CASE STUDY ON REAL- TIME MONITORING AND FUNCTIONING OF CONTROL PANEL IN THE 33/11KV SUBSTATION

A Project Report Submitted in the Partial Fulfillment of the Requirement For

The Award of the Degree of

BACHELOR OF ENGINERRING

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

BY

KANTHI RAJKUMAR (160717734032)

Under the Esteemed Guidance of

MR. K. PULLA REDDY, M. TECH

Department of Electrical & Electronics Engineering

METHODIST COLLEGE OF ENGINEERING AND TECHNOLOGY

(An Autonomous Institution, Affiliated to Osmania University & Approved by AICTE, Accredited by NAAC with A+ and NBA)

King Koti, Abids, Hyderabad, Telangana – 500001

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CERTIFICATE

This is to certify that the project titled– "**REAL TIME MONITORING AND FUNCTIONING OF THE CONTROL PANEL IN THE 33/11KV SUBSTATION"** submitted by **KANTHI RAJKUMAR (ROLL No. 160717734032),** is a record of student own work carried by them under my guidance and supervision in partial fulfilment for the degree of **Bachelor of Engineeering in Electrical And Electronics Engineering** from **Methodist college of Engineering And Technology, King Koti, Abids, Hyderabad, Telangana – 500001.**

Guide	**HOD**
Mr. K. PULLA REDDY	**Mrs. Y. MASTANAMMA**
Assistant Professor, EEE Dept.	**Associate Professor, EEE Dept.**

Project In-charge	**External Examinar**
Dr. B. LAXMAN	
Associate Professor, EEE Dept.	

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I would also like to thank the Department of Electrical and Electronics Engineering, Methodist College of Engineering and Technology for providing us the opportunity to develop this project.

I am highly indebted to our parents for their constant encouragement and support during our studies.

I am honestly thankful to our friends for their help during the preparation of our project. Last but not the least, we are thankful to all those who helped us directly or indirectly in this endeavour.

ABSTRACT

In this project I am going to know the monitoring and functioning of each and every equipment in the controlling panel i.e. SCADA panel, relays, energy meter, breaker control, circuit breaker and how the tripping occurs in the above equipments.

In this project I am going to conduct 4-5 case study on different faults like over current (o/c), over voltage(o/v) and E/L faults and we are going to note down the values of the ammeter, voltmeter from low voltage(LV) side(11kv).

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1.INTRODUCTION

The real-time operation and monitoring of control panel in 33kv/11kv . In this project to observe the real-time monitoring and control panels we took KPHB substation for case study and we analysed the faults caused in transmission lines.

A control panel is cabinet which contains collection of electrical components designed to control and monitor the equipment's. The selection of component for a control panel us mainly based on

1) Power rating of the equipment

2) Incoming supply

3) Application of the equipment.

TSSPDCL is professionally manage for supplying reliability and cost efficiency of electricity to every citizen of KPHP Colony through highly motivated employee and state of art technology, providing economic returns.

The faults in power system network causes over current, under voltage, unbalance of phases, reversed power and high voltage surges. This result in severe electrical fires and failure of equipments.

2.CONSTRUCTIONAL DETAILS

2.1 CONTROL PANEL:

The control and relay panel shall be simplest type and access door shall be provided at the back of each panel where no instruments and relays shall be mounted. The indicating and signalling devices and relays etc. shall be mounted on the front side and auxiliaries which shall be inside the panel. The access door shall be back side and double door type.

The complete panel shall incorporated all necessary instrument, meters, relays, auxiliary relays, control switches, indicating lamps, mimic, annunciator, audible alarm, horizontal and vertical wiring trough, wiring support, interior lighting system, terminal blocks, fuses and links and SCADA etc.

2.2 CONSTRUCTIONAL FEATURES:

a) The control and relay panel shall comprise of cubic al type panels placed in juxta position to form a continuous board for each system voltage. If the panel are required to be alligned in the right angular formation, the tender shall be required to arrange covering plates for the uniform formulations without any extra price.

b) The manufacture shall be ensure that the equipment specified and such unspecified complementary equipment required for completeness of protection scheme be properly accomadated in the panels without congestion and if necessary to provide panels with large width. No price increses at a later date on this account shall be allowed.

c) Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degreeof protection not less that IP-31 in accordance with IS-2147.

d) Panels shall be free standing, floor mounting type and shall comprise structural frames enclosed completely with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of panels such as base frame, front sheets and door frames and not less than 2mm for sides, door, top & bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation.

e) All doors, removable covers and panels shall be of gasketed all around with neoprene gaskets. Ventilating covers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

f) Design, material selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent front outside, with all exterior surfaces tune and smooth.

g) Metal seals in the form of metal channels properly drilled shall be furnished by the Contractor along with anchor bolts and necessary hardware for mounting the panels. Panels shall be mounted on the other end of the channel.

h) Cable entries to the panel shall be from the bottom. The bottom plates of the panel shall be fitted with removable gland plates and fixed with cable glands. Necessary number of cable glands of sizes to suit external cables to the panels shall be supplied by the bidder. Cable glands shall be screwed type made of brass and shall be suitable for PVC armoured cable.

2.3MOUNTING:

a) All equipment on and inside the panels shall be mounted and completely wired to the terminal blocksready for external connection. The equipment of panel shall be mounted flush.

b) Equipment shall be mounted such that removal and replacement can be accomplishedindividually without interrupting of service to adjacent devices and are readily accessiblewithout use of special tools. Terminal marking shall be clearly visible and of permanent nature.

c) The contractor shall carry out cut out, mounting and wiring of the bought out items which are to bemounted in the panel in accordance with the corresponding equipment manufacturer's drawings.

d) The centre line of switches, push buttons and indicating lamps shall be not less than 750mm from thebottom of the panel. The centre line of relays and meters and recorders shall be not less than 450mm from the bottom of the panel.

e) The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat anduniform appearance. Likewise the top of all meters, relays and recorders etc. shall be in one line.

f) The control switches for circuit breakers and isolators shall be located on the mimic diagramcorresponding to their exact position of the controlled equipment in the single

line drawing. Thelocation of the switches shall be within working height from the floor level for easy and comfortable operation.

g) No equipment shall be mounted on the doors.

h) All the panels in the control room shall be matched with the other panels of the same C&R board inrespect of dimension, colour and appearance. Control equipment on front side of the panel shall be similarly placed.

i) All the equipment connections and cabling shall be designed and arranged to minimise the risk of fire and damage.

2.4 PAINTING:

a) All unfinished surface of the steel panels and frame work shall be sand blasted to remove rust, scale, foreign adhering material or grease.

b) A suitable rust resisting primer shall be applied on the interior and exterior surfaces of the steel, which shall be followed by of an under coat suitable to serve as base and binder for the finishing coat.

Sl.No	**Painting :**		
1	Type of painting	Powder coating	
2	colour	a)external colour shade	Shade RAL7032
		b)internal colour shade	White
		c)external finish	Texture semi glossy
		d)internal finish	Texture semi glossy
		e)base frame colour shade	Black
3	Thickness of paint	Average of powder coating	80-100 microns
4	phosphating	Sheet steel shall be phosphated in accordance to IS 6005	
5	Special instruction	Small quantity of paint shall be supplied for minor touch work required at site.	

2.4 Painting

2.5 WIRING:

All wiring shall be carried out with 1100 volts grade single core, multistrand flexibletinned copper wires with PVC insulation which has provided its utility in tropical regionagainst hot and moist climate and vermin (Misc. white ant and cockroaches etc.) Rubberinsulated wiring will not be accepted. Wire numberings and colour code for wiring shall beas per IS: 5578/1984. The wiring should be encased in suitable width PVC casing. Thewiring diagram for various schematics shall be made on thick and laminated durable whitepaper in permanent black ink and same should be pasted on the inside surface of the door.

5.2 The sizes of wiring in different circuit shall not be less than these specified below:

TABLE-1

Circuit	Permissible size of wire
Metering and Relaying Circuits connected Current Transformer	2.5 mm^2
Potential Circuits for metering and Relaying, Control, Visual Audible Alarms and Signalling Circuit	1.5 mm^2

2.5.1 Size of wire

The following colour schemes shall be used for the Wiring:

TABLE – II

Circuit where used	Colour of Wire
Red Phase of Instrument Transformer Circuits	Red
Yellow Phase of Instrument Transformer Circuits	Yellow

Blue Phase of Instrument Transformer Circuits	Blue
Neutral connection, earthed or not earthed in the instrument Transformer Circuit	Black
A.C. Control Wiring Circuits using auxiliary supply and	Black
D.C. Control Wiring Circuit using Battery Supply	Grey
Earth Connection	Green

2.5.2 Colour of wire

5.3 a) All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & trough shall be used for this purpose.

b) Longitudinal troughs extending throughout the full length of the panel shall be used for inter panel wiring. Inter connections to adjacent panels shall be brought out to a separate set of terminal blocks wires. All bus wiring for inter panel connection shall preferably be provided near the top of the panels running throughout the entire length of the panels.

c) Wiring connected to the space heaters in the cubicles shall have porcelain beaded insulation over a safe length from the heater terminals.

d) Wire termination shall be made with solder less crimping type and tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided to all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected for any purpose. Termination shall be such that no strand of a conductor shall left loose or overhanging. Conductor termination shall be secured to the holding nuts/screws, terminal blocks etc. with washers interposed between the terminals/holding nuts/screw heads. The terminals

shall be so connected that no conductor ferrule code gets masked due to overlay of conductors.

e) All spare contacts of relays shall be wired up to terminal blocks.

f) Each wire shall be continuous from end to end and shall not have any joint within itself individually.

g) Wires shall be connected only at the connection terminals or studs of the terminal blocks, meters, relays, instruments and other panel devices. Terminal Ends of all wires shall be provided with numbered Ferrules . At point of inter-connection where a change of number is necessary, duplicate Ferrules shall be provided with the appropriate numbers on the changing end.

3.SINGLE LINE DIAGRAM OF KPHB SUBSTATION

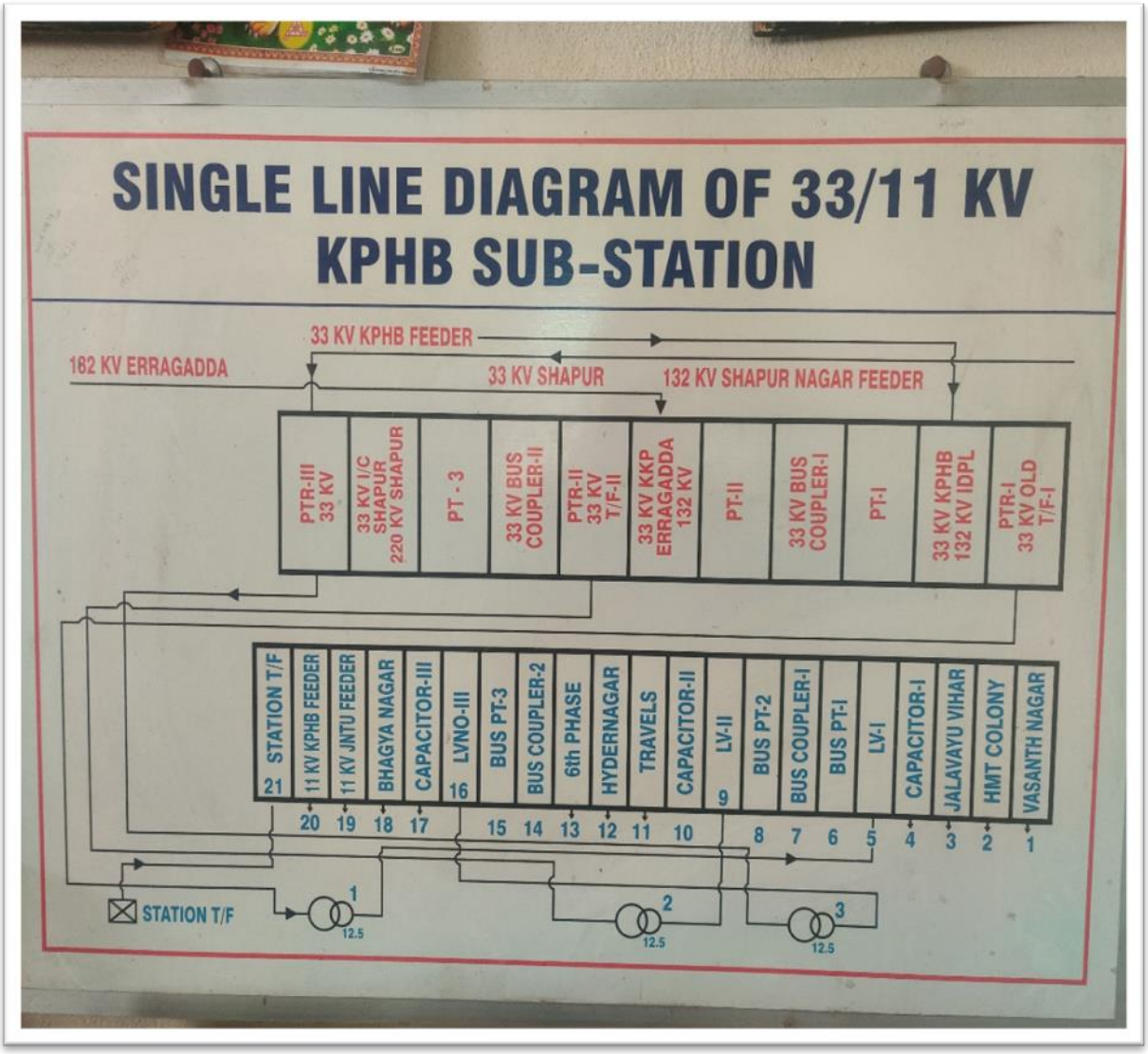

Fig. 3.Single line diagram

4.0 DISTRIBUTION AND CONTROL OF AUX. POWER CIRCUIT

4.1 D.C. CIRCUIT:

There shall be only one 30V D.C. for the entire Control and Relay Panel fed from a D.C. Distribution Panel. A continuous D.C. Bus shall be provided in the Control and Relay Panel and D.C. supply for control, protection, indication and supervision of circuit breaker and other equipment shall be teed off from D.C. bus through a set of 20 Amp rated H.R.C. Fuse on positive and negative side. D.C. supply to be teed off shall be distributed within the Panel as below:

Fig. 4.Battery charger

A substation battery charger ensures all the essential electrical systems in a substation continue to operate in the event of a power outage. An absence of an electrical supply could result in damage to equipment and personne

(a) Control DC scheme both positive and negative side with 16 Amp fuse

(b) Close/Trip Ckt 1 and Trip Ckt 2 without fuse; closing circuit with 10A fuse.

€ Indication Circuit through a set of 6 Amp. HRC Fuse both at +ve and –ve side

(d) Protective relay circuits through 6A fuse both at +ve and –ve side

€ Annunciation ckt with 6Amp fuse on both at +ve and –ve side

(f) DC Emergency Lamp with 6Amp fuse both at +ve and –ve side

Three nos. of D.C. operated no-volt auxiliary relay(self reset type) provided with hand reset type flag with inscription — 'Main D.C. Fail' , 'Control Dc fail' & 'Protection DC fail' with 4NO+4NC in each relay. 2 NC contact for 'DC fail' alarm and Indication, 1NO wired upto SCADA TB and 1NO wired upto spare TB.

One Push button having N/C Contact used in Series with the above relay for 'D.C. Fall Test' purpose.

4.2 A.C. CIRCUITS

230 Volts, Single Phase A.C. Aux. Supply to the Control and Relay Panel will be fed from A.C. Distribution Panel through a 16Amp MCB provided there. One 16 Amps rated HRC Fuse shall be provided at the Control & Relay Panel for the Incoming A.C. Supply. Two A.C. operated no volt auxiliary relay(self reset type) rated for 230V shall be provided with hand reset flag with inscription — 'A.C. Fail' & 'DC Fail Accept' with 4NO+4NC contacts for each relay. One push button having N/C Contact used in Series with above relay for — 'A.C. Fail Test' purpose.

5.CONTROL PANEL

Fig. 5. Contol panel

5.1 LABELING:

All front mounted as well as internally mounted items including MCBs shall be provided with individual identification labels. Labels shall be mounted directly below the respective equipment and shall clearly indicate the equipment designation. Labelling shall be on aluminium anodised plates of 1 mm thickness, letters are to be properly engraved.

5.2 EARTH BUS:

Each panel shall be provided with two earth bus of size 25 x 6 mm (min) each. The earth bus shall be of tinned plated copper, and all metallic cases of relays, instruments etc. shall be connected to this earth bus independently for their effective earthing. The wire used for earth connections shall have green insulation.

5.3 CIRCUIT BREAKER CONTROL SWITCH:

1 PISTOL GRIP TYPE Non- discrepancy T-N-C spring return type switch shall be provided for remote operation of circuit breaker to ensure that manual pumping of closing solenoid not possible. The switch shall be mounted in the mimic diagram itself such that the stay-put ('N') position will render the continuity of the mimic. One green LED for 'breaker open' indication and one red LED for 'breaker closed' indication shall also be provided adjacent to the T-N-C switch.

2 Switches should have finger touch proof terminals. For the convenience of maintenance, screw driver guide should be from top/bottom of the switch and not from the side. Terminal wire should be inserted from the side of the switch terminal.

3 Terminal screws must be captive to avoid misplace during maintenance.

4 Switch shall be with 48 mm x 48 mm escutcheon plate marked with Trip & Close.

5 Trip-neutral-close, with pistol grip handle must be pushed in to spring return to either trip or close position from Neutral position for safety and not just turn to trip.

6 One contact to close in each position of Trip and Close. Contact rating shall be 12 A at 30 V DC.

7 One spare contact is required in off & on position.

5.4 LOCAL/REMOTE SWITCH:

Local/Remote switch should be 4-pole, 2 way Lockable and stay put type.

5.5 INDICATING LAMPS:

L.E.D. Type Indicating Lamps shall be provided on the Control Panel to indicate the following:

Sl. No.	Functions	Quantity	Colour of Lamp
1	C.B. Spring charged indication	1 No.	Blue
2	C.B. trip Coil/Circuit healthy Indication	2 No.	White

3	C.B. Auto tripped indication	1 No.	Amber
4	Panel D.C. Fail indication	1 No.	Amber
5	P.T. Supply indicating Lamp	2 sets	Red/Yellow/Blue
6	C.B. —ON indication	1 No.	Red
7	C.B. —OFF indication	1 No.	Green

5.5.1 Indicating lamps

5.6 CONTACT MULTIPLIER:

230 Volts, Single Phase, 50 hz A.C.. Supply operated Contact Multiplier to be provided, if required.

5.7 TERMINAL BLOCK / TTB:

1. Terminal Blocks for incoming A.C and D.C. Circuit and C.T., P.T. & SCADA Circuit should be located on the left hand side and Transformer supervision, breaker control and spare in right hand side of the wall of the Panel seen from back side respectively.

2. 3-Phase, 4-Wire Link type Test Terminal Block having sealing provision shall be provided in Metering Circuit of each Panel.

5.8 SAFETY EARTHING:

1. Earthing of metallic parts or metallic bodies of the equipment on the Panel shall be done with soft drawn single conductor bare Copper Tail connections shall have minimum area of 16 sq, mm. and the main earthing connection 60 sq.mm. These wires shall be connected by suitable terminals and clamps junction. Soldered connections shall not be employed.

2. The neutral point of star connected LV winding of instrument transformers and one corner of the open delta connected LV side of instrument transformers shall be similarly earthed by tail connected with main earth wire of Panel Earthing System. Multiple earthing of any instrument transformer circuit shall be avoided.

6. INDICATING INSTRUMENT AND METERS

a. All instruments shall be flush mounted, back connected type and provided with dust tight cases for tropical use with dull black enamel finish. All fixing screws, nuts and threaded parts shall be designed to Indian Standards.

b. All instruments shall be of class 0.5 type. The calibration of the instruments shall function satisfactorily when mounted on steel panels or alternatively magnetically shielded instruments shall be used.

c. Instruments shall be capable of indicating freely when operated continuously at any temperature from 0 to 50 degree C.

d. All circuits of instruments shall be capable of withstanding applied load of 20% greater

than the rated capacity for a period of eight hours.

e. The instruments shall be capable of withstanding the effect of shock vibration and a dielectric test of 2000 Volts r.m.s. to ground for one minute as per relevant ISS.

6.1 AMMETERS:

All ammeters shall be provided with direct reading scale. Full Scale Value of the Ammeters shall be 100% of the nominal current of maximum C.T. ratio. The ammeters shall be connected to measuring C.T. Core. Ammeters shall be suitable for R.Y.B. Phase measurements. However, the ammeters to be supplied shall be of type ―DIGITAL‖. The auxiliary power of the ammeters should be 230V AC.

6.2 VOLTMETERS:

Volt Meter shall be provided with direct reading scale. The maximum value of the volt-scale be 15% in excess of the normal Circuit Voltage. The rated voltage of the Volt Meter shall be 110V A.C. However, the voltmeters to be supplied shall be of type ―DIGITAL‖. The auxiliary power of the voltmeters should be 230V AC.

Voltmeter Selector Switch

One Voltmeter selector switch having 7 position 6 way stay-put type shall be provided.

PT Selector Switch

One PT selector switch, 2 position, stayput type shall be provided.

6.3 ENERGY METERS:

Tariff Metering Equipments

(a) Three element Tri-vector Meters shall be supplied by the WBSEDCL. But Panel Wiring for the Meters along with Test Terminal Block and space for the Tri-vector Meters are to be provided for the Panels.

Fig.6.3. Energy meter

7.BUS COUPLER

Bus coupler is a device which is used to couple one bus to the other without any interruption in power supply and without creating hazardous arcs. Bus coupler is a breaker used to couple two busbars in order to perform maintenance on other circuit breakers associated with that busbar

Fig. 7. Bus coupler

7.1 ANNUNCIATOR:

A. ELECTRONIC ANNUNCIATOR

1. Suitable Multi-way Microprocessor based electronic Annunciator for the visual and audible alarm on the control panel using bright LEDs shall be provided in each panel to indicate over current and earth fault protection operated. In addition to above, each electronic annunciator of Transformer Control Panel shall have provision to indicate Transformer trouble trip/alarm function operated. Also one window of the Annunciator shall have to be used for Non-Trip A.C. Fail Alarm Indication and one window for Trip Circuit unhealthy indication. Each Electronic Annunciator shall have provision for connection with accept/reset/lamp test/mute Push buttons for proper functions. Electronic annunciator shall have provision for connection with Electronic Buzzer/Electronic Bell for Trip & Non-Trip Audio Alarm of common annunciation scheme. Electronic Annunciation shall have provision for flashing illuminating display with inscription for operation of respective Protection Relay. The Micro-Processor based Electronic Annunciator should have separate coloured windows for Trip & Non-Trip Annunciation for easy detection.

2. Annunciator fascia units shall have translucent plastic windows for each alarm point.

3. Electronic Annunciator shall have first Fault Indication Facilities & System Watch Dog

4. Annunciator facia plate shall be engraved in black lettering with respective alarm inscription as specified. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall be about 5 mm. The inscriptions shall be visible only when the respective facia LED will glow.

5.Annunciator facia units shall be suitable for flush mounting on panels. Replacement of individual facia inscription plate and LED shall be possible from front of the panel.

6. Unless otherwise specified, one alarm buzzer meant for non-trip alarms and one bell meant for trip alarms shall be provided in each control panel (mounted inside).

7. Each annunciator shall be provided with ‘Accept’, ‘Reset’ and ‘Test’ push buttons, in addition to external PB.

8. Special precaution shall be taken by the manufacturer to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels.

9. In case ‘RESET’ push button is pressed before abnormality is cleared, the LEDs shall continue to glow steadily and shall go out only when normal condition is restored.

10. Any new annunciation appearing after the operation of ‘Accept’ for previous annunciation, shall provide a fresh audible alarm with accompanied visual alarm, even if the process of “acknowledging” or “resetting” of previous alarm is going on or is yet to be carried out.

Provision for testing healthiness of visual and audible alarm circuits of annunciator shall be available.

16 Window Annunciation Scheme for 10 MVA Transformer (individually controlled) to indicate following functions:-		
i)	Differential protection(87) operated	1 no.
ii)	Non-directional protection (O/C+E/F) operated	1 no.
iii)	Oil Temp./Winding Temp/MOG Alarm for transformer	1 no.
iv)	Oil Temp./Winding Temp Trip for transformer	1 no.
v)	REF 64R(HV side) tripped	1 no.
vi)	REF 164R(LV side) tripped 1 no.	1 no.
vii)	Buchholz Alarm for transformer	1 no.
Viii)	Buchholz Trip for transformer	1 no.
ix)	OLTC Buchholz/ Main Tank PRV Trip for transformer	1 no.
x)	AC fail	1 no.
xi)	Trip Circuit/Coil 1or Trip Circuit/Coil 2 Unhealthy	1 no.
xii)	Non-directional O/C & E/F Relay Trouble	1 no.
xiii)	Differential relay troubl	1 no.
xiv)	Spare	1 no.
xv)	Spare	1 no.
xvi)	Spare	1 no.

Mounting	**flush**
No of facia windows	16
Supply voltage	30v DC
No. of LEDs per windows	2
Lettering on facia plate	Properly engraved

7.1.1 16 Window annunciation

12 Window Annunciation Scheme for 6.3 MVA Transformer (individually controlled) to indicate following functions:-		
i)	Non-directional protection (O/C+E/F) operated	1 no.
ii)	Oil Temp./Winding Temp/MOG Alarm for transformer	1 no.
iii)	Oil Temp./Winding Temp Trip for transformer	1 no.
iv)	REF 64R(HV side) tripped	1 no.
v)	REF 164R(LV side) tripped 1 no.	1 no.
vi)	Buchholz Alarm for transformer	1 no.
vii)	Buchholz Trip for transformer	1 no.
viii)	OLTC Buchholz/ Main Tank PRV Trip for transformer	1 no.
ix)	Panel AC fail	1 no.
x)	Trip Circuit/Coil 1 or Trip Circuit/Coil 2 Unhealthy	1 no.
xi)	Non-directional O/C & E/F Relay Trouble	1 no.
xii)	Spare	1 no.

Mounting	**flush**
No of facia windows	12i
Supply voltage	30v DC
No. of LEDs per windows	2
Lettering on facia plate	Properly engraved

7.1.2 12 Window annunciation

12 Window Annunciation Scheme for Feeders to indicate following functions:-		
i)	Non-directional protection (O/C) operated	1 no.
ii)	Non-directional protection E/F operated	1 no.
iii)	Panel D.C Fail	1 no.
iv)	Trip Circuit /Coil 2 Unhealthy	1 no.
v)	Panel A.C Fail	1 no.
vi)	Trip Circuit /Coil 1 Unhealthy	1 no.
vii)	Non-directional O/C &E/F Relay Trouble	1 no.
viii)	PT MCB Tripped	1 no.
ix)	Spare	1 no.
x)	Spare	1 no.
xi)	Spare	1 no.
xii)	Spare	1 no.

Mounting	**flush**
No of facia windows	12i
Supply voltage	30v DC
No. of LEDs per windows	2
Lettering on facia plate	Properly engraved

7.1.3 12 Window annunciation

7.2 PANEL D.C. FAIL ALARM SCHEME:

Control & Relay Panel shall have a common ― 'Panel D.C. Fail' Alarm Scheme operated by 230 V Single phase A.C. Aux. Supply for audible as well as visual alarm in case of failure of D.C. incoming supply to the Panel.

Another Single Element Relay without Flag and 1 no. self-reset type N/O & 1 no. N/C contact having inscription ― 'Panel D.C. fail' alarm accept Relay shall be provided. Besides above, 1 no. Indicating Lamp, 1 no. A.C. Operated Electric Hooter and 2 nos. Push Button, one having 1 no. N/C contact, the other having 1 no. N/O contact shall also be provided for successful operation of the scheme. All auxiliary relays required to render Annunciation System operative and shall be considered to be within the scope of the tender.

AC fail, DC fail scheme shall be operated by relay not contactor

8. P.T SECONDARY CIRCUIT

There may be two nos. 33KV bus PT, one in each bus section. P.T. supply shall be available from selected 33 KV Bus P.T through suitable PT selection scheme by switch. Two sets of Fuse and link of suitable rating shall be provided for the Incoming P.T supplies and two sets, one for each PT of 3 nos. coloured LED indicating lamps shall be provided for supervision of the Fuse. Lamps shall be connected between respective phases and neutral. The arrangement of distribution of P.T. Secondary Circuit shall be as follows:

Fig. 8 Potential transformer

a) Potential supply to the protective relay circuit for Feeder where necessary shall be fed from selected Bus P.T. supply bus.

(b) Potential supply to meters, Energy meters and indicating instrument of each panel shall be fed from selected Bus P.T. supply bus.

I Selected P.T. secondary supply to the protective relays of each panel shall be fed through 4 poles – MCB and link in neutral in each panel where necessary with two changes over contacts for annunciation.

d) Selected P.T. secondary supply for metering and indicating instruments of each panel shall be fed through 4 pole MCB in each phase and link in neutral in each panel of 33KV system voltage.

e) Two position (PT-1/PT-2), minimum 4(four) way PT selector switch (stay put type), minimum 16A rating shall be provided in each panel for metering ckt. Additional 4-way PT selector switch is required for protection wherever applicable. The no. of way may increase during detailed engineering.

9.RELAYS

9.1 GENERAL REQUIREMENT:

The main protective relays SCADA Compatible Numerical Directional/Non Directional O/C & E/F Relays shall be of panel manufacturer_s own make. However, multinational company manufacturing panel in India may import required/desired relays from their foreign counterpart with same brand name at their own risk, cost and responsibility without hampering the stipulated delivery schedule as stated in the tender notification.

Credential for offered relays shall also to be furnished along with C&R panel in tender documents as pre-requisites of tender.

All numerical relays shall be provided with 'Relay Failure Annunciation contact'. Live demonstration of any offered relay has to be arranged by the party at the laboratory of Distribution Testing Department of WBSEDCL, if felt necessary by WBSEDCL before finalizing the Bid.

9.2 SCADA COMPATIBLE NUMERICAL DIRECTIONAL/NON DIRECTIONAL O/C & E/F RELAYS:

The primary requirements of the relays are to protect the respective single circuit or double circuit feeders and 33/11KV Power Transformers in the event of fault. The Directional/Non Directional E/F relays shall provide suitable sensitivity for limited earth fault current.

The relay should be suitable for substation automation, primary circuit breaker operation through SCADA from remote control room .

9.3 OTHER PROTECTIVE RELAYS:

 Differential relay shall be of numerical type

 REF relay etc. may be of static type.

9.4 OTHER PARTICULARS RELATED TO ALL RELAYS:

1) All shall conform to the requirement of IS: 3231 / IEC 255 and shall be suitable for operation within a temperature range 0ºC to 55ºC and 95% relative humidity. Relays shall be suitable for flush / semi flush mounting on the panel with connections from the rear, protected with dust tight cases for tropical use and with transparent cover removable from the front.

3) All A.C. relays shall be suitable for operation at 50Hz. The current coils shall be rated for a continuous current of 1 amp and the voltage coil for 230V normal. The contacts of the relays shall be properly designed to prevent or minimise damage due to arcs which have to be broken successfully against 30V +/- 10% volt DC. When open, the contacts shall withstand a voltage of 115% of the normal circuit voltage. The relays shall be designed for satisfactory operation between 70% to 110% of rated D.C. voltage of the sub-station. The voltage operated relays shall have adequate thermal capacity for continuous operation.

4) Timers shall be of static type. Pneumatic timers are not acceptable.

5) The Relays shall preferably be provided with suitable Seal-in-Devices. Relays should be immune to all types of external influences like Electro static, Electromagnetic, Radio interference, shock etc.

6) All the numerical relay should have provision for setting all the features available in the relay and viewing those setting as well as different other parameters through both built in display unit as well as through PC. All numerical relays shall have self monitoring feature with watch dog contact. The supply of relay should be inclusive of necessary software and hardware for interfacing with a PC, to be supplied by the bidder.

9.5 PROTECTION SCHEMES

9.5.1 PROTECTION SCHEMES FOR 33 KV FEEDER

NON-DIRECTIONAL OVER CURRENT AND E/F PROTECTION:

This relay shall be used for 33KV radial feeder. The relay shall

a) be three O/C & one E/F element type.

b) have IDMT characteristics with time current characteristics of 3 sec at 10 times current setting.

C) have variable current setting of 50% to 200% of rated current and adjustable time setting.

d) have high set unit with current setting 500%-2000% for protection and 33 KV feeder protection, with very low transient overreach.

e) Definite Time Sensitive Earth Fault Protection may be inbuilt function of Numerical overcurrent Relay and shall have a variable current setting range minimum 1% to 40% in very small steps of CT secondary current and wide range of definite time setting range minimum. 0.1 to 10 Sec. This relay shall be used in 33 KV feeder for detection of line to ground fault current of both very low and high magnitude where the 33 KV system is grounded through earthing transformer.

e) LED indication for numerical relays of different type of faults including phase identification.

9.5.2 PROTECTION SCHEMES FOR 33 KV PARELLEL FEEDERS AT RECEIVING ENDS

DIRECTIONAL PROTECTION :

Directional O/C & Directional Instantaneous E/F Relays shall be required for 33 KV parallel feeders as specified in the schedule of requirement. Each Feeder shall be provided with 3 elements IDMT Voltage polarized O/C Relays and single element voltage polarized E/F Relay. The O/C Relays shall be IDMT type with high set element. The E/F Relay shall have directional sensitive E/F setting having wide range of setting (1-40%) & wide range of definite time setting range minimum. 0.1 to 10 Sec. The relay

shall also have instantaneous unit. The relay shall have necessary P.T. fuse failure monitoring scheme.

Characteristics: -

O/C Element: IDMT with High Set Unit	**Current Settings & Operating time**	IDMT-50-200%, 0-3 sec, Inst.-5002000%or 400-1600%
MTA	Selectable MTA for Directional Relay should cover 1st quadrant in a non-effectively grounded system	
Polarized P.T. Voltage	110 V A.C.	
E/F Element		
Current Setting	1-40% (minimum.) in	
	very small steps	
Operating Time of Relay	Instantaneous	
Operating Time of Timer	0.1 to 10 Sec in very small steps	
MTA	Selectable MTA for Directional Relay should cover 1st quadrant in a non-effectively grounded system	
Open Delta P.T. Voltage	63.5 V A.C.	

9.5.2. Directional protection

The numerical directional relay shall have in-built feature for derivation of zero sequence voltage internally. If separate IVT is required for derivation of zero sequence voltage for directional earth fault element, the particulars shall be as per following Technical

Parameters: -

1	Insulation Level	1.1KV
2	Over Voltage Factor	1.2 Cont./1.9 for 8 Hrs.
3	Transformation Ratio	110 V/√3 / 110/√3
4	VA Burden/Phase	7.5
5	Accuracy Class	3P
6	No. of Phase	Single
7	Type	Epoxy Cast Resin Indoor Single Phase Voltage Transformer
8	Formation	3 nos. Single Phase P.T. shall be connected in primary as Star and Secondary as Open Delta with neutral of Primary and one end of Open Delta earthed.

9.5.2.2. Parameter

9.5.3 PROTECTION OF 33 KV INDIVIDUAL TRANSFORMERS :

For protection of H.V. Side of the Transformers, following main protective relays are required

Numerical O/C protection.

ii) 2 sets Restricted E/F Relay shall be provided for HV and LV side of individual control transformer panel.

iii) 1 set Differential Relay in addition to above, shall be provided for 10 MVA 33/11KV transformer panel.

Differential Relay shall be

Provided at 33KV panel of the transformers to be protected. It shall be numerical adjustable/variable percentage biased type differential relay.

Necessary software, cables, connectors and other accessories as required for download, analyze data etc. shall be within the scope of successful bidder.

The relay shall be very fast in operation with an operating time less than 40 millisecond at 5 times setting.

The relays shall be inherently stable for external through fault conditions without affecting the speed of operation for internal faults.

The relay shall have either a built in facility of ratio and phase angle correction or necessary interposing Auxiliary current transformers of universal type, shall be provided in the respective panel.

The relay shall be provided with 2^{nd} harmonic restraint or any other inrush proof feature to prevent operation due to magnetizing in rush current when the transformer is charged either from HV or LV side. But this shall not affect the speed of operation for internal fault.

It shall be provided with 5^{th} harmonic restraint features to prevent operation due to possible over excitation of the transformer. This shall also not affect the speed of operation for internal fault.

The relay shall have adjustable bias setting range 20% to 50% and adjustable operating setting range of 10% to 50% at zero bias.

It shall have three instantaneous high set over current units for clearing heavy internal fault.

The relay shall be with 2-bias winding.

The relay shall be such that there will not be any necessity of changing the setting of the relay whenever the transformer taps are changed from +5% to-10%.

The bidder has to furnish the type test report from CPRI/NABL accredited Govt. recognized Test House and performance certificate from Power Utilities in India.
Differential relay shall have facility for setting, parameterization, downloading the storage data, data captured by disturbance recorder etc. locally through PC. The necessary PC, Windows based Licensed software for establishing the facility to be considered in the scope of the supply by the Bidder.

The relay shall have disturbance recording (with time stamping) function with suitable no. of analog and digital channels, Memory size and number of disturbances stored in the relay shall be clearly indicated in the offer. No. of site selectable BI, BO and watchdog contact details, communication port details (front, rear) along with necessary hardware and software details shall be furnished with the Bid documents.

9.5.4 RESTRICTED EARTH FAULT PROTECTION :

The above protection shall be provided for 33/11 KV transformers at HV and LV side. The Relay shall be:

a) Single pole type.
b)Current/voltage operated high impedance type with a suitable setting to cover the maximum portion of transformer winding. Necessary calculation to prove the above winding coverage shall be furnished along with the tender.

a) Tuned to the system frequency.
b) Have suitable nonlinear resistor to limit the peak voltage and stabilizing resistance.
c) Operating time shall be less than 40 ms.
d) Shall be standalone type.
e) Have suitable stabilizing resistor to prevent mal operation during external faults if necessary.

9.5.5

A set of D.C. Voltage Operated Aux. Relays with coil cut-off arrangement and 4No and 4 NC contacts, hand reset with flag indicator type shall be provided for each

Transformer for

- Buchholz Alarm
- Buchholz Trip
- Winding Temp. Trip & winding temp. alarm
- Oil Temp trip & Oil Temp. Alarm
- Low Oil Level Alarm
- Pressure Release Device Trip
- OSR for OLTC trip

Each Transformer Panel shall be provided with a High Speed Tripping Relay with coil cut off arrangement having 6 NO and 4 NC electrical reset with flag indicator type .

9.5.6 AUXILIARY RELAYS, TRIP RELAYS and TRIP COIL/ CIRCUIT SUPERVISION RELAYS :

Auxiliary Relays- D.C. Voltage operated auxiliary relays provided with mechanically operated hand reset indicator and sufficient no. of hand reset contacts shall be provided for protection and supervision against transformer internal trouble/faults. No of elements and number of relays shall be as per requirement of individual transformer.

For Trip Circuit Supervision Relays - All Panels should be provided with D.C. Voltage operated Trip Circuit Supervision Relay having provisions for pre & post close supervision of Trip Circuit with set of self-reset contacts provided for Trip Circuit Healthy Indication and Trip Circuit unhealthy indication& Alarm in respect of Trip Coil/circuits of respective Breakers.

Tripping Relays- All Panels should be provided with D.C. Voltage operated High Speed Tripping Relays having self reset contacts capable to make, carry and break trip coil current. Sets of Trip Contacts shall be provided for Inter-tripping function of corresponding 11 KV Incoming Switchgear and closing blocking function of 33 KV & 11 KV Breakers in respect of Transformer Control Panels. Each set of trip relay shall have minimum two nos. NO and 1No. NC contact as SPARES. The operating time of master trip relay shall be less than 40 ms and electrical reset type.

9.5.7 TRIP CIRCUIT/COIL SUPERVISION SCHEME:

Trip circuit supervision scheme shall be such that testing of trip circuit healthiness is possible irrespective of whether the C. B. is in the closed or open position. The Trip Circuit Healthy LED should glow continuously in CB _ON' Position and on demand in C.B. _OFF‖ position. The rating of dropping resistance in series with Trip Circuit Healthy LED shall be such that the Trip Coil should not get damaged because of continuous current flowing through it.

9.5.8 Principal requirements of protective relays, metering equipments, auxiliary relays breaker control switches etc. are as follows:

9.5.8.1 AMMETER:

Each circuit one ammeter shall be provided with the following:

Mounting	Flush
Size	96 x 96 mm. case
Response Time	1 second
Operating Temperature	Up to 55°C

Dielectric Strength	**16** kV RMS for 1 minute
Auxiliary Supply	230 volt A.C, 50 Hz
Operating Current	1 A from CT Secondary.
Type	Panel Mounting with $3^1/_2$ Digital Display.

9.5.8.1. Ammeter

9.5.8.2 VOLT METER:-

Mounting	Flush
Size	96 x 96 mm. case
Response Time	1 second
Operating Temperature	Up to 55°C
Dielectric Strength	**16** kV RMS for 1 minute
Auxiliary Supply	230 volt A.C, 50 Hz
Operating Current	1 A from CT Secondary.
Type	Panel Mounting with $3^1/_2$ Digital Display.

9.5.8.2.Voltmeter

9.5.8.3 BUZZER :

One DC buzzer shall be provided in the panel for non-trip alarm. One DC Bell shall be provided for Trip alarm and one AC Bell for Panel DC fail alarm.

9.5.8.4 HIGH SPEED TRIPPING RELAY ELECTRICALLY RESETTABLE TYPE CONFIRMING TO IS – 3231

Aux. voltage	30 V or 110 V D.C to 33ppro. Voltage 30 V or 110 V D.C to be decided during detailed engineering stage
Coil rating	30V D.C., voltage band for satisfactory operation : 50 to 120% of rated voltage
Operating Time	40 m. seconds nominal at rated voltage
Burden Of relay coil watts (Max)	Low burden 40 Watt at rated voltage
Operating temp	-10 deg C to 55 deg C.
Operational indication for each element	Mechanical red colour Flag : Electrical Reset Type
Contact Configuration	6 NO + 4 NC combination with additional hand reset coil cut of contact (Seal in contact)

9.5.8.4. high speed tripping relay

CONTACT RATINGS:

Make and carry	A.C. 1250 VA with max 5 amp & 660 Volts D.C. 1250 W dc with max 5 amp & 660 Volts
Make and carry for 3 sec.	A.C. 7500 VA with max 30 amp & 660 Volts D.C. 7500 W dc with max 30 amp & 660 Volts
Break	A.C. 1250 VA with max 5 amp & 660 Volts D.C. – 100 W resistive 50 watt inductive with max 5 amp & 660 Volts
Insulation	2 KV RMS, 50Hz for 1 min. 3.2.5 KV/1 sec between all terminals & case as per IS 3231. 1 KV RMS, 50Hz for 1 min. across open contact
Type of mounting	Flush

9.5.8.4. Contact rating

9.5.8.5 NUMERICAL BASED DIFFERENTIAL PROTECTION RELAY WITH INBUILT CURRENT AMPLITUDE & VECTOR GROUP COMPENSATION FEATURE & ALSO WITH DIFFERENTIAL HIGH SET ELEMENT FOR TWO WINDING POWER TRANSFORMER COMPLIANT TO IEC 60255.

Aux. voltage	30 V or 110 V D.C to be decided during detailed engineering stage
C.T. secondary	Selectable 1 amps / 5 amps for both HV & LV sides

Online display of HV & LV phase currents & differential current	
Adjustable bias setting	10 to 50% In.
Operation based on fundamental frequency	
Programmable HV/LV CT ratio of T/F vector group	
Inbuilt REF protection	
Inbuilt HV & LV side over current & earth fault protection	
Inbuilt transformer trouble auxiliary relay	
Backlit LCD display	
Harmonic restrain feature	
Storing facility of latest 5 fault events with real time clock	
Password protection	
DC burden	Quiescent condition – 35pprox. 4 watt Under trip condition – 30 Volt – 35pprox. 4 watt, 110 Volt – 35pprox. 7 watt.
AC burden	Through current only – 35pprox. 0.15 VA for 1 amp & 0.30 VA for 5 amp (per bias circuit) Bias & differential Ckt only: 2.8 VA for 1 amp & 3.2 VA for 5 amp.
Contact arrangements	Two change over self reset tripping contacts & two annunciation contacts

Contact rating	Make & carry 7500VA for 0.2 sec. with max 30 A & 300 V AC or DC carry continuously 5 amp AC or DC break 1250 VA AC or 50 W DC resistive, 25 W L/R – 0.04 s subject to max. 5 amp & 300 Volts
Current Input	Six for differential & one for REF
Self diagnosis feature for healthiness of relay	
Flush mounted / draw out type	

9.5.8.5. Differential protection relay

10.CONTROL & RELAY PANELS

Control or relay boards are built up by using requisite number of self-contained sheet steel cubicles, comprising a front panel to carry the control apparatus & the hinged or removable back cover to give access to interior wiring, cable termination. This type is called as Simplex type panel. When panels are arranged back to back in corridor formation, and door is then fitted at each end, are called as Duplex panels. Depending upon the size of the substation the control and relay board may incorporate the followings:

1) Indicating and metering instruments mounted on front.

2) Relays mounted on the backside in Duplex panel, flush mounting on front in Simplex panel.

Fig10.1 Relay panel

3) A mimic diagram representing main circuit connections is incorporated on the front panel. It is a single line diagram incorporated on the front side of the control panel. This diagram represents the actual physical position of various HT electrical equipments in the sub-station

yard along with status of equipments, ON and OFF positions of various breakers and isolators through semaphore indication or lamp indication.

4) Circuit Breaker control switch (TNC switch) is fitted on front. Normally switch is on Normal (Centre) position. Handle is moved to the right or left to initiate close or trip operations.

5) Indication lamps mounted for various purposes follow a standard colour code.

Red – C.B. or switch CLOSED

Green – C.B. or switch OPEN

White – Trip circuit healthy

Amber – Alarm indication i.e. CBs tripped on fault

6) Annunciation System – It gives alarm in case of any abnormality in the system.

Alarm bell rings and appropriate facia lamp flashes ON & OFF. Substation

operator has to ACCEPT the signal by pressing a button, which silences the bell and causes the lamp to show a steady light. After taking remedial action, the operator RESETS the alarm circuit by pressing another push button, the lamp being simultaneously extinguished.

10.2 COMMON FERRULE NUMBERS USED IN WIRINGS:

A: CT secondary connection for primary protection like Differential, Distance,

REF Relay). Small "a" used for PT secondary connection in PT terminal box.

B: Bus bar Protection (CT secondary connection). B for B phase indication.

C: Back up Protection (CT secondary connection for O/C & E/F Relay).

D: Metering (CT secondary connection).

E: Metering & Protection (PT secondary connection).

H: A.C. supply.

J: D.C. main supply

K: D.C Control cable

L: Indication circuit

M: Motor Supply (spring charging Motor in Circuit Breaker).

N: RTCC (Tap Changer) connection. Also for denoting A.C. Neutral connection.

P: PT primary connection & DC circuit of Bus bar protection scheme.

R: R Phase Indication.

S: CT secondary connection in Terminal Box.

U: Circuit Breaker auxiliary contacts.

X: TB Numbering.

Y: Y Phase Indication

11. STATION TRANSFORMER

This is a small distribution transformer located in the substation premises. It has given protection through proper rating of D.O.Fuse. Incoming HT supply to the transformer is tapped from LT bus of substation through Isolator. The output voltage 440 Volt is terminated to ACDB through LT cables. The main purpose of station transformer in substation is to provide auxiliary supply to various equipments through A.C. Distribution Board (ACDB) via MCBs or Switch Fuse

UNITS:

1) A.C. supply is used for battery charger, which converts A.C. to D.C. supply for charging the batteries and parallel provides D.C. source for various controls of substation equipments. In case of A.C. supply failure, batteries will take care of D.C. supply continuity for equipment's controls.
2) A.C. supply is used for OLTC for tap changing operation of transformer and
also cooling arrangement of transformer.
3) A.C. supply is used for spring charging mechanism of breakers.
4) A.C. supply is used for Office and Yard Illumination.
5) A.C. supply is used for Oil filtration, some miscellaneous welding work, and
Test supply for carrying out testing of various equipments in switchyard

12 BATTERIES & BATTERY CHARGER

For controlling various operations of substation equipments, suitable D.C. supply is required. In battery charger panel, A.C. 1 phase or 3 phases is given, which converts A.C. to D.C. supply. This D.C. supply is given to various control panels of substation and for charging the batteries through D.C.Distribution Board. (DCDB) In case of A.C. supply failure, batteries provide D.C. supply for controlling the operations of substation equipment in normal or abnormal conditions. Battery capacity is expressed in 'Ampere Hours' which is the useful quantity of electricity that can be taken from a battery at the specified rate of discharge before its cell voltage falls to the specified value, which is equal to 1.75 volts multiplied by the number of cells. Ampere hours is equal to the product of the specified discharge current in amperes multiplied by the number of hours before the battery discharges to the specified extent.

12.1 PRECAUTIONS / MAINTENANCE:

- Batteries should be cleaned regularly.
- Cell voltages & Specific gravity is to be recorded as per schedule.
- Batteries should be charged in a well-ventilated place, so that the gases and the acid fumes are
  Blown away
- Do not disturb any connection with charger on, as there is risk of sparking.
- If acid or electrolyte gets spattered into the eyes, wash them immediately with large quantity of
  Clean,cold water.
- Tighten connections periodically. Apply petroleum jelly to terminals to prevent corrosion.
- Maintain level of the electrolyte – Add only the distilled water. Add electrolyte
  only if some of the electrolyte spills out.

13. MEASURING INSTRUMENTS

VOLTMETER:

Voltage in an AC circuit is measured by voltmeter. The voltmeter is connected across the load or winding. For high voltage, voltage transformer is necessary to step down the voltage for measurement. Voltmeter is connected across the secondary circuit of PT. Voltmeter can be replaced on line by removing fuses or keeping voltmeter selector switch in OFF position.

AMMETER:

Current in a circuit is measured by ammeter connected in series of current path. If current is high, suitable current transformer (CT) is necessary to step down current for measurement. Ammeter is connected in series of secondary circuit of CT. Ammeter can be replaced by shorting CT secondary wires or keeping ammeter selector switch in OFF position.

ENERGY METER:

The Power in electrical circuit is measured by energy meter. Energy is the total power consumed over a certain period and is measured in kilowatt-hour (KWH). One kilowatt-hour is equal to the energy consumed when power is utilized at the rate of one kilowatt for one hour. The term ‘unit’ used for expressing consumption of electrical energy is equal to one kilowatt-hour, and all tariffs for energy consumption are based on this unit. A registering mechanism in the energy meter indicates the total energy consumption. Energy meters willrecord correctly, if connections are made with due care to the polarity and the terminal markings. Energy meters can be changed or replaced while in service by use of T.T.B. (Test terminal block). In TTB, CT secondary can be shorted during removal of Meter (avoiding open circuit of CT secondary) & PT supply can be made OFF by disconnecting type arrangement or by removing fuses. Energy meter records Import / Export energy parameters. Import parameters are displayed by arrow $\longrightarrow$ in direction and Export parameters $\longleftarrow$ in direction.

14.EARTHING OF EHV SUBSTATION

One of the important aspects in the operation of the protective equipment is proper earthing. By earthing, it means making a connection to the general mass of the earth. Earthing also increases the reliability of the supply service as it helps to provide stability of voltage conditions, prevent excessive voltage peaks during disturbances and also as a means of providing a measure of protection against lightning. For outdoor substation, a main earthing ring should be provided round the substation which should be connected to all earth electrodes. The ring should be laid so as to have shortest connection from transformers, circuit breakers etc.

14.1 TYPES OF EARTHING:

It can be divided into Neutral earthing & Equipment earthing.

NEUTRAL EARTHING deals with the earthing of system neutral to ensure that neutral points are held at earth potential and return path is available to neutral current.

Points to be earthed: Transformer neutral is to be earthed to two separate and distinct earth electrodes interconnected with substation earth mat.

EQUIPMENT EARTHING deals with earthing of non-current carrying parts of equipments to ensure safety to personnel & protection against lightning. Points to be earthed: All non-current carrying metallic parts of equipments, structures, enclosures, overhead shielding wires, flanges of bushings, cores of transformer, cable sheaths, earthed screens, pipes, portable appliances, fences, doors, screens.

14.2 COMMON EARTH SYSTEM FOR LOW AND HIGH VOLTAGE SYSTEMS:

There should be common earth bus for both high and low voltage systems. If the low voltage neutral is not connected to the common earth system but has a separate earth bus, then there will be a difference of potential between the high voltage and low voltage neutrals and there can exist a dangerous potential gradient across earth surface which can endanger life. With a low resistance earth bus and the neutrals connected to a common earth system, there will be no danger to the low voltage system and advantages in keeping everything in the station at a common potential above earth will outweigh the disadvantages.

A) LA EARTHING – The earthing lead for any LA shall not pass through any iron or steel pipe, but shall be taken as directly as possible from the LA to a separate earth electrode interconnected with substation earth mat. Individual earth electrodes should be provided for

each station type lightning arrester, while for distribution type lightning arrester, one electrode may be provided for a set of lightning arresters.

B) COUPLING CAPACITORS EARTHING – A separate earth electrode, generally a driven rod or pipe, should be provided immediately adjacent to the structure supporting the coupling capacitors of carrier current equipment. This earth should be used for the high frequency equipment only.

C) OVERHEAD LINES EARTHING – Overhead lines are earthed:

a) to eliminate danger from broken line conductors and insulators by ensuring the operation of the protective control-gear under such conditions.

b) to discharge lightning strokes to earth.

c) to minimize inductive interference with the communication circuits. One or more earth wires of G.I. Are run along the power line (above the conductors)

14.3 SOME COMMON DEFINITIONS:

A) EARTH ELECTRODE: Any plate, pipe or rod embedded in the earth to obtain effective electrical connection with general mass of the earth is known as Earth Electrode.

B) TOUCH POTENTIAL: If a person standing on substation floor touches a faulted structures by raised fingers, potential between his raised fingers and the feet is called touch potential.

C) STEP POTENTIAL: If fault current flowing through the ground of the sub-station, a potential between two steps of a person standing on the ground is called step potential. A person moving in the switchyard and touching an earthed metallic structure should not get a shock. Hence touch potential should be below 45 Volt. Also step potential should be below 45 Volt so that a person walking on substation floor does not get shock due to high step potential.

14.4 FACTORS TO BE CONSIDERED FOR DESIGN OF EARTH MAT FOR A SUBSTATION: -

1) **SOIL RESISTIVITY: -**

Before designing earth mat, it is necessary to determine the soil resistivity of the area in which substation is to be located. Resistivity of the earth varies considerably from 10 to 10,000 Ω-m depending on the types of the soil. Also resistivity varies at different depth depending upon the type of soil, moisture content and temperature etc., at various depths,

which affects the flow of current due to the fact that the earth fault current is likely to take its path through various layers.

2) TOLERABLE LIMITS OF BODY CURRENT: -

Effect of current passing through vital organs of human body depends on magnitude, duration and frequency of current. Current in the range of 1-8 mA are known as 'let go current' because these currents, though unpleasant, impair the ability of a person, holding an energised object to release it. Currents in the range of 9-25 mA may be painful and impair the ability to release energised object. Still higher currents make breathing difficult. However, if the current is less than about 60 mA, the effects are not permanent & disappear when current is interrupted. Currents higher than 60 mA may lead to ventricular fibrillation, injury & death.

3) **FAULT CURRENT: -**

As the earthing system has to carry the earth currents, the maximum earth fault current likely to flow in the system is considered for designing of earthing. A goodearthing system for substation can be designed using an earth mat which is formed by a grid of horizontally buried conductors which serves to dissipate the earth fault currents to earth, also as an equipotential bonding conductor system, along with required number of vertical earth electrodes which are connected to the points of earthing of various equipment's, structures and also interconnected with the horizontal earth mat. M.S. Rods are generally used for the earthing of substation. Total Earth resistance of the station system must be below 3 ohms for low voltage domestic system, below 0.5 ohms for low voltage and medium voltage substation, and below 0.1 ohm for 220 KV and 400 KV sub-station and power plants. If value of Earth Pit resistance is found high, then it is to be treated to bring back the value within the normal range.

15.PROTECTIVE RELAYS

Relay is a device by which electrical circuit is indirectly controlled during a fault condition. The purpose of relay is to operate the correct circuit breaker, so as to disconnect only the faulty equipment from the system as quickly as possible, thus minimising the trouble and damage caused by faults when they do occur.

ESSENTIAL QUALITIES OF PROTECTION (RELAY): -

1) **Reliability**: - Protection scheme must operate, when the system condition calls upon to do so. Failure in the trip and control circuit of the breaker can be determined by continuous supervision arrangement (Trip circuit healthy lamps in the panel)

2) **Selectivity**: - Protective system must be such that it should correctly select the faulty section and cut off the same from the system without disturbing other healthy sections.

3) **Speed**: - To avoid unnecessary damage to plant, protection must operate quickly.

4) **Stability**: - The protection system should be stable and it must actuate from the concerned signal only and not from any other similar signal.

Back Up Relaying: If due to some reason the primary relaying system fails to operate, the backup relays must operate and isolate the faulty equipment.

Auto Reclosing Relays: These relays are used to reconnect the circuit so that if the fault is of transient nature, the system is returned to normal operation. This system is used mostly on overhead lines where 80 to 90% faults are of transient nature. (Lightning, birds passing near or through lines, tree branches, etc.)

THREE TYPES OF RELAYS:

1) Relay back up – To trip same breaker by other relay if main relay fails.

2) Local Breaker back up (LBB) – To trip next breaker on the same bus.

3) Remote back up – To trip breaker at upper station.

EHV LINE PROTECTION: -

DISTANCE RELAY: - This Relay is directional type & works on the principal of Impedance rather than current. Generally there are 3 Zones in forward direction and 1 Zone in reverse direction.

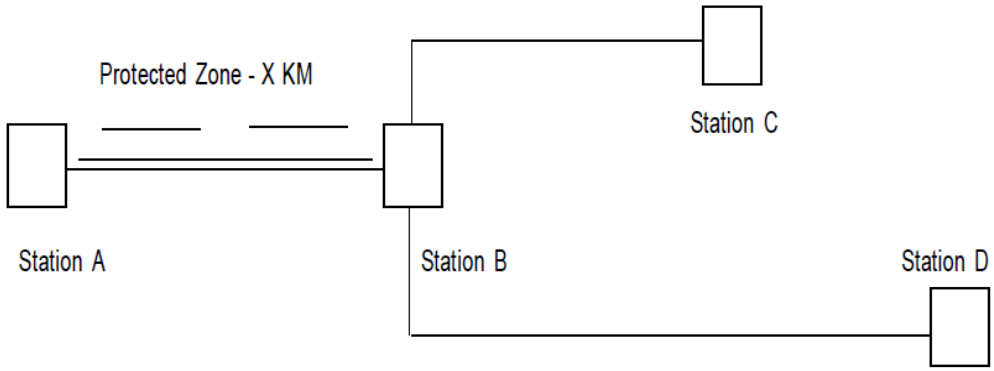

Fig. 15.1 Distance relay

Suppose Distance between Station A & Station B is X km. Distance between Station B & Station C, which is the nearest Station from Station B, is Y km. Distance between Station B & Station D, which is the far away Station from Station B, is Z km. Setting of relays is done on the impedance parameters of Overhead Line conductor (Given by the conductor Manufacturer). Setting of Relay at Station A is given below: -

Zone 1: - Zone 1 mostly covers protected line. Setting of Zone 1 is taken as 80% of protected line length. So any fault in this zone, Station A will trip first and if fails to trip, then Station B trips in Zone 2 at it's end.

Zone 2: - Setting of Zone 2 is 100% of X + 50% of Y

Zone 3: - Setting of Zone 3 is 100% of X + 100% of Z

Zone 4: - Setting of Zone 4 is 10% of Zone 1 (Reverse Zone)

2) OVER CURRENT & EARTH FAULT RELAY: -

This Relay is made directional type & is a backup for Distance Relay.

TRANSFORMER PROTECTION: -

DIFFERENTIAL RELAY: - This Relay compares the currents in the windings of the transformer through CTs whose ratios are such as to make their currents normally equal. The polarities of the CTs are such as to make the current circulate without going through the relay during load conditions and external faults. During internal faults, the balance condition is disturbed and relay operates

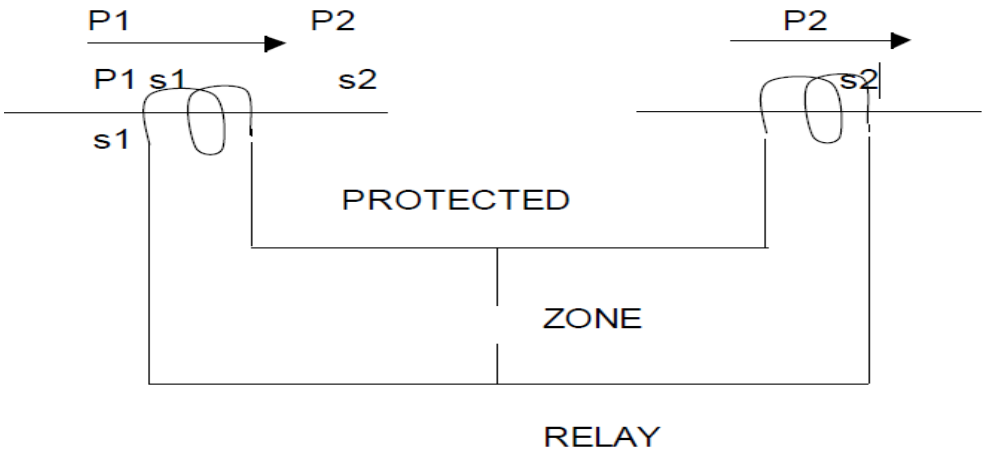

Fig. 15.2 Differential relay

2) **RESTRICTED EARTH FAULT RELAY**:

This protection helps easy and quick detection of fault in the star connected winding of power transformer. The relay operates whenever there is a fault in the tap changer or the star connected winding. Normally the balance three-phase loads are feed through the transformer. There is no current flow through the star point neutral to the earth in this normal situation. One CT of similar ratio and the protection class is provided in neutral side of the transformer which is used for matching / balancing the circulating current through the main CTs in case of external faults.

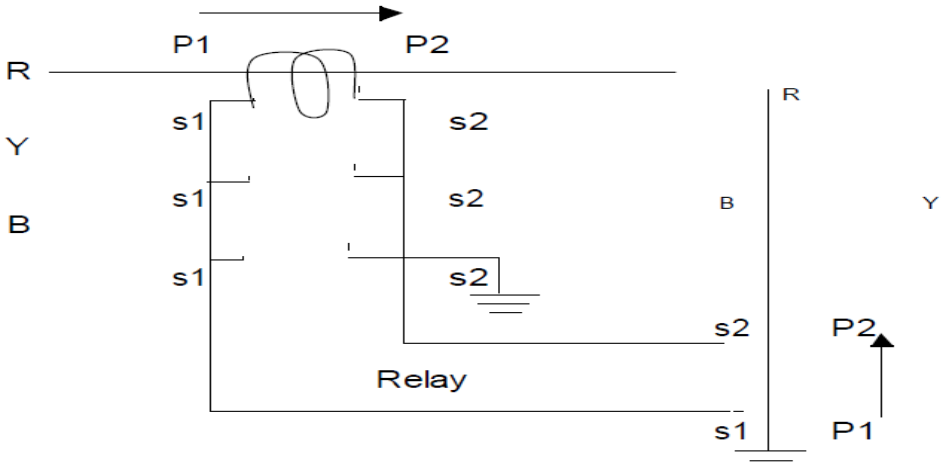

Fig. 15.3 Restricted earth fault relay

FEEDER PROTECTION: -

OVER CURRENT & EARTH FAULT RELAY: -

These Relays work on IDMT characteristic & are made directional and nondirectional as per requirement. Wiring Diagram of combined over current & earth fault relay:-

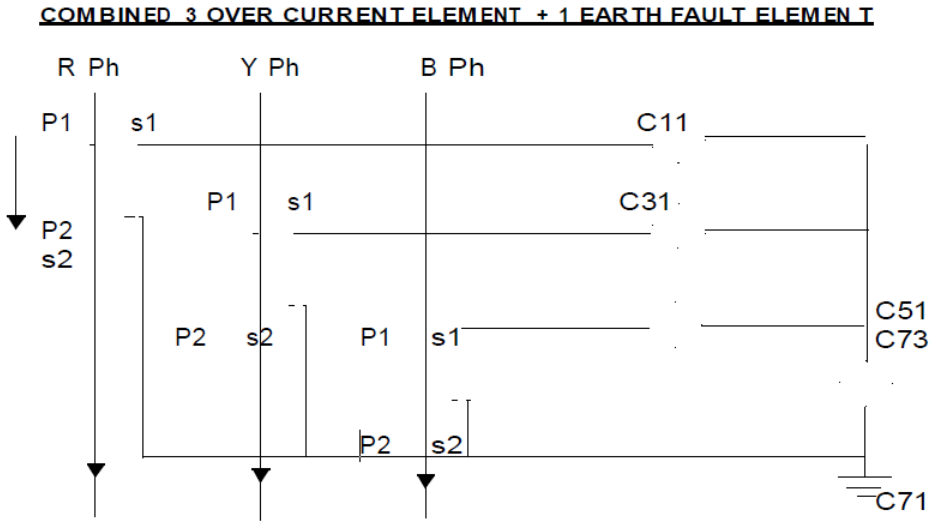

Fig.15.4. Over current relay

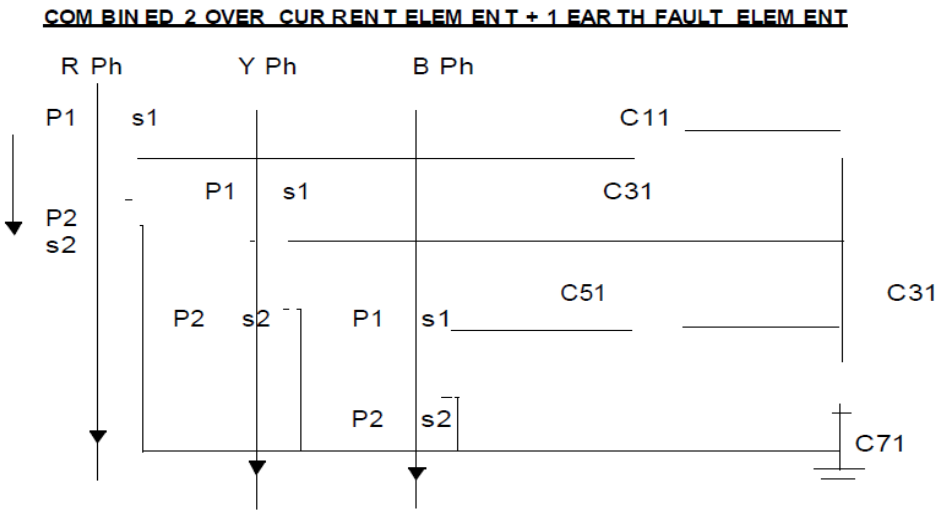

Fig.15.5. Earth fault relay

16.SCADA PANEL:

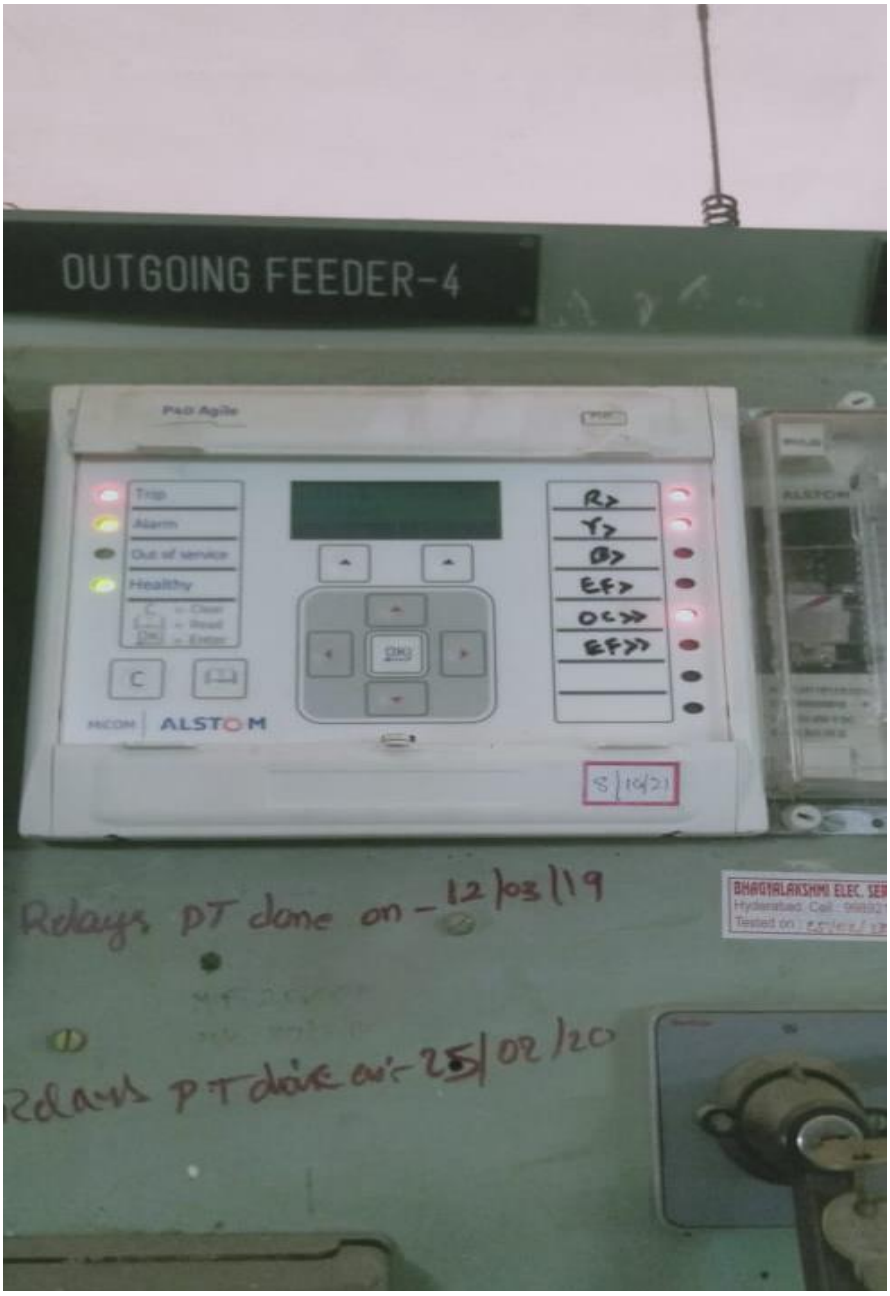

Fig. 16. Scada panel

SCADA is a automatic fault sensing device. Which gives alarm when it sense fault and gives information to the operator.

17.FAULTS:

17.1 LG FAULT:

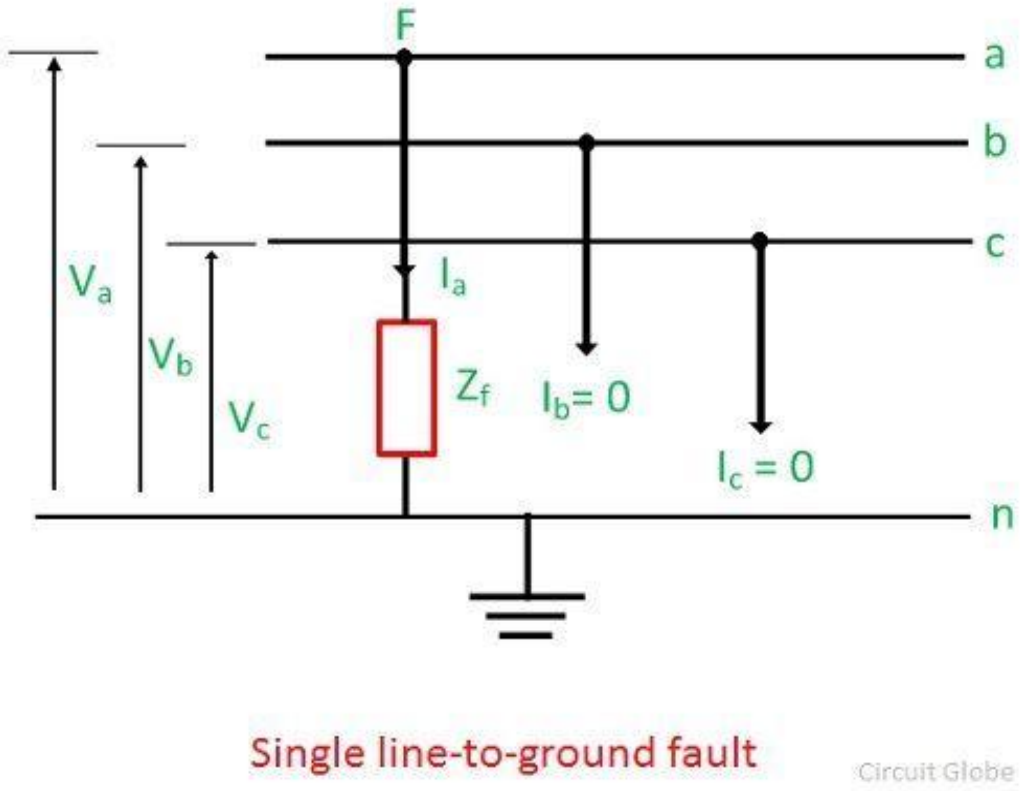

Fig. 17.1. Single line-to-ground fault

A single line to ground fault on a transmission line occurs “when one conductor drops to the ground or comes in contact with the neutral conductor”. Such types of failures may occur in power system due to many reasons like high-speed wind, falling of tree, lightning, etc.

Fig. 17.2 LG fault

17.2 LL FAULT:

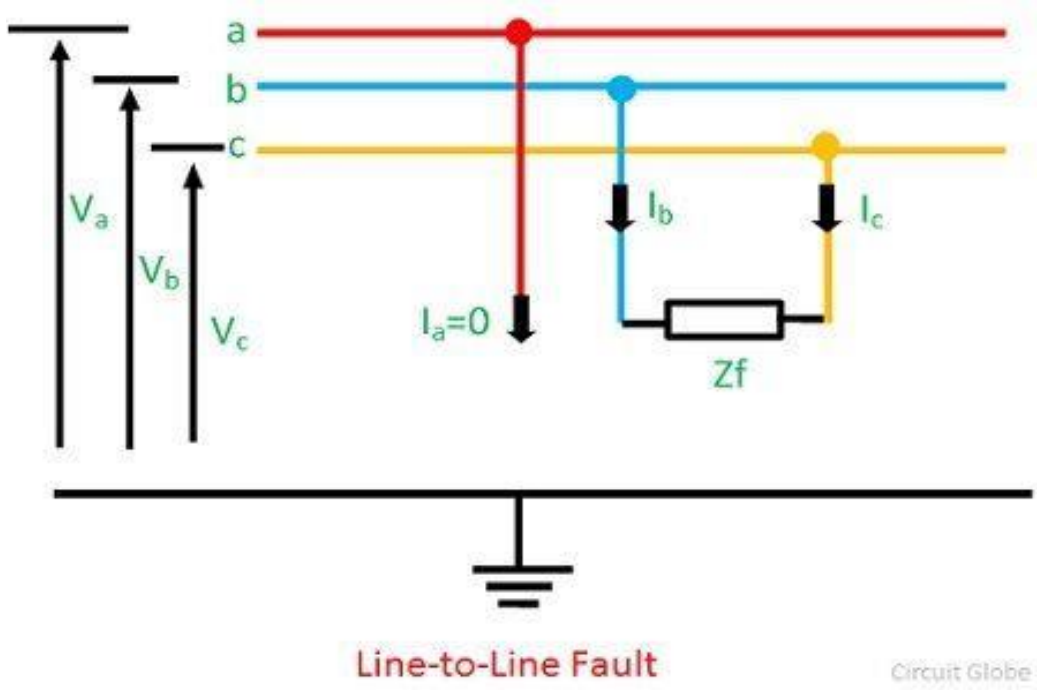

Fig. 17.3. Line-to-line fault

A line-to-line fault is also called as unsymmetrical fault. It occurs “when two conductors are short circuited”.

Fig. 17.4 LL fault

17.3 LLG FAULT:

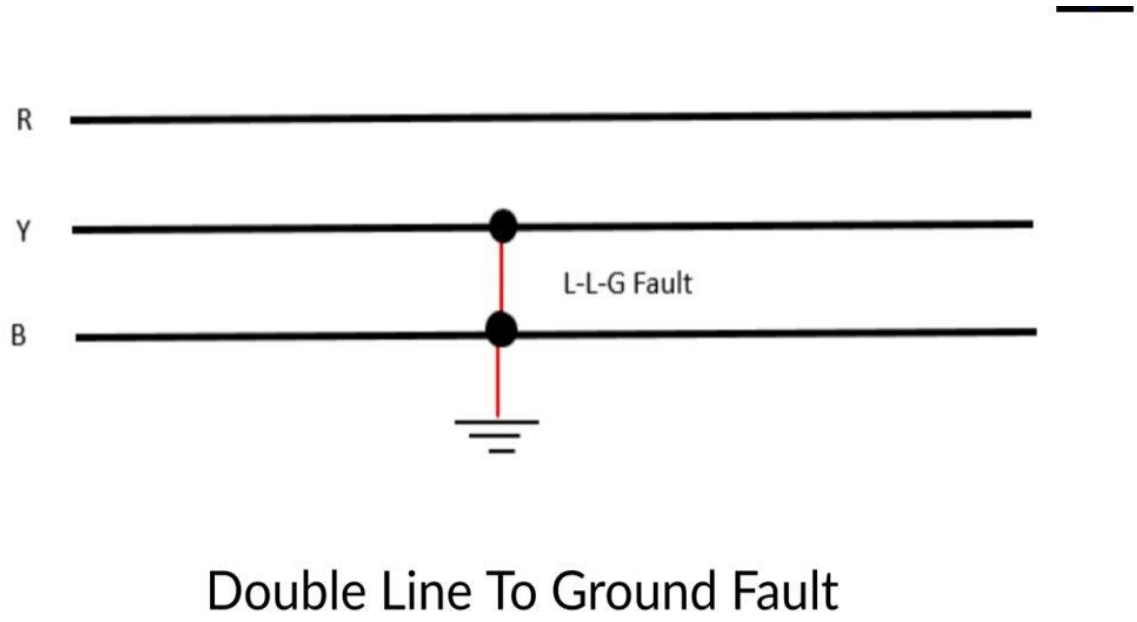

Fig. 17.5. Double line to ground fault

A double line to ground fault on a transmission line occurs “when he two lines contact with each other along with the ground”.

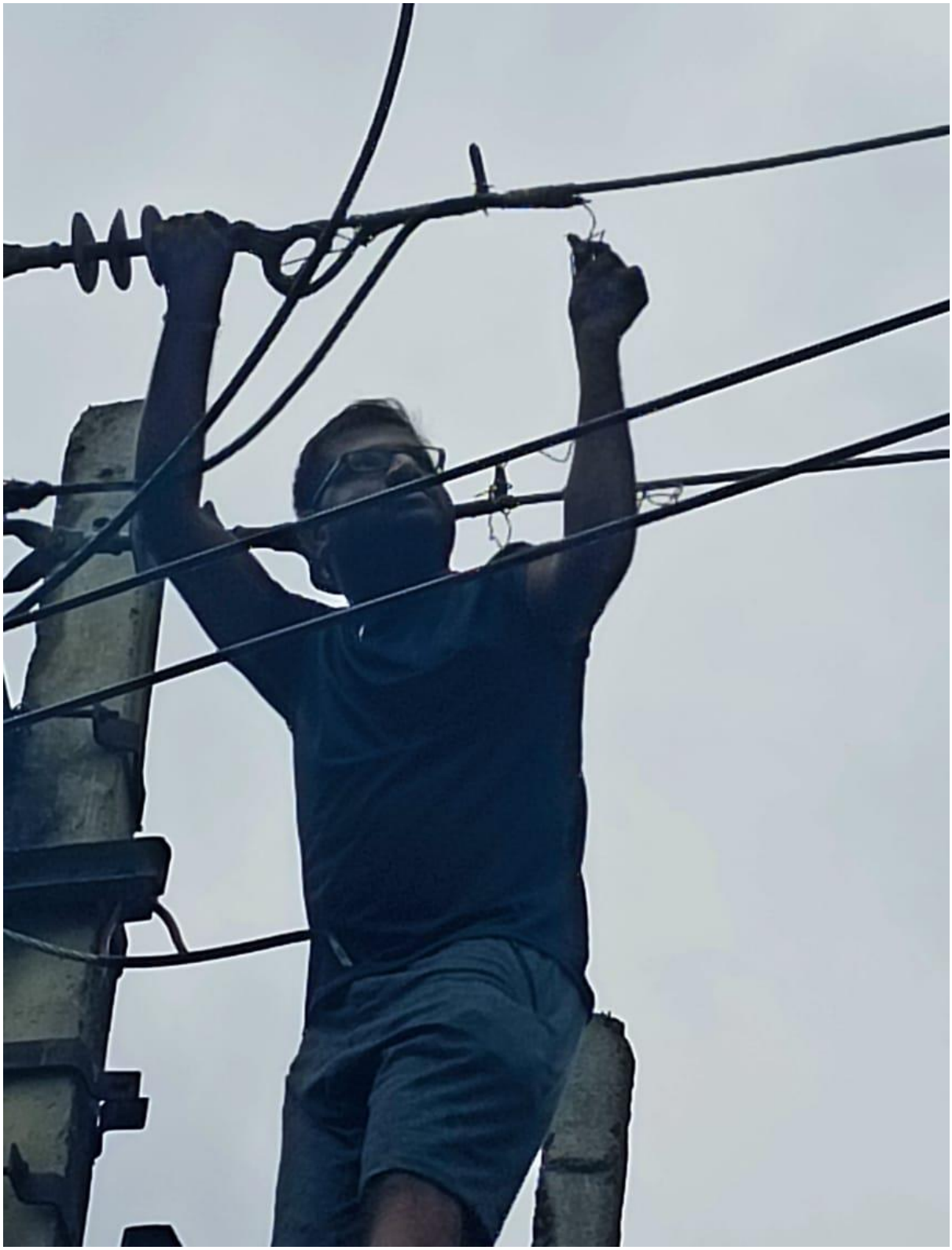

Fig. 17.6 LLG fault

LLL FAULT:

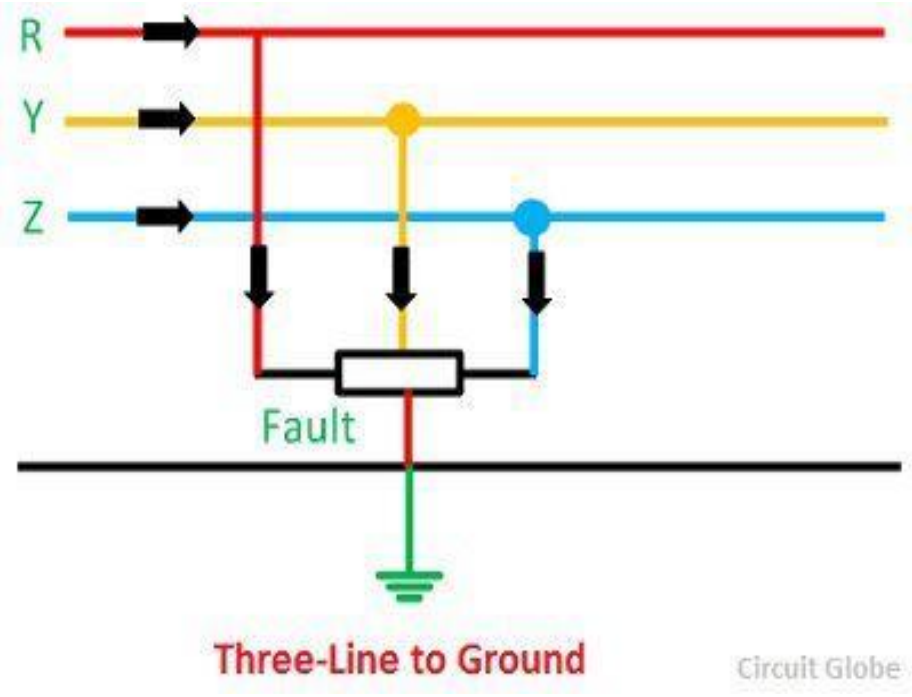

Fig. 17.7. Three line to ground

A triple line to ground fault on a transmission line occurs “when three conductors fall on the ground or come in contact with the neutral conductor. It is a symmetrical fault.

Fig. 17.8. LLL fault

Fig. 17.9. Normal condition

TERMS USED THROUGH THE DOCUMENTATION:

Sl. No	Symbol reference	Description
1	A1-A2- A3, Ah	Ammeter
2	V	Voltmeter
3	VS	Manual Voltmeter Selector Switch
4	EM	Tri-Vector Meter
5	CS	Control switch T-A/T-N-A/C-C spring return type
6	L/R	Local/Remote switch
7	IL-R	CB ,'ON' Indication Red lamp
8	IL-G	CB , 'OFF' Indication Green lamp
9	IL-W	Trip /Close signal received from Remote Indication white lamp
10	IL-B	"Spring charged" Indication Blue lamp
11	IL-A	CB " Auto trip" Indication Amber lamp
12	PB	Push Button
13	ANN	DC operated electric Buzzer and Microprocessor based Electronic annunciator with built in watch dog and first fault indication facility. The annunciator shall have provision for trip and non trip alarm functions and Accept/Test/Reset/Mute Push buttons
14	H,HS,TH	Heater, Heater Switch, Thermostat
15	FS	Fuse
16	LK	Link
17	MCB1 MCB 2	pole 32 A for DC supply
18	MVS	Manual PT selector switch
19	IR-I	Remote inter tripping contact from 33 kV Transformer Control and relay Panel

20	TC	Tripping Coil
21	CC	Closing Coil
22	PT	Potential Transformer
23	CT	Current Transformer
24	TTB	Test Terminal Block

86 Tripping Relay for Tripping function

52 Vacuum Circuit breaker

52a,52b NO and NC contacts of Breaker Auxiliary switch respectively

51/50 RY-B-N O/C and E/F protection

67 R-YB-N Directional O/C and E/F protection

64 Restricted Earth Fault Protection

87 Differential Protection

OBSERVATIONS:

17.10 Fig. Daily log sheet

CONCLUSON:

As an overall conclusion from our case study on real-time monitoring and functioning of control panel in 33/11kv substation we learnt operation of each and every equipment in the control panel. We came to know to the applications of control panel in substation like analysing faults is one of the major application. The faults caused in the transmission lines can be observed in the control panel elements readings. We observed the different types of faults caused in transmission lines and the reason like how it is actually caused.