

## **Syllabus for Paper III (core)**

**Post Code: ELE**

### **Taken from curriculum of diploma course in electrical and electronics engineering (State board of Kerala Technical education)**

#### **ELECTRIC CIRCUITS & NETWORKS:**

Electric Current, Voltage, Resistance, Definitions and units. Laws of resistance - Specific resistance - Conductance of conductivity - Effect of temperature on Resistance - Temperature co-efficient problems. D.C Circuits - Ohm's law - Series, parallel, series - parallel circuits. Calculation of branch currents and voltages. Network Theorems - Kirchoff' Laws, Super position theorem, Thevenin's theorem, and Norton's theorem.

#### **ELECTROSTATICS & MAGNETISM:**

Static electricity - Absolute and relative permittivity of a medium, Dielectric constant - Laws of electrostatics. Electric field, Field strength or field intensity, Electrostatic induction, Electric flux density - potential and potential difference, Potential at a point, Potential of a charged sphere - Equipotential surfaces - Potential gradient - Breakdown voltage and dielectric strength. Capacitance Capacitor and capacitance - Capacitance of an isolated Sphere - Spherical capacitor and parallel plate capacitor - Variable capacitors - Capacitors in series and parallel - Energy stored in a capacitor Secondary cells Primary and secondary cells - Comparison of lead acid and alkaline cells - initial charging and commissioning of new batteries - charging methods. Calculation of ampere hour efficiency and Watt hour efficiency Care and maintenance of batteries -specification Magnetism Absolute and relative permeability, field strength, magnetizing force, flux and flux density. Relation between flux density and magnetizing force, B.H. curve

#### **ELECTROMAGNETISM & A.C FUNDAMENTALS**

Force on a current carrying conductor lying in a magnetic field - Magnetizing force of long straight conductor, long solenoid Magnetic circuit Definition of magnetic circuit - magnetomotive force, reluctance, Ampere-turns, permeance, reluctivity. Comparison of magnetic of electric circuit - calculation of ampere-turns.

Faradays laws of electromagnetic induction problems - direction of induced emf and current (Fleming's right hand rule, Lenz's law) statically and dynamically induced e m f. Expression for dynamically and statically induced emf. Self and mutual inductance - coefficient of self and mutual induction - coefficient of self and mutual induction - coefficient of coupling - problems. Energy stored in magnetic field - problems. A.C fundamentals Generation of alternating voltage and current - equation of instantaneous values of voltage and current. Simple and complex waveforms. Definition of (a) cycle (b) frequency (c) time period (d) amplitude value (e) average value (f) R.M.S. Value (g) form factor and peak factor phase and phase difference. Relation between  $f$ ,  $p$ ,  $n$  deviation of r.m.s and average value for sinusoidal waveforms. Different forms of e.m.f equation

#### **SINGLE PHASE AC CIRCUITS**

A.C Through resistance, inductance and capacitance - voltage, current, power, p.f impure resistive, inductive, capacitive - circuits – problems. Series A.C circuits - AC through R and L, R and C, R, L and C circuits – active, reactor and apparent power, Q factor. Resonance in R-L-C circuits - problems in series circuits Parallel A.C circuits - vectors or phase method, solving problems in R, L, C parallel circuits - resonance in parallel circuit - Q factor

### **POLYPHASE CIRCUITS**

Generation of poly phase voltages, - advantages, phase sequence. Inter connection of three phases, star and delta connection. Relation between phase and line voltages and current in star and delta - derivation with phase diagram. Simple problem. Derivation of expression for power in three-phase system in star and delta. Calculation of power, current and power factor in a three phase balanced system. Balanced and unbalanced three phase system (only principle). Balanced star - delta and delta - star conversion - problems Three-phase power measurements - single wattmeter, three-watt meter and two-watt meter methods. Two-watt meter method of power measurement (balanced star and delta). Derivation with vector diagram, problems.

### **Diodes and Transistors**

Characteristics of active components - PN junctions – depletion layer – potential barrier – behaviour of PN junctions – F.B & R.B, Zener diode – F.B and R.B characteristics – applications - Bipolar transistor – current carriers – PNP – NPN – current flows- Common base - common emitter - common collector - configurations – Input and output characteristics – Region of operations - amplification factors

### **Rectifiers, FET, UJT and circuits UJT**

operations and characteristics – applications FET – constructions - N channel – P channel – characteristics - advantages – disadvantages MOSFET – enhancement N channel – applications – difference between JFET and MOSFET Half wave - full wave- Centre tap and bridge type – rectifiers using diodes – wave forms - P.I.V – ripple factor – regulator – efficiency comparison – filters – different types Clipping circuits – series – shunt – biased type – double clipper circuits Clamping circuits – positive pole - negative pole and other level clamping circuits

**Classes of Insulating Materials:** Transformer oil – properties - dielectric strength - testing transformer oil for dielectric strength - wire for winding - types of insulation - coating materials for wires - coating of synthetic resins - super enamel cotton silk etc. Common solidifying insulating materials resins – Nitrocellulose- Poly Vinyl Chloride (PVC) – polyethylene - nylon - cross linked Polymer - drying oils - waxes - paraffin - varnishes - properties of each and field of application - vacuum and pressure impregnation - coating and adhering - Insulation compound -bituminous compound - cable compounds Examples of each class

**Measurement of Power and Energy:** Construction and working principle of dynamometer type wattmeter – errors – and their remedy-correction factor – compensated wattmeter – low power factor wattmeter – multiplication factor -

Constructions and working of single phase induction type energy meter – errors – their remedy – poly phase energy meters – 3 element and 2 element 3 phase energy meter – calibration of energy meter by direct loading and phantom loading – wattmeter and energy meter connections using CT and PT

### **Measurement of R, L, C**

Classifications of resistance – low, medium and high - Measurement of low resistance by potentiometer method - measurement of medium resistance by wheat stone bridge and slide Wire Bridge Measurement of high resistance – insulation resistance by megger – working principle and construction details of megger Measurement of earth resistance by fall of potential method and 4-electrode earth tester Localization of cable fault – measurement of R-L-C by LCR methods – potential drop method Bridge – measurement of resistance – measurement of inductance – Max well's inductance bridge – Max well's inductance capacitance bridge – measurement of capacitance – Schering's bridge – wein's bridge

### **Electrical Power Generation:**

Introduction - Sources of energy – Conventional– layout and working of Hydro – electric power stations – thermal power station - Nuclear power station - gas based power station and diesel power stations - Estimations of available energy from Hydroelectric power stations - Choice of site for power stations - Comparison of cost of different power stations

### **Economics of Power:**

cost of generation– fixed and running cost – interest –depreciation - total annual cost Maximum demand - average demand and load factor (daily and annual) - diversity factor of generation - effect of load factor and diversity factor on cost of generation – total generating cost per kWh. Tariff - types of tariff – problems. Power Factor improvement – necessity of determination of KVAR - rating of capacitors for the power factor improvement for 1 and 3 phase loads – Problems

### **Transmission Line elements:**

Transmission of electrical energy – different systems of transmission and circuit - conductor size in AC systems - Choice of voltage - Principles and advantages of DC transmission system -Transmission line constants - Inductance and capacitance of round and parallel conductors 1) single phase 2) three phase with symmetrically spaced conductors- Transposition of conductors and its necessity - inductances - capacitance of transposed lines (formula only) –Performance of transmission lines – definition of short, medium and long lines - lumped and distributed parameters – Equivalent circuit and vector diagram of short transmission lines for different power factor - conditions at receiving end – calculations of sending end voltage and power factor - Regulation and transmission efficiency from receiving end conditions- - Skin effect in ACSR conductors – corona in transmission lines – Ferranti effect .

### **Concepts of Distribution Systems**

Insulators – types of insulators - advantages of each type – voltage distribution across insulator string - Definition of string - efficiency – use of guard ring and arc horns – testing of insulators - flash over - Comparison between DC and AC distribution systems.  
General arrangement of an AC distribution system – Problems in DC , AC distribution systems-fed at one end and both ends.

**Basic concepts of rotating electrical machines:** Basic electromagnetic laws-EMF generation in a rotating electrical machine-Physical concepts of production of torque-Elementary concepts of electrical machines-Common features of rotating electrical machines-Types of rotating electrical machines-MMF and Flux distribution in DC and AC machine - Voltages in DC and AC machines-Torque balance-Power losses and efficiency-Methods of Ventilation and cooling of machines.

**Know the performance of D.C Generators:** Principle of working of a simple loop generator – practical generator and construction details – commutator assembly e.m.f equation and problems- Classifications of generators based on method of excitations – separately excited and self-excited types –shunt - series and compound generators - relation between terminal voltage and induced e.m.f on load. Armature windings-drum winding, lap winding, wave winding, equalizer connections

**Characteristics of D.C Generators:** Armature reaction – effects – de magnetizing and cross magnetizing- Commutation – method of improving commutations interpole – compensating windings Generator characteristics – O.C.C – external and internal characteristics of shunt, series and compound generators - Critical field resistance and critical speed – conditions of excitations - uses of D.C. generators

**Performance of D.C Motor:** Motor principle – back emf - Voltage equation of a motor - torque equation – problems - Types of motor shunt, series and compound motors - Motor characteristics – torque/armature current - speed/armature current - speed /torque for D.C shunt series and compound motors - derive the equation of compound motors Factors controlling motor speed – field control and armature control - methods of shunt - Series and compound motors Starting of D.C. motors – necessity of starters – Types of starters-two point- three point and four point starters

**Characteristics of D.C Motor:** Testing of D.C motor – losses in D.C. machines - determinations of efficiency by direct loading – Swinburne’s test - advantages and disadvantages - efficiency of machine working motor and generator – Constructions – working – performance – speed control – advantages, disadvantages and applications of Permanent Magnet D.C. motor, low inertia D.C motors

### **Transformer Principles:**

Principle – advantages - construction and classification - core- shell, radial types - core materials – grain oriented silicon steel - insulation - different types of insulation - construction of single phase transformer - three phase transformer - explosion vent -

breather - conservator tank etc. - emf equation – transformation ratio - step up and step down transformers- Transformer on no load - Vector diagram - component of no load current - no load parameters and no load losses - Transformer on load - difference between leakage flux and mutual flux - Primary and secondary leakage reactance - transformer constants on load. Vector diagram of transformer on load with different power factors - equivalent impedance as referred to primary and secondary. Simple problems on determination of primary current losses - secondary current and efficiency based on approximate equivalent circuit - determination of approximate voltage drop – exact voltage drop – equivalent circuit. Voltage regulation- definition – percentage – regulation - percentage impedance - permit values of resistance - reactance and impedance - Problems - losses and efficiency - condition of maximum efficiency - KVA output at maximum efficiency – Problems

### **Testing of Transformers:**

Polarity tests - Ratio tests - open circuit test - short circuit test - load test on single-phase transformer as BIS code of practice - Determination of transformer – parameters such as percentage resistance, percentage reactance and percentage impedance - Predetermination of efficiency and regulation at various loads and power factors. Three phase transformer- connection - methods of connection - vector group - specific areas of applications - Open delta connection - Distinction between power transformer and distribution transformer - tertiary winding and its use- Define the term All day efficiency and compute All day efficiency from given data with reference to distribution transformer-problems.

### **Special purpose transformers:**

Auto transformers – constructions - saving of copper fields of applications - advantage and disadvantages over two winding transformers - necessity of tap changing - OFF LOAD tap changing system and ON LOAD tap changing - Automatic tap changing systems Necessity of cooling - classification of transformer based on method of cooling - Method of cooling described with sketches

**Instrument transformers:** current transformers: schematic diagram-specifications - uses of C.T - Applications of C.T in current and power measurements - class of accuracy of CT & PT Potential transformers: Schematic diagram – specification - electromagnetic and capacitor type – applications - precautions in the use of P.T.

**Principles of Induction Motor** Three :phase induction motor - Principle of operation - production of rotating magnetic field in a three phase induction motor – speed of rotating magnetic field Constructional details of squirrel cage and phase wound motors TEFC/Flame proof - construction of Induction motors – skewing of rotor conductors in squirrel cage motor – advantages Slip and frequency of rotor currents - Relation between rotor emf and stator emf - Resistance and reactance of rotor - Stand still rotor reactance - Rotor power factor Analogy between Induction Motor and transformer- exact and approximate equivalent circuit - Relationship between rotor input, rotor copper loss and rotor output- power transfer from stator to rotor. Torque equation of induction motor – relationship between torque and rotor resistance - Torque slip characteristics – torque in synchronous watts and Newton meters - Relation of full load torque to stand still

torque - Effect of voltage on Induction motor operation - maximum torque and condition for maximum torque-power flow diagram-losses & efficiency.

**Speed control of induction motor:** No load and blocked rotor tests - determination of equivalent circuit- relation of circle diagram of induction motor from simplified equivalent circuit - power scale and determination performance characteristics using circle diagram at various loads-measurement of slip- Starting of induction motors - necessity of starters for squirrel cage and slip ring induction motors - Improving starting torque in cage and phase wound motors. Speed control of induction motors - pole change - Change of stator frequency, rotor resistance control. Design of diameter and length of induction motor (formula only)

### **Short Circuit Current Calculation & Fuses:**

Faults in power system - calculation of fault current - sources of fault - limitations of fault current - percentage and per unit reactance - base KVA - Synchronous - transient and sub transient reactants - Symmetrical fault calculations - Problems - Reactors - use of reactors - construction of unshielded and magnetically shielded types - location of reactors (generator, feeder and bus bar reactors)- Fuses - fusing element - rated current of fuse element - fusing factor - factors affecting current carrying capacity of fuse elements - Prospective current of a circuit- cut off - pre-arcing time - arcing time and operating time of fuses - Inverse current characteristics - classification of fuses - Description of expulsion and cartridge fuses-Drop out fuse - characteristic of HRC fuses - Cut off current and time current - characteristics of HRC fuses - Rupturing capacity - selection of HRC fuse - advantages and disadvantages of HRC fuses

### **Circuit breakers**

Circuit breakers - functions - fault clearing process - trip circuit - classification based on arc quenching process - high resistance and current zero - arc extinguish - idea of arc voltage - recovery voltage - restriking voltage - current chopping - switching - principles and applications Oil circuit breakers - working principle - classification of circuit breakers Air blast - circuit breaker - advantages - principles with simple sketches - vacuum circuit breaker - principles with simple sketches - air circuit breaker -SF6 circuit breakers-circuit breaker advantages - working with simple sketch - Selections and specification of circuit breakers - circuit breaker ratings -breaking capacity and making capacity - short time current rating and rated voltage normal current rating-testing of circuit breakers

### **Relays:**

Protective relays- Importance of protective relays - primary and back up protection - properties of relays - Inverse time definite minimum time properties - Current setting time - setting and tripping time - Classification of relays - electromagnetic relays - induction relays - Construction and working of attracted armature type electromagnetic relay - directional and non- directional - induction over current relays - Static relays-functional circuits - brief description with block diagram - Electronic time delay - relay using transistors- microprocessor based digital relays

### **Protection:**

Protection of alternators – differential protection against internal faults - Principle and schematic diagram and working - Protection against loss of excitation –over load, over voltage, over speed protection motoring-rotor fault protection-vibration, bearing protection-back up protection-Principle and necessity of field suppression.-Protection of ac motors. Protection of transformers – differential protection – schematic diagram - working - current transformer connections in star and delta – safety devices of the transformers - Buchholz relay – brief description and working Bus bar protection-arrangement-bus-zone fault-back up protection-differential over current protection. Protection of transmission lines – over current, over load and earth fault-time graded – current graded pilot wires protection-protection of radial and ring system by graded time lag protection – Protection of parallel feeders

### **Earthing and Lightning arresters:**

Surges – causes of transient- over voltage- mechanism of lightning phenomena-lightning strokes-Lightning arresters- thyrite lightning arrestor – surge absorbers --rod gap, sphere gap, horn gap, multiple gap arresters-testing of arresters. Earthing-effects on human body-soil resistivity and measurement-earthing mat-size of earthing conductor Power stations – substations and electrical apparatus protection by ground wire – Neutral grounding – comparison of Earthed and isolated three phase systems - Types of grounding - description of solid - resistance and reactance earthing of neutral – earthing transformers-sub station earthing

**Renewable and non-renewable sources of energy:** Brief review of conventional sources of energy -Brief review of non-conventional sources of energy like solar, wind, ocean, geo thermal, biomass, chemical etc -Greenhouse effect and global warming, Description of solar thermal devices like furnaces cookers, stills water heater, refrigerators etc-Solar thermal power storage Generation of electric power from MHD Generator

**Solar energy:** Description of photovoltaic effect-schematic view of PV Cells-Electric characteristic of photovoltaic cells-equivalent circuit of solar cell-Instruments for measurements for solar radiations pyrhelimeter and pyranometer-Basic PV System for power generation-Applications of Solar energy devices-Advantages & disadvantages of PV.

### **Synchronous Generator:**

Synchronous generator - Principles of a.c generator – single phase and three phase - Constructional details of salient pole and turbo generators with sketches - Relationship between speed, frequency and number of poles. Methods of exciting the field - main and pilot exciter - static excitations Armature windings - single layer and double layer types - Full pitched and short pitched windings - fractional Slot windings – pitch factor and distribution factor Methods of obtaining sinusoidal waveform in generators - EMF equation on an A.C generator

### **Characteristics and parallel operation of Alternator:**

Armature reaction Resistance and leakage reactance – Armature reactions under leading - lagging and unity power factor loads - Synchronous reactance and synchronous impedance - Vector diagram of alternator on load at lagging, leading and unity power factors. Voltage regulation- definition - determination of regulation by EMF, MMF and ZPF

methods - Problems Synchronizing of alternator to infinite bus bar conditions dark lamp - bright lamp and synchroscope methods - Active and reactive power output - Effects of excitation - Effect of variation of prime mover - input, output sharing - Power sharing - Problems - Cooling of alternators

### **SYNCHRONOUS MOTORS:**

3 Phase synchronous motor - Principle of operation - Effect of excitation of armature current and power factor - Power developed by a synchronous motor - Torques of synchronous motors - V curves and inverted V curves - Synchronous condenser - use of synchronous motor - field of applications - methods of starting - hunting - prevention of hunting by damper windings - related problems.

### **Single phase Induction Motors:**

Single phase induction motors: - Principle of operation - Revolving double field theory - split phase equivalent circuit - torque equation - Torque-Speed characteristics of single phase induction motors - shaded pole - repulsion start - capacitor start - capacitor run motor - series motor - universal motor - field of application of each type.

### **F.H.P Motors:**

Fractional kW motors - classification based on principle of working - commutator, induction and synchronous types - stepper motors - types of stepper motors - variable reluctance stepper motors - permanent magnetic stepper motor - hybrid stepper motor - multi stack VR stepper motor - constructional features - working - advantage - disadvantage and applications Permanent magnet synchronous motors - Construction advantages and applications Printed circuit motors - hysteresis motor Self - synchronizing reactors - synchronous - type of synchronous - constructional features and applications switched reluctance motor - construction working advantages & disadvantages - applications - construction and applications, Principles of AC servomotors

### **Electric Welding:**

Electric welding - types - resistance welding - spot welding - pre welding, seam welding and butt-welding - Electric arc welding - electrical properties of negative resistance - Types of arc welding - requirements of welding generators and transformers - Use of reactor for control of welding current - Third brush and Bipolar welding generator - description - problems

### **Industrial wiring and estimation**

Earthing - purpose - rules regarding earthing as per IS - estimation of materials used for a standard pipe earthing and plate earthing - costing Rules regarding power circuit wiring - estimates and cost of materials regarding wiring pump set in single phase and 3 phase systems - estimation and costing of control panel & wiring of small workshops - design factors - current density of copper and aluminium - conductor size - estimation and costing of service connection (single phase and 3 phase systems) - wiring using Underground cables and Overhead lines.

### **Overhead Lines:**

Extension of Overhead lines – Prepare estimate and cost for extending single phase Low tension distribution lines – 3 phase distribution lines – street lighting using O.H lines – U.G cables – Estimate and costing of 11 KV O.H line extension.

**Estimation of Substations:**

Estimation of sub station – IE rules regarding spacing of conductor - distance from building etc – materials used for erecting 11 KV substation – Preparation of the distribution sub station – 4 pole mounted sub station – plinth mounted sub stations Define installation scheme for a large industry - Prepare Schematic diagram for a given load Design of ratings of back-up fuse, ACBS, MCCB, bus bar, cables, capacitor banks, generator, change over mechanism, transformer etc as per rules