one correspondence between number of pulses applied and the number of steps through which the motor has actually moved.

There are two modes of operation.

Start-Stop mode Also called as pull in curve or single stepping mode.

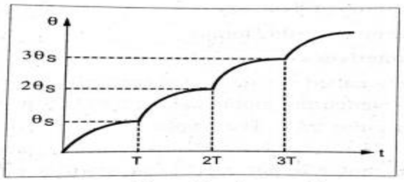


Fig . slewing mode

Slewing mode In slewing mode the motor will be in synchronism, but it cannot be started or stopped without losing synchronism.

To operate the motor in slewing mode first the motor is to be started in start stop mode and then to slewing mode.

4

Explain the operation of driver system and control circuitry for stepper motor (13M) (Nov/Dec 15, April 2017) BTL-2

Answer: Page 2.62 to 2.75 – R.Srinivasan

Drive System of a Stepping Motor (5M)

- The stepper motor is a digital device that needs binary (digital) signals for its operation Depending on the stator construction two or more phases have to be sequentially switched using a master clock pulse input.
- The clock frequency determines the stepping rate, and hence the speed of the motor.
- The control circuit generating the sequence is called a translator or logic sequencer.

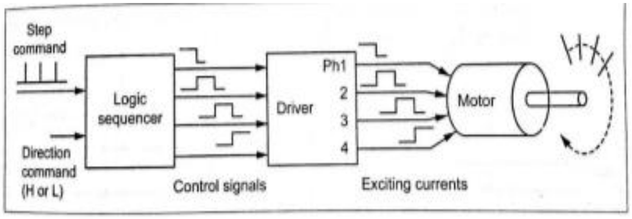


Fig. Block Diagram of the drive system of a stepping motor.

- It consists of a logic sequencer, power driver and essential protective circuits for current and voltage limiting.
- This control circuit enables the stepper motor to be run at a desired speed in either direction.

LOGIC SEQUENCER (3M)

- A logic sequencer is usually composed of a shifter register and logic gates such as NANDs, NORs etc.
- But one can assemble a logic sequencer for a particular purpose by a proper combination of JK flip flop, IC chips and logic gate chips.

Power Driver Circuit (5M)

(a) Resistance drive (L/R drive) Here the initial slope of the current waveform is made higher by adding external resistance in each winding and applying a higher voltage proportionally.

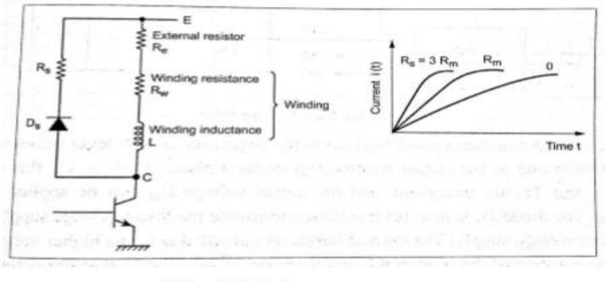
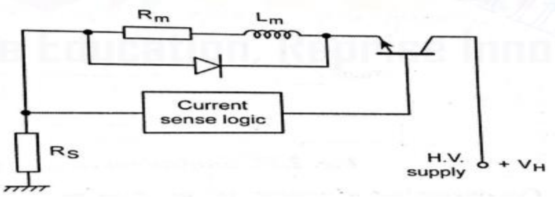


Fig. L/R drive

(b)Chopper drive Here a higher voltage 5 to 10 times the related value is applied to the phase winding as shown in fig. and the current is allowed to raise very fast.



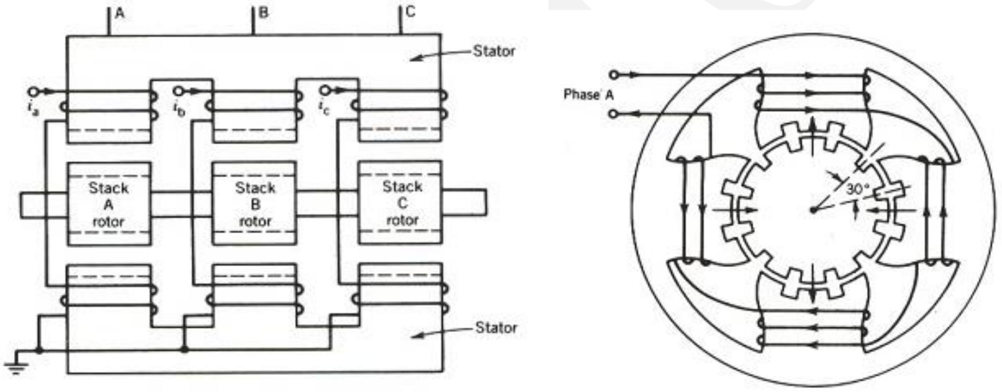
5

Explain in detail the multi stack Variable Reluctance Stepping motor?(8M) (June 13, Dec 2016,June 2016) BTL-5

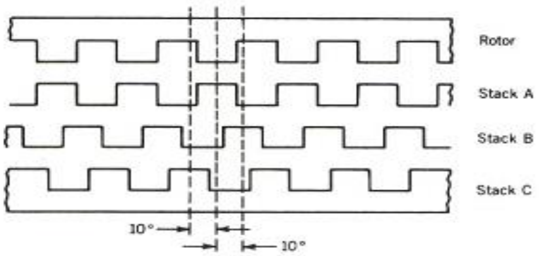
Answer: Page 2.18 to 2.21 – R.Srinivasan

Multi-Stack Variable Reluctance Stepper Motors (8M)

Cross section view of a typical three-stack variable reluctance stepper motor



Teeth position for a 3-phase, 4-pole, 12-teeth, three-stack, variable reluctance stepper motor when phase a is energized



- The VR stepper motors mentioned up to this point are all single-stack motors. That is, all the phases are arranged in a single stack, or plane.
- The disadvantage of this design for a stepper motor is that the steps are generally quite large (above 15°).
- Multi-stack stepper motors can produce smaller step sizes because the motor is divided along its axial length into magnetically isolated sections, or stacks.

6

A stepper motor has resolution of 180 steps/rev. Find the pulse rate required in order to obtain a speed of 2400rpm. (13M) (Dec 2016) BTL-6

Solution:

Ressolution = 180 steps/rev

Required motor speed = 2400 rpm

Speed in rps (n) = Speed in rpm/60 **(5M)**

= 2400/60

Speed in rps (n) = 40 rps

Step angle (β) = 360^0 / (Number of steps/ rev) (3M)

= 360/180

$\beta = 2^0$

From the expression , n = (β*f)/ 360^0 (5M)

f = (n *360)/ β

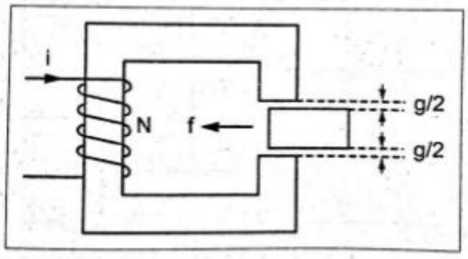
f = (40*360)/2

f = 7200 HZ

7

Explain the concept of torque production in variable reluctance stepping motor.(13M) (Dec 13) BTL-5

Answer: Page 2.40 to 2.46 – R.Srinivasan



Let e(t) = voltage applied per stack

R = winding resistance per stack

L(θ) = winding inductance per stack (a function of rotor position only and independent of coil current because of linear magnetic circuit assumption)

i(t) = current per stack

θ(t) = angular position of rotor

Kirchoff's mesh equation for stator winding is $e(t) = Ri(t) + \frac{d\lambda}{dt}$

where λ = flux linkages of stator winding = iL(θ).

Therefore,

$$= Ri(t) + \underbrace{L(\theta)\frac{di}{dt}}_{\text{Transformer emf}} + \underbrace{i\frac{dL(\theta)}{d\theta}\frac{d\theta}{dt}}_{\text{speed emf}} \ldots\ldots\ldots\ldots\ldots(1)$$

Energy stored in air gap is

$$W = \tfrac{1}{2} L(\theta)\, i^2(t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Mechanical torque developed is given by

$$T = \frac{\partial}{\partial\theta} W(i,\theta)$$

$$= \frac{1}{2} i^2(t) \frac{dL(\theta)}{d\theta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

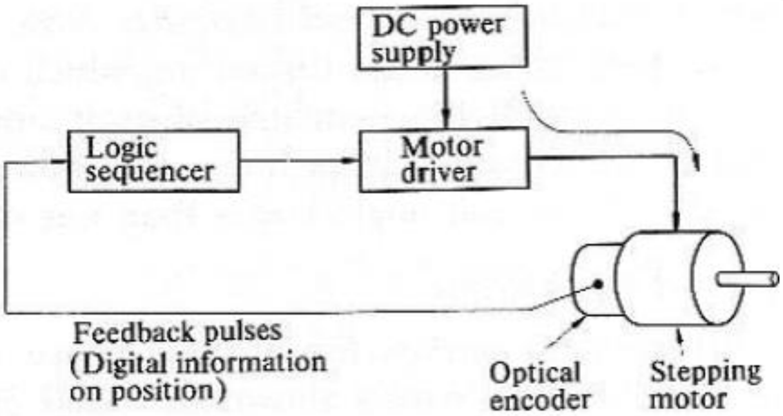
Rotor dynamics is governed by

$$T = J\frac{d^2\theta}{dt^2} + f\frac{d\theta}{dt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

In a toothed structure, reluctance and therefore winding inductance varies continuously (even function) as function of θ over and above an average value, i.e.,

$$L(\theta) = L_1 + L_2 \cos T\theta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Substituting in equation 3,

	$T = -\frac{1}{2} L_2 T i^2 (t) \sin T\theta$
	PART * C
1	**With a neat block diagram, explain the closed loop operation of stepping motor. (15M) (June 13)** BTL-6 **Answer: Page 2.81 to 2.83 – R.Srinivasan** ➢ When the stepping motor is in running condition or about to start, the optical encoder coupled to the rotor detects the rotor position and supplies its information to the logic sequencer. ➢ Then, the sequencer determines the proper phase(s) to be excited, taking account of the position information ➢ The relation between the rotor's present position and the phases to be excited is specified in terms of lead angle. 
2	**Explain the operation of driver system and control circuitry for stepper motor (15M) (Nov/Dec 15, April 2017)** BTL-5 **Answer: Page 2.62 to 2.75 – R.Srinivasan** ➢ The stepper motor is a digital device that needs binary (digital) signals for its operation Depending on the stator construction two or more phases have to be sequentially switched using a master clock pulse input. (1M) ➢ The clock frequency determines the stepping rate, and hence the speed of the motor. (1M) ➢ The control circuit generating the sequence is called a translator or logic sequencer. (1M)

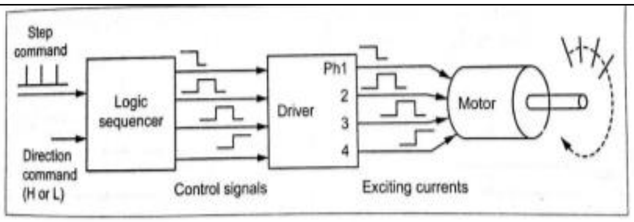


Fig. Block Diagram of the drive system of a stepping motor.

- It consists of a logic sequencer, power driver and essential protective circuits for current and voltage limiting. (1M)
- This control circuit enables the stepper motor to be run at a desired speed in either direction. (1M)

a) **Logic Sequencer (2M)**
b) **Power drive circuit (2M)**

Improvement of current build-up/special driver circuits

a) **Resistance drive (L/R drive) (1M)**
b) **Dual voltage drive (or) Bi-level drive (1M)**
c) **Chopper Drive (1M)**
d) **Problems with drivers circuits (1M)**

3

a) What is the motor torque Tm required to accelerate an initial load of 2x10-4 kg – m2 from f1 = 500Hz to f2 = 1500Hz during 50msec. The frictional torque Tf is 0.03 Nm and the step angle is 1.18°. (8M) . BTL-6

Step angle $\theta_s$in radians= $\theta_s in\ degrees\ \frac{\pi}{180}$

$=1.18°\text{x}\frac{\pi}{180}$

$$\theta_s = 0.0205\ rad$$

ω_1=$\theta_s f_1$
ω_2=$\theta_s f_2$

Motor Torque Tm=J$\frac{d\omega}{dt}$+T_f

Tm=0.11 Nm

b) Comparison of variable reluctance stepper motor with permanent magnet stepper motor.(7M) BTL-5

Sl.No	**Variable reluctance stepper motor**	**Permanent magnet stepper motor**
1	The rotor is not having permanent magnet	The rotor has permanent magnet

2	It does not have a detent torque	Its main advantages is the presence of a detent torque
3	Torque per ampere of stator current is lower	It produces higher torque per ampere of stator current
4	High torque to inertia ratio	Lower torque to inertia ratio
5	High rates of acceleration	Acceleration is slow
6	The Dynamic response is fast	Very slow dynamic response
7	Maximum stepping rate can be as high as 1200 pulses per second	Maximum stepping rate can be around 300 pulses per second
8	Very small step angle is possible	The step angle are high in the range of 30° to 90°

UNIT III - SWITCHED RELUCTANCE MOTORS (SRM)

Constructional features – Rotary and Linear SRM - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers –Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control – Applications.

PART * A

Q.No **Questions**

1 **What is switched reluctance motor?** BTL-1

The switched reluctance motor is a doubly salient, singly excited motor. This means that it has salient poles on both the rotor and the stator, but only one member (usually the stator) carries windings. The rotor has no windings; magnet is or cage windings but is built up from stacks of salient pole laminations.

2 **State the advantages of Switched Reluctance motor?(Dec 13, June 2016)** BTL-2

Rotor is simple and it tends to have a low inertia, The stator is simple to wind, In most applications the bulk of the losses appear on the stator, which is relatively easy to cool, Due to the absence of magnet the maximum permissible rotor temperature may be higher than in PM motors, Under fault conditions the open circuit voltage and short circuit current are zero or varying small, Extreme by high speeds are possible.

3 **What is the difference between Switched Reluctance motor and variable reluctance stepper motor?(May12)** BTL-4

Switched Reluctance motor	**Variable reluctance stepper motor**
Conduction angle for phase current is controlled and synchronized with the rotor position, usually by means of a shaft position sensor.	Stepper motor is usually fed with a square wave of phase current without rotor position feedback.
The SRM is designed for high speed.	It is usually designed with a limited speed.
Closed loop control is necessary	Closed loop control is required for high frequency operation

4 **What are the applications of Switched Reluctance motor?(Dec 2016)** BTL-2

Precision position control system for Robotics and Low power servo motor.

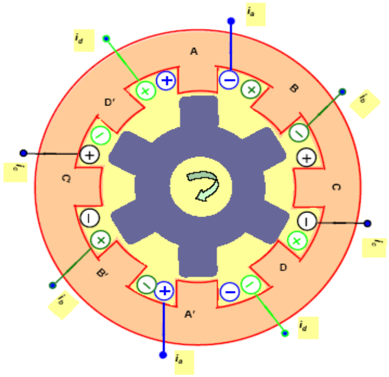
5	**Give basic features or characteristics of Switched Reluctance motor. (June 14, May 15)** BTL-4 The switched reluctance motor is a doubly-salient, singly-excited motor. This means that it has salient poles on both the rotor and the stator but only one member (usually the stator) carries windings. The rotor has no windings, magnets, or cage windings, but is built up from a stack of salient-pole laminations.
6	**What are the disadvantages of a Switched Reluctance motor?** BTL-2 The absence of free PM excitation imposes the burden of excitation on the stator windings and the controllers and increases the per unit copper losses, η is limited, torque/ampere is limited, Non uniform nature of the torque production which leads to torque ripple and may contribute to acoustic noise.
7	**Mention different modes of operation of SRM.(Dec 15)** BTL-4 Low speed mode, High Speed mode
8	**List the application of micro stepping VR stepper motor? (Dec 14)** BTL-2 Application are Printing, photo type setting .V.R type stepper motor with μ stepping provides very smooth low speed operation and high resolution.
9	**Write the relations between the speed and fundamental switching frequency.** BTL-4 $f=nN_r=(r.p.m./60)N_r$ Hz , N_r=No. of rotor poles, If there are q phases there are qN_r steps per revolution and the step angle or stroke is given by $\varepsilon=2\pi/(qN_r)$ rad. The number of stator poles usually exceeds the number of rotor poles.
10	**What is co-energy?** BTL-1 In the ψ –i curve of a motor, the area between the curve and horizontal i axis is the co-energy W' and the other part is the stored field energy W_f.
11	**Give the expression for torque of a Switched Reluctance motor.(May 12, June 13)** BTL-6 The torque is given by $T = [\partial W'/\partial\theta]_{i=const}$ Or by $T = [\partial W_f / \partial\theta]_{\psi=const.}$ With magnetic saturation negligible and with ψ–i curve straight line,$\psi=Li$, $W'=W_f=(½)Li^{2z}$, $T = (½)i^2\, dL/d\theta$ Nm where T is the torque, L is the inductance, W_f is the stored field energy.

12	**Why rotor position sensor is essential for the operation of Switched Reluctance motor? (Dec 12, Dec 2016)** BTL-1 It is normally necessary to use a rotor position sensor for communication and speed feedback. The turning ON and OFF operation of the various devices of power semiconductor switching circuit are influenced by signals obtained from rotor position sensor.
13	**List the types of power controllers used for Switched Reluctance motor? (Dec' 15)** BTL-4 Using two power semiconductors and two diodes per phase, (n + 1) power switching devices and (n+ 1) diodes per phase, Phase windings using Bifilar wires , Dump–C– converter, Split power supply converter.
14	**What is the step angle of an 5 phase Switched Reluctance motor and commutation frequency in each phase for the speed of 6000 rpm. SRM having 10 stator poles and 4 rotor poles.** BTL-6 **Solution:** Step angle $(\theta)=(2\pi/qN_r)=(360°/5*4)=18°$. Commutation frequency at each phase=$(N_r*\omega)/2\pi=(4*6000)/60=400$Hz.$[\omega = 2\pi N]$.
15	**List the merits of Dump C – Converter?** BTL-1 This topology uses lower number of switching devices and has only one switch voltage drop, the converter has full regenerative capability, and there is faster demagnetization of phases during commutation.
16	**What are the merits of split power supply Converter?** BTL-1 It requires lower number of switching devices, there is faster demagnetization of phases during commutation.
17	**State the merits of classic converter or power controller in SRM? (May 12)** BTL-4 Control of each phase is completely independent of the other phases; the energy from the off going phase is feedback to the source, which results in useful utilization of the energy.
18	**Why SR machines popular in adjustable speed drives?(Dec 12)** BTL-1 Rotor is simple and it tends to have a low inertia, The stator is simple to wind, In most applications the bulk of the losses appear on the stator, which is relatively easy to cool, Due to the absence of magnet the maximum permissible rotor temperature may be higher than in PM motors, Under fault conditions the

	open circuit voltage and short circuit current are zero or varying small, Extreme by high speeds are possible.
19	**Mention some position sensors used in switched reluctance motor .(June 13)** BTL-4 Optical encoder, resolver, Speed sensors and Hall Effect sensor.
20	**What is the significance of closed loop control in switched reluctance motor.(Dec 13, June 2016)** BTL-4 Switched reluctance motor is always operated with closed loop control. Normally we have to use a rotor position sensor for commutation and speed feedback. Here the phase windings are energized by using power semiconductor circuit. Turning on and off operation of the various semiconductor devices are influenced by signals obtained from rotor position sensor. It is the main significance of closed loop control in SR motor.
21	**Give the advantages of sensorless operation of switched reluctance motor?(June 14)** BTL-2 Low cost, Reliable and it avoids additional cost size.
22	**List out the advantages and disadvantages of the converter circuit with two power semiconductor devices and two diodes per phase? (Dec 14)** BTL-4 **Advantages** • The converter has low number of switching devices which reduces the cost of the converter. • The converter is able to freewheel during the chopping thus reducing the switching frequency and losses. **Disadvantages** • The common switch conducts for all phases and thus have higher switching stress. • Disability to magnetize a phase while the off going phase is still demagnetizing which results in high torque ripple during commutation.
23	**What is Hysteresis current control?** BTL-1 This type of current controller maintains a more or less constant throughout the conduction period in each phase. This controller is called hysteresis type controller.
	PART * B
1	**Explain the construction and working of Switched Reluctance motor? (13M) (May 12, Dec 13)** BTL-4

Answer: Page 3.2 to 3.4 – R.Srinivasan

Construction of Switched Reluctance motor (3M)



Principle (4M)

Faradays law of electromagnetic interaction. Whenever a current carrying conductor is placed in a magnetic field, it experiences a force. The direction of force given by Flemings left hand rule .The SRM develops an torque due to variable reluctance

Construction: (6M)

- The switched reluctance motor is a doubly salient, singly excited motor.
- This means that it has salient poles on both the rotor and the stator, but only one member (usually the stator) carries windings.
- The rotor has no windings; magnet is or cage windings but is built up from stacks of salient pole laminations.
- The stator is made up of silicon steel stampings with inward projecting poles.
- The number of poles in the stator is either an even number or odd number. Most of the motors have even number of stator poles.
- All these stator poles carry field coils.
- The rotor is made up of silicon steel stampings with outward projecting poles.
- Number of poles of rotor is different from the number of poles of stator.
- The rotor shaft carries a position sensor.

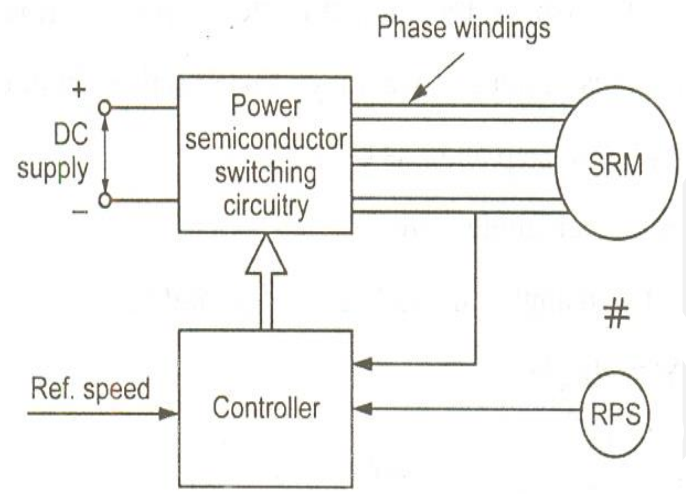
2

Explain in detail about microprocessor based control of Switched Reluctance motor.(13M) (May 12, Dec12,Dec 14, Dec 2016) BTL-2

Answer: Page 3.59 to 3.60 – R.Srinivasan

- The input DC supply is fed to the power semiconductor switching circuits.
- The power semiconductor devices are turned on and off by control circuit.
- The microprocessor or computer functions can be general be categorized as follows

1) control of feedback loops 2) Optimal and adaptive control 3) Estimation of feedback signals 4)General sequencing control 5)Protection and fault overriding control



3\. **Discuss the various converter topologies for a three phase SRM with merits and demerits of each. Explain any two of them (April/May 2017) (Nov/Dec 2016).**

(Or)

Write a note on power controllers used in SRM. (April/May 2013), (April/May 2008)

(Or)

Enumerate different operation modes of SRM with neat sketch (13M) (Nov/Dec 2012)

BTL-4

Answer: Page 3.18 to 3.25 – R.Srinivasan

- The selection of power semiconductor devices in switching circuits depends upon the application of SRM.
- The main objectives of the thrust on the design of the converter are the performance and cost of SRM drive.

Basic requirements of power controller circuits: (3M)

- Each phase of the SRM should be able to conduct independent of the other phases.
- The power converter should be able to free wheel during the chopping period to reduce the switching frequency.
- The converter should be able to demagnetize the phase before it steps into the generating region if the machine is operating as a motor and should be able to excite the phase before it steps into the generating region if operated as a generator
- .The converter should be able to utilize the demagnetization energy from the outgoing phase [phase which is switched off] in a useful way by either feeding it back to the source or using it in the next conducting phase.

Types of Power Controllers for SRM The following are the power controller or power converter circuits available for switched reluctance motor.

1. Two-power semiconductor switching devices per phase circuit or classic converter circuit. (2M)
2. (n + 1) power switching devices for n-phase motor. (2M)
3. Phase winding using bifilar wires or in a nutshell it is called as bifilar windings.(2M)
4. Split-link circuit used with even-phase number. (2M)
5. C-dump circuit. (2M)

4

Describe the Hysteresis type and PWM type current regulator for one phase of Switched Reluctance motor. (13M) (Dec 14) BTL-2

Answer: Page 3.52 to 3.53 – R.Srinivasan

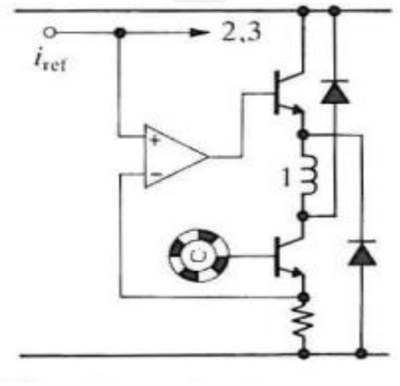
The control methods available for SRM are two types (4M)

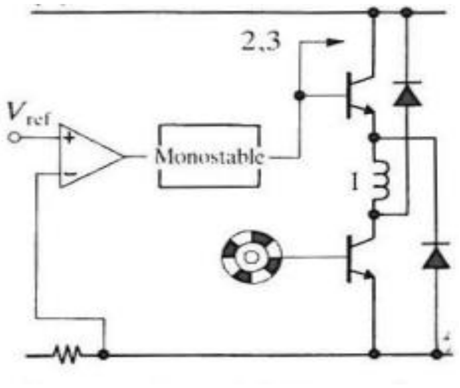
1.hysteresis type current regulator (2M)

This type of current controller maintains a more or less constant throughout the conduction period in each phase. This controller is called hysteresis type controller.

voltage PWM control or duty cycle control (7M)

- The circuit consists of two transistors T1 and T2, two energy feedback diodes D1 and D2, phase windings A and control circuit.
- The transistor T2 is turned on by applying base signal from rotor position sensor.
- The operational amplifier compares reference voltage signal and actual voltage signal.
- The output of the error signal is fed to the monostable multivibrator.





5

Derive the voltage and torque equation of Switched Reluctance motor (13M) (Dec 12,Dec 14, Dec 2016) BTL-6

Answer: Page 3.13 to 3.18 – R.Srinivasan

Voltage equation of SRM= $iR+\partial\lambda/\partial t$; $V= iR+L(\partial i/\partial t)+i\omega(\partial L/\partial\theta)$ **(7M)**

$\partial\lambda/\partial t$-slope of magnetic curve

∂L-incremental inductance

iR-resistive drop

$L(\partial i/\partial t$- emf due to incremental inductance

$i\omega(\partial L/\partial\theta$- Self emf depends on current ,speed and rate of change of inductance with rotor angle.

Torque equation (6M)

The torque is given by $T = [\partial W' / \partial\theta]_{i=const}$ Or by $T = [\partial W_f / \partial\theta]_{\psi =const}$ With magnetic saturation negligible and with ψ –i curve straight line ,

- $\psi = L i$,$W' = W_f = (½) L i^2$,$T = (½) i^2 dL /d\theta$ Nm

6

Explain torque-speed characteristics of SRM with neat sketch (13M) (Nov/Dec 2012), (Nov/Dec 2007) BTL-2

Answer: Page 3.13 to 3.18 – R.Srinivasan

Characteristics of SRM (5M)

- The torque developed by switched reluctance motor depends upon the current waveforms of each phase winding.
- The current waveform depends upon the conduction period and chopping duty cycle and speed.
- For low speed operating condition, the current is assumed to be almost flat shaped. Hence, the developed torque is constant.
- For high speed operating condition, the current waveform gets changed and the average torque developed gets reduced.

Torque-speed capability curve (8M)

- For speeds below ωb, the torque is limited by the motor current (or the controller current, whichever is less) upto the base speed ωb, it is possible by means of regulators in Fig. to get any value of current into the motor, upto the maximum.

- The precise value of current at a given operating point depends on the load characteristics, the speed and the regulator and control strategy.
- The tiring angles of the converter can be chosen such as to optimize the efficiency or minimize torque ripple.
- The maximum torque developed in a motor and the maximum power that can be transferred are usually restricted by the mechanical subsystem design parameters.

7

Calculate the step angle of a 6-phase SRM having 12 stator poles and 8 rotor poles. What is the commutation frequency at each phase at a speed of 4800 rpm. (6M) BTL-6

i) Step angle=$\frac{2\pi}{qN_r}$

ii) Commutation frequency in each phase=$N_r \frac{speed}{60}$

What is the step angle of a 5ϕ SRM having 10 stator poles and 6 rotor poles. Also what is the commutation frequency in each phase for the speed. (7M) BTL-6

i) Step angle=$\frac{2\pi}{qN_r}$

ii) Commutation frequency in each phase=$N_r \frac{speed}{60}$

8

Compare and contrast the performance of SR motor and VR stepper motor. (13M) (Dec 13)

BTL-4

Answer: Page 3.64 to 3.65 – R.Srinivasan

Switched Reluctance motor	**Variable reluctance stepper motor**
Conduction angle for phase current is controlled and synchronized with the rotor position, usually by means of a shaft position sensor	Stepper motor is usually fed with a square wave of phase current without rotor position feedback.
The SRM is designed for efficient power conversion at high speed	It is usually designed as a torque motor with a limited speed.
It is meant for continuous rotation	It rotates in steps
Closed loop control is essential for its optimal working	It works in open loop operation
It has power ratings upto 75W	It has comparatively lower power rating

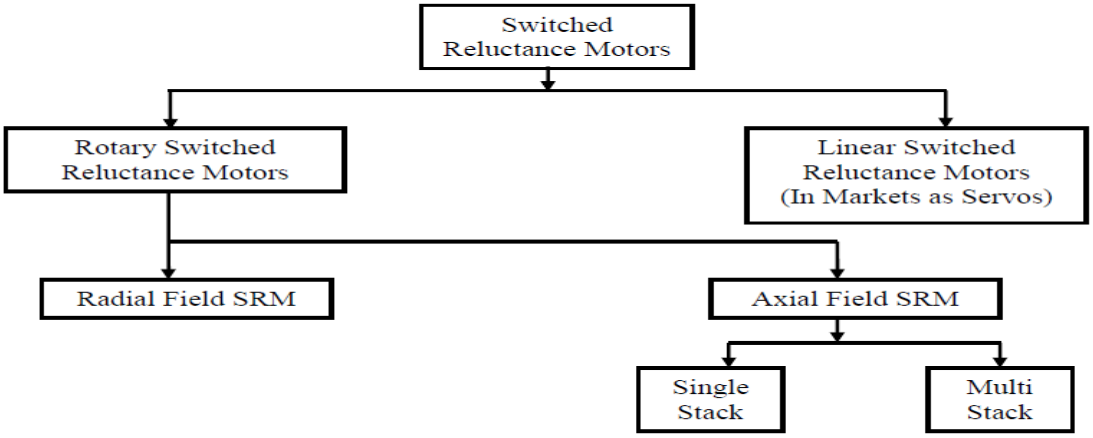
SRM requires a rotor- position sensor	It does not require rotor-position sensor

PART * C

1

Describe the construction and working of rotary and linear switched reluctance motors. (15M) (June 13,Dec 14, June 2016) BTL-4

Answer: Page 3.5 to 3.6 – R.Srinivasan



- Since the torque in SRM drives is independent of the excitation current polarity, the SRM drives require only one switch per phase winding.
- This is contrary to the ac motor drives where at least two switches per phase are required for current control.
- Moreover, the windings are not in series with the switches in ac motor drives, leading to irreparable damage in shoot-through faults.
- The SRM drives always have a phase winding in series with a switch.
- In case of a shoot-through fault, the inductance of the winding limits the rate of rise in current and provides time to initiate protective relaying to isolate the faults.
- The phases of the SRM are independent and, in case of one winding failure, uninterrupted operation of the motor drive operation is possible, although with reduced power output.

2

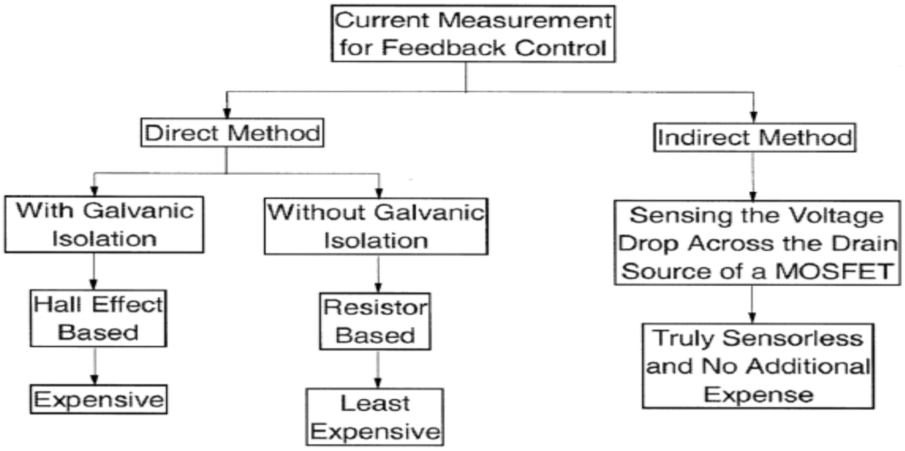
Discuss methods of rotor position sensing and sensorless operation. (15M) (June 13, Dec 14)

BTL-6

Answer: Page 3.6 to 3.8 – R.Srinivasan

Sensorless Operation of SRM Drives

1. **CURRENT SENSING**



CURRENT –SENSING METHODS (7M)

- Current control could be inexpensively achieved both with sensors and without sensors.
- Direct measurement with galvanically isolated current transducer is still an expensive solution. Noninductive, low-ohmic resistors can be used to monitor the current by measuring the voltage drop across them.
- They are not galvanically isolated, as in many applications galvanic isolation is not a strict requirement.
- This method provides the most accurate current measurement with the least amount of investment in materials and processing circuitry, but it does introduce an external resistor component in the circuit that consumes power on the order of a watt or less.

SENSORLESS ROTOR POSITION ESTIMATION (8M)

Incremental Inductance Measurement

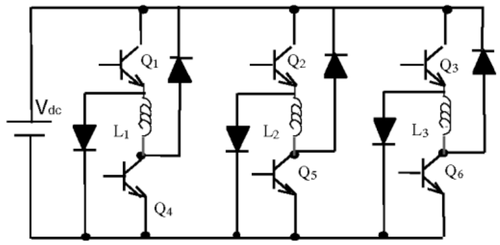
- This method uses the fact that the current rise and fall times are proportional to the incremental inductance, and under certain assumptions the rise and fall times reflect the incremental inductance and hence the rotor position itself.
- Both these techniques are described in detail and their merits and demerits are discussed.
- The only advantage of this method is that it only needs to measure the current and its rise or fall time to predict the rotor position and can use the active phase itself.
- Therefore, it can be implemented in real time and online with very little or no extra cost other than some software codes required in the controller.

3

Describe the various power controller circuits to Switched Reluctance motor and explain the operation of any one scheme with suitable circuit diagram. (15M) (June 2016, Dec 2016) BTL-4

Answer: Page 3.18 to 3.20 – R.Srinivasan

Classic Converter/ Two –phase semiconductor switching devices per phase (7M)



- The phase winding A is connected to the DC supply through the power semiconductor devices T1 and T2.
- Depending upon the rotor position, in order to energized the phase winding A, the devices T1, and T2 are turned ON.
- This conduction mode is usually initiated before the process of overlapping of rotor and stator poles, so that the phase current reaches the references value, before the phase inductance begins to increase.

Merits:

1. Control of each phase is independent of other phase.
2. The converter is able to freewheel during the chopping period.
3. The energy from the off going phase is feedback to the source.

Demerits:

1. Higher number of switches required in each phase which makes the converter expensive.

b. State the advantages of sensorless operation. (8M) (June 2016) BTL-2

- The method works in a speed range from stand-still to rated speed (high-speed sensorless operation is still under research).
- For low-dynamic applications (estimation of commutation angles only), the method is highly robust against heavy saturation of the machine.
- The position information can be extracted from a large-amplitude voltage signal.
- Depending on the bus bar voltage used, the measured signal can have an amplitude of hundreds of Volts.
- Such a signal is less prone to disturbances compared to small-amplitude voltage or current signals.
- Due to the very short test pulses, no current flows in the idle phase winding.

	UNIT IV - PERMANENT MAGNET BRUSHLESS D.C. MOTORS
	Permanent Magnet materials – Minor hysteresis loop and recoil line-Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation - Power Converter Circuits and their controllers – Motor characteristics and control– Applications.
	PART * A
Q.No	**Questions**
1	**Why adjustable speed drives are preferred over a fixed speed motor?** BTL-1 The common reasons for preferring an adjustable speed drives over a fixed speed motor are: Energy saving e.g. Fan or pump flow process, Velocity and position control e.g. Electric train, portable tools, washing machine, Amelioration of transients: Starting and stopping of motors produce sudden transients. It can be smoothened using adjustable speed drives.
2	**What is the structure of an adjustable speed drive system?** BTL-1 The general structure of a motion control system or drive consists of the following elements: The load, the motor, the power electronic converter; and the control.
3	**Write briefly about the construction and types of a Brushless DC machines.** BTL-4 1) Brushless PM machines are constructed with the electric winding on the stator and PMs on the rotor. There are several conventional PM machine configurations and other more novel concepts conceived in recent years to improve performance. 2)The configuration of a PM machine and the relationship of the rotor to the stator determine the geometry and the shape of the rotating magnetic field. PM machines in which the magnetic flux travels in the radial direction are classified as radial-flux machines. 3)They are cylindrical in shape, and the rotor is usually located inside the stator but can also be placed outside the stator. PM machines in which the magnetic flux travels in the axial direction are classified as axial-gap machines. They can have multiple disk or pancake-shaped rotors and stators. The stator-rotor-stator configuration is typical.
4	**State the advantages of PM machine?** BTL-2 1)In general, PM machines have a higher efficiency as a result of the passive, PM-based field excitation. PM machines have the highest power density compared with other types of electric machines, which implies that they are lighter and occupy less space for a given power rating.

2)The amount of magnet material that is required for a given power rating is a key cost consideration. The cost of magnet material is high compared with the cost of the other materials used in electric motors, and design attributes that minimize the required amount of magnet material are important considerations in motor selection.

3)The stators of PM machines are generally fabricated in the same manner as induction machine stators; however, modifications are sometimes necessary, such as the design of a stator lamination to accommodate high flux density.

5

What are the differences between mechanical and electronic commutator? (Dec 13, Dec 2016)

BTL-4

MECHANICAL COMMUTATOR	**ELECTRONIC COMMUTATOR**
1. Commutator arrangement is located in the rotor.	1. Commutator arrangement is located in the stator.
2. Shaft position sensing is inherent in the arrangement	2.It requires a separate rotor position sensor.
3. Sparking takes place.	3.There is no sparking.
4. It requires regular maintenance.	4. It requires less maintenance.
5. Sliding contacts between commutator and brushes.	5.No sliding contacts.

6

State permeance coefficient? (June 14) BTL-1

The line drawn from the origin through the operating point is called load line and absolute value of its slope normalized to μ_0 is called permeance coefficient.

Permeance coefficient= $\mu_{rec}((1+P_{rl}R_g)/(P_{mo}R_g))$where $\mu_{rec=}$relative recoil permeability,R_g=air gap reluctance,P_{mo}=internal leakage permeance,P_{rl}=normalized rotor leakage permeance.

7

Discuss briefly about the types of Permanent Magnets used in electrical machines. BTL-2

PM strength and other key properties :The various types of PMs include the following:

Alnico—a family of magnets made from aluminum, nickel, and cobalt characterized by excellent temperature stability, high residual induction, and enough energy for a number of industrial and commercial applications. Ceramic—a hard, low-cost ferrite made of barium and strontium ferrite with excellent stability. Ceramic magnets tend to be brittle, hard, and resistant to corrosion.

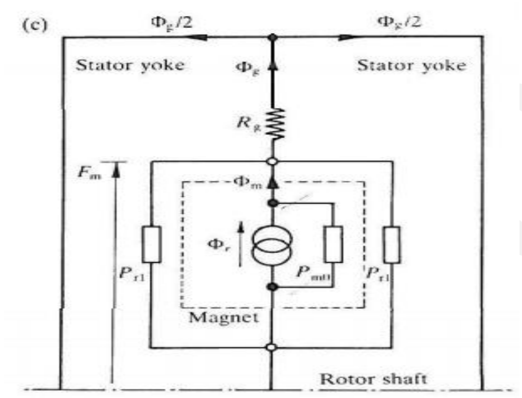
8

What is commutation.(June 13) BTL-1

Because of hetropolar magnetic field in the air gap of DC machine the emf induced in the armature conductors is alternating in nature. This emf available across brushes as unidirectional emf because of commutator and brushes arrangement. It provides less spark, easy to control, less maintenance, more efficient, small in size (compact).

9

Draw the magnetic equivalent circuit of PMBLDC motor.(Dec 13) BTL-2



Magnetic equivalent circuit

10

Compare brushless DC motor with P.M. commutator motor. BTL-4

Brushless DC motor	**P.M. Commutator motor**
1. No Brushes. Maintenance problems (RFI, sparking, ignition and fire accidents) eliminated.	1. Commutator based DC machines need carbon brushes, so sparking and wear and tear is un avoidable.
2. More cross sectional available for armature windings. Conduction of heat through the frame is improved.	2. Armature winding is inside and the magnet is on the stator outside.
3. Increase in electric loading is possible, providing a greater specific torque. Higher efficiency.	3. Efficiency less.
4. Space saving, higher speed possible, with reduced inertia.	4. Commutator restricts speed.

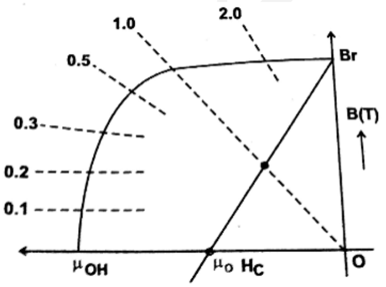
5. Maximum speed limited by retention of magnet against centrifugal force.	5. Magnet is on the stator. No problem.
6. Shaft position sensor is a must.	6. Not mandatory.
7. Complex electronics for controller.	7. Simple

11 **Give the emf and torque equations of the square wave BLDC motor.** BTL-6

The emf equation is given by E = kφω and the torque equation is given by T = kφI. where k is the armature constant depending on the number of turns in series per phase in the armature winding, ω is rotor speed in rad / sec and φ is the flux (mainly contributed by the Permanent Magnet on the rotor). I is the load current.

12 **What is meant by demagnetization in PM-BLDC motor.(Dec 14)** BTL-1

In the absence of externally applies ampere turn, the magnets operating point is at the intersection of demagnetization curve and the load line.



Demagnetization curve

13 **Write the principle of operation of PM-BLDC motor? (Dec 14)** BTL-1

When a D.C supply is switched on to the motor the armature winding draws a current. The current distributes with the stator armature winding depends upon rotor position and the devices turned on. As per faradays law of electromagnetic induction a emf is dynamically induced in the armature conductors. This back emf as per lenz law opposes the cause. As a result developed torque reduces. Finally the rotor attain the steady speed.

14 **Compare 120 degree and 180 degree operation of BLDC motor.** BTL-4

The 180 degree magnetic arc motor uses 120 degree mode of inverter operation. The motor with 120 degree magnetic arc uses 180 degree mode of inverter operation.

In 180 degree mode of inverter has 1.5 times copper losses but produce same torque with only 2/3 of

	magnetic material. Motor operation is less efficient.
15	**Give the expression for self and mutual inductances of a BLDC motor.** BTL-6 Self inductance is given by $L_g=(\psi/i)=(\pi\mu_0 N^2lr_1)/(2g'')$where $g''= g'+l_m/\mu_{rec}$,$g'= K_cg$,N=Number of conductors in the slot, I = current, l_m = magnet length in radial direction , g' = air gap, g'' = air gap including radial thickness of the magnet, μ_{rec} = relative recoil permeability, Mutual inductance is given by $M_g=-(1/3)L_g$.
16	**What are the types of sensors used with PMBLDC motors?** BTL-4 Hall effect sensors are most commonly used for speed, position sensing with PMBLDC motors. Optical Disc based sensors are also used. Presently rotor position sensors are avoided by using alternative methods called as Sensorless control methods, which uses terminal emf measurement, third harmonic voltage measurement, flux estimation and neuro – fuzzy techniques etc.
17	**Write the dynamic equations of the PMBLDC motor.** BTL-6 The dynamic model equations of PMBLDC motor is given by $di_a/dt=(v_{an}-Ri_a-e_a(\theta))/L$ $di_b/dt=(v_{bn}-Ri_b-e_b(\theta))/L$ $di_c/dt=(v_{cn}-Ri_c-e_c(\theta))/L$ $d\omega/dt=[T_e-T_l-B\omega]/J$ $d\theta/dt = P\omega/2$ where the Torque developed is given by $T_e=(e(\theta)i_a+e_a(\theta)i_b+e_a(\theta)i_c)/\omega$,$T_L$=Load torque applied is the coefficient of friction and J is the moment of inertia.
18	**State the relative merits and demerits of brush less DC motor drives? (Dec 2016)** BTL-4 **Merits**: Commutator less motor, Specified electrical loading is better, Heat can be easily dissipated, No sparking takes place due to brush, Source of EMI is avoided. **Demerits**: Above 10 kW, the cost of magnet is increase, Due to centrifugal force the magnet may come out.

19 **What are the difference between conventional DC motor and PMBLDC motor?(Dec 12)** BTL-4

DC	PMBLDC
Brushes are present.	Brushes are not present.
Sparking may occur due to brush.	Sparking will not occur as brush is not present.
Brush tend to produce RF1.	RF1 problem does not occur.
There is a need for brush maintenance.	No need of brush maintenance.

20 **List the various kinds of permanent magnets? (June 14)** BTL-4

There are basically three different types of permanent magnets which are used in small DC motors

Alnico magnets, Ferrite or ceramic magnet, and Rare - earth magnet (samarium – cobalt magnet).

21 **What is meant by multiphase brushless motors?(May 12)** BTL-1

A multi-phase brushless motor including a stator having a plurality of drive coils each corresponding to a specific phase and a rotor having a plurality of field magnet poles of successively alternating polarity. The stator further has a plurality of Hall generators for detecting the positions of the rotor and a speed sensor for detecting the rotational speed of the rotor.

22 **Give the uses of sensors in motors. (May 12)** BTL-3

It is used to identify the position of the rotor and it is also used to excite the coils in proper manner.

23 **List some applications of BLPM DC motor. (Dec 15, June 2016)** BTL-4

Fans, Pump drive, Traction and Hydraulic power steering, precision high speed spindle drivers for hard disk drivers etc.,.

24 **Why brushless permanent magnet motor is called as electronically commutated motor? (Dec'15, June 2016)** BTL-1

The switching instants of the individual transistor switches, Q1 – Q6 with respect to the trapezoidal emf wave is synchronized with the rotor. So switching the stator phases synchronously with the emf wave make the stator and rotor mmfs rotate in synchronism. Thus, the inverter acts like an electronic commutator that receives switching logical pulses from the rotor position sensor. This is why a BLDC drive is also commonly known as an electronically commutated motor (ECM).

25 **How the demagnetization occurs in PMBLDC motor. (May 15)** BTL-1

During the normal operation of motor, when the torque and back emf are constant, if the field flux level becomes low, then demagnetization occurs.

26 **List the classifications of BLPM dc motor? (May 15)** BTL-4

1. BLPM square wave motor.
2. BLPM sine wave motor.

27 **What are the two types of BLPM SQW DC motor?** BTL-4

1. 180^0 pole arc BLPM square wave motor.

2. 120^0 pole arc BLPM square wave motor.

28 **State the ways by which demagnetization can be limited in permanent magnet?** BTL-4

There are several ways to limit the demagnetization. One way is to keep the current below the maximum value and another way is y use of pole shoes to a permanent magnet to collect the flux and then transfer it to the air gap.

29 **Define the energy product and maximum energy product of a permanent magnet.** BTL-1

The absolute values of the product of the flux density and the field intensity at each points along the demagnetization curve is called energy product. The maximum value of the energy product is called maximum energy product and this quantity is one of the strengths of the permanent magnet.

PART * B

1 **Compare the Electronic commutator and Mechanical commutator.(13M) (May 15, Dec 16)**BTL-4

Answer: Page 4.7 – R.Srinivasan

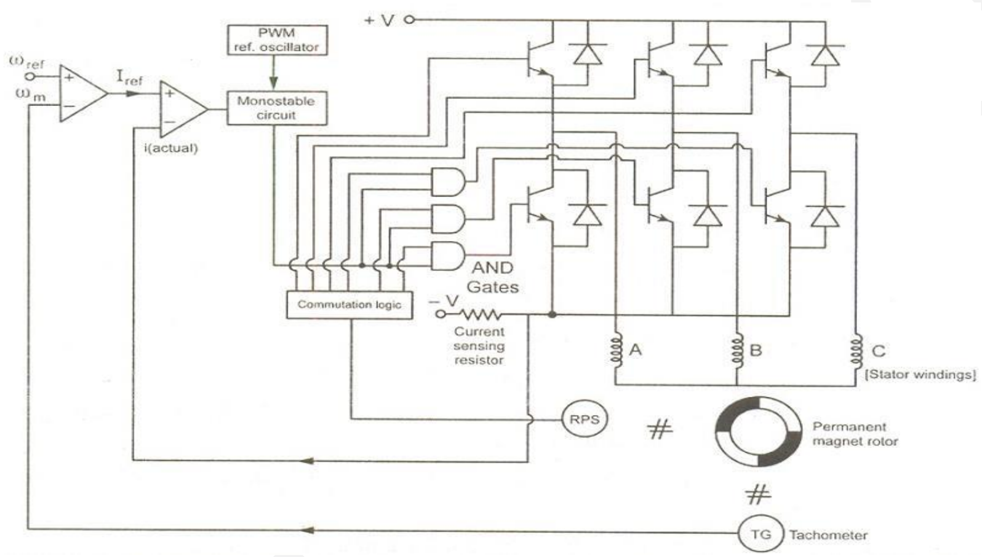
Electronic commutator	Mechanical commutator
1.Commutator arrangement is located in the rotor	1.Commutator arrangement is located in the stator.
2.Shaft position sensing is inherent in the arrangement	2.It requires a separate rotor position sensor
3. Sparking takes place	3.There is no sparking
4.It requires regular maintenance	4. It requires less maintenance
5. Sliding contacts between commutator and brushes	5.No sliding contacts
6.Numbers of commutator segments are very high.	6. Number of switching devices is limited to 6.

7. Interpole windings are employed to have Sparkles commutation.	7. By suitable operating the switching devices, better performance can be achieved. 3
8.Difficult to control the voltage available across the tappings.	8. The voltage available across armature tappings can be controlled by employing PWM techniques.

2

Sketch the structure of controller for permanent magnet brushless DC motor and explain the functions of various blocks.(different types of power controllers) (13M) (June 13,June 14, dec 2016) BTL-6

Answer: Page 4.49 to 4.51 – R.Srinivasan



Power circuit: (5M)

- It consists of six power semiconductor switching devices connected in bridge configuration across a DC supply.
- A suitable shunt resistance is connected in series to get the current feedback. Feedback diodes are connected across the device.

Control circuit: (3M)

- The control circuit consists of a commutation logic unit which gets the information about the rotor shaft position and decides when switching devices should be turned on and which devices are to be turned off.

Rotor position sensors: (3M)

- It converts the information of rotor shaft position into a suitable electrical signal.

- This signal is utilized to switch on and off the various semiconductor devices of electronic switching and commutation circuitry of BLPM motor.
- Two popular rotor position sensors: Hall effect position sensors, Optical position sensors

Driving circuits: (2M)

- The position sensors are kept in the stator such that they are influenced by the rotor positions.
- By suitably connecting the position sensors to the controller required pulses to the devices of the electronic commutator are given.

3. **A PMBLDC motor has toque constant 0.12 Nm/A referred to DC supply. Find the motors no load speed when connected to 48V DC supply. Find the stall current and stall torque if armature resistance is 0.15Ω/phase and drop in controller transistor is 2V. (6M) (Dec 12, Dec 13, June 2016)**

BTL-6

Given data :

K_m =0.1 Nm/A, V=48V

Solution:

$$\omega_{mo} = \frac{V}{K_m} = 48/0.12 = 400 rad/\sec$$

$$\omega_{mo} = 2\pi No/60$$

$$N_0 = (480*60)/2\pi = 3819.71 rpm$$

$$R_{ph} = 0.15\Omega$$

$$V_{dd} = 2V$$

Starting current or stall current= $I_{st} = \frac{V - V_{dd}}{2R_{ph}} = \frac{(48-2)}{(2*0.15)} = 153.33A$

Starting torque or Stall torque= $T_{st} = K_e I_{st} = 0.12*153.33$

=18.4 N-m

4 **A permanent magnet DC commutator motor has a no load speed of 6000 rpm when connected to a 120V dc supply. The armature resistance is 2.5Ω and rotational and iron losses may be neglected. Determine the speed when the supply voltage is 60V and the torque is 0.5 Nm. (6M) (Dec 12, Dec 13,Dec 2016)** BTL-6

$$V_s = 120V$$

$$R_a = 2.5\Omega$$

$$T = 0.5N - m$$

$$E = K_m \omega_m$$

$$V = K_m \omega_{mo}$$

$$T = K_m I$$

$$K_m = \frac{V}{\omega_{mo}} = \frac{120}{(2\pi N/60)} = 0.19V/rad/\sec$$

$$I = \frac{T}{K_m} = (.5/0.19) = 2.617A$$

$$E = V - I_a R_a = (60 - 2.617 * 2.5) = 53.45V$$

$$\omega_m = \frac{E}{K_m} = (53.45/0.19) = 281.34 rad/\sec$$

$$\omega_m = \frac{2\pi N}{60}$$

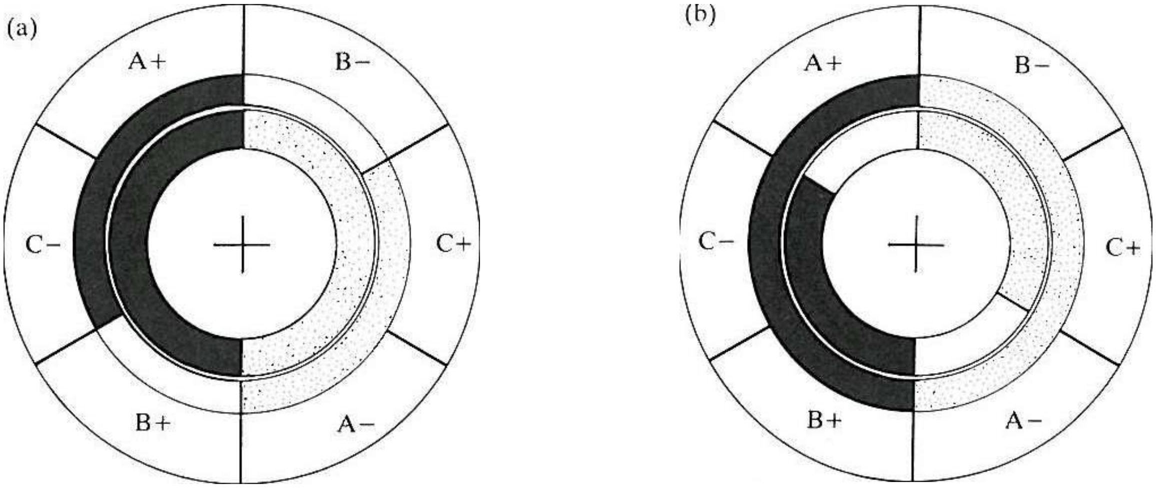
$$N = \frac{281.34 * 60}{2\pi} = 2686.6rpm$$

Ra =2.5Ω

5

Illustrate in detail, the operation of PMBLDC motor with 180 magnet arcs and 120 square wave phase currents. (13M) (Dec 12) BTL-2

Answer: Page 4.17 to 4.25 – R.Srinivasan



(a) BLDC motor with 180° magnet arcs and 120° square-wave phase currents. (7M)

(b) BLDC motor with 120° magnet arcs and 180° square-wave phase currents. (6M)

- The 180º magnet arcs were assumed to produce a rectangular distribution of flux density in the airgap. The phase windings are assumed to be star connected.
- The 120º pole arc motor is less efficient than 180 º pole arcs motor, the phase current waveforms of delta connected converters is shown above.
- In this machine, the effect of fringing flux, slotting and commutation overlap combine to produce torque ripple.

6

Explain briefly about construction and operating principles of PMBLDC. (13M) (Nov/Dec 14), (Nov/Dec 16), (April/May 2017) BTL-5

Answer: Page 4.13 to 4.17 – R.Srinivasan

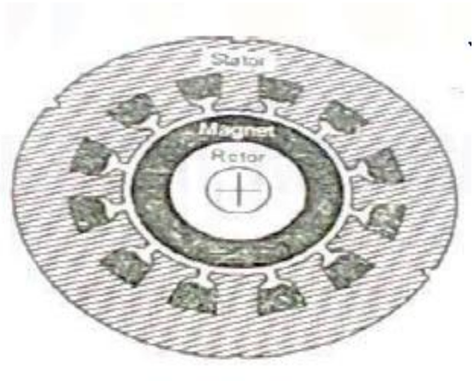
Construction

Stator: (7M)

- The stator of the BLPM dc motor is made up of silicon steel stampings with slots in its interior surface.
- These slots accommodate either a closed or opened distributed armature winding usually it is closed.
- This winding is to be wound for a specified number of poles.
- This winding is suitably connected to a dc supply through a power electronic switching circuitry (named as electronic commutator).

Rotor: (6M)

- Rotor is made of forged steel. Rotor accommodates permanent magnet.
- Number of poles of the rotor is the same as that of the stator.
- The rotor shaft carries a rotor position sensor.
- This position sensor provides information about the position of the shaft at any instant to the controller which sends suitable signals to the electronic commutator.
- This electronic commutator function is similar to the conventional mechanical commutator DC motor.



7

Write the torque equation of PMBLDC & Explain the characteristics (7M) (May/June 15) BTL-6

Answer: Page 4.40 to 4.44 – R.Srinivasan

Power input = VI
The applied voltage
$V= [2\ e_{ph} + 2\ I\ R_{ph} + 2\ V_{dd}]$
$VI = [2\ e_{ph} + 2\ I\ R_{ph} + 2\ V_{dd}]\ I$
$= [2\ I\ e_{ph} + 2\ I_2\ R_{ph} + 2\ I\ V_{dd}]$ ……………………………. (1)
Where
VI = electrical power input
$2\ I\ e_{ph}$= Power converted as mechanical
$2\ I_2\ R_{ph}$ = Power loss in the armature winding
$2\ I\ V_{dd}$ = Power loss in the device
Mechanical Power developed = $2\ e_{ph}\ I$
We know that $e_{ph} = 2\ [2B_{g}rlT_{ph}\omega_{m}]\ I$
$e_{ph} = 4B_{g}r\ l\ T_{ph}\omega_{m}\ I$ …………………………. . (2)
Mechanical Power =$\omega_{m}T$
Where
N= Speed in rpm
T= Torque in N-m
ω_{m}= Speed in rad/sec
Therefore $T = 4B_{g}r\ l\ T_{ph}\ I$ …………………………… (3)
$T = K_{t}\ I$ ……………………………. (4)

TORQUE EQUATION OF BLPM SQUARE WAVE MOTOR (6M) (April/May 17) BTL-6

TORQUES- SPEED CHARACTERSISTICS OF BLPM SQM DC MOTOR

Answer: Page 4.56 to 4.59 – R.Srinivasan

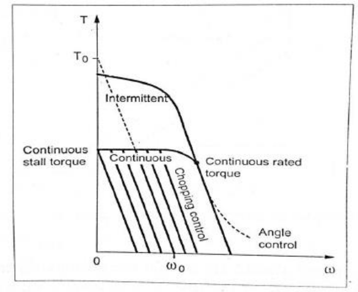


Fig. Torque speed characteristics of ideal brushless DC motor

- If the phase resistance is small as it should be in an efficient design, then the characteristics to that of a shunt dc motor.
- The speed is essentially controlled by the voltage V and may be changed by changing the supply voltage.
- Then the current drawn just to drive the torque at its speed.
- As the load torque is increased, the speed drops and the drop is directly proportional to the phase resistance and the torque.
- The voltage is usually controlled by chopping or PWM. This gives rise to a family of torque speed characteristics as shown in fig. 4.22. The boundaries of continuous and intermittent limits are shown.
- Continuous limit - determined by the heat transfer and temperature rise.
- Intermittent limit - determined by the maximum ratings of semiconductor devices in circuit.
- In practice the torque speed characteristics deviates from the ideal form because of the effects of inductance and other parasitic influences.
- Also the speed range can be extended by increasing the dwell of conduction period relative to the rotor position.

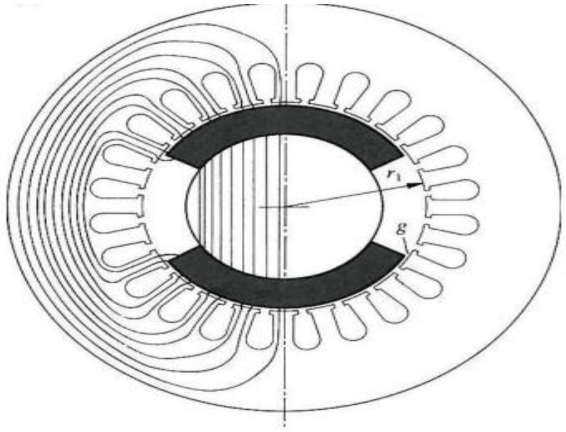
PART * C

1

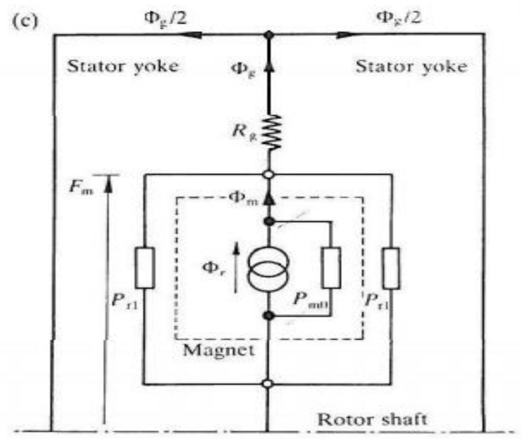
a) Explain in detail the magnetic circuit analysis of brushless DC motor on open circuit. (7M) (June 13) BTL-5

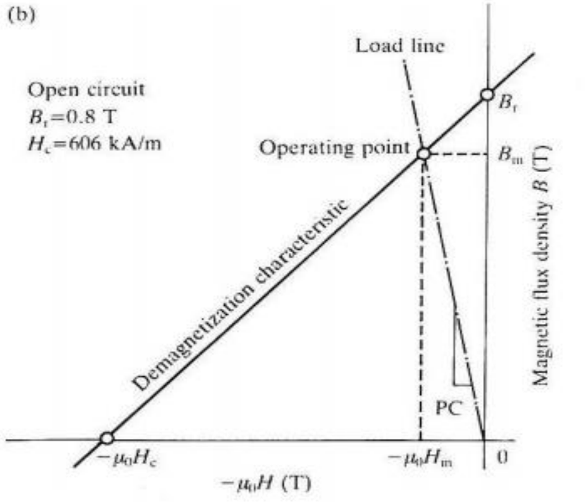
Answer: Page 4.25 to 4.32 – R.Srinivasan

- The Cross section of a 2 pole brushless d.c. motor having high energy rare earth magnets on the rotor and the demagnetization curve.



- Only half of the equivalent circuit is shown and the lower half is the mirror image of the upper half about the horizontal axis, which is an equipotential.





Permeance coefficient PC= $\mu_{rec}[(1+P_{rl}R_g)/(P_{m0}R_g)]$

b. What are the advantages of BLPM DC motor over conventional DC motor. (8M) BTL-2

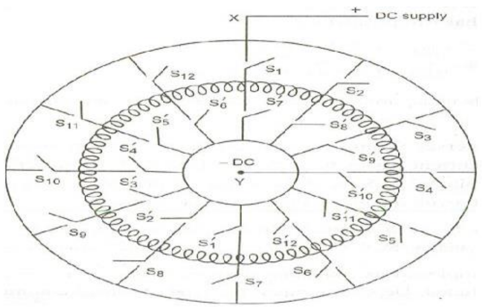
- Brushless DC motors offer several advantages over conventional DC motors, including high torque to weight ratio, more torque per watt (increased efficiency), increased reliability, reduced noise, longer lifetime (no brush and commutator erosion), elimination of ionizing sparks from the commutator, and overall reduction of electromagnetic interference(EMI).
- With no windings on the rotor, they are not subjected to centrifugal forces, and because the windings are supported by the housing, they can be cooled by conduction, requiring no airflow inside the motor for cooling.
- This in turn means that the motor's internals can be entirely enclosed and protected from dirt or other foreign matter.

2

Analyse the operation of electronic commutator of PMBLDC motor with neat diagram. (15M) (May 15) BTL-4

Answer: Page 4.5 to 4.7 – R.Srinivasan

Electronic Commutators



ELECTRONICCOMMUTATOR:

- In electronic commutator, 6switching devices are employed. Here the winding may be connected either star or delta connections.
- Therefore, the winding should have 3 tappings.
- The power semiconductor switches can be on and off by information get it from the rotor position sensor signals.
- Interpoles windings are employed to have sparkles commutations.
- By suitably operating the switching devices better performance can be achieved.

3

Explain the power controller for BLPM SQW DC Motor (15M) (May/June 15) (Nov/Dec 16) BTL-5

Power Circuit (4M)

Power Circuit of BLPM de motor is as shown fig consists of six power semiconductor switching device connected in bridge configuration across a dc supply.
A suitable shunt resistance is connected in series to get the current feedback.
Feedback diodes are connected across the device.
The armature winding is assumed to be star connected.
Rotor has a rotor position sensor and a techo-generator is coupled to the shaft to get feedback signal.

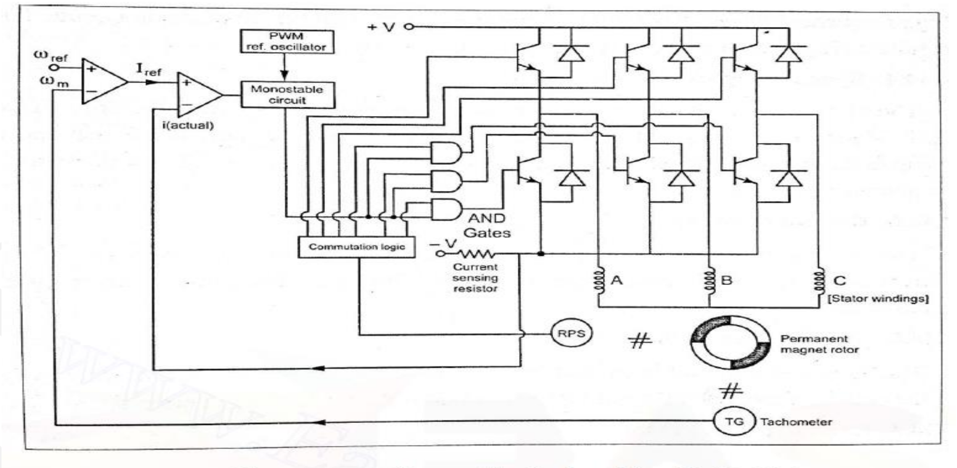


Fig structure of controller for brushless PM DC Motor

Control circuit (1M)
Commutation logic circuit (1M)
Speed Comparator (1M)
Current Comparator (1M)
Monostable Circuit (1M)

Rotor Position sensors for BLPM motor (2M)

- It converts the information of rotor shaft position into suitable electrical signal.
- This signal is utilized to switch ON and OFF the various semiconductor devices of electric switching and commutation circuitry of BLPM motor.

Two popular rotor sensors are

a. Optical Position Sensor b. Hall Effect Position Sensor.

(a) Optical position sensor (2M)

This makes use of six photo transistors. This device is turned into ON state when light rays fall on the devices. Otherwise the device is in OFF state the schematic representation is shown in fig.

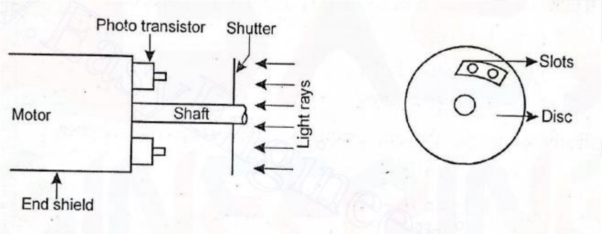


Fig Optical position sensor

(b) Hall effect position sensor (2M)

Consider a small pellet of n-type semiconducting material as shown in fig

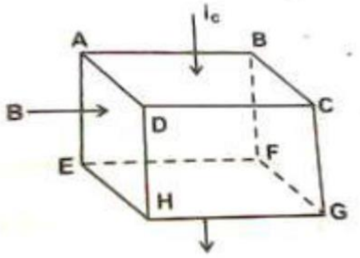


Fig Hall Effect

- A current $i_c$is allowed to pass from the surface ABCD to the surface EFGH. Let the surface ABEF be subjected to a North pole magnetic field of flux density B tesla.
- As per Fleming left hand rule, the positive charge in the pellet get concentrated near surface ADHE and negative charges near the surface BCFG.
- Since n-type material has free negative charges, there electrons gets concentrated near the surface BCGF.
- This charge in distribution makes the surface ADHE more positive than thesurface BCGF. This potential known as Hall emf or emf due to Hall Effect.

UNIT V - PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM)

Principle of operation – Ideal PMSM – EMF and Torque equations – Armature MMF – Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements– Applications.

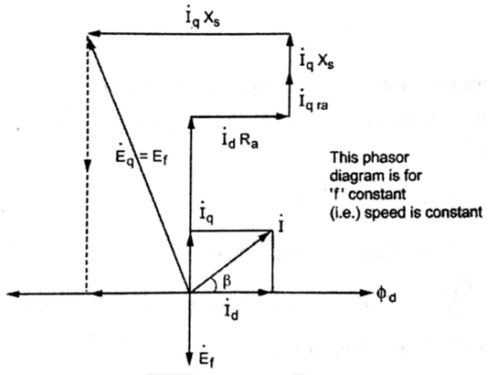
PART * A

Q.No **Questions**

1 **Distinguish PM synchronous motor from BLPM DC motors.(Dec'15)** BTL-4

PMSM	**PM Brushless DC motor**
Sinusoidal or quasi–sinusoidal distribution of magnetic flux in the air gap	Rectangular distribution of magnetic flux in the air gap
Sinusoidal or quasi-sinusoidal current waveforms	Rectangular current waveforms
Quasi-sinusoidal distribution of stator conductors. (short pitched and distributed or concentric stator windings)	It has concentrated stator windings

2 **Draw the output phasor diagram of PMSM (May 2016)** BTL-6



This phasor diagram is for 'f' constant (i.e.) speed is constant

3 **Explain in detail the vector control of permanent magnet synchronous motor.(Dec 14)** BTL-5

1)BLPM SNW motor is usually employs for variable speed applications. For this we keep V/f constant and vary V and f to get the desired speed and torque. From the theory of BLPM SNW motor it is known that as the speed is varied from a very low value up to the corner frequency, the desired operating point of current is such that Id =0 and I is along q-axis.

2)When the frequency is more than the corner frequency it is not possible to make Id=0, due to voltage

	constraints. In such a case a better operating point for current is obtained with minimum I value after satisfying the voltage constraints. Controlling BLPM SNW motor taking into considerations the above mentioned aspects is known as vector control of BLPM SNW motor.
4	**Compare the performance of PMSM with BLDC motor.** BTL-4 With equal r.m.s. phase currents the torque of the square wave motor exceeds that of sine wave motor by a factor 1.47. With equal peak currents the factor is 1.27. For the same flux-density flux per pole of a square wave motor exceeds that of a sine wave motor by a factor π/2. Square wave motor has a slightly better utilization of the peak current capability of the converter switches. In PMSM three devices conduct at a time (180 degree mode of inverter), where as in BLDC only two devices conduct at a time in 120 degree mode.
5	**What is meant by field oriented control of PMSM?** BTL-1 In general for field oriented control the stator currents are transformed into a frame of reference moving with the rotor flux. In the PMSM the rotor flux is stationary relative to the rotor. The rotor flux is therefore defined by the mechanical angle of rotation α, this is obtained from a rotor position sensor. Thus, the control is much easier to implement than in the case of induction motor.
6	**Write the expression for the self and synchronous reactance of PMSM.** BTL-6 The sum of the magnetizing and leakage reactance define synchronous reactance. $X_S = X_M + X_l$, X_s = Synchronous reactance, X_M = Magnetizing reactance, X_l = Leakage reactance
7	**What are the applications of PMBLDC and PMSM motors?** BTL-2 PMBLDC: (Low rating application) turn table drives for record players, Hard disc drives, Low cost instruments, Small fans for cooling electronic equipment, (High rating application)Air craft, Satellite system, Traction system (in future). PMSM are used in low to medium power (up to several hundred HP) Applications, Fiber spinning mills, Rolling mills, Cement mills, Ship propeller, Electric Vehicles, Servo and robotic drives and Starters / generator for air craft engine.

<table>
<tr><td>8</td><td>
What are the features of permanent magnet synchronous motor? BTL-1

Robust, compact and less weight, No field current or rotor current in PMSM, unlike in induction motor, Copper loss due to current flow which is largest loss in motors is about half that of induction motor and High efficiency.
</td></tr>
<tr><td>9</td><td>
Explain the difference between synchronous motor and PMSM. BTL-4

<table>
<tr><th>Synchronous Motor</th><th>PMSM</th></tr>
<tr><td>3 phase AC or six step voltage or current source inverter is used as supply.</td><td>3 phase sine wave ac or PWM ac is used as supply.</td></tr>
<tr><td>This type of motor is used in very large compressor and fan drives.</td><td>Here it is used in low integral HP industries drives, fiber spinning mills.</td></tr>
</table>
</td></tr>
<tr><td>10</td><td>
What are the assumptions made in derivation of emf equation for PMSM? (Dec 14) BTL-6

Flux density distribution in the air gap is sinusoidal, Rotor rotates with an uniform angular velocity of ω_m (rad/sec), Armature winding consists of full pitched, concentrated similarly located coils of equal number of turns.
</td></tr>
<tr><td>11</td><td>
Why PMSM operating in self – controlled mode is known as commutatorless DC Motor? BTL-1

Load side controller performs somewhat similar function as commutator in a DC machine. The load side converter and synchronous motor combination functions similar to a DC machine. First it is fed from a DC supply and secondly like a DC machine. The stator and rotor field remain stationary with respect to each other at all speeds. Consequently, the drive consisting of load side converter and synchronous motor is known as commutator less DC motor.
</td></tr>
<tr><td>12</td><td>
Explain the distribution factor for PMSM. (Dec 15) BTL-5

Distribution factor (K_d): Distribution factor is given by the ratio of the MMF performed in the concentrated windings compared to the distributed windings. Coils in the stator are displaced from each other by a certain electrical angle, each coil produce sinusoidal MMF with a shift angle β.

$$K_d = \frac{\sin\frac{m\beta}{2}}{\frac{m\beta}{2}}$$
Where ‘m’ is no.of coils/pole/phase
</td></tr>
</table>

13 **Write down the expressions for torque of a PMSM?(Dec 13)** BTL-6

$T=3EI\sin\beta/\omega_m$ N-m ω_m is the angular velocity,T is the torque produced, β is the torque angle or power angle, E is the induced emf .

14 **What are the features of closed- loop speed control of load commutated inverter fed synchronous motor drive?** BTL-4

Higher efficiency, Four quadrant operation with regeneration braking is possible, Higher power ratings and run at high speeds (6000 rpm).

15 **Write down the emf expressions of PMSM?(Dec 13)** BTL-6

$E_{ph} = 4.44\, f\, \Phi_m\, K_w\, T_{ph}$ volts, This is the rms value of induced emf per phase, where f = Frequency in Hertz, Φ_m = flux per pole, K_w = Winding factor, T_{ph} = Turns per phase

16 **Define self-control in PMSM drive?(Dec 12)** BTL-1

- As the rotor speed changes the armature supply frequency is also changes proportionally so that the armature field always moves (rotates) at the same speed as the motor.
- The armature and rotor field move in synchronism for all operating points.
- Here accurate tracking of speed by frequency is realised with the help of rotor position sensor.

17 **What are advantages and disadvantages of PMSM? (May 12, May 15)** BTL-2

Advantages: Runs at constant speed**,** No field winding, no field copper loss, better efficiency, High power density, Lower rotor inertia, Robust construction of rotor, No sliding contact hence requires less maintenance .

Disadvantages: Loss of flexibilities of field flux control, Demagnetization effect and High cost.

18 **Distinguish between self control and vector control of PMSM? (May 12)** BTL-4

S.No.	**Self control**	**Vector control**
1.	Dynamic performance is poor	Dynamic performance is better
2.	Control circuit is simple	Control circuit is complex

19 **Brief-up the advantages of load commutation in permanent magnet synchronous motor. (Dec 12) .** BTL-2

Commutation of thyristors by induced voltages of load is known as “load commutation”. Here, frequency of operation is higher and it does not require commutation circuits.

20

Define the term load angle.(May 15) BTL-1

The phase **angle** introduced between the induced emf phasor, E and terminal voltage phasor , V during the **load** condition of an **Alternator** is called **load angle**.

In PMSM the load angle is the angle between stator field and rotor field when the machine is rotated at synchronous speed. It is represented as δ.

21

Write the advantages of optical sensors. BTL-2

Quite suitable for sinusoidal type motor as it is a high resolution sensor. The signal from the photodiode rises and falls quite abruptly and the sensor outputs are switched high or low so the switching points are well defined.

22

Classify the different types of PMSM?(Dec 2016) BTL-4

a) General classification: There are two types of PMSM :

1) Surface mounted rotor: further classified as

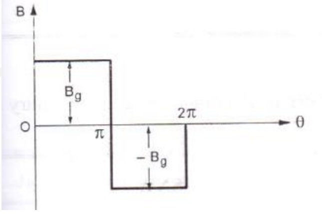
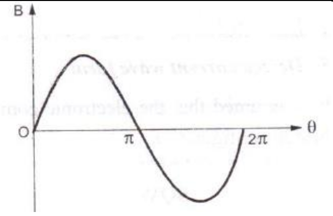
a) Projected type b) Insert type

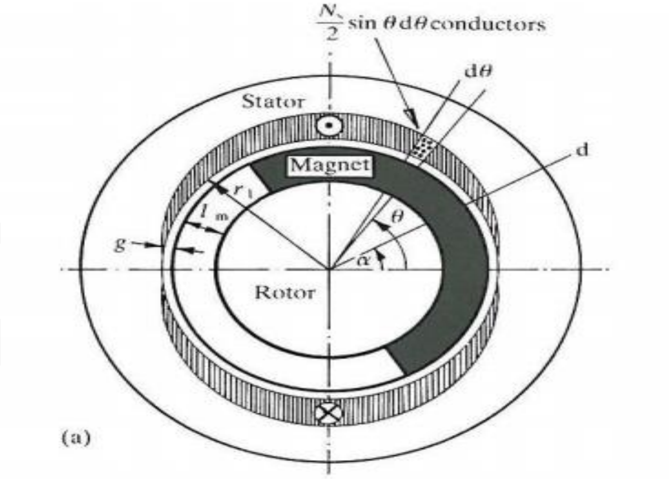
2)interior(or buried) rotor

b) Classification based on rotor configuration: 1)Peripheral 2) Interior 3)Claw-pole 4)Transverse

23

Differentiate Square wave and sine wave motor(Dec 2016) BTL-4

Features	BLPM Square wave motor	BLPM Sine wave motor
Flux density distribution		
Flux per pole (Φ)	$\Phi = B_g \tau l Wb$ $\tau = \frac{2\pi r}{2p}$	$\Phi = B_{av} \tau l$ $= \left(\frac{2\,\hat{B}}{\pi}\right) \pi l \text{ Wb}$
RMS value of the line current to the motor	$I_{rms} = \sqrt{\frac{2}{3}}\, I_d$	$I_{rms} = I = \frac{I_m}{\sqrt{2}}$

24	**Define synchronous reactance in PMSM(May 2016)** BTL-1 The synchronous reactance is the fictitious reactance employed to account for the voltage effects in the armature circuit produced by the actual armature leakage reactance and the change in the airgap flux caused by the armature reaction. For an ideal two pole sine distributed three phase winding with N_s turns in series per phase neglecting the leakage inductance of the slots and end-turns, the expression for synchronous reactance is given by μ_0 $$X_s = \frac{3\pi\mu_0 {N_s}^2 l r_1 \omega}{8p^2 g''}$$
	PART * B
1	**Derive the EMF and torque equation of BLPM Sine wave motor.(13M) (May 12, Dec 12, June 13, Dec 13)** BTL-6 **Answer: Page 5.7 to 5.17 – R.Srinivasan** An ideal sine wave brushless motor with pure sine distributed phase winding and permanent magnet rotor with sine distributed flux.  $$E_{ph} = 4.44 f\phi_m T_{ph}.volts$$ $$T = \frac{3}{2} I\sqrt{2}\,\frac{\pi r_1 lBN_s}{2}\sin\beta$$
2	**Write short notes on Volt ampere requirements in PMSM motor. (8M) (June 13,June 14, June 2016) . .** BTL-1 **Answer: Page 5.43 to 5.44 – R.Srinivasan**

Fundamental component of ampere turns per phase of a practical one= $\frac{4}{\pi}(iT_{ph}K_{w1})$

The total sinusoidally distributed ampere turns is equal to = $\frac{4}{\pi}(\frac{3}{2})\sqrt{\mathbf{2}}\,I_{ph}K_{w1}T_{ph}$

The amplitude of the ampere conductor density distribution shows is equal to the total sinusoidally distributed ampere turns divided by 2.

3.

With neat sketch, discuss the torque – speed characteristics of PMSM. (8M) (May 12 June 13,June 14,Dec 14, Dec 2016, June 2016) BTL-6

Answer: Page 5.44 to 5.46 – R.Srinivasan

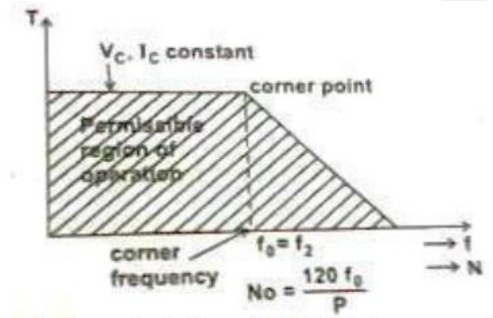


Fig Torque-speed characteristics of BLPM sine wave (SNW) motor.

- For a given and (i.e) maximum permissible voltage and maximum permissible current, maximum torque remains constant from a low frequency to (i.e) corner frequency. (1M)
- Any further increase in frequency decreases the maximum torque. (1M)
- At f= (i.e.) the torque Developed is zero. (1M)
- Shaded pole represents the permissible region of operation in torque speed characteristics. (1M)

Effect of over speed (4M)

- In the torque speed characteristics, if the speed is increased beyond the point D, there is a risk of over current because the back emf continues to increase while the terminal voltage remains constant.
- The current is then almost a pure reactive current flowing from the motor back to the supply.
- There is a small q axis current and a small torque because of losses in the motor and in the converter.
- The power flow is thus reversed.This mode of operation is possible only if the motor over runs the converter or is driven by an external load or prime mover.

4

Explain the concept of vector control of blpm snw motor (13M) (May/June 15) BTL-5

Answer: Page 5.38 to 5.40 – R.Srinivasan

- Electromagnetic torque in any electrical machine is developed due to the interaction of current carrying armature conductors with the air gap flux. (1M)
- Consider a two machine whose armature conductor currents and air gap flux are as shown in fig. Here the flux is in quadrature with the armature mmf axis. (1M)

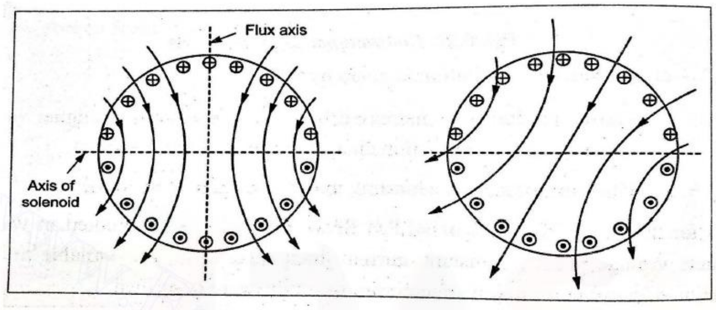


Fig. vector control

- Each and every armature conductor experiences a force which contributes the torque. (1M)
- The torque contributed by various armature conductors have the same direction even through their magnitude may vary. (1M)
- It is observed that the steady state and dynamic (behaviors) performance of a most of such an arrangement are better. (1M)

Principle of vector control (8M)

- BLPM SNW motor is usually employed for variable speed applications.
- For this we keep V/f constant and vary V and f to get the desired speed and torque.
- From the theory of BLPM SNW motor it is known that as the speed is varied from a very low value up to the corner frequency, the desired operating point of current is such that Id =0 and I is along the q-axis.
- Such a condition can be achieved by suitably controlling the voltage by PWM technique after adjusting the frequency to a desired value.
- When the frequency is more than the corner frequency it is not possible to make Id =0, due to the voltage constraints.
- In such a case a better operating point for current is obtained with minimum Id value after satisfying the voltage constraints.
- Controlling BLPM SNW motor taking into consideration the above mentioned aspects is known as ―vector Control of BLPM SNW motor.

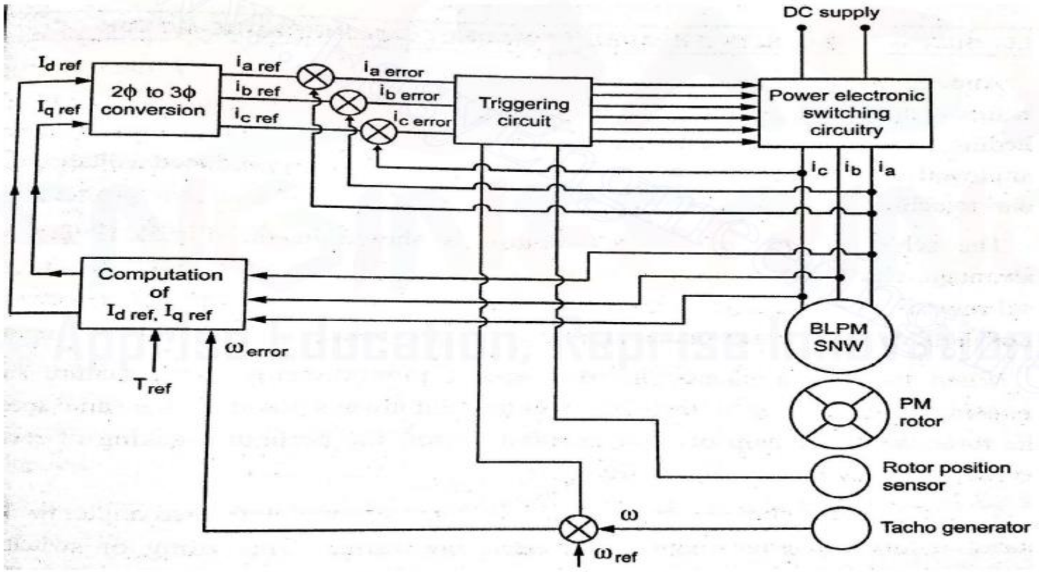


Fig. Schematic diagram of vector control

5

Explain the construction and principle of operation of PMSM (13M) (Apr /May14) (Apr /May 17) BTL-5

Answer: Page 5.3 to 5.7 – R.Srinivasan

Construction (6M)

- ➢ It consists of the stationary member of the machine called stator.
- ➢ Stator laminations for axial air gap machines are often formed by winding continuous strips of soft steel.
- ➢ Various parts of the laminations are the teeth slots which contain the armature windings.
- ➢ Yoke completes the magnetic path.
- ➢ Lamination thickness depends upon the frequency of the armature source voltage and cost.
- ➢ Armature windings are generally double layer (two coil side per slot) and lap wound. Individual coils are connected together to form phasor groups.

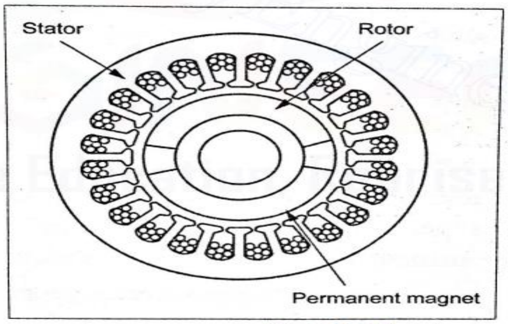
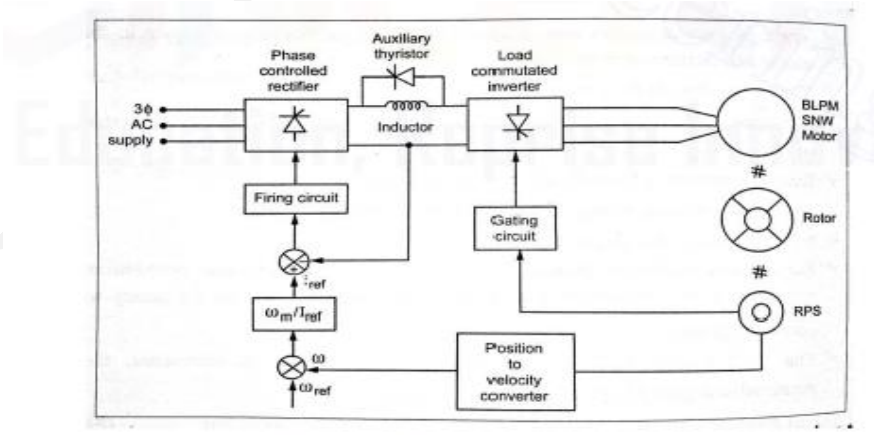


Fig.PMSM stator

Synchronous machines are classified according to their rotor configuration. There are four general types of

	rotors in permanent magnet synchronous machines. They are 1. Peripheral rotor (2M) 2. Interior rotor (2M) 3. Claw pole or lundell rotor. (2M) 4. Transverse rotor.(1M)
	PART * C
1	**Explain the self control of PMSM (15M)** BTL-5 **Answer: Page 5.40 to 5.42 – R.Srinivasan** ➢ As the rotor speed changes the armature supply frequency is also change proportionally so that the armature field always moves (rotates) at the same speed as the rotor. ➢ The armature and rotor field move in synchronism for all operating points. ➢ Here accurate tracking of speed by frequency is realized with the help of rotor position sensor. ➢ When the rotor makes certain predetermined angle with the axis of the armature phases the firing pulses to the converter feeding the motor is also change. ➢ The switches are fired at a frequency proportional to the motor speed. ➢ Thus the frequency of the voltage induced in the armature is proportional to the speed. ➢ Self-control ensures that for all operating points the armature and rotor fields move exactly at the same speed. ➢ The torque angle is adjusted electronically hence there is an additional controllable parameter passing greater control of the motor behavior by changing the firing of the semiconductor switches of an inverter.  Fig Schematic diagram of self-control
2	**Write a detailed technical note on the following (i) vector control of PMSM (ii) microprocessor based control.(15M) (Dec 12)** BTL-5 **Answer: Page 5.38 to 5.40 & 5.47-5.49 – R.Srinivasan**

vector control of PMSM (8)

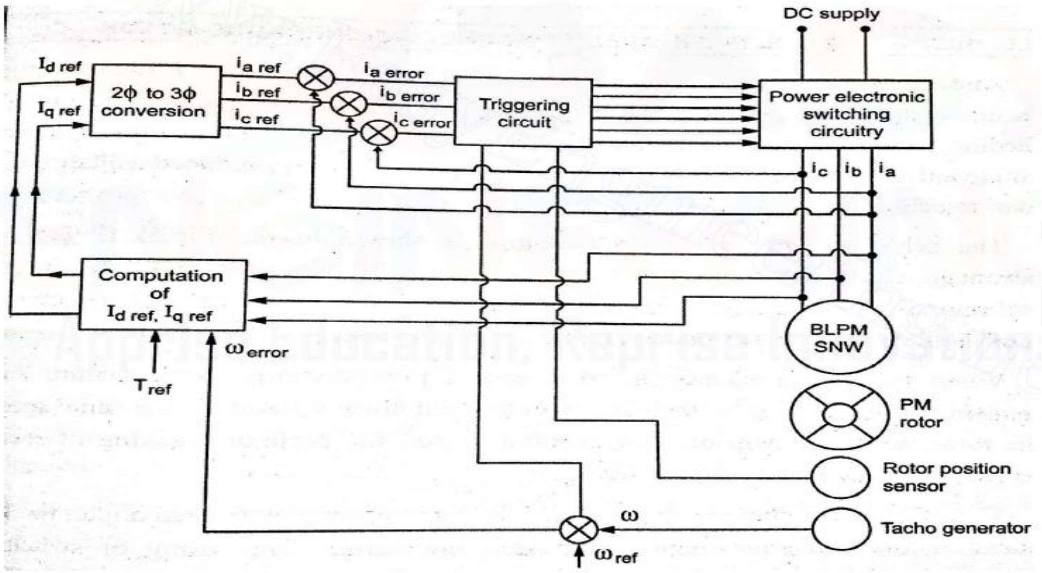


Fig. Schematic diagram of vector control

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- When the frequency is more than the corner frequency it is not possible to make Id=0, due to voltage constraints. In such a case a better operating point for current is obtained with minimum I value after satisfying the voltage constraints.
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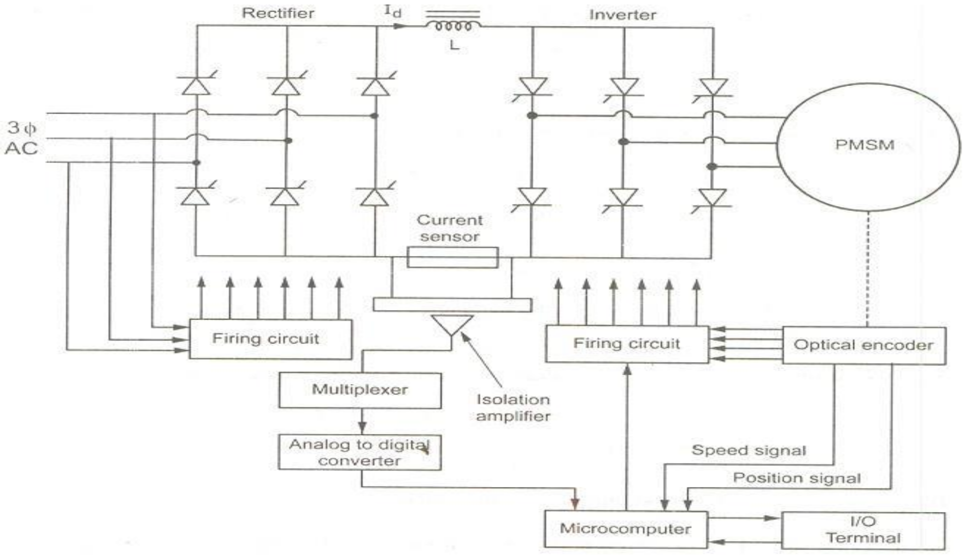
Microprocessor based control (7M)



- The advent of microprocessor has raised interest in the digital control of power systems and electronic motor drives since the microprocessor provides a flexible and low cost alternative to the conventional method.
- The optical encoder provides rotor speed and position signals.
- The inverter triggering pulses are synchronized to the rotor position reference signals with a delay angle determined by an 8-bit control input.
- The speed signal, which is a train of pulses of frequency, proportional to motor speed, is fed to a programmable counter used for speed sensing.
- The stator current is detected by current sensor and amplified by optional isolation amplifier.

3

A 3 phase ,12 pole synchronous motor has a star-connected winding with 108 slots with 8 conductors per slot. The flux per pole is 0.25 Wb, Sinusoidally distributed and the speed is 500 rpm. Detemine the frequency, the emf induced per phase and line voltage. Assume full pitched coil. (15M) BTL-6

Answer: Refer Book

Solu:
Frequency=50HZ
Distribution factor=0.9598
Line voltage=1328.5

MG6851 **PRINCIPLES OF MANAGEMENT** **L T P C**

3 0 0 3

OBJECTIVES:

To impart knowledge on the

- Evolution of Management, to study the functions and principles of management and to learn the application of the principles in an organization.

UNIT I INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS 9

Definition of Management – Science or Art – Manager Vs Entrepreneur - types of managers - managerial roles and skills – Evolution of Management – Scientific, human relations , system and contingency approaches – Types of Business organization - Sole proprietorship, partnership, company-public and private sector enterprises - Organization culture and Environment – Current trends and issues in Management.

UNIT II PLANNING 9

Nature and purpose of planning – planning process – types of planning – objectives – setting objectives – policies – Planning premises – Strategic Management – Planning Tools and Techniques – Decision making steps and process.

UNIT III ORGANISING 9

Nature and purpose – Formal and informal organization – organization chart – organization structure – types – Line and staff authority – departmentalization – delegation of authority – centralization and decentralization – Job Design - Human Resource Management – HR Planning, Recruitment, selection, Training and Development, Performance Management, Career planning and management.

UNIT IV DIRECTING 9

Foundations of individual and group behaviour – motivation – motivation theories – motivational techniques – job satisfaction – job enrichment – leadership – types and theories of leadership – communication – process of communication – barrier in communication – effective communication – communication and IT.

UNIT V CONTROLLING 9

System and process of controlling – budgetary and non-budgetary control techniques – use of computers and IT in Management control – Productivity problems and management – control and performance – direct and preventive control – reporting.

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to have clear understanding of managerial functions like planning, organizing, staffing, leading & controlling and have same basic knowledge on international aspect of management

TEXT BOOKS:

1. Stephen P. Robbins & Mary Coulter, "Management", Prentice Hall (India) Pvt. Ltd., 10th Edition, 2009.
2. JAF Stoner, Freeman R.E and Daniel R Gilbert "Management", Pearson Education, 6th Edition, 2004.

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1. Stephen A. Robbins & David A. Decenzo & Mary Coulter, "Fundamentals of Management" Pearson Education, 7th Edition, 2011.
2. Robert Kreitner & Mamata Mohapatra, "Management", Biztantra, 2008.
3. Harold Koontz & Heinz Weihrich "Essentials of Management" Tata McGraw Hill,1998.
4. Tripathy PC & Reddy PN, "Principles of Management", Tata Mcgraw Hill, 1999.

Subject Code: MG6851 **Year/Semester: IV/07**
Subject Name: Principles of Management **Subject Handler: Mrs. E. Priya**

UNIT I - INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS

Definition of Management – Science or Art – Manager Vs Entrepreneur - types of managers - managerial roles and skills – Evolution of Management – Scientific, human relations , system and contingency approaches – Types of Business organization - Sole proprietorship, partnership, company-public and private sector enterprises - Organization culture and Environment – Current trends and issues in Management.

PART * A

Q. No	Questions
1	**Define Management? [May 2011,Dec 2012, Dec 2014, May 2016, May 2017, Dec 2017, Dec 2018, May 2019]** BTL1 According to KOONTZ & WEIHRICH, "Management is the process of designing and maintaining of an environment in which individuals working together in groups efficiently accomplish selected aims". "Management is the art of getting things through and with people in formally organized groups". Ex: Human Resource Management, Financial Management.
2	**Is Management - an art or science?** **What is the relation between art and science of management?[May 2012]** BTL4 Managing as practice is an art; the organized knowledge underlying the practice is a science. Managing has the following features that make it an art. • Creative • Individual approach • Application and dedication • Initiative and • Intelligence. The following features make it a science. • Systematic decision making • Universal management process • Situational output and • Universally accepted management. Thus management can be called both as an art and science.
3	**What are the essential skills of Managers? [Dec 2018]** BTL2 The major skills required or expected out of managers are:- • Technical skills – Pertaining to knowledge and proficiency in activities involving methods and procedures; • Human skills – Ability to work effectively with other persons and to build up cooperative group relations to accomplish organizational objectives; • Conceptual skills – Ability to recognize significant elements in a situation; and to understand the relationship among those elements; and • Design skills – Ability to solve problems in ways that will benefit the enterprise
4	**Define Scientific Management.[May 2008, May 2011, May 2015]** BTL1 Scientific management involves specific method of determination of facts through

	observation. The concept of scientific management was introduced by Frederick Winslow Taylor in the USA in the beginning of 20th century. It was further carried on by Frank and Lillian Gilbreth, Henry Gantt, etc. It was concerned essentially with improving the operational efficiency at the shop floor level. "Scientific Management is concerned with knowing exactly what you want men to do and then see in that they do it best and cheapest way".
5	**List the principles of Scientific Management.** BTL2 Scientific management was introduced by F.W Taylor who is known as the Father of Scientific Management. He adopted scientific methods to increase the productivity and greater efficiency in production. The principles of Scientific Management are:- • Separation of planning and working • Functional foremanship • Job analysers • Time study • Motion study • Fatigue study • Standardization • Scientific selection of training • Financial incentives and • Economy and mental revolution.
6	**List the contributions of Fayol towards Management.** BTL2 Henry Fayol is a French industrialist whose contributions are termed as operational management or administrative management. He followed 'The Classical Approach' to the evolution of management thought. His contributions are given as follows:- • Grouping of activities of an industrial organization into six groups, namely Technical, commercial, financial, security, accounting and managerial; • Identified six types of qualities of a manager are- Physical, mental, moral, educational, technical and experience; • Fourteen principles of Management namely- Division of Work, Authority and responsibility and so on; and • Five elements/functions of management- Planning, organizing, commanding, coordinating and controlling.
7	**What are the functions of management[May 2007, May 2009, May 2011, Dec 2012, May 2016]** BTL2 • Planning • Organizing • Staffing • Leading or Direction or Coordination • Controlling
8	**List out the Management level and functions.[Dec 2011]** BTL2 • Top-level management • Middle level management • Lower level management **Top level management functions** 1. To formulate goals and policies 2. To formulate budgets 3. To appoint top executives **Middle level management functions.** 1. To train motives &develop supervisory level 2. To monitor and control the operations performance

	Low level management 1. To train &develop workers 2. To assign job 3. To give orders and instructions 4. To report the information about the workers
9	**What are the roles played by a Manager?[May 2011,May 2014, May 2015, Dec 2016, May 2018, Dec 2018]** BTL2 **Interpersonal roles** 1. Figurehead role 2. The leader role 3. The liaison role **Informational roles** 4. The recipient role 5. The disseminator role 6. The spokesperson role **Decision roles** 7. The entrepreneurial role 8. The disturbance-handler role 9. The resource allocator role 10. The negotiator role
10	**Define 'Sole proprietorship'.** BTL1 A Business unit that is owned and controlled by a single individual is known as sole trading or sole proprietorship concern. He uses his own savings for running the business. The sole trader makes all purchases and sells on his own and maintains all the accounts. He alone enjoys all the profits and bears all the losses. Ex: A Fancy store.
11	**What do you mean by a 'Partnership firm'?** BTL1 A partnership is an association of two or more persons to carry on business and to share its profit and losses. The relation of a partnership arises from contract. The maximum number of partners is limited to 10 in the case of banking business and 20 in the case of other business. Ex: Chand & Co.
12	**What do you understand by the term 'Joint Stock Company'?** BTL2 "By a Company we mean an association of many persons who contribute money or money's worth to a common stock and employs it in some trade or business and also shares the profit and loss as the case may be arising there from". There are two types of Joint stock companies:- * Private Limited company – Ex: M/s Key Media Pvt. Ltd. * Public Limited company – Ex: M/s Pearl credits Ltd.
13	**Who is (i) an active partner (ii) a sleeping partner?** BTL4 **Active partner**: Any partner who is authorized by others to manage the business is known as active partner. **Sleeping partner**: Any partner who does not express his intention to participate in the business can be called as a sleeping partner. He will be just an investor who has a right to share profits.
14	**What is a Co-operative Enterprise?** BTL1 A Co-operative enterprise is a voluntary association of persons for mutual benefit and its aims are accomplished through self-help and collective effort. It may be described as a protective device used by the relatively less strong sections of society to safeguard their economic interests in the face of exploitation by producers and sellers working solely for maximizing profits. Ex: AAVIN Milk Federation Cooperative Society.
15	**What is a Private limited company?** BTL1 A Private limited company is a company which has a minimum paid up capital as may be

prescribed. It can be incorporated with just two persons. It can have a maximum of 50 members. It cannot go in for a public issue. It restricts the transfer of its shares. It is particularly suitable for industrial ventures which can get many concessions in respect of income tax.

Ex: M/s Key Media Pvt. Ltd.

16 **What is a Public limited company?** BTL1

A Public limited company should have a minimum of 7 members and the maximum limit is unlimited. It can issue shares to the Public. The financial statement should be sent to all the members and to the Registrar of Companies. The shares of a public limited company can be transferred by the members to the others without any restriction by the company. Such transfers are made through organized markets called ‘stock markets’ or ‘stock exchanges’.

Ex: M/s Pearl credits Ltd.

17 **What is a Public sector Enterprise?** BTL1

Public enterprise or State enterprise is an undertaking owned and controlled by the local or state or central government. They are financed and managed by the government. They are started with a service motive.

Ex: NLC Ltd.

18 **What is a Public Corporation?** BTL2

A Public corporation is an autonomous body corporate created by a special statute of a state or central government. A public corporation is a separate legal entity created for a specific purpose.

Ex: LIC.

19 **Distinguish between Administration and Management [May 2008,Dec 2009,May 2014,Dec 2014]** BTL2

Administration	**Management**
Higher level of functions	Lower level of functions
Refers to the owners of the organisation	Refers to the employees
Concerned with decision making	Concerned with execution of decision
Acts through the management	Acts through the organisation

20 **Name the different forms of organisation?[Dec 2009]** BTL4

- Sole proprietorship
- Partnership
- Joint stock company
- Co-operative enterprises
- Public enterprise

21 **What is the meaning for entrepreneur? [May 2019]** BTL2

Entrepreneur is a person who starts the business and utilizes the resources of men, money, materials and machines.

22 **Define administration [Dec 2007, May 2013]** BTL1

Administration is concerned with decision making and policy formulation while the management is concerned with the execution of what has been laid down by the administrators.

23 **What are the functions performed by a low level manager? [Dec 2013]** BTL2

- To assign jobs to workers
- To give orders and instructions
- To report feedback information about workers
- To train and develop the efficiency of the workers

24 **Who is known as the father of modern operation management theory? [May2012]** BTL1

Henri Fayol

25 **What is meant by Esprit De corps? [May 2009]** BTL2

Union is strength. In organisation, employees should be harmony and unity. It improves the employee morale.

26 **What is time study? [May 2010]** BTL2

It is the studies of the movements which take a minimum time are the best one.

27 **Define partnership? [Dec 2017]** BTL1

Partnership is the relation between persons competent to make contracts who have agreed to carry on a lawful business in common with a view to private gain

28 **Define Organisation culture? [May 2017]** BTL2

It is a system of informal rules that spells out how people have to behave in most of the time

29 **Distinguish between public and private limited companies? [May 2018]** BTL4

Public limited company	**Private limited company**
Company which is owned and traded publicly	Company which is owned and traded privately
After receiving certificate of incorporation and certificate of commencement of business	After receiving certificate of incorporation

30 **Give the current trends in management [Dec 2016]** BTL5

- Workforce diversity
- Internal environment
- Technological advances
- Management of human relations

31 **How does effectiveness differ from efficiency? [May 2009]** BTL4

Efficiency means doing things right. It defines the ability to minimize the use of resources in achieving organisational objectives.

Effectiveness means "Doing the right thing". The ability is to determine the appropriate objectives.

32 **Define Globalization? [Dec 2006, May 2012, May 2013]** BTL1

It is the process of transformation of local or regional phenomena in to global ones. It can be described as a process by which the people of the world are unified into a single society and function together.

33 **What is multinational corporation (MNC)? [May 2010]** BTL1

An enterprise which own or control the production or service facilities outside the country in which they are based is called Multinational Corporation.

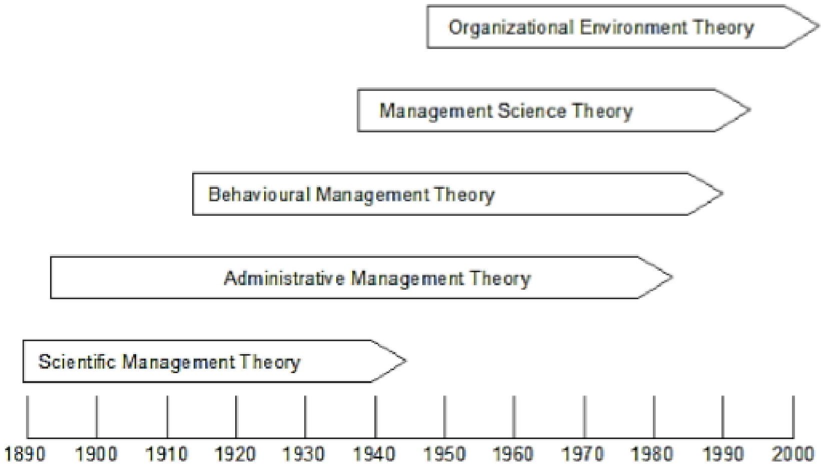
PART * B

1

Trace the evolution of management with reference to the contributions made by management thinkers. [Dec 2016]
Write an essay about the contributions made by F.W.Taylor, Henri Fayol, L.Gantt, Frank and Lillian Gilberth, George Elton Mayo and others to the field of management. [May 2004, May 2005, May 2008, May 2009, May 2011, May 2012, May 2018] (13M)
Describe about the evolution of management thought. [May 2012, May 2011, Dec 2016, May 2016, Dec 2018] BTL4

Answer: Page 1.23 - Dr. G.K. Vijayaraghavan

Management is defined for conceptual, theoretical and analytical purposes as that process by which managers direct, maintain and operate purposive organizations through systematic, coordinated, cooperative human efforts. Management is a process involving planning, organizing, staffing, directing and controlling human efforts to achieve stated objective in an organization. (1M)



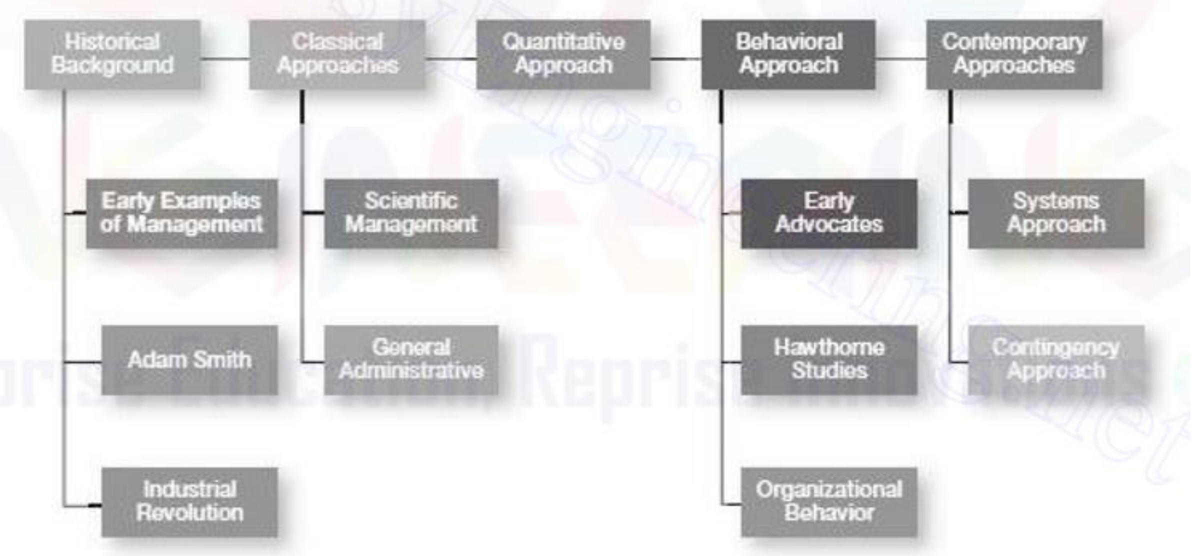
(2M)

Fredrick w Taylor (1986-1915) rested his philosophy on four basic principles. (3M)
1. The development of a true science of management so that the best method for performing each task could be determined.
2. The Scientific selection of workers so that the each worker would be given responsibility for the task for which he or she was best suited.
3. The scientific education and development of workers.
4. Intimate friendly cooperation between management and labor.

The scientific management schools
1. Scientific management theory arose in part from the need to increase productivity.
2. In the United States especially, skilled labor was in short supply at the beginning of the twentieth century.
3. The only way to expand the productivity was to raise the efficiency of workers.

Therefore ,Fredrick W.Taylor, Henry Gantt, and Frank and Lillian Gilberth devised the body of principles known as Scientific management theory

Taylor contended that the success of these principles required" a complete mental revolution" on the part of management and labor.



THE GILBRETHS (2M)

Frank B. and Lillian M.Gilbreth (1968-1924) and (1878-1972) made their contribution To the scientific management movement as a husband and wife team. Lillian and Franck collaborated on fatigue and motion studies and focus on ways on promoting the individual workers welfare to them the ultimate aim of scientific management was to help workers reach their full potential as human beings.

In their conception motion and fatigue were intertwined every motion that was eliminated reduced fatigue.

Using motion picture cameras they tried to find out the most economical motions for each task in order to upgrade performance and reduce fatigue.

CLASSICAL ORGANIZATION THEORY SCHOOL Scientific management was concerned with increasing the productivity of the shop and the individual worker. Classical organization theory grew out of the need to find guidelines for managing such complex organization as factories.

HENRI FAYOL (3M)

Henri Fayol (1841-1925) is generally hailed as the founder of the classical management school –not because he was the first to investigate managerial behaviour but because he was the first to systematize it.

Fayol believed that sound manage

1. **DIVISION OF LABOR**

The most people specialize the more efficiency they can perform their work. This principle is epitomized by the modern assembly line.

2. **AUTHORITY**

Managers must give orders so that they can get things done while this format give them a right to command managers will not always compel obedience unless they have

Personal authority (such as relevant) expert as well

3. **DISIPLINE MEMBERS IN AN ORGANIZATION**

needs to respect the rules and agreement that govern the organization. To Fayol, discipline leadership at all levels of the organization fair agreements and judiciously enforced penalties

	for infractions. **4. UNITY OF COMMANDS** Each employee must receive instruction from one person, Fayol believe that if employee reported. More than one manager conflict in instruction and confusion in of authority would result. **5. UNITY OF DIRECTION** Those operations with in the same organization that have the same objective should be directed by only one manager using one plan. For example the personnel department in the company should not have a two directors each with a different hiring policy. **6. SUBORDINATE OF INDIVIDUAL INTEREST TO COMMON GOOD** In any undertaking the interest of employees should not take the precedence over the interest of organization as a whole 7. **REMUNERATION:** Compensation of work done should be common to both employees and employers. 8. **CENTRALIZATION:** Decreasing the role of subordinates in decision making is centralization, increasing their role is decentralization. Fayol believed that the managers should retain the final responsibility. But should at the same time give their subordinate enough authority to do the jobs properly. The problem is finding the proper degree of centralization in each case. 9. **THE HIERARCHY** The line of authority in an organization should represent in the neat box and the line of chart runs in order of rank from top management and lowest levels of enterprise. 10. **ORDER:** Materials and the order should be in the right place at the right time. In particular should be in job or position they are most suited to. 11. **EQUITY:** Managers should be fair and friendly to their subordinate. 12. **STABILTY OF STAFF:** A high employee turnover rate undermines the efficient functioning of an organization. 13. **INITIATIVE:** Subordinate should be given the freedom to conceive and carry out their plans even though some mistake may result. 14. **ESPRIT DE CROPS:** Promoting team spirit will give the organization a sense of unity. To Fayol even the small factor help to develop the spirit. He suggested for example the use of verbal communication instead of formal, written communication whenever possible. **Elton Mayo (1M)** His contributions came as a part of the Hawthorne studies which is a series of experiments that rigorously applied classical management theory only to reveal its shortcomings. **Henry Gantt (1M)** A bar graph measures the planned and completed work along each stage of production.
2	**Explain the different roles and functions of a manager [May 2012, May 2017] (8M)** BTL2 **Answer: Page 1.15 Dr. G.K. Vijayaraghavan** **Different roles of a Manager (4M)** **Interpersonal roles** 1. Figurehead role 2. The leader role 3. The liaison role **Informational roles**

4. The recipient role 5. The disseminator role 6. The spokesperson role

Decision roles

7. The entrepreneurial role 8. The disturbance-handler role 9. The resource allocator role 10. The negotiator role

functions of a manager (4M)

- To formulate the goals and policies of the company
- To formulate the budgets
- To appoint the top executives
- To decide the distribution of profits etc..,

3 **Explain the fourteen principles of management as advocated by Henry Fayol. [Dec 2006, May 2007, May 2013, Dec 2014, May 2016, Dec 2017, Dec 2018] (8M)** BTL4

Answer: Page 1.24 -Dr. G.K. Vijayaraghavan

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Fayol believed that sound manage (5M)

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Personal authority (such as relevant) expert as well

3. **DISIPLINE MEMBERS IN AN ORGANIZATION**

Each employee needs to respect the rules and agreement that govern the organization. To Fayol, discipline leadership at all levels of the organization fair agreements and judiciously enforced penalties for infractions.

4. **UNITY OF COMMANDS**

Each employee must receive instruction from one person, Fayol believe that if employee reported. More than one manager conflict in instruction and confusion in of authority would result.

5. **UNITY OF DIRECTION**

Those operations with in the same organization that have the same objective should be directed by only one manager using one plan. For example the personnel department in the company should not have two directors each with a different hiring policy.

6. **SUBORDINATE OF INDIVIDUAL INTEREST TO COMMON GOOD**

In any undertaking the interest of employees should not take the precedence over the interest of organization as a whole

7. **REMUNERATION:** Compensation of work done should be common to both employees and employers.

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4 **Explicate the different types of business organisation [May 2005, Dec 2016, May 2017, May 2019] (13M)** BTL2

Answer: Page 1.46-Dr. G.K. Vijayaraghavan

Business organisation (2M)

According to Urwick and Hunt, "A business is an enterprise which distributes or provides an article or services where other members of the community need and they are able and willing to pay for it".

Types of business organization(1M)

- Sole proprietorship
- Partnership
- Joint stock company
- Co-operative enterprises
- Public enterprise

Sole proprietorship(2M)

A Business unit that is owned and controlled by a single individual is known as sole trading or sole proprietorship concern. He uses his own savings for running the business. The sole trader makes all purchases and sells on his own and maintains all the accounts. He alone enjoys all the profits and bears all the losses.

Ex: A Fancy store.

Partnership(2M)

A partnership is an association of two or more persons to carry on business and to share its profit and losses. The relation of a partnership arises from contract. The maximum number of partners is limited to 10 in the case of banking business and 20 in the case of other business.

Ex: Chand & Co.

Joint stock company(2M)

"By a Company we mean an association of many persons who contribute money or money's worth to a common stock and employs it in some trade or business and also shares the profit and loss as the case may be arising there from".

There are two types of Joint stock companies:-

* Private Limited company – Ex: M/s Key Media Pvt. Ltd.
* Public Limited company – Ex: M/s Pearl credits Ltd.

Co-operative enterprises(1M)

A Co-operative enterprise is a voluntary association of persons for mutual benefit and its aims are accomplished through self-help and collective effort. It may be described as a protective device used by the relatively less strong sections of society to safeguard their economic interests in the face of exploitation by producers and sellers working solely for maximizing profits.

Ex: AAVIN Milk Federation Cooperative Society.

Public sector enterprise(1M)

Public enterprise or State enterprise is an undertaking owned and controlled by the local or state or central government. They are financed and managed by the government. They are started with a service motive.

Ex: NLC Ltd.

Private limited company (1M)

A Private limited company is a company which has a minimum paid up capital as may be prescribed. It can be incorporated with just two persons. It can have a maximum of 50 members. It cannot go in for a public issue. It restricts the transfer of its shares. It is particularly suitable for industrial ventures which can get many concessions in respect of income tax.

Ex: M/s Key Media Pvt. Ltd.

Public limited company (1M)

A Public limited company should have a minimum of 7 members and the maximum limit is unlimited. It can issue shares to the Public. The financial statement should be sent to all the members and to the Registrar of Companies. The shares of a public limited company can be transferred by the members to the others without any restriction by the company. Such transfers are made through organized markets called ‘stock markets’ or ‘stock exchanges’.

Ex: M/s Pearl credits Ltd.

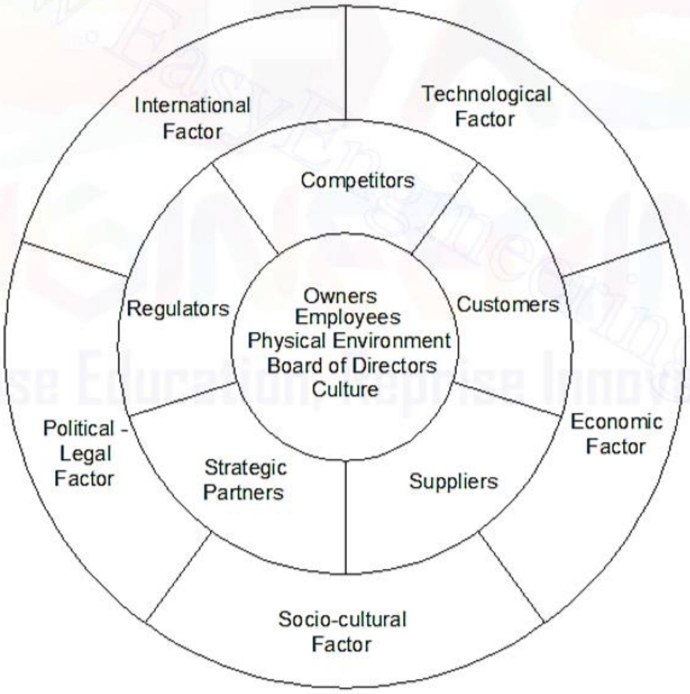
5 **Enumerate the trends and challenges of management in globalised era [Dec 2012, May 2013, May 2014, Dec 2017]** BTL2

(or) Explain about the major tendencies favouring the development of a unified global theory of management. [May 2007, May 2010, May 2011] BTL2

Answer: Page 1.81-Dr. G.K. Vijayaraghavan (13M)

Changes in socio economic and political conditions are bound to bring the changes in the environment within the organizations

i. Workforce diversity
ii. Changing demographics of workforce
iii. Changing employee expectations
iv. Internal environment
v. Building organizational capabilities
vi. Job design and organizational structure
vii. Changing psycho social system
viii. technological advances
ix. Management of human relations
x. Changes in legal environment

	xi. Change in industrial relations xii. Expanding Globalization
6	**Enlighten the relevance of environmental factors that affects global business [Dec 2012, May 2018] (16M)** BTL4 **Answer: Page 1.75-Dr. G.K. Vijayaraghavan** The factors which may affect the way of business is operated is called environmental factors.  The organizational environment is the set of forces surrounding an organization that have the potential to affect the way it operates and its access to scarce resources. The organization needs to properly understand the environment for effective management. Scholars have divided these environmental factors into two main parts as, a) Internal Environment, b) External Environment. **Internal Environment** The internal environment consists of the organization's owners, board of directors, regulators, physical work environment and culture. In the internal environment include strength and weakness of an organization. Elements of internal environment are: 1. Trade union 2. Management 3. Current employee 4. Shareholders. **External Environment:** As per the Daft theory (1997) , An organization's environment is defined as all the elements existing outside the boundary of the organization that have the potential to affect all or part of the organization Examples include government regulatory agencies, competitors, customers, suppliers, and pressure from the public. Daft (1997) identified 10 environmental

sectors that may have an impact on particular organizations: 1)industry, 2) raw materials, 3) human resources, 4) financial resources, 5) markets, 6) technology, 7) general economy, 8) government/legal, 9) sociocultural, 10) international. Each of these sectors may be divided into two basic components.

They are: 1) Task (Specific) Environment: 2) General Environment.

Task Environment: Task environment is composed of the specific dimensions of the organization's surrounding that are very likely to influence of the organization. It also consists of five dimensions: Competitors, Customers, and Employees, Strategic, Planners and suppliers.

General Environment: General environment is composed of the nonspecific elements of the organization's surrounding the might affect its activities. It consists of five dimensions:

(a) Economic Factor Economic factors refer to the character and direction of the economic system within which the firm operates. Economic factors include

- The balance of payments,
- The state of the business cycle,
- The distribution of income within the population, and
- Governmental monetary and fiscal policies.

The impact of economic factors may also differ between industries. BALANCE OF PAYMENTS. The balance of payments of a country refers to the net difference in value of goods bought and sold by citizens of the country. To decrease the value of goods imported into a country, it is common practice to construct barriers to entry for particular classes of products. Such practices reduce competition for firms whose products are protected by the trade barriers.

Example: Mexico has limited the number of automobiles that can be imported. The purpose of this practice is to stimulate the domestic automobile market and to allow it to become large enough to create economies of scale and to create jobs for Mexican workers. A side effect of the import restriction, however, has been an increase in the price and a decrease in the quality of automobiles available to the public.

Another potential consequence of import restrictions is the possibility of reciprocal import restrictions. Partially in retaliation to import restriction on Japanese televisions and automobiles by the United States, the Japanese have limited imports of agricultural goods from the United States. Lowering trade restrictions as a means of stimulating the economy of a country may meet with mixed results. The North American Free Trade Agreement (NAFTA) has opened the borders between the United States, Canada, and Mexico for the movement of many manufacturers. Government officials in the United States argue the results have been positive, but many local communities that have lost manufacturing plants question the wisdom of the agreement. BUSINESS CYCLE The business cycle is another economic factor that may influence the operation of a firm. Purchases of many durable goods (appliances, furniture, and automobiles) can be postponed during periods of recession and depression, as can purchases of new equipment and plant expansions. Economic downturns result in lower profits, reductions in hiring, increased borrowing, and decreased productivity for firms adversely affected by the recession. Positive consequences of recessions may include reductions in waste, more realistic perceptions of working conditions, exit of marginally efficient firms, and a more efficient system.

INCOME DISTRIBUTION

The distribution of income may differ between economic systems. Two countries with the same mean (per capita) income levels may have dramatically different distributions of income. The majority of persons in the country are considered middle income, with only a relatively small number of persons having exceptionally high or low incomes.

Many developing countries have citizens who are either extremely wealthy or extremely poor. Only a few persons would qualify as middle class. Therefore, although both countries had the same mean income, opportunities to market products to the middle class would be greater in the United States.

TRANSFER PAYMENTS.

Transfer payments (e.g., welfare, social security) within the country change the distribution of income. Transfer payments provide money to individuals in the lower income brackets and enable them to purchase goods and services they otherwise could not afford. Such a redistribution of income may not be the practice in other economic systems. Thus, large numbers of people in need of basic goods and services do not assure that those people will be able to purchase such goods and services.

MONETARY AND FISCAL POLICIES.

Monetary and fiscal policies utilized by the federal government also influence business operations. Monetary policies are controlled by the Federal Reserve System and affect the size of the money supply and interest rates. Fiscal policies represent purchases made by the federal government.

Example : Allocation of funds to defense means expenditures for weapons and hardware. If appropriations had gone to the Health and Human Services and Education Departments instead, much of the money would have constituted transfer payments. The primary beneficiaries of such a fiscal policy would be firms in the basic food and shelter businesses. No matter how government expenditures are reallocated, the result is lost sales and cut budgets for some companies and additional opportunities for others.

(b) Technological Factor Technology is another aspect of the environment a firm should consider in developing strategic plans. Changing technology may affect the demand for a firm's products and services, its production processes, and raw materials. Technological changes may create new opportunities for the firm, or threaten the survival of a product, firm, or industry. Technological innovation continues to move at an increasingly rapid rate.

DEMAND Technology can change the lifestyle and buying patterns of consumers. Recent developments in the field of microcomputers have dramatically expanded the potential customer base and created innumerable opportunities for businesses to engage in business via Internet. Whereas computers were traditionally used only by large organizations to handle data processing needs, personal computers are commonly used by smaller firms and individuals for uses not even imagined fifteen years ago. Similarly, new developments in technology led to a reduction in prices for computers and expanded the potential market. Lower prices allow computers to be marketed to the general public rather than to business, scientific, and professional users—the initial market.

Technology may also cause certain products to be removed from the market. Asbestos-related illnesses have severely limited asbestos as a resource used in heat-sensitive products such as hair dryers. Further, a number of chemicals that have been commonly used by farmers to control insects or plants are prohibited from use or require licensure as a consequence of those chemicals appearing in the food chain.

PRODUCTION PROCESSES Technology also changes production processes. The introduction of products based on new technology often requires new production techniques. New production technology may alter production processes. Robotics represents one of the most visible challenges to existing production methods. Robots may be used in positions considered hazardous for people or that require repetitive, detailed activities. The consequences for other jobs currently occupied by people are not clear. When production was first automated, although some workers were displaced, new jobs were created to produce and maintain the automated equipment. The impact of robotics on jobs is in large part a function of the uses made of the technology and the willingness of workers to learn to use new technology. In some industries, use of robots during the early 2000s increased production and efficiency but resulted in significant numbers of job losses. However, technological innovation can also result in increased job growth.

Example: Ford Motor Company's $375-million technology update to its Norfolk assembly plant to build its 2004 F-150 resulted in the ability to build more models on its assembly line and consequently created about 270 new jobs, an 11% increase.

EVALUATING TECHNOLOGICAL CHANGES There is little doubt that technology represents both potential threats and potential opportunities for established products. Products with relatively complex or new technology are often introduced while the technology is being refined, making it hard for firms to assess their market potential.

Example: When ballpoint pens were first introduced, they leaked, skipped, and left large blotches of ink on the writing surface. Fountain pen manufacturers believed that the new technology was not a threat to existing products and did not attempt to produce ball-point pens until substantial market share had been lost

Another technology, the electric razor, has yet to totally replace the blade for shaving purposes. Perhaps the difference is that the manufacturers of blades have innovated by adding new features to retain customers. Manufacturers of fountain pens did not attempt to innovate until the ballpoint pen was well established. It is quite difficult to predict the impact of a new technology on an existing product. Still, the need to monitor the environment for new technological developments is obvious. Attention must also be given to developments in industries that are not direct competitors, since new technology developed in one industry may impact companies and organizations in others.

(c) Sociocultural The sociocultural dimensions of the environment consist of customs, lifestyles, and values that characterize the society in which the firm operates. Socio-cultural components of the environment influence the ability of the firm to obtain resources, make its goods and services, and function within the society. Sociocultural factors include anything within the context of society that has the potential to affect an organization. Population demographics, rising educational levels, norms and values, and attitudes toward social responsibility are examples of sociocultural variables. POPULATION CHANGES Changes in population demographics have many potential consequences for organizations. As the total population changes, the demand for products and services also changes. For instance, the decline in the birthrate and improvement in health care have contributed to an increase in the average age of the population in the country. Many firms that traditionally marketed their products toward youth are developing product lines that appeal to an older market.

Example: Clothing from Levi Strauss & Co. was traditionally popular among young adults. While its popularity in this market has waned, the firm has been able to develop a strong following in the adult market with its Dockers label.

Other firms are developing strategies that will allow them to capitalize on the aging population. Firms in the health-care industry and firms providing funeral services are expected to do well give the increasing age of the country population.

RISING EDUCATIONAL LEVELS. Rising educational levels also have an impact on organizations. Higher educational levels allow people to earn higher incomes than would have been possible otherwise. The increase in income has created opportunities to purchase additional goods and services, and to raise the overall standard of living of a large segment of the population. The educational level has also led to increased expectations of workers, and has increased job mobility. Workers are less accepting of undesirable working conditions than were workers a generation ago. Better working conditions, stable employment, and opportunities for training and development are a few of the demands businesses confront more frequently as the result of a more educated workforce.

NORMS AND VALUES Norms (standard accepted forms of behaviour) and values (attitudes toward right and wrong) are differ across time and between geographical areas. Lifestyles differ as well among different ethnic groups. As an example, the application in the United States of Japanese-influenced approaches to management has caused firms to re-evaluate the concept of quality. Customers have also come to expect increasing quality in products. Many firms have found it necessary to re-examine production and marketing strategies to respond to changes in consumer expectations.

SOCIAL RESPONSIBILITY Social responsibility is the expectation that a business or individual will strive to improve the welfare of society. From a business perspective, this translates into the public expecting businesses to take active steps to make society better by virtue of the business being in existence. Like norms and values, what is considered socially responsible behaviour changes over time. In the 1970s agreeing action was a high priority. During the early part of the twenty-first century prominent social issues were environmental quality (most prominently, recycling and waste reduction) and human rights, in addition to general social welfare. More than just philanthropy, social responsibility looks for active participation on the part of corporations to serve their communities.

(d) **Political-Legal Factor** The political-legal dimension of the general environment also affects business activity. The philosophy of the political parties in power influences business practices. The legal environment serves to define what organizations can and cannot do at a particular point in time.

ATTITUDES TOWARD BUSINESS A pro-business attitude on the part of government enables firms to enter into arrangements that would not be allowed under a more anti-business philosophy. The numerous joint ventures between U.S. and Japanese automobile manufacturers could have been termed anticompetitive by a less pro-business administration. The release of many acres of government land for business use (logging, mining) angered many environmentalists who had been able to restrict business use of the land under previous administrations. Changes in sentiments toward smoking and its related health risks have altered the public's attitude toward the tobacco industry. These changes have been reflected in many organizations by limiting smoking to designated areas or completely prohibiting it at work. The transformation in attitude has also caused firms within the tobacco industry to modify marketing strategies, encouraging many to seek expansion opportunities abroad. LEGISLATION The legal environment facing organizations is becoming more complex and affecting businesses more directly. It has become increasingly difficult for businesses to take action without encountering a law, regulation, or legal problem. A very brief listing of significant laws that affect business would include legislation in the areas of consumerism, employee relations, the environment, and competitive practices. Many of the laws also have an associated regulatory agency.

LEVELS OF GOVERNMENT INFLUENCE We generally speak about "the government" as referring to the federal government. It is the federal government that passes and enforces legislation concerning the entire country. Actions by the federal government affect a large number of firms and are consistent across state boundaries. Environmental analysis, however, should not overlook actions by both state and local governments. Regulations concerning many business practices differ between states. Tax rates vary widely. Laws regarding unionization (e.g., right-to-work states) and treatment of homosexual workers differ between states. Local governments have the potential to affect business practices significantly. Some local governments may be willing to provide incentives to attract business to the area. Some may build industrial parks, service roads, and provide low-interest bonds to encourage a desirable business to move into the community. Regulatory measures such as building codes and zoning requirements differ significantly between communities. Infrastructure such as electric and sewer services, educational facilities, and sewage treatment capabilities may not be able to accommodate the increased demand associated with certain industries, making that locale unsuitable for establishing some businesses.

(e**)** **International Factor** A final component of the general environment is actions of other countries or groups of countries that affect the organization. Governments may act to reserve a portion of their industries for domestic firms, or may subsidize particular types of businesses to make them more competitive in the international market. Some countries may have a culture or undergo a change in leadership that limits the ability of firms to participate in the country's economy.

ECONOMIC ASSOCIATIONS One of the most recent joint efforts by governments to influence business practices was NAFTA. The agreement between the United States, Canada, and Mexico was intended to facilitate free trade between the three countries. The result has been a decrease in trade barriers between them, making it easier to transport resources and outputs across national boundaries. The move has been beneficial to many businesses, and probably to the economies of all three countries. In most economic associations, preference is also given to products from member countries at the expense of products from non-members. Probably the best-known joint effort by multiple countries to influence business practices is the Organization of Petroleum Exporting Countries (OPEC). The formation of OPEC, an oil cartel including most major suppliers of oil and gas, led to a drastic increase in fuel prices. Rising fuel prices had a significant effect on the demand for automobiles worldwide. The increases in oil prices also contributed to inflation all over the world. OPEC's early success encouraged countries producing other basic products (coffee beans, sugar, bananas) to attempt to control the prices of their products.

INTERGOVERNMENTAL RELATIONS Changing relationships between the United States and other countries may alter the ability of firms to enter foreign markets. The United States' establishment of trade relations with China in the 1970s created opportunities for many firms to begin marketing their products in China. The rise of Ayatollah Ruhollah Khomeini to power in Iran altered the lives of many Iranian citizens. Wine, vodka, music, and other forms of entertainment were prohibited. Black markets provided certain restricted items. Other products, such as wine, began to be produced at home.

7 **Describe the distinction between administration and management [May 2010, May 2011, May 2012] (4M)** BTL4

Answer: Page 1.10-Dr. G.K. Vijayaraghavan

Administration	**Management**
Higher level of functions	Lower level of functions
Refers to the owners of the organisation	Refers to the employees
Concerned with decision making	Concerned with execution of decision
Acts through the management	Acts through the organisation

8 **Is management is science or art? Discuss. [Dec 2006, May 2007, May 2016, Dec 2018] (8M)** BTL2

Answer: Page 1.8-Dr. G.K. Vijayaraghavan

Managing: Science or Art?

The best response to the question of whether management is an art or a science is that it is both. Managing, like all other practices (e.g., music composition, medicine, or even tennis) is an art. To manage effectively, peoples must have not only the necessary abilities to lead but also a set of critical skills acquired through time, experience, and practice. If we define art as a personal aptitude or skill, then management has certain artistic components. On the other hand, the organized knowledge underlying the practice may be referred to as a science. To perform at high levels in a variety of situations, managers must be able to draw on the sciences - particularly economics, sociology, mathematics, political science, psychology, and political science - for assistance and guidance. The tasks of modern managers require the use of techniques, practices, and skills. In this context science and art not mutually exclusive but complementary.

Management as an Art (4M)

Art involves the systematic application of theoretical knowledge and personal skills to achieve desired results. The function of art is to effect change and to bring about desired results through deliberate efforts. Art represents 'how' of human behaviour because it is the know-how to accomplish concrete practical results. Art is a personalized process as every artist has his own style. Art is essentially creative and the success of an artist is measured by the results he achieves. A carpenter making furniture out of wood and a goldsmith shaping gold into ornaments are examples of art. Art prescribes how to do things and it can be improved through continuous practice. Art is result-oriented involving practical way of doing specific things. It consists of bringing about desired results through the use of skills. Art involves practical application of theoretical knowledge.

Management is essentially an art because of the following reasons:

(a) The process of management involves the use of knowledge and skills. Every manager has to apply certain knowhow and skills while dealing with people.

(b) Management seeks to achieve concrete practical results, e.g., profits, service, etc.

	According to Prof. John F. Mee, "management is the art of securing maximum results with a minimum of effort so as to secure maximum prosperity and happiness for both employer and employee and give the public best possible service." (c) Like any other art, management is creative. It brings out new situations and makes resources productive. In fact, management is one" of the most creative arts because it requires moulding and welding the attitudes and behaviour of people at work for the accomplishment of specific goals in a changing environment. It is the art of securing desired response from people. Management makes things happen. (d) Like any other art, management is a personalized process. Every manager has his own approach and technique depending upon his perception and the environmental conditions. (e) As an art, management requires judgment and skills. The art of management can be refined with continuous practice of management theories and principles. The art of management is as old as human civilization. The importance of management art has increased with rapid growth in the number size and complexity of organizations. **Management as a Science: (4M)** Science is an organized or systematized body of knowledge pertaining to a particular field of enquiry. Science is systematized in the sense that it establishes cause and effect relationship between different variables. Such systematized body of knowledge contains concepts, principles and theories which help to explain past events and to predict the outcome of specific actions. These principles are capable of universal application, i.e., they can be applied under different situations. They represent fundamental truths derived through empirical results. These principles or basic truths are developed through scientific methods of continuous observation, experiment and testing. When generalizations or hypotheses are empirically verified for accuracy through continuous observation and experimentation they become principles. Science explains 'why' of human behaviour. Management is a science because it contains all the characteristics of science. Firstly, there is a systematized body of knowledge in management. Principles are now available in every function of management and these principles help to improve managerial effectiveness. For instance, there are a number of principles which serve as guidelines for delegating authority and thereby designing an effective organization structure. Similarly, there are several techniques (ways of doing things) in the field of management. Budgeting, cost accounting, ratio analysis, rate of return on investment, critical path method (CPM), programed evaluation and review technique (PERT) are some of these techniques which facilitate better management. Secondly, principles of management have been developed through continuous observations and empirical verification. Thirdly, management principles are capable of universal application. Thus management can be called both as an art and science.
9	**Mention the scientific principles of management and also specify the features of scientific management. [Dec 2007, May 2010]** BTL4 **Answer: Page 1.23-Dr. G.K. Vijayaraghavan** **PRINCIPLES OF MANAGEMENT (8M)** The management activities are known as principles of management which are as follows: • Forecasting and Planning, • Organizing • Commanding,

- Co-ordaining and
- Controlling

Forecasting and Planning

Planning means looking ahead or to foresee. To foresee means, “Both to assess the future and make provision for it. To plan means to foresee and provide means for future.

The process of planning includes:

1. The identification of organizational goals. The aim of any insurance company is to insure life or property of the human being. The goal is to insure maximum number of person or the property so that the risk can be spread on number of persons.
2. The line of action to be followed. Once aim is set to insurer human being or property then the next step is how to insure human beings or property. The action will be to create a Marketing Department for a company.
3. The various stages through which the action would pass: To sell the insurance product only marketing department at one place i.e head office cannot achieve the results therefore various offices at different location to be set up to sell the insurance products.
4. The method to be used to achieve the desired goals: The next issue comes how to sell the insurance products. Whether it should be through Agents or Corporate Agent or Broker. Accordingly the action of the insurance company will start to recruit the manpower.

Organizing

To organize means building up the dual structure, material and human of the organization. To organize means to provide the organization with everything useful to its functioning raw material, tools, capital and personnel.

Example: An insurance company may not require the raw material but it requires other material i.e. tool (computers), capital and personnel. A sound organization should have the following to achieve the good relationship between material and human.

A single competent and energetic guiding authority: There should be a single person to be overall in-charge of the organization who will report to the Board of directors. Like Chief Executing Officer (CEO) or Managing Director is appointed in all organization whether it is insurance or other type of organization. Irrespective of the size of the organization. Efficient selection of personnel: Any organization is run by the human beings therefore it is always endeavour of the CEO /Managing Director to recruit the manpower weather technical or finance or marketing the person should be intelligent and efficient. It saves the cost because the efficient people understand the working of the organization and take the decisions quickly. In an insurance industry the trained manpower is required because the insurance policies ate technical in nature and requires lot of skill to make the understand to the customer Clear definition of duties at all levels: The duties of each employee should be defined to get the better results from the employees. If duties are not defined then the employees will be confused what to do or not to do. In an insurance company the target should be given to the marketing personnel to insure so many lives or property and being a marketing function, it should not be assigned to Finance Department. Moreover there will be many employees in the department the target should be given to the Head of the Department and then he will assign the targets to his juniors at different locations.

Initiative and responsibility: The management should ensure that employees take initiative to complete the job assigned to them. The employees should be held responsible for not doing the things. In an insurance company the marketing team should be very strong to sell the insurance products. The team should take initiative to meet the number of persons to get the insurance business. The team should not wait for the instruction of their superiors to meet the customers.

Minimum paper work: In the computer era the paper work can be reduced and the employees of the organization should maximum use the computers to save paper work. In insurance the marketing team should send the daily performance report through email which will reduce the paper work.

Reward & efficiency: The good performers should be awarded cash or noncash award which boost the moral and efficiency of the employees.

Unit of command: Every employee should report to one superior not to more than otherwise the performance and controlling of the employees will be very difficult.

Clear and precise decision making: Any decision taken by any employee should not be ambiguous i.e double meaning because it creates confusion. Proper control of Disincentives for faults and error: For any fault of any employee or non-performer should be penalized otherwise it will affect the working of the performers. Supremacy of general interest in relation to individual etc.: Any individual interest should not be clash with the organization interest. The organization interest should be protected.

Commanding

It means setting the business going to get the desired optimum results from the subordinates. The managers must possess the requisites personal qualities and knowledge to command effectively.

The managers must

- Have a thorough knowledge of his personnel
- Have capacity to spot the right and competent workers so as to eliminate the incompetent
- Set a good example i.e leadership
- Conduct periodic assessment or audit of performance
- Be well versed in agreement binding the business and its employees
- Have lively and constant touch with subordinates
- Aim at making unity, energy imitative and loyalty prevail among personnel

Coordinating

It means the process developed by a manger to secure an orderly pattern of group effort among his personnel through unity of action to pursue the common goals. The coordination should be within the resources available in the organization.

Controlling

The controlling means to ensure that everything is done in accordance with the established rules and instruction given to the workmen. The purpose of control is to point out weaknesses and errors in order to rectify them and prevent their recurrence.

The effective control must be Prompt, Followed with sanctions and include measure to prevent recurrence of variances a or error

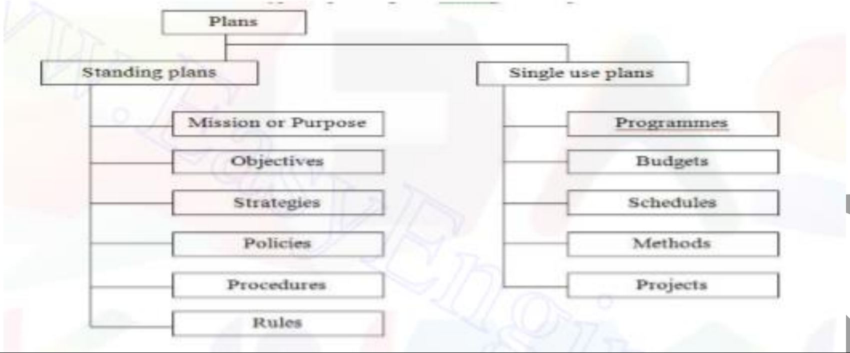
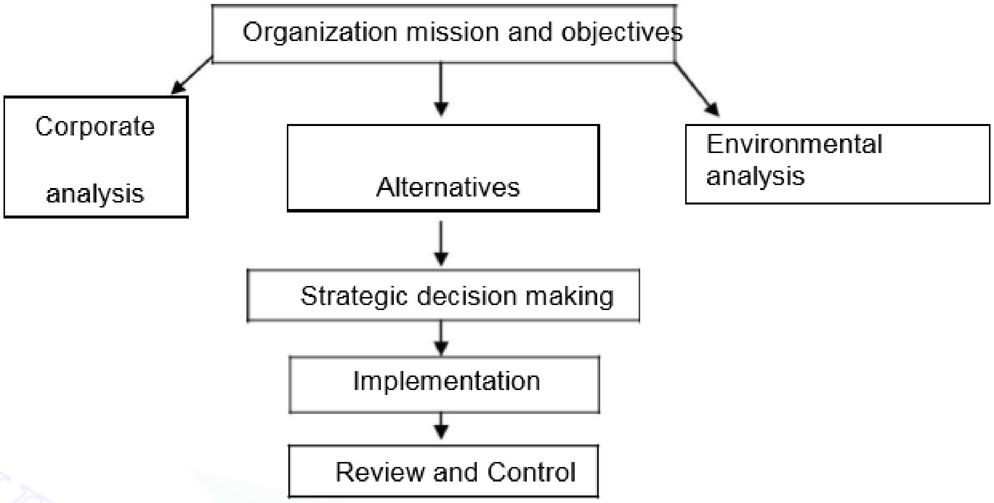
10 **Discuss the various functions of management [Dec 2007, May 2009, May 2011, May 2012] (8M)** BTL4

Answer: Page 1.6-Dr. G.K. Vijayaraghavan

Functions of management

	Planning : Determination of short term and long term objectives Development of strategies to achieve the objectives **Organizing :** Identification of activities to achieve the objectives Matching job and employees Establishing coordinating relationships **Leading :** Staffing Manpower requirement Selection, training and development of employees. Directing Communication Motivation leadership **Controlling :** Establishing standard of performance Measuring current performance Comparing Corrective action to rectify the deviation
	PART * C
1	**“present global environment leads to the success of business”-comment [May 2011]** **Answer: Page 1.81-Dr. G.K. Vijayaraghavan (12M)** BTL4 Changes in socio economic and political conditions are bound to bring the changes in the environment within the organizations i. Workforce diversity ii. Changing demographics of workforce iii. Changing employee expectations iv. Internal environment v. Building organizational capabilities vi. Job design and organizational structure vii. Changing psycho social system viii. technological advances ix. Management of human relations x. Changes in legal environment xi. Change in industrial relations xii. Expanding Globalization

<table>
<tr><td></td><td>UNIT II - PLANNING</td></tr>
<tr><td></td><td>Nature and purpose of planning – planning process – types of planning – objectives – setting objectives – policies – Planning premises – Strategic Management – Planning Tools and Techniques – Decision making steps and process.</td></tr>
<tr><td></td><td>PART * A</td></tr>
<tr><td>Q. No</td><td>Questions</td></tr>
<tr><td>1</td><td>Define planning? [Dec 2008,Dec 2009, May 2018, May 2019] BTL1
Planning is a process of selecting the objectives & determining the course of action required to achieve these objectives. Planning involves selecting missions and the objectives and the actions to achieve them. It ends with decision making, which is choosing the best alternative from the avail-able future courses of action. EG: The goal set for limited period like five year plans</td></tr>
<tr><td>2</td><td>What are the objectives of planning?[May 2013, Dec 2013,May 2015] BTL2
It helps in achieving the objectives
It is done to cope with uncertainly and range
It helps in facilitating control and coordination
It increase organizational effectiveness</td></tr>
<tr><td>3</td><td>What is meant by strategy? [May 2009, Dec 2012, Dec 2017, May 2019] BTL1
A strategy may be defined as special type of plan prepared for meeting the challenges posted by the activities of competitors and other environment forces.</td></tr>
<tr><td>4</td><td>Define policies? [May 2014,Dec 2014, Dec 2016] BTL1
Policies are general statement or understanding which provides guidance in decisions making to various managers.</td></tr>
<tr><td>5</td><td>Define MBO? [May 2011, May 2012, Dec 2016] BTL1
KOONTZ &WEIHRICH: Management by objectives (MBO) is defined as a comprehensive managerial system that integrates many key managerial activities in a systematic manner and that is consciously directed towards the effective and efficient achievement of organizational and individual objective.
"MBO is a process whereby the superiors and the subordinate managers of an enterprise jointly identify its common goals, define each individual major areas of responsibility in terms of results expected of him, and use these measures as guides for operating the unit and assessing the contribution of each of its members." - GEORGE ODIORNE</td></tr>
<tr><td>6</td><td>Distinguish between strategic planning and tactical planning? [May 2014] BTL4
<table>
<tr><th>strategic planning</th><th>tactical planning</th></tr>
<tr><td>Long range plan</td><td>Medium range plan</td></tr>
<tr><td>Covers a time period up to 10 years</td><td>Covers a time period of 1 to 2 years</td></tr>
<tr><td>Not detailed one</td><td>Somewhat detailed</td></tr>
</table></td></tr>
<tr><td>7</td><td>Mention the characteristics of programmed and non programmed decisions? [Dec 2016] BTL5
Programmed decisions are also called as routine decisions. These types of decisions are</td></tr>
</table>

	taken frequently and they are repetitive in nature. Such decisions are generally taken by the middle or lower level managers and have a short term impact. Non programmed structures are also called strategic decisions. This decision is taken by the top management people whenever the need arises. This decision deal with unique problems. Such problems cannot be tackled in a predetermined manner.
8	**Classify the various types of plans? [Dec 2012]** BTL2 
9	**List the steps in decision making process [Dec 2013, May 2017]** BTL5 • Recognize the need for a decision • Definition of the problem • Search and develop the alternatives • Evaluate the alternatives • Selecting an alternative course of an action
10	**Name any four quantitative forecasting techniques? [May 2013]** BTL4 • Regression models • Econometric models • Economic indicators • Substitution effect
11	**Specify the strategic management process** BTL2 
12	**Explain in brief about the two approaches in which the hierarchy of objectives can be explained?** BTL2

	There are two approaches in which the hierarchy can be explained. 1. top-down approach 2. bottom-up approach In the top-down approach, the total organization is directed through corporate objective provided by the top-level management. In the bottom up approach, the top level management needs to have information from lower level in the form of objectives.
13	**Define planning premises? [May 2018]** BTL1 Planning premises are defined as the anticipated environment in which plans are expected to operate. They include assumptions or forecasts of the future & known conditions that will effects the operation of plans.
14	**State the purpose of planning? [May 2012, May 2017]** BTL4 • It helps in achieving objectives • It helps in facilitating control • It helps in coordination • It increases organizational effectiveness
15	**List the planning tools available in business management [May 2017]** BTL5 1. Environmental assessment technique • Environmental scanning • Forecasting methods • Benchmarking • Scheduling • Breakeven analysis • Linear programming 2. Contemporary planning tools • Project management • Contingency planning
16	**Distinguish between policy and rules [Dec 2017]** BTL4 Policies are general statement or understanding which provides guidance in decisions making to various managers. Rules are chronological orders of actions required to implement a policy and to achieve an objectives.
17	**Define corporate planning? [Dec 2014]** BTL1 It is a process used by business to map out a course of action that will result in revenue growth and increased profits.
18	**What are the steps involved in strategic planning? [Dec 2018]** BTL4 1. Mission and objectives. 2. Environmental analysis 3. Corporate analysis 4. Identification of alternatives. 5. Strategic decision making 6. Implementations review & control.
19	**Name the classification of planning premises?** BTL2 1. Internal and external 2. Tangible and intangible premises. 3. Controllable and uncontrollable premises
20	**Define Decision Making [May 2004, May 2006, Dec 2014]** BTL1 Decision Making is defined as selection of a course of action from among alternatives. It is a core of planning. A plan cannot be said to exist unless a decision – a commitment of

	resources, direction or reputation has been made. Until that point, there is only planning studies and analysis.
21	**What are the three approaches in selecting an alternative?** BTL3 1. Experience 2. Experimentation 3. Research and Analysis Experience: Relying on post experience, the choice among alternatives is selected to avoid mistakes. Experimentation: A firm may test a new product in a certain market before expanding its sale nationwide. Research and Analysis: The trend in research and analysis is simulation i.e. to develop mathematical tools.
22	**What is tows metrics?** BTL1 The tows metrics is a conceptual frame work for a systematic analysis, which facilitates matching the external threats and opportunities with the internal weakness & strength of the organization. In the tows metrics 'T' stands for threat's' stands for opportunities 'W' for weakness and 'S' for Strength
23	**Define Forecasting?** BTL1 Forecasting is the process of predicting future conditions that will influence and guide the activities, behaviour and performance of the organization. EG: forecasting the output by sales department.
24	**List out the features of MBO?** BTL3 • MBO is concerned with goal setting and planning for individual managers and their units. • The essence of MBO is a process of joint goal setting between a supervisor and a subordinate. • Managers work with their subordinates to establish the performance goals that are consistent with their higher organizational objectives. • MBO focuses attention on appropriate goals and plans.
25	**List out the essentials required for policy formation?** BTL5 • A policy should be definite, positive and clear. It should be understood by everyone in the organization. • A policy should be translatable into the practices. • A policy should be flexible and at the same time have a high degree of permanency. • A policy should be formulated to cover all reasonable anticipatable conditions. • A policy should be founded upon facts and sound judgment. • A policy should conform to economic principles, statutes and regulations.
26	**How will you evaluate the importance of a decision?** BTL4 **(or) What do you understand by decision making? [Dec 2018]** BTL2 • Decision making implies that there are various alternatives and the most desirable alternative is chosen to solve the problem or to arrive at expected results. • The decision-maker has freedom to choose an alternative. • Decision-making may not be completely rational but may be judgemental and emotional.

- Decision-making is goal-oriented.
- Decision-making is a mental or intellectual process because the final decision is made by the decision-maker.
- A decision may be expressed in words or may be implied from behaviour.
- Choosing from among the alternative courses of operation implies uncertainty about the final result of each possible course of operation.

PART * B

1 **What is planning? Explain the steps involved in planning? [Dec 2004, May 2005, Dec 2006, May 2009, Dec 2009, May 2010, May 2011, May 2012, May 2013, Dec 2013, May 2014, Dec 2014, May 2017, May 2019]** BTL4 **(or)**

What are the objectives of planning? Illustrate how you will set objectives for a manufacturing organization. [Dec 2018] BTL4

Answer: Page 2.1-2.6-Dr. G.K. Vijayaraghavan

Definition According to Koontz O'Donnel - "Planning is an intellectual process, the conscious determination of courses of action, the basing of decisions on purpose, acts and considered estimates".

Nature of Planning

- Planning is goal-oriented: Every plan must contribute in some positive way towards the accomplishment of group objectives. Planning has no meaning without being related to goals.
- Primacy of Planning: Planning is the first of the managerial functions. It precedes all other management functions.
- Pervasiveness of Planning: Planning is found at all levels of management. Top management looks after strategic planning.
- Middle management is in charge of administrative planning. Lower management has to concentrate on operational planning.

ordering to the quality of the mind of the manager.

Purpose of Planning

- To manage by objectives: All the activities of an organization are designed to achieve certain specified objectives. However, planning makes the objectives more concrete by focusing attention on them.
- To offset uncertainty and change: Future is always full of uncertainties and changes. Planning foresees the future and makes the necessary provisions for it.
- To secure economy in operation: Planning involves, the selection of most profitable course of action that would lead to the best result at the minimum costs.
- To help in co-ordination: Co-ordination is, indeed, the essence of management, the planning is the base of it. Without planning it is not possible to coordinate the different activities of an organization.
- To make control effective: The controlling function of management relates to the comparison of the planned performance with the actual performance. In the absence of plans, a management will have no standards for controlling other's performance.
- To increase organizational effectiveness: Mere efficiency in the organization is not important; it should also lead to productivity and effectiveness. Planning enables the

manager to measure the organizational effectiveness in the context of the stated objectives and take further actions in this direction.

Features of Planning

- It is primary function of management.
- It is an intellectual process
- Focuses on determining the objectives
- Involves choice and decision making
- It is a continuous process
- It is a pervasive function

Planning Process

The various steps involved in planning are given below

Perception of Opportunities Although preceding actual planning and therefore not strictly a part of the planning process, awareness of an opportunity is the real starting point for planning. It includes a preliminary look at possible future opportunities and the ability to see them clearly and completely.

Establishing Objectives

The first step in planning itself is to establish objectives for the entire enterprise and then for each subordinate unit. Objectives specifying the results expected indicate the end points of what is to be done, where the primary emphasis is to be placed, and what is to be accomplished by the network of strategies, policies, procedures, rules, budgets and programs. Enterprise objectives should give direction to the nature of all major plans which, by reflecting these objectives, define the objectives of major departments. Major department objectives, in turn, control the objectives of subordinate departments, and so on down the line.

Considering the Planning Premises

Another logical step in planning is to establish, obtain agreement to utilize and disseminate critical planning premises. These are forecast data of a factual nature, applicable basic policies, and existing company plans. Premises, then, are planning assumptions – in other words, the expected environment of plans in operation. This step leads to one of the major principles of planning. The more individuals charged with planning understand and agree to utilize consistent planning premises, the more coordinated enterprise planning will be. Planning premises include far more than the usual basic forecasts of population, prices, costs, production, markets, and similar matters. Because the future environment of plans is so complex, it would not be profitable or realistic to make assumptions about every detail of the future environment of a plan.

Identification of alternatives

Once the organizational objectives have been clearly stated and the planning premises have been developed, the manager should list as many available alternatives as possible for reaching those objectives. The focus of this step is to search for and examine alternative courses of action, especially those not immediately apparent. There is seldom a plan for which reasonable alternatives do not exist, and quite often an alternative that is not obvious proves to be the best. The more common problem is not finding alternatives, but reducing the number of alternatives so that the most promising may be analyzed. Even with mathematical techniques and the computer, there is a limit to the number of alternatives that may be examined. It is therefore usually necessary for the planner to reduce by preliminary

	examination the number of alternatives to those promising the most fruitful possibilities or by mathematically eliminating, through the process of approximation, the least promising ones. **Evaluation of alternatives** Having sought out alternative courses and examined their strong and weak points, the following step is to evaluate them by weighing the various factors in the light of premises and goals. One course may appear to be the most profitable but require a large cash outlay and a slow payback; another may be less profitable but involve less risk; still another may better suit the company in long–range objectives. If the only objective were to examine profits in a certain business immediately, if the future were not uncertain, if cash position and capital availability were not worrisome, and if most factors could be reduced to definite data, this evaluation should be relatively easy. But typical planning is replete with uncertainties, problems of capital shortages, and intangible factors, and so evaluation is usually very difficult, even with relatively simple problems. A company may wish to enter a new product line primarily for purposes of prestige; the forecast of expected results may show a clear financial loss, but the question is still open as to whether the loss is worth the gain. **Choice of alternative plans** An evaluation of alternatives must include an evaluation of the premises on which the alternatives are based. A manager usually finds that some premises are unreasonable and can therefore be excluded from further consideration. This elimination process helps the manager determine which alternative would best accomplish organizational objectives. **Formulating of Supporting Plans** After decisions are made and plans are set, the final step to give them meaning is to numbered them by converting them to budgets. The overall budgets of an enterprise represent the sum total of income and expenses with resultant profit or surplus and budgets of major balance– sheet items such as cash and capital expenditures. Each department or program of a business or other enterprise can have its own budgets, usually of expenses and capital expenditures, which tie into the overall budget. If this process is done well, budgets become a means of adding together the various plans and also important standards against which planning progress can be measured.
2	**Classify the types of goals organizations might have and the plans they use for accomplishment? [May 2008, Nov 2008, Dec 2017, May 2018]** **(or)** **Discuss in detail about the classification of planning practices? [Dec 2016, Dec 2017]** BTL 2 **Answer: Page 2.10-Dr. G.K. Vijayaraghavan** **Types of Plans / Components of Planning** In the process of planning, several plans are prepared which are known as components of planning. Plans can be broadly classified as **Strategic plans** A strategic plan is an outline of steps designed with the goals of the entire organization as a whole in mind, rather than with the goals of specific divisions or departments. **Tactical plans** A tactical plan is concerned with what the lower level units within each division must do,

how they must do it, and who is in charge at each level. Tactics are the means needed to activate a strategy and make it work. Tactical plans are concerned with shorter time frames and narrower scopes than are strategic plans. These plans usually span one year or less because they are considered short-term goals. Long-term goals, on the other hand, can take several years or more to accomplish. Normally, it is the middle manager's responsibility to take the broad strategic plan and identify specific tactical actions.

Operational plans

The specific results expected from departments, work groups, and individuals are the operational goals. These goals are precise and measurable. "Process 150 sales applications each week" or "Publish 20 books this quarter" are examples of operational goals. An operational plan is one that a manager uses to accomplish his or her job responsibilities. Supervisors, team leaders, and facilitators develop operational plans to support tactical plans (see the next section). Operational plans can be a single-use plan or a standing plan.

Contingency plans

Intelligent and successful management depends upon a constant pursuit of adaptation, flexibility, and mastery of changing conditions. Strong management requires a "keeping all options open" approach at all times — that's where contingency planning comes in. Contingency planning involves identifying alternative courses of action that can be implemented if and when the original plan proves inadequate because of changing circumstances. Keep in mind that events beyond a manager's control may cause even the most carefully prepared alternative future scenarios to go awry. Unexpected problems and events frequently occur. When they do, managers may need to change their plans. Anticipating change during the planning process is best in case things don't go as expected. Management can then develop alternatives to the existing plan and ready them for use when and if circumstances make these alternatives appropriate.

3 **Define MBO. Describe the benefits and weakness of MBO and ways to overcome them. [Dec 2004, May 2005, May 2009, May 2011, May 2018, Dec 2017]** BTL 5

Answer: Page 2.29-Dr. G.K. Vijayaraghavan

KOONTZ &WEIHRICH: Management by objectives (MBO) is defined as a comprehensive managerial system that integrates many key managerial activities in a systematic manner and that is consciously directed towards the effective and efficient achievement of organizational and individual objective.

"MBO is a process whereby the superiors and the subordinate managers of an enterprise jointly identify its common goals, define each individual major areas of responsibility in terms of results expected of him, and use these measures as guides for operating the unit and assessing the contribution of each of its members." - GEORGE ODIORNE

features of MBO

- MBO is concerned with goal setting and planning for individual managers and their units.
- The essence of MBO is a process of joint goal setting between a supervisor and a subordinate.
- Managers work with their subordinates to establish the performance goals that are consistent with their higher organizational objectives.
- MBO focuses attention on appropriate goals and plans.

Benefits of MBO

- improvement of managing
- clarification of organization
- team work
- personnel satisfaction
- development of effective control
- fast decision making

weakness of MBO

- Failure to teach the philosophy of MBO
- Difficulty of setting goals
- Failure to give guidelines to goal setters
- Emphasis on short time goals
- Time consuming
- Paper work

4 **Explain the various types of decision? [May 2004, May 2010, May 2012, May 2017, May 2019] (or) Is decision making a rational process [Dec 2017]** BTL 5

Answer: Page 2.79-Dr. G.K. Vijayaraghavan

Decision Making

It is defined as selection of a course of action from among alternatives. It is a core of planning. A plan cannot be said to exist unless a decision – a commitment of resources, direction or reputation has been made. Until that point, there is only planning studies and analysis.

importance of a decision

- Decision making implies that there are various alternatives and the most desirable alternative is chosen to solve the problem or to arrive at expected results.
- The decision-maker has freedom to choose an alternative.
- Decision-making may not be completely rational but may be judgemental and emotional.
- Decision-making is goal-oriented.
- Decision-making is a mental or intellectual process because the final decision is made by the decision-maker.
- A decision may be expressed in words or may be implied from behaviour.

Choosing from among the alternative courses of operation implies uncertainty about the final result of each possible course of operation.

Types of Decisions

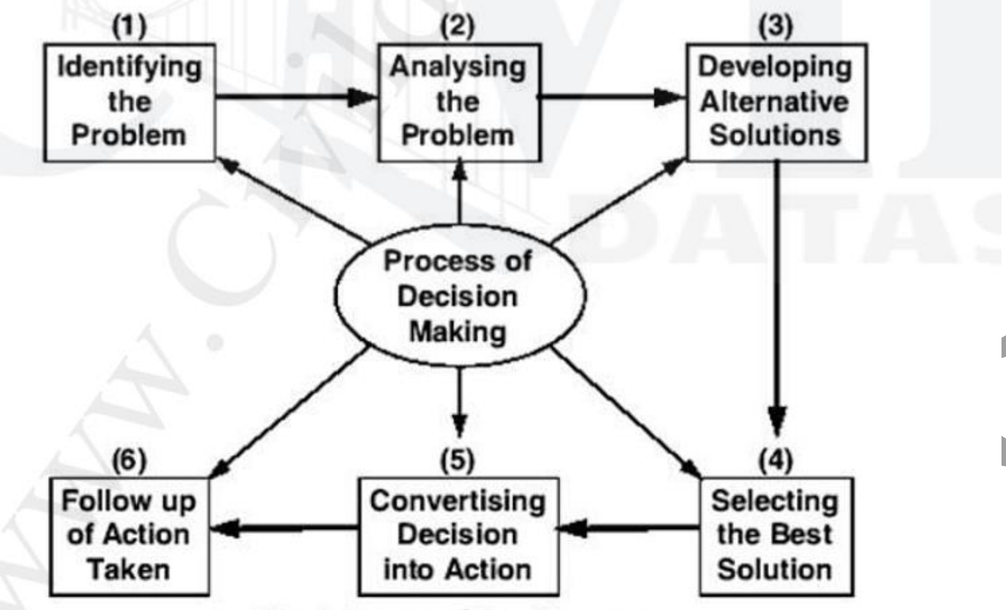
Programmed decisions:

Programmed decisions are routine and repetitive and are made within the framework of organizational policies and rules. These policies and rules are established well in advance to solve recurring problems in the organization. Programmed decisions have short-run impact. They are, generally, taken at the lower level of management.

Non-Programmed Decisions:

Non-programmed decisions are decisions taken to meet non-repetitive problems. Non-programmed decisions are relevant for solving unique/ unusual problems in which various alternatives cannot be decided in advance. A common feature of non-programmed decisions is that they are novel and non-recurring and therefore, readymade solutions are not available.

	Since these decisions are of high importance and have long-term consequences, they are made by top level management. **Strategic and Tactical Decisions:** Organizational decisions may also be classified as strategic or tactical.
5	**Explain the process of decision making with the help of an example? [May 2004, Dec 2005, May 2008, Dec 2008, May 2010, May 2011, May 2012, May 2013, May 2016, Dec 2016, May 2017, Dec 2018, May 2019]** BTL5 **Answer: Page 2.69-Dr. G.K. Vijayaraghavan** **Specific Objective:** The need for decision making arises in order to achieve certain specific objectives. The starting point in any analysis of decision making involves the determination of whether a decision needs to be made. **Problem Identification:** A problem is a felt need, a question which needs a solution. In the words of Joseph L Massie "A good decision is dependent upon the recognition of the right problem". The objective of problem identification is that if the problem is precisely and specifically identifies, it will provide a clue in finding a possible solution. A problem can be identified clearly, if managers go through diagnosis and analysis of the problem. Diagnosis: Diagnosis is the process of identifying a problem from its signs and symptoms. **Search for Alternatives:** A problem can be solved in several ways; however, all the ways cannot be equally satisfying. Therefore, the decision maker must try to find out the various alternatives available in order to get the most satisfactory result of a decision. A decision maker **Evaluation of Alternatives:** After the various alternatives are identified, the next step is to evaluate them and select the one that will meet the choice criteria. /the decision maker must check proposed alternatives against limits, and if an alternative does not meet them, he can discard it. Having narrowed down the alternatives which require serious consideration, the decision maker will go for evaluating how each alternative may contribute towards the objective supposed to be achieved by implementing the decision. **Choice of Alternative:** The evaluation of various alternatives presents a clear picture as to how each one of them contribute to the objectives under question. A comparison is made among the likely outcomes of various alternatives and the best one is chosen. **Action:** Once the alternative is selected, it is put into action. The actual process of decision making ends with the choice of an alternative through which the objectives can be achieved. **Results:** When the decision is put into action, it brings certain results. These results must correspond with objectives, the starting point of decision process, if good decision has been made and implemented properly. Thus, results provide indication whether decision making andits implementation is proper.

	 *Decision-making Process*
	PART * C
1	**Discuss how decision making under different conditions are made. [Dec 2004, May 2005, May 2014]** BTL6 **Answer: Page 2.81-Dr. G.K. Vijayaraghavan** • Decision under certainity • Decision under uncertainity • Decision under risk **i.** a priori probability **ii.** empirical probability subjective probability

	UNIT III - ORGANISING
	Nature and purpose – Formal and informal organization – organization chart – organization structure – types – Line and staff authority – departmentalization – delegation of authority – centralization and decentralization – Job Design - Human Resource Management – HR Planning, Recruitment, selection, Training and Development, Performance Management , Career planning and management.
	PART * A
Q. No	**Questions**
1	**Define Organization.** BTL1 An identified group of people contributing their efforts towards the attainment of goals is called an organization. Organization is the process of establishing relationships among the members of the enterprise.
2	**What is the purpose of Organization?** BTL3 • Facilitates Administration • Increases the efficiency management • Stimulates creativity and innovation • Facilitates growth and diversification and • Facilitates co-ordination and communication.
3	**What is organizing? [May 2011, May 2013]** BTL2 Organizing refers to the formal grouping of people and activities facilitate achievement of the firm's objectives. Organizing may be defined as the process of i) Identifying and classifying the required activities i.e. Job Design ii) Grouping the work to be performed i.e., Departmentation iii) Defining and delegating responsibility and authority i.e. Delegation of authority iv) Span of Control
4	**What is Job design? (or) Experiment the term design? [May 2018, May 2019]** BTL5 Job design is usually broad enough to accommodate people's needs and desires. It may be especially appropriate to design jobs for exceptional persons in order to utilize their potential. People spend a great deal of time on the job and it is therefore important to design jobs so that individuals feel good about their work. Two important goals of job design are, • To meet the organizational requirements such as higher productivity, operational efficiency, quality of products/service etc. • To satisfy the needs of the individual employees like interests, challenge, achievement etc.
5	**What is Organisation Structure?** BTL2 In organisation structure simply by means the systematic arrangement of people working for the organisation. The organisation is concerned with establishment of positions and relationship between positions. The organisation structure has two dimensions. 1. Horizontal 2. Vertical
6	**What is an Organizational chart? [Dec 2017]** BTL4

	According to George Terry, "Organizational chart is a diagrammatical form, which shows the important aspects of an organization including the major functions and their respective relationships, the channels of supervision, and the relative authority of each employee who is in charge of each respective function". It is a representation of the framework or structure of an organization. It may be a vertical or top-down chart, horizontal or left to right chart and circle or concentric chart
7	**Mention the uses of Organisation Chart** BTL5 1. The organisation chart pinpoints the weakness of an organisation. This will helps to overcome the short coming of organisation. 2. It tells quickly who is responsible for particular function. 3. It is useful in showing nature of an organisation and changes if any in the existing staff and new comers.
8	**Distinguish between authority and power** BTL4 Power is the ability of individuals or groups to induce r influence the beliefs or actions of other persons or groups. Authority in organisation is the right in a position to exercise discretion in making decisions and affecting others.
9	**What are the different bases of power?** BTL2 1. Legitimate Power 2. Referent Power 3. Reward Power 4. Coercive Power
10	**Define Functional Authority** BTL1 It is the right which is delegated to an individual or a department to control specified processes practices, policies or other matters relating to activities, undertaken by persons in other departments.
11	**Define formal organization? [May 2019]** BTL1 The structure of jobs and positions with clearly defined functions and relationship as prescribed by the top management and bound by rules, systems and procedures.
12	**Define informal organization?** BTL1 A network of interpersonal relationships that arise when people associate with each other.
13	**Define departmentation? [Dec 2016]** BTL1 The organizational process of determining how activities are to be grouped is called departmentation. Departmentation is a means of dividing the large and complex organization into smaller, flexible administrative units.
14	**Define empowerment?** BTL2 Empowerment means that employees, managers or teams at all levels in the organization are given the power to make decision without asking their superiors for permission.
15	**What is meant by delegation of authority? [May 2011, May 2012, May 2017]** BTL2 It is a process which enables a person to assign works to others and delegate them with adequate authority to do it.
16	**Define staffing [Dec 2014]** BTL2 It is the part of the management process which is concerned with the procurement utilization, maintenance and development of a large satisfied work force on the organisation.
17	**What are the limitations of matrix organization structure [Dec 2013]** BTL4

- Since use of this matrix means the use of multiple commands, managers often end up with conflicts
- The organizational relationship becomes very complex and there is a great confusion among personnel

18 **What are the objectives of performance appraisal [May 2012]** BTL5

- To find out individual potential identification
- To improve the management development
- To improve the employees performance

19 **Differentiate decentralization and centralization? [May 2013/Dec 2013]** BTL4

Decentralization is the tendency to disperse decision making authority in an organized structure. It is a fundamental aspect of delegation.

Centralization is the process of transferring and assigning decision making authority to higher levels of an organization hierarchy.

20 **List down the different types of training? [May 2014]** BTL2

i. Job rotation
ii. Apprenticeship and coaching
iii. Committee assignments
iv. Experience
v. Temporary promotions

21 **What is meant by performance appraisal [Dec 2016]** BTL1

It is the process of obtaining, analysing and recording information about the relative worth of an employee. The focus of the performance appraisal is measuring and improving the actual performance of the employee and also the future potential of the employee.

22 **What is decentralization? [Dec 2012, May 2016]** BTL1

Decentralization is the tendency to disperse decision making authority in an organized structure. It is a fundamental aspect of delegation.

23 **What is span of control? [May 2004, May 2007, May 2009, May 2011, May 2013]** BTL2

It means the number of people managed effectively by a single superior in an organization. The term Span of management is also known as span of supervision, span of authority and span of responsibility.

24 **Define authority and list out the sources of authority? [Dec 2014]** BTL4

Authority is the right to give orders and the power to exact obedience.

Various sources are

i. Formal authority theory
ii. Acceptance authority theory
iii. Competence theory

25 **Distinguish between authority and power [May 2018]** BTL4

Authority	**Power**
Authorities comes from the duties and responsibilities delegated to a position holder in a bureaucratic structure	Power is the possession of authority, control or influence by which a person influences the actions of others either by direct authority or by some other more intangible means
The authority of knowledge is often	A prime source of power is the possession

independent of levels or positions	of knowledge.

26 **List the different types of departmentation** BTL1

S.No	Types of Departmentation
1	Departmentation by matrix
2	Departmentation by time.
3	Departmentation by Enterprise function
4	Departmentation by Territory or Geography
5	Departmentation by Customers
6	Departmentation by equipment or process
7	Departmentation by product or service.

27 **Define centralization? [Dec 2018]** BTL1

Centralization is the process of transferring and assigning decision making authority to higher levels of an organization hierarchy.

28 **What is human resource planning? [Dec 2018]** BTL2

It is the process by which an organization ensures that it has the right number and kind of people at the right place at the right time, capable of effectively and efficiently completion, those tasks that will help the organization achieve its overall objectives.

29 **Define career management? [Dec 2017]** BTL1

It is a process for enabling employees to better understand and develop their career skills and interests most effectively both within the company and after they leave the firm.

30 **Why performance management is important?** BTL4 **[May 2017]**

- To facilitate the organisation
- To simulate creativity and initiative
- To facilitate growth and diversification

PART * B

1 **Explain the nature and purpose of organization. (13M) [Dec2006, Dec 2018]** BTL2

Answer Page: 3.2 Dr. G.K. Vijayaraghavan

EXPLANATION:(13 M)

- Division of Work
- Coordination
- Plurality of Persons
- Common Objectives
- Well-defined Authority and Responsibility
- Organization is a Structure of Relationship
- Organization is a Machine of Management
- Organization is a Universal Process

2 **Explain the concept of organisation process. (13M) [Dec 2007, May 2018]** BTL2

Answer Page. No.3.4 Dr. G.K. Vijayaraghavan

Explanation – (13 M)

- Determination of Objectives
- Enumeration of Objectives

	• Classification of Activities • Assignment of Duties • Delegation of Authority
3	**Bring out the Characteristics centralization/Decentralization. Also highlight the merits and demerits of centralization/Decentralization with examples. (13M) [May2008]** BTL2 **Answer Page. No.3.79 Dr. G.K. Vijayaraghavan** **Characteristics (5 M)** • ·**Philosophy / emphasis on**: top-down control, leadership, vision, strategy. • **Decision-making**: strong, authoritarian, visionary, charismatic. • Organizational change: shaped by top, vision of leader. • **Execution**: decisive, fast, coordinated. • Able to respond quickly to major issues and changes. · • **Uniformity** Low risk of dissent, conflicts between parts of organization. **Advantages of Centralization: (2 M)** • Provide Power and prestige for manager • Promote uniformity of policies, practices and decisions · • Minimal extensive controlling procedures and practices · • Minimize duplication of function **Disadvantages of Centralization:(2 M)** • Neglected functions for mid-level less motivated beside personnel. • Nursing supervisor functions as a link officer between nursing director **Advantages of Decentralization:(2 M)** • Raise morale and promote interpersonal relationships and Relieve from the daily administration • Bring decision-making close to action · • Promote employee's enthusiasm and coordination · **Disadvantages of Decentralization:(2 M)** • Top-level administration may feel it would decrease their status • Managers may not permit full and maximum utilization of highly qualified
4	**Discuss in detail about the Factors Affecting Span of control.** BTL2 **(13M)** **[May 2007, May 2013]** **Answer Page. No.3.65: Dr. G.K. Vijayaraghavan** **EXPLANATION:(13 M)** • Capacity of Superior • Capacity of Subordinates • Nature of Work • Degree of Centralization or Decentralization • Degree of Planning • Communication Techniques. • Use of Staff Assistance • Supervision of others

5	**Describe the HR Planning process and objectives. [May 2007, Dec 2018]** BTL2**(13M)** **Answer Page. No.2.7 & 2.17 Dr. G.K. Vijayaraghavan** **Objectives: (4 M)** • Every organization has goals. • To make a profit for the company's owners. • Lowest cost for the greatest profit margin. **Process: (9 M)** The Best of Brian Tracy • Assessing Human Resources • Demand Forecasting • Supply Forecasting • Matching Demand And Supply • Action Plan
6	**Explain the methods of performance appraisal.** BTL2 **(13M) [May 2012]** **Answer Page. No.3.145 Dr. G.K. Vijayaraghavan** **Traditional methods: (7 M)** **Modern Methods: (6 M)** **TRADITIONAL METHODS** • **Ranking method** The 'worth' of a job is usually based on judgements of skill, effort • **Paired comparison** Pairs to judge which of each entity is preferred • **Grading** Arrange in or allocate to grades; classify or sort based on output, result. • **Force distribution method** Evaluation **method** of forced distribution to check capacity of manpower • **Checklist method** A type of job aid used to reduce failure by compensating for potential limits of human memory • **Critical incident method** Used for collecting direct observations of human behaviour, have critical significance • **Graphic scale method** To find Traits or behaviours that important for effective performance by graphs • **Essay method** A statement about employee being appraised • **Field review method** Appraisal is conducted by rater who does not belong to employees' department • **Confidential report** General assessment of work performed by a Government servant to reporting authority

MODERN METHOD

- **Management by Objectives**
  Model that aims to improve the performance of an organization by clearly defining objectives
- **Behaviourally anchored rating scale**
  Aims to combine the benefits of narratives, critical incidents, and quantified **ratings**
- **Assessment canters**
  A process where candidates are assessed to determine their suitability
- **360 degree appraisal method**
  Employees receive confidential, anonymous **feedback** from the people who work around them
- **Cost accounting method**
  An activity or accomplishing a purpose are collected, classified, and recorded.

7 **Distinguish between formal and informal organization. [Dec2012]** BTL4**(13M)**

Answer Pg. No.3.11 Dr. G.K. Vijayaraghavan

Formal organization	**Informal orgaanization**
Established with the explicit aim of achieving well defined goals	Spring on its own.
Bound together by authority relationships among members.	Characterized by a generalised sort of power relationships
Recognises certain tasks and activities	Does not have any well-defined tasks
The roles and relationships of people are impersonally defined	The relationship among people are interpersonal
Characterized by efficiency, discipline, consistency and control	Characterized by relative freedom, spontaneity, homeliness and warmth.

8 **Explain the significance of organization structure and the principles of organisation structure. (13M) [May 2013,Dec 2013]** BTL2

Answer Page. No.3.18 &3 Dr. G.K. Vijayaraghavan

Significance: (6 M)

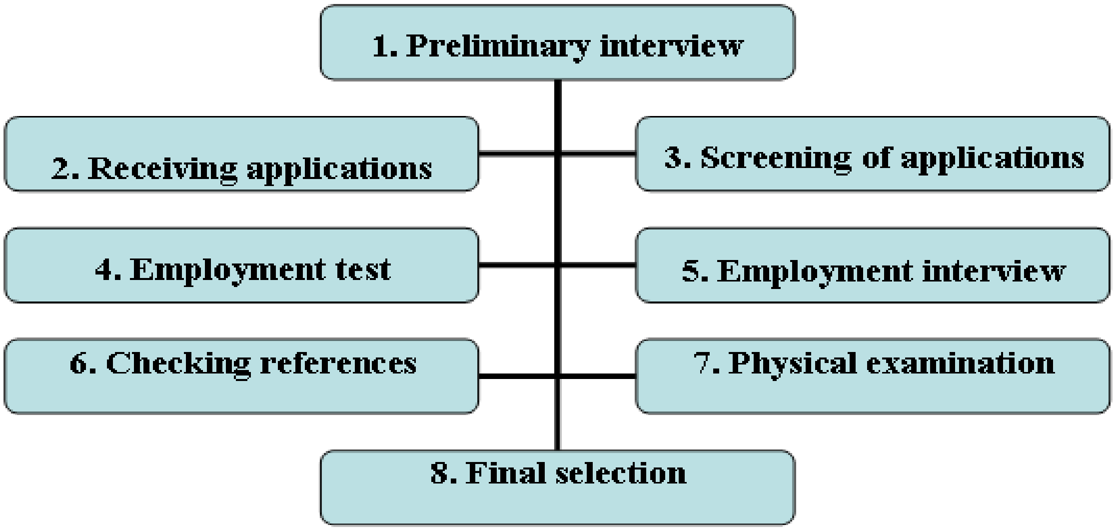
- Improve teamwork and productivity
- Organization structure, location of decision-making
- Creative thinking and initiative
- Growth of enterprise by increasing its capacity
- Pattern of communication and coordination.
- Awareness to identify the roles.

Principles :(7 M)

- Line and Staff Relationships
- Departmentalization
- Span of Control

	• De-centralization and Centralization
9	**Explain the types of organizational structures (13M) [Dec 2013, Dec 2017]** BTL2 **Answer Page : 3.18 Dr. G.K. Vijayaraghavan** **EXPLANATION:(13 M)** • Line organizational structure. • Staff or functional authority organizational structure. • Line and staff organizational structure. • Committee organizational structure. • Divisional organizational structure. • Project organizational structure. • Matrix organizational structure • Hybrid organizational structure.
10	**Explain the different types of Departmentation. (13M)** BTL2 **Answer Page : 3.47 Dr. G.K. Vijayaraghavan** **EXPLANATION:(13 M)** • Departmentation by function Based on functions like, Production, Finance, Marketing etc • Departmentation by Product Based on Product like, Television, Radio, Laptop, camera etc. • Departmentation by service Based on service like, Loan, savings, Mutual funds, Money exchange in a bank • Departmentation by Customer Based on customers like, Regular customer, Occasional customer, Festival customer etc • Departmentation by process Based on process like, cleaning, colouring, printing, cutting, packaging etc • Departmentation by place Based on place like, South zone, North zone, East zone, West zone • Departmentation by Time Based on tine like, Moring shift, evening shift, night shift.
11	**Elaborate the merits and demerits of line and staff organisation (13M)** BTL4 **[May 2019]**
	PART * C
1	**Enumerate in detail about the selection process which is widely followed in selecting IT professionals. Also highlight the different types of interviews that can be used in the selection process. (15M) [May2008, May 2018]** BTL2 **(or)Illustrate the steps involved in the recruitment process [May 2019]** **Answer Page : 3.117& 3.120 Dr. G.K. Vijayaraghavan** **Selection process:(10 M)**

Interviews:(5 M)



Selection Process

- **Preliminary Interview**
  Sort of a filtering process used by recruiters to help them sort out best candidate
- **Receiving Applications**
  It is used to process receipts for materials.
- **Screening of Applications**
  Selecting candidates for interview who meet all minimum requirements
- **Employment test**
  The practice of administering written, oral, or other tests
- **Employment Interview**
  A conversation between a job applicant and a representative of an employer
- **Checking References**
  When an employer contacts a job applicant's previous employers
- **Physical examination**
  A medical examination to determine a person's bodily fitness.
- **Final selection**
  Final hiring decision should completed

2 **Define matrix organization. Why matrix organization is used? Discuss the problems with matrix management and guidelines for making matrix management effective. (15M)** BTL2 **[May 2009]**

Answer Page : 3.60 Dr. G.K. Vijayaraghavan

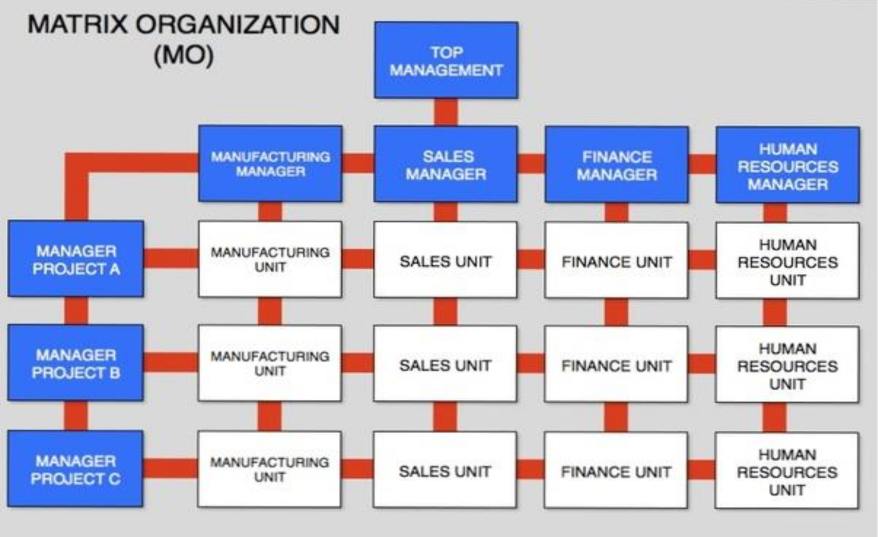
Define:(2 M)

The mixed forms of organization are referred to as matrix or grid organization's According to the situations, the patterns of Organizing varies from case to case. The form of structure must reflect the tasks, goals and technology if the originations the type of people employed and the environmental conditions that it faces. It is not unusual to see firms that utilize the function and project organization combination.

Problems: (4 M)

- Feeling of ambiguity caused by employees moving from one project to another as required by their line manager,
- Conflict of loyalty between line managers and project managers over the allocation of resources — for instance, where groups neglect their usual duties and responsibilities,
- The outcome of dual reporting is the loss of unity of command, which can lead to problems of coordination and prioritisation,
- Project managers may experience problems of authority over their team members, especially if they are from another department or team,
- Project management may fail to gain the support of other functional managers,
- If teams have a lot of independence they can be difficult to monitor, which is why the agreements between project and line management are essential, and
- Costs can be increased if more project managers are created through the use of project teams.

Diagram:(2 M)



Guidelines for Making Matrix Management Effective: (3 M)

- Define the objectives clearly
- Clarify the role, authority and responsibility of managers and team members
- Ensure that influence is based on knowledge and information, rather than on rank
- Balance the functional and project managers
- Select manager having thorough experience and capable of leadership
- Install appropriate cost, time and quality control system
- Rewards project managers and term members fairly

Uses: (2 M)

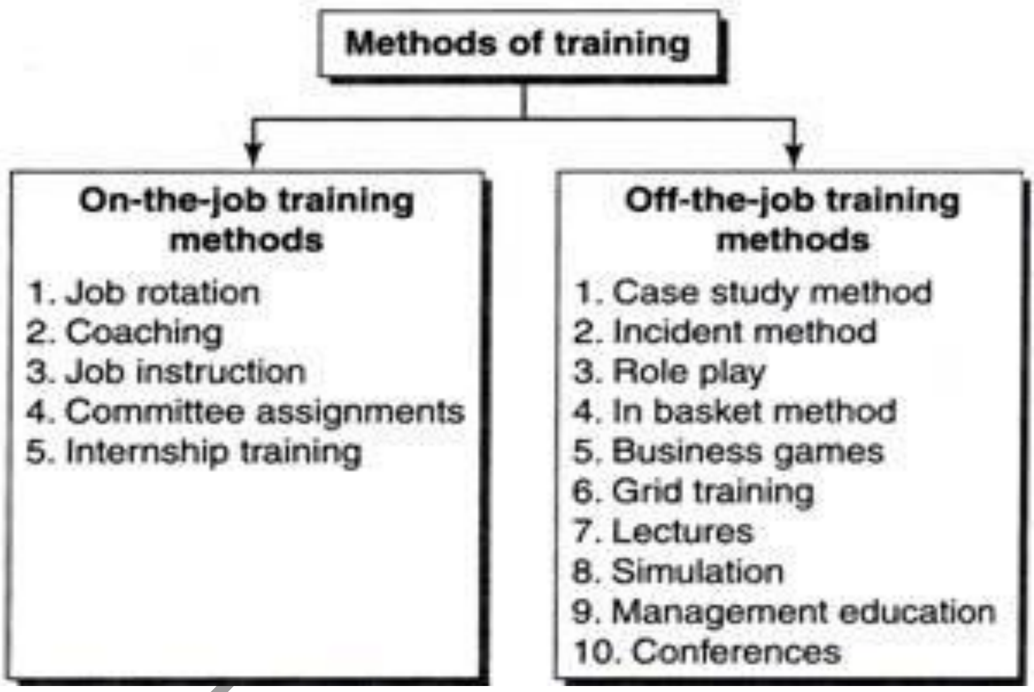
- Improves Workplace Communication
- Boosts Team Concept
- Empowers Employees by Providing Greater Authority

3. **Briefly discuss the types of training in a successful organisation. (15M) [May2011, Dec 2017]** BTL2

Answer Pg. No.3.131 Dr. G.K. Vijayaraghavan

On The Training: (6 M)

Off The Training: (9 M)



On the job Training

- Job Rotation
  The practice of moving employees between different tasks to promote experience and variety.
- Coaching
  Client in achieving a specific personal or professional goal by providing training and guidance
- Job Instruction
  A step-by-step, relatively simple technique used to train employees on the **job**
- Committee assignment
  A person or group of persons elected or appointed to perform some service or function
- Internship training
  Trainee works in an organization, sometimes without pay, in order to gain work experience

Off the job training

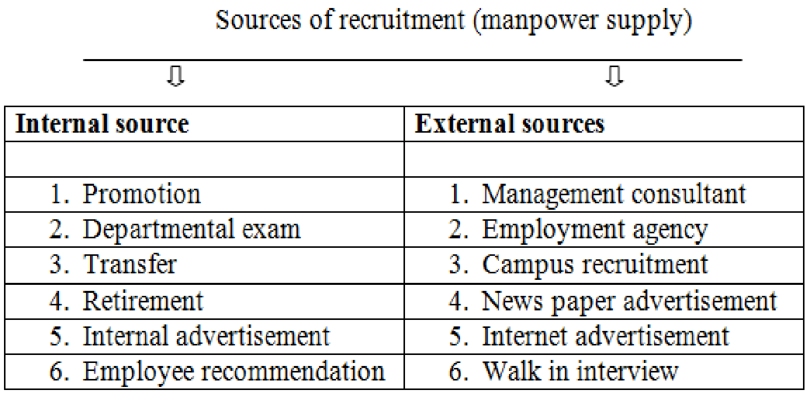
- Case study method
  Analyzed with a view toward formulating general principles.
- Critical Incident method
  Actions of an employee is recorded and examined during the critical situation.
- Role play
  act out or perform the part of a person or character in training or psychotherapy
- In basket method
  A test used by companies and governments in hiring and promoting employees
- Business Games
  Simulation games that are used as an educational tool for teaching
- Grid Training
  The comprehensive organization development programme developed by Blake and Mouton
- Lectures
  An educational talk to an audience, especially one of students in a university.
- Simulation
  The production of a computer model of something, especially for the purpose of study.
- Management education
  A collective group of professionals that includes principals, teachers and other education
- Conferences
  A formal meeting of people with a shared interest on the specified area or domain.

4. **Explain the methods of Recruitment in detail. (15M) (May/June 2009)** BTL2

Answer Page : 3.111 Dr. G.K. Vijayaraghavan

INTERNAL SOURCES: (6 M)

EXTERNAL SOURCES: (9 M)



Sources of recruitment (manpower supply)

⇩ ⇩

Internal source	**External sources**
1. Promotion	1. Management consultant
2. Departmental exam	2. Employment agency
3. Transfer	3. Campus recruitment
4. Retirement	4. News paper advertisement
5. Internal advertisement	5. Internet advertisement
6. Employee recommendation	6. Walk in interview

Internal Source

	- Promotion An activity, supports or encourages a cause, venture, or aim - Departmental exam Basic test to know the interest, competency level - Transfer Move from one place to another - Retirement The action or fact of leaving one's job and ceasing to work - Internal advertisement Company will use internal sources of recruitment to fill a vacancy - Employee recommendation organizations to identify potential candidates from their existing employees' social networks **External Source** - Management consultant Professional advice about how to run a company or organization more effectively. - Employment agency A business that finds employers or employees for those seeking them - Campus recruitment Employers undertake an organised program of attracting and hiring students - Newspaper advertisement Ads are generally used by businesses and corporations towards promotion - Internet advertisement A form of marketing and advertising which uses the internet to deliver promotional marketing - Walk in interview A prospective employee reaches the respective office or place without any prior appointment

	UNIT IV - DIRECTING
	Foundations of individual and group behaviour – motivation – motivation theories – motivational techniques – job satisfaction – job enrichment – leadership – types and theories of leadership – communication – process of communication – barrier in communication – effective communication – communication and IT.
	PART * A
Q. No	**Questions**
1	**Define Directing.** BTL1 Directing may be defined as the process of instructing, guiding and inspiring human factors in the organization to achieve organization objectives.
2	**State two important characteristics of Directing.** BTL4 Any two characteristics of Directing are: • Directing is an important managerial function through which the management initiates actions in the organisation. • It is a continuous process and it continues throughout the life of the Organization.
3	**Mention the importance of Leadership** BTL2 • Motivating Employees • Leader develops team work • Better utilization of manpower • Creating confidence to followers • Directing group activities • Building morale • Maintaining discipline
4	**Name the various leadership styles. [Dec 2018]** BTL3 • Autocratic or Dictatorial leadership • Participative or Democratic leadership • Laissez – faire or Free – rein leadership
5	**What are the advantages of democratic leadership?** BTL2 • The subordinates are motivated by participation in decision – making process. This will also increase job satisfaction • Absence of leader does not affect output • Labor absenteeism and turn – over will be minimum • The quality of decision is improved • The leader multiplies his abilities through the contribution of his followers.
6	**What is laissez-faires** BTL1 Complete freedom is given to the subordinates so that they plan, motivate, control and otherwise be responsible for their own actions.
7	**List out the human factors in managing.** BTL4 The Human factors in managing include: • Multiplicity of roles

	• Individuality and • Personal dignity.
8	**Define creativity?** BTL1 Creativity is defined as the ability to produce new and useful ideas through the combination of known principles and components in novel and non-obvious ways. Creativity exists throughout the population largely independent of age, sex and education.
9	**What are the steps involved in creative process?** BTL4 Creativity is defined as the ability to produce new and useful ideas through the combination of known principles and components in novel and non-obvious ways. The steps involved in creative process are: • Saturation • Preparation • Frustration and incubation • Inspiration or illumination • Verification
10	**How are problems solved by creative tool?** BTL3 Creativity tools are designed to help you devise creative and imaginative solutions to problems. Creativity tools are designed to help you devise creative and imaginative solutions to problems.
11	**What is a SCAMPER tool?** BTL2 SCAMPER is a checklist that helps us to think of changes where S - Substitute C - Combine A - Adapt M - Modify P - Put to another use E - Eliminate and R - Reverse.
12	**What is a meant by reframing matrix?** BTL1 Reframing matrix is a simple technique that helps to look at business problems from a number of different viewpoints. The approach relies on the fact that different people with different experience approach problems in different experience approach in different ways.
13	**What are the steps involved in simplex tool?** BTL4 Simplex tool is an industrial-strength creativity tool. The steps involved in simplex tool are:- • Problem finding • Fact finding • Problem definition • Idea finding • Selection and evaluation • Planning • Sell data and • Action.
14	**Differentiate Innovation and Invention.** BTL4 Innovation means the use of creative ideas. It is not only relevant to high-tech enterprises but also crucial for old-line, traditional companies, which may not service without the infusion of innovation. Ex: A new product or a service. Invention means really finding new things that are not already available. It is mostly applicable in the field of science. Ex: Invention of radio.

15	**How can be harmonizing objectives achieved?** BTL3 Harmonizing objectives can be achieved through: • Mutual trust • Cooperation and understanding and • Workers participation in management.
16	**Define Multiplicity of Roles.** BTL1 Individuals are not only the productive factor in management Plans. They are members of social system of many organizations.
17	**Mention the various factors involved in using motivational techniques?** BTL4 • Money • Reward : intrinsic and extrinsic • Participation • Quality of working life
18	**What is job enrichment? [May 2015, May 2017, Dec 2017]** BTL1 Building into jobs a higher sense of challenge and achievement. (or) Job enrichment is therefore based on the assumption that in order to motivate personnel, the job itself must provide opportunities for the achievement, recognition, responsibility, advancement and growth.
19	**What are the limitations of job enrichment?** BTL2 1. Job enrichment is based on the assumption that workers want more responsibility. But, in practice, most of the workers may prefer less responsible jobs with good social interaction. Such workers may show feelings of inadequacy and fear of failure to job enrichment. 2. Some jobs cannot be enriched beyond a certain point.
20	**Give the required guidelines to make effective job enrichment.** BTL3 1. Use job enrichment selectively after taking into account situational variables such as job characteristics, personal characteristics of employees, Organisational level etc. 2. Provide a supportive climate for innovation and change.
21	**Define Leadership [May 2019]** BTL1 Leadership is the process of influencing the behaviour of others towards the accomplishment of goals in a given situation. Leadership is the ability to influence others and enthusiastically making them to achieve the desired results.
22	**What is Communication? [Dec 2009]** BTL1 Communication is passing of information from one person to another person with understandable manner.
23	**Mention the various elements in the process of communication [Dec 2014]** BTL3 • Sender • Communication Channels • Symbols • Receiver • Noise and feedback in communication
24	**List the different types of communication flow** BTL4 i. Downward Communication ii. Upward communication
25	**Explain the creative process?** BTL1

Creativity: Creativity is the ability to create large number of ideas quickly. Creative process has interacting and over lapping phase.

It has four phases:

i. Unconscious Scanning
ii. Intuition
iii. Insight
iv. Logical Formulation

Unconscious Scanning: A condition beyond consciousness. Intuition: It connects unconscious with conscious Insight: It is the result of hard work Logical Formulation: referred to as verification

26 **What is brainstorming? [May 2013, May 2018]** BTL2

This kind of training is given to increase people's creativity and decisional ability. These types of training individual participants are encouraged to give their own ideas to resolve the existing problem

27 **Compare theory X and theory Y.** BTL2

S.No	**Theory X**	**Theory Y**
1	The average human dislikes work	Work is as natural as play or rest.
2	People are unambitious and prefer to be directed by other.	Ambitious and capable of directing their own.
3	They avoid responsibility.	They accept responsibility under proper conditions.
4	External control, threatening and close supervision are required.	Self directed and self are controlled.

28 **What are the four basic ingredients of leadership skill? OR Mention any two leadership qualities.** BTL1

- Physical qualities: Sound health, vitality, appearance, physical and nervous energy, forcefulness, physique, enthusiasm.
- Intellectual qualities: High intelligence, sound judgment ability to teach, scientific approach, decisiveness, self understanding.
- Morale qualities: Integrity, moral courage, fair play, will power, sense of purpose, objectivity.
- Social qualities: Ability to inspire, tact, percussiveness, self-confidence, empathy, initiative, knowledge of human nature human relations attitude.

29 **Differentiate single and multiple channel networks.** BTL4

S.No.	**Single channel communication**	**Multiple channel communication**
1	The communication is allowed on only one path called as line authority.	The communication is allowed in more than one path.
2	It is simply referred as through proper channel.	It is simply referred as through various channel.
3	Communication flow is slow	Communication flow is faster,
4	Easy to maintain orderly in nature.	Potential problems may occur.

5	Miscommunication reduced.	Miscommunication is increased.

30	**Define the term "Grape Vine".** BTL2 The information actually transmitted through the informal channels may be inaccurate, distorted, a half- truth, a rumour, a gossip, a private interpretation and sometimes truth. It is called as grapevine.
31	**Define motivation [Dec 2012, May 2011, May 2014, May 2019]** BTL1 Sott defines, "Motivation means a process of stimulating people in action to accomplish desired goals"
32	**What are the elements in the Maslows hierarchy of needs? [Dec 2016]** BTL4 i. Basic needs ii. Safety needs iii. Social needs iv. Esteem needs v. Self-actualisation needs
33	**What do you mean by the term noise in communication? [May 2016]** BTL3 Communication is affected by noise at any stage. It may be the sender, the transmission or the receiver stage. If anyone is affected, the proper communication will not reach the receiver. To ensure the effective communication, we have to provide noiseless environment.
34	**Who is a leader? [Dec 2012]** BTL1 Leader is one who influences people so that they will strive willingly and enthusiastically towards achievement of the goal
35	**What are the different types of management strategies involved in leadership? [May 2013]** BTL4 • Autocratic leader • Democratic • Free-rein leader • Paternalistic leadership
36	**How does a leader differ from manager? [May 2015]** BTL3 Leader is one who influences people so that they will strive willingly and enthusiastically towards achievement of the goal Manager influences by exercising planning, staffing, directing and controlling.
37	**What is effective communication? [May 2007, Dec 2016]** BTL1 If the message sent by the sender to the receiver is understood by the receiver in the same series, it is called effective communication.
38	**What is job satisfaction? [Dec 2017]**BTL2 A pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences.
39	**Define personality? [May 2016, May 2017]** BTL4 It is the combination of qualities form an individual's distinctive character

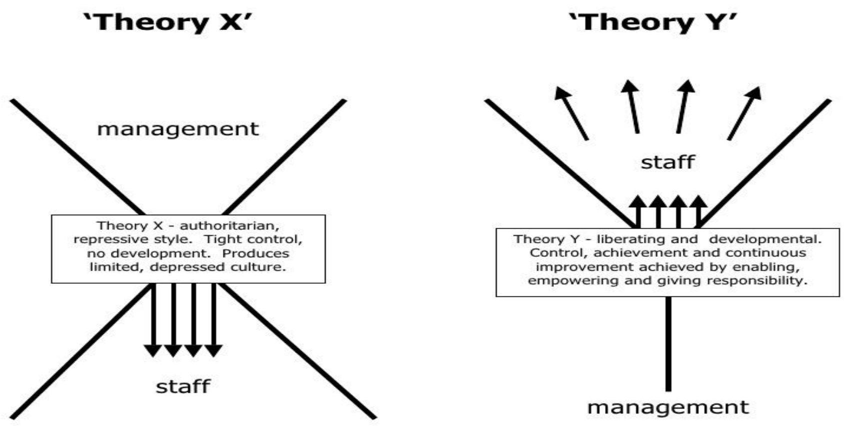
40	**What is meant by downward communication? [Dec 2018]** BTL2 The information is sent from the higher level to the lower level.
41	**What are the advantages of democratic leadership styles? [May 2018]** BTL4 • Absence of leader does not affect the output • The quality of decision is improved
	PART * B
1	**Explain the type of leadership with examples and write down the advantages and Disadvantages. (13M) [Dec 2006, Dec 2018]** BTL3 **Answer: Page :4.70 - Dr. G.K. Vijayaraghavan** **LEADERSHIP STYLES** **The leadership style we will discuss here are:** **Autocratic style** • Characterized by individual control over all decisions and little input from group members. **Disadvantages** More group hostility More dependence on leader More apathy in group Slower execution of decisions **Advantages** More group productivity while leader watches Group makes quicker decisions Often does the task themselves as it is quicker Pushes the group. **Democratic Style** • Members of the group take a more participative role in the decision-making process. **Disadvantages** Slower decision making Less initial production Leader can be unsure and makes everything a matter for group discussion. **Advantages** More individual responsibility More friendliness Better implementation More personal growth More motivation Greater ultimate production **Laissez Faire Style** Leaders are hands-off and allow group members to make the decisions. **Disadvantages:**

	Less group satisfaction Less group productivity Poorer quality of work Less personal growth Jobs fall back on someone else or are not completed Who takes credit or blame? **Advantages:** No work for the leader Frustration may force others into leadership roles Allows the visionary worker the opportunity to do what they want, free from interference Empowers the group
2	**Explain dimension, advantages and disadvantages of job enrichment to maintain competitiveness. (13M) [Dec 2006]**BTL2 **Answer: Page: 4.60 - Dr. G.K. Vijayaraghavan** **INTRODUCTION: (2 M)** • Addition to a job of tasks that increase the amount of employee control or responsibility. • Job enrichment has its roots in Frederick Herzberg's two-factor theory, according to which two separate dimensions contribute to an employee's behaviour at work. **DIMENSION: (4 M)** **The first dimension**: • Hygiene factors, involves presence or absence of job dissatisfaction, such as wages, working environment **The second dimension :** • Factors that satisfy higher-level needs. **Advantages of job enrichment : (4 M)** • Interesting and challenging job :- When a certain amount of power is given to employees. It makes the job more challenging for them. • Improves decision making :- Improve decision making ability of employee by asking him to decide. **Disadvantages of job enrichment : (3 M)** Workers have complete knowledge to take decisions and they have the right attitude. Negative implications ie. Along with usual work decision making work is also given to employees and not many may be comfortable with this.
3	**Explain Maslow's theory of motivation and compare and contrast XY theory. (13M) [Dec 2007, May 2009, May 2017, Dec 2017, May 2018, Dec 2018, May 2019]** BTL2 **Answer: Page: 4.28 & 4.24 - Dr. G.K. Vijayaraghavan** **EXPLANATION: (4 M)** • Physical: The basic need of human being such as water, air, food, dress.

- Security: The need of safety , shelter, stability
- Social : The need of being loved, belonging , Inclusion
- Ego: The need of self-esteem, Power, Prestige
- Self-actualisation: The need of development, Creativity.

DIAGRAM: **(2 M)**

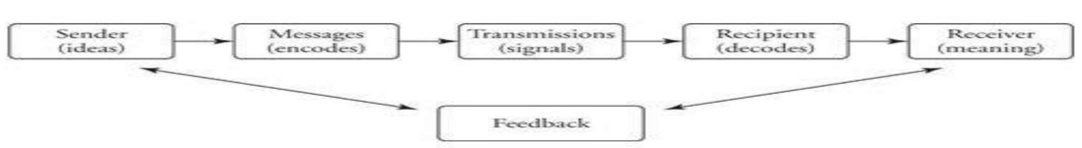
DIAGRAM: **(2 M)**



Based on Douglas McGregor's XY-Theory. www.businessballs.com

EXPLANATION: **(5 M)**

- **Theory X**
- Managers tend to take a pessimistic view of their people
- Assume that they are naturally unmotivated, dislike work.
- Team members need to be prompted, rewarded, punished constantly to make sure that they complete their tasks.
- **Theory Y**
- Managers have an optimistic, positive opinion of their people

	• Use a decentralized, participative management style. • This encourages a more collaborative , trust-based relationship
4	**Define communication. Explain the process of communication. [May2008, May 2012, Dec 2013] (13M)** BTL2 **Answer: Page: 4.92 - Dr. G.K. Vijayaraghavan** **Define: (2 M)** According to Koontz and O'Donnell, "Communication, is an intercourse by words, letters symbols or messages, and is a way that the organization members shares meaning and understanding with another". **DIAGRAM: (2 M)**  **Figure 1** Communication model. **EXPLANATION : (9 M)** • Sender : The person who send the message • Encoding: The process of converting common language to machine language. • Transmission: The process of selecting channel or method of communication • Decoding: The process of converting machine language to common language • Receiver: The person who receive the message • Feedback: It is a source of acknowledging the message from receiver to sender
5	**Briefly describe the individual and group behaviour (13M)** BTL2 **Answer: Page: 4.4 & 4.9 - Dr. G.K. Vijayaraghavan** **Foundation of individual and group behaviour: (13 M)** • Individual level of analysis Helps to identify the individual attitude and behavior • Group level of analysis Helps to identify the team attitude and behavior • Organizational level of analysis Helps to identify the entire organizational attitude and behavior
6	**Explain the various types of organizational communication. (13M) [May 2007]** BTL2 **Answer: Page: 4.100 - Dr. G.K. Vijayaraghavan** **Formal Communication: (6 M)** • Downward Communication communication from top management to lower level management • Upward Communication communication from lower level management to top management

	• Horizontal Communication communication between same set of people **Informal Communication or Grapevine: (7 M)** • Oral Communication Communication by language through mouth • Written Communication Communication by documents and proofs through hand writing • Body language Communication by signal and symbols through body actions
7	**Briefly summarise Barriers in effective communication. (13M) [May 2007, May 2017, Dec 2017, May 2018, May 2019]** BTL2 **Answer: Page: 4.103 & 4.105 - Dr. G.K. Vijayaraghavan** **EXPLANATION: (13 M)** • Filtering • Selective Perception • Emotions • Language • Stereotyping - Repeating the same concept • Status Difference • Use of Conflicting Signals • Reluctance to Communicate • Projection • The "Halo Effect"- influencing the first impression
8	**Explain the leadership theories in detail. (13M) [May2011]** BTL2 **Answer: Page: 4.75 - Dr. G.K. Vijayaraghavan** **EXPLANATION: (13 M)** • Great Man Theory The impact of great men, or heroes; highly influential individuals who, due to either their personal charisma, intelligence, wisdom, or political skill used their power. • Trait Theory Study of human personality. Trait theorists are primarily interested in measurement of traits, • Behavioural Theory Theory of learning. The idea that all behaviours are acquired through conditioning. • Participative Leadership A managerial style that invites input from employees on all company decisions. • Situational Leadership Manager of an organization must adjust his style to fit the development

	• Contingency Theory There is no best way to organize a corporation, to lead a company • Transactional Leadership Style of leadership that focuses on supervision, organization, and performance • Transformational Leadership A leader works with teams to identify needed change, creating a vision to guide the change through inspiration.
9	**Name the various motivation theories. Explain any three out of these theories.(13M)**BTL2 **[May2011, May 2012]** **Answer: Page: 4.23 - Dr. G.K. Vijayaraghavan** **EXPLANATION: (13 M)** • McGregor's Theory X and Theory Y Theory X is a conventional approach to motivation, based on negative assumptions. Theory Y is diametrically opposite to theory X • Abraham Maslow's "Need Hierarchy Theory Subsequently extended the idea to include his observations of humans' innate curiosity. • Frederick Herzberg's motivation-hygiene theory Factors in the workplace that cause job satisfaction, while a separate set of factors cause dissatisfaction • Victor Vroom's Expectancy theory Individual will Behave or act in a certain way because they are motivated to select a specific behaviour • Clayton Alderfer's ERG theory The existence group is concerned with providing the basic material existence requirements of humans. • McClelland's Theory of Needs It attempts to explain how the needs for achievement, power, and affiliation • Stacey Adams' Equity Theory It focuses on determining whether the distribution of resources is fair to both relational partners. • Skinner's Reinforcement Theory It states that individual's behaviour is a function of its consequences.
10	**Discuss the Guidelines for effective Communication. [May 2013]** BTL2**(13M)** **Answer: Page: 4.105 - Dr. G.K. Vijayaraghavan** **EXPLANATION: (13 M)** • Senders of message must clarify in their minds what they want to communicate. • Encoding and decoding be done with symbols that are familiar to the sender and receiver of message. • For the planning of the communication, other people should be consulted and

	encouraged to participate. • It is important to consider needs of receivers of information. • In communication, tone of voice, the choice of language • Communication is complete only when message is understood by receiver. . • The function of communication is more than transmitting the information • Effective communicating responsibility not only of sender but also of receiver of information.
	PART * C
1	**How to overcome the barriers in Communication –Discuss. (15M) [Dec2007]** BTL2 **Answer: Page:** 4.103 - **Dr. G.K. Vijayaraghavan** **EXPLANATION: (15 M)** • Have Clarity In Your Thoughts • Understand the needs of your audience • Seek the Advice of others before Communicating • Take adequate care of your Tone, Language • Have a Feedback from the receiver • Retain Consistency about the Message • Keep a Routine check on the communication system • Make use of the body language • Avoid overloading too much of information • Reduce the level of noise as far as possible • Communication chain should be short
2	**Explain in detail about the Blake and Mouton's managerial grid. (15M)[May 2008, May 2009]** BTL2 **Answer: Refer Notes.** **Definition: (2 M)** Robert Blake and Jane Mouton have developed the Managerial Grid, also called as a leadership grid. According to them, the leadership styles can be identified on the basis of manager's concern for people and production. Here, concern for people means the degree to which an individual is committed towards the goal achievement, maintaining self-esteem to workers and satisfying interpersonal relationships. Whereas, the concern for production means an attitude of superiors towards the quality of procedures and policies, creativeness of research, effectiveness of staff, work efficiency and volume of output **EXPLANATION: (10 M)** **The managerial grid identifies five leadership styles based on two behavioural dimensions as shown in the figure below:** • **1.1 - "Impoverished"** - minimum management/leadership and minimum requirements for the task • **1.9 - "Country club"** - high concern on people and interpersonal relationships, minimum focus on the task • **5.5 - "Middle-of-the-road"** - medium level of focus on relationships and focus on

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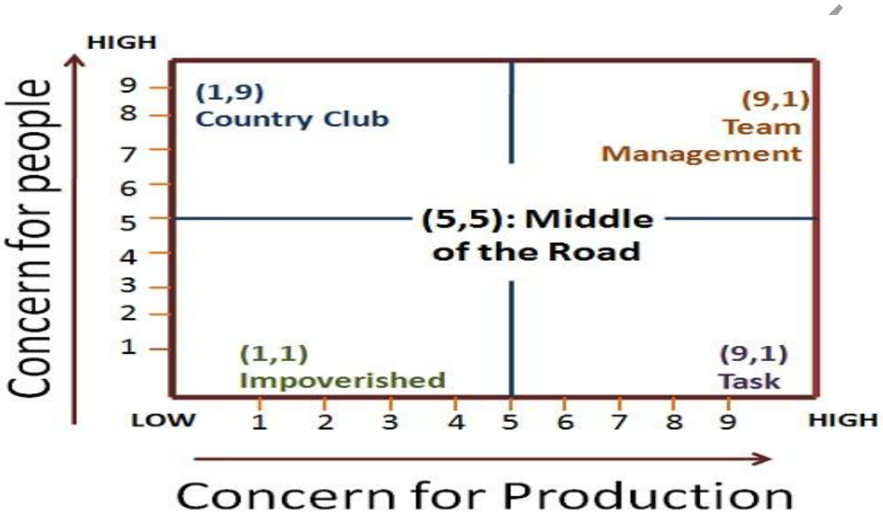
the task satisfactorily

- **9.1 - “Produce or Perish”** - the minimum respect for people, high requirements for the task
- **9.9 - “Team”** - the highest concern on people and relationships and also highest concern on the task

DIAGRAM: (3 M)



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Explain the use of computers and IT in management control system (15M) [May 2009]
BTL2

Answer: Page: 5.46 - Dr. G.K. Vijayaraghavan

Diagram: (4 M)

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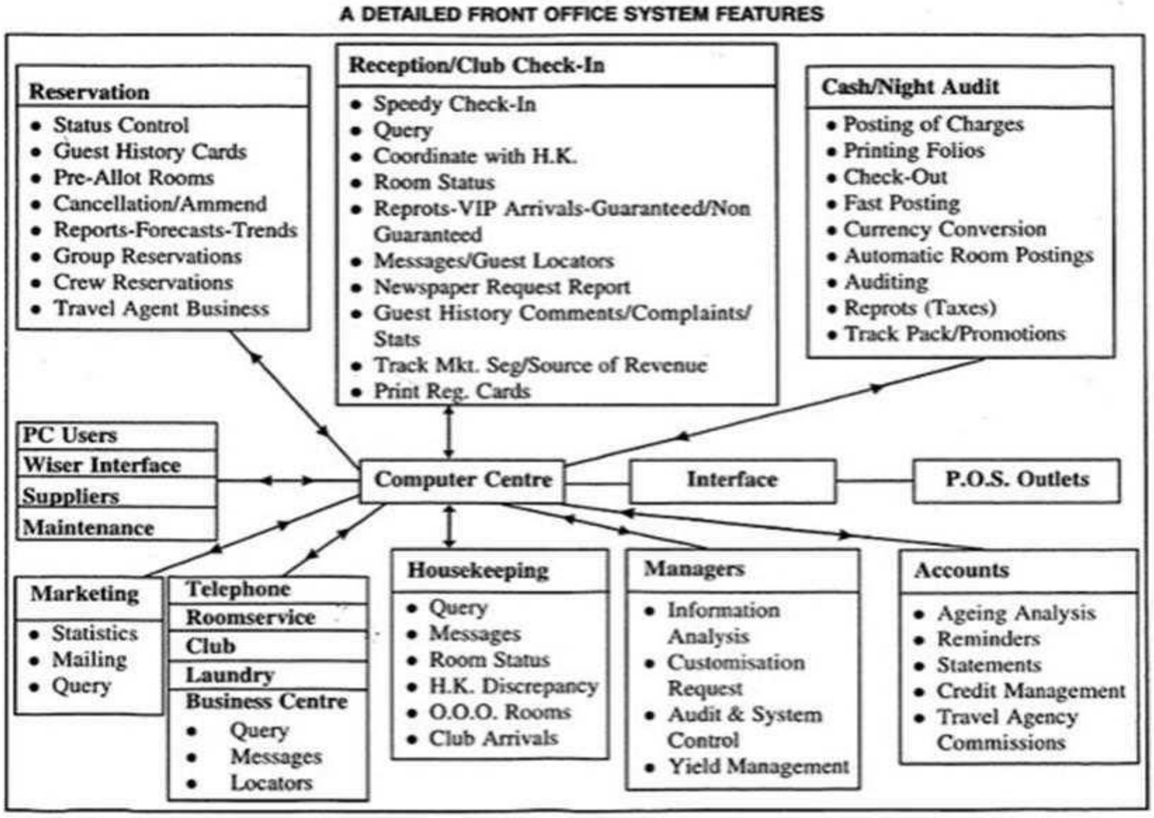


EXPLANATION: **(11 M)**

- Uses of the computer in Education field
- Use of computers in the business.
- Uses of the computer in hospitals
- Uses of the computer in the banking sector
- Uses of the computer in government offices
- Uses of the computer in the home
- Uses of the computer in marketing
- Computer used by various people around the world for different reasons and purposes
- Uses of computer in new habits—Impact of computer in our life
- Uses of computer to change life: -Computer changed our lives in this way

	UNIT V - CONTROLLING
	System and process of controlling – budgetary and non-budgetary control techniques – use of computers and IT in Management control – Productivity problems and management – control and performance – direct and preventive control – reporting.
	PART * A
Q. No	**Questions**
1	**What is Feed Forward Control?** BTL1 Feed Forward Control involves evaluation of input and corrective measures before a particular sequence of operation is completed. It is based on timely and accurate information about changes in the environment.
2	**What is Concurrent Control?** BTL1 Concurrent Control is also known as "real-time" or steering" control. It provides for taking corrective actions or making adjustments while the programmes is still in operation and before any major damage occurs.
3	**List out the important features of controlling?** BTL4 • Function of Management. • Continuous function • Future -oriented and • Action-oriented.
4	**What is Flexible Budget?** BTL1 **[May 2012]** Flexible Budget is one which is designed to change in accordance with the level of activity actually attained. It is suitable when the estimation of demand is uncertain and the enterprise works under conditions of lack of material and labor power.
5	**What are the benefits of control?** BTL2 • Control eliminates actions which deviate or which is not in conformity with the cherished goals of the firm. • It offers enough information for future planning and Organising.
6	**List out the characteristics of Control function?** BTL4 **[May 2018]** • Functional Management • Continuous function • Future-oriented • Action-oriented • Measuring the performance and • Planning the control
7	**What are the basic steps involved in the process of controlling?** BTL2 **[Dec 2018]** • establishment of standards • measurement of performance • comparing performance with the slandered • taking corrective action
8	**What is performance Appraisal?** BTL1 **[May 2018]**

Performance appraisal is the system of measuring Employee performance and giving feedback to the employee regarding his performance.

9 **Define control.** BTL2 **[May 2019]**

According to Koontz "Controlling to the measurement and correction of performance in order to make sure that enterprise objectives and the plans devised to attain them are accomplished".

10 **What are the characteristics of control?** BTL2 **[May 2018]**

1. Control process is universal
2. Control is a continuous process.
3. Control is action based.
4. Control is forward looking.

11 **Write the types of control.** BTL2 **[May 2010, May 2013]**

1. Feedback control
2. Concurrent control
3. Feed forward control

12 **List on the differences between Feedback control and feed forward technique.** BTL1

	Feedback	**Feed forward**
1	It measure only output of the process.	It measures input of the process.
2	It is submissive approach.	It is aggressive approach.
3	Less benefit.	More benefit.

13 **What are the requirements for effective control?** BTL2

1. The control should be economical,
2. It must be simple,
3. It should be flexible,
4. It should be clear objectives.

14 **Define: MIS.** BTL2

"A system of obtaining abstracting, storing and analyzing data to productions information for use in Planning, controlling and decision making by managers at the time they can most effectively use it".

a)To find out the new opportunities.
b) To provide sales forecasting.
c) To allocate resources.
d) To provide effective managerial activities.

15 **Differentiate PERT nad CPM** BTL2

S.No.	**CPM**	**PERT**
1	It is activity oriented	PERT is event oriented

2	CPM is planning device	PERT is control device
3	It estimates only one time	It estimates three times
4	It is a deterministic model	It is probabilistic model

16	**What are global theories of management?** BTL2 • Situational and contingency approach • Motivation and leadership theory • Organizational behaviour
17	**What are MIS Resources?** BTL2 • To provide the information up to date • To take effective decision making • To provide the right information available in the right form at the right time
18	**What is Operation Research?** BTL2 Operation Research is an applied decision theory, which uses scientific, mathematical and logical means to take decisions.
19	**Why controlling is important? [May 2017]** BTL2 • helps to increase the coordination of the subordinates in the organisation • ensures the organizational efficiency and effectiveness
20	**Define budgetary control? [May 2007, May 2011, Dec 2012, Dec 2014, Dec 2017]** BTL1 It is the process of determining various budgets for the business unit for future. It serves as a method of control. It is a system of controlling costs through preparation of budgets.
21	**What are the uses of computers in handling information? [May 2016, Dec 2016]** BTL4 1. sales forecast and control 2. payroll 3. business management 4. accounting
22	**Define productivity. List the types of productivity?** BTL4 **[Dec 2005, May 2009, May 2014, Dec 2017]** It is a measure of how much input is required to produce a given output. Types 1. labor productivity 2. capital productivity 3. material productivity.
23	**What is preventive control?** BTL1 **[May 2005, May 2012, May 2016, May 2017]** An efficient manager applies the skills in managerial philosophy to eliminate an undesirable activity which are the reasons for poor management.
24	**Name at least four budgetary control techniques? [May 2019]** BTL1 1. zero base budgeting 2. variance analysis 3. adjustment of funds 4. human resource accounting
	PART * B
1	**Explain the characteristics and importance of controlling. (13M) [Dec2006]** BTL2

Answer: Page: 5.2 & 5.4 - Dr. G.K. Vijayaraghavan

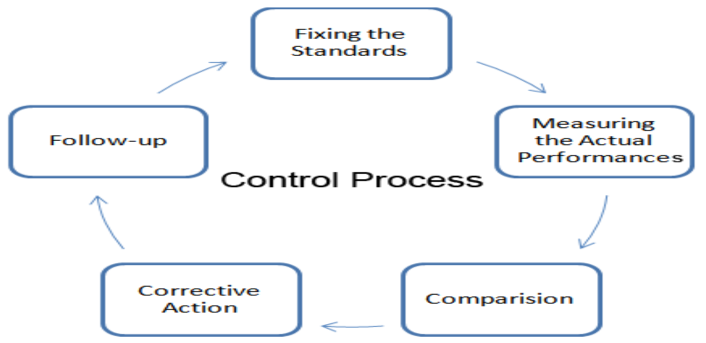
EXPLANATION: **(13 M)**

- Control is an essential function of management ·
- Control is an ongoing process
- Control is forward – working because pas cannot be controlled
- Control involves measurement
- The essence of control is action ·
- Control is an integrated system

2 **Explain the steps in controlling process. (13M) [Dec2007, May 2013, May 2017, May 2018, Dec 2017, May 2019]** BTL2

Answer: Page: 5.9 - Dr. G.K. Vijayaraghavan

Diagram – **(3M)**



Explanation – **(10 M)**

1.Fixing the standards

The first and primary focus should be fixing the standard of controlling process.

2.Measuring the actual performance

Actual performance will be monitored and evaluated in the right way.

3.Comparision

Compare the actual plan with scheduled controlling process.

4.Corrective Action

Corrective measures will be taken for evaluate the process.

5.Follow up

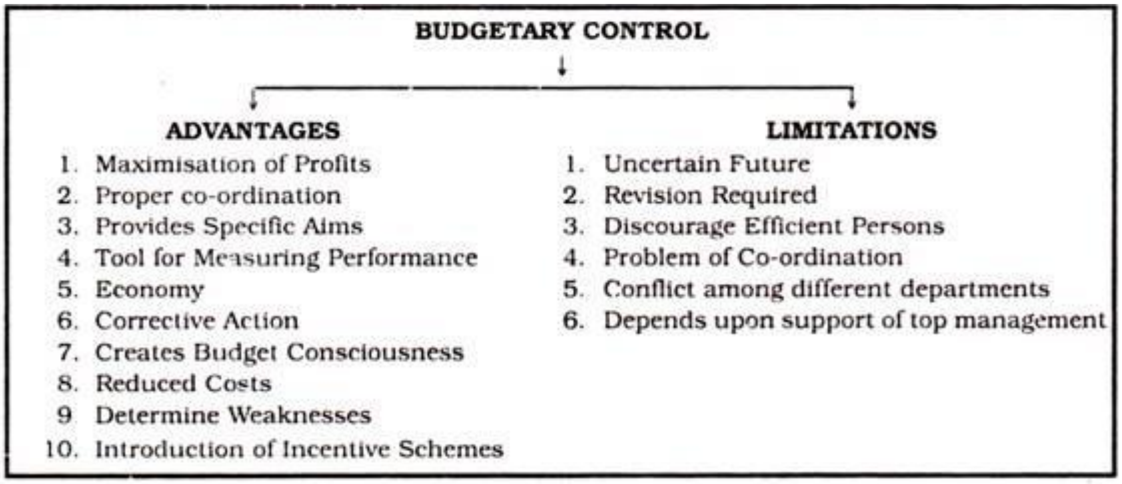
Follow up the process for continuous course of action.

3 **What is budgetary control? Explain the advantages and Limitations. (13M) [Dec2007, Dec 2018]** BTL2

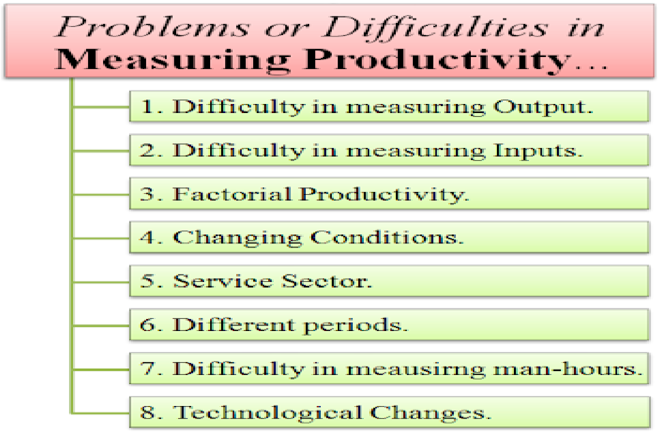
Answer: Page: 5.20 - Dr. G.K. Vijayaraghavan

DEFINITION: **(2 M)**

Budgetary Control is defined as "the establishment of budgets, relating the Responsibilities of executives to the requirements of a policy, and the continuous comparison of actual with budgeted results either to secure by individual action the

	objective of that policy or to provide a base for its revision.  **BUDGETARY CONTROL** **ADVANTAGES** 1. Maximisation of Profits 2. Proper co-ordination 3. Provides Specific Aims 4. Tool for Measuring Performance 5. Economy 6. Corrective Action 7. Creates Budget Consciousness 8. Reduced Costs 9 Determine Weaknesses 10. Introduction of Incentive Schemes **LIMITATIONS** 1. Uncertain Future 2. Revision Required 3. Discourage Efficient Persons 4. Problem of Co-ordination 5. Conflict among different departments 6. Depends upon support of top management **ADVANTAGES:** **(6 M)** 1. Maximisation of Profits 2.Proper Co-ordination 3.Provides Specific Aims 4.Tool for measuring performance 5.Economy 6.Corrective action 7.Creates budget consciousness 8.Reduced Cost 9.Determine Weakness 10.Introduction of Incentive Schemes **LIMITATION:** **(5 M)** 1.Uncertain Future 2.Revision Required 3.Discourage Efficient persons 4.Problem of Co-Ordination 5.Conflict among different departments 6.Depends upon support of top management
4	**Bring out the different characteristics of control system. Also bring out the factors influencing control system (13M) [May 2007, Dec2012, May 2019]** BTL4 **Answer: Page: 5.2 - Dr. G.K. Vijayaraghavan** **Characteristics:** **(7 M)** Management control systems designed in an organisation should fulfil the following characteristics: (i) Management control systems should be closely aligned to an organisation’s strategies and goals.

	(ii) Management control systems should be designed to fit the organisation's structure and the decision-making responsibility of individual managers. (iii) Effective management control systems should motivate managers and employees to exert efforts toward attaining organisation goals through a variety of rewards tied to the achievement of those goals. **Factors influencing: (6 M)** Factors influencing the design of Management Control Systems are as follows: (i) Size and Spread of the Enterprise: (ii) Organisational Structure, Delegation and Decentralisation: (iii) Nature of Operations and Divisibility: (iv) Types of Responsibility Centres: (v) People and their Perceptions:
5	**Explain the advantages of Purchase control [May 2009, Dec 2018]** (BTL2)**(13M)** **Answer: Refer Book Principles Of Management By Dr. G.K. Vijayaraghavan Pg. No.5.69** **Explanation – 13 M** **Key Points:** a) Continuous availability of materials b) Purchasing of right quantity c) Purchasing of right quality d) Economy in purchasing e) Works as information centre f) Development of business relationship **g)** Finding of alternative source of supply: h) Fixing responsibilities:
6	**What do you mean by productivity? Describe the problems involved in measuring the productivity of knowledge workers. (13M)** BTL2 [**May2011]** **Answer: Page: 5.61 - Dr. G.K. Vijayaraghavan** **Meaning: (2 M)** Productivity refers to the ratio between the output from production processes to its input. Productivity may be conceived of as a measure of the technical or engineering efficiency of production. As such quantitative measures of input, and sometimes output, are emphasized. **Explanation : (11 M)**



1.Difficulty in measuring Output
2.Difficulty in measuring Input
3.Factorial Productivity
4.Changing Conditions
5.Service sector
6.Different periods
7.Difficulty in measuring man-hours
8.Technology Changes

7 **Explain the steps involved in the quality control process with advantages and disadvantages. [Dec2013] (13M)** BTL2

Answer: Page: 5.75 - Dr. G.K. Vijayaraghavan

Explanation – 9 Mark

Steps: **(7 M)**

- Determine what parameter is to be controlled.
- Establish its criticality and whether you need to control before, during or after results are produced.
- Establish a specification for the parameter to be controlled which provides limits of acceptability and units of measure.
- Produce plans for control which specify the means by which the characteristics will be achieved and variation detected and removed.
- Organize resources to implement the plans for quality control.
- Install a sensor at an appropriate point in the process to sense variance from specification.
- Collect and transmit data to a place for analysis.
- Verify the results and diagnose the cause of variance.
- Propose remedies and decide on the action needed to restore the status quo.
- Take the agreed action and check that the variance has been corrected.

Advantages : **(3 M)**

- Better products, services ultimately establishing a good reputation for a company
- Higher revenue from having more satisfied customers.

Disadvantages: **(3 M)**

- Need more manpower/operations to maintain quality control
- Adding more time to the initial process.

8 **Explain the budgetary control techniques. (13M) [May2011]** BTL2

Answer: Page: 5.18 - Dr. G.K. Vijayaraghavan

EXPLANATION: **(13 M)**

- Revenue and Expense Budgets
  The amount of money allocated to the maintenance and growth of a business
- Time, Space, Material, and Product Budgets
  The production **budget** calculates the number of units of **products** that must be manufactured
- Capital Expenditure Budgets
  A formal plan that states the amounts and timing of fixed asset purchases by an organization
- Cash Budgets
  A **budget** or plan of expected **cash** receipts and disbursements during the period
- Variable Budget
  The budget amount will change based on the changes of output.
- Zero Based Budget
  A method of budgeting in which all expenses must be justified for each new period.

9 **Explain the Non-budgetary control techniques [Dec2012] (13M)** BTL2

Answer: Page: 5.34 - Dr. G.K. Vijayaraghavan

EXPLANATION: **(13 M)**

- Statistical data
  Statistics is especially useful in drawing general conclusions about a set of **data** from a sample of it.
- Break- even point analysis
  It lets us determine what you need to sell, monthly or annually, to cover your costs of doing business
- Operational audit
  Operational Audit is a systematic review of effectiveness, efficiency and economy of operation.
- Personal observation
  A subset category, in which the researcher is the primary instrument for monitoring and data collection
- PERT
  The program evaluation and review technique is a statistical tool used in project

	management • GANTT CHART A type of bar chart that illustrates a project schedule, named after its inventor
10	**Explain the Essentials of a Good Reporting System. [May 2013] (13M)** BTL2 **Answer: Page: 5.89 - Dr. G.K. Vijayaraghavan** **EXPLANATION: (13 M)** 1. Proper Form 2. Proper Time 3. Proper Flow of Information 4. Flexibility 5. Facilitation of Evaluation 6. Economy
	PART * C
1	**What is productivity? Explain the methods of improving productivity [Dec2006] (15M)** BTL2 **Answer: Page: 5.60 - Dr. G.K. Vijayaraghavan** **Meaning: (2 M)** Productivity refers to the ratio between the output from production processes to its input. Productivity may be conceived of as a measure of the technical or engineering efficiency of production. As such quantitative measures of input, and sometimes output, are emphasized. **METHODS: (13 M)** • Training programme for labour • Incentives in contract for good performance • Enough tools in working place and proper planning • Optimising site facilities • Availability of resource • Competition between crews, areas and shifts • Good supervision and optimum manpower • Short interval scheduling • Innovative materials and equipment • Time lapse film analysis for critical activities • Cost reporting and work sampling of critical activities
2	**Explain the different types of reporting. [May 2007] (15M)** BTL2 **Answer: Page: 5.91 - Dr. G.K. Vijayaraghavan** **EXPLANATION: (15 M)** • External Reports The issuance of financial statements to parties outside of the **reporting** entity. • Internal Reports A vital component of a well-run business, but in most organizations, it's fraught with

challenges including versioning overlap and manual processes

- Intra Report
  A report between the sub departments for sharing their views and information
- Control Reports
  Every business should have internal **control** procedures such as management **control reports**
- Investigating Reports
  A form of journalism in which reporters deeply investigate a single topic of interest, such as serious crimes, political corruption, or corporate wrongdoing.
- Routine Reports
  A **Routine Report** is prepared and presented as a **routine** work and at a regular period of time
- Special Reports
  The results and data where drawn based on special demand and requirement s
  Operating reports:
  It's the process reporting the operative profit and status
  Financial Reports
  It gives the overall financial information and data for managerial decision.

3. **Explain the use of computers and IT in management control system (15M) [May 2009, May 2017, Dec 2017, Dec 2018]** BTL2

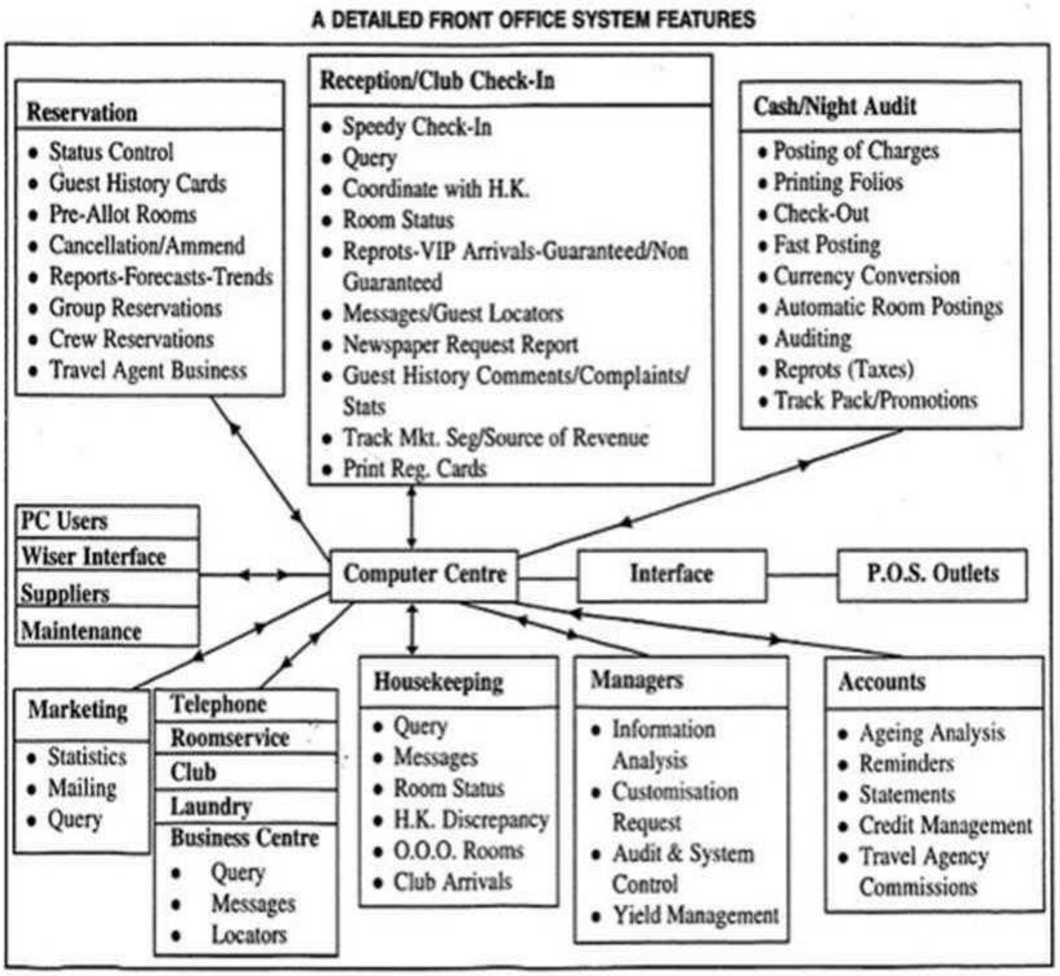
Answer: Page: 5.46 - Dr. G.K. Vijayaraghavan

EXPLANATION: (11M)

- Use of computer in the business
- Uses of the computer in hospitals
- Uses of the computer in the banking sector
- Uses of the computer in government offices
- Uses of the computer in the home
- Uses of the computer in marketing
- Computer used by various people around the world for different reasons and purposes
- Uses of computer in new habits—Impact of computer in our life

Uses of computer to change life: -Computer changed our lives in this way.

DIAGRAM: (4 M)


A DETAILED FRONT OFFICE SYSTEM FEATURES
Reservation
• Status Control
• Guest History Cards
• Pre-Allot Rooms
• Cancellation/Ammend
• Reports-Forecasts-Trends
• Group Reservations
• Crew Reservations
• Travel Agent Business
Reception/Club Check-In
• Speedy Check-In
• Query
• Coordinate with H.K.
• Room Status
• Reprots-VIP Arrivals-Guaranteed/Non Guaranteed
• Messages/Guest Locators
• Newspaper Request Report
• Guest History Comments/Complaints/ Stats
• Track Mkt. Seg/Source of Revenue
• Print Reg. Cards
Cash/Night Audit
• Posting of Charges
• Printing Folios
• Check-Out
• Fast Posting
• Currency Conversion
• Automatic Room Postings
• Auditing
• Reprots (Taxes)
• Track Pack/Promotions
PC Users
Wiser Interface
Suppliers
Maintenance
Computer Centre
Interface
P.O.S. Outlets
Marketing
• Statistics
• Mailing
• Query
Telephone
Roomservice
Club
Laundry
Business Centre
• Query
• Messages
• Locators
Housekeeping
• Query
• Messages
• Room Status
• H.K. Discrepancy
• O.O.O. Rooms
• Club Arrivals
Managers
• Information Analysis
• Customisation Request
• Audit & System Control
• Yield Management
Accounts
• Ageing Analysis
• Reminders
• Statements
• Credit Management
• Travel Agency Commissions

EE6005 POWER QUALITY L T P C
3 0 0 3

OBJECTIVES:

- To introduce the power quality problem
- To educate on production of voltages sags, over voltages and harmonics and methods of control.
- To study overvoltage problems
- To study the sources and effect of harmonics in power system
- To impart knowledge on various methods of power quality monitoring.

UNIT I INTRODUCTION TO POWER QUALITY 9

Terms and definitions: Overloading - under voltage - over voltage. Concepts of transients - short duration variations such as interruption - long duration variation such as sustained interruption. Sags and swells - voltage sag - voltage swell - voltage imbalance - voltage fluctuation - power frequency variations. International standards of power quality. Computer Business Equipment Manufacturers Associations (CBEMA) curve.

UNIT II VOLTAGE SAGS AND INTERRUPTIONS 9

Sources of sags and interruptions - estimating voltage sag performance. Thevenin's equivalent source - analysis and calculation of various faulted condition. Voltage sag due to induction motor starting. Estimation of the sag severity - mitigation of voltage sags, active series compensators. Static transfer switches and fast transfer switches.

UNIT III OVERVOLTAGES 9

Sources of over voltages - Capacitor switching – lightning – ferro-resonance. Mitigation of voltage swells - surge arresters - low pass filters - power conditioners. Lightning protection – shielding – line arresters - protection of transformers and cables. An introduction to computer analysis tools for transients, PSCAD and EMTP.

UNIT IV HARMONICS 9

Harmonic sources from commercial and industrial loads, locating harmonic sources. Power system response characteristics - Harmonics Vs transients. Effect of harmonics - harmonic distortion - voltage and current distortion - harmonic indices - inter harmonics – resonance. Harmonic distortion evaluation - devices for controlling harmonic distortion - passive and active filters. IEEE and IEC standards.

UNIT V POWER QUALITY MONITORING 9

Monitoring considerations - monitoring and diagnostic techniques for various power quality problems - modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools - power line disturbance analyzer – quality measurement equipment - harmonic / spectrum analyzer - flicker meters - disturbance analyzer. Applications of expert systems for power quality monitoring.

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to understand and analyze power system operation, stability, control and protection.

TEXT BOOKS:

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.WayneBeaty, 'Electrical Power Systems Quality' McGraw Hill,2003.(For Chapters1,2,3, 4 and 5).
2. Eswald.F.Fudis and M.A.S.Masoum, "Power Quality in Power System and Electrical Machines," Elseviar Academic Press, 2013.
3. J. Arrillaga, N.R. Watson, S. Chen, 'Power System Quality Assessment', Wiley, 2011.

REFERENCES:

1. G.T. Heydt, 'Electric Power Quality', 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994). (For Chapter 1, 2, 3 and 5)
2. M.H.J Bollen, 'Understanding Power Quality Problems: Voltage Sags and Interruptions', (New York: IEEE Press, 1999). (For Chapters 1, 2, 3 and 5)
3. G.J.Wakileh, "Power Systems Harmonics – Fundamentals, Analysis and Filter Design," Springer 2007.
4. E.Aeha and M.Madrigal, "Power System Harmonics, Computer Modelling and Analysis, " Wiley India, 2012.
5. R.S.Vedam, M.S.Sarma, "Power Quality – VAR Compensation in Power Systems," CRC Press 2013.
6. C. Sankaran, 'Power Quality', CRC press, Taylor & Francis group, 2002.

Subject Code: EE6005 **Year/Semester: IV /07**
Subject Name: Power Quality **Subject Handler: Mr.K.Jayavelu**

	UNIT I – INTRODUCTION TO POWER QUALITY
	Terms and definitions: Overloading - under voltage - over voltage. Concepts of transients - short duration variations such as interruption - long duration variation such as sustained interruption. Sags and swells - voltage sag - voltage swell - voltage imbalance - voltage fluctuation - power frequency variations. International standards of power quality. Computer Business Equipment Manufacturers Associations (CBEMA) curve.
	PART –A
1	**Define voltage swell. (Nov 21018)**BTL 2 Voltage swell is defined as a temporary increase in the RMS value of the voltage of more than 10 percent of the nominal voltage, at the power frequency, for durations from 0.5 cycles to 1 min.
2	**List the major power quality issue.** BTL 1 ➢ Power frequency disturbances ➢ Power system transients ➢ Grounding and Bonding ➢ Electromagnetic interference ➢ Power system harmonics ➢ Electrostatic discharge ➢ Power factor
3	**Define voltage sag. (Nov 2018)**BTL 2 Voltage sag is defined as a decrease to between 0.1 and 0.9 pu in RMS voltage or current at the power frequency for durations of 0.5 cycles to 1 min.
4	**What are the commonly used terms that describe the parameters of electrical power that describe or measure power quality?** BTL 1 Sag, swell, interruption, transients, harmonics, waveform distortion, over voltages, undervoltages, voltage imbalance, power frequency variations, etc.
5	**What is the most common power quality problem?** BTL 1 Voltage sags are considered the most common power quality problem. These can be caused by the utility or by customer loads. When sourced from the utility, they are most commonly caused by faults on the distribution system. These sags will be from 3 to 30 cycles and can be single or three phase. Depending on the design of the distribution system, a ground fault on 1 phase can cause a simultaneous swell on another phase.

6	**Define momentary interruption and components of waveform distortion.** BTL 2 Momentary interruption is said to occur when the RMS voltage decrease less than 0.1 per unit for time duration of 0.008333 second to 3 second. **Causes:** Utility re-closer operation, faulty circuit breakers, bad wiring connections. **Effects:** Lost data, destruction of files, damaged hard disk. Components of waveform distortion: ➢ DC offset ➢ Notches ➢ Flickering ➢ Harmonics ➢ Noises ➢ Inter-harmonics
7	**How can power quality problems be detected?** BTL 4 ➢ A piece of equipment mis-operates at the same time of day. ➢ Circuit breakers trip without being overloaded. ➢ Equipment fails during a thunderstorm. ➢ Automated systems stop for no apparent reason.
8	**Comment" harmonics affect the electrical system".** BTL 2 Harmonics cause magnetic portions of the electrical system to overheat such as transformers, line reactors, magnetic relays and power factor capacitors.
9	**How do harmonics affect the load?** BTL 2 The effect of harmonics on loads varies a great deal and is dependent on the load itself. Most loads are not affected by moderate levels of harmonics. Exceptions to this are loads that perform electrical measurements in the frequency domain of the harmonics.
10	**How do you measure power quality?** BTL 2 It requires power quality measurement equipment to measure, record and diagnose harmonic problems. Power quality instruments offer a service of characterizing all aspects of power quality and determining if it is acceptable to the load.
11	**Classify the types of power quality solutions available on the market today.** BTL 1 There are hundreds of manufacturers making thousands of different Power Quality solutions today. The categories of these solutions are: ➢ Utility based solutions for the substation level. ➢ User based solution for whole facility protection. ➢ User load level solutions for specific loads. ➢ Designed in solutions, built in by the equipment manufacturer to reduce the sensitivity to Power Quality problems.
12	**Why is power conditioning needed?** BTL 2 Effective power conditioning will prevent the erosion of your equipment and by filtering out these harmful properties will substantially enhance its reliability.
13	**What types of equipment are affected by power line noise?** BTL 2 Any equipment based on semiconductor technology can be affected which includes all computers, telecommunications PBXs and key systems, automated manufacturing and design systems, computerized medical equipment and point of sale terminals.

14	**What represent quality of power?** BTL 2 This term covers technical aspects as well as non-technical aspects like the interaction between the customer and the network operator. Eg. The speed with which the network operator reacts to complaints, etc.
15	**Comment transients or noise on the power line causing problems now.** BTL 4 Advances in digital logic technology have produced smaller and more sophisticated devices. This new generation of micro-circuitry is extremely dense and substantially more susceptible and transient damage.
16	**What are the power quality issues?** BTL 1 Power frequency disturbances, power system transients, grounding and bonding, electromagnetic interference, power system harmonics, electrostatic discharge, power factor.
17	**Classify power quality events in short duration events.** BTL 1 ➢ Sag ➢ Swell ➢ Interruption.
18	**Mention the types of sag.** BTL 1 ➢ Instantaneous sag. ➢ Momentary sag ➢ Temporary sag.
19	**Mention the types of swell.** BTL 1 ➢ Instantaneous swell ➢ Momentary swell ➢ Temporary swell.
20	**List the types of interruption.** BTL 1 ➢ Sustained interruption ➢ Momentary interruption ➢ Temporary interruption.
	PART –B
1	**What are the major power Quality issues? Explain them. (13 M) (Nov 21018)**BTL2 **Answer: Page 1.8 - C.Ravichandran** ➢ **Power Frequency Disturbances(2 M)** Low frequency phenomena that result in voltage sags or swells Source or load generated due to faults or switching operations ➢ **Power System Transients(2 M)** Fast and short duration events that produce distortions such as notching, ringing etc ➢ **Grounding and Bonding (2 M)** The fundamental objective of grounding is safety The second objective is to provide a low impedance path The third use of grounding is to create a ground reference plane ➢ **Electromagnetic Interference(2 M)** Interaction between electric and magnetic fields and sensitive electronic circuits and devices High frequency phenomenon ➢ **Power System harmonics(2 M)** Low frequency phenomena characterized by waveform distortion

- **Electrostatic discharge (1 m)**
  Very common and unlikable occurrence
  Uncomfortable nuisance we are subjected to when we open the door of a car or the refrigerated case in the supermarket.
- **Power Factor (2 M)**
  Power factor is an economic issue in the operation of a power system
  As utilities are increased faced with power demands that exceed generation capability, the penalty for low power factor is expected to increase.

2. **Explain the following: (13 M)** BTL 2

   (a) Total harmonic distortion (7 M)

   (b) Total demand distortion (6 M)

Answer: Page 1.45 C.Ravichandran

Key Points:

(a)Total Harmonic Distortion (7 M)

Definition(2 M)

It is the term used to describe the net deviation of a non-linear waveform from ideal sine wave characteristics.

Expression & Explanation(5 M)

$$\text{THD} = \sqrt{\frac{\sum_{n=3,5,7,\cdots} V_n^2}{V_1^2}}$$

Where V_1 – Fundamental Component, V_h– harmonic component, h – harmonic order

(b)Total Demand Distortion (6 M)

Definition(2 M)

Total demand distortion is defined as the square root of the sum of the squares of the RMS value of the currents from 2nd to the highest harmonic divided by the peak demand load current and is expressed as percent.

Expression & Explanation(4 M)

TDD = I_{RMS} distorted / Maximum demand load current ($I_{d\ max}$)

Two ways to measure $I_{d\ max}$ – Average maximum demand current readings for the preceding time period with a load already present in the system and estimated based on the predicted load profiles for a new facility.

3. **Write the various IEEE and IEC power quality Standards. (13 M) (Nov 21018)**BTL 1

Answer: Page 1.8 - 1.54 C.Ravichandran

Key Points:

IEEE Standards(7 M)

- IEEE Std 141 – 1993
- IEEE Std 142 – 1991
- IEEE Std 241 – 1990
- IEEE Std 242 – 1986
- IEEE Std 399 – 1990
- IEEE Std 446 – 1987
- IEEE Std 487 – 1992
- IEEE Std 493 – 1990

	➢ IEEE Std 518 – 1982 **IEC Standards(6 M)** IEC 61000 Series Electromagnetic Compatibility defines for the following ➢ Part 1 – Definitions and methodology ➢ Part 2 – Environment ➢ Part 3 - Limits ➢ Part 4 – Tests and measurements ➢ Part 5 – Installation and mitigation ➢ Part 6 – Generic immunity and emissions
4.	**Discuss the following characteristics of power quality events. (Nov 2017, June 2014)** BTL 2 **(i) Short duration variation (4M)** **(ii) Long duration variation (4 M)** **(iii) Transient (5 M)** **Answer: Page 1.13 C.Ravichandran** **Keypoint:** ➢ Short Duration variation: o Voltage sag ▪ Instantaneous ▪ Momentary ▪ Temporary o Voltage swell ▪ Instantaneous ▪ Momentary ▪ Temporary o Interruption ▪ Momentary ▪ Temporary ➢ Long duration variation: o Under voltage o Over voltage o Sustained interruption ➢ Transient: o Impulsive transient o Oscillatory transient
5.	**Explain the impact of poor power quality on utility and consumer.(13 M) (May 2015)** BTL1 **Answer: Page 1.8 C.Ravichandran** **Keypoint:** **Diagram (5 M)** **Explanation (8M)** o Power frequency disturbance o Power system transients o Grounding and Boding o Electromagnetic interference o Power system harmonics o Electrostatic discharge

- Power factor

PART*C

1. **With a waveform sketch, explain the terms. (15 M) (June 2014, May 2015)**BTL 4

   (a) Voltage Sag (3 M)
   (b) Voltage interruption (3 M)
   (c) Voltage swells (3 M)
   (d) Sag with harmonics (3 M)
   (e) Transients (3 M)

Answer: Page – 1.13 C.Ravichandran

Key Points:

Voltage Sag: (3 M)

Decrease in the RMS voltage at the power frequency for periods ranging from a half cycle to a minute.

Types:

Instantaneous (0.5 – 30 cycles), Momentary (30 cycles – 3s) , Temporary (3s – 1 min)

Voltage interruption: (3 M)

Supply voltage decreases to less than 0.1 pu for a period of time not exceeding 1 min.

Types:

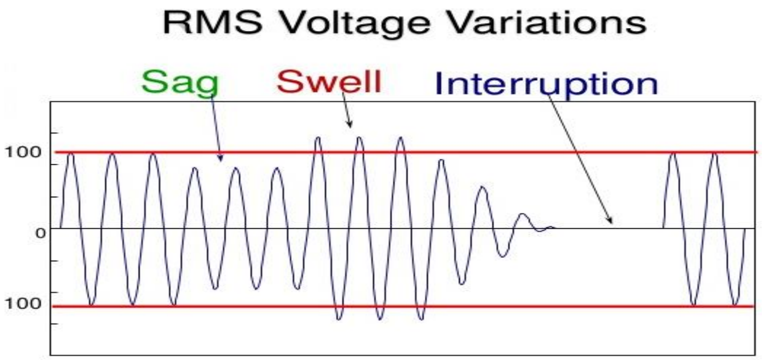
Momentary (0.5 – 30 cycles), Temporary (30 cycles – 3 s)

Voltage Swell: (3 M)

Increase up to a level between 1.1 and 1.8 pu in RMS voltage at the power frequency.

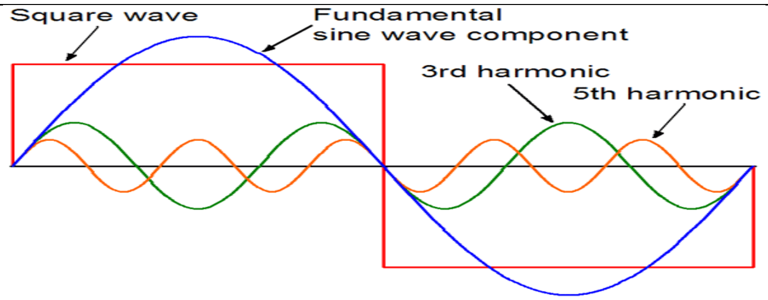
Types:

Instantaneous (0.5 – 30 cycles), Momentary (30 cycles – 3s) , Temporary (3s – 1 min)



Sag with harmonics: (3 M)

Harmonics are sinusoidal currents and voltages with frequencies that are integral multiples of the fundamental power line frequency.

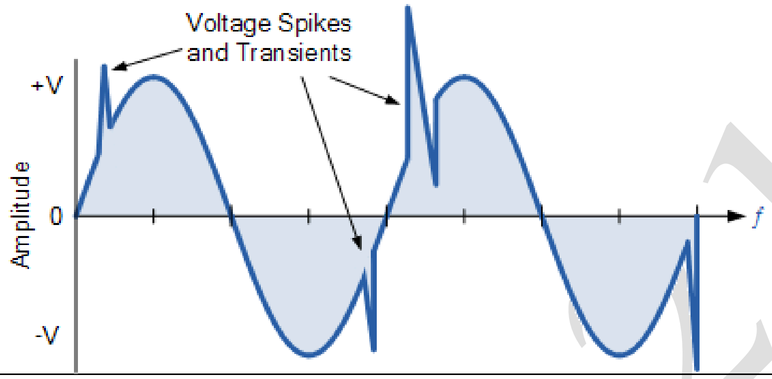


Transients: (3 M)

Disturbances that occur for a very short duration.

Types:

Impulsive – occurs due to lightning, Oscillatory – occurs due to switching



2. **Discuss about the CBEMA curves. Explain about the events described in the curve. (15 M) (Nov 21018)**BTL 5

Answer: Page 1.48 C.Ravichandran

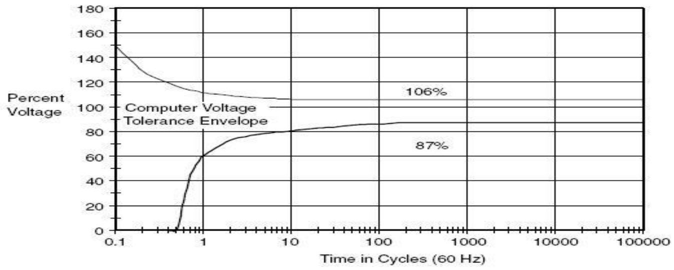
Key points:

Definition(2 M)

CBEMA stands for Computer & Business Equipment Manufacturers Associations (CBEMA).

CBEMA developed the curve employing historical data from mainframe computer operations showing the range of acceptable power supply voltages for computer equipment.

Curve and its explanation(3 M)



Horizontal axis – Duration of sag or swell

Vertical axis – percent change in line voltage

Events – 7 types**(10 M)**

- Steady-State Tolerances
- Line Voltage Swell
- Low-Frequency Decaying Transient Ring wave
- High-Frequency Impulse and Ring wave
- Voltage sags

- Dropout
- No Damage Region
- Prohibited Region

3. **What is the need of power quality evaluation procedure? Explain the basic process involves it. (15 M)** BTL 2

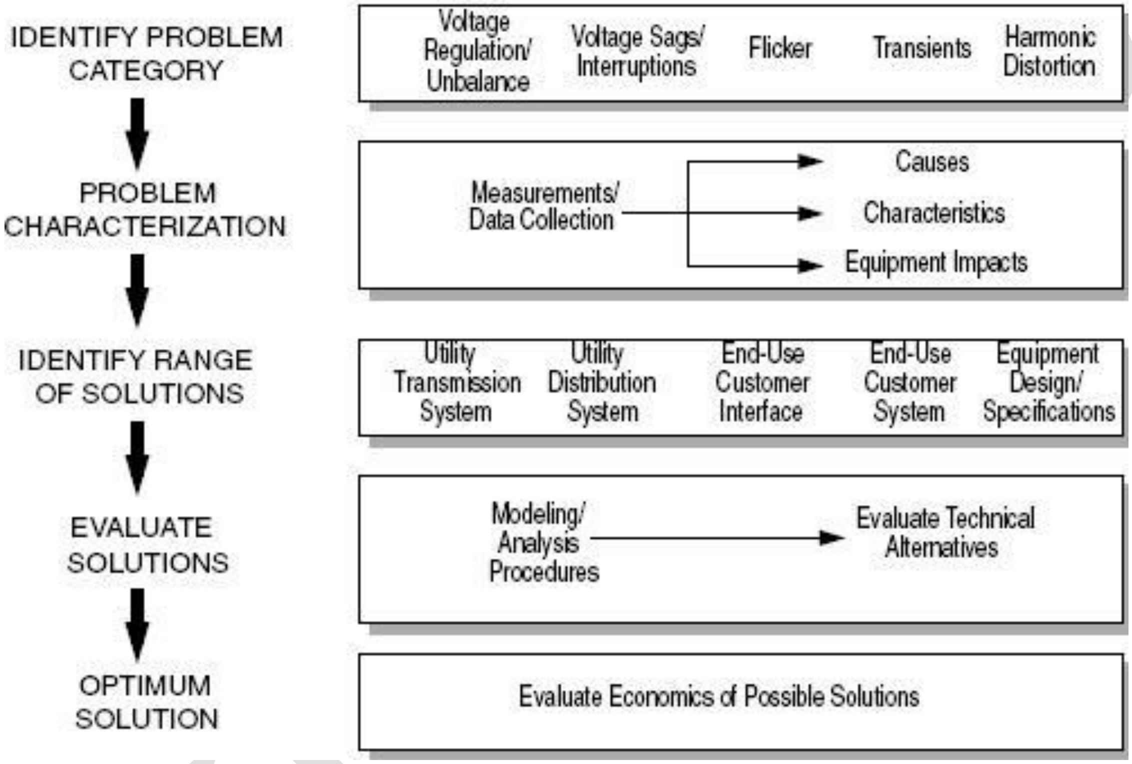
Answer: Page 1.52 C.Ravichandran

Key points:

Need (3 M)

To improve the power quality and equipment performance.

Explanation (7 M)



General Procedure includes the following: (5 M)

- Evaluation
- Measurements
- Solutions

UNIT – II VOLTAGE SAGS AND INTERRUPTIONS

Sources of sags and interruptions – estimating voltage sag performance. Thevenin's equivalent source analysis and calculation of various faulted condition. Voltage sag due to induction motor starting. Estimation of the sag severity – mitigation of voltage sags, active series compensators. Static transfer switches and fast transfer switches.

PART – A

1 **When sag leads to interruption?** BTL 4

Voltage sag is a reduction in voltage for a short time. The voltage reduction magnitude is

	between 10% and 90% of the normal root mean square (RMS) voltage at 50 Hz/ 60 Hz. An interruption is a complete loss of voltage, or a drop to less than 10% of nominal voltage in one or more phases.
2	**What is voltage sag?** BTL 2 A sag or dip is a decrease in RMS voltage or current at the power frequency for durations from 0.5 cycles to 1 minute, reported as the remaining voltage. Typical values are between 0.1 pu and 0.9 pu.
3	**What are the causes of sag?** BTL 2 ➢ Voltage sags are usually associated with voltage sag. ➢ Equipment sensitive to both the magnitude and duration of voltage sag. ➢ Equipment sensitive to have characteristics other than magnitude and duration.
4	**What are the three levels of possible solutions to voltage sag and momentary interruption problems?** BTL 2 ➢ Power System Design ➢ Equipment design ➢ Power conditioning equipment.
5	**List some industry standards associated with voltage sags.** BTL 1 ➢ SEMI F47-0200 ➢ CBEMA curve
6	**What are the sources of sags and interruption? (Nov 21018)**BTL 2 ➢ A sudden increase in load results in a corresponding sudden drop in voltage. ➢ Any sudden increase in load, if large enough will cause a voltage sag in motors, faults, switching. ➢ Recloser operation.
7	**Give some economic impacts due to sag.** BTL 1 ➢ Process outrages ➢ Damaged products ➢ Lost time for restarting.
8	**What is the importance of estimating sag performance?** BTL 2 It is important to understand the expected voltage sag performance of the supply system so that facilities can be designed and equipment specifications developed to assure the optimum operation of production facilities.
9	**What are the various factors affecting the sag magnitude due to faults at a certain point in the system?** BTL 1 ➢ Distance to the fault ➢ Fault impedance ➢ Type of fault ➢ Pre-sag voltage level ➢ System configuration ➢ System impedance ➢ Transformer connections
10	**Name the different motor starting methods.** BTL 1 ➢ Resistance and reactance starters ➢ Autotransformer starters ➢ Star-Delta starters
11	**What are the causes for voltage sags due to transformer energizing?** BTL 2

	➢ Normal system operation, which includes manual energizing of a transformer. ➢ Reclosing actions.
12	**How voltage sag can be mitigated?** BTL 4 Voltage sag can be mitigated by voltage and power injections into the distribution system using power electronics based devices which are also known as custom power devices.
13	**Name the three levels of possible solutions to voltage sag and momentary interruption problems.** BTL 1 ➢ Equipment Design ➢ Power conditioning equipment ➢ Power system design
14	**Name any four types of sag mitigation devices.** BTL 1 ➢ Dynamic Voltage Restorer(DVR) ➢ Active Series Compensators ➢ Distribution Static Compensator(DSTATCOM) ➢ Solid State Transfer Switches(SSTS)
15	**Define Dynamic Voltage Restorer (DVR).** BTL 2 A DVR is a solid state power electronics switching device consisting of either GTO or IGBT , a capacitor bank as an energy storage device and injection transformers. It is connected in series between a distributed system and a load.
16	**What is the important role of a DVR?** BTL 2 The basic idea of a DVR is to inject a controlled voltage generated by a forced commuted converter in series to the bus voltage by means of an injecting transformer.
17	**Define active series compensation devices.** BTL 2 A device that can boost the voltage by injecting a voltage in series with the remaining voltage during a voltage sag condition.
18	**What is the need of DSTATCOM?** BTL 2 It allows effective control of active and reactive power exchanges between the DSTATCOM and the ac system.
19	**What is the main function of DSTATCOM?** BTL 2 ➢ Voltage regulation and compensation of reactive power ➢ Correction of power factor ➢ Elimination of current harmonics.
20	**What is the role of SSTS?** BTL 2 ➢ Can be used very effectively to protect sensitive loads against voltage sags, swells and other electrical disturbance. ➢ It ensures continuous high quality power supply to sensitive loads by transferring , within a time of milliseconds , the load from a faulted bus to a healthy one.
	PART * B
1.	**What is the need of estimating sag performance? Explain the different methods of estimating voltage sag performance. (13 M)(June 2014, Nov 21018)** BTL 4 **Answer: Page 1.8 - 2.12 C.Ravichandran** **Key points:** **Need:(3 M)** To design the facilities and equipment specifications to assure the optimum operation of production facilities. **General procedure:(5 M)**

- Determine the number and characteristics of voltage sags that result from transmission system faults
- Determine the number and characteristics of voltage sags that result from distribution system faults
- Determine the equipment sensitivity to voltage sags
- Evaluate the economics of different solutions

Methods:(5 M)

- Data Required for Estimation – System parameter & Fault event-related parameter
- Voltage sag Magnitude – Analysis of fault need accurate information of all the impedances
- Duration Determination – Determining the duration of the voltage sag need complete information of the type, location and settings of the protective relays.

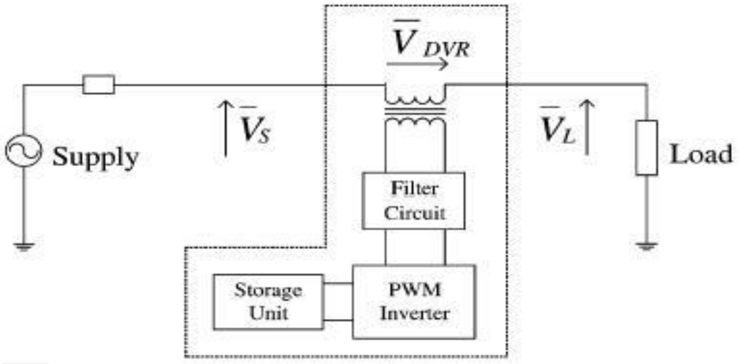
2. **Explain the principle of DVR operation used for sag mitigation. (13 M)** BTL 2

Answer: Page - 2.20 C.Ravichandran

Key points:

Principle & Diagram: (6 M)

- A DVR is a solid state power electronics switching device consisting of either GTO or IGBT, a capacitor bank as an energy storage device and injection transformers.
- The basic idea of the DVRis to inject a controlled voltage generated by a forced commutated converter in series to the bus voltage by means of an injecting transformer.



Explanation:(7 M)

- During normal operating condition, the DVR injects only a small voltage to compensate for the voltage drop of the injection transformer and device losses.
- When voltage sag occurs in the distribution system, the DVR control system calculates and synthesizes the voltage required to maintain output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system to the critical load.

3. **Explain the procedure for estimating the sag severity indices. (13 M)** BTL 4

Answer: Page -2.18 C.Ravichandran

Key points:

Procedure: (8 M)

Step 1: Obtain sampled voltages with a certain sampling rate and resolution
Step 2: Calculate event characteristics
Step 3: Calculate single-event indices
Step 4: Calculate site indices from the single-event indices
Step 5: Calculate system indices from the site indices

Flowchart: (5 M)

4 **Discuss the operation of active series compensator with necessary circuit diagram. (8M) (June 2011)** BTL 2

Answer: Page -2.34 C.Ravichandran

Key points:

Circuit diagram (3 M)

Explanation (5 M)

- Advances in power electronic technologies and new topologies for these devices have resulted in new options for providing voltage sag ride through support to critical loads. One of the important new options is a device that can boost the voltage by injecting a voltage in series with the remaining voltage during a voltage sag condition.
- These are referred to as active series compensation devices. They are available in size ranges from small single-phase devices (1 to 5 KVA) to very large devices that can be applied on the medium-voltage systems (2 MVA and larger).
- A one-line diagram illustrating the power electronics that are used to achieve the compensation is shown in Fig. When a disturbance to the input voltage is detected, a fast switch opens and the power is supplied through the series-connected electronics.
- This circuit adds or subtracts a voltage signal to the input voltage so that the output voltage remains within a specified tolerance during the disturbance. The switch is very fast so that the disturbance seen by the load is less than a quarter cycle in duration. This is fast enough to avoid problems with almost all sensitive loads. The circuit can provide voltage boosting of about 50 percent, which is sufficient for almost all voltage sag conditions.

PART*C

1. **Explain the following sag mitigation technique. (15 M) (June 2014)** BTL 4

(a)Static UPS with minimal energy storage(5 M)

(b)Backup storage energy supply (BSES)(5 M)

(c)Flywheel with UPS system(5 M)

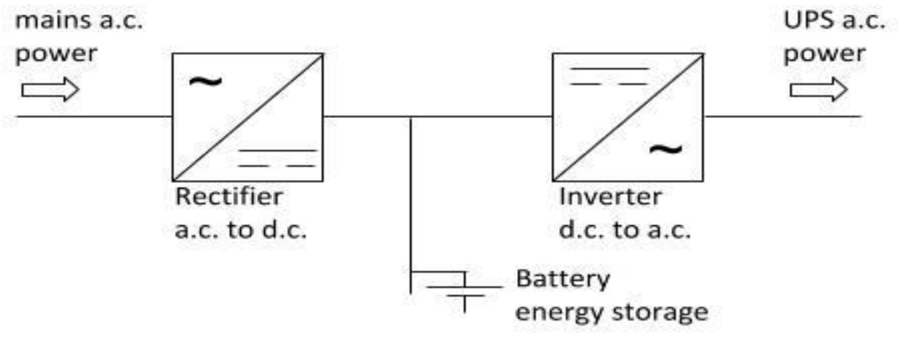
Answer: Page - 2.42 C.Ravichandran

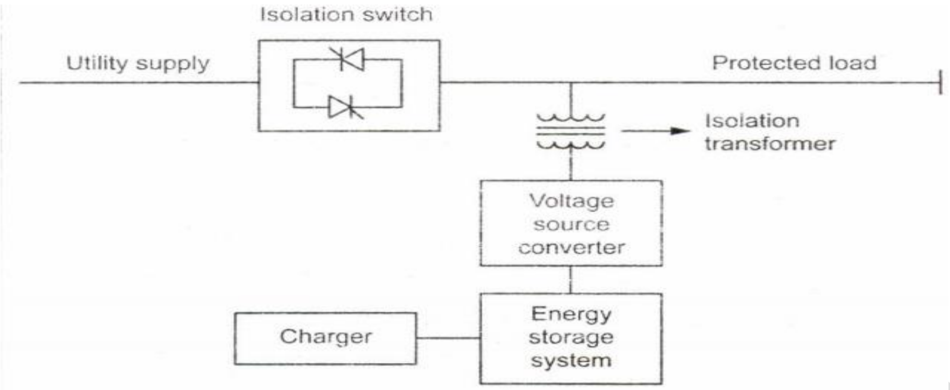
Key points:

Static UPS with minimal energy storage:(5 M)

These devices are primarily intended to maintain supply during supply interruptions. During an interruption the load is fed from the battery through dc/ac converter.

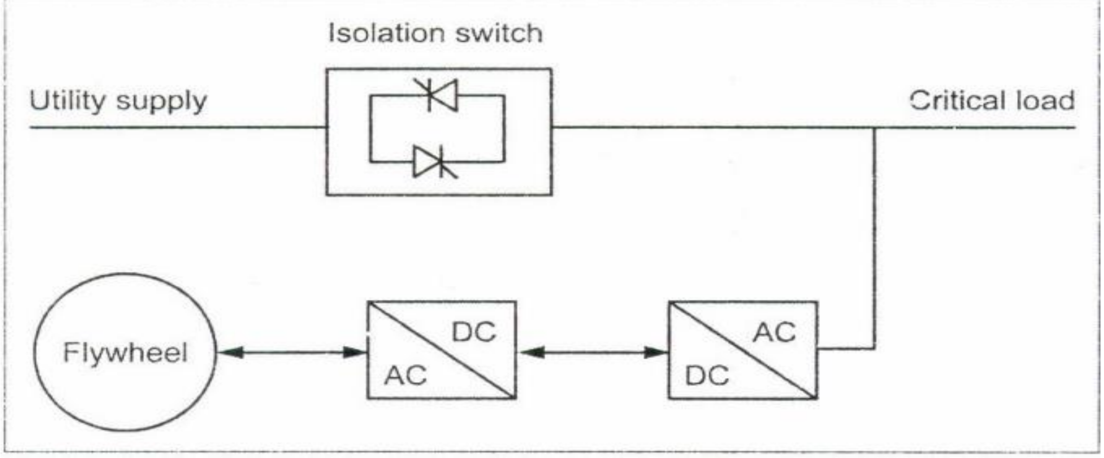
Backup storage energy supply (BSES)(5 M)





This device disconnects a protected load from the utility supply within milliseconds after a disturbance and supplies the entire load using stored energy and appropriate power electronics.

Flywheel with UPS system:(5 M)



The flywheel with UPS integrates the function of a motor, flywheel rotor and generator into a single integrated system.

Modern flywheels provide energy storage for many seconds of ride through support in the event of a disturbance.

2. **Explain the solid state transfer switch with the transfer operation. (15M) (Dec 2011, Nov 21018)** BTL 5

Answer: Page - 2.38 C.Ravichandran

Key points:

Definition:(3 M)

Solid transfer switches use solid state devices, thyristors (SCR) to perform their fast transfer function.

Transfer Function:(2 M)

Two approaches – Open transition & Closed transition

Open transition:(5 M)

Break before make operation where the current to the load is interrupted for a brief period of time

<u>Advantages:</u>

No need of synchronizing gear, No paralleling of sources

	Disadvantages: Requirement of new source, De-energization of load **Closed transition:(5 M)** Make before break operation where the current to the load is not interrupted during the transfer. Advantages: Seamless transition, No in-rush currents Disadvantages: Requirement of synchronizing and paralleling equipment, Problems on one source transferred to the other.

	UNIT III – OVERVOLTAGES
	Sources of over voltages - Capacitor switching – lightning – ferro-resonance. Mitigation of voltage swells - surge arresters - low pass filters - power conditioners. Lightning protection – shielding – line arresters - protection of transformers and cables. An introduction to computer analysis tools for transients, PSCAD and EMTP.
	PART – A
1	**Define transient over voltages.** BTL 2 A transient over voltage can be defined as the response of an electrical network to a sudden change in network conditions, either intended or accidental, (e.g. a switching operation or a fault) or network stimuli (e.g. lightning strike).
2	**What are the types of transient over-voltages?** BTL 1 1) Impulsive 2) Oscillatory
3	**Define impulsive transients. Give example for impulsive transient over voltages.** BTL 2 ➢ An impulsive transient is a sudden, non-power frequency change in the steady state condition of the voltage and/or current waveforms that is essentially in one direction, either positive or negative, with respect to those waveforms. ➢ The most common cause of this type of transient is lightning.
4	**Give examples for oscillatory transient over voltages.** BTL 1 Switching operations within the distribution network are a major cause of oscillatory transient over voltages. Such operations include (a) Switching of utility capacitor banks, (b) Switching of circuit breakers to clear network faults, and (c) Switching of distribution feeders to rearrange the network for maintenance or Construction
5	**What is the effect of capacitor switching transients on network?** BTL 4 ➢ Transients of this magnitude and duration are usually not a problem on the utility system, but they can produce problems at a user facility. ➢ Severe over voltages can appear on user facility capacitors through a phenomenon known as voltage magnification.

6	**What are the causes of voltage magnification on network?** BTL 2 The voltage magnification will not result in capacitor damage. The problem that usually occurs is the failure or mis-operation of sensitive loads in the facility where the low voltage capacitors are installed.
7	**Define voltage magnification phenomena?** BTL 2 The highest transient voltages occur at the low voltage capacitor bank when the characteristic frequency of the switching transient is nearly equal to the resonant frequency of the low voltage system and when the switched capacitor is ten or more times the size of the low voltage capacitor.
8	**Mention the two important concerns for capacitor bank switching transients.** BTL 1 Voltage transients at the capacitor bank substation and neighbouring substations Power quality impact on sensitive customer loads due to variations in voltage when energizing capacitor banks
9	**Give the various aspects of equipment specific design and protection issues for the capacitor switching transients.** BTL 4 ➢ Phase-to-ground and phase-to-phase insulation switching withstand to voltage stresses ➢ Controlled closing for circuit breakers (pre-insertion resistors/reactors or synchronous switching) ➢ Capacitor bank and substation Circuit breakers ANSVIEEE C37 requirements / Current limiting reactor requirements
10	**What specify the IEEE standard for shunt power capacitors causing transient Over-voltages?** BTL 4 The IEEE Standard for Shunt Power Capacitors, ANSI/IEEE Std. 18-1992, specifies that capacitors "may reasonably be expected to withstand" transient over-voltages from 205% to 354% of rated peak voltage, depending on the number of times a year the overvoltage occurs.
11	**What are the various Causes of over-voltages?** BTL 2 Over-voltages, i.e. brief voltage peaks (transients, surges, spikes) can be attributed to the following main causes: 1.Atmospheric discharges, i.e. lightning (LEMP - Lightning Electro-Magnetic Pulse) 2.Switching operations in the public grid and low-voltage mains 3.Electrostatic Discharges (ESD) 4.Ferroresonance
12	**Give the basic principles of overvoltage protection of load equipment**. BTL 2 ➢ Limit the voltage across sensitive insulation. ➢ Divert the surge current away from the load. ➢ Block the surge current entering into the load. ➢ Bonding of equipment with ground
13	**What is the need of surge arrestors?** BTL 2 ➢ A surge arrester is a protective device for limiting surge voltages on equipment by discharging or bypassing surge current. ➢ Surge arresters allow only minimal flow of the 50Hz/60Hz power current to ground.
14	**Differentiate between transient voltage surge suppressors (TVSS) and surge arrestors.** BTL 4 ➢ Arresters and TVSS devices protect equipment from transient over-voltages by limiting the maximum voltage, and the terms are sometimes used interchangeably. However, TVSSs are generally associated with devices used at the load equipment.

	➢ A TVSS will sometimes have more surge-limiting elements than an arrester.
15	**Mention the types of surge arrestors.** BTL 1 ➢ Metal-oxide varistor type ➢ Gapped silicon - carbide type
16	**What is metal-oxide surge-arrester?** BTL 2 A metal-oxide surge-arrester (MOSA) utilizing zinc-oxide block provides the best performance, as surge voltage conduction starts and stops promptly at a precise voltage level, thereby improving system protection
17	**Give any two advantages of metal-oxide arresters over conventional silicon carbide distribution class arresters.** BTL 2 ➢ Improved Surge Duty Capability ➢ Improved Temporary Overvoltage Capability
18	**What is the need of Transmission Line Arresters?** BTL 2. Transmission Line Surge Arresters conduct lightning surges around the protected insulator so that a lightning flashover is not created. They are designed to be installed functionally in parallel with the line insulator. The arrester conducts the lightning surges around the protected insulator so that a subsequent 50Hz / 60 Hz fault on the circuit is not created.
19	**Mention the Benefits of Transmission Line Surge Arresters.** BTL 1 Lowers initial cost of new or transmission line upgrades by making construction more compact and transmitting more energy in the same right of way. ➢ Reduces the height of transmission lines by eliminating shield wire ➢ Improves outage statistics by eliminating back flashover from the tower ground lead to the phase conductor
20	**What is the role of surge arrestor on shielded and unshielded transmission line?**BTL 2 ➢ On shielded transmission lines or under-built distribution circuits, the arrester prevents tower to phase insulator back-flashovers during a lightning strike. ➢ On unshielded sub transmission or distribution circuits, the arrester prevents phase-to-ground flashover.
21	**What is the need of low pass filter in transient protection?**BTL 4 ➢ This LC combination provides a low impedance path to ground for selected resonant frequencies. ➢ Low-pass filters employ pi principle to achieve better protection even for high- frequency transients.
22	**What is the need of Shunt protectors or surge reduction filters?**BTL 2 ➢ An in-line filter specifically designed to reduce the rate of voltage rise (dv/dt) of the pre-clamped waveform. ➢ It gives some series impedance between input and output terminals. This type of product is highly recommended for the protection of sensitive electronic equipment
23	**What is the application of Power Conditioners in transient protection?**BTL 2 Low-impedance power conditioners are used primarily to interface with the switch-mode power supplies found in electronic equipment. Low-impedance power conditioners differ from isolation transformers in that these conditioners have much lower impedance and have a filter as part of their design when on the device to position the power conditioners to avoid voltage swells.
24	**Differentiate between TVSS, Filter and Data/signal protection devices.** BTL 4 ➢ **Transient**: focus on limiting high-voltage spikes to an acceptable level.

- **Filtering**: protect against low-energy transients and high frequency noise
- **Data/signal protection devices**: Products that guard sensitive instrumentation against what were for to as 'back door' transients and noise

25 **Define lightning phenomena.**BTL 4

Lightning is an electrical discharge in the air between clouds, between different charge centre within the same cloud, or between cloud and earth (or earthed object).Even though more discharges occur between or within clouds, there are enough strokes that terminate on the earth to cause problems to power systems and sensitive electronic equipment.

PART –B

1. **Write short notes on the following: (13 M) (Nov 21018)**BTL 4

(i) Ferro resonance (7 M)

(ii) Low pass filter (6 M)

(i)Ferro resonance (7 M)

Answer: Page - 3.22 C.Ravichandran

Definition (2 M)

Ferroresonance is a special case of series LC resonance where the inductance involved is nonlinear and it is usually related to equipment with iron cores.

Causes (2 M)

- It occurs when line capacitance resonates with the magnetizing reactance of a core while it goes in and out of saturation.
- It occurs when a non-linear inductor is fed from a series capacitor.
- The non-linear inductor in power system can be due to bank type transformer, core type transformer, Shell type transformer etc.

Problems associated with Ferro resonance (3 M)

- Overheating
- Audible noise
- High overvoltages and surge arrester failure.

(ii)Low pass filter (6 M)

Answer: Page - 3.35 C.Ravichandran

Definition (2 M)

- Low pass filters are composed of series inductors and parallel capacitors in general electric circuits.
- This LC combination provides a low impedance path to ground for selected resonant frequencies.

Explanation (4 M)

- It combines two surge suppressors and a low pass filter to provide maximum protection.
- It uses a gap-type protector on the front end of line to provide maximum protection.

2. **Explain the various methods of protection against lightning. (13 M) (June 2014)**BTL 4

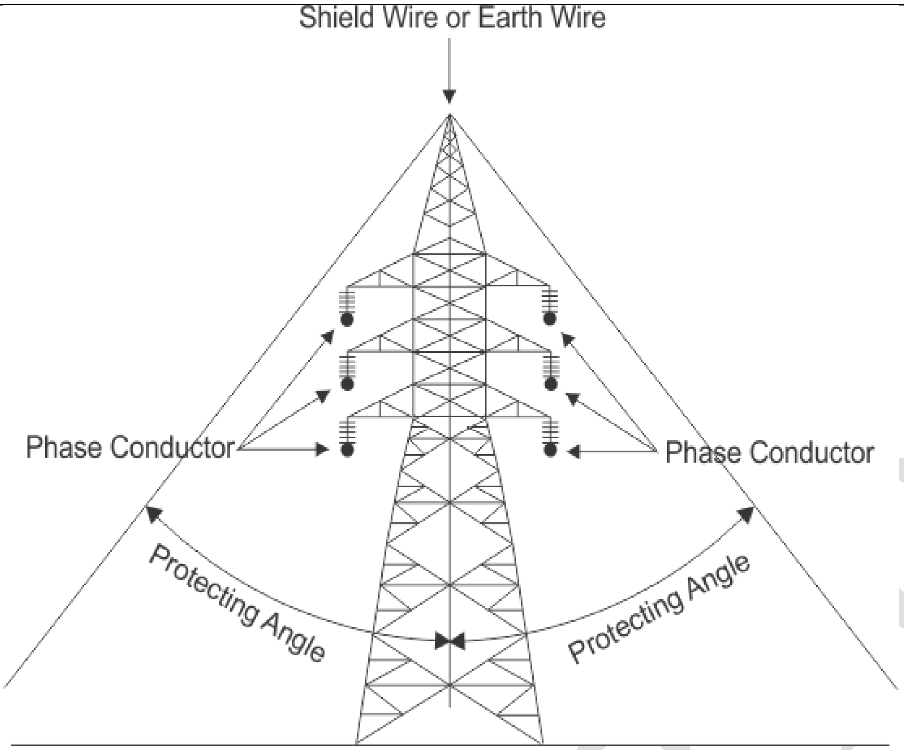
Answer: Page - 3.37 C.Ravichandran

Key points:

Line shielding(6 M)

Explanation & Diagram (3+3)

The line with shield wire can reduce the number of flashovers in open ground and number of flashovers with nearby objects



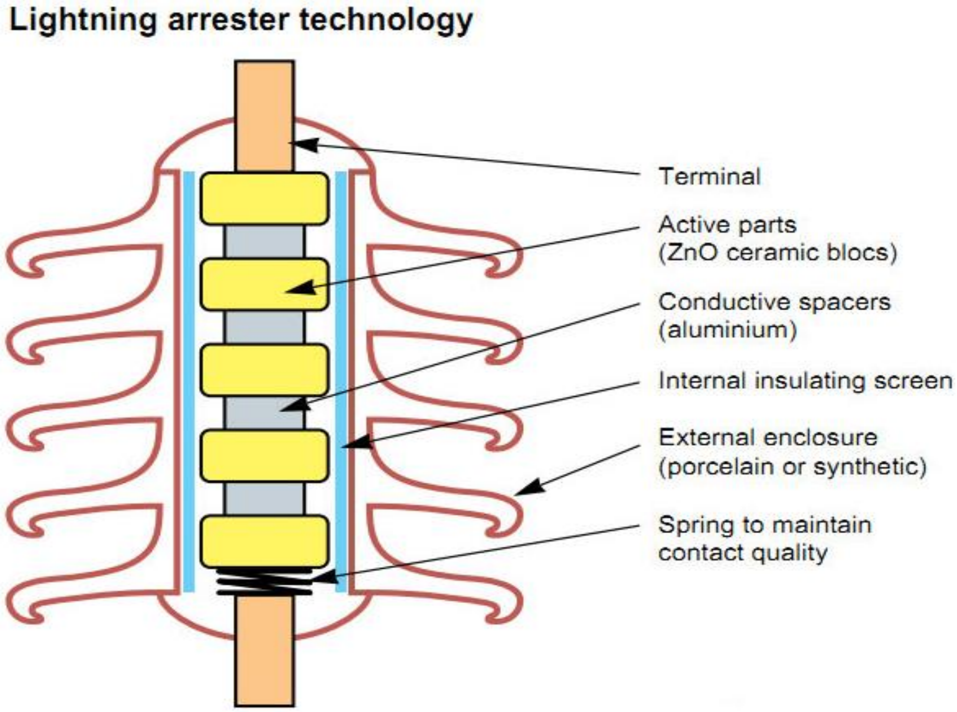
Surge Arrestors(7 M)

Explanation & Diagram (3+4)

Transmission Line surge arresters conduct lightning surges around the protected insulator so that a lightning flashover is not created.

They are designed to be installed functionally in parallel with the line insulator.

The arrester becomes a low ohmic path for the surge as voltage across it increases.



3 **Explain the methods used for protection of trnasformer and cable against over voltge. (13 M) (Nov 2018)** BTL2

Answer: Page 3.40 C.Ravichandran

Key points:

Protection of transformer: (6M)

- Use transformer with interlaced secondary winding
- Use surge arrestres at low voltge terminals.

Tyes

- External Elbow arresters
- Extrnal live front arresters
- Under oil arrester

Protection of cable: (7 M)

- Diagram (3 M)
- Explaination: (4M)
  - Open point arrester
  - Next to last transformer
  - Under oil arrester
  - Elbow arrester
  - Lower discharge arrester
  - Fluid injection

4 **Write short notes on the following: (i) surge arrester (ii) Lighting arrester. (13 M) (May 2015)** BTL 2

Answer: Page 3.37 C.Ravichandran

Key points:

Diagram (5 M)

Explanation (8 M)

- It basically diverts the high voltage current directly to the insulation or to the ground to avoid damaging the system.
- It does not absorb all of the high voltage that passes through it. It simply diverts it to the ground or clamps it to minimize the voltage that passes through it using MOV or Metal Oxide Varistor.
- Surge arrestors are NOT generally designed to offer protection against a direct lightning strike, but rather against electrical transients which might occur due to lightning in the vicinity of the line or conductor.
- A lightning arrester is a device used on electrical power systems and telecommunications systems to protect the insulation and conductors of the system from the damaging effects of lightning. The typical lightning arrester has a high-voltage terminal and a ground terminal.

PART-C

1. **Explain the role of PSCAD/EMDTC in transient analysis with example models. (15 M)** BTL 5

Answer: Page 3.50 C.Ravichandran

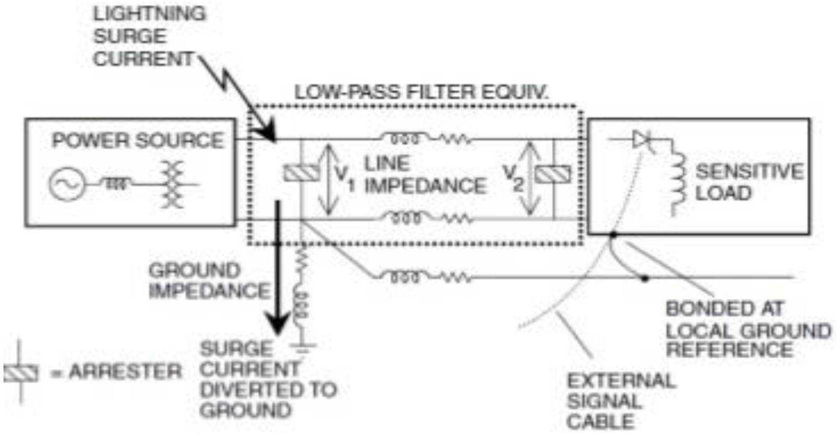
Key points:

Role of PSCAD: **(3 M)**

PSCAD stands for Power System Computer Aided Design

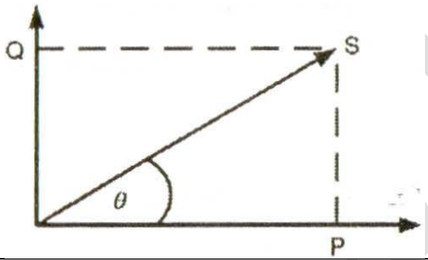
PSCAD is a powerful and flexible graphical user interface to the EMTDC solution engine.

	PSCAD enables the user to schematically construct a circuit, run a simulation, analyze the results, and manage the data in a completely integrated, graphical environment. **Transient studies: (1M)** Transient over voltage studies, Line energizing, Breakers re-strike etc. **Transformers:(1 M)** Inrush current issues, Saturation, Representing different core types etc. **Faults:(1 M)** Preparing the simulation to perform a sequence of events, DC offset in fault current. **Protection systems:(1 M)** Detailed CT saturation models, Modeling a simple relay scheme **Power Quality:(1 M)** Voltage dips, swells and interruptions, Induction motor starting, system faults. **Induction machines:(1 M)** Large induction motors starting issues including flicker and voltage dip problems. **Power Electronics Basics: (1 M)** Using power electronic modules and designing simple firing systems, PSCAD Interpolation method. **FACTS Devices:(1 M)** SVC, STATCOM, Active Filters **Synchronous machines:(1 M)** Controls including governors, exciters **Example models:(3 M)** Surge arrestor model, Transmission line model.
2.	**Explain in detail about various methods to mitigate voltage swells. (15 M) (June 2014, Nov 2018)**BTL 4 **Answer: Page - 3.26 C.Ravichandran** **Key points:** **Basic principles:(6 M)** ➢ Limit the voltage across sensitive insulation ➢ Divert the surge current away from the load ➢ Block the surge current entering into the load ➢ Bonding of equipment with ground ➢ Prevent surge current flowing between grounds ➢ Design a low pass filter using limiting and blocking principle **Circuit Diagram:(4 M)**



Various methods used are:(5 M)

- Surge Arrestors and Surge Suppressors – Protective device for limiting surge voltages on equipment by discharging or bypassing surge current.
- Transient Voltage Suppressors – Semiconductor devices designed to provide protection against voltage and current transients.
- Over Voltage protection – Low Voltage Crowbar (LVC)
  LVC offers a quick, economical fix to the problem and it is installed inside a power supply or between the power supply and sensitive equipment.

	UNIT IV – HARMONICS
	Harmonic sources from commercial and industrial loads, locating harmonic sources. Power system response characteristics - Harmonics Vs transients. Effect of harmonics - harmonic distortion - voltage and current distortion - harmonic indices - inter harmonics – resonance. Harmonic distortion evaluation - devices for controlling harmonic distortion - passive and active filters. IEEE and IEC standards.
	PART – A
1	**What are the important concepts to bear in mind to understand power system harmonics?** BTL 1 There are two important concepts to bear in mind with regard to power system harmonics. The first is the nature of harmonic current producing loads (nonlinear loads) and the second is the way in which harmonic currents flow and how the resulting harmonic voltages develop.
2	**Draw the relationship between between P, Q, S in sinusoidal condition.** BTL 4 
3	**Define true power factor.** BTL 2 **True power factor** is calculated as the ratio between the total active power used in a circuit (including harmonics) and the total apparent power (including harmonics) supplied from the source. **True power factor = Total active power (P) / apparent power (S)**
4.	**What is the reason for existence of harmonic distortion?** BTL 2 Harmonics distortion exists due to the nonlinear characteristics of the devices and loads on the power system. These devices act as current sources that inject harmonic currents into the power system.
5	**Differentiate between linear loads and non-linear loads.** BTL 4 **Linear load:** Any load that draws current at supply fundamental frequency only is a linear load. The current drawn does not contain any harmonics (multiples of the supply frequency). Motors, resistors, inductors and capacitors are all linear loads. **Non Linear load:** Any load that draws harmonic currents from the supply is a nonlinear load. The current waveform of such non-linear loads, is discontinuous and non-sinusoidal because of the presence of harmonics.
6.	**What is voltage and current distortion?** BTL 2 ➢ Voltage distortion is any deviation from the nominal sine waveform of the AC line voltage. ➢ Current distortion is any deviation from the nominal sine waveform of the AC line current.
7.	**Mention the commonly used indices used for measuring harmonic component of waveform.** BTL 1 The two most commonly used indices for measuring the ham10nic content of the waveform are

	the total harmonic distortion (THD) and total demand distortion (TDD). 1. If a generator produces a non-ideal sinusoidal waveform, the voltage waveform will contain a certain amount of harmonics 2. In motors, decreased efficiency, excessive heating, and vibration are symptoms of harmonic voltage distortion.
8.	**Mention at least two causes of harmonics made on distribution systems.** BTL 1 In the distribution system, transformers are capable of producing harmonics due to magnetic core saturation. This is more prevalent at a lighter loading of the transformer. Large load currents in the neutral wires of a 3 phase system. Theoretically the neutral current can be up to the sum of all 3 phases therefore causing overheating of the neutral wires. Since only the phase wires are protected by circuit breakers of fuses, this can result in a potential fire hazard.
9.	**What is harmonic index? State its significant.** BTL 2 The power quality industry has developed certain index values that help us assess the quality of service as it relates to distortion caused by the presence of harmonics. These values, or harmonic indices, serve as a useful metric of system performance. The two most commonly used indices under harmonic studies are (a) Total harmonic distortion (THD) (b) Total demand distortion (TDD)
10	**Mention the problems created by harmonics.** BTL 1 A large load current flows in the neutral Wires of a 3 phase system. Theoretically the neutral current can be up to the sum of all 3 phases therefore causing overheating of the neutral wires. Poor power factor conditions that result in monthly utility penalty fees for major users (factories, manufacturing, and industrial) with a power factor less than 0.9.
11	**Mention the harmonic effects on devices and loads Insulation stress (voltage effect).**BTL 1 ➢ Thermal stress (current effect) ➢ Load ruptures (abnormal operation)
12	**What is the effect on transformer due to Harmonics?** BTL 2 The primary effect of power system harmonics on transformers is the additional heat generated by the losses caused by the harmonic contents generated by the load current.
13	**Mention he harmonic sources from commercial loads.** BTL 1 ➢ Single phase loads such as Switch mode power supplies, fluorescent lighting and UPS systems ➢ Three phase loads such as high voltage AC drives system
14	**Mention the harmonic sources from industrial load.** BTL 1 ➢ Three phase converter with Adjustable speed drives (DC drives and AC drives) ➢ Arcing Devices (Arc furnaces, weiders, Discharge lamps etc) ➢ Saturable devices (transformer, electromagnetic devices etc with steel core)
15	**What is the advantage of three phase converter?** BTL 2 Three-phase electronic power converters do not generate third-harmonic currents mainly when compared with single-phase converters. This is a great advantage because the third harmonic current is the largest component of harmonics shown in harmonics spectrum
16	**What is the disadvantage of 12 pulse drive?** BTL 2 The disadvantages of the l2-pulse drive are that there is more cost in control design and an extra transformer is usually required.
17	**State the different types of inverters.** BTL 1 ➢ Variable voltage inverter (VVI) ➢ Current source inverter (CSI)

	➢ Pulse width modulated (PWM)
18	**What is Variable Voltage Inverter?** BTL 2 The variable voltage inverter (VVI), or square-wave six-step voltage source inverter (VSI), receives DC power from an adjustable voltage source (either from thyristor converter or DC-DC converter fed by Diode Bridge) and adjusts the frequency and voltage.
19	**What is current Source inverter?** BTL 2 The current source inverter (CSI) receives DC power from an adjustable current source and adjusts the frequency and current.
20	**What is the need of locating harmonic sources?** BTL 4 When harmonic problems are caused by excessive voltage distortion on the supply system, it is important to locate the sources of harmonics in order to develop a solution to the problem.
	PART –B
1.	**What are the various causes and effects of harmonics in distribution power system? (13 M)** BTL 2 **Answer: Page - 4.32 C.Ravichandran** **Key points:** **Causes of Harmonics: (6 M)** There are many causes of harmonics on a power system. Harmonics can arise in the generating system, in the distribution system, and from the loads connected to the network. If a generator produces a non-ideal sinusoidal waveform, the voltage waveform will contain a certain amount of harmonics. The greatest production of harmonics is the harmonic current generation from non-linear loads. The problems of power system harmonics have increased considerably with the use of static power converters. Switching actions result in harmonics. Harmonic producing loads are treated a current source. Group of harmonic that produces harmful effects are called third harmonics. **Effects of Harmonics:(7 M)** Insulation stress – Voltage effect Thermal stress – current effect Load rupture – abnormal operation Effect on transformers: Additional heat generated by the losses Effect on motors: Increased losses. Effect on circuit breakers: Misoperation of blowout coils
2.	**What is the need of locating harmonic sources? Explain the identification procedure on the basis of thevenins equivalent circuit. (13 M)** BTL 2 **Answer: Page - 4.63 C.Ravichandran** **Key points**: **Need:(2 M)** When harmonic problems are caused by excessive voltage distortion on the supply system, it is important to locate the sources of harmonics in order to develop a solution to the problem. **Two approaches: (2 M)** ➢ Compare the time variations of the voltage distortion with specific customer and load characteristics. ➢ Monitor flow of harmonic currents on the feeder with capacitor banks off. **Thevenins Equivalent circuit:(4 M)**

	Identification Procedure: **(5 M)** If $\lvert V_U \rvert > \lvert V_C \rvert$ - Harmonic source is at the utility side If $\lvert V_C \rvert > \lvert V_U \rvert$ - Harmonic source is at the customer side Where V_U - Thevenins voltages for utility V_C – Thevenins voltage for customer
3.	**Explain the devices for controlling harmonic distortion. (13 M)(N0v 2018)** BTL 2 **Answer: Page - 4.90 C.Ravichandran** **Key points:** **Series Reactors(1 M)** Connected in series upstream of a non-linear load **Zigzag Transformers (1 M)** To control zero-sequence harmonic components **Specially connected Transformers (1 M)** Inhibits propagation of third-order harmonic currents and their multiples **Using 6-pulse Diode Rectifier(2 M)** Consists of 6 uncontrollable rectifiers or diodes and an inductor, which together with a DC capacitor forms a low-pass filter for smoothing the DC current. **Using 12-pulse or 24-pulse Diode Rectifier(1 M)** Formed by connecting two 6-pulse rectifiers in parallel to feed a common DC-bus **Using Phase Controlled Thyristor Rectifier (1 M)** Accomplished by replacing the diodes in a 6-pulse rectifier with thyristors **Using IGBT Bridge(2 M)** Control the Dc voltage level and displacement power factor regardless of the power flow direction **Using a Larger DC or AC Inductor (1 M)** Connected in its AC input or DC bus **Harmonic Filters (3 M)** Active and Passive Filters
	PART - C
1.	**Explain for the following: (15 M) (June 2014, Nov 218)** BTL 4 **1.Harmonic sources from commercial loads (5 M)** **2.Harmonic sources from industrial loads (5 M)** **3.Harmonic sources from residential loads (5 M)** **Answer: Page - 4.43 C.Ravichandran** **Key points:** **Harmonic sources from commercial loads(5 M)** In commercial buildings, sources of harmonic current generation are generally small in size and large in number. Two categories: Single phase loads Three phase loads **Harmonic sources from industrial loads(5 M)** Three phase converter with adjustable speed drives (DC and AC drives) Arcing Devices (Arc furnaces, Welders, Discharge lamps etc.) Saturable devices (Transformers, electromagnetic devices etc. with steel core)

	Harmonic sources from residential loads(5 M) It is mostly from the devices like Uninterruptible power supplies, Electronic fluorescent lighting ballasts etc. Harmonics depends on the diversity of the different load types
2.	**Design Harmonic Source Identification Procedure for two source systems. (15 M)** BTL 6 **Answer: Page - 4.66 C.Ravichandran** **Key points:** Identification of harmonic sources at the point of Common Coupling based on voltage indices. **Procedure:** Step 1: Measure harmonic voltage and current at Point of Common Coupling (PCC)**(3 M)** Step 2: Calculate I_U and Z_U and also I_C and Z_C**(3 M)** Step 3: Calculate voltage at the utility and customer side**(3 M)** Step 4: Compare the measured harmonic voltage at PCC, Voltage at the utility and the customer side.**(3 M)** Step 5: Identify the source of harmonics.**(3 M)**
3.	**Analyze the power system response characteristics under the presence of harmonics. (15 M)** BTL 4 **Answer: Page - 4.66 C.Ravichandran** **Key points:** The response of the power system at each harmonic frequency determines the true impact of the nonlinear load on harmonic voltage distortion. Three important variables affecting the power system response characteristics are: **The system impedance characteristics(5 M)** Parallel Resonance - High impedance path to the flow of current Series Resonance – Low impedance path to the flow of current **The presence of a capacitor bank causing resonance(5 M)** Parallel Resonance – shunt capacitor banks appear to the harmonic source as being in parallel with the system source reactance. Series Resonance – Capacitor appears to be in series with line impedance. **The amount of resistive loads in the system(5 M)** When the resistive load increases, the overall damping factor of the circuit increases and the sharpness of the resonance decreases. When the resistive load decreases, the damping factor also decreases but the sharpness of the resonance increases. The sharpness of the resonance determines the impedance that is seen by the harmonic currents.

UNIT V – POWER QUALITY MONITORING

Monitoring considerations - monitoring and diagnostic techniques for various power quality problems - modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools - power line disturbance analyzer – quality measurement equipment - harmonic / spectrum analyzer - flicker meters - disturbance analyzer. Applications of expert systems for power quality monitoring.

PART – A

Q.No.	Questions
1	**What is the importance of power quality monitoring?** BTL 2 Power Quality Monitoring is necessary to- detect and classify disturbance at a particular location on the power system. PQ monitoring assists in preventive and predictive maintenance. Problems can be detected before they cause widespread damage by sending

	automated alerts. PQ Monitoring can be used to determine the need for mitigation equipment.
2	**What are the monitoring objectives***?* BTL 4 ➢ Continuous evaluation of the electric supply system for disturbances and power quality variations. ➢ Document performance of power conditioning equipment, such as static switches, UPS systems, other ride through technologies, and backup generators.
3	**What are the purposes of power quality monitoring system?** BTL 4 ➢ Preventive maintenance ➢ Load analysis ➢ Equipment diagnostics ➢ Long-time surveys
4	**What is proactive monitoring***?* BTL 1 The traditional approach to power quality monitoring is reactive. We need to know when a problemis going to occur before it happens. Permanent power quality monitoring systems are designed tohelp proactively identify conditions and events that may cause problems should be addressed. This iscalled proactive monitoring.
5	**What are the steps involved in power quality monitoring***?* BTL 1 ➢ Planning for the monitoring ➢ Preparing for the monitoring ➢ Inspecting the site ➢ Monitoring the power ➢ Analyzing, monitoring and inspecting data ➢ Applying corrective solutions
6	**What are the requirements of monitoring for a voltage regulation and unbalance?** BTL 1 ➢ 3 phase voltages ➢ RMS magnitudes ➢ Continuous monitoring with periodic maximum/minimum/average samples
7	**What are the requirements of monitoring for a harmonic distortion?** BTL 1 ➢ Currents for response of equipment ➢ 3 phase voltages and currents ➢ Waveform characteristics ➢ 128 samples per cycle minimum ➢ Synchronized sampling of all voltages and currents ➢ Configurable sampling characteristics
8	**What are the Characteristics of power quality monitoring equipment***?* BTL 2 **Harmonic Analysis** Harmonic analyses are usually conducted by obtaining and interpreting measurements of waveforms. Equipment normally required to perform a harmonic study consists of a harmonic analyzer,an oscilloscope, and an RMS responding voltmeter and ammeter. Spectrum analysis is usually performed up to the 50th harmonic (3 kHz).
9	**What are the Characteristics of power line monitors?** BTL 1 ➢ Portable, rugged, lightweight ➢ Simple to use, with proper training ➢ Designed for long-term unattended recording ➢ Definition of line disturbance parameters varies between manufacturers

10	**What is the Types of power quality measurement equipment**? BTL 1 ➢ Hand-held single-phase power quality monitors ➢ Portable three-phase power quality monitors ➢ Harmonic analyzers ➢ Distortion analyzers ➢ Multimeters
11	**Mention the factors that should be considered for selecting the instrument.** BTL 1 ➢ Number of channels (voltage and/or current) ➢ Temperature specifications of the instrument ➢ Input voltage range (e.g., a to 1000 V) ➢ Ability to measure three-phase voltages
12	**What is the use of oscilloscope**? BTL 1 Oscilloscopes with fast sampling rates and automatic triggering function can be very useful for trace of transients.
13	**What is the use of spectrum analyzer**? BTL 1 A spectrum analyzer can be used for trace of high frequency harmonics.
14	**What is the use of simple single phase hand-held power quality monitor?** BTL 1 Power quality problems like measuring the occurrence of harmonics or checking the voltage level or the power frequency can easily be made by using a simple single phase hand-held power quality monitor.
15	**Mention the Instruments used for the analysis of non-sinusoidal voltage and currents?** BTL 1 ➢ Oscilloscope ➢ Spectrum analyzer ➢ Harmonic analyser
16	**Mention the basic categories of instruments for harmonic analysis?** BTL 1 ➢ Simple meters ➢ General-purpose spectrum analyzers ➢ Special-purpose power system harmonic analyzers ➢ Digital Harmonics Measuring Equipment ➢ Distortion Analyzers ➢ Data Logger
17	**What is Spectrum analyzer?** BTL 2 An instrument used for the analysis and measurement of signals throughout the electromagnetic spectrum. Spectrum analyzers are available for sub audio, audio, and radio-frequency measurements, as well as for microwave and optical signal measurements.
18	**What is the operation of spectrum analyzer?** BTL 2 A spectrum analyzer separates the signal into two components: amplitude (displayed vertically) and frequency (displayed horizontally). In some low frequency analyzers, phase information can also be displayed. Low-frequency analyzers are sometimes called as ***"Harmonic analyzers"*.** Vertical scale displays the amplitude and horizontal scale displays the frequency.
19	***What is Swept heterodyne technique?*** BTL 2 Any signal at the input, at a frequency such that the difference between its frequency and the local oscillator is within the bandwidth of an intermediate- frequency filter, will be detected and will vertically deflect the spot on the display by an amount proportional to the amplitude

	of the input signal being analyzed.
20	**What is Swept heterodyne technique?** BTL 2 Any signal at the input, at a frequency such that the difference between its frequency and the local oscillator is within the bandwidth of an intermediate- frequency filter, will be detected and will vertically deflect the spot on the display by an amount proportional to the amplitude of the input signal being analyzed.
21	**What are the advantages of FFT**? BTL 1 ➢ FFT technique is much faster. ➢ Measurement is virtually real time.
22	**What are the disadvantages of FFT**? BTL 1 ➢ Restricted to lower frequencies. ➢ Complex due to need of A/D converter.
23	**What is the use of digital storage**? BTL 2 Digital storage gives the effect of a constant display, even though a very slow sweep may have been used to acquire the displayed data.
24	**What is tracking generator**? BTL 2 The tracking generator enhances the applications of spectrum analyzers. Its output delivers a swept signal whose instantaneous frequency is always equal to the input tuned frequency of the analyzer.
25	**What is harmonic analyzer**? BTL 2 Spectrum analyzers covering up to typically 100 kHz can also be called harmonic analyzers.
	PART – B
1.	**(i) Draw the block diagram of advanced power quality monitoring systems. Explain it in details. (8 M) (Nov 2018)** BTL 2 **Answer: Page - 5.1 C.Ravichandran** **Key points:** **Block Diagram: (4 M)** **Explanation: (4 M)** ➢ Monitoring as part of a facility site survey ➢ Determining what to monitor ➢ Choosing monitoring locations ➢ Options for permanent power quality monitoring equipment Digital Fault Recorders Smart Relays and other IEDs Voltage Recorders Implant power monitors Special purpose power quality monitors Revenue meters **(ii)Analyze the equipments used for power quality monitoring. (7 M) (Nov 2018)**BTL 4 **Answer: Page - 5.1 C.Ravichandran** **Key points:** **Types of Instruments: (3 M)** ➢ Wiring and grounding test devices

- Multimeter
- Oscilloscopes
- Disturbance Analyzers
- Harmonic / spectrum analyzers
- Combination of Disturbance and Harmonic analyzers
- Flicker meters
- Energy monitors

Explanation: (4 M)

The following are the important factors to be considered when choosing the instrument:

- Number of channels (voltage and/or current)
- Temperature specifications of the instrument
- Ruggedness of the instrument
- Input voltage range (e.g., 0 to 600 V)
- Power requirements
- Ability to measure three-phase voltages
- Input isolation (isolation between input channels and from each input to ground)
- Ability to measure currents
- Housing of the instrument (portable, rack-mount, etc.)
- Ease of use (user interface, graphics capability, etc.)
- Documentation
- Communication capability (modem, network interface)

2. **Illustrate the importance of power quality monitoring and also enlighten the role of the power quality monitoring instruments. BTL 4 (13 M)**

Answer: Page - 5.1 C.Ravichandran

Key points:

Importance of power quality monitoring:

The monitoring objectives determine the choice of monitoring equipment, triggering thresholds, methods for data acquisition and storage, and analysis and interpretation requirements.

1.Monitoring to charactering system performance (2 M)

- A power produces may find this objective important if it has the need to understand its system performance and then match that system performance with the needs of customer
- System characterization is a proactive approach to power quality monitoring.

2.Monitoring to characterize specific problem(2 M)

This is a reactive mode of power quality monitoring, but it frequently identifies the cause of equipment incompatibility, which is the first stage to a solution.

3.Monitoring as part of an enhanced power quality service(2 M)

These services offer differentiated levels of power quality to match the needs of specific customers.

4.Monitoring as part of predictive or just in time maintenance(2 M)

- Power quality data gathered over time can be analyzed to provide information relating to specific equipment performance.
- Equipment maintenance can be quickly ordered to avoid catastrophic failure

Role of the power quality monitoring instruments:

1.Monitor Connections(2 M)

- To provide input power to the monitor from a circuit other than the circuit to be

	monitored. ➢ Grounding of the power disturbance monitor is an important consideration. The disturbance monitor will have a ground connection for the signal to be monitored and a ground connection for the power supply of the instrument. **2.Setting Monitors Thresholds(1 m)** The best approach for selecting threshold is to match them with the specifications of the equipment that is affected. This may not always be possible due to lack of specifications or application guidelines. **3.To measure Quantities and Duration(1 m)** ➢ Current measurements are used to characterize the generation of harmonic by non-linear loads on the system. ➢ Voltage measurements helps characterize the system response to gathered harmonic currents. **4.Finding the source of a disturbance(1 m)** ➢ Identifying the source of a disturbance is to correlate the disturbance waveform with possiblr causes. ➢ Identification becomes more straight forward when the cause has been determined.
3.	**Discuss in detail about IEEE flicker meter and also explain the statistical analysis of long term and short term flicker evaluation. (13 M) (June 2014)**BTL 4 **Answer: Page - 5.29 C.Ravichandran** **Key points:** **Definition: (2 M)** A flicker meter is a device that demodulates the flicker signal, weighs it according to established flicker curves and performs statistical analysis on the processed data. **Block diagram: (4 M)** **Explanation: (4 M)** Two parts: ➢ Simulation of the response of the lamp eye brain chain. ➢ Online statistical analysis of the flicker signal and presentation of the results. These meters can be divided into 3 sections First section – The input waveform is demodulated, thus removing the carrier signal. Second section – Removes the unwanted terms using filters Third section – Statistical analysis of the measured flicker Six Blocks: Block 1: Input voltage adaptor Block 2: Square low demodulator Block 3: Two filters Block 4: Squaring multiple and sliding mean filter Block 5: Statistical Analysis of the instantaneous flicker level. **Flicker Standards: (3 M)** ➢ IEEE Standard 141 – 1993 ➢ IEEE Standard 519 – 1992 ➢ IEC standard 61000 – 4 – 15 (formerly IEC 868)
4	**Give a brief account on disturbance analyzer for power quality monitoring. (13M) (Nov 2017)** BTL2 **Answer: Page - 5.24 C.Ravichandran** **Key points:**

	Diagram: (5 M) **Explanation: (8 M)** o Voltage transformer o Current transformer o A/D converter o Signal compensator o VDU o Power estimator
5	**Explain the features of spectrum analyzer. (13 M) (May 2015)** BTL2 **Answer: Page - 5.26 C.Ravichandran** **Key points:** **Diagram: (5 M)** **Explanation: (8 M)** o Swept heterodyne technique o Digital technique o Control o Digital storage o Tracking generator
	PART-C
1.	**Bring out the applications of expert system for power quality monitoring. (15 M) (Nov 2018)**BTL 6 **Answer: Page - 5.46 C.Ravichandran** **Key points:** **Diagram: (5 M)** **Explanation: (5 M)** The development of an autonomous expert system calls for many approached such as Signal processing and rule – based techniques along with the knowledge – discovery approach commonly known as data mining. The process of turning raw measurement data into knowledge involves the following operations: ➢ Selection and preparation ➢ Information extraction from selected data ➢ Information assimilation ➢ Report presentation **Steps: (5 M)** The first step in the knowledge discovery is to select appropriate measurement quantities and disregard other types of measurements that do not provide relevant information. The data selection task is responsible for ensuring that all required phase voltage and current waveform data are available before proceeding to the next step. The second step attempts to represent the data and project them onto domains in which a solution is more favorable to discover. The data are already projected on other spaces or domains that are ready to extract the desired information. A simpler harmonic frequency extracting process might be accomplished by first computing the noise level in the frequency domain – signal. Any magnitude higher than the threshold number may indicate the presence of harmonic frequencies.

The data mining step usually results in scattered pieces of information.
The last step in the chain is interpretation of knowledge and report presentation.

2. **Explain the function of active filters and how it overcomes the drawbacks of passive filter in controlling harmonics.BTL 4 (15 M)**

Answer: Page - 5.1 C.Ravichandran

Key points:

Explanation: (7 M)

Filters are used where effective reduction or elimination of certain harmonics is required. It is generally classified as

- Passive Filters
- Active Filters

The application of passive tuned filters introduces new system resonances whichdepend on specific system conditions.

Passive filters are required to be significantly overrated in order to account for possible harmonic absorption from the power system and also the ratings must synchronize with reactive power requirements of the loads. Therefore it is often difficult to design such filters to avoid leading power factor operation for some loading conditions.

A flexible and reliable solution to voltage or current quality problems is provided by active power filters. Active filters have the advantage of compensating harmonics without frequency reactive power concerns.

They are based on PWM converters and are connected to low and medium voltage distribution power system in shunt or in series.

Drawbacks of Passive filter: (4 M)

- Insufficient fitness for large bands of harmonic frequencies, which insists the use of more number of filters.
- Possibility of series and parallel resonance with the grid which may cause dangerous amplification of neighboring frequency harmonics.
- Highly dependent on the grid, load parameters and main frequency.
  Bulky equipments
- Very low flexibility for load variations which implies new filter design for each load variation.

Advantages of Active filter: (4 M)

The active filters present many advantages over traditional methods for harmonic compensation such as:

- Adaptation with the variation in the loads.
- Possibility of selective harmonic compensation.
- Limitations in the compensation power.
- Possibility of reactive power compensation.
- Do not resonate with the power system
- Operate autonomously with respect to the system impedance characteristics.

3. **Briefly discuss the common objectives of power quality monitoring? (15 M)** BTL 2

Answer: Page - 5.2 C.Ravichandran

Key points:

The monitoring objectives determine the choice of monitoring equipment, triggering thresholds, methods for data acquisition and storage, and analysis and interpretation requirements.

1.Monitoring to charactering system performance (3 M)

- A power produces may find this objective important if it has the need to understand its system performance and then match that system performance with the needs of customer
- System characterization is a proactive approach to power quality monitoring.

2.Monitoring to characterize specific problem(3 M)

This is a reactive mode of power quality monitoring, but it frequently identifies the cause of equipment incompatibility, which is the first stage to a solution.

3.Monitoring as part of an enhanced power quality service(3 M)

These services offer differentiated levels of power quality to match the needs of specific customers.

4.Monitoring as part of predictive or just in time maintenance(3 M)

- Power quality data gathered over time can be analyzed to provide information relating to specific equipment performance.
- Equipment maintenance can be quickly ordered to avoid catastrophic failure

5.To measure Quantities and Duration(3 M)

- Current measurements are used to characterize the generation of harmonic by non-linear loads on the system.
- Voltage measurements helps characterize the system response to gathered harmonic currents.

EE6008 MICROCONTROLLER BASED SYSTEM DESIGN L T P C

3 0 0 3

OBJECTIVES:

To introduce the architecture of PIC microcontroller
To educate on use of interrupts and timers
To educate on the peripheral devices for data communication and transfer
To introduce the functional blocks of ARM processor
To educate on the architecture of ARM processors

UNIT I INTRODUCTION TO PIC MICROCONTROLLER 9

Introduction to PIC Microcontroller–PIC 16C6x and PIC16C7x Architecture–PIC16cxx– - Pipelining - Program Memory considerations – Register File Structure - Instruction Set - Addressing modes – Simple Operations.

UNIT II INTERRUPTS AND TIMER 9

PIC Microcontroller Interrupts- External Interrupts-Interrupt Programming – Loop time subroutine- Timers- Timer Programming-Front Panel I/O – soft keys- state machines and key switches – Display of constant and variables strings.

UNIT III PERIPHERALS AND INTERFACING 9

I^2C Bus for Peripherals Chip Access– Bus operation-Bus subroutines– Serial EEPROM— Analog to Digital Converter–UART-Baud rate selection–Data handling circuit–Initialization - LCD and keyboard Interfacing -ADC, DAC, and Sensor Interfacing.

UNIT IV INTRODUCTION TO ARM PROCESSOR 9

ARM Architecture –ARM programmer's model –ARM Development tools- Memory Hierarchy –ARM Assembly Language Programming–Simple Examples–Architectural Support for Operating systems.

UNIT V ARM ORGANIZATION 9

3-Stage pipeline Arm organization- 5-stage pipeline Arm organization- Arm Instruction Execution- ARM Implementation– ARM Instruction Set– ARM coprocessor interface– Architectural support for High Level Languages – Embedded ARM Applications.

TOTAL: 45 PERIODS

OUTCOMES:

To understand and apply computing platform and software for engineering problems. To understand ethical issues, environmental impact and acquire management skills.

TEXT BOOKS:

1. Peatman,J.B., "Design with PIC Micro Controllers"PearsonEducation,3rdEdition, 2004.
2. Furber,S., "ARM System on Chip Architecture" Addison Wesley trade Computer Publication, 2000.

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1. Mazidi, M.A.,"PIC Microcontroller" Rollin Mckinlay, Danny causey Printice Hall of India, 2007.

REGULATION :2013 **ACADEMIC YEAR : 2019-2020**

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Subject Name:Microcontroller Based System Design **Subject Handler: Ms.G.Gaja**

UNIT I – Introduction to PIC microcontroller

Introduction to PIC Microcontroller–PIC 16C6x and PIC16C7x Architecture–PIC16cxx–- Pipelining - Program Memory considerations – Register File Structure - Instruction Set - Addressing modes – Simple Operations.

PART * A

Q.No. **Questions**

1. **What is PIC Microcontroller? (APR'15)** (BTL1)

PIC stands for peripheral Interface controller coined by Microchip Technology to identify its single chip microcontrollers. These devices have been phenomenally successful in 8-bit microcontroller market. The main reason is that Microchip Technology has constantly upgraded the device architecture and added needed peripherals to the microcontroller to 'suit customers' requirements.

2 **What are the PIC16C6X Microcontroller core features? (NOV'15)** (BTL1)

High performance RISC CPU

- Only 35 single word instruments to learn
- Interrupt capability
- 8 level deep hardware stack
- Power saving sleep mode
- Programmable code protection

3 **Give an example of an embedded system.** (BTL1)

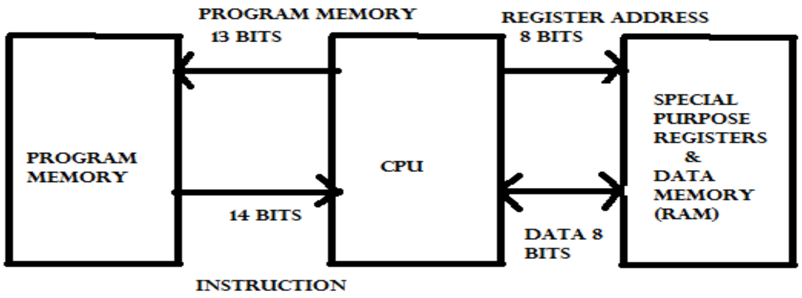
Home	**Office and commerce**	**Motor car**
Washing machine	Photocopier	Door
Fridge	Checkout machine	Climate control
Burglar alarm	Printer	Brakes
Microwave	Scanner	Engine control

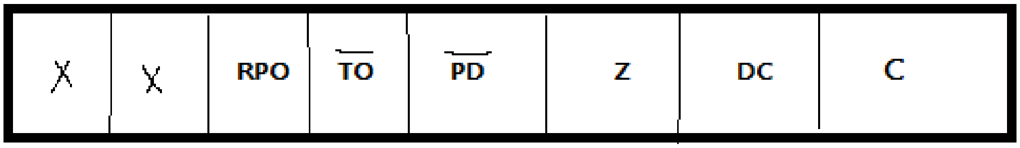
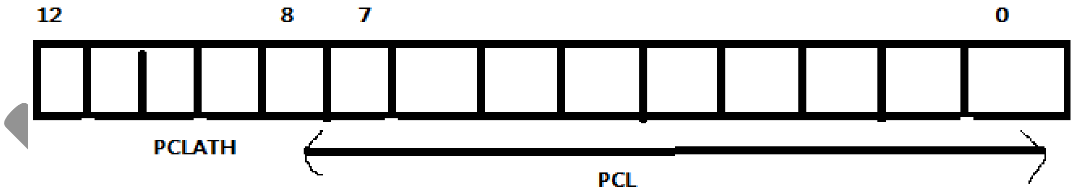
4 **Write the operation of CISC AND RISC Processor. (APR'15)** (BTL1)

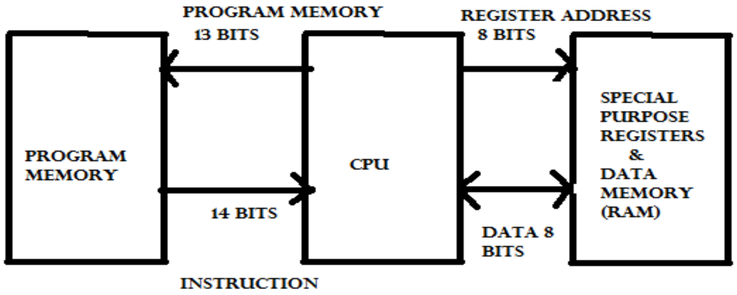
- One approach to build sophisticated cpus with exotic instruction sets, with an instruction ready for every foreseeable operation.
- This leads to the CISC, the complex instruction set computer. A CISC has many instructions and considerable sophistication.
- Another approach is to kept the CPU very simple and have a limited instructions set.
- This leads to the RISC approach- the reduced instruction set computer.
- The instruction set, and hence overall design, is kept simple. This leads to fast operation.

5 **What is Low end Architectures?** (BTL1)

- Microchip PIC microcontrollers are available in various types.
- When PIC-Micro MCU first became available from general instruments in early 1980's, the microcontroller consisted of a very simple processor executing 12-bit wide

	instructions with basic I/O functions.
6	**What is Mid-range Architectures?** (BTL1) Mid-range Architectures are built by upgrading low end architecture with more number of peripherals, more numbers of register and more data memory. Some of the mid range devices are 16C6X 16c7X, program memory type.
7	**What is Brown out delay?** (BTL1) When the power supply drops below a certain voltage (4V in case of PIC) it causes PIC to reset.
8	**List the Addressing modes of the PIC microcontroller.(Jan'15)(May'19)** (BTL4) The PIC microcontroller support only two addressing modes. They are (i) Direct addressing mode (ii) Indirect addressing mode
9	**Illustrate the CPU- Harvard architecture of PIC microcontroller. (NOV'15)** (BTL4) 
10	**Classify instructions set of the PIC Microcontroller.** (BTL4) All the instructions of the PIC microcontroller are classified into nearly 9 groups. They are given below (i) Arithmetic operations (ii) Logical Instructions (iii) Increment/ decrement Instructions (iv) data transfer instructions
11	**List out the modules in the memory of pic microcontroller.** (BTL4) The memory module of the pic controller has three memory blocks. (i) Program memory (ii) Data memory (iii) stack
12	**How to select the memory bank in the pic microcontroller** (BTL1) RPI and RPO bits are used for selecting the bits of the memory bank RPI :RPO (status)=00 -> Bank 0 = 01 -> Bank 1 = 02 -> Bank 2 = 03 -> Bank 3
13	**Define instruction pipelining with example. (NOV'16)** (BTL2) In many CPUs these two steps are done one after the other, first the cpu fetches and then it executes. If however, program memory has its own address and data bus, separate from data memory (i.e. a Harvard structure), then there is no reason why a CPU cannot be designed so that while it is executing one instruction, it is already fetching the next. This is called pipelining.
14	**What are the CPU registers?** (BTL2) (i) working register-W (similar to accumulator) (ii) status register (iii) FSR – File select register (Indirect data memory address pointer) (iv) INDF (v) Program counter

15	**What is working register?** (BTL2) Working register is used by many instructions as the source of an operand .It also serves as the destination for the result of instruction execution and it is similar to accumulator in other µcs and µps.
16	**Define status register.** (BTL1) This is an 8-bit register which denotes the status of ALU after any arithmetic operation and also RESET status and the bank select bits for the data memory**.** 
17	**What is FSR- File select register?** (BTL2) It is the pointer used for indirect addressing. In the indirect addressing mode the 8-bit reg file address is first written into FSR. It is a special purpose registers this at serves as an address pointer to any address throughout the entire register file.
18	**What is INDF- Indirect file?** (BTL2) It is not a physical register addressing but this INDF will cause indirect addressing. Any instruction using the INDF registers actually access the register pointed to by the FSR.
19	**What is Program Counter?** (BTL2) PIC has a 13 bit program counter in which PCL is the lower 8-bits of the PC and PCLATH is the write buffer for the upper 5 bits of the PC. PCLATH (program counter latch can be read or from or written to without affecting the program counter). The upper 3 bits of PCLATH remain zero. It is only when PCL is written to that PCLATH is automatically written in the PIC at the same time. 
20	**Differentiate between Harvard architecture & von-Neumann architecture. (AP'15)** (BTL2) To begin with, the pic16cxx uses Harvard architecture in which program and data are accessed from separate memories using separate buses. This improves bandwidth over traditional von-Neumann architecture in which program and data are fetched from the same memory using the same bus.
PART-B	
1	**Explain instruction pipelining (Harvard Architecture) in PIC16CXX. 13M (NOV'16) or Explain how the instruction pipelining implemented in PIC. 6M (NOV'18)** (BTL2) **Answer page : 1.29- Dr.C.R.Balamurugan** • Draw the Harvard architecture diagram and explain (6m)



- Draw the instruction pipeline flow diagram and explain in detail (7m)
  1. Many CPUs two steps done one after the other, first CPU fetches and then it executes.
  2. However, program memory has own address, data bus, separate data memory (i.e. a Harvard structure).
  3. No reason why CPU cannot be designed while executing one instruction, fetching the next called pipelining.

2

Explain about Program Memory considerations of PIC16cxx family. (13 m) **(**BTL2)

Answer page : 1.49 - C.Ravichandran

- Draw the program memory map and stack (7m)
- Explain about register file structure (6m)
- **General purpose register file:**
  1. Another name for microcontrollers RAM.
  2. Data can written each 8-bit location, updated and retrieved number of times.
- **Special purpose register file structure:**
  1. It contains input and output ports as well the control registers.
  2. Used to establish each bit port as either an input or output.
  3. Registers that contain control bits selecting the mode of operation.
  4. Chip resource enabling or disabling operation.
  5. Classified into two sets (core and peripheral)

3

Explain the register file structure of PIC 16c6x. 13 M **(**BTL1)

Answer page : 1.55 - C. Ravichandran

- Draw the register file structure (6m)
- Explain about selection of banks (7m)

RP1	**RP0**	**SELECTION**
0	0	BANK 0
0	1	BANK 1
1	0	BANK 2
1	1	BANK 3

4

Briefly explain and draw the architecture of PIC16CXX microcontroller. 7 M (NOV'18) or Explain the architecture of the PIC 16c6x with neat diagram. 13 M (NOV'17) **(**BTL1)

Answer page : 1.30 - C. Ravichandran

	• Draw the architecture diagram & explain detail(13m) **Functional blocks:** • I/O ports • Timers, counters, program counter • Instruction decoder and control • Watch dog timer • Brown out reset • Power on reset • Capture, compare and pwm module • USART, SSP,PSP,ADC
5	**What are the Various addressing modes in PIC microcontroller? What is the role of INDF in indirect addressing mode? 13 M (NOV'17)** **(**BTL2) **Explain in detail about any two addressing modes of PIC microcontroller. 6M (NOV'18)** **Answer: Refer page : 1.60 in C. Ravichandran** **Types of addressing modes (2m)** • Direct addressing mode (5m) • Indirect addressing mode(6m) 1. Direct & Indirect addressing modes 2. Direct addressing mode done through 9-bit address. 3. This obtained connecting 7th bit direct address instruction with two bits(RP1,RP0) status register. 4. Indirect addressing does not take an address from instruction. 5. But makes help IRP bit of status and FSR registers.
6	**Explain the instruction set of PIC16c6x. 13 M (APR'17) or** **(**BTL2) **Briefly explain the instruction set of PIC microcontroller. 6M (Nov 2018)** **Answer page : 1.66 - C. Ravichandran** • Types of instruction set (5m) 1. Data Transfer instructions 2. Arithmetic and logic instructions 3. Bit operations instructions • Write the syntax with Example (8m) 1. ADDWF f,d 2. CLRF f 3. INCF f,d 4. MOVF F,D 5. NOP
7	**Explain various RAM Addressing modes used in PIC 16CXX microcontrollers.13 M** **(**BTL4) **Answer page : 1.60 - C. Ravichandran** • Draw the flow diagram of direct addressing mode and explain (6m) 1. Direct Addressing done through 9-bit address. 2. This address connecting 7th bit of direct address instruction with two bits (RP1,RP0) from STATUS register. 3. Any access to SFR registers be example of direct addressing.

	• Indirect addressing mode, INDF and FSR registers. (7m) 1. The INDF register not physical register. 2. Indirect addressing possible using way of addressing the INDF register. 3. Any instruction using INDF register actually accesses register pointed by FSR.
8	**Explain the memory organization of the PIC microcontroller**. 13M **(APR'15)** **(**BTL2) **Answer page : 1.49- C. Ravichandran** • Explain about program and data memory(6m) 1. Flash memory makes up program block 2. Program memory space PIC program resides, 0.5K, 1k, 2k program memory sizes, majority of PIC devices. 3. Data memory all variables stored. 4. RAM, which means when PIC is disconnected power all the data memory is lost. • Special function registers(7m) 1. SFR gateway interaction between CPU & peripherals.. 2. SFR registers used CPU & peripheral modules controlling desired operation device. 3. Makes it 'special' that bits memory location has dual purpose.
9	**Explain different functions carried out in port c of PIC microcontroller. 13M** **(**BTL2) **Answer page :1.48 - C. Ravichandran** • Port C bidirectional I/O port (6m) • Explain each pin functions in detail (7m) 1.Port c bidirectional I/O port 2.RC0/T1OSO/T1CK1 selected timer1 oscillator output or timer1 clock input 3. RC2/CCP1 selected capture1 input/ compare 1 output/pwm1 output.
10	**Explain different RAM Addressing modes used in PIC 16CXX microcontrollers. 13 M** **Explain in detail the Addressing modes of PIC microcontroller. 6M (Apr/May 2019)** **Answer page : 1.60 - C. Ravichandran (**BTL4) • Draw the flow diagram of direct addressing mode and explain (6m) 1. Direct Addressing done through 9-bit address. 2. Address obtained connecting 7th bit direct address instruction with two bits (RP1,RP0) from STATUS register. 3. Any access to SFR registers example of direct addressing. • Indirect addressing mode, INDF and FSR registers. (7m) 1. The INDF register not physical register. 2. Indirect addressing possible using way of addressing INDF register. 3. Instruction using INDF register accesses register pointed by file select register.
Part-C	
1	**Explain about Instruction set handled by PIC Microcontroller with an example. 15M (Jan 2013, Jan 2015).** **(**BTL2) **Explain in detail the Control instructions. 7M (Apr 2019)** **Answer page : 1.43 - Dr.C.R.Balamurugan** **Instruction set types:** • Byte , Bit oriented, literal & control Instructions (6m) • Explain each instructions with syntax and example (9m) 1. ADDLW 2. BCF 3. BSF

	4. CLRWDT 5. CLRW 6. INCF 7. RETLW 8. RLF 9. RRF 10.SLEEP
2	**Explain the memory organization of the PIC microcontroller**. 15M **(Apr'16)** **Answer page : 1.49, C. Ravichandran (**BTL1) • Draw the program memory map and stack (7m) • Explain about register file structure (8m) **General purpose register file** • Another name for the microcontrollers RAM. • Data written each 8-bit location, updated retrieved number of times. **Special purpose register file structure** • Contains input, output ports as control registers establish each bit port as either input or output. • Registers contains control bits selecting mode operation, chip resource as enabling or disabling operation. • It classified into two sets(core and peripheral)
3	**Explain the architecture of the PIC 16C74A with neat diagram. 15M (Jun'12, Jun/July'13) (**BTL2) **Explain with neat diagram the architecture of PIC16C7x microcontroller. 13M (Apr'2019)** **Answer page : 1.30 - C. Ravichandran** • Draw the architecture diagram (7m) • Explain each block in detail (8m) 1. I/O ports 2. Timers, counters, program counter 3. Instruction decoder and control 3. Watch dog timer, brown out reset 4. Power on reset, Capture 5. Compare, pwm module USART. 6. SSP,PSP,ADC

UNIT II – Interrupts and Timer

PIC Microcontroller Interrupts- External Interrupts- Interrupt Programming- Loop Subroutine-Timers-Timer Programming- Front panel I/O – Soft Keys - State machines and key switches – Display of constant and variable Strings.

PART * A

S.No. **Questions**

1. **What are the two parameters of interrupt source?** BTL1

- The minimum time interval between interrupts from source, denoted by TP_i
- The maximum time it takes the CPU to execute the interrupt source handler subroutine and its call from within In-service, denoted by $T_{i.}$
- The minimum time interval between interrupt for a given interrupts source is determined by the application 9600Bd UART.

2 **What is GIE? (Apr'15)** BTL1

- Global interrupt enable bit, GIE (INTCON) enables all un-masked interrupts (if GIE set) or disables (if GIE cleared) all interrupts.
- When bit GIE is enabled, and an interrupt flag bit and mask bit are set, the interrupt will vector immediately.
- Individual interrupts can be disabled through their corresponding enable bits in the INTCON register. GIE is cleared on reset.

3 **What is the WATCH DOG TIMER (WDT)?** BTL1

- The watchdog timer is a free running on-chip oscillator which does not require any external components.
- This RC oscillator is separate from the RC oscillator of the OSCI/CLKIN pin. That means that the WDT will run, even if the clock on the OSCI/CLKIN and OSCI/CLKOUT pins of the device has been stopped.
- During normal operation, a WDT timeout generates a device reset.
- If the device is in sleep mode, a WDT can be permanently disabled by clearing configuration bit WDTE.

4 **Write the WATCH DOG TIMER REGISTER.** BTL1

Address	**Name**	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
2007h	config bits	1	BODEN	CP1	CP0	PWRTE	WDTE	FOSC1	FOSC0
81h,181h	OPTION	RBP0	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0

5 **Write the interrupts which wake up the peripheral interrupts from sleep.** BTL1

The following peripheral interrupts can wake up device from sleep:

- TMR 1 interrupts. Timer1 must be operating as an asynchronous counter.
- SSP (start/stop) bit detect interrupt.
- SSP transmit or receive in slave mode (SPI/I2C)
- CCP capture mode interrupt.

	• Parallel slave port read or write • USART TX or RX (Synchronous slave mode)
6	**What is TIMER 0?** BTL1 • The Timer 0 module is a simple 8-bit overflow counter. • The clock source can be either the internal system clock or an external clock. • When the clock source is an external clock, the timer 0 module can be selected to increment on either the rising or falling edge. • The maximum frequency is 50Mhz, given the high and low time requirements of the clock. • TMR0 can increment at the following rates 1:1
7	**What is Timer 1?** BTL1 • Timer 1 can be operated in one of two mode: 1. As a Timer 2. As a counter. • The clock source can be either the internal system clock (Fosc/4), an external clock, or an external crystal. • When used with a CCP module, timer 1 is the time base for 16-bit capture or 16-bit compare and must be synchronized to the device.
8	**What is the RBIF register? (Jan'17)** BTL1 • RBIF-Register B interrupt flag • Port B will set the RBIF bit in the INTCON register. If the interrupts have been enabled by the setting of INTCON,s RBIE and GIE bit then the CPU will be interrupted.
9	**What are the steps for two step process?** BTL1 • Read port B to copy the upper four bits of port B into the hardware copy thereby removing the mismatch condition. • bcf INTCON, RBIF
10	**What are the two parameters for display?** BTL1 • The conversion of number entered digit by digit from a keyboard into its binary equivalent. • The display of fixed and variable strings of characters
11	**What is sequence for KEYSTATE?** BTL1 The following steps are used for KEYSTATE • Debounce the key switch • Determine which key is pressed • Take appropriate action once for the press of the key • Wait for the release of that key
12	**Explain the display string format.** BTL2 • Cursor-positioning code • ASCII string of characters to be displayed • End of string designator
13	**What is the RPG?** BTL2 • For the instrument design the display plus either key switches or a rotary pulse generator

	(RPG) in their design of the front panel. • The display serves to display measurement • The display combines key switches of RPG for the entry of setup parameters
14	**What is the use of key switch?** BTL2 • The key switches are not changed very fast; they can be checked once each time around the mainline loop in a key switch subroutine. • Recall that a loop time of 10ms was selected because the maximum key bounce time of the most mechanical key switches is less than 10ms. • If the key switch detects that a key is newly pressed, it can be assured that the next time it is called, 10ms later, any erratic bouncing of the key contacts will have settled out, with the contact firmly closed.
15	**How the constant string used.** BTL2 The labels associated with soft keys represent one application. The units associated with a variable represent another application.
16	**What is CCP module? (Jun'15)** BTL2 • Capture/ compare/PWM module. • Pic chip having two ccp modules if both modules are being used for either a compare function or capture function, they will share TMR1. In this case TMR1 should never a changed by writing to it.
17	**Define RTOS. (NOV'17)** BTL2 A real-time operating system is an operating system intended to serve real-time application requests. It must be able to process data as it comes in, typically without buffering delays. Processing time requirements are measured in tenths of seconds or shorter.
18	**Distinguish between hardware and software interrupts.** BTL4 • In Hardware interrupts, some pins on the 8051 allow peripheral device to interrupt the main program for I/O operation, where microcontroller are used to receive interrupt requests are called H/W Interrupt. • Software Interrupts: In S/w interrupts, the cause of the interrupt is an execution of this instruction.
19	**How timer 1 performs in timer mode and counter mode.** BTL2 • Timer mode is selected by clearing the TMR1CS bit. In this mode, the input clock to the timer is FOSC/4. The synchronize control bit T1SYNC has no effect since the internal clock is always in synchronized. • Counter mode is selected by setting bit TMR1CS. In this mode the timer increments on every rising edge of clock input on pin RC1/T1OSC1/CCP2 when bit T1OSCEn is set or pin RC0/T1OSO/T1CK1 when bit T1OSCEN is cleared.
20	**List the applications of microcontroller.** BTL1 • Stepper motor interfacing • Length measurement • Square wave generator • Traffic light control
	Part-B

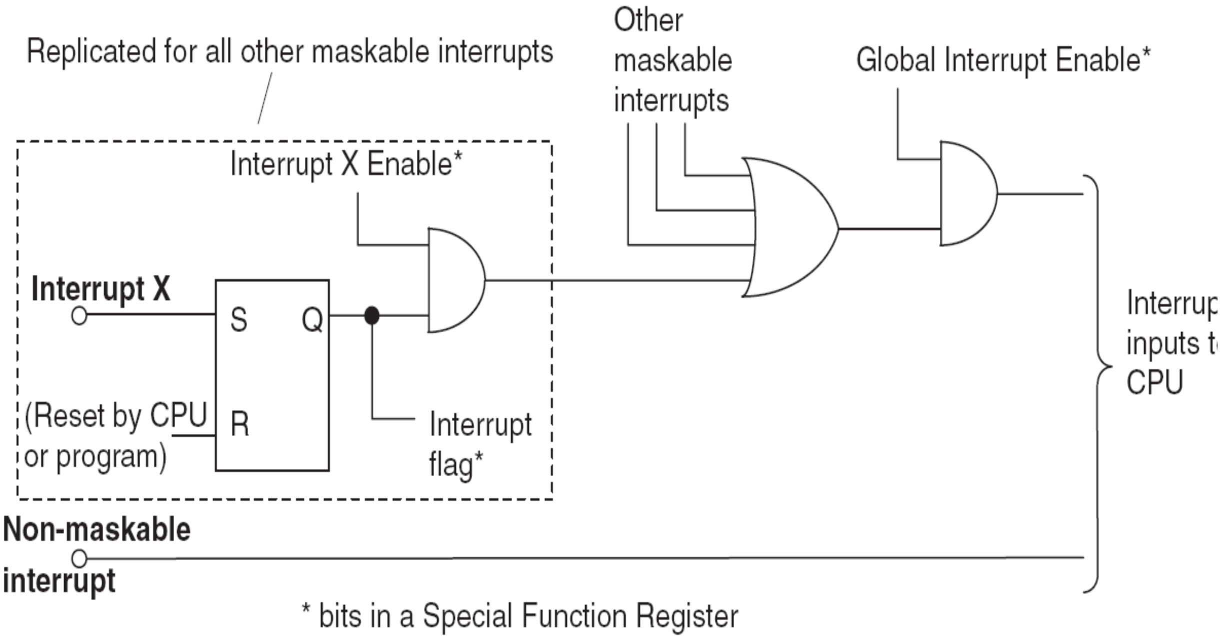
1

What is interrupt? Explain the interrupt structure of PIC microcontroller with neat diagram. (13M) (NOV’17,18) (APR’19) BTL2

Answer : Page :2.3- C. Ravichandran

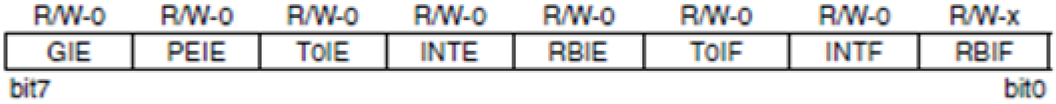
Interrupts:

- Draw the interrupt service routine structure (5M)



* bits in a Special Function Register

- Registers associated with interrupts (4M)
  1. INTCON REGISTER



R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-x
GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF
bit7							bit0

  2. PIE REGISTER
  3. PIR REGITER
- CPU response to an interrupt process (4M)

1. Whenever device needs service, device notifies the Microcontroller sending interrupt signal.

2. Receiving interrupt signal, the Microcontroller interrupts doing serves device.

3. The program associated interrupts called ISR (interrupt service routine) or interrupt handler.

2

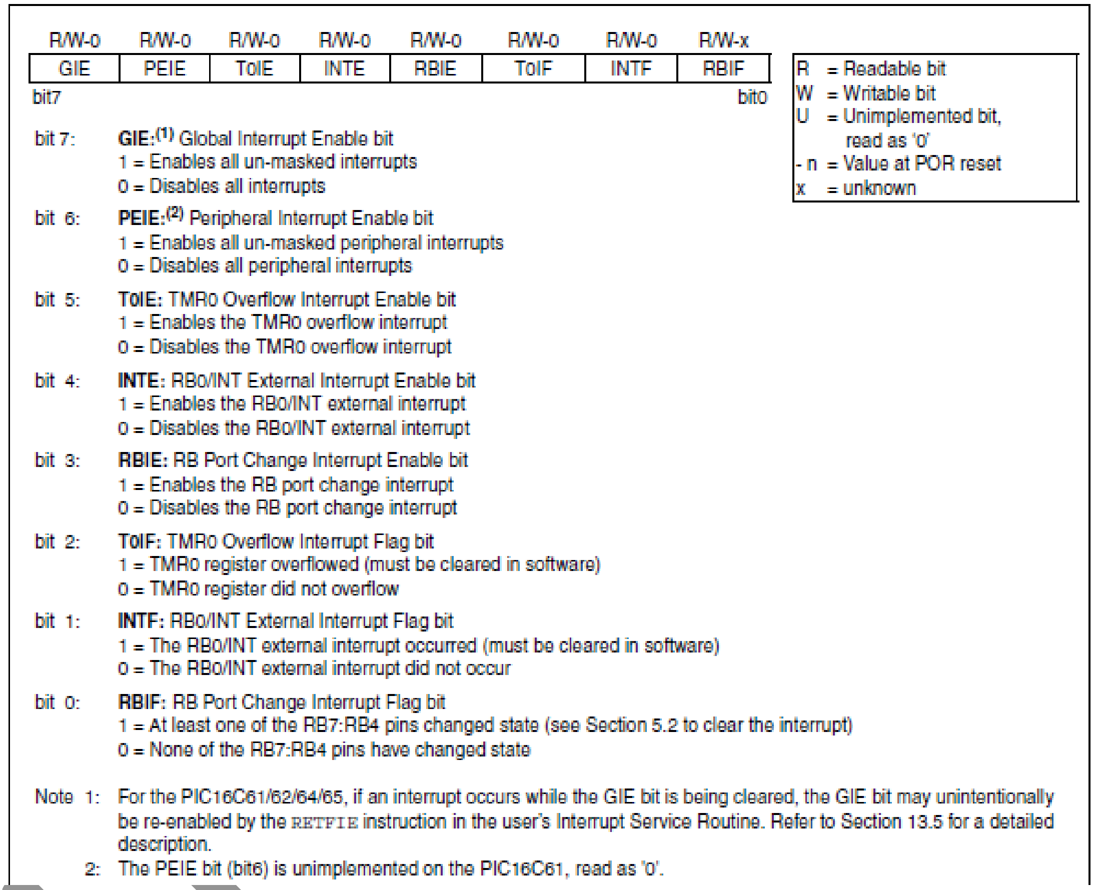
Describe briefly about various registers associated with PIC16cxx interrupts. (13M) (Jan’16) BTL2

Answer :Page :2.6 -C. Ravichandran

Registers:

- Draw the INTCON register structure (6M)

INTCON REGISTER (ADDRESS 0Bh, 8Bh, 10Bh 18Bh)



R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-x
GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF

bit7 bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset
x = unknown

bit 7: **GIE:**[1] Global Interrupt Enable bit
1 = Enables all un-masked interrupts
0 = Disables all interrupts

bit 6: **PEIE:**[2] Peripheral Interrupt Enable bit
1 = Enables all un-masked peripheral interrupts
0 = Disables all peripheral interrupts

bit 5: **T0IE:** TMR0 Overflow Interrupt Enable bit
1 = Enables the TMR0 overflow interrupt
0 = Disables the TMR0 overflow interrupt

bit 4: **INTE:** RB0/INT External Interrupt Enable bit
1 = Enables the RB0/INT external interrupt
0 = Disables the RB0/INT external interrupt

bit 3: **RBIE:** RB Port Change Interrupt Enable bit
1 = Enables the RB port change interrupt
0 = Disables the RB port change interrupt

bit 2: **T0IF:** TMR0 Overflow Interrupt Flag bit
1 = TMR0 register overflowed (must be cleared in software)
0 = TMR0 register did not overflow

bit 1: **INTF:** RB0/INT External Interrupt Flag bit
1 = The RB0/INT external interrupt occurred (must be cleared in software)
0 = The RB0/INT external interrupt did not occur

bit 0: **RBIF:** RB Port Change Interrupt Flag bit
1 = At least one of the RB7:RB4 pins changed state (see Section 5.2 to clear the interrupt)
0 = None of the RB7:RB4 pins have changed state

Note 1: For the PIC16C61/62/64/65, if an interrupt occurs while the GIE bit is being cleared, the GIE bit may unintentionally be re-enabled by the `RETFIE` instruction in the user's Interrupt Service Routine. Refer to Section 13.5 for a detailed description.

2: The PEIE bit (bit6) is unimplemented on the PIC16C61, read as '0'.

- Explain about PIE, PIR register structure (7M)

U-0	U-0	U-0	U-0	U-0	U-0	U-0	R/W-0
-	-	-	-	-	-	-	CCP2IE

3

Explain the RB0/INT External interrupt input. (13M) BTL2

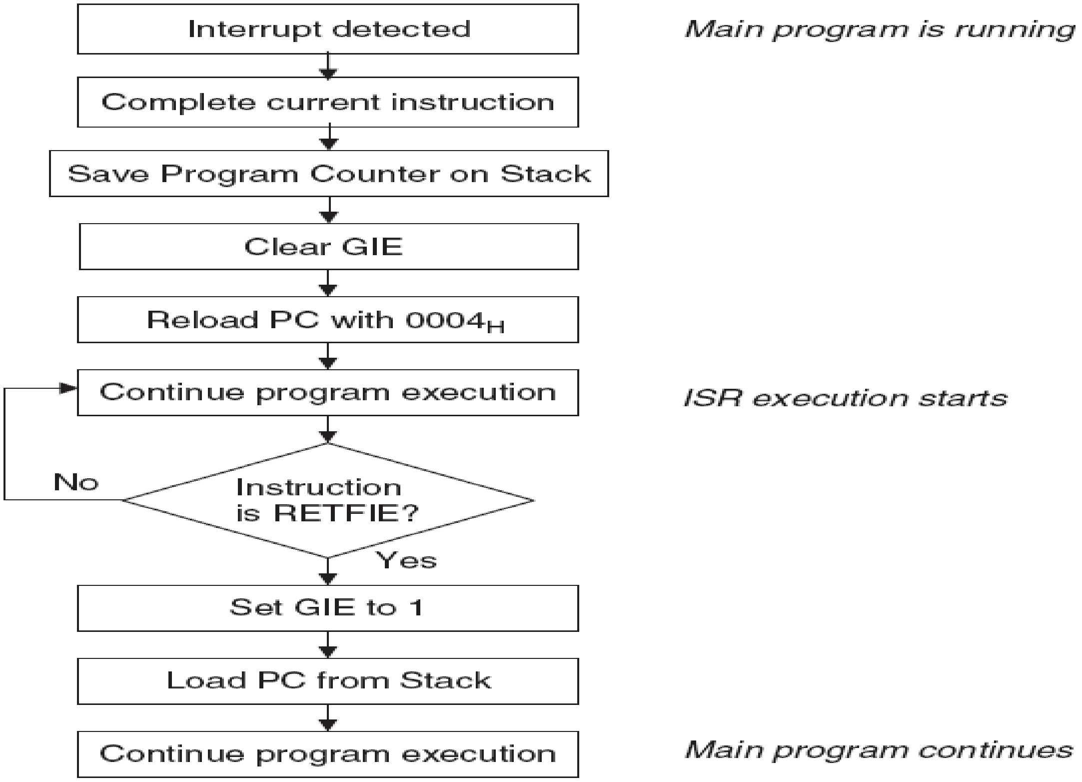
Answer :Page: 2.23 - C. Ravichandran book

RB0/INT External interrupt:

- Explain Intservice service routine (6M)

1. Timer interrupt occurs CPU automatically pushes return address program counter
2. Top of stack clears global interrupt enable bit disabling further interrupts.
3. The INT interrupts can wake processor SLEEP mode, enable bit INTE set prior going SLEEP.
4. The status global enable bit GIE decides processor branches interrupt vector wake-up.

	• Looptime subroutine (7M) 1. With aid timer2 subroutine IntService, Looptime subroutine led main loop 2. Able create time around loop (example exactly 10ms) 3. INTF flag is sampled (every Q1) 4. CLKOUT available in RC oscillator mode.
4	**Explain the compare/capture mode. (13M)** BTL2 **Answer :Page : 2.47- C. Ravichandran book** **Compare/Capture mode:** • Draw and explain capture & compare mode (7M) CCP Mode Timer Resource 1. Capture Timer 1 2. Compare Timer 1 3. PWM Timer 2 • Explain about PWM duty cycle(6M) PWM DUTY CYCLE= ((CCPR1L:CCP1CON) x Tosc x (TMR2 Prescalar value)
5	**Write about display of variable strings and program for display of constant strings. (13M)** BTL1 **Answer: Page: 2.63, 2.66 - C. Ravichandran** • Explain the format of display a string (4M) 1. Cursor positioning code 2. ASCII string of characters to be displayed 3. End-of-string designator, 00h • Give an example of variable string & program (9M) 1. Movlw 2. movwf 3. incf
6	**Describe the CPU response to an interrupt process with neat flowchart. (13M)** BTL1 **Answer :Page : 2.11- C. Ravichandran** • Draw the flowchart of PIC16cxx interrupts response sequence of events (6M)



- Explain about interrupt programming (7M)
    1. Start INR interrupt vector, location 0004
    2. Enable interrupt used, setting enable bit INTCON register.
    3. set global interrupt enable bit.
    4. Clear interrupt flag within ISR
    5. End the ISR with retfie instruction.

7 **Explain the following in relevant with PIC 16C6X series of microcontrollers. (13M)** BTL1

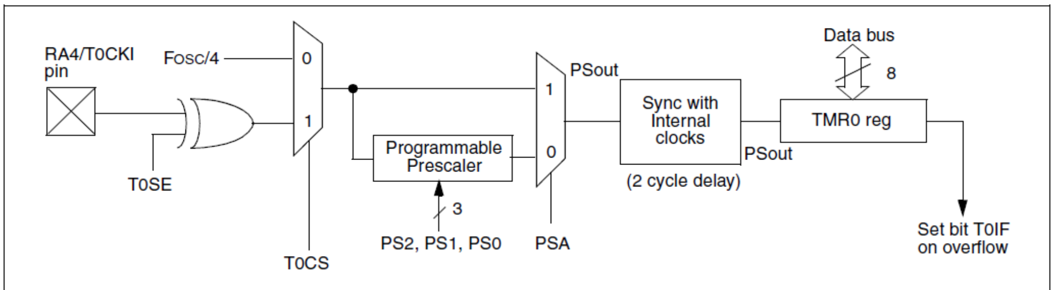
(i) TMR0 INTERRUPT

(ii) INT INTERRUPT

Answer: Page : 2.20 -C. Ravichandran

- Draw and explain TMR0 Interrupt Timing diagram (7M)

TIMER0 BLOCK DIAGRAM



Note 1: Bits, T0CS, T0SE, PSA, and PS2, PS1, PS0 are (OPTION<5:0).
2: The prescaler is shared with Watchdog Timer (refer to Figure 7-6 for detailed diagram).

- Explain about INT pin interrupt timing (6M)
    1. INTF flag sampled
    2. Imterrupt latency= 3 TCY for synchronous interrupt & 3-4TCY for asynchronous

interrupt.

8

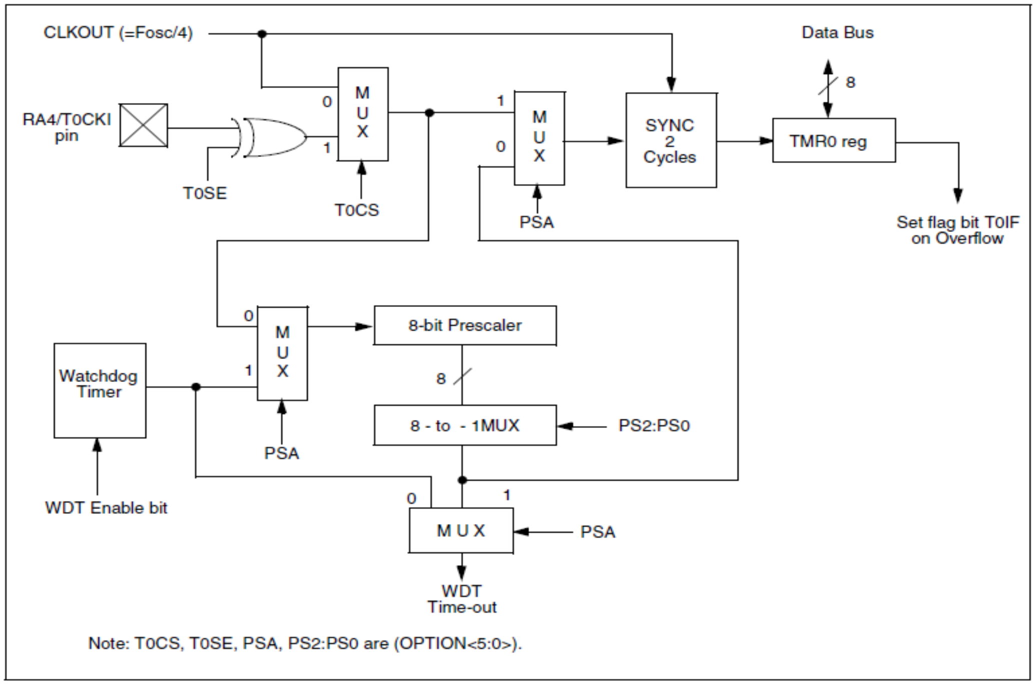
Explain in detail operation of TIMER 0 modules with neat block diagram. (13M) (NOV'17) or Briefly explain the timer modeules in PIC microcontroller. (13M) (NOV'18)

BTL2

Answer : Page : 2.33 - C. Ravichandran

- Explain the features and interrupt timing diagram(6M)
  1. 8-bit timer/counter
  2. Readable and writable
  3. 8-bit software programmable prescalar
  4. Internal or external clock select
  5. interrupt on overflow from FF to 00
- Timer 0 operation with and without prescalar.(7M)

BLOCK DIAGRAM OF THE TIMER0/WDT PRESCALER



Note: T0CS, T0SE, PSA, PS2:PS0 are (OPTION<5:0>).

9

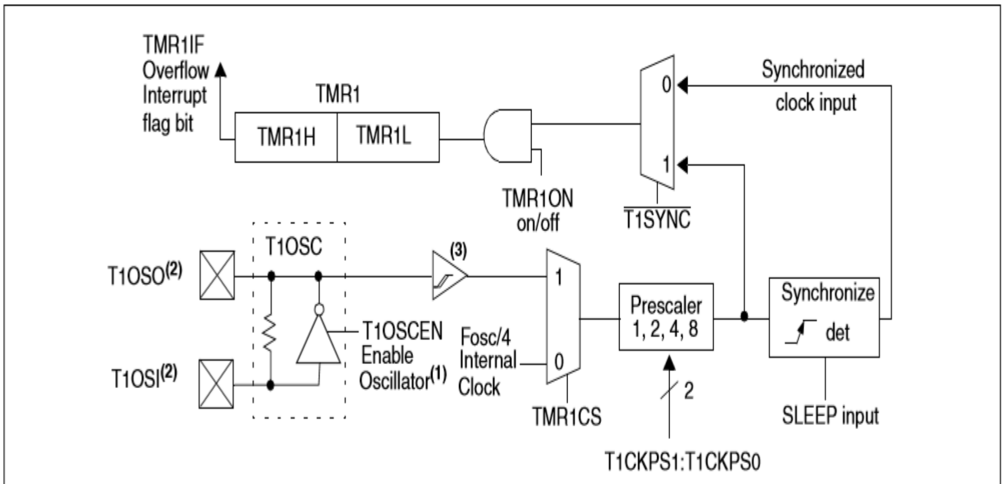
Briefly explain the timer modules in PIC microcontroller. (13M) (NOV'18)

Explain in detail operation of TIMER 1 module with neat block diagram. (13M) BTL2

Answer : Page : 2.38- C. Ravichandran

- It can be operated as two modes (5M)
  1. As a timer
  2. As a counter
- As a timer & As a counter (4M)
  1. The operating mode determined clock select bit
  2. TMR1CS timer mode, timer1 increments every instruction cycle.
  3. Counter mode, increments on every rising edge of the external clock input.
- Draw and explain about timer 1 control registers (4m)

TIMER1 BLOCK DIAGRAM



Note 1: When enable bit T1OSCEN is cleared, the inverter and feedback resistor are turned off. This eliminates power drain.
2: See pinouts for pins with T1OSO and T1OSI functions.
3: For the PIC16C62/64/65, the Schmitt Trigger is not implemented in external clock mode.

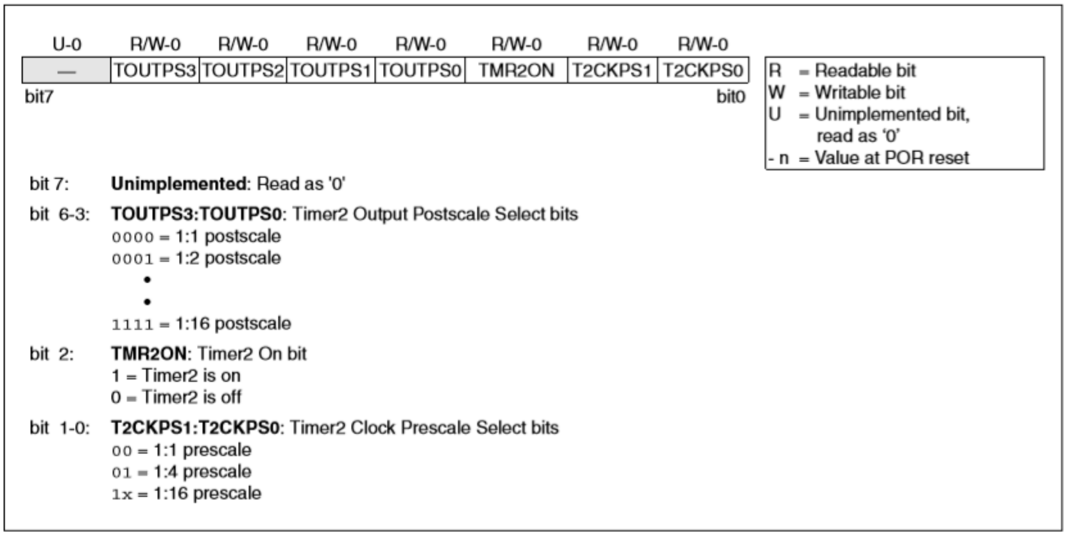
10

Explain in detail operation of TIMER 2 modules with neat block diagram. (13M) BTL2

Answer: Page : 2.42- C. Ravichandran

- It can be operated in two modes , Timer2 registers (5M)

T2CON: TIMER2 CONTROL REGISTER (ADDRESS 12h)



U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7: **Unimplemented**: Read as '0'

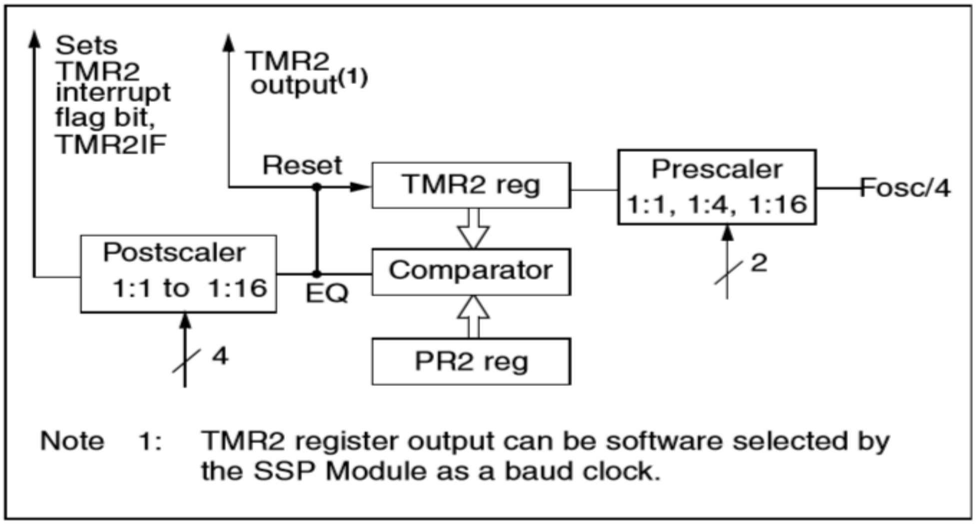
bit 6-3: **TOUTPS3:TOUTPS0**: Timer2 Output Postscale Select bits
0000 = 1:1 postscale
0001 = 1:2 postscale
•
•
1111 = 1:16 postscale

bit 2: **TMR2ON**: Timer2 On bit
1 = Timer2 is on
0 = Timer2 is off

bit 1-0: **T2CKPS1:T2CKPS0**: Timer2 Clock Prescale Select bits
00 = 1:1 prescale
01 = 1:4 prescale
1x = 1:16 prescale

- As a timer & As a counter (4M)
- Draw and explain about timer 2 control registers (4M)

TIMER2 BLOCK DIAGRAM



Note 1: TMR2 register output can be software selected by the SSP Module as a baud clock.

Part-C (15 Marks)

1 **Explain about front panel I/O – soft keys, state machines & key switches in PIC 16cxx microcontroller. (15M)** BTL2

Answer :Page : 2.59, 2.60- C. Ravichandran

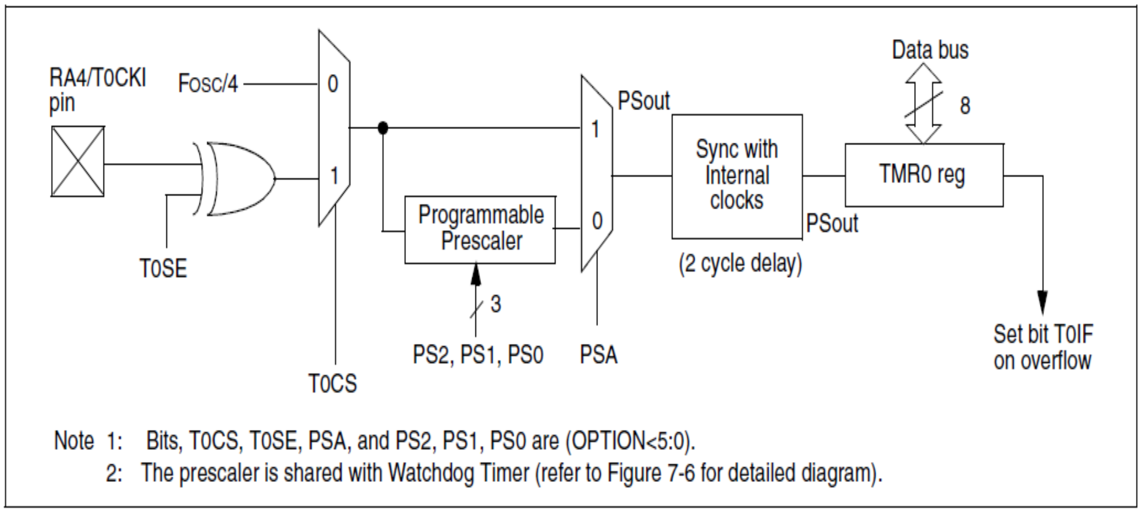
- Explain about interfacing of soft key and keypad (7M)
    1. Represents small pushbutton switches associate right each line display.
    2. Label switch demonstrated and changed.
    3. Right edge of the row corresponding that switch.
- Draw the algorithm of key switch subroutine (8M)

2 **Explain the timer of the PIC microcontroller. (15M) (Apr’15)** BTL1

Answer: Page : 2.30- C. Ravichandran

- Timer modules (7M)
- Explain Timer 0, Timer 1, Timer 2 operation without prescaler. (8M)
    1. Timer0 module simple 8-bit overflow counter.

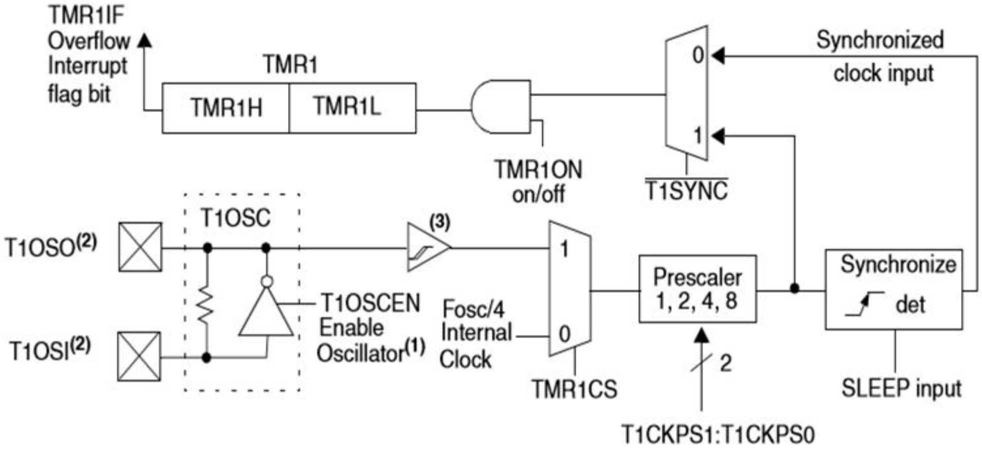
TIMER0 BLOCK DIAGRAM



Note 1: Bits, T0CS, T0SE, PSA, and PS2, PS1, PS0 are (OPTION<5:0).
2: The prescaler is shared with Watchdog Timer (refer to Figure 7-6 for detailed diagram).

2. Clock source either internal system clock (Fosc/4) or external clock.

3. Timer1 16-bit timer/counter.



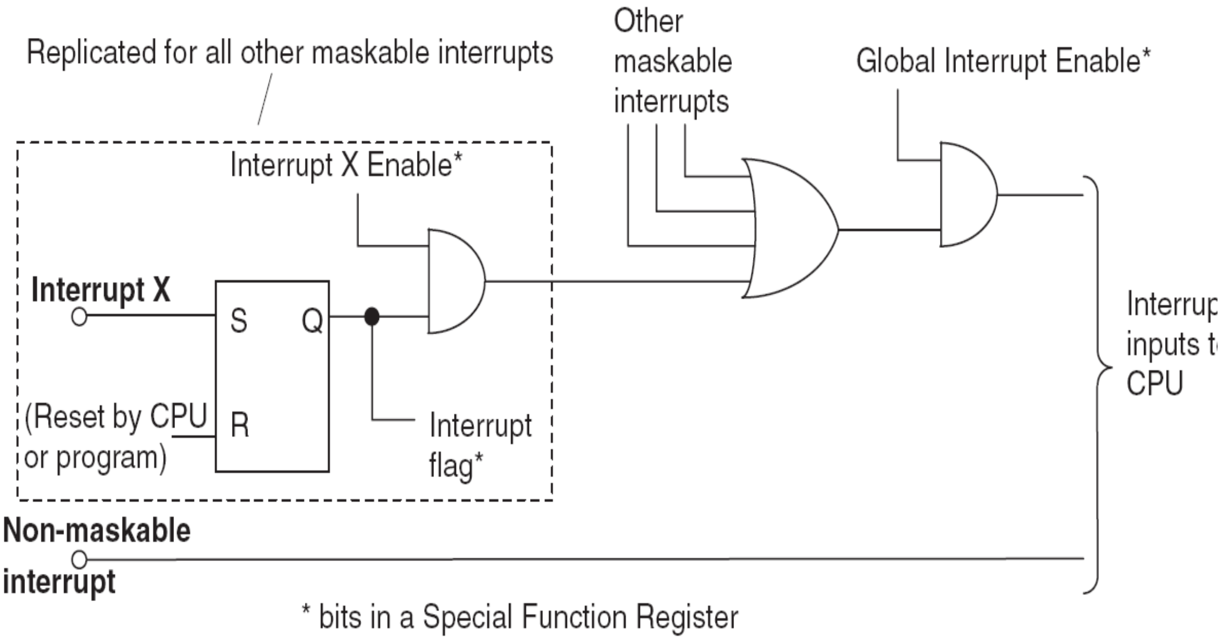
4. Clock source either internal system clock (Fosc/4) externa1 clock or external crystal.

3

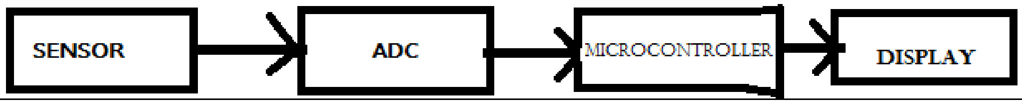
Discuss the interrupt structure in PIC Microcontrollers. List out the various interrupt sources in PIC16c7x. (15M) (Apr'16) BTL2

Answer :Page :2.3 - C. Ravichandran

- Draw the interrupt service routine structure (6M)



- Registers associated with interrupts (5M)
  1. INTCON REGISTER
  2. PIE REGISTER
  3. PIR REGITER
- CPU response to an interrupt process (4M)
  1. Whenever device needs service, device notifies the Microcontroller sending interrupt signal. 2. Receiving interrupt signal, the Microcontroller interrupts doing serves device.

<table>
<tr><td colspan="2">UNIT III- Peripherals & Interfacing</td></tr>
<tr><td colspan="2">I^2C Bus for Peripherals Chip Access– Bus operation-Bus subroutines– Serial EEPROM—Analog to Digital Converter–UART-Baud rate selection–Data handling circuit–Initialization - LCD and keyboard Interfacing - ADC, DAC, and Sensor Interfacing.</td></tr>
<tr><td colspan="2">PART * A</td></tr>
<tr><td>Q.No.</td><td>Questions</td></tr>
<tr><td>1.</td><td>What are the different capture modes available in the capture module of PIC microcontroller? (BTL1)
Three modules are
(i) CCP1
(ii) CCP2
(iii) CCP3</td></tr>
<tr><td>2</td><td>Write the function of the bits EEPGD and WRERR bits in the EECON1 register in PIC Microcontroller.(June 2012) (BTL1)
EEPGD- flash program or data EEPROM memory select bit
1= access program flash memory; 0= access data EEPROM memory
WRERR-write error flag bit
1= write operation is prematurely terminate; 0= the wire operation is completed.</td></tr>
<tr><td>3</td><td>Calculate the resolution of 10 bit ADC having max. analog value+ 10.0 volts. (June 2013) (BTL4)
Resolution of a converter determines the degree of accuracy in conversion. It is equal to $1/2^{n}$ so, $1/2^{10} = 0.000976$</td></tr>
<tr><td>4</td><td>What are the interrupts available in pic? (Jan’ 14) (BTL2)
<table>
<tr><th>Interrupt source</th><th>Enabled by</th><th>completion status</th></tr>
<tr><td>EXTERNAL INTERRUPT FROM INT</td><td>INTE=1</td><td>INTF=1</td></tr>
<tr><td>TMR0 INTERRUPT</td><td>T0IE=1</td><td>T0IF=1</td></tr>
<tr><td>RB4-RB7 STATE CHANGE</td><td>RBIE=1</td><td>RBIF=1</td></tr>
<tr><td>EEPROM WRITE COMPLETE</td><td>EEIE=1</td><td>0</td></tr>
</table></td></tr>
<tr><td>5</td><td>How EEPROM memory stores the information? (Jan’15, Jan’14) (BTL2)
A EEPROM is a memory that allows storing the variables, as a result of burning the written program.</td></tr>
<tr><td>6</td><td>What is flash memory?(Jan’15/ Jan’ 13) (BTL1)
Erasure of the entire contents takes less than a second or one might say in a flash, hence its name flash memory. Flash memory’s contents are erased (or written to), the entire device is erased.</td></tr>
<tr><td>7</td><td>Using pic microcontroller how the analog signal is converted into digital? (Jan’13) (BTL2)
ADC to translate the analog signals to digital numbers. So, that the microcontrollers can read and process them.

 </td></tr>
</table>

8 **What do you mean by I^{2}C Bus?** (BTL2)

- At the low end of the spectrum of communication options for “inside the box” communication is I^{2}C. The name I^{2}C is shorthand for a standard inter-IC bus.
- I^{2}C provides good support for communications with various slow, on-board peripheral devices that are accessed intermittently, while being extremely modest in its hardware resources needs. It is simple, low-bandwidth, short-distance protocol.
- Most available I^{2}C devices operate at speeds up to 400 Kbps.

9 **How can the LCD be tested whether it is ready to receive a command or data?(june’12)** (BTL2)

The steps that has to be done for initializing the LCD display is given below and these steps are common for almost all applications.

- Send 38H to the 8-bit data line for initialization
- Send 0fH for making LCD ON, Cursor ON and cursor blinking ON.
- Send 06H for increment cursor position
- Send 01H for clearing the display and return the cursor

10 **What is data acquisition system?** (BTL2)

- The data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer.
- Data acquisition system typically converts analog waveforms into digital values.

11 **What are the advantages of microcontroller based control over conventional control?(June/July 2013)** (BTL2)

1. speed is high
2. hardware requirement is very less

12 **While programming for LCD display, what initialization has to be done? What is the need for D/A converter?** (BTL5)

When D7=0, the LCD is ready to receive new information. D/A converter is used to interface the microcontroller output with the external device.

13 **In what ways CISC and RISC processors differ? (Jan’16, Apr’15)** (BTL4)

CISC	RISC
It provides number of addressing	It provides very few addressing modes
It has a micro programmed unit with a control memory	It has a hardware unit without a control Memory
An easy compiler design	complex compiler design
Provides precise and intensive calculations slower than a RISC	Provides precise and intensive calculations faster than a CISC

14 **Write about UART.** (BTL2)

Universal asynchronous receiver transmitter. UART is useful for receiving and transmission of data in asynchronous mode.

15 **How do you calculate timer0 preload count?** (BTL3)

The preload count for Timer 0 id given by 256-
(timer0 delay x fosc)/ (prescaler value x 4)

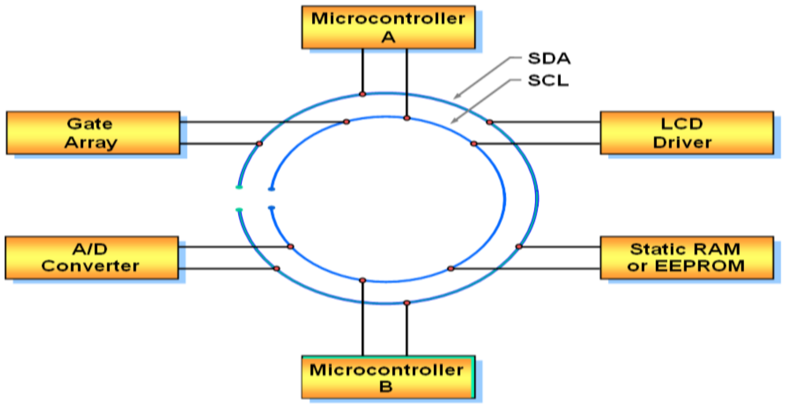
16 **How USART can be configured?** (BTL2)

The universal synchronous Asynchronous receiver Transmitter (USART) module is one of the two

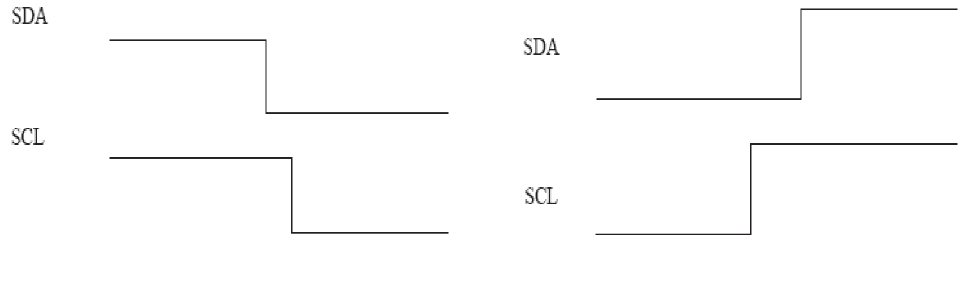
<table>
<tr><td></td><td>serial I/O modules. USART is also known as serial communication interface or SCI. it can be configured as:
1. Asynchronous (full duplex)
2. synchronous – master (half duplex)</td></tr>
<tr><td>17</td><td>What do you mean by Baud rate generator (BRG)? (BTL2)
The BRG supports both the asynchronous and synchronous modes of the usart. It is a dedicated 8-bit baud rate generator. The SPBRG register controls the period of a free running 8-bit timer the desired baud rate and fosc, the nearest integer value fir the PBRG register can be calculated using the formula
<table>
<tr><td>SYNC</td><td>BRGH=0(low speed)</td><td>BRGH=1(high speed)</td></tr>
<tr><td>0</td><td>(asynchronous) baud rate=FOSC/(64(X+1))</td><td>BAUD RATE=FOSC/16(X+1))</td></tr>
<tr><td>1</td><td>(synchronous) baud rate=FOSC/(4(X+1))</td><td>NA</td></tr>
</table></td></tr>
<tr><td>18</td><td>Write a program to initialize port A. (BTL4)
Org 0
BcfSTATUS.RP)
Clrf PORTA
Bsf STATUS.RP0
Movlw 00010000H
Movwf TRISA.End</td></tr>
<tr><td>19</td><td>What is the function of TRISA pin? (BTL1)
Setting TRISA bit will configure port A as input and resetting will configure as output port</td></tr>
<tr><td>20</td><td>What is synchronous and asynchronous data transmission? (BTL1)
Start and stop bit allowed for transmission of data. Synchronous- no start and stop bit only block header data.</td></tr>
<tr><td colspan="2">Part-B</td></tr>
<tr><td>1</td><td>Explain the features of I^{2}C bus operation for peripheral chip access. (13M) (June ’12)

Discuss in detail of I^{2}C bus in PIC microcontroller. (7M) (Nov’18)
BTL1
Answer: Page : 3.6 - C. Ravichandran

• Define I^{2}C bus , master and slave working (6M)
1. I^{2}C bus two wire serial interface
2. Developed by Philips corporation.
3. The original specification or standard mode, was for data transfer of up to 100 kbps.</td></tr>
</table>



- **Master:**
  1. Initiates a transfer by generating start and stop conditions
  2. Generates the clock
  3. Transmits the slave address
  4. Determines data transfer direction
- **Slave:**
  1. Responds only when addressed
  2. Timing controlled clock line
- Features of I^{2}C bus with start and stop conditions timing diagram.(7M)



START Condition STOP Condition

1. A peripheral chip address read/ write bit designating that peripheral chip is read successive bytes.
2. Internal registers of peripheral or address byte.

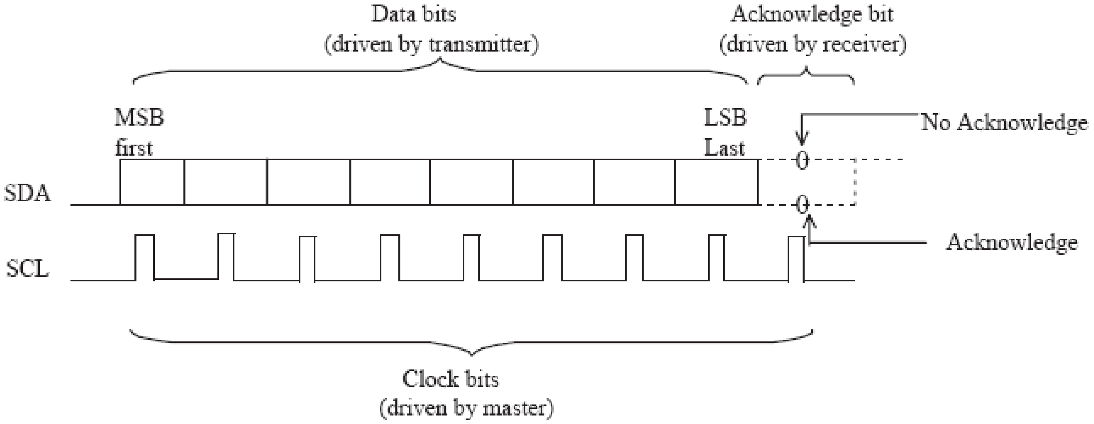
2 **Explain I^{2}C bus subroutine algorithm with programming example. (13M) (Jun’16)** BTL1

Answer : Page : 3.18 - C. Ravichandran

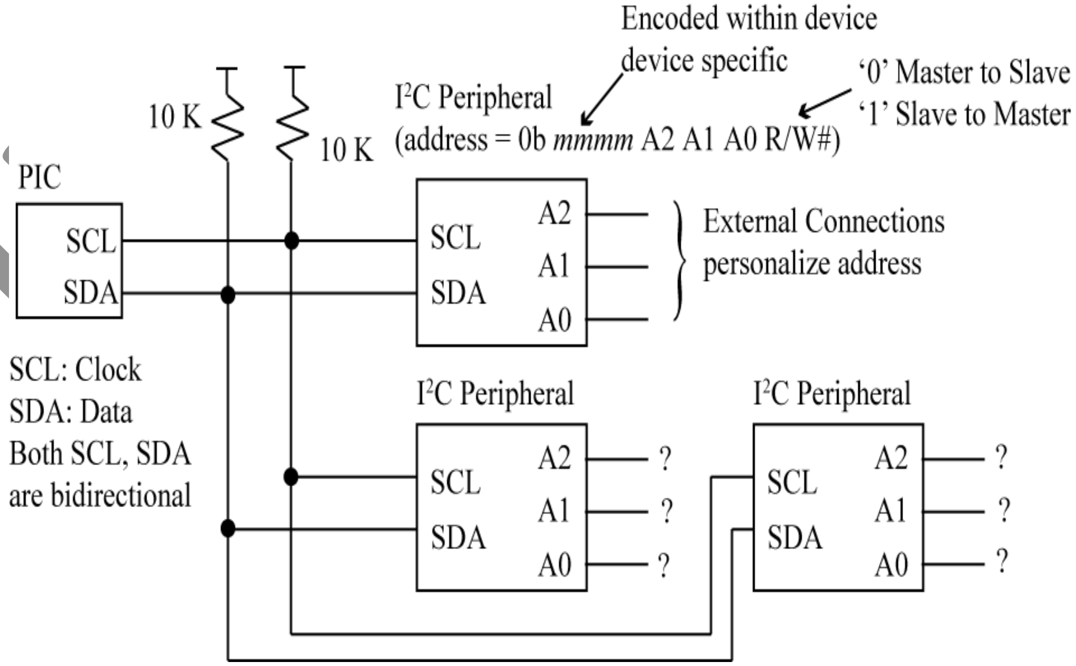
- Implementation of open drain outputs: (3M)

Requires two open-drain I/O pins.
Port-C of PIC IC can be used for I^{2}C communication.
SCL (Serial Clock) RC3/SCK/SCL
SDA (Serial Data) RC4/SDI/SDA

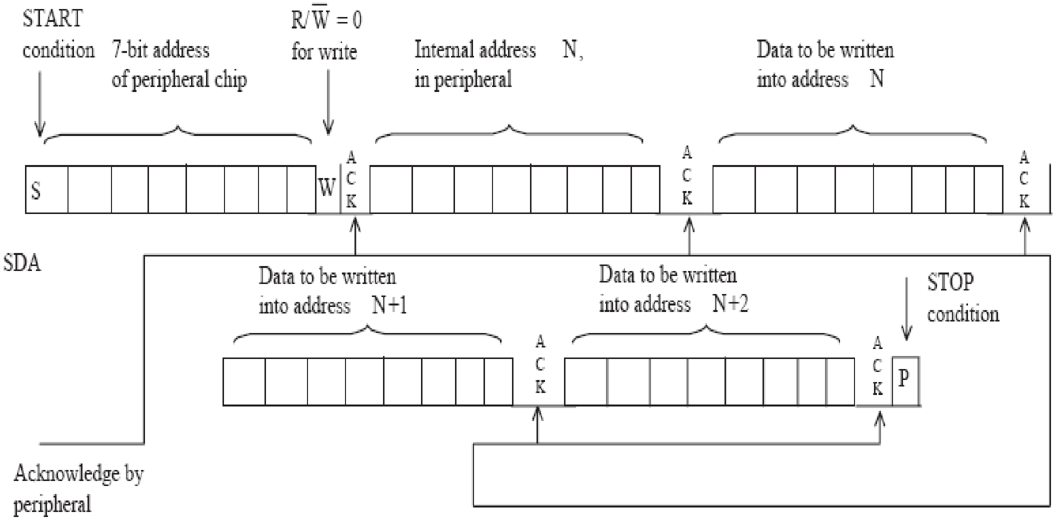
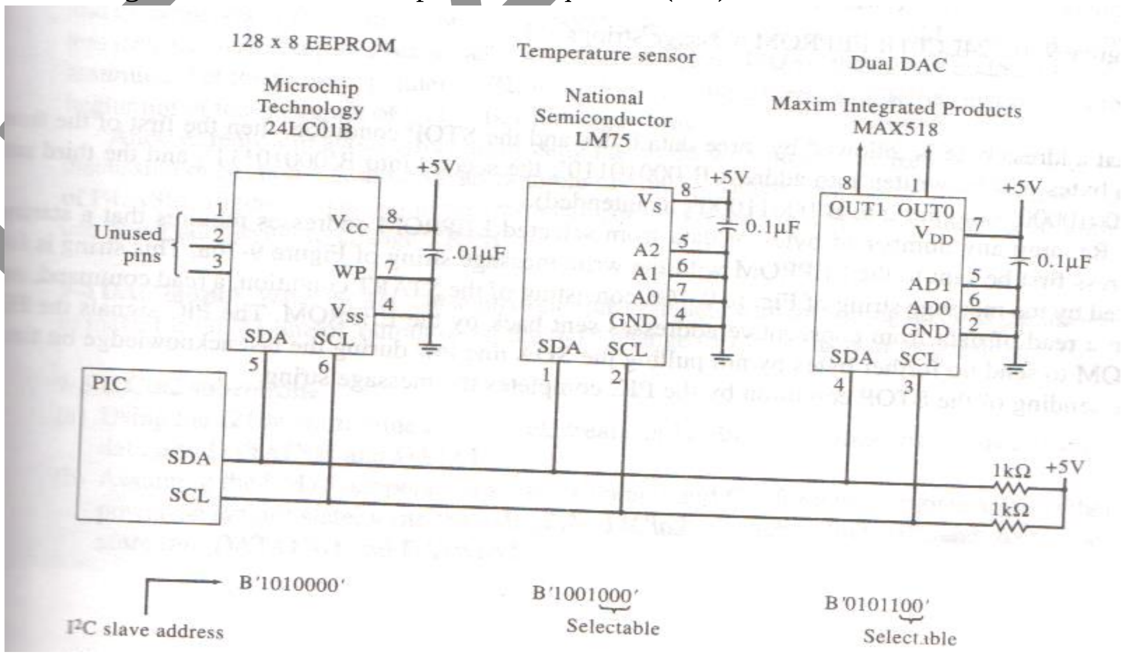
- **Byte transfer and acknowledge (5M)**

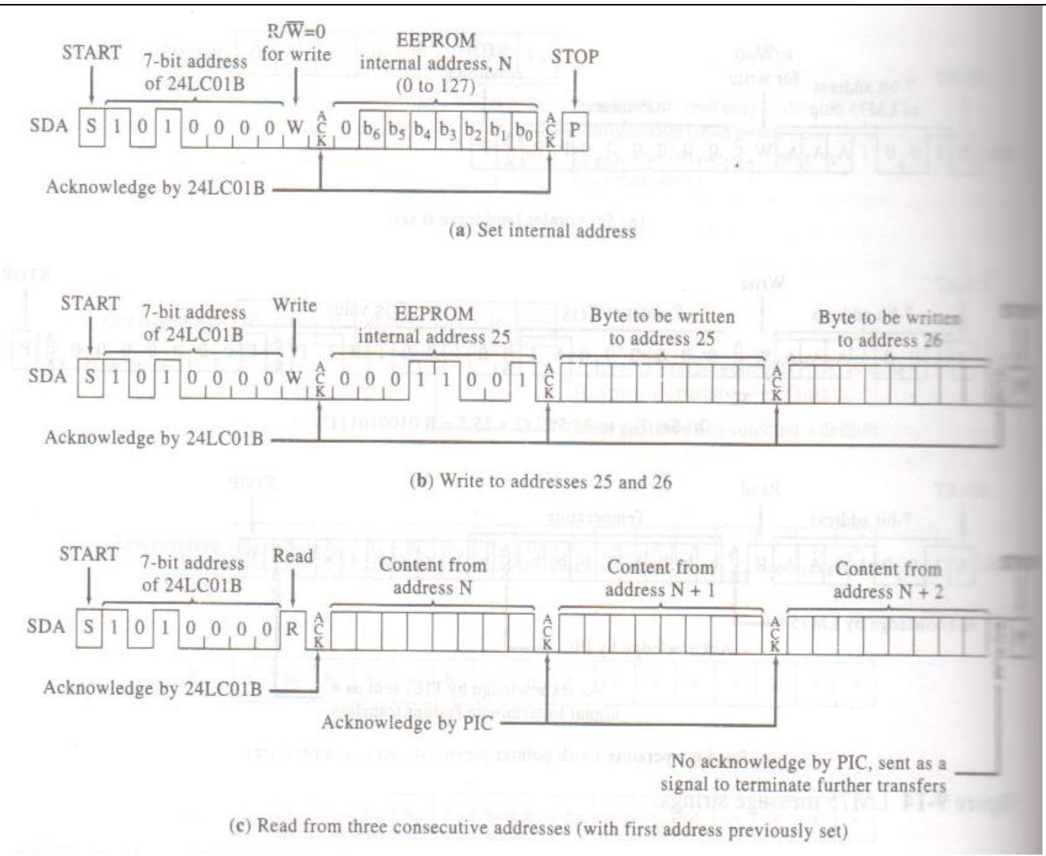


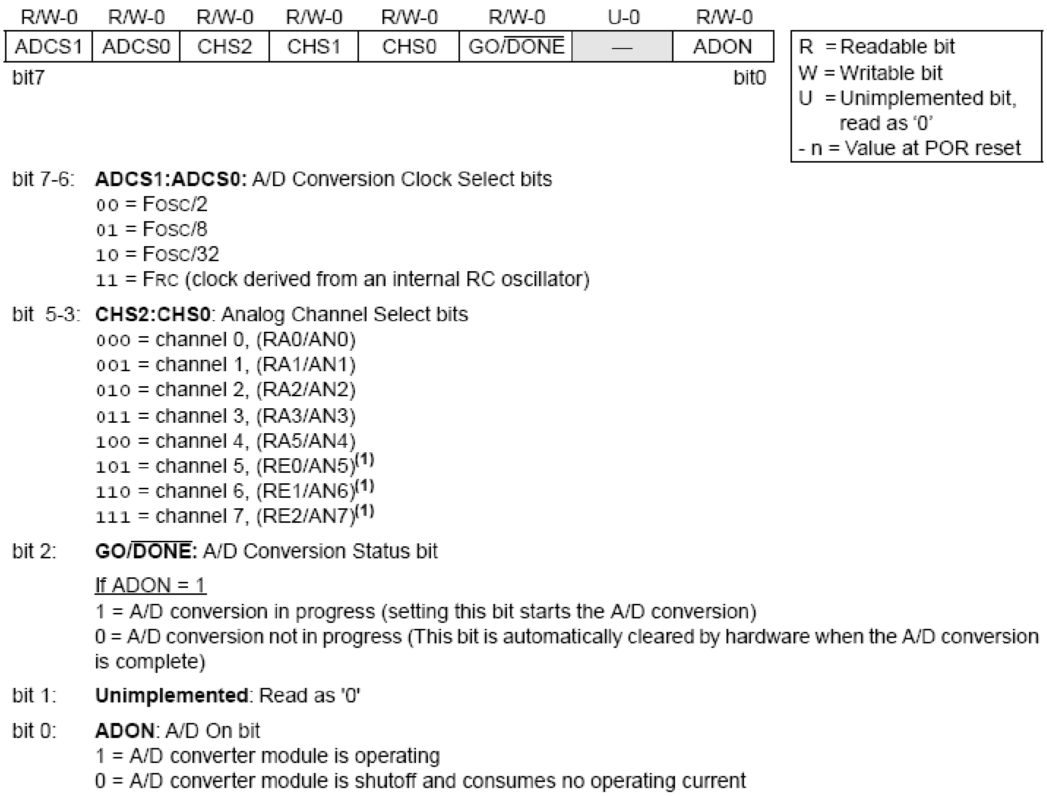
- **I^{2}C bus addressing: (2M)**



- **I^{2}C bus subroutine: (3M)**

	 General format to write to several peripheral internal registers or addresses.
3	**Explain the features and functional description of serial EEPROM with relevant diagram. (13M)** BTL1 **Answer: Page : 3.25- C. Ravichandran** - Write the features of serial EEPROM along with pin diagram (4M) 1. Single supply with operation done to 1.7V 2. Low-power CMOS Technology 3. 2-wire serial interface, I^{2}C - Block diagram & read & write operation sequence (9M) 

	 (a) Set internal address (b) Write to addresses 25 and 26 (c) Read from three consecutive addresses (with first address previously set)
4	**Explain the interfacing concept of external A/D converter with PIC 16CXX microcontroller. Also illustrate programming example and algorithm? (13M) or** **Draw and explain the architecture of on chip ADC of PIC microcontroller in detail and write a suitable assembly language program for configuration the ADC. (13M) (Nov'18)** BTL2 **Answer: Page : 3.37 - C. Ravichandran** • **A/D module registers (9M)** **1. A/D Result Registers** The ADRES register contains the result of the A/D conversion. When the A/D conversion is complete, the result is loaded into the ADRES register, the GO/DONE bit (ADCON0<2>) is cleared, and A/D interrupt flag bit ADIF is set. **2. A/D control registers 0**



R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7-6: **ADCS1:ADCS0:** A/D Conversion Clock Select bits
00 = Fosc/2
01 = Fosc/8
10 = Fosc/32
11 = FRC (clock derived from an internal RC oscillator)

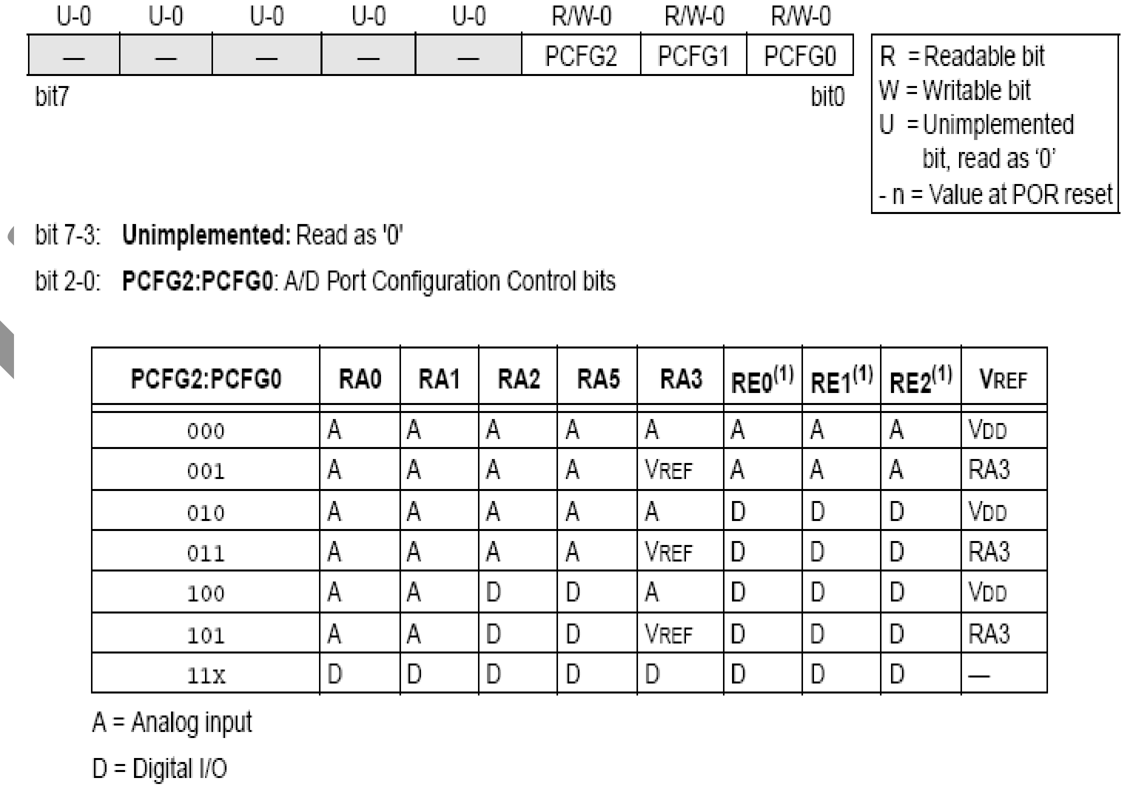
bit 5-3: **CHS2:CHS0**: Analog Channel Select bits
000 = channel 0, (RA0/AN0)
001 = channel 1, (RA1/AN1)
010 = channel 2, (RA2/AN2)
011 = channel 3, (RA3/AN3)
100 = channel 4, (RA5/AN4)
101 = channel 5, (RE0/AN5)(1)
110 = channel 6, (RE1/AN6)(1)
111 = channel 7, (RE2/AN7)(1)

bit 2: **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit
If ADON = 1
1 = A/D conversion in progress (setting this bit starts the A/D conversion)
0 = A/D conversion not in progress (This bit is automatically cleared by hardware when the A/D conversion is complete)

bit 1: **Unimplemented**: Read as '0'

bit 0: **ADON**: A/D On bit
1 = A/D converter module is operating
0 = A/D converter module is shutoff and consumes no operating current

3. A/D control registers 1



U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0
—	—	—	—	—	PCFG2	PCFG1	PCFG0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7-3: **Unimplemented:** Read as '0'

bit 2-0: **PCFG2:PCFG0**: A/D Port Configuration Control bits

PCFG2:PCFG0	RA0	RA1	RA2	RA5	RA3	RE0(1)	RE1(1)	RE2(1)	VREF
000	A	A	A	A	A	A	A	A	VDD
001	A	A	A	A	VREF	A	A	A	RA3
010	A	A	A	A	A	D	D	D	VDD
011	A	A	A	A	VREF	D	D	D	RA3
100	A	A	D	D	A	D	D	D	VDD
101	A	A	D	D	VREF	D	D	D	RA3
11x	D	D	D	D	D	D	D	D	—

A = Analog input

D = Digital I/O

- ADC Characteristics (4M)

1. Eight input channels

2. An analog multiplexer
3. Track and hold circuit for signal on selected input channel
4. Alternative clock sources carrying out conversion.
5. An adjustable autonomous sampling rate.
6. The choice of internal or external ref. voltage.
7. 8-bit conversion
8. Interrupt response when conversion completed.

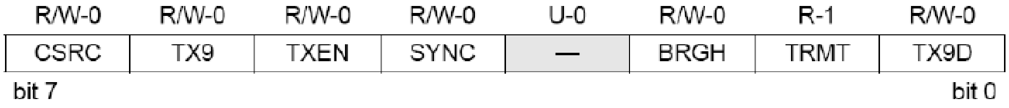
5

Describe about various UART initialization registers with neat configurations.(13M) or Briefly explain about UART in PIC microcontroller. (6M) (Nov'18) BTL1

Answer: Page : 3.60, 3.65- C. Ravichandran

- Draw the TRISC, SPBRG,TXSTA,RCSTA,PIR1,PIE1,INTCON Registers(6M)

TXSTA – TRANSMIT STATUS AND CONTROL REGISTER (ADDRESS: 98h)



R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0	R-1	R/W-0
CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D
bit 7							bit 0

CSRC: Clock Source Select bit (for Synchronous mode only)

TX9: 9-bit Transmit Enable bit

1 = Selects 9-bit transmission

0 = Selects 8-bit transmission

TXEN: Transmit Enable bit

1 = Transmit enabled

0 = Transmit disabled

SYNC: USART Mode Select bit

1 = Synchronous mode

0 = Asynchronous mode

BRGH: High Baud Rate Select bit (For Asynchronous mode only)

1 = High speed

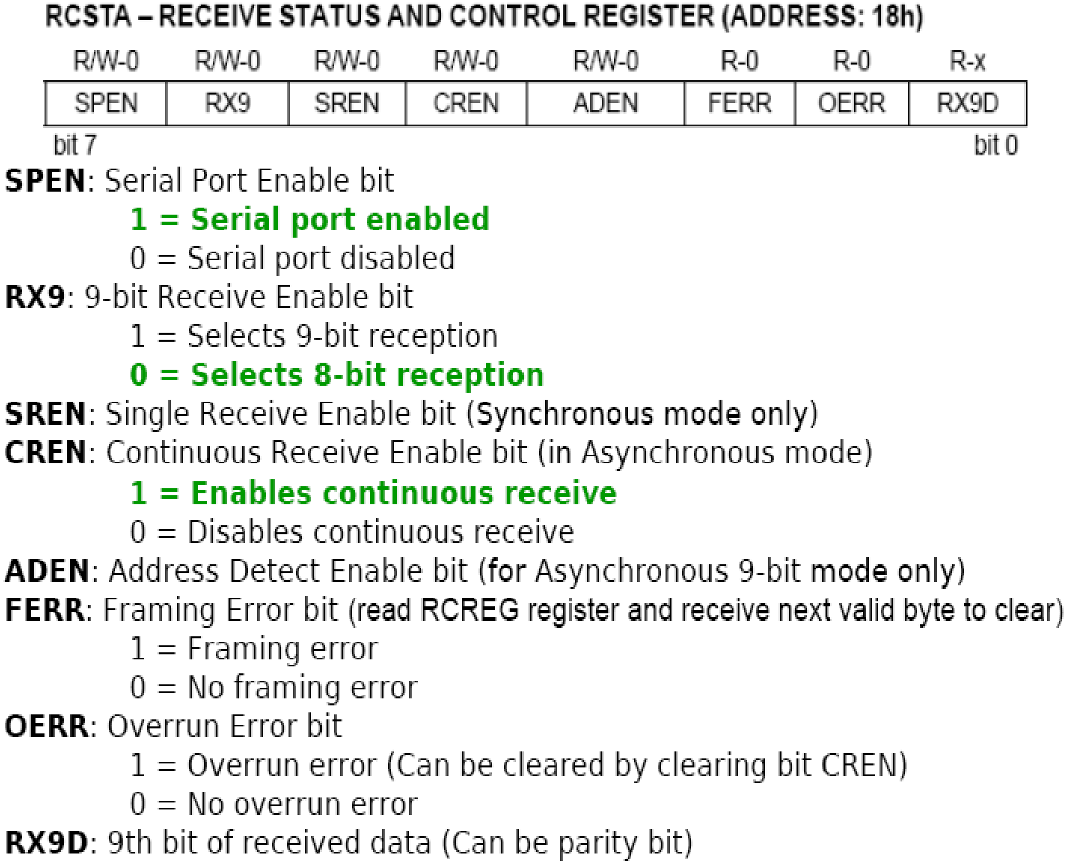
0 = Low speed

TRMT: Transmit Shift Register Status bit

1 = TSR empty

0 = TSR full

TX9D: 9th bit of transmit data. Can be parity bit.



RCSTA – RECEIVE STATUS AND CONTROL REGISTER (ADDRESS: 18h)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R-0	R-0	R-x
SPEN	RX9	SREN	CREN	ADEN	FERR	OERR	RX9D
bit 7							bit 0

SPEN: Serial Port Enable bit

1 = Serial port enabled

0 = Serial port disabled

RX9: 9-bit Receive Enable bit

1 = Selects 9-bit reception

0 = Selects 8-bit reception

SREN: Single Receive Enable bit (Synchronous mode only)

CREN: Continuous Receive Enable bit (in Asynchronous mode)

1 = Enables continuous receive

0 = Disables continuous receive

ADEN: Address Detect Enable bit (for Asynchronous 9-bit mode only)

FERR: Framing Error bit (read RCREG register and receive next valid byte to clear)

1 = Framing error

0 = No framing error

OERR: Overrun Error bit

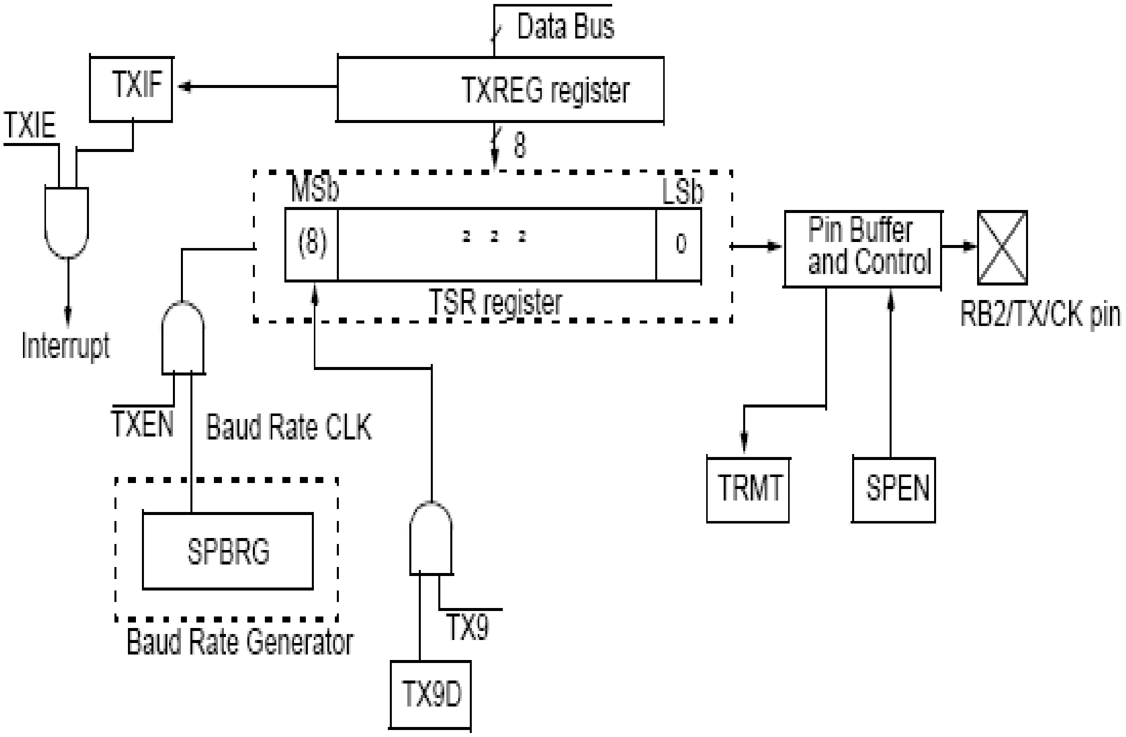
1 = Overrun error (Can be cleared by clearing bit CREN)

0 = No overrun error

RX9D: 9th bit of received data (Can be parity bit)

- UART Application (2M)

  It uses a RS-232 Motorola chip to translate between the 0V and +5V logic level signal swings on the PIC RX and TX pins
- PIC UART interface to a PC (5M)

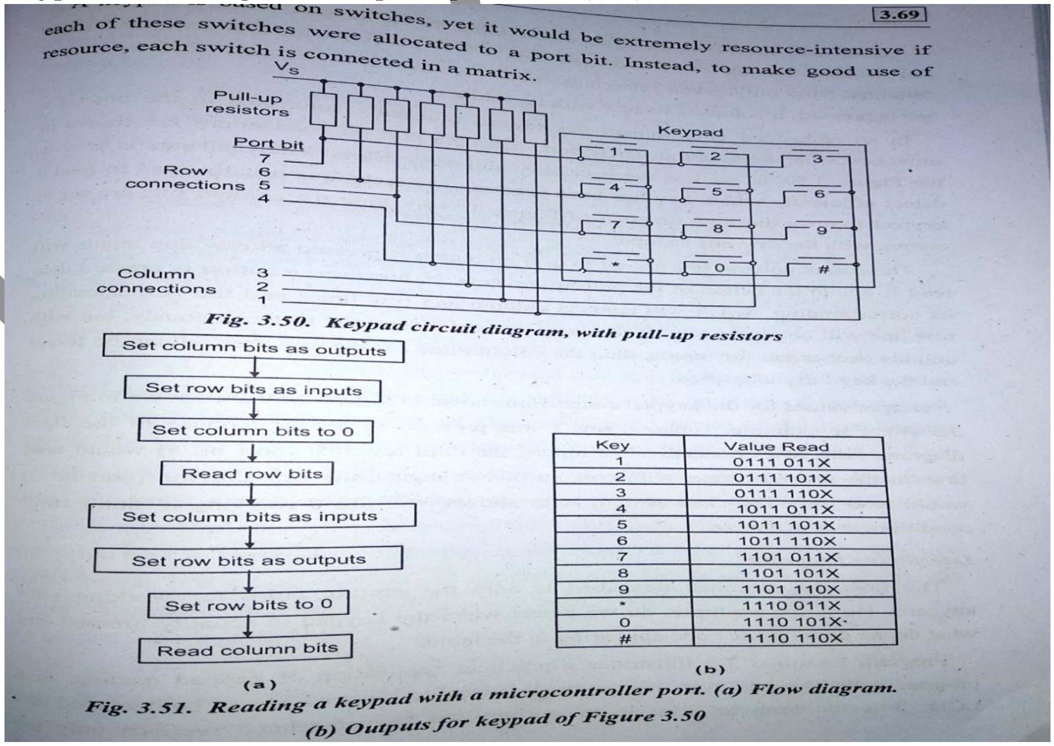


6

Explain the interfacing concepts of keyboard with PIC 16CXX microcontroller. Also illustrate programming examples, flowchart and algorithm. (13 M) BTL1

Answer: Page : 3.68 - C. Ravichandran

- Keypad circuit diagram with pull up resistors(5M)



3.69

sed on switches, yet it would be extremely resource-intensive if each of these switches were allocated to a port bit. Instead, to make good use of resource, each switch is connected in a matrix.

Fig. 3.50. Keypad circuit diagram, with pull-up resistors

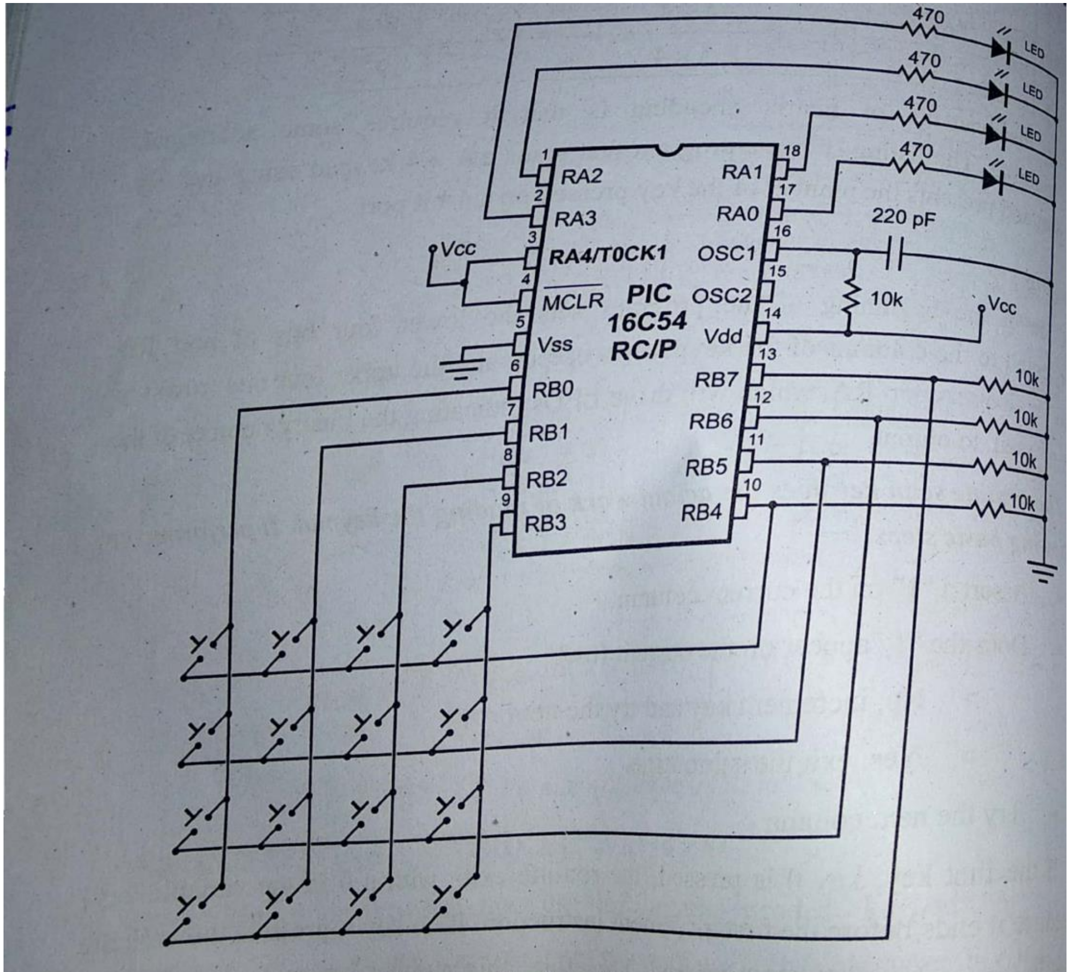
Set column bits as outputs
Set row bits as inputs
Set column bits to 0
Read row bits
Set column bits as inputs
Set row bits as outputs
Set row bits to 0
Read column bits

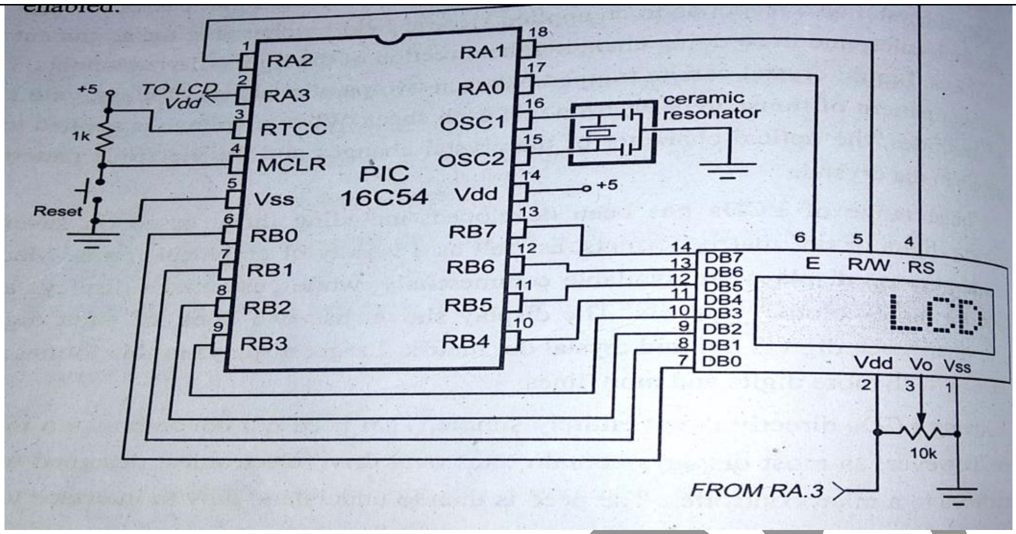
(a)

Key	Value Read
1	0111 011X
2	0111 101X
3	0111 110X
4	1011 011X
5	1011 101X
6	1011 110X
7	1101 011X
8	1101 101X
9	1101 110X
*	1110 011X
0	1110 101X
#	1110 110X

(b)

Fig. 3.51. Reading a keypad with a microcontroller port. (a) Flow diagram. (b) Outputs for keypad of Figure 3.50

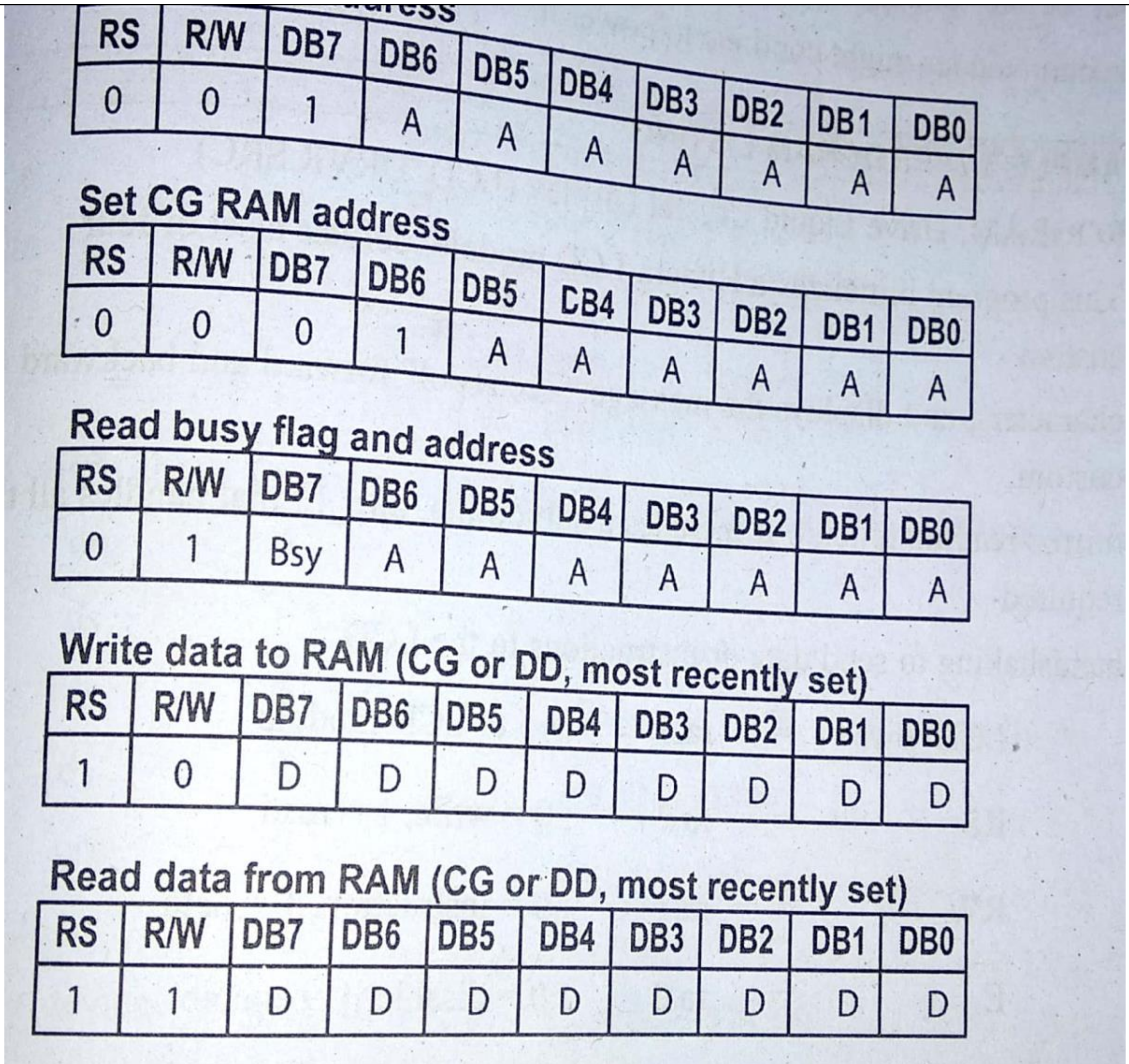
	- Write a program for test keypad, writing key pressed to LCD display(8M)  *Fig. 3.54. 4 × 4 keyboard interfacing using PIC*
7	**Explain the interfacing concept of LCD with PIC 16CXX microcontroller. Also illustrate programming example and algorithm. 13M (MAY 2019** BTL1 **Answer: Page: 3.81 - C. Ravichandran** - LCD Interfacing with PIC (4M)



- Write the control line functions (3M)

E	0 1	LCD DISABLED LCD ENABLED
R/W	0 1	WRITE TO LCD READ FROM LCD
RS	0 1	INSTRUCTIONS CHARACTERS/ BYTES

- Explain the commonly used memory operations (6M)



RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	A	A	A	A	A	A	A

Set CG RAM address

RS	R/W	DB7	DB6	DB5	CB4	DB3	DB2	DB1	DB0
0	0	0	1	A	A	A	A	A	A

Read busy flag and address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	Bsy	A	A	A	A	A	A	A

Write data to RAM (CG or DD, most recently set)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	D	D	D	D	D	D	D	D

Read data from RAM (CG or DD, most recently set)

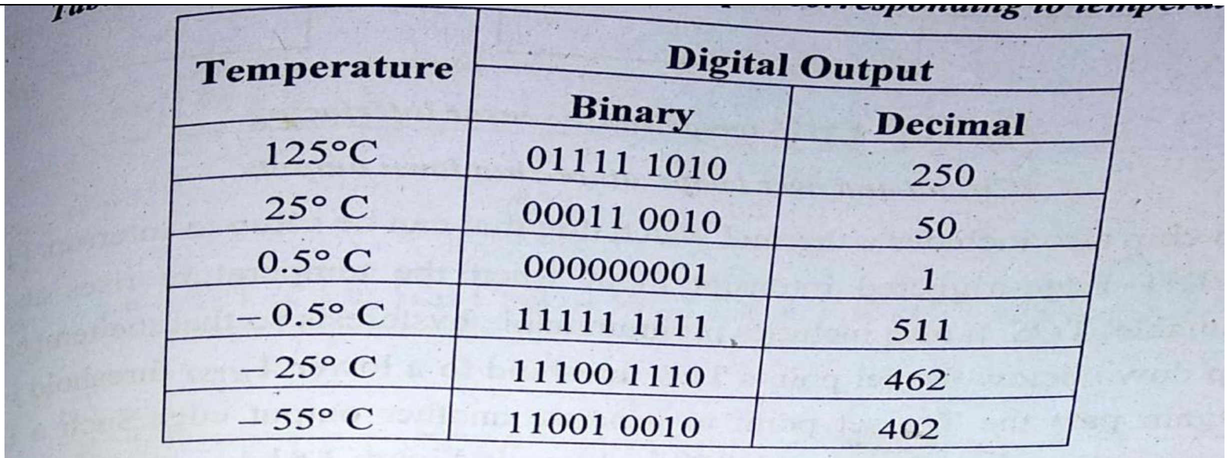
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	1	D	D	D	D	D	D	D	D

8

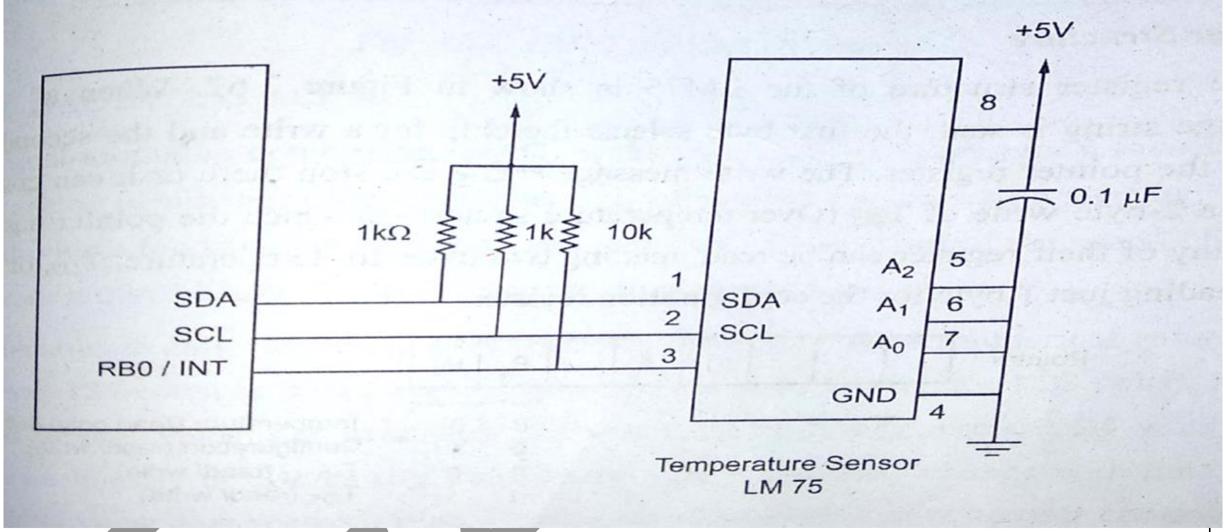
Explain the interfacing concept of sensor with PIC 16CXX microcontroller. (13M) (May 2019) BTL2

Answer:Page : 3.95 - C.Ravichandran

- Explain about light dependent resistors (6M)
    1. Light-dependent resistor (LDR) made from piece of exposed semiconductor material.
    2. Light falls on it, creates hole electron pairs material, improve the conductivity.
- Interfacing a temperature sensor (7M)



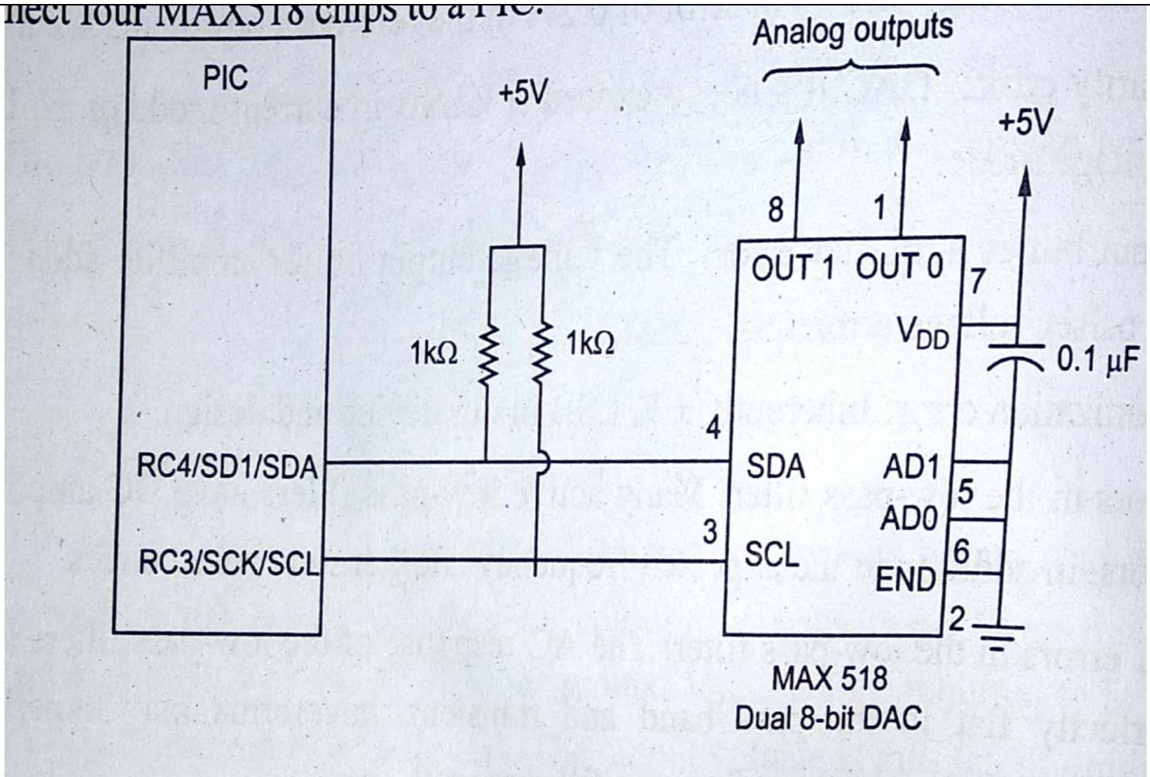
Temperature	Digital Output	
	Binary	Decimal
125°C	01111 1010	250
25° C	00011 0010	50
0.5° C	000000001	1
– 0.5° C	11111 1111	511
– 25° C	11100 1110	462
– 55° C	11001 0010	402



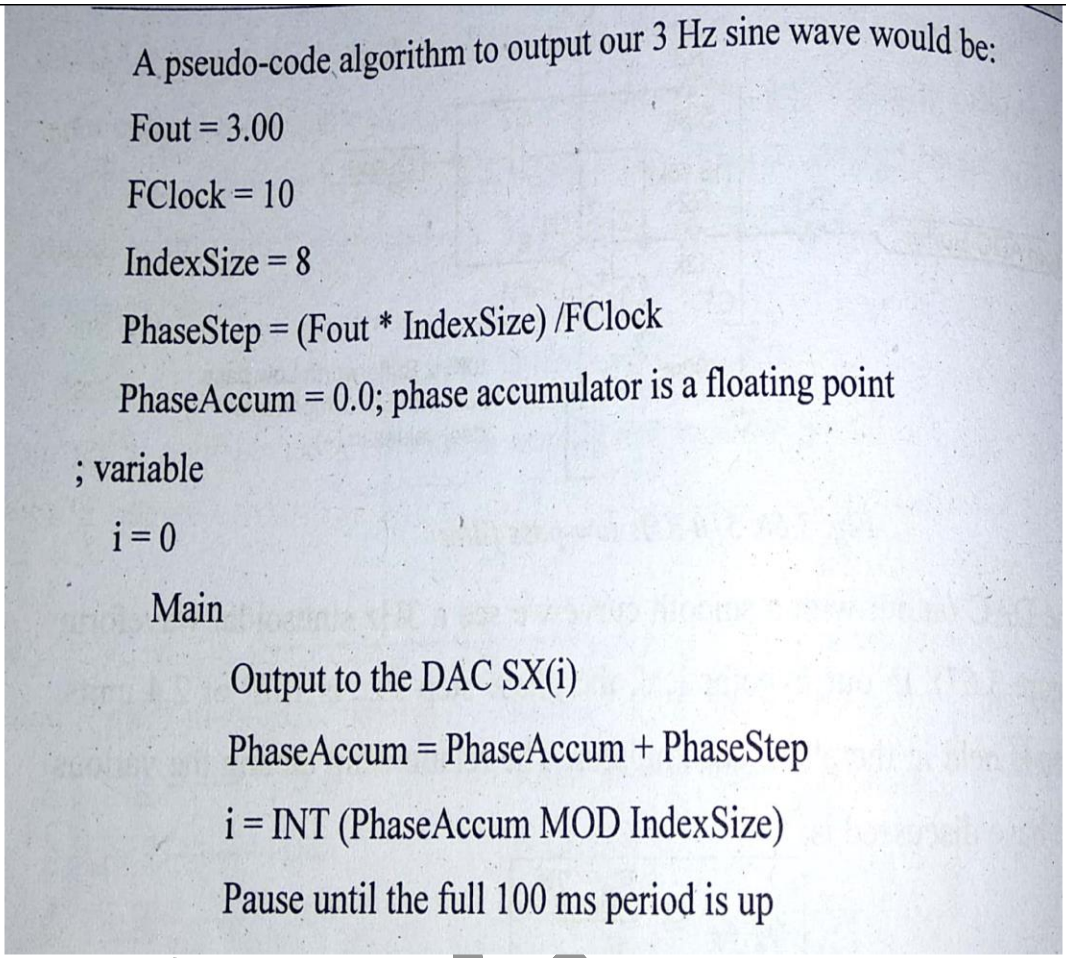
9 **Explain the interfacing concept of DAC with PIC 16CXX microcontroller. Also illustrate programming example and algorithm. 13M** BTL1

Answer: Page : 3.99 - C.Ravichandran

- Explain interfacing MAX518 DAC with PIC (7M)



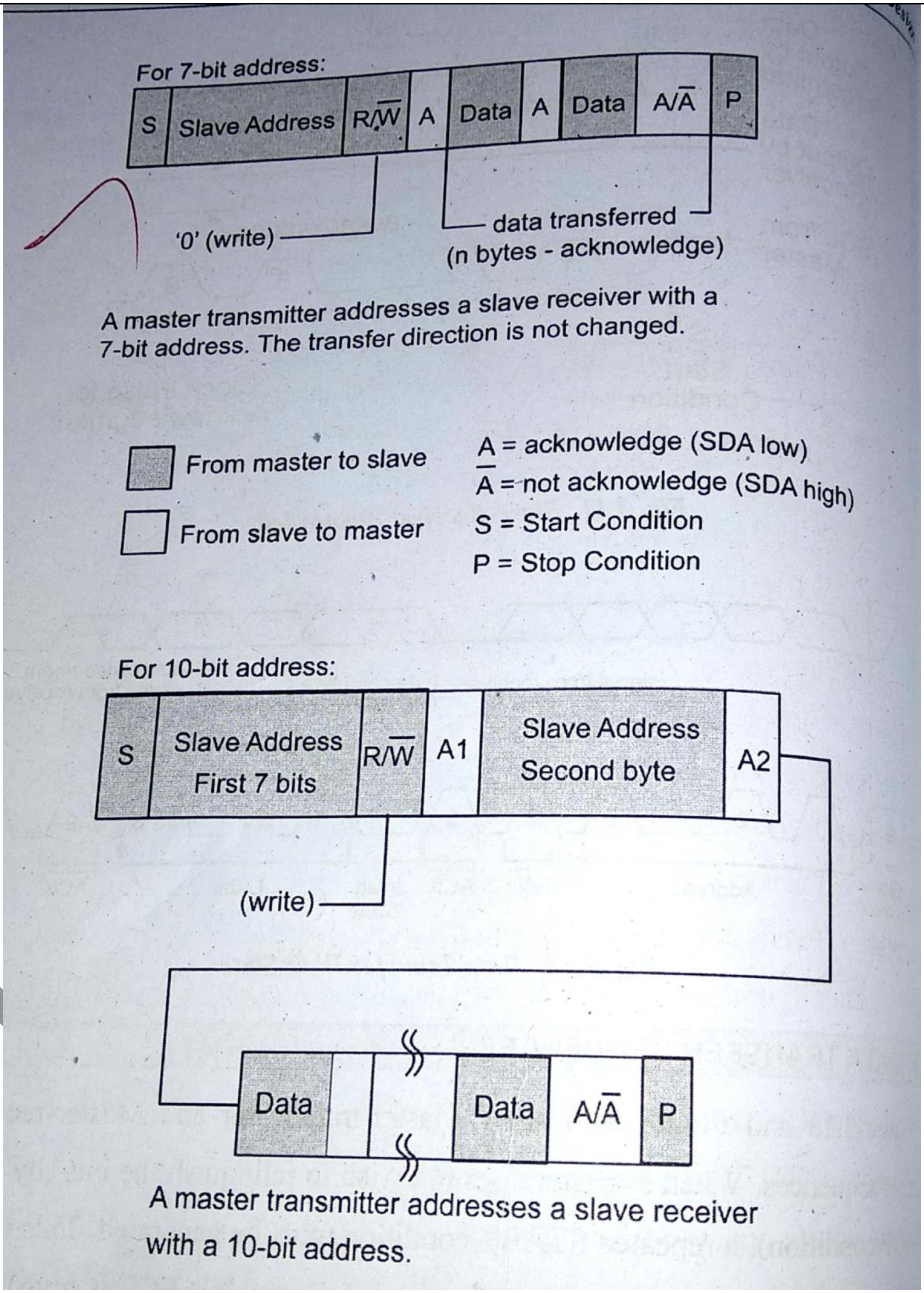
- Write a DAC program (6M)



A pseudo-code algorithm to output our 3 Hz sine wave would be:

```
Fout = 3.00
FClock = 10
IndexSize = 8
PhaseStep = (Fout * IndexSize) /FClock
PhaseAccum = 0.0; phase accumulator is a floating point
; variable
i = 0
Main
    Output to the DAC SX(i)
    PhaseAccum = PhaseAccum + PhaseStep
    i = INT (PhaseAccum MOD IndexSize)
    Pause until the full 100 ms period is up
```

10	**Explain about the data handling circuit in transmitter and receiver modes of operation with neat schematic. 13 M** BTL2 **Answer: Page : 3.13 - C.Ravichandran** • Draw & explain the master – transmitter sequence **(**4M)



A master transmitter addresses a slave receiver with a 7-bit address. The transfer direction is not changed.

▨ From master to slave

☐ From slave to master

A = acknowledge (SDA low)

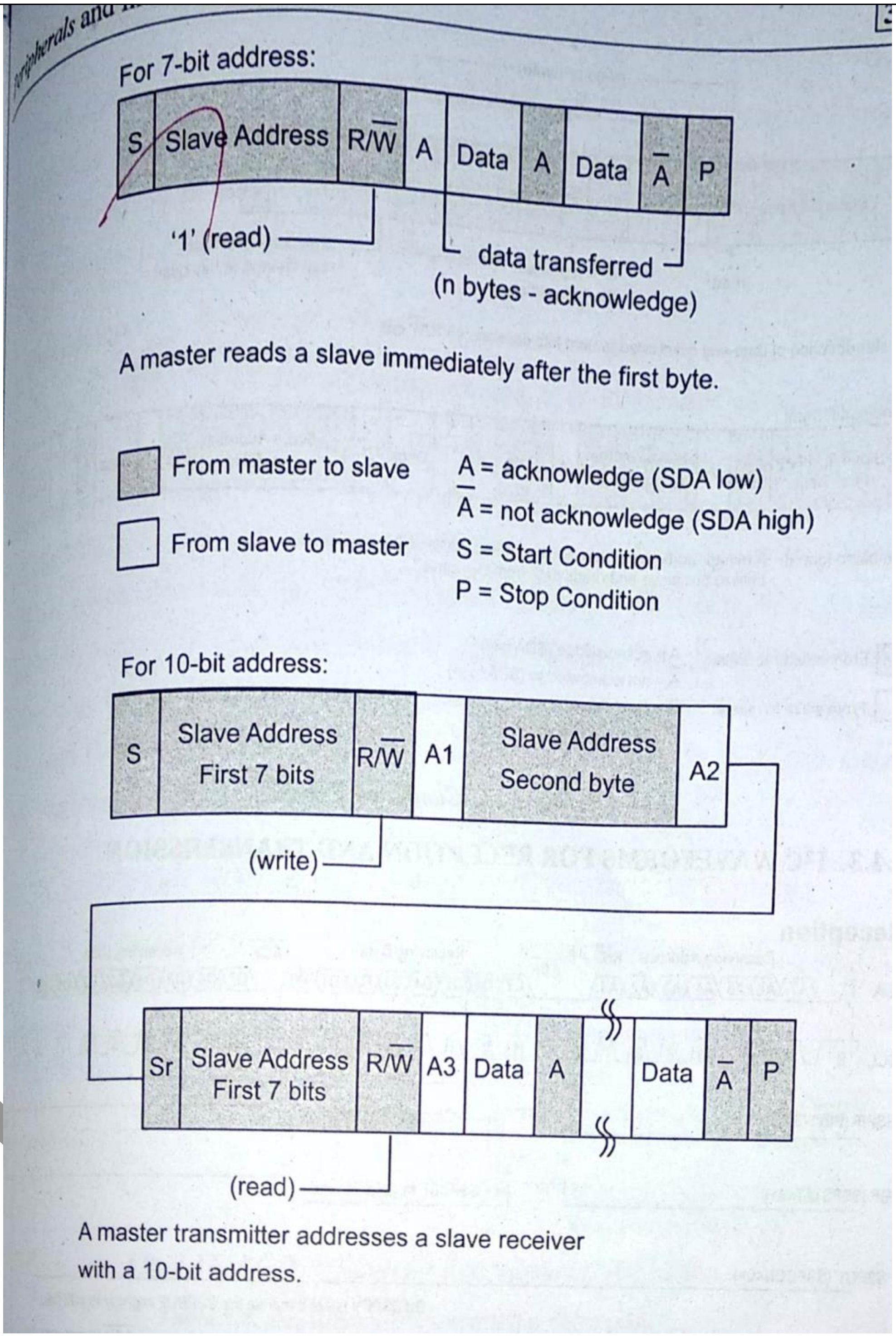
$\overline{A}$ = not acknowledge (SDA high)

S = Start Condition

P = Stop Condition

A master transmitter addresses a slave receiver with a 10-bit address.

- Draw & explain the master – receiver sequence (4M)



A master reads a slave immediately after the first byte.

▨ From master to slave

☐ From slave to master

A = acknowledge (SDA low)

$\overline{A}$ = not acknowledge (SDA high)

S = Start Condition

P = Stop Condition

A master transmitter addresses a slave receiver with a 10-bit address.

- Explain about combined format of transmitter and receiver (5M)

Part-C

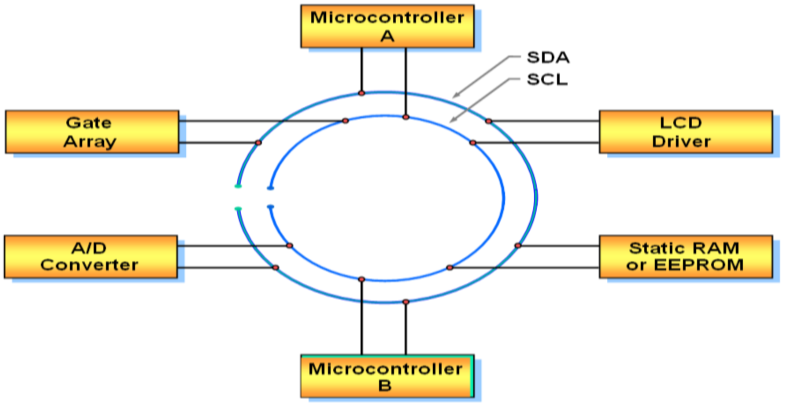
1

Explain the features of I^{2}C bus operation for peripheral chip access. (15M) (June '12) BTL1

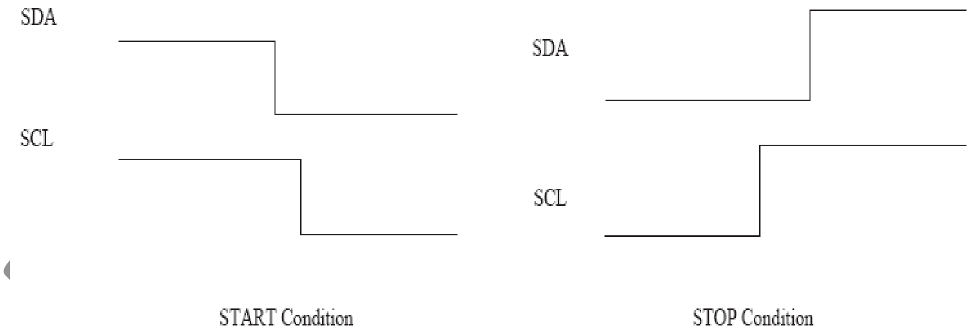
Answer: Page : 3.6 - C.Ravichandran

- Define I^{2}C bus , master and slave working (8M)
  1. I^{2}C bus is a two wire serial interface
  2. Developed by Philips corporation.

3. The original specification or standard mode, for data transfer of up to 100 kbps.



- **Master:**
    1. Initiates a transfer by generating start and stop conditions
    2. Generates the clock
    3. Transmits the slave address
    4. Determines data transfer direction
- **Slave:**
    1. Responds only when addressed
    2. Timing is controlled by the clock line
- Features of I^2C bus with start and stop conditions timing diagram.(7M)

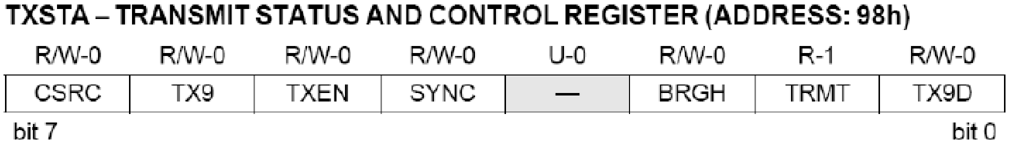


1. A peripheral chip address and a read/ write bit designating that the peripheral chip is to read successive bytes.
2. Internal registers of peripheral or address byte.

2 **Describe about various UART initialization registers with neat configurations. (15M)** BTL2

Answer: Page : 3.60, 3.65 - C.Ravichandran

- Draw the TRISC, SPBRG,TXSTA,RCSTA,PIR1,PIE1,INTCON Registers(6M)



TXSTA – TRANSMIT STATUS AND CONTROL REGISTER (ADDRESS: 98h)

R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0	R-1	R/W-0
CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D
bit 7							bit 0

CSRC: Clock Source Select bit (for Synchronous mode only)

TX9: 9-bit Transmit Enable bit

1 = Selects 9-bit transmission

0 = Selects 8-bit transmission

TXEN: Transmit Enable bit

1 = Transmit enabled

0 = Transmit disabled

SYNC: USART Mode Select bit

1 = Synchronous mode

0 = Asynchronous mode

BRGH: High Baud Rate Select bit (For Asynchronous mode only)

1 = High speed

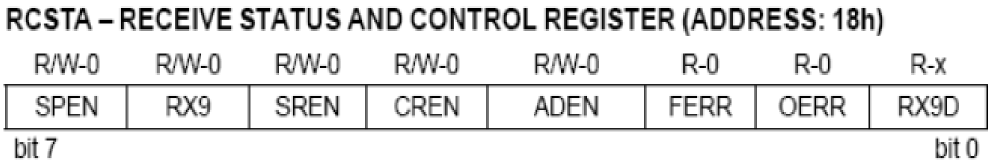
0 = Low speed

TRMT: Transmit Shift Register Status bit

1 = TSR empty

0 = TSR full

TX9D: 9th bit of transmit data. Can be parity bit.



RCSTA – RECEIVE STATUS AND CONTROL REGISTER (ADDRESS: 18h)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R-0	R-0	R-x
SPEN	RX9	SREN	CREN	ADEN	FERR	OERR	RX9D
bit 7							bit 0

SPEN: Serial Port Enable bit

1 = Serial port enabled

0 = Serial port disabled

RX9: 9-bit Receive Enable bit

1 = Selects 9-bit reception

0 = Selects 8-bit reception

SREN: Single Receive Enable bit (Synchronous mode only)

CREN: Continuous Receive Enable bit (in Asynchronous mode)

1 = Enables continuous receive

0 = Disables continuous receive

ADEN: Address Detect Enable bit (for Asynchronous 9-bit mode only)

FERR: Framing Error bit (read RCREG register and receive next valid byte to clear)

1 = Framing error

0 = No framing error

OERR: Overrun Error bit

1 = Overrun error (Can be cleared by clearing bit CREN)

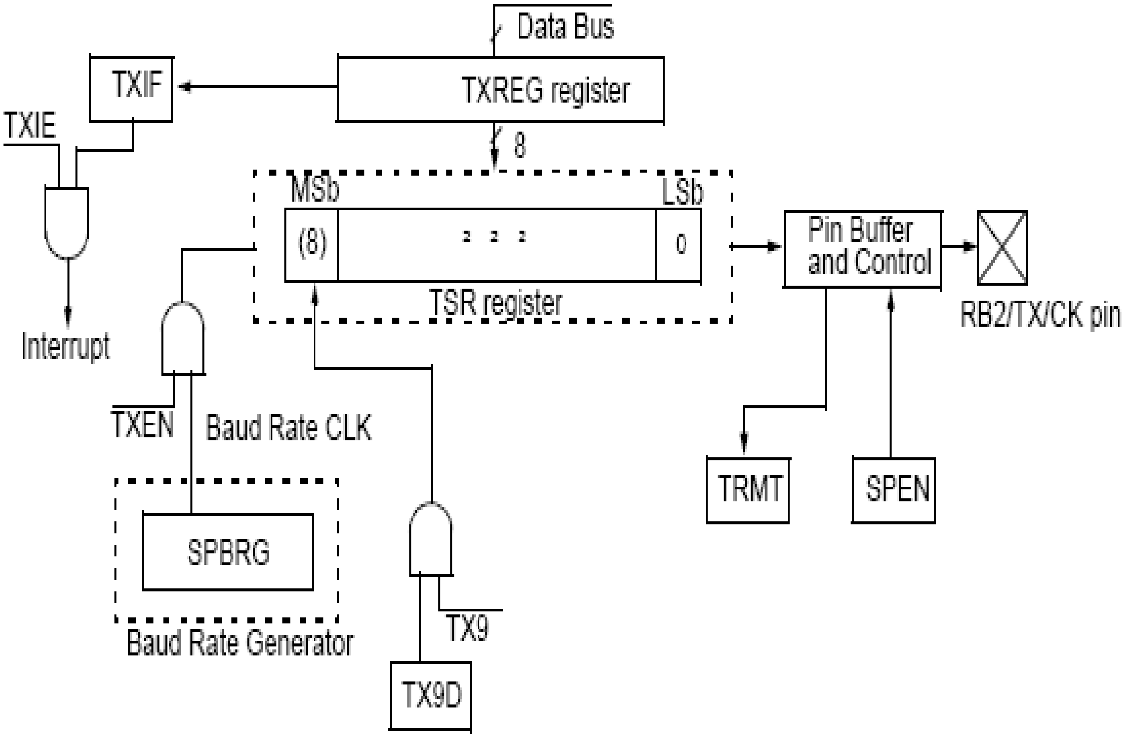
0 = No overrun error

RX9D: 9th bit of received data (Can be parity bit)

- UART Application (2M)

1. It uses RS-232 Motorola chip to translate between the 0V and +5V logic level signal swings on the PIC RX and TX pins

- PIC UART interface to a PC (7M)

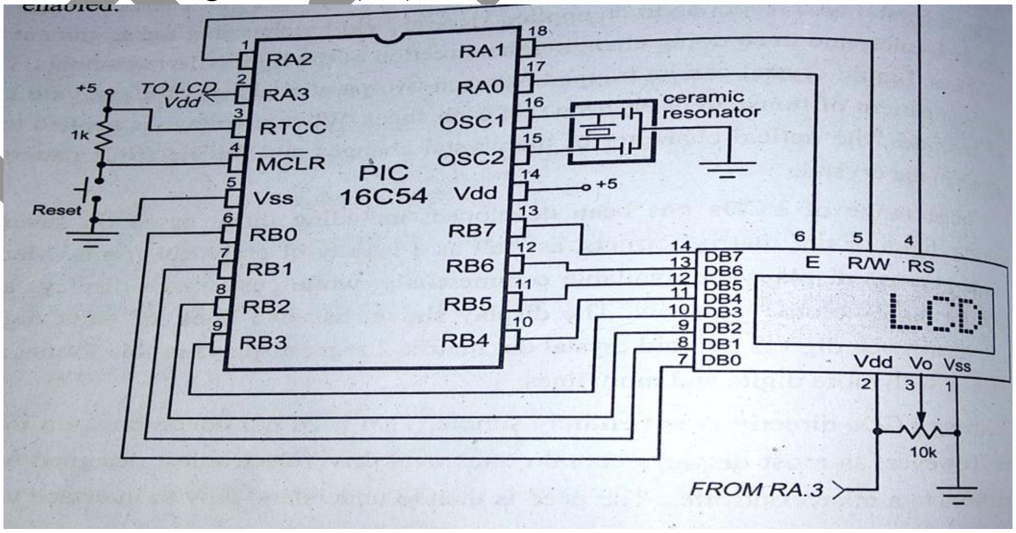


3

Explain the interfacing concept of LCD with PIC 16CXX microcontroller. Also illustrate programming example and algorithm. (15M) (May 2019) BTL4

Answer: Page : 3.89 - C.Ravichandran

- LCD Interfacing with PIC (4M)

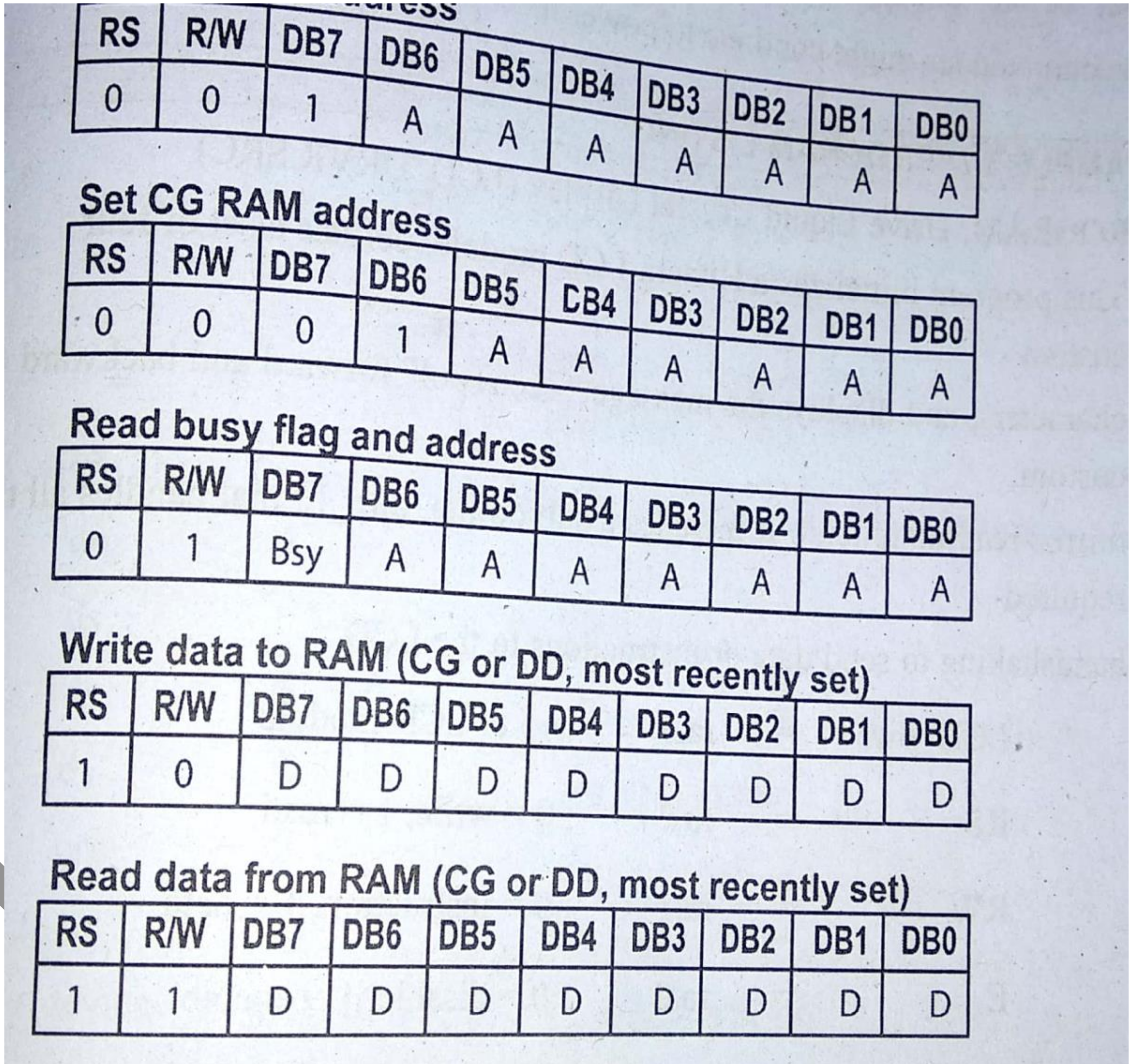


- Write the control line functions (3M)

E	0 1	LCD DISABLED LCD ENABLED
R/W	0	WRITE TO LCD

	1	READ FROM LCD
RS	0 1	INSTRUCTIONS CHARACTERS/ BYTES

- Explain the commonly used memory operations (8M)



RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	A	A	A	A	A	A	A

Set CG RAM address

RS	R/W	DB7	DB6	DB5	CB4	DB3	DB2	DB1	DB0
0	0	0	1	A	A	A	A	A	A

Read busy flag and address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	Bsy	A	A	A	A	A	A	A

Write data to RAM (CG or DD, most recently set)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	D	D	D	D	D	D	D	D

Read data from RAM (CG or DD, most recently set)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	1	D	D	D	D	D	D	D	D

UNIT IV - INTRODUCTION TO ARM PROCESSOR

ARM Architecture –ARM programmer’s model –ARM Development tools- Memory Hierarchy –ARM Assembly Language Programming–Simple Examples–Architectural Support for Operating systems.

Q.No.	Part*A
1.	**What is ARM Processor?** (BTL1) - An ARM processor is one of a family of CPUs based on the RISC(Reduced instruction set computer) architecture developed Advanced RISC machine (ARM). - Arm makes 32-bit and 64-bit risc multi-core processor. - Risc processor designed to perform a smaller number of types of computer instructions so they can operate at a higher speed, performing more millions of instructions per second (MIPS)
2	**What are the features of ARM processor?** (BTL1) - Load/ store architecture - An orthogonal instrument set - Mostly single cycle execution - Enhanced power saving design - 64 & 32 bit execution states for scalable high performance.
3	**Write the applications of ARM processor?** (BTL1) Arm processors are extensively used in consumer electronic, devices such as smartphones, tablets, multimedia players and other mobile devices, such as wearables. Because of their reduced instruction set, they require fewer transistors, which enables a smaller die size for the integrated circuitry(IC).
4	**What is meant by pipelining? (Apr’17)** (BTL1) To improve the utilization of the hardware resources, and also the processor throughout, would be start the next instruction before the current one has finished. This technique is called pipelining.
5	**What are the performance and drawbacks of Risc?** (BTL4) - Pipelining, a high clock rate with single cycle execution-3 Mhz for random accesses and 6 Mhz for sequencial accesses. - Drawbacks: 1. Risc generally have poor code density compared with CISCs 2. Riscs don’t execute x86 code 3. It is hard to fix, though pc emulation software is available for many RISC platforms.
6	**What is a software development tool of ARM processor?** (BTL2) The arm is supported by a toolkit which includes an instruction set emulator for hardware modeling and software testing and benchmarking, an assembler, c and c++ compliers, a linker and a symbolic debugger.
7	**Write two examples of RISC architecture.** (BTL2**)** 1. Berkeley RISC I & II 2. standard MIPS
8	**What are the registers of ARM processor?** (BTL1) User level program: The 15 general purpose 32-bit registers (r0 to r14) , the program counter (r15) and the current program status register (cpsr) and the remaining registers are used only for system level programs.

9	**What are the three categories of arm instruction?** (BTL1) • Data processing instruction • Data transfer instruction • Control flow instruction
10	**What is the function of assembler? (NOV'14)** (BTL1) The arm assembler is a full assembler which produces arm object format output that can be linked with output from the compiler.
11	**What is the function of linker?** (BTL1) The linker takes one or more object files and combines them into and executable program. It resolves symbolic references between the object files and extracts object modules from libraries as needed by the program.
12	**Write about ARMsd. (Apr'13)** (BTL1) The ARM symbolic debugger is a front end interface to assist in debugging programs running either under emulation (on the ArMulator) or remotely on a target system such as the ARM development board.
13	**What is meant by ARMulator? And list the various levels of accuracy.** (BTL2) The ARMulator (ARM emulator) is a suite of programs that models the behaviour of various ARM processor core in software on a host system. • Instruction accurate • Cycle accurate • Timing accurate
14	**List the various instruction set of ARM Processor.** (BTL1) a) arithmetic operations b) Bitwise logical operations c) Register movement operations (Data transfer) d) comparison operations e) shift register operations
15	**What are the four formats of stack?** (BTL4) • Full ascending • Empty ascending • Full descending • Empty descending
16	**What are the advantages of on-chip RAM?** (BTL2) It enables the processor to allocate space in it using knowledge of the future processing load.
17	**Define cache miss and cache hit. (Jan/Nov'13)** (BTL2) An access to the memory item which is not in the cache memory is called cache miss. An access to the memory item which is in the cache memory is called **cache hit.** The proportion of all the memory accesses that are satisfied by the cache is the cache hit rate and the proportions that are not the **miss rate.**
18	**What are the types of cache memory organization?** (BTL2) • Direct mapped • Two way set associative • Fully associative
19	**What are the principles of memory management?** (BTL2)

- Segmentation- it allows a program to have its own private view of memory and to coexist transparently with other programs in the same memory space.
- Paging: Most processor incorporate a memory mapping scheme based on fixed-size chunks of memory called pages.

20 **Give details about memory hierarchy.** (BTL2)

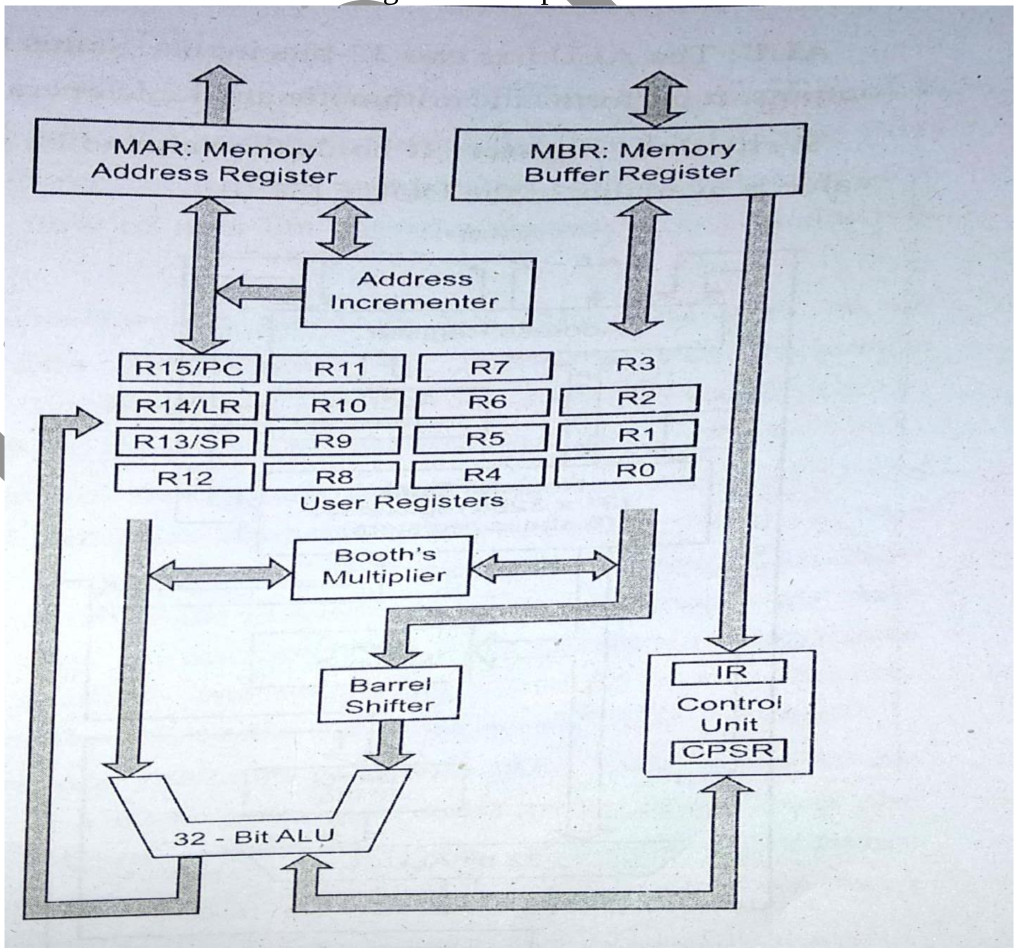
a) processor registers : 100 bytes, 1 ns
b) on-chip cache or RAM : 10 kbytes, 5ns
c) off-chip ROM and RAM : Mbytes, 50ns
d) backup store : Gbytes, 5ms.

Part*B

1 **Explain in detail the functional block diagram of ARM architecture.(13M)(Nov'18) (May'19)** BTL1

Answer: Page : 4.10 - C. Ravichandran

- Write the features of arm processor. (4M)
  1. Load/store architecture
  2. An orthogonal instruction set
  3. Mostly single-cycle execution
  4. Enhanced power-saving design
  5. 64 and 32bit execution states for scalable high performance
- Draw the arm architecture diagram and explain each blocks (9M)



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Explain in detail about ARM development tools. (13M) (Nov/Jul’16) BTL1

Answer: Page : 4.29 - C. Ravichandran

- Draw the overall structure of arm cross-development tools (7M)

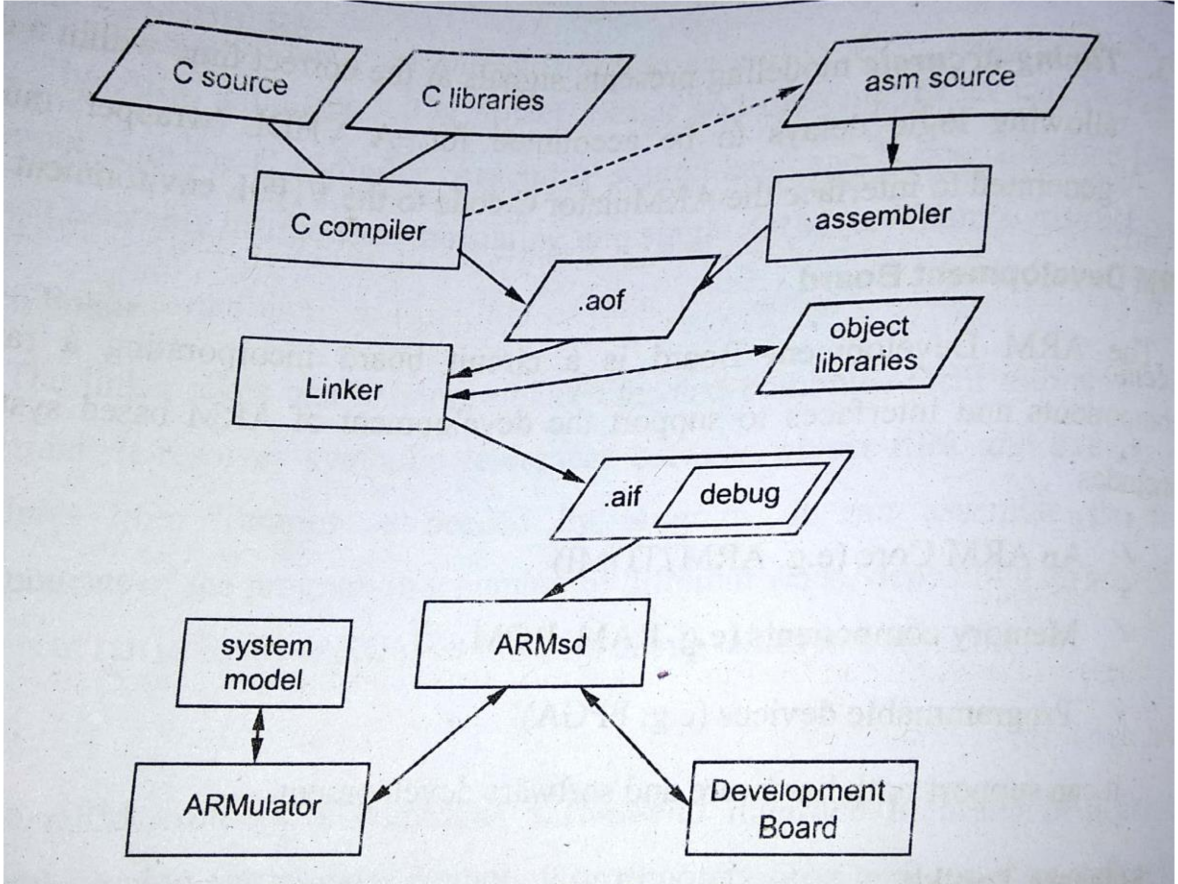

Fig. 4.11. Overall Structure of the ARM Cross-Development Toolkit

- Explain each blocks with example (6M)
    1. ARM Assembler
    2. The linker
    3. ARMsd
    4. ARMulator

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<tr>
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<td>

Explain in detail about Instruction set of ARM processor. (13M) (May’19) BTL1

Answer: Page : 4.26 - C. Ravichandran

- Classification of instruction set (5M)
- Branch instructions
- Data-processing instructions
- Status register transfer instructions
- Load and store instructions
- Coprocessor instructions
- Exception – generating instructions
- Explain in detail about each instruction with example (8M)

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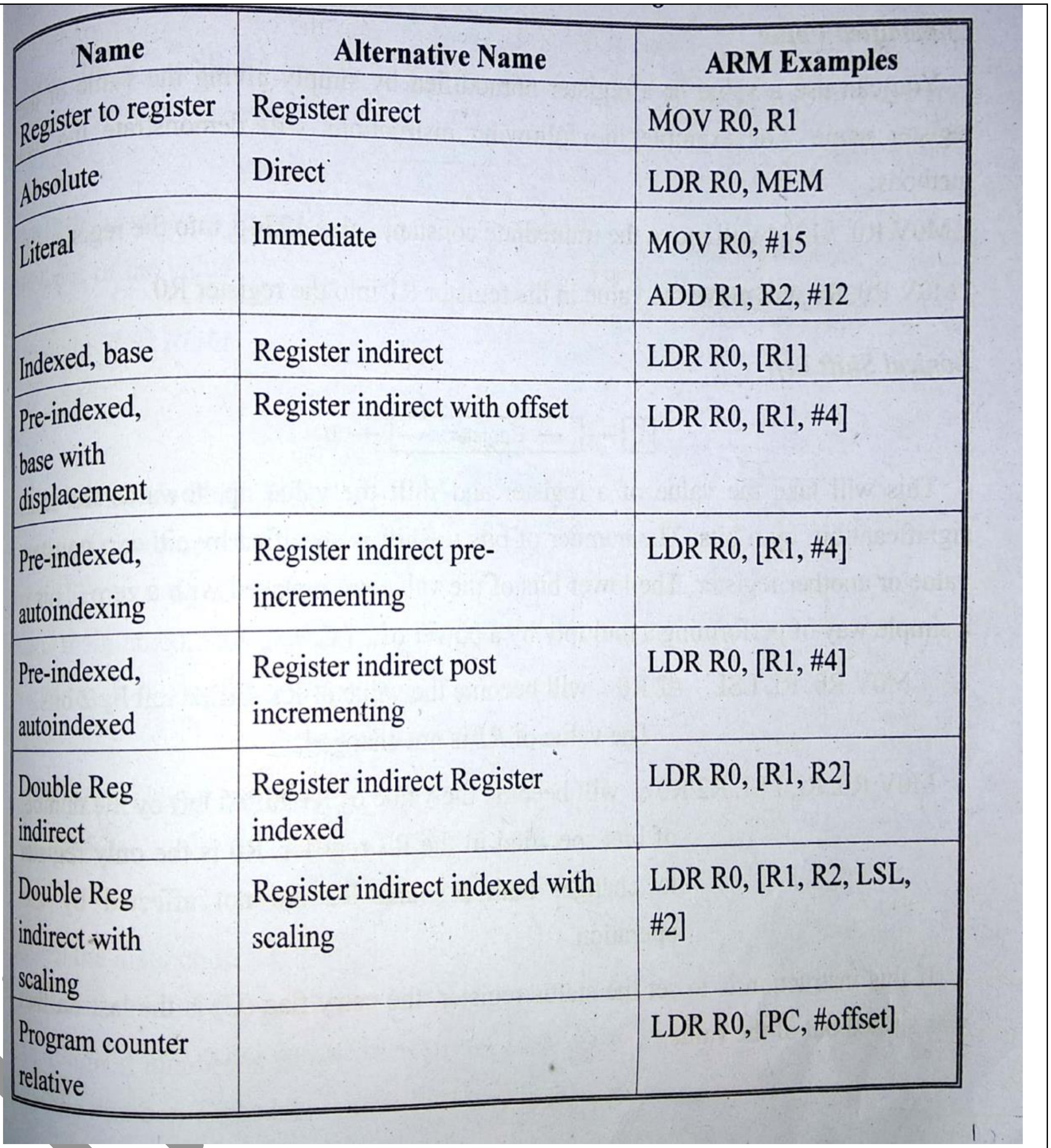

Name	Alternative Name	ARM Examples
Register to register	Register direct	MOV R0, R1
Absolute	Direct	LDR R0, MEM
Literal	Immediate	MOV R0, #15 ADD R1, R2, #12
Indexed, base	Register indirect	LDR R0, [R1]
Pre-indexed, base with displacement	Register indirect with offset	LDR R0, [R1, #4]
Pre-indexed, autoindexing	Register indirect pre-incrementing	LDR R0, [R1, #4]
Pre-indexed, autoindexed	Register indirect post incrementing	LDR R0, [R1, #4]
Double Reg indirect	Register indirect Register indexed	LDR R0, [R1, R2]
Double Reg indirect with scaling	Register indirect indexed with scaling	LDR R0, [R1, R2, LSL, #2]
Program counter relative		LDR R0, [PC, #offset]

4

Describe the various operating characteristics of arm programmer's model. (13M) (Jan'14) or Briefly explain ARM programmer's model.(13M)(Nov-18) BTL2

Answer: Page : 4.17 - C. Ravichandran

- Registers available in user mode (4M)
- Explain about RISC & CISC (4M)
  <u>RISC features:</u>
- A large uniform file
- Simple addressing modes, with all load/store addresses being determined from registers contents and instruction fields only.
- Draw the structure of CPSR(current program status register) (5M)

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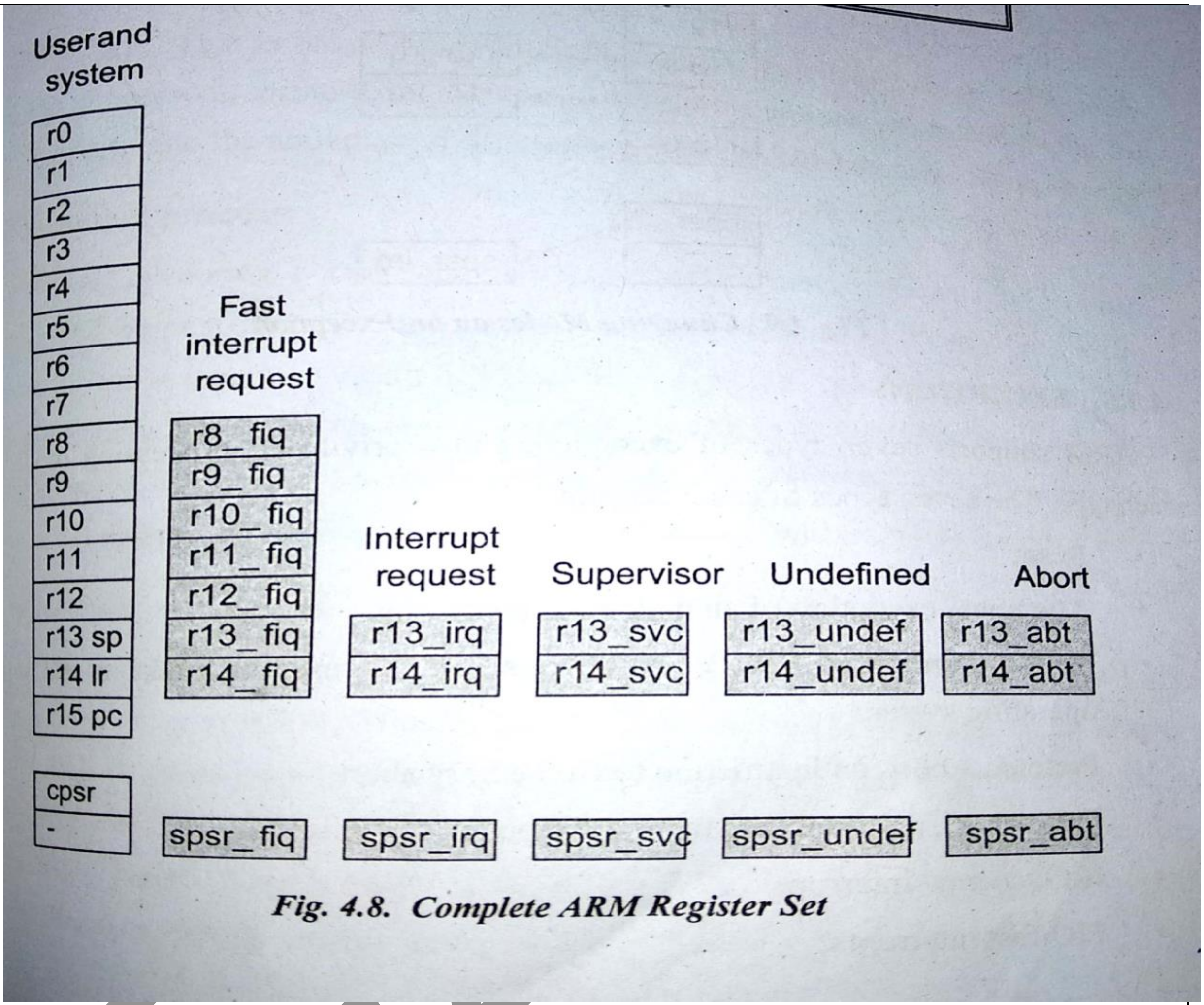
<tr><td></td><td>

<i>Fig. 4.8. Complete ARM Register Set</i></td></tr>
<tr><td>5</td><td>Explain the various addressing modes used in ARM processor with examples.(13M) (NOV’15)
BTL1
Answer: Page : 4.43 - C. Ravichandran

Explain types of addressing modes, and explain each with an example (13M)
Data processing operands
Memory access operands
Offset addressing
Pre-index addressing
Post index addressing
</td></tr>
<tr><td>6</td><td>Explain in detail about ARM MMUU architecture. (13M) BTL1
Answer: Page : 4.88 - C. Ravichandran

➢ Draw the flow chart access permission checking scheme (5M)
</td></tr>
</table>

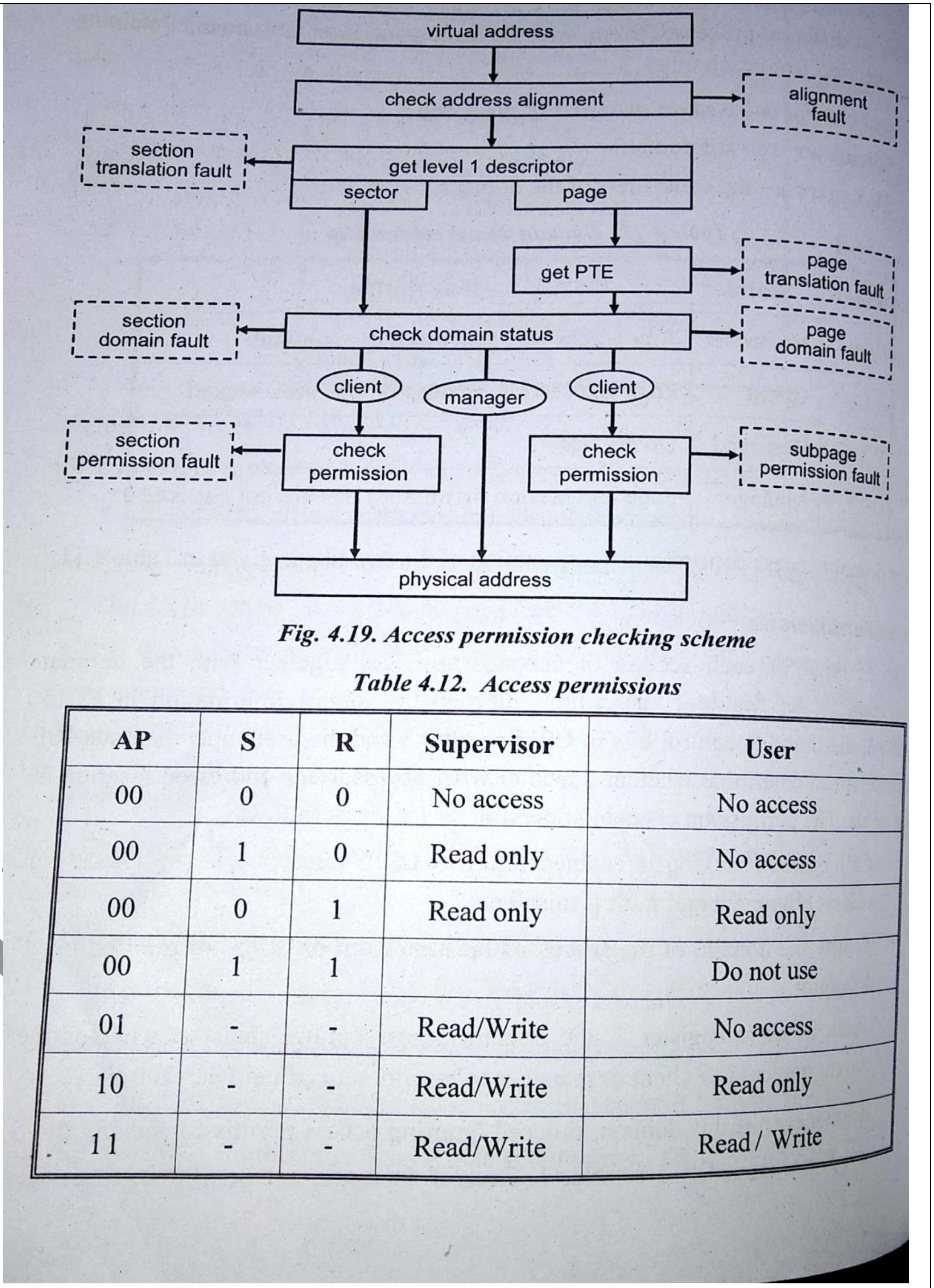


Fig. 4.19. Access permission checking scheme

Table 4.12. Access permissions

AP	S	R	Supervisor	User
00	0	0	No access	No access
00	1	0	Read only	No access
00	0	1	Read only	Read only
00	1	1		Do not use
01	-	-	Read/Write	No access
10	-	-	Read/Write	Read only
11	-	-	Read/Write	Read / Write

- Explain about synchronization, mutual exclusion, swap & content switching (8M)

1. Mutually exclusive access to the data structure

2. Process to perform operation on shared data structure

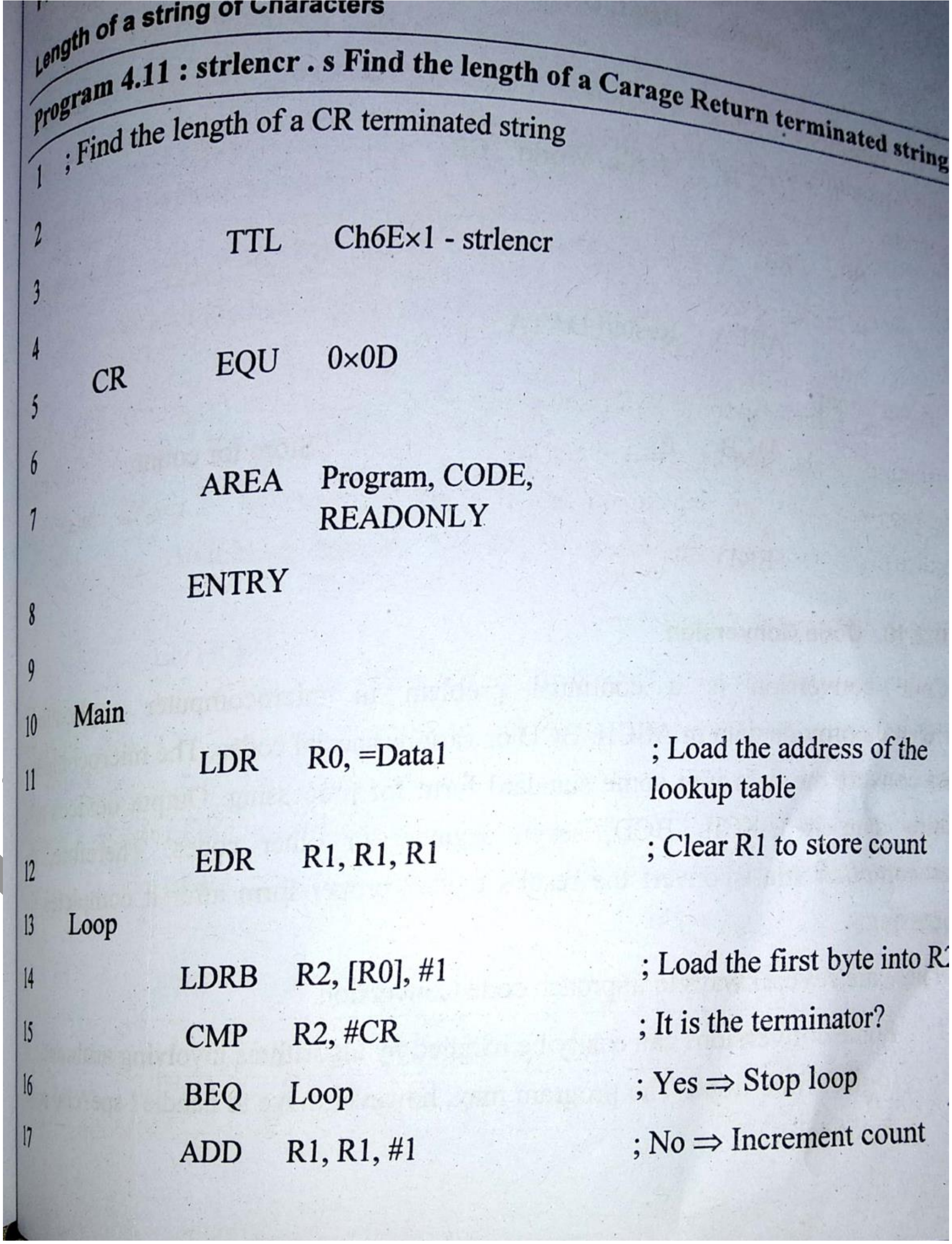
3. More convenient solution to use an atomic ‘ test & set’ instruction

7

Explain about a string of characters and give example. (13M) BTL2

Answer: Page : 4.74- C. Ravichandran

- Write a program to explain about string of characters (13M)



Length of a string of Characters

Program 4.11 : strlencr . s Find the length of a Carage Return terminated string

```
; Find the length of a CR terminated string

         TTL     Ch6E×1 - strlencr

CR       EQU     0×0D

         AREA    Program, CODE,
                 READONLY
         ENTRY

Main
         LDR     R0, =Data1          ; Load the address of the
                                     lookup table
         EDR     R1, R1, R1          ; Clear R1 to store count
Loop
         LDRB    R2, [R0], #1        ; Load the first byte into R
         CMP     R2, #CR             ; It is the terminator?
         BEQ     Loop                ; Yes ⇒ Stop loop
         ADD     R1, R1, #1          ; No ⇒ Increment count
```

8

Elaborate on memory Hierarchy of ARM? (10M)

Answer: Page : 4.33 - C. Ravichandran BTL2

- Types of memory (4M)
- ROM. FLASH, DRAM,SRAM,DISK BASED STORAGE
- L1 & L2 cache memory (3M)

  1. The entries in the cache do not need cleaned and/or invalidated by software for different virtual to physical mappings.

  2. Aliases to the same physical address may exist in memory regions
- Explain about Direct mapped cache organizations (3M)

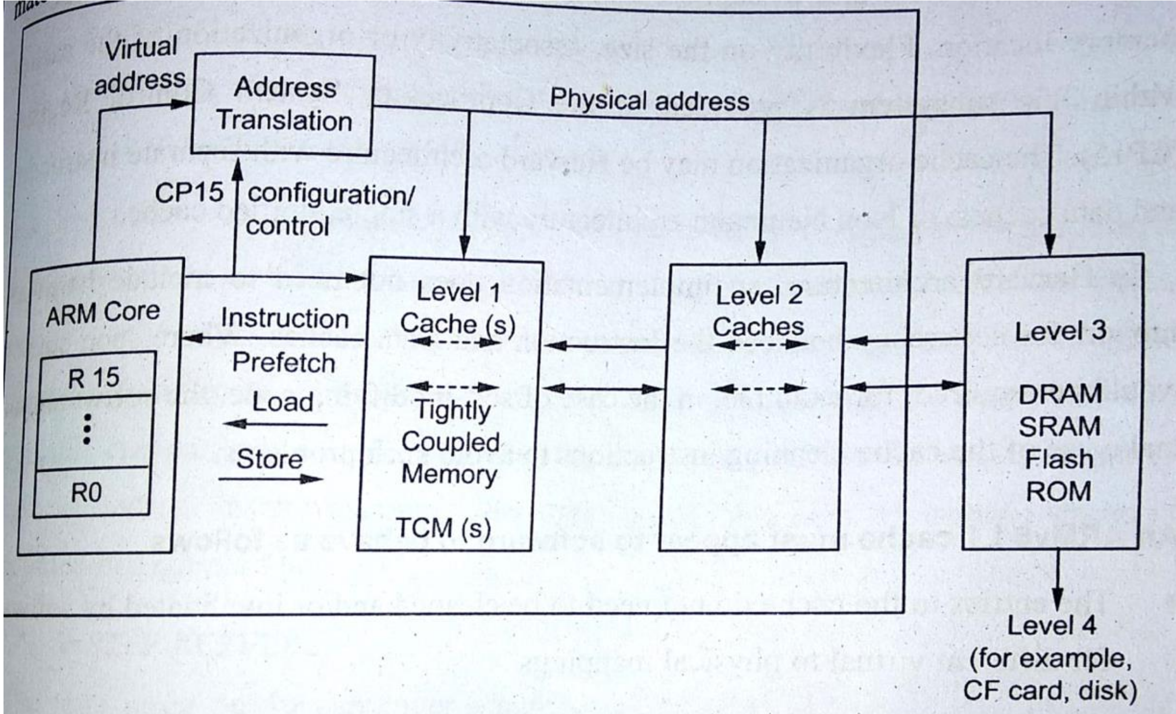


Fig. 4.12. Memory Hierarchy Examples

9 **In detail explain the architectural support for operating systems. (13 M) (Apr'17)** BTL1

Answer: Page : 4.85 - C. Ravichandran

- Explain about arm system control coprocessor (4M)

  1. The arm system control coprocessor is an on-chip coprocessor.

  2. Using logical number 15 which controls the operation of the on-chip cache

  3. Memory management or protection unit, write buffer, pre-fetch buffer, branch target cache and system configuration signals.
- Draw the structure of Protection unit registers (4M)
- ARM protection unit (5M)

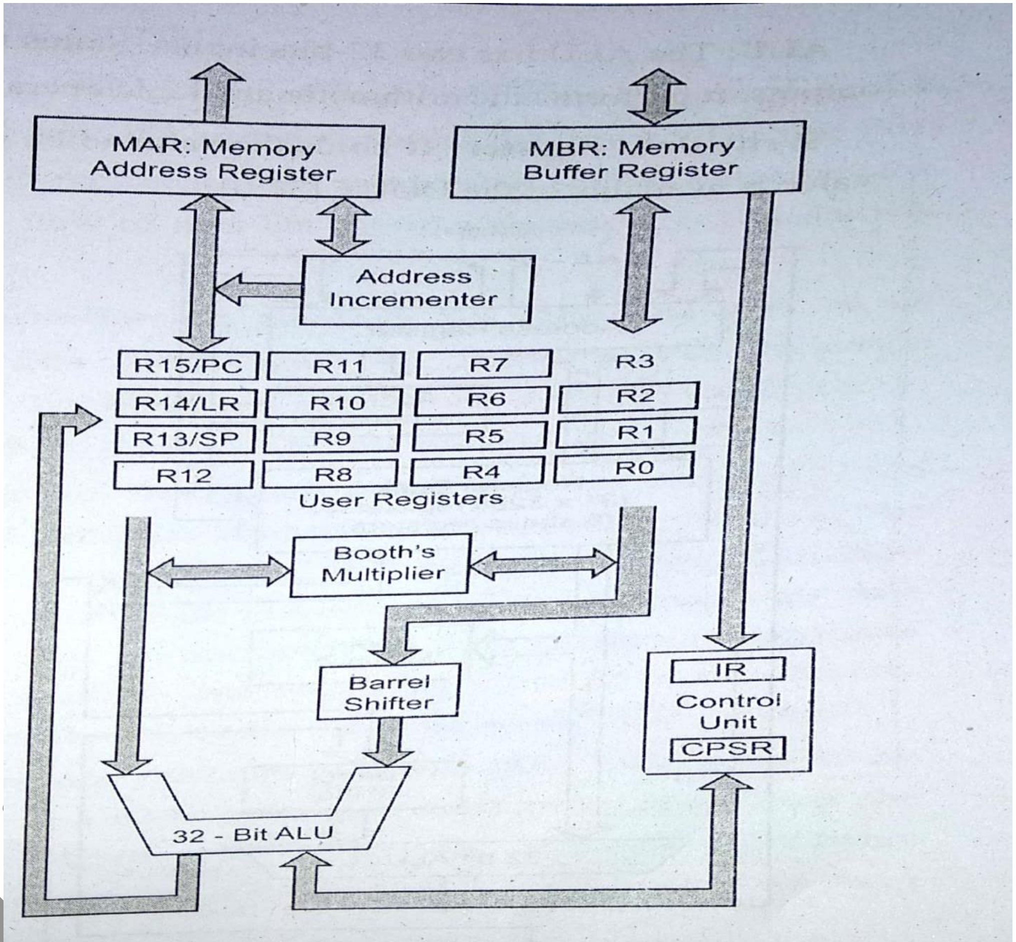
  ARM CPUs proposed for embedded applications includes a memory protection unit which defines various protection and cache functions.

Part*C

1 **Explain in detail about ARM architecture. (15M)** BTL2

Answer: Page : 4.10 - C. Ravichandran

- Write the features of arm processor (6M)
- Load/store architecture
- An orthogonal instruction set
- Mostly single-cycle execution
- Enhanced power-saving design
- 64 and 32bit execution states for scalable high performance
- Draw the arm architecture diagram and explain each blocks (9M)

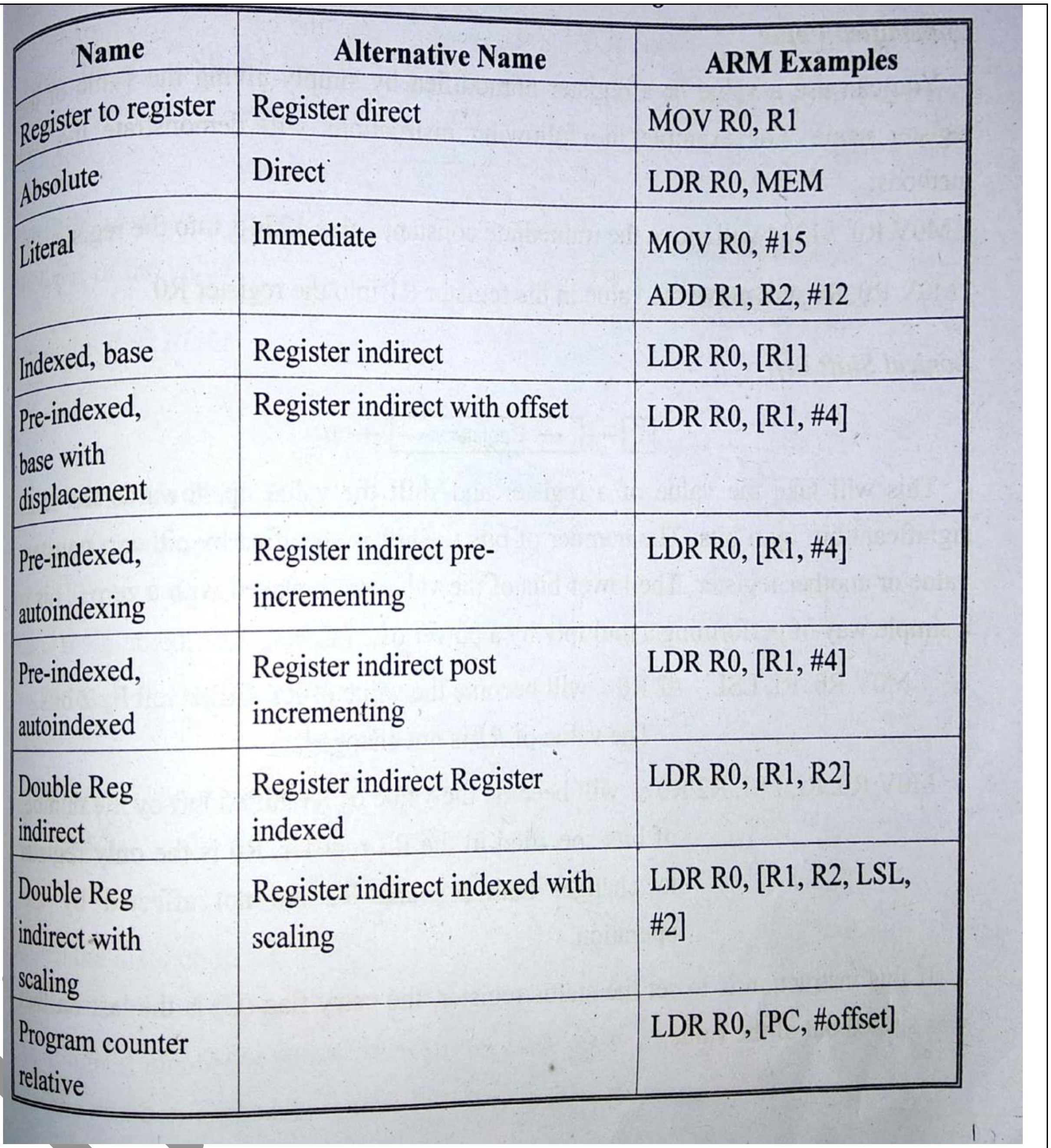


2

Explain in detail about Instruction set of ARM processor. (15M) (Nov'15) BTL2

Answer: Page : 4.26 - C. Ravichandran

- Classification of instruction set (7M)
- Branch instructions
- Data-processing instructions
- Status register transfer instructions
- Load and store instructions
- Coprocessor instructions
- Exception – generating instructions
- Explain in detail about each instruction with example (8M)



Name	Alternative Name	ARM Examples
Register to register	Register direct	MOV R0, R1
Absolute	Direct	LDR R0, MEM
Literal	Immediate	MOV R0, #15 ADD R1, R2, #12
Indexed, base	Register indirect	LDR R0, [R1]
Pre-indexed, base with displacement	Register indirect with offset	LDR R0, [R1, #4]
Pre-indexed, autoindexing	Register indirect pre-incrementing	LDR R0, [R1, #4]
Pre-indexed, autoindexed	Register indirect post incrementing	LDR R0, [R1, #4]
Double Reg indirect	Register indirect Register indexed	LDR R0, [R1, R2]
Double Reg indirect with scaling	Register indirect indexed with scaling	LDR R0, [R1, R2, LSL, #2]
Program counter relative		LDR R0, [PC, #offset]

Unit 5 ARM ORGANIZATION

3-Stage Pipeline ARM Organization– 5-Stage Pipeline ARM Organization–ARM Instruction Execution- ARM Implementation– ARM Instruction Set– ARM coprocessor interface– Architectural support for High Level Languages – Embedded ARM Applications.

Part*A

1 **What is meant by 3 stage pipeline?** BTL2

- Fetch/decode/Execute
- Allow multi-cycle execution
- Register, two read ports, one write port, additional register read/write for r15 (program counter)

2 **What is the role of 5 stage pipeline processors?** BTL2

- Fetch/decode/execute/ masm /write-back
- Introduce forwarding path

3 **Difference between ARM7 and ARM9.** BTL4

ARM 7	ARM 9
1. 3 Stage	1. 5 stage
2. Thumb instruction decodes	2. Parallel decoding Stage.
3 ALU (arithmetic, and logic is active all time	3. Two units are partitioned to same power

4 **What are the different types of ARM instruction set?** BTL4

- Data processing instructions
- Data transfer instructions
- Block transfer instructions
- Branching instructions
- Multiply instructions
- software interrupt instructions

5 **What are the features of arm instruction set?** BTL4

- Load/ store architecture
- 3-addressing data processing instructions
- Conditional execution.
- load/store multiple registers
- Shift and ALU operation in single clock cycle.

6 **What is the role of block transfer instructions?** BTL1

- Load/store multiple instructions (LDM/STM)
- Whole register bank or a subject copied to memory or restored with single instructions

7 **Give the functions of swap instruction.** BTL2

- Exchanges a word between registers
- Two cycles but single atomic action
- Support for RT semaphores

8	**How to modify the status registers.** • Only indirectly • MSR moves contents from CPSR/SPSR to select GPR • MRS moves contents from selected GPR to CPSR/SPSR • Only in privileged modes	BTL4
9	**What are the various types of multiply instructions?** • Integer multiplication (32 bit) • Long integer multiplication (64 bit result) • Built in multiply accumulate unit(MAC) • Multiply and accumulates instruction and product to running total.	BTL4
10	**Write some examples of multiply instruction.** • MUL • MULA • UMULL • UMLAL • SMULL • SMLAL	BTL4
11	**List the instruction set for embedded systems.** • Variable cycle execution for certain instructions • Inline barrel shifter leading to more complex instructions • Thumb 16 bit instruction set • Conditional execution • Enhanced instructions	BTL4
12	**List the various applications of arm processor (Jun'16)** • Home gateways • DSL modems • 802.11 wireless communications	BTL4
13	**Write the program execution time for 5 stage pipeline.** Program execution time: $T_{prog} = N_{inst} . CPI/ f_{clk}$	BTL2
14	**List the different types of cache.** • Unified cache • Separature instruction and data caches • Direct-mapped cache • Set associative cache	BTL4
15	**What is the meaning of errors and list the types of errors.** • Assemblers normally provide error messages, of then consisting of an error code number. Some typical errors are: • Illegal character • Invalid expression • Missing operand	BTL1
16	**What is the role of loaders? Mention its Types**	BTL1

The loaders are the program which actually takes the output (object code) from assembler and places it in memory. Loaders range from the very simple to the every complex.

- Boost traps loader
- Relocating loader
- Linking- loader

17 **What is the function of pre-index and post index addressing?** BTL1

- In pre-index addressing the memory address is formed in the same way as for offset addressing. The address is not only used to access memory, but also the base register is also modified to hold the new value. In the arm system this is known as a write back and is denoted by placing a exclamation mark after at the end of the OPZ code.
- In post index address the memory address is the base register value. As a side effect, an offset is added to or subtracted from the base register value and the result is written back to the base register

18 **Mention various types of subroutines.** BTL4

- Relocatable
- Position independent
- Re entrant
- Recursive

19 **Write an ALP to swap the contents of register r0 & r1.** BTL4

```
     Start:
              MOV r2,r0
            MOV r0,r1
           MOV r1.r2
  Stop     B   Stop
```

20 **List the various types of assemblers. (nov'17)** BTL4

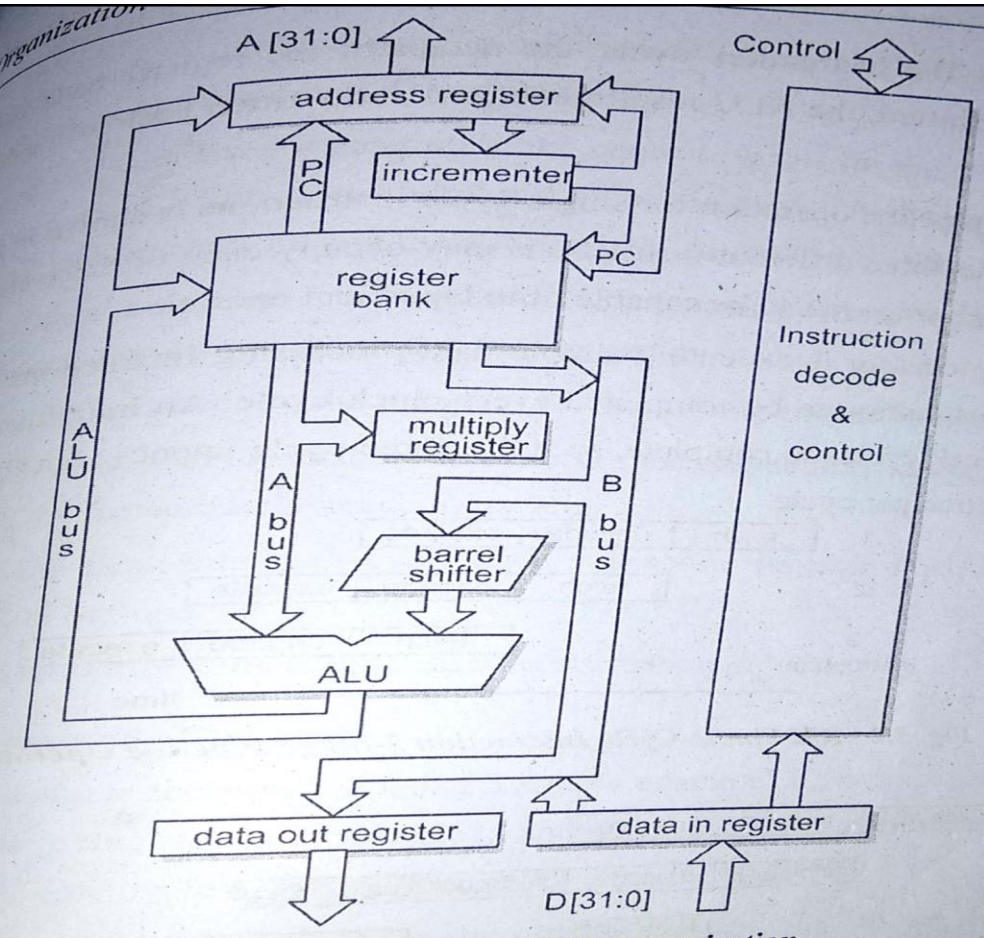
- Cross assembler
- Self assembler (or) resident assembler
- Micro assembler
- One pass assembler
- Two pass assembler

Part*B

1 **Discuss in detail about 3- stage pipeline ARM organization? (13M) (Dec'18) (May'19)** BTL2

Answer: Page: 5.2 - C. Ravichandran

- Draw the 3-stage pipeline arm organization diagram (7M)

	 *Fig. 5.1. 3-Stage Pipeline ARM Organization* - Explain each blocks with its operation (6M) 1. Fetch: The instruction fetched from memory and placed in instruction pipeline. 2. Decode: The instruction decoded and data path control signals prepared for next cycle. 3. Execute: The instruction 'owns' data path, register bank read, an operand shifted, the ALU result generated and written back into a destination register.
2	**Explain in detail the 5 stage pipeline ARM organization? (13M)** BTL2 **Answer: Page: 5.7 - C. Ravichandran** - Draw the 5-stage pipeline arm organization diagram (7M)

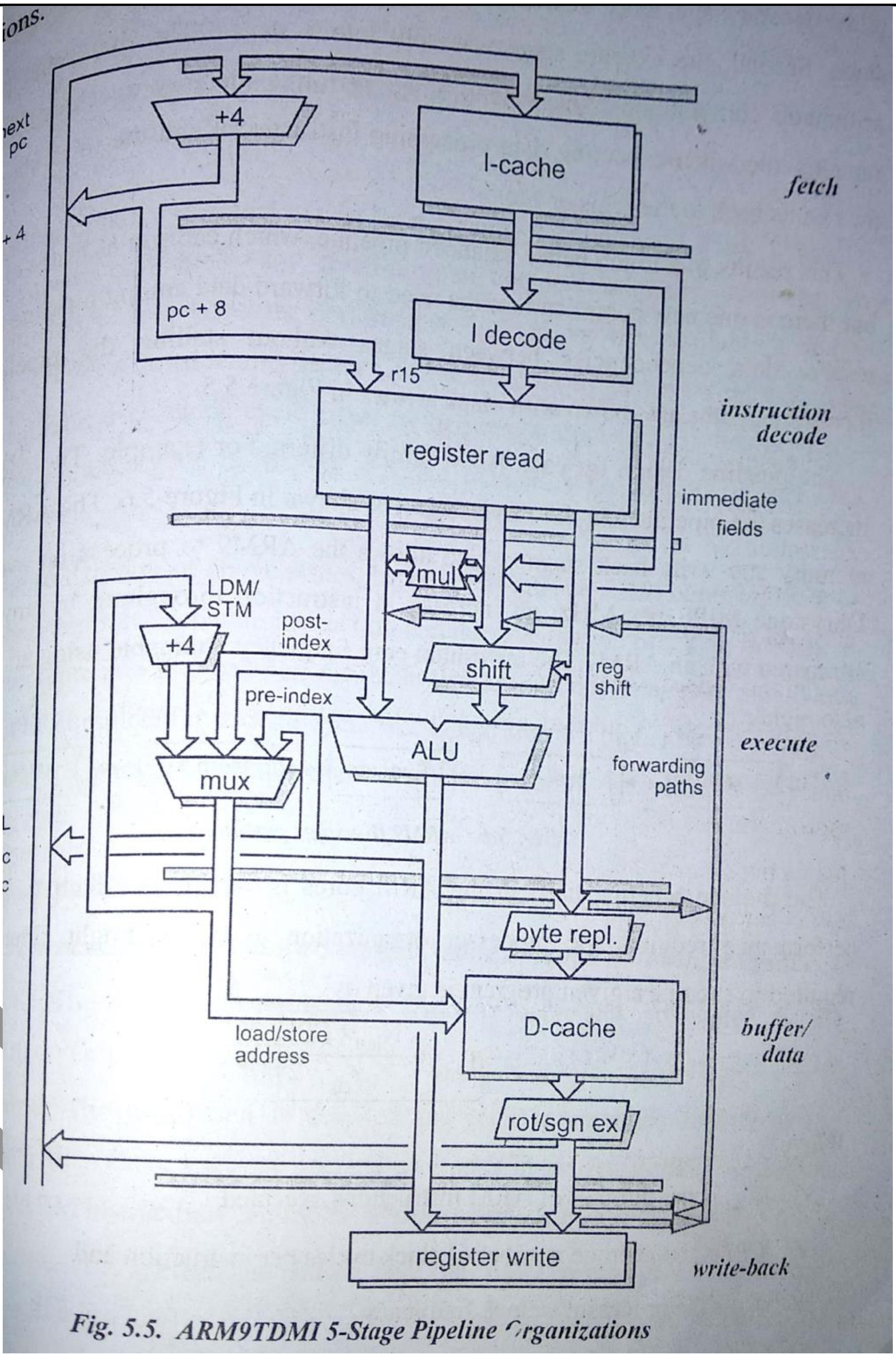


Fig. 5.5. ARM9TDMI 5-Stage Pipeline Organizations

- Explain each blocks with its operation (6M)

1. **Fetch:** The instruction fetched from memory and positioned in the instruction pipeline.
2. **Decode**: The instruction is decoded and register operands read from the register file.
3. **Execute**: An operand is shifted and the ALU result generated. If the instruction is a load or store the memory address is computed in ALU.
4. **Buffer/Data**: Data memory is accessed if required. Otherwise the ALU result is simply buffered for one clock cycle.

5. **Write-back**: The results generated by the instruction are written back to the register file, including any data loaded from memory.

3

Briefly explain about ARM Instruction execution? (Apr'16) (13M) BTL2

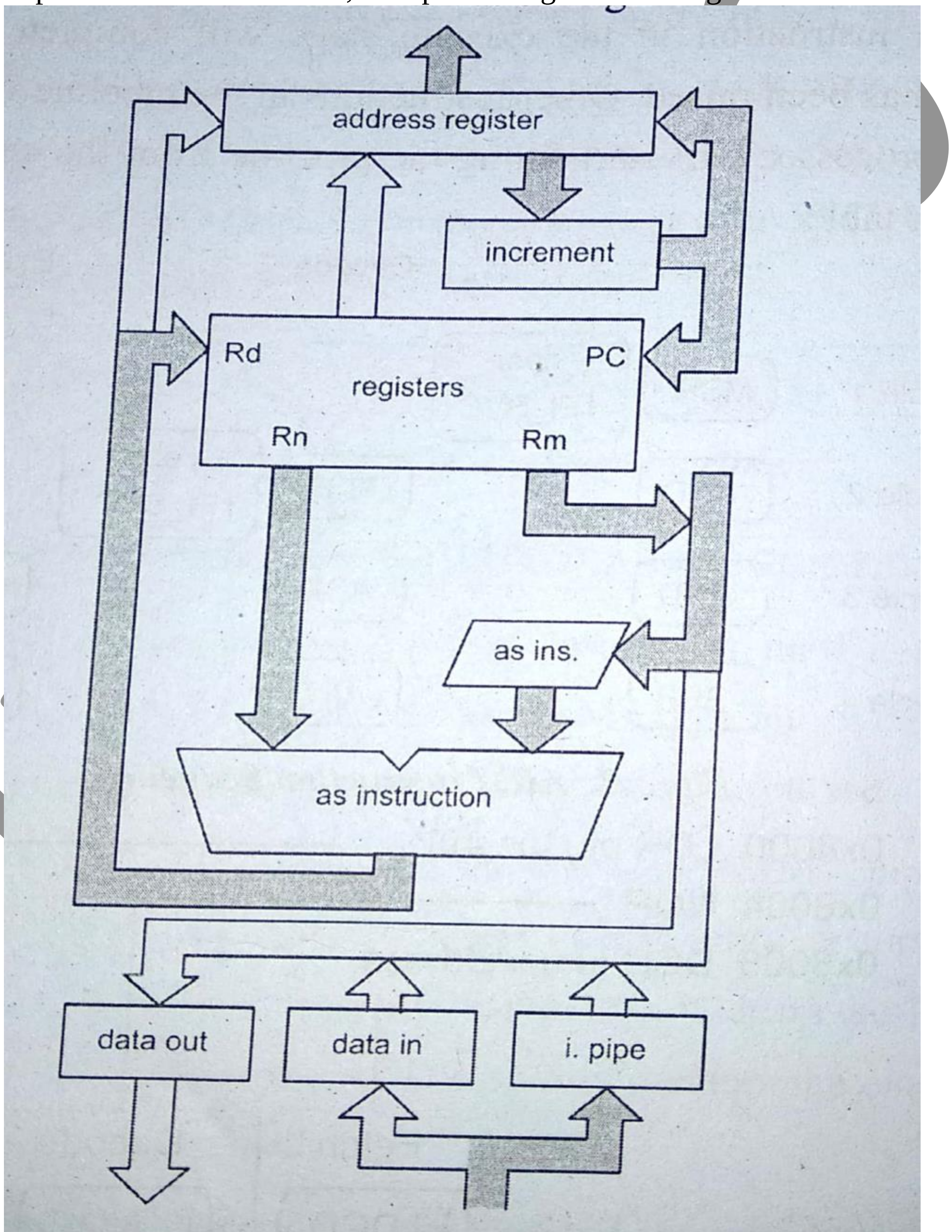
Answer: Page: 5.10 - C. Ravichandran

- Explain the arm instruction sequence (5M)

  1. First, the execution of a branch instruction or branching by the direct modification of the PC causes the ARM core to flush its pipeline.

  2. Second, ARM10 uses branch prediction which reduces the effect of a pipeline flush by predicting possible branches and loading the new branch address prior to the execution of the instruction.

- Explain about Data transfer, data processing & branching instructions execution(8M)



(a) Register-Register operations

4	**Discuss about ARM implementation. (13M) (Jun'15)** BTL1 **Answer: Page: 5.17 - C. Ravichandran** • **Clocking scheme** (2M) The most of the ARMs do not operate with edge-sensitive registers and operating design is based on 2 phase a non overlapping clock. • Describe about Data path timing, ALU functions, barrel shifter (6M) 1. The register read buses are dynamic and are pre charged. 2. When phase 1 goes high, the selected registers discharge the read buses which become valid early in phase 1. 3. One operand is passed through the barrel shifter, which also uses dynamic techniques and the shifter output becomes valid a little later in phase 1. • **Register banks** (5M) The register bank is a last major block on the ARM data path. This is constructed with 31 general purpose 32 bit registers, amounting to around 1 Kbits of data altogether.
5	**Explain in detail about ARM instruction set? (13M)** BTL1 **Answer: Page: 5.30 - C. Ravichandran** • Types of instruction set (4M) • Data transfer instructions • Move instructions • Arithmetic instructions • Logical instructions • Comparison instructions • Explain each with syntax and example (9M)
6	**What is the role of ARM coprocessor interface? Explain in detail? (13 M)** BTL2 **Answer: Page : 5.76 - C. Ravichandran** • **Features of coprocessor interface** (6M) 1. Support up to maximum of 16 logical coprocessors 2. Each coprocessor can have up to 16 private registers of any reasonable size, they are not limited to 32 bits. 3. Coprocessors use load-store architecture, with instructions to perform internal operations on registers. • **Coprocessor instructions** (7M) The handshake uses three signals: 1. CPI (from ARM to all coprocessors)- coprocessor instruction 2. CPA(from the coprocessors to ARM)- coprocessor absent 3. CPB (from the coprocessors to ARM)- coprocessor busy
7	**Write a detailed note on architectural support for high level languages? (13 M)** BTL2 **Answer: Page : 5.7 - C. Ravichandran** • **Data types** (4M) 1. The number of bits required 2. The ordering of bits 3. The uses to which the group of bits is put. • **Floating points data types** (4M) Floating point numbers attempt to represent real numbers with uniform accuracy. A

general way to represent a real number is in the form:

$$R = axb^n$$

- **Use of memory** (5M)

  Stack: whenever a function is called, a new activation frame is created on the stack containing a back trace record, local variables, and so on.

  Heap: Heap is an area of memory used to satisfy program requests for more memory for new data structures.

  It comprises:

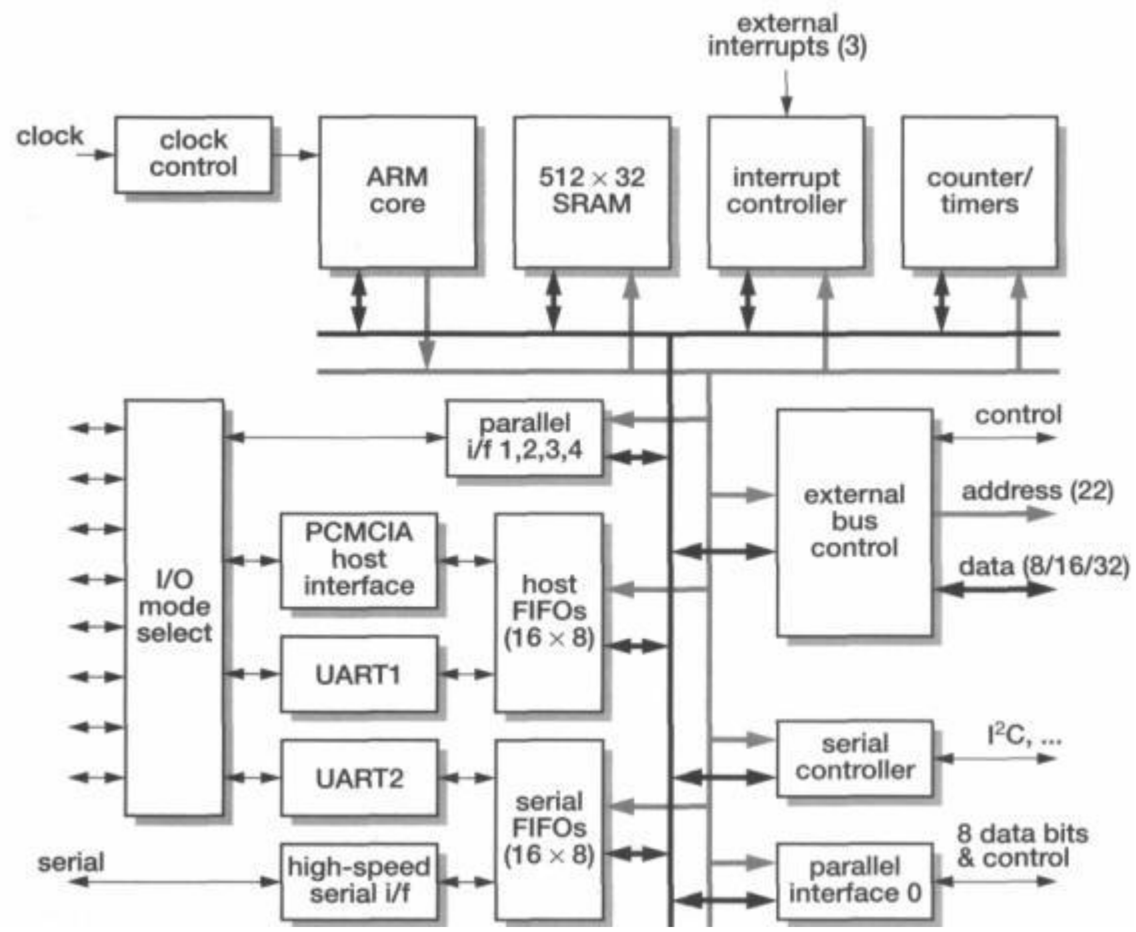
  1. Stack-limit checking functions
  2. Stack and heap management
  3. Program start up
  4. Program termination

8

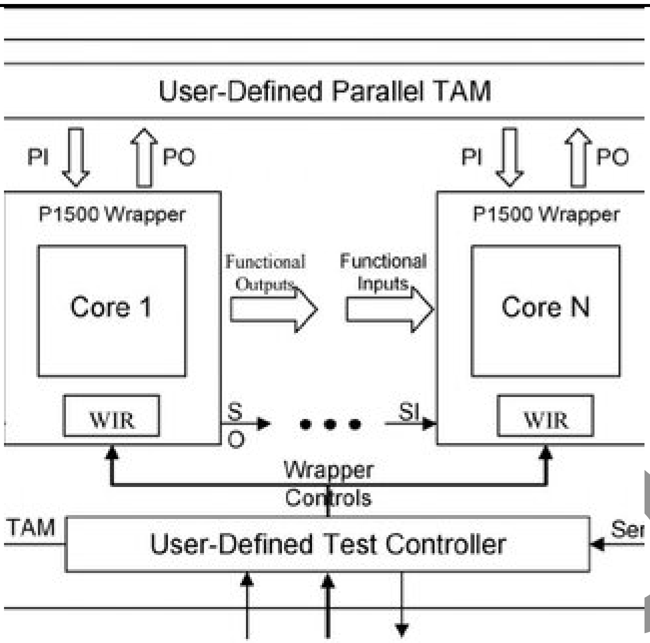
Write short notes on Embedded ARM applications? (13M) (Jul'13)(Dec'18) BTL4

Answer: Page: 5.95 - C. Ravichandran

- The VLSI ruby –II advanced communications processor (5M)



- Bluetooth baseband controller organization (8M)

		
	Part*C	
1	**Explain in detail the 5 stage pipeline ARM organization?(15M) (Apr’14)** **Answer: Page : 5.7- C. Ravichandran** • Draw the 5-stage pipeline arm organization diagram	BTL3 (8M)

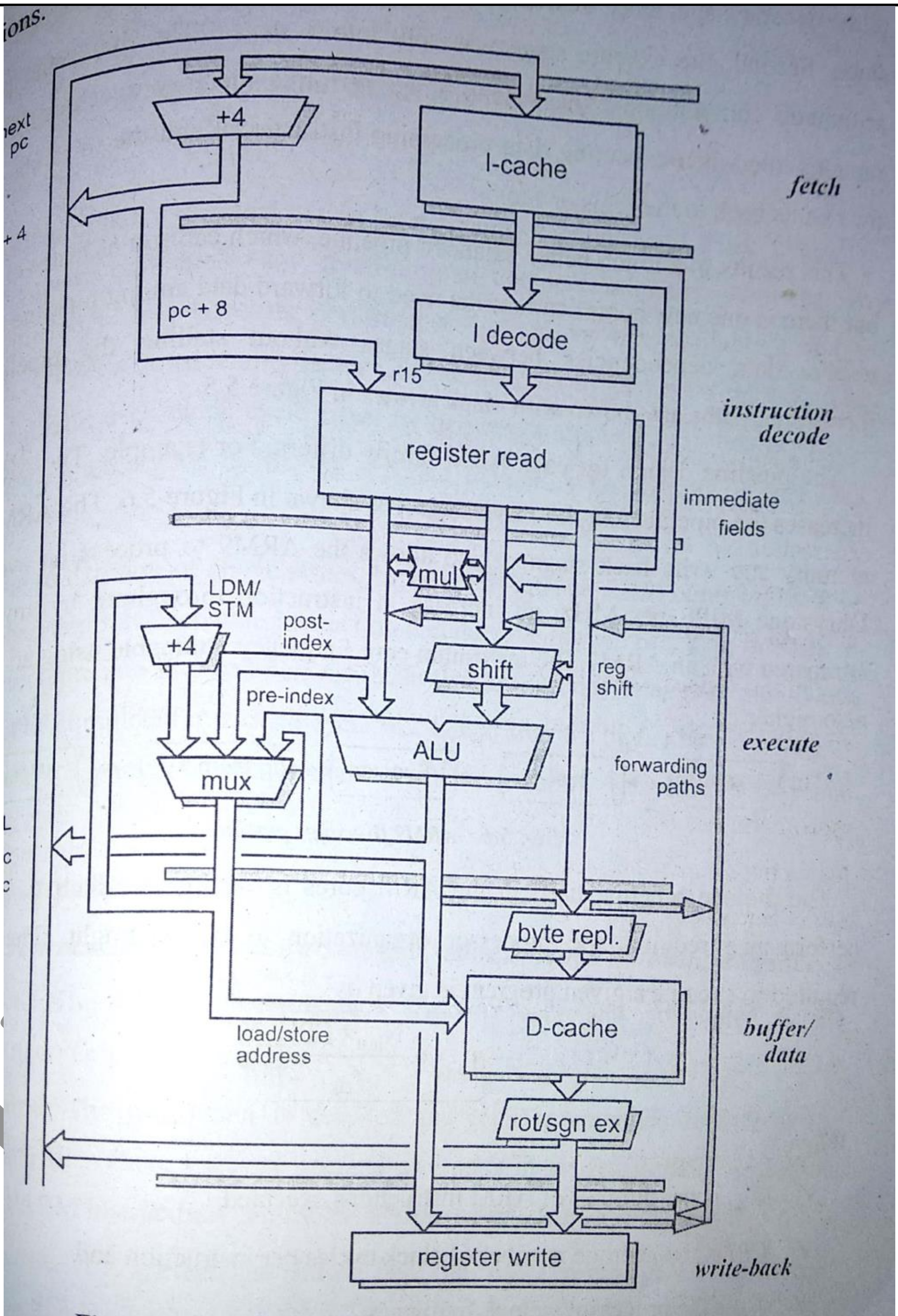


Fig. 5.5. ARM9TDMI 5-Stage Pipeline Organizations

- **Explain each blocks with its operation** (7M)

1. Fetch: The instruction fetched from memory and positioned in the instruction pipeline.
2. Decode: The instruction is decoded and register operands read from the register file.
3. Execute: An operand is shifted and the ALU result generated. If the instruction is a load or store the memory address is computed in ALU.
4. Buffer/Data: Data memory is accessed if required. Otherwise the ALU result is simply

	buffered for one clock cycle. 5. Write-back: The results generated by the instruction are written back to the register file, including any data loaded from memory.
2	**Write a detailed note on architectural support for high level languages? (15M)** BTL2 **Answer: Page: 5.80 - C. Ravichandran** • **Data types** (4M) 1. The number of bits required 2. The ordering of bits 3. The uses to which the group of bits is put. • **Floating points data types** (4M) Floating point numbers attempt to represent real numbers with uniform accuracy. A general way to represent a real number is in the form: $R= axb^n$ • **Use of memory** (7M) Stack: whenever a function is called, a new activation frame is created on the stack containing a back trace record, local variables, and so on. Heap: Heap is an area of memory used to satisfy program requests for more memory for new data structures. **It comprises:** 1. Stack-limit checking functions 2. Stack and heap management 3. Program start up 4. Program termination