

**Eligibility** : Degree/ Diploma in Electrical Engineering

### **SYLLABUS –**

The Course deals with Electrical Power distribution system design including – equipment Selection, Specification, data sheets, & procurement & inspection of electrical equipment, Power / Lighting / earthing layouts, - Substation Design, Electrical network monitoring system & automation.

The subjects are detailed with reference to the following

- Overview of industry and their requirement of electrical systems.
- Role, Importance, Responsibility of Electrical Engineer.
- Client requirements & collection of specific data for projects.
- Use of International Standards, Design Basis, std. practices/procedure and specifications
- Understanding Basic Design requirement based on the type of various plants.
- Intra-discipline co-ordination with Instrumentation, Civil, Process, Mechanical, Piping, Telecom, HVAC, EHT etc...
- Calculations for Load list, Transformer sizing, DG sizing, Cable sizing, Earthing systems, Lightning systems, Lighting, Capacitor sizing, UPS & battery
- Introduction to Heat Tracing systems and cathodic protection.
- Electrical Power distribution protections
- Vendor drawing review and approval – typical transformer / LV switchgear
- Introduction to testing and Inspection of Equipment including FAT procedure.

### **Engineering of various types of Projects -----**

The Participants are introduced to various aspects of Engineering of Electricals of projects, the role played by electrical engineer in user friendly design of projects from concept to commissioning. Interfaces involved with other departments & their importance for smooth execution & commissioning of stage. Projects are discussed.

### **Key Processes in Electrical Project Design -----**

Overall project execution involves various stages such as FEED (front end engineering design), extended, Proposal engineering, basic engineering design,, detailed engineering design, Procurement of Electrical Equipment, Inspection of equipment, site support, Installation and commissioning, project handover

### **Electrical system design basis:**

This is fundamental document in any project which describes overall design philosophy of Electrical system and shall be considered as main guideline for system design from power generation to power distribution till the end.

### **Key single line diagram:**

This document indicates overall power distribution of electrical systems with ratings of main power components. Overall electrical system operating philosophy is understood from this document. This is basic document required for any project.

### **Protection and metering single line diagram:**

This document specifies detailed control, measuring & protection requirements for each type of feeder including hard wired interface and soft communication interface with other systems. Scheme drawings are prepared based on this document.

### **Load list (User list)**

Load list is also called as User list. Sometimes it is also referred as Utility list. This document contains all types of loads along with their rating. The loads are distributed as per key single line diagram in different HV/LV switchboards. Input to this documents is received from other departments like Instrumentation, Mechanical, HVAC, HSE, EHT, Metallurgy etc:

The transformer / DG sizing is decided based on this document considering different load factors. This document helps in deciding switchboard ratings and feeders.

### **Short Circuit analysis and symmetrical short circuit calculation**

This module explains short circuit fundamentals and short circuit analysis. Symmetrical short circuit calculation based on PU method is explained with example. Some of the highlights are :

- DC component in short circuit current
- Why does Short circuit current, remains very high for initially few cycles and gradually decreases and finally gets into steady state mode.
- Three types of reactance ----- Sub transient reactance  $X'd$  / Transient reactance  $X'd$  / Synchronous reactance  $X_d$ --- how long the sub transient/ transient and steady state current lasts
- What is the current and time the CB and the board are to withstand --- what is interrupting duty expected --- can the withstanding capacity be lower than interrupting capacity etc

- What is the meaning of high , low X/R ratio
- Motors contributions in fault calculation

### **Electrical Equipment's -----**

Understanding specifications & data sheets of electrical equipment from operation, utilization, construction and safety point of view.

Following electrical equipment's of the project are covered in detail during the course.

|     |                       |      |                                |
|-----|-----------------------|------|--------------------------------|
| A.1 | TRANSFORMER           | A.9  | LIGHT FITTINGS                 |
| A.2 | HV SWITCHBOARD        | A.10 | DG SET                         |
| A.3 | LT SWITCHBOARD        | A.11 | TG SET                         |
| A.4 | CABLES                | A.12 | BATTERY CHARGER                |
| A.5 | BUS-DUCT              | A.13 | CAPACITORS & ITS CONTROL PANEL |
| A.6 | MOTORS                | A.14 | NEUTRAL GROUNDING RESISTOR     |
| A.7 | LOCAL CONTROL STATION | A.15 | VFD                            |
| A.8 | DISTRIBUTION BOARD    | A.16 | UPS                            |

### **HV Switchgear -----**

The typical values of short circuit ratings / current ratings for Busbars / Standard voltage ratings of HV switchgear for Industrial premises as per applicable standard – type of CB– SF6 type breaker– Vacuum circuit breaker, – Fuse contactor units – Interlocks, Features IEC 62271 standard such as IAC classifications / Loss service continuity / Partition classes - double bus bar construction - list of type and routine tests

Introduction to Gas Insulated substation (GIS) - Typical construction – Layout drawing

### **HV switchgear construction & components**

1. Bus bar compartment
2. Low-voltage compartment
3. Panel ventilation (forced ventilation)
4. Connecting cables to low-voltage lug connector
5. Withdrawable vacuum circuit-breaker
6. Truck
7. Wipers of withdrawable section
8. Cover (stainless steel) to cable connection compartment (tool required to open)
9. Ventilation flap
10. Metal shutters (internal protection against solid foreign bodies and touch) made of stainless steel
11. Current Transformer, Potential Transformer
12. Make-proof earthing switch

### **Transformer -----**

- Construction – Conservator type & Hermetically sealed type --Tank --Base -- Reinforced to prevent distortion-- Base Safety & measuring instruments
- Transformer specifications and data sheets
- Impedance and short circuit rating
- Vector group -- Tap changers – OLTC – OCTC – Voltage regulation – Efficiency – KVA rating at no load condition – Transformer parallel operation
- Protections
- Type test -- Routine test -- Similarity report

### **LV Switchgear (PCC – MCC—PMCC-- Distribution boards)**

- Construction – Applicable standards – voltage category -- Separation Forms – IP code – IK code – Continuous current rating – Short circuit withstand rating – specification & data sheet – Front access / rear access construction – typical dimensions – Switchgear component utilization category – Icu / Ics / Icw terminologies – Type 2 co-ordination – let through energy concept – MCB types – type of motor starters

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#### **Cables -**

Why do we need cable? Types of cables -- Cable voltage specification (3.3/6.6 kV : 6.6/6.6 kV : 6.6/11 kV) –construction of HV and LV cable and component usage -- conductor types – temp withstand of insulations – laying conditions – derating factors applicable – SC withstand rating of cable -- cable sizing calculation -- bending radius -- points to be considered when selecting cables -- selection of cable based on protection equipment used

##### **➤ Bus Duct -----**

What is Busduct – HV – LV – phase segregated -- expansion joints at suitable intervals – wall frame assembly – different adopter chambers phase cross over chambers – Installation

##### **➤ Motors -----**

Type of motors – Different parts of motor – Motor specification – Different types of Induction motor starters (DOL / Start Delta / VFD / Soft starter / Magnetic amplifier) – basic criteria for selection of motor starter Cooling & Heating time constant Motor Insulation – Motor GA Enclosures – Cooling methods – Mounting types – Frame size – Motor duties - Temp detectors – Motors for VFD application

##### **▪ Local Control Station or RCU -----**

What is local control station.- types 'NO' 'NC' contact concept and use – ambient temperature effect. Control cable cores & cable entry requirements spare terminals— effect of extreme temperatures on MOC of LCS

##### **Lighting DB: -----**

Construction – SC rating – Lighting transformer use -- Lighting DB SLD –Load distribution

##### **➤ Lighting -----**

Understanding of different terms used in lighting -- Good lighting for productivity & comfort feeling. Types of Lighting (Plant lighting, Street lighting, Escape lighting, Office lighting, decorative lighting) – types of Light source & fixtures -- standard installation drawings. Lighting calculation methods

##### **➤ Diesel Generator Set -----**

Power Generation System -- Prime Mover/Generator -- Generator & AVR -- Generator Excitation Control Systems – self and separate excitation – Brush less generator – Generator auxiliary equipment – acoustic enclosure - Generator Protection -- Generator Synchronisation – Continuous / Prime / Standby duty --main task of AVR – how to read droop characteristics and analyse generator operation – synchro methods

##### **➤ Battery and chargers -----**

Battery classification-Types- applications – duties – types – vented vs valve regulated – allowed Hydrogen concentration -- Battery Room ventilation requirements – sizing fundamentals – typical load profile – Charger requirements

##### **➤ Power factor Correction -----**

Sizing power factor improvement Capacitor Banks:

- Calculate total kW demand and power factor on each switchboard-(Refer to the load list for each switchboard)
- Determine the value of the power factor to be improved (power factor shall generally be higher than 0.9 lag and below unity )
- Effect of harmonics on capacitors

##### **➤ Packages -----**

- What is package in project engineering - Package specifications – Electrical role in package – Package scope and interface with other departments

##### **➤ Uninterruptable Power Supply (UPS) -----**

What is UPSUPS applications – AC UPS – DC UPS UPS Configurations – UPS components and function - UPS & Battery Sizing

## Operation Modes:

➤ **Variable Speed drive (VFD) -----**

Introduction -- What is a Variable Frequency Drive? – Working principle – V/F ratio – Type of VFD – Voltage and current wave from at output of VFD – Type of cable to be used for VFD motors – Harmonics generation – 6 pulse / 12 pulse VFD and their characteristics Advantages and disadvantages of VFD – Energy saving concept – motor cooling consideration for VFD driven motors

➤ **Schemes -----**

Understanding scheme (wiring) diagram concept – Study of typical DOL & Star Delta motor starter scheme drawing – scheme drawing and protection / metering SLD relation – Interconnection diagram

➤ **Earthing -----**

Purpose of earthing -- classification of earthing --concept of earthing -- applicable standards -- quantities of good earthing --factors affecting the earthing resistance -- different types of earthing electrode -- calculating resistance of buried earthing strip -- inputs required for earthing calculation -- . calculation of no. of earthing electrode factors effect on ground resistance

➤ **Hazardous area Classification -----**

What is area classification classification Types (Zone / Gas Group / Temperature class) -- How to avoid explosion – use of fire tringle in practical situations- types of hazardous area equipment & applications – auto ignition temperature -- MEAG & max flame path- certification understand -- Dust Hazard

➤ **Substation -----**

Substation as load center – Substation equipment – layout – clearances between panels – escape path – material handling – coordination with HVAC & Instrumentation – Cellar and cable routing – bus duct – clearances above panels – exhaust duct – Substation automation system – Substation cutouts for cable entry – panel installation methods / base frame engineering – maintenance of equipment – arc flash – future expansion provisions – beam obstacle

➤ **Power Lighting Earthing layouts -----**

- How to prepare – how to coordinate – generate weld able surface on concrete – construction friendly design for short execution time – Various methods of cable engineering
- Light fitting installation standards
- lightning protection – coordinate with Civil for conductor fixing on sheets of warehouse
- Earth pits and interconnections – Earth bus – Earthing conductor

➤ **Protection -**

Protective relays general – Introduction / operation principle / terminology of protective relay / types of relays / instantaneous overcurrent relay / definite time over current relay inverse time overcurrent relay / directional over current relay

Motor protection requirements - abnormal motor operating conditions. Prolonged starting / locked rotor condition -- Failure of / inadequate ventilation --Bearing failure -- overloads -- Frequent starting / jogging - Single phasing -- Inverted phase sequence -- Under voltages / Over voltages -- Under frequencies / over frequencies -- Surge voltages -- Internal faults within the motor -- Earth faults

Protection principles for Generator, Transformer, Transmission line

➤ **Calculations -----**

Transformer Sizing -- Cable Sizing -- Lightning Protection -- Earthing Design Board Sizing -- Lighting Design --DG Sizing – Approach to battery sizing

➤ **Cathodic Protection & Heat tracing -----**

**Cathodic protection**

- Stray direct current corrosion
- Bi-metallic corrosion
- Galvanic corrosion of a single metal
- Cathodic protection
- Methods of applications
- Selection of CP

**Heat Tracing**

- Types of heat tracing system
- Overview of heat tracing system
- Selection and sizing of appropriate heat tracer
- Codes, approvals and standard

➤ **Document list -----**

Details all the documents generated by electricals – its input source - output sent to whom & why – specification list – calculations list – various schedules – standard drawings – P/L/E layouts – inter conn schedule are all addressed

➤ **Tutorials – assignments – unit test- final exam -----**

During the training the students are given assignments & tutorial work. These are followed by Weekly Assessments & final exam. The number of assignments will be at discretion of the faculty based on participants. The duration of Weekly Assessment & final exam are 2 & 3 hours respectively. These will be increased suitably based on participant's enthusiasm, interest. These tests are designed to increase confidence of the participants by exposing them to variety of questions.

➤ **Data sheets -----**

The data sheets form integral part of any equipment – Typical HV board, Transformer and MCC discussed

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