

NOTES:  
1. Height of 220kV GIS Hall: 10m

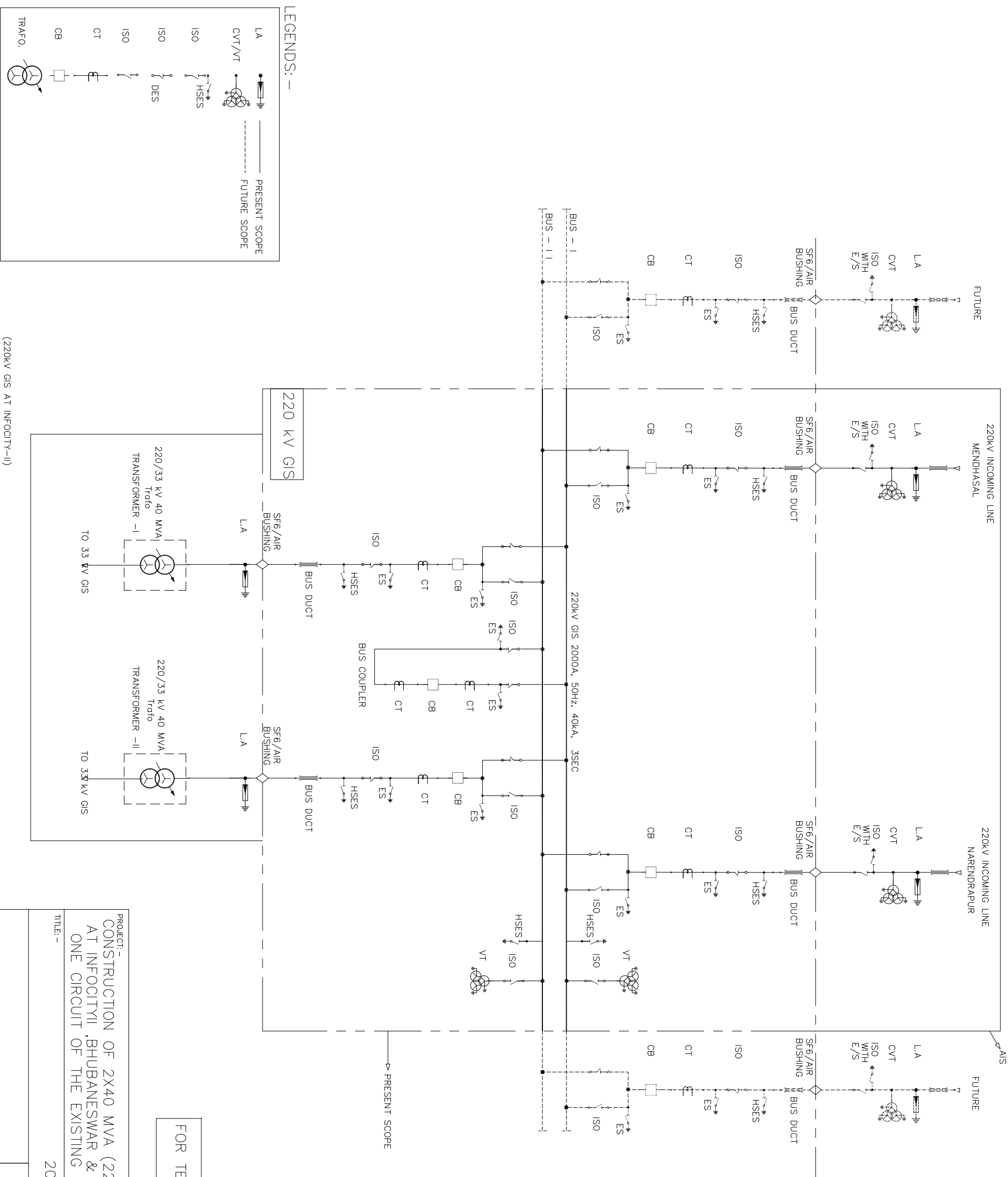
BOUNDARY WALL

FOR TENDER PURPOSE ONLY

OPTCL

CLIENT :	OPTCL
PROJECT :	220/33kV GIS SUB-STATION
TITLE :	LAYOUT PLAN OF 220/33kV LAYOUT & SECTION (INDICATIVE)
DRAWING NO. :	DRW009
DATE :	2023

INDICATIVE SLD FOR 220KV SIDE OF PROPOSED 220/33KV GIS S/S AT INFOCITY II



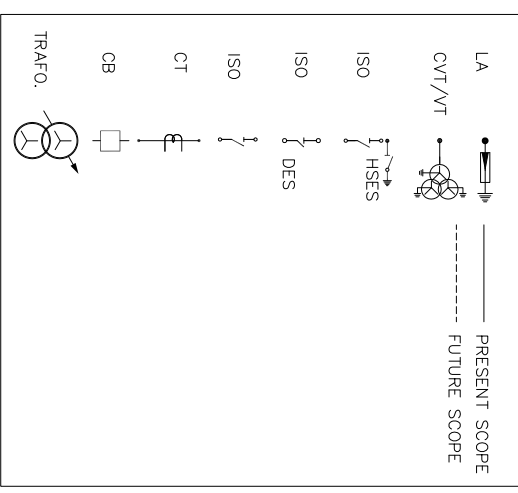
FOR TENDER PURPOSE ONLY

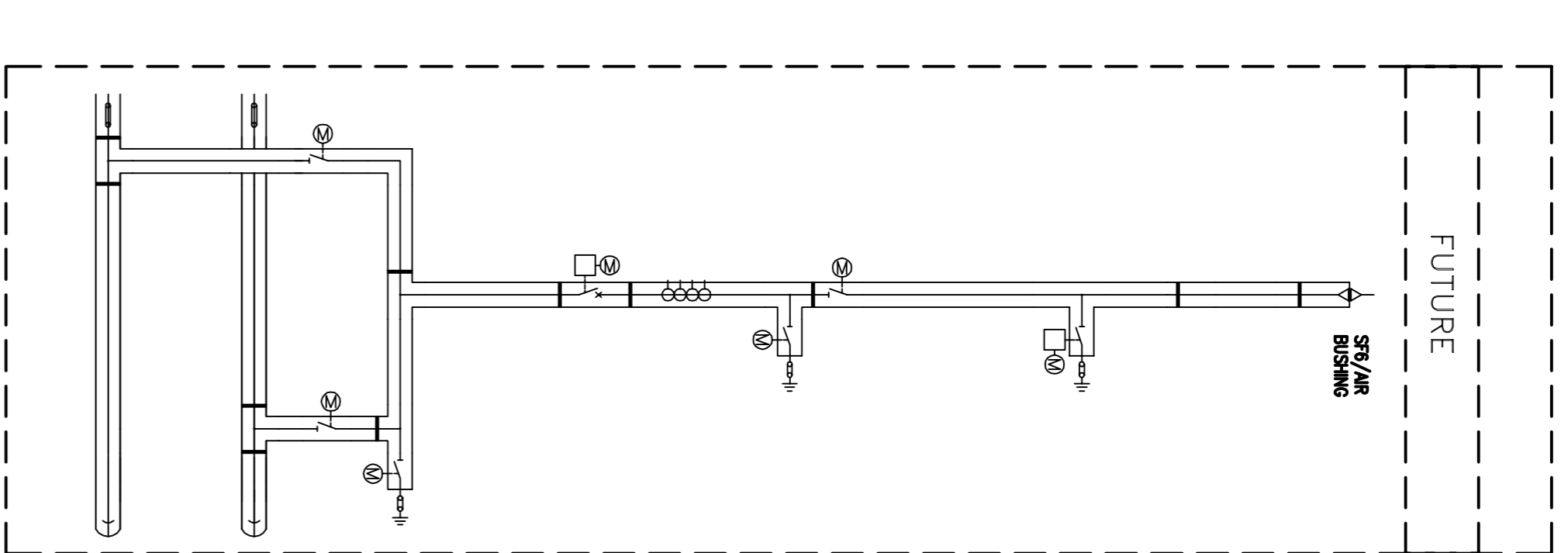
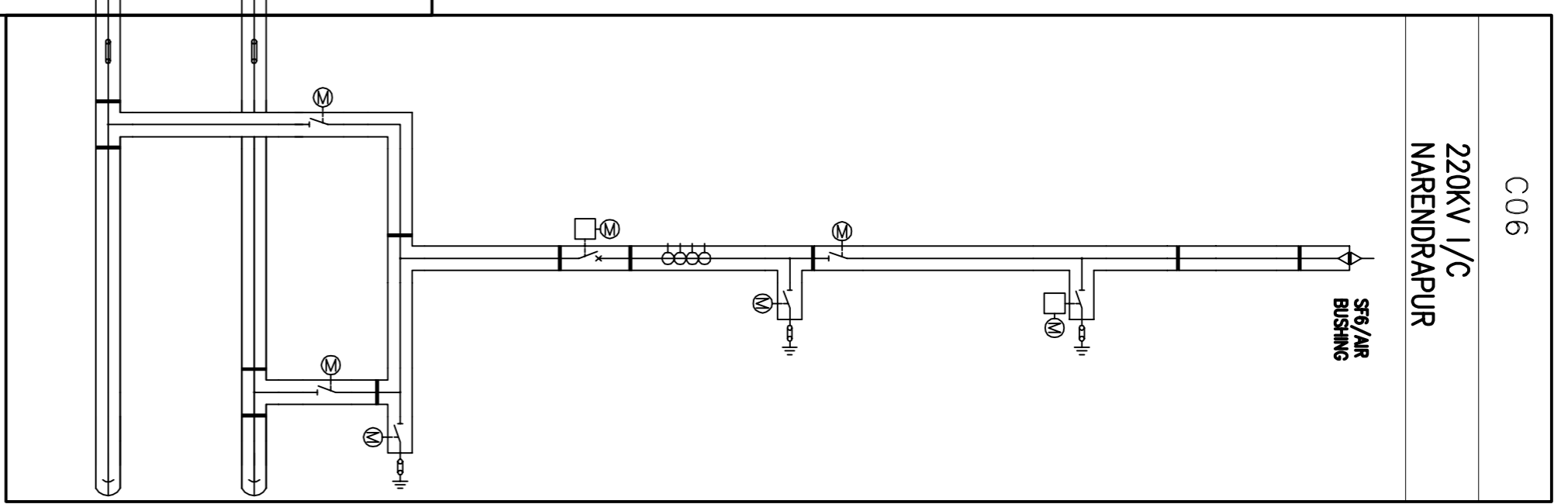
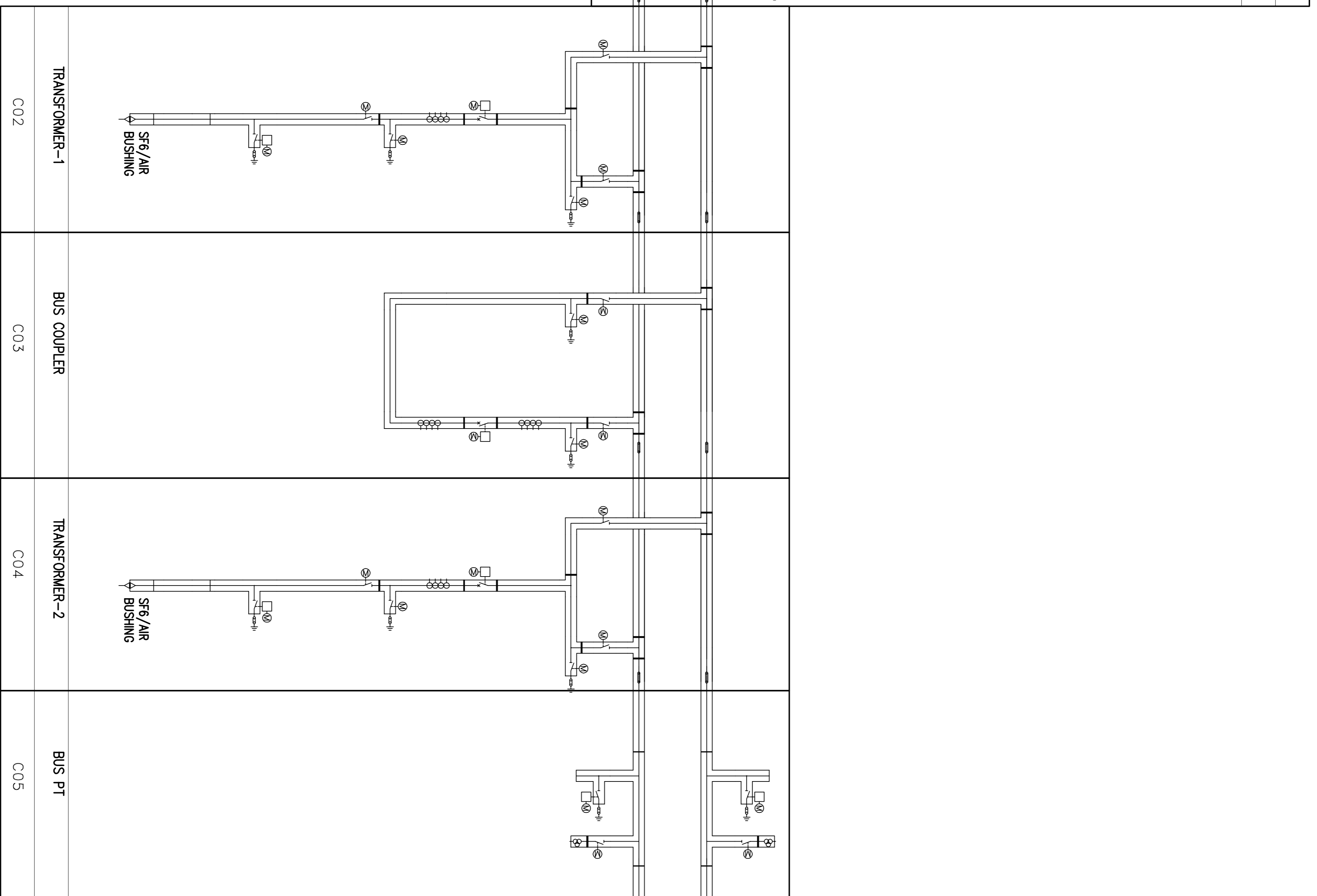
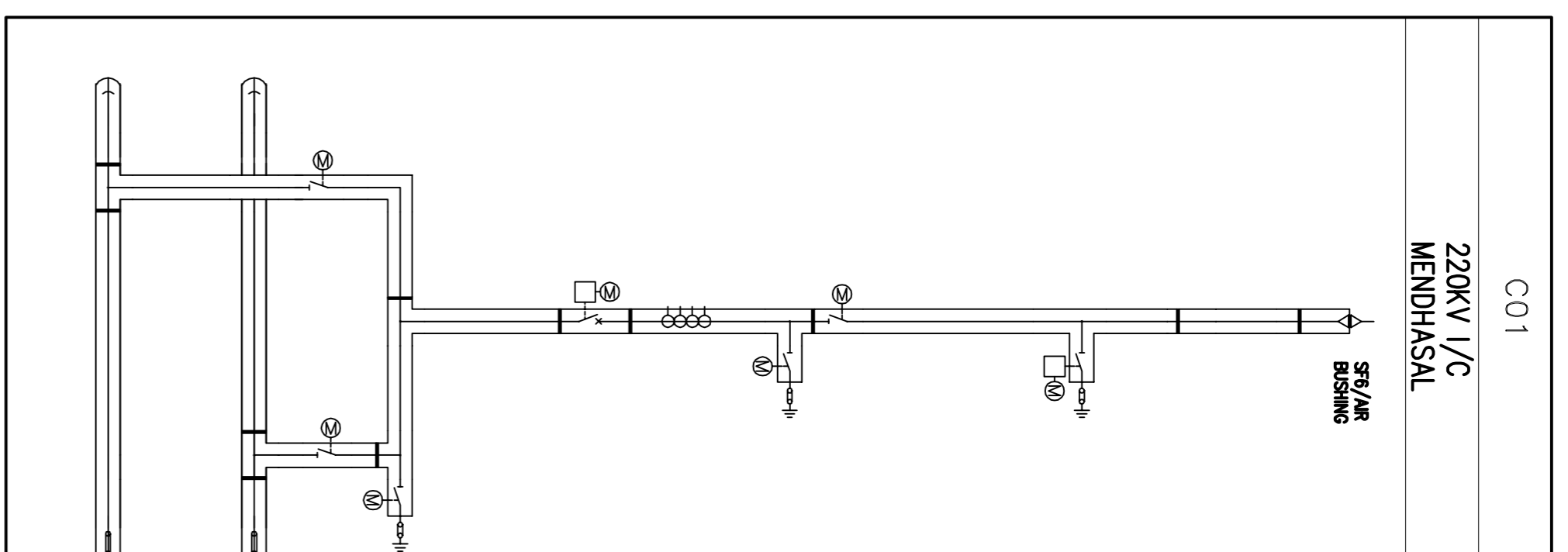
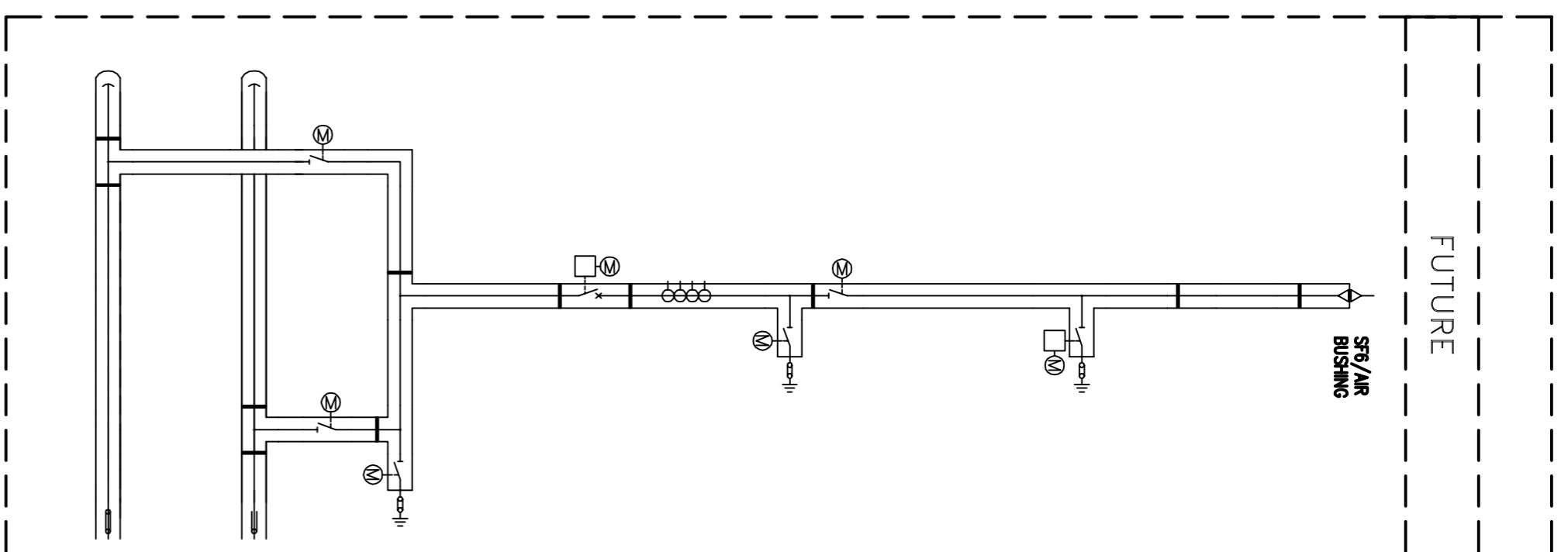
PROJECT:-  
CONSTRUCTION OF 2X40 MVA (220/33 KV) 220/33 KV GAS INSULATED (SF6) SUBSTATION AT INFOCITY II, BHUBANESWAR & ASSOCIATED 220 KV DC LILo LINE ARRANGEMENT ON ONE CIRCUIT OF THE EXISTING NARENDRAPURMENDHASAL DC LINE ON TURNKEY BASIS.

TITLE:-  
200KV GIS SLD TYPICAL  
ODISHA POWER TRANSMISSION CORPORATION LIMITED

(220KV GIS AT INFOCITY-II)

LEGENDS:-



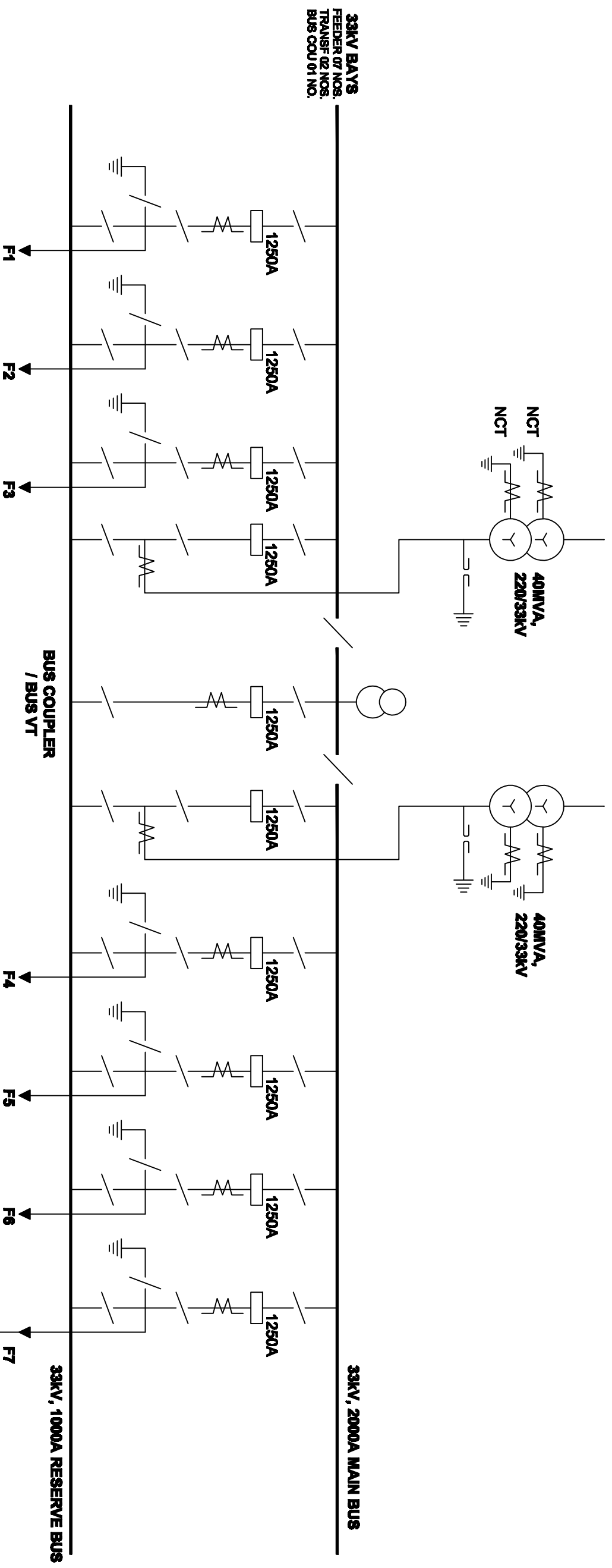


LEGENDS																									
<table border="1"> <tr> <th>SYMBOL</th> <th>GIS MODULE</th> <th>SYMBOL</th> <th>GIS MODULE</th> </tr> <tr> <td></td> <td>CIRCUIT BREAKER</td> <td></td> <td>CURRENT TRANSFORMER</td> </tr> <tr> <td></td> <td>VOLTAGE TRANSFORMER</td> <td></td> <td>END COVER</td> </tr> <tr> <td></td> <td>ISOLATOR</td> <td></td> <td>REMOVABLE LINK / TELESCOPIC ELEMENT / LATERAL DISARMING ELEMENT</td> </tr> <tr> <td></td> <td>MAINTENANCE EARTHING SWITCH</td> <td></td> <td>SF6 TO AIR BUSHING</td> </tr> <tr> <td></td> <td>HIGH SPEED EARTHING SWITCH</td> <td></td> <td>BARRIER INSULATOR</td> </tr> </table>	SYMBOL	GIS MODULE	SYMBOL	GIS MODULE		CIRCUIT BREAKER		CURRENT TRANSFORMER		VOLTAGE TRANSFORMER		END COVER		ISOLATOR		REMOVABLE LINK / TELESCOPIC ELEMENT / LATERAL DISARMING ELEMENT		MAINTENANCE EARTHING SWITCH		SF6 TO AIR BUSHING		HIGH SPEED EARTHING SWITCH		BARRIER INSULATOR	
SYMBOL	GIS MODULE	SYMBOL	GIS MODULE																						
	CIRCUIT BREAKER		CURRENT TRANSFORMER																						
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	ISOLATOR		REMOVABLE LINK / TELESCOPIC ELEMENT / LATERAL DISARMING ELEMENT																						
	MAINTENANCE EARTHING SWITCH		SF6 TO AIR BUSHING																						
	HIGH SPEED EARTHING SWITCH		BARRIER INSULATOR																						

C01	220KV I/C MENDHASAL				
C02	TRANSFORMER-1				
C03	BUS COUPLER				
C04	TRANSFORMER-2				
C05	BUS PT				
C06	220KV I/C NARENDRAPUR				

PROJECT:-  
 CONSTRUCTION OF 2X40 MVA (220/33 KV) 220/33 KV GAS INSULATED (SF6) SUBSTATION AT INFOCITY, BHUBANESWAR & ASSOCIATED 220 KV DC LILo LINE ARRANGEMENT ON ONE CIRCUIT OF THE EXISTING NARENDRAPURMENDHASAL DC LINE ON TURNKEY BASIS.

TITLE:-  
 200KV GIS GAS SCHEMATIC DRAWING



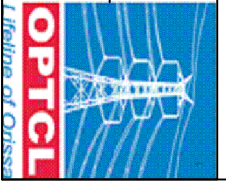
- A CT RATIO:-**
- 1) FEEDERS (F1-F7) & BUS COUPLER - 800-400-200/1-1-1 A
  - 2) 40MVA TRANSFORMER FEEDER - 800-400-200/1-1-1-1 A
- B AU FEEDER SHALL BE CONNECTED THROUGH 33kV XLPE CABLES.**

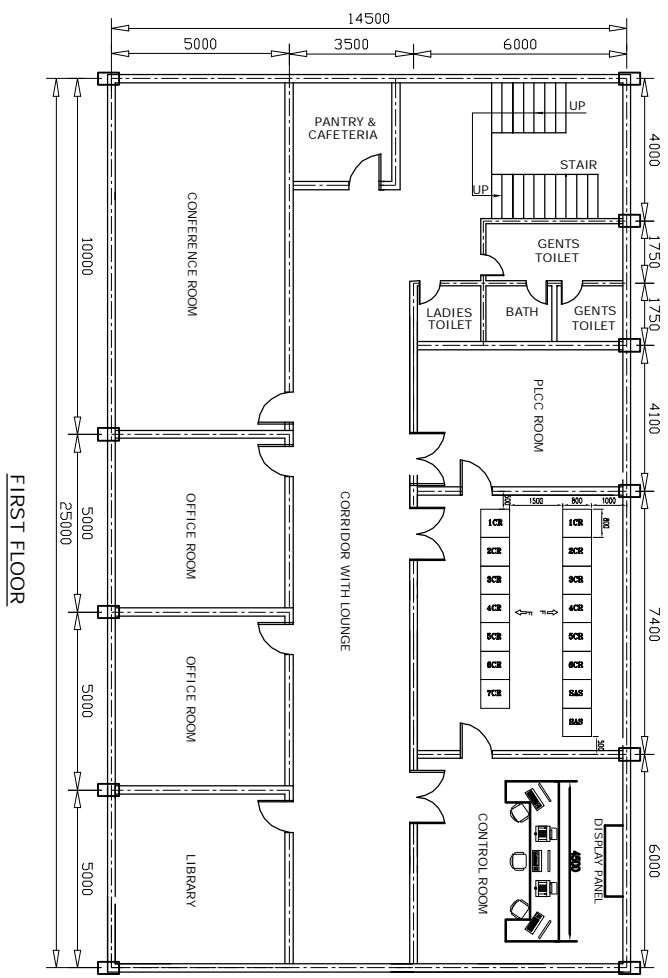
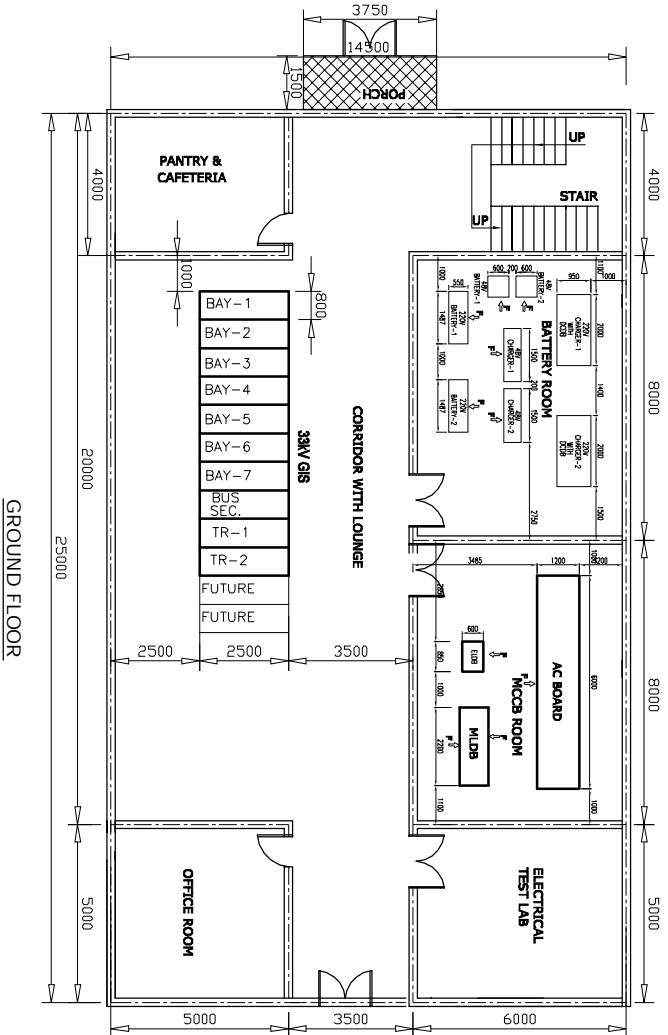
LEGEND:-	
	SURGR ARRESTER
	CURRENT TRANSFORMER
	IND VOLTAGE TRANSFORMER
	CAP VOLTAGE TRANSFORMER
	EARTH SWITCH
	CKT BKR
	POWER TRANSFORMER
	ISOLATOR

**NOTE:-**  
CIVIL DETAILS SUBJECT TO OPTCL APPROVAL DURING ENGINEERING STAGE.

**Project:**  
CONSTRUCTION OF 2x40MVA, 220/33kV GIS SUB STATION

**Title:**  
33kV SINGLE LINE DIAGRAM



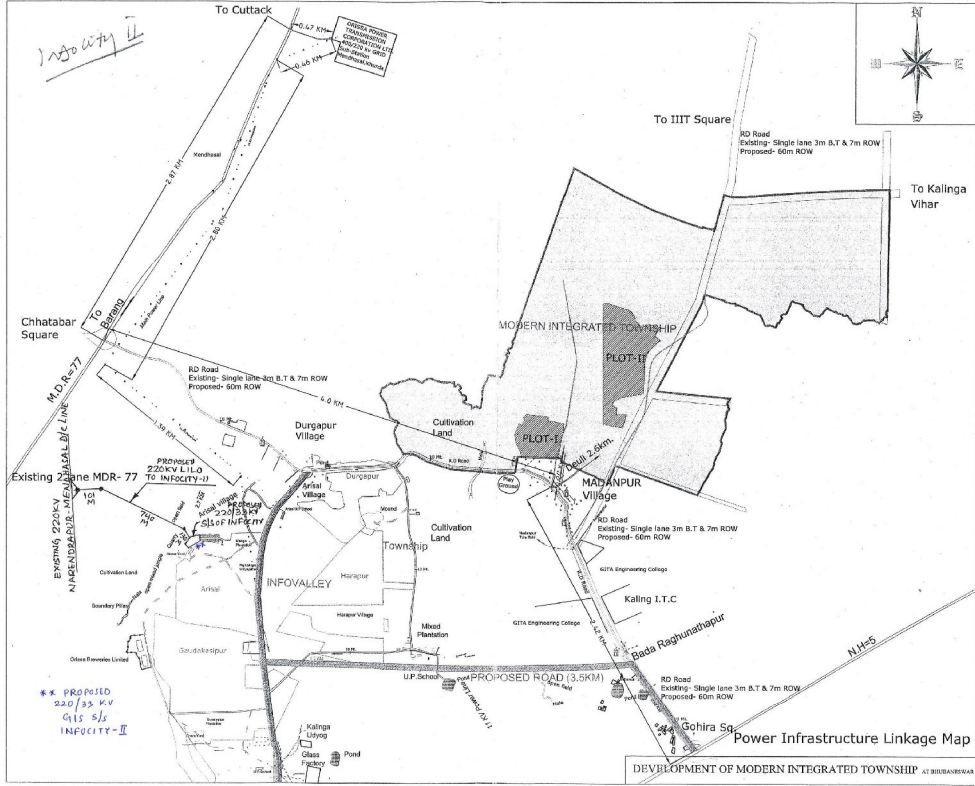


- NOTES:**
1. Cable Cellar at Ground Floor - Height: 2.5m
  2. First Floor - Height: 5m
  3. Second Floor - Height: 5m

CONTROL ROOM CUM 33KV GIS ROOM

FOR TENDER PURPOSE ONLY

CLIENT :	OPTCL
PROJECT :	220/33kV GIS SUB-STATION
TITLE :	PANEL ARRANGEMENT IN CONTROL ROOM CUM GIS BUILDING (INDICATIVE)
DRAWING NO. :	A1
SCALE :	AS SHOWN
DATE :	01/0





# **TECHNICAL SPECIFICATION**

**FOR**

**11/33 KV H.T. XLPE POWER CABLE**

## 1. SCOPE:

The specification covers design, manufacture, shop testing, packing and delivery of 11 & 33 kV , single/multi core , cross linked polyethylene insulated ,armoured, copper conductor power cables by road/rail to the designated Store Centers /project site in the State of Odisha. These cables shall be suitable for the 3 phase AC-50 Hz system with the nominal voltage of 11/33 KV which may reach maximum of 12/36 KV respectively.

These cables shall primarily be designed for effectively earthed neutral system.

## 2. SERVICE CONDITIONS:

Equipment to be supplied against this specification shall be suitable for satisfactory continuous operation under the following tropical conditions.

2.1	Maximum ambient temperature (deg C)	50
2.2	Maximum temperature in shade (deg C)	45
2.3	Minimum temperature in air (deg C) in shade	3.5
2.4	Relative Humidity (%)	10 to 100
2.5	Maximum annual Rainfall (mm)	1450
2.6	Maximum Wind Pressure (kg/mm <sup>2</sup> )	150
2.7	Maximum altitude above mean sea level (Meters)	1000
2.8	Isoceraunic level (days/year)	50
2.9	Seismic level (Horizontal acceleration)	0.3 g.
2.10	Moderately hot and humid tropical climate, conducive to rust and fungus growth.	

## 3. STANDARDS:

3.1 Unless otherwise specified elsewhere in this specification, the rating as well as performance and testing of the HT XLPE power cables shall conform to the latest



revisions available at the time of placement of order of all the relevant standards as listed in, but not limited to **Annexure-I**.

#### **4. GENERAL TECHNICAL REQUIREMENTS:**

4.1 6.35/11 kV & 19/33 kV earthed, single/multi core power cables shall normally be with stranded compacted Annealed plain copper conductor as per IS: 8130 ,IEC 60228 (amended upto date), provided with conductor screening (of extruded semi-conducting cross link material) and shall be insulated with XLPE of natural colour Identification of cores shall be by colour, as per provision of clause 13.1 of IS: 7098 (Part 2) ,IEC 60502 (amended upto date). The insulation (XLPE) screening shall be provided consisting of extruded semi-conducting cross link material in combination with a metallic layer of copper tapes. Three such screened cores shall be laid up together with fillers and/or binder tapes where necessary and provided with extruded inner sheathing of heat resistant PVC conforming to type ST-2 of IS: 5831 - 1984(amended upto date).

Maximum continuous operating temperature shall be 90 deg C under normal operation and 250 deg C under short circuit condition.

Armouring shall be provided consisting of single galvanized round steel wires (In case of Single core cable armouring shall be of Non-magnetic material) conforming to IS:7098 Pt 2/IS: 3975 /IEC 60502-Pt 2 (amended upto date) and over the armouring a tough outer sheath of PVC compound shall be extruded. The PVC compound for the outer sheath shall conform to type ST-2 of IS: 5831/IS:7098 Pt 2/IEC 60502 Pt 2 (amended upto date). The colour of the outer sheath shall be black. The cable shall be manufactured strictly conforming to IS:7098 (Part 2) /IEC 60502( amended upto date) and shall bear **ISI** mark.

#### **4.2 SEQUENTIAL MARKING OF LENGTH ON CABLE**

Non erasable Sequential Marking of length shall be provided by embossing on outer sheath of the cable for each meter length.

The quality of insulation should be good and insulation should not be deteriorated when exposed to the climatic conditions.

#### 4.2.1 DISCHARGE FREE CONSTRUCTION:

Inner conductor shielding, XLPE insulation and outer core shielding shall be extruded in one operation by special process (viz. Triple Extrusion Process) to ensure that the insulation is free from contamination and voids and perfect bonding of inner and outer shielding with insulation is achieved. The bidders are requested to elaborate the manufacturing technique adopted by their manufacturers to achieve this motive.

The Company will order the verification of triple extrusion process at manufacturer's works as a pre qualification if it is technically accepting the bid.

During verification if it is found that the firm is not manufacturing the cable with triple extrusion process the offer shall be rejected.

#### 5. CONTINUOUS A.C. CURRENT CAPACITY:

Continuous a.c. current capacity shall be as per Table given below.

Conductor sizes in sq.mm.	Continuous a.c. current capacity in Amps at maximum conductor temp. of 90 deg .c. for 33 kV cable	
	When laid direct in the ground 30 deg.C	When laid in air 40 deg.C.
70 sq.mm	155	165
95 sq mm	175	200
120 sq mm	195	230
150 sq mm	225	265
185 sq mm	255	310
240 sq mm	290	345
300 sq mm	325	396
400 sq mm	385	460
500 sq mm	450	590

630 sq mm	660	1000
800 sq mm	720	1140
1000 sq mm	760	1240

#### 4.5 SHORT CIRCUIT CURRENT

Short circuit current of 11,22 & 33 kV XLPE cable shall be as per given below.

Duration of Short Circuit t in sec	Area of Al. Conductor A	Short circuit current 33 kV in kA
t	A	$I=0.094 \times A/\text{sq.rt}(t)$
1	70 sq.mm	6.58
1	95 sq mm	8.93
1	120 sq mm	11.28
1	150 sq mm	14.1
1	185 sq mm	17.39
1	240 sq mm	22.56
1	300 sq mm	28.2
1	400 sq mm	37.6
1	500 sq mm	47
1	630 sq.mm	59.2
1	800 sq mm	75.17
1	1000 sq mm	93.97

## **5. TESTS AND TESTING FACILITIES :**

### **5.1 TYPE TESTS:**

All the type tests in accordance with IS: 7098 (Part 2) ,IEC 60228, (amended upto date), shall be performed on cable. The same is to be furnished for verification if the type test has been conducted in last five years from the date of submission of GTP & drawing for approval. If the same is not available than the firm to conduct the type test again and submission for verification.

### **5.2 ROUTINE TESTS:**

All the Routine tests as per IS:7098 (Part 2) ,IEC 60228,( amended upto date) shall be carried out on each and every delivery length of cable. The result should be given in test report. Partial discharge test must be carried out in a fully screened test cell. It is, therefore, absolutely essential that the manufacturer should have the appropriate type of facility to conduct this test which is routine test.

The details of facility available in the manufacturer's works in this connection should be given in the bid.

### **5.3 ACCEPTANCE TESTS:**

All Acceptance tests as per IS:7098 (Part 2) /IEC 60228,( amended upto date) including the optional test as per clause no 18.4 and Flammability Test shall be carried out on sample taken from the delivery lot.

### **5.4 SHORT CIRCUIT TEST:**

The contractor shall also undertake to arrange for the short circuit test as a type test on any one size of each voltage grade i.e on one size of 11 kV, one size of 22 kV and one size of 33 kV earthed grade shielded XLPE cables. If facilities for carrying out short circuit tests are available at the works of the supplier, and provided the certification procedure is approved by the Purchaser, testing at the supplier's works will be acceptable.

Short Circuit test shall be witnessed by the purchaser's representative.

5.4.1 The short circuit test shall be preceded and followed by the following tests so as to ensure that the characteristics of the cable remain within the permissible limits even after it is subjected to the required short circuit rating.

- a) Partial Discharge Test.

b) Conductor Resistance Test.

c) High Voltage Test.

5.4.2 The manufactured cable will be acceptable only after such a sample test is successfully carried out at CPRI or at suppliers works and approved by the Purchaser.

## 5.5 TESTING FACILITIES

The supplier / tenderer shall clearly state as to what testing facilities are available in the works of manufacturer and whether the facilities are adequate to carry out type, routine and acceptance tests mentioned in specified IS. The facilities shall be provided by the bidder to purchaser's representative for witnessing the tests in the manufacturer's works. If any test cannot be carried out at manufacturer's works reason should be clearly stated in the tender.

## 6 PACKING AND MARKING :

### 6.1 IDENTIFICATION MARKS ON CABLE:

The following particulars shall be properly legible embossed on the cable sheath at the intervals of not exceeding one meter through out the length of the cable. The cables with poor and illegible embossing shall be liable for rejection.

a) Manufactures name and/or Trade name.

b) Voltage grade.

c) Year of manufacture.

d) Successive Length.

e) Size of cable

f) ISI mark

6.2 The cable shall be supplied in continuous standard length of 250 running meters with plus minus 5% tolerance wound on non returnable wooden drum of good quality and non-standard lengths not less than 100 meters upto 5% of the ordered quantity shall be accepted. Alternately cable can be supplied wound on non-returnable steel drum without any extra cost to the purchaser. Packing and marking shall be as per clause No. 21 of IS:7098 (Part 2)/IEC 60228,( amended upto date)

6.3 Supplier should provide statistical data regarding cables of all sizes viz.-

- 1) Weight of one meter of finished product of cable of various sizes and ratings.
- 2) Weight of one meter of bare conductor used for cables of various sizes and ratings.

#### **7 QUALITY ASSURANCE PLAN:**

A detailed list of bought out items which got into the manufacture of cables should be furnished indicating the name of the firms from whom these items are procured. The bidder shall enclose the quality assurance plan invariably along with offer followed by him in respect of the bought out items, items manufactured by him & raw materials in process as well as final inspection, packing & marking. The Company may at its option order the verification of these plans at manufacturer's works as a pre qualification for technically accepting the bid. During verification if it is found that the firm is not meeting with the quality assurance plan submitted by the firm, the offer shall be liable for rejection.

#### **8 SCHEDULES:**

8.1 The tenderer shall fill in the following schedule which form part of the offer. Schedule `C' - Tenderer's Experience.

8.2 The tenderer shall submit the list of orders for similar type of equipments, executed or under execution during the last three years, with full details in the schedule of Tenderer's experience (Schedule `C') to enable the purchaser to evaluate the tender.

## SCHEDULE - C

### SCHEDULE OF TENDERER'S EXPERIENCE

Tenderer shall furnish here a list of similar orders executed/under execution by him to whom a reference may be made by purchaser in case he considers such a reference necessary.

---

Sr. No.	Name of client	Value of order	Period of supply and commissioning	Name and address to and description
1	2	3	4	5

---

NAME OF FIRM

NAME & SIGNATURE OF TENDERE

DESIGNATION

DATE

## ANNEXURE-I

### LIST OF STANDARDS

(All amended up to date)

SR.NO.	STANDARD NO.	TITLE
1.	IS: 8130 ,IEC 60228:	Conductors for insulated electric cables and flexible cords.
2.	IS :7098 (Part 2) ,IEC 60502:	XLPE PVC sheathed cable for working voltages from 3.3 kV upto and including 33 kV.
3.	IS:7098(pt-2),IEC 60502:	Insulation XLPE.
4.	IS: 7098(pt-2),IEC:60502:	Insulation Metallic & Non Metallic Screen.
5.	IS: 7098(pt-2),IEC:60502:	Fillers: Non Hygroscopic PVC/Polypropeline Fiber to maintain roundness of cable.
6.	IS:7098 (pt-2),IS:3975,IEC:60502 (pt-2):	Armour.
7.	IS:7098(pt-2), IEC:60502 (pt-2):	Outer Sheath:PVC ST 2.
8.	IS :10462 ( Part I) –1983 :	Fictitious calculation method for determination of dimensions of protective coverings of cables.



# **MORE INFORMATION ON POWER & CONTROL CABLES [FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 V]**

## **CRITERIA FOR SELECTION OF POWER & CONTROL CABLES**

1.1 Aluminium conductor XLPE insulated armoured cables shall be used for main power supply purpose from LT Aux. Transformers to control room, between distribution boards and for supply for colony lighting from control room.

1.2 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switch yard area/control room except for control/protection purposes.

1.3 For all control/protection/instrumentation purposes PVC insulated control cables of minimum 2.5 sq. mm. size with stranded Copper conductors shall be used.

1.4 The sizes of power cables to be used per feeder in different application shall be as applicable, described here under.

1.5 Bidder may offer sizes other than the sizes specified in clause 1.4. In such case and for other application where sizes of cables have not been indicated in the specification, sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

1.6. Cables shall be laid conforming to IS : 1255.

1.7 While preparing cable schedules for control/protection purpose following shall be ensured:

1.7.1 Separate cables shall be used for AC & DC.

1.7.2 Separate cables shall be used for DC1 & DC2.

1.8 For different cores of CT & CVT separate cable, core wise shall be used .The minimum sizes of the conductor for each terminal shall be 2X2.5 sqmm.

1.9 For control cabling, including protection circuits, minimum 2.5 sq.mm. size copper cables shall be used per connection.

## **TECHNICAL REQUIREMENTS**

### **2. General**

2.1 The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by

water.

2.2 They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

2.3 The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

2.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables armours shall be of H4 grade Aluminium.

2.5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

2.6 Progressive sequential marking of the length of cable in metres at every one meter shall be provided on the outer sheath of all cables.

2.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS : 1554 (Part 1 ) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

2.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

2.9 All the cables shall pass fire resistance test as per IS:1554 (Part-I)

2.10 The normal current rating of all PVC insulated cables shall be as per IS:3961.

2.11 Repaired cables shall not be accepted.

### 3. **XLPE Power Cables**

3.1 The XLPE (**90°C**) insulated cables shall be of FR type, C1 category conforming to IS:7098 (Part-I) and its amendments read alongwith this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted.

In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC of type ST-2 of IS:5831. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC of Type ST-2 of IS:5831 for all XLPE cables.

#### **4. PVC Power Cables**

4.1. The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read alongwith this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multicore cables. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables.

#### **5. PVC Control Cables**

5.1 The PVC (70°C) insulated control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read alongwith this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour .

### **6. HV POWER CABLES [ FOR WORKING VOLTAGES FROM 3.3 kV AND INCLUDING 33 kV]**

#### **6.1. HV POWER CABLE FOR AUXILIARY POWER SUPPLY**

The HV cable of voltage class as specified for LT transformer shall be, XLPE insulated, armoured cable conforming to IS 7098 (Part-II) or IEC 60502-2 1998. Terminating accessories shall conform to IS 17573-1992 or IEC 61442-1997/IEC60502-4 1998.

#### **6.2. Constructional Requirements**

*Cable shall have compacted circular Aluminium conductor, Conductor screened with extruded semi conducting compound , XLPE insulated, insulation screened with extruded semi conducting compound, armoured with non-magnetic material, followed by extruded PVC outer sheath(Type ST-2), with FR properties .*

6.3 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

6.4 The cables shall have outer sheath of a material with an Oxygen Index of not less than 29 and a Temperature index of not less than 250°C.

## 7. TYPE TESTS

7.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IS.

### THE SIZES OF POWER CABLES TO BE USED PER FEEDER IN DIFFERENT APPLICATION SHALL BE AS APPLICABLE, DESCRIBED HERE UNDER.

S.No.	From	To	Cable size	Cable type
1.	Main Board Switch	LT Transformer	2-1C X 630 mm <sup>2</sup> per phase 1-1C X 630 mm <sup>2</sup> for neutral	XLPE
2.	Main Board Switch	AC Distribution Board	2-3½C X 300 mm <sup>2</sup>	XLPE
3.	Main Board Switch	Oil Filtration Unit	1-3½C X 300 mm <sup>2</sup>	XLPE
4.	Main Board Switch	Colony Lighting	1-3½C X 300 mm <sup>2</sup>	XLPE
5.	Main Board Switch	HVW pump LCP	1-3½C X 300 mm <sup>2</sup>	XLPE
6.	Main Board Switch	Main Lighting distribution board	1-3½C X 300 mm <sup>2</sup>	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	2-3½C X 300 mm <sup>2</sup>	PVC
8	AC Distribution Board	Emergency Lighting distribution board	1-3½C X 70 mm <sup>2</sup>	PVC

<b>9</b>	AC Distribution Board	ICT MB	1-3½C X 70 mm <sup>2</sup>	PVC
<b>10</b>	AC Distribution Board	Bay MB	1-3½C X 70 mm <sup>2</sup>	PVC
<b>11</b>	Bay MB	AC Kiosk	1- 3 ½ x 35 mm <sup>2</sup>	PVC
<b>12</b>	AC Distribution Board	Battery Charger	1-3½C X 70 mm <sup>2</sup>	PVC
<b>13</b>	DCDB	Battery	2-1C X 150 mm <sup>2</sup>	PVC
<b>14</b>	DCDB	Battery Charger	2-1C X 150 mm <sup>2</sup>	PVC
<b>15</b>	DCDB	Protection/PLCC panel	1-4C X 16 mm <sup>2</sup>	PVC
<b>16</b>	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm <sup>2</sup>	PVC
<b>17</b>	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm <sup>2</sup>	PVC
<b>18</b>	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm <sup>2</sup>	PVC
<b>19</b>	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm <sup>2</sup>	PVC
<b>20</b>	Lighting Panel	Sub lighting panels	1-4C X 16 mm <sup>2</sup>	PVC
<b>21</b>	Lighting Panel	Street Lighting Poles	1-4C X 16 mm <sup>2</sup>	PVC
<b>22</b>	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	1-2C X 6 mm <sup>2</sup>	PVC



***ORISSA POWER TRANSMISSION CORPORATION LIMITED***  
**OFFICE OF THE SR. GENERAL MANAGER,**  
**CENTRAL PROCUREMENT CELL,**  
**JANAPATH, BHUBANESWAR – 751022.**

## **TECHNICAL SPECIFICATION**

### **RELAY PANEL**

# RELAY PANELS

## **6.0 Protection System**

### **Protective system**

#### **6.1 Protection discrimination**

On the occurrence of a fault on the power system network the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted electrical element from the network.

Protection equipment associated with adjacent electrical elements may detect the fault, but must be able to discriminate between an external fault and a fault on the electrical element which it is designed to protect. Sequential time delayed tripping is not permitted except in the following specific circumstances:

- Protection for short connections between post current transformer housings and circuit breakers when the technical advantages of complete overlapping of the protection are outweighed by economic considerations, (i.e. short-zone protection)
- Operation of time graded back-up protection takes place as a result of either the complete failure of the communication links associated with the main protection systems, or the fault resistance is substantially greater than a value which can be detected by main protection systems.
- Operation of line back-up protection to disconnect primary system faults in the case of a circuit breaker failing to operate, (i.e. circuit breaker failure protection)
- All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the transmission system.

#### **6.2 Protection settings**

A list of the settings to be applied to all protection systems together with all associated calculations, shall be provided for review and approval not less than three months prior to the first programmed date for commissioning. The settings for line protection shall be such as to permit correct operation of the protection for earth faults with up to 100 ohms fault resistance. Any limitations imposed on the power system as a result of the settings proposed shall be explicitly stated. In the absence of system data required for calculation purposes, assumptions may be made providing these are clearly identified as such in the relevant calculations.

#### **6.3 Fault clearing time**

The protection equipment shall be capable of achieving the following discriminative fault clearing times, inclusive of circuit breaker and signalling times:

- One millisecond for all electrical elements whose boundary connections are defined by circuit breakers located within a given substation.

- For interconnecting tie lines in which the boundary connections of the electrical element being protected are defined by circuit breakers located in adjacent switching stations, an additional 20 ms fault clearance time is allowed at the substation remote from the fault point. This additional fault clearance time is permitted subject to the requirement that the positive sequence impedance of the primary circuit from the switching terminal to the point of fault shall not be less than ten ohms. The Contractor shall supply the Project Manager with details of the operating times under defined conditions of all protection equipment proposed. Any limitation in operating time performance shall be declared by the Contractor, e.g. end of zone faults where distance protection is applied, high resistance faults, faults at high X/R with significant DC component and time constant, faults coincident with communication channel noise. The Contractor shall specify the increase in operating time which could occur under such conditions.

#### **6.4 Signalling equipment operating times:**

For design purposes the operating times of signalling equipment to provide a contact signal for use with associated distance protection shall be assumed to be as follows:

- Intertripping (transfer trip) not greater than: 20 milliseconds
- Permissive transfer trip: 15 to 20 milliseconds
- Blocking signal operate time: 10 milliseconds
- Blocking signal reset time: 10 milliseconds

### **Protection Schemes**

#### **6.5 Line protection**

##### **General requirement for line protection relays**

The line protection relays shall protect the line and clear faults on line in the shortest possible time with reliability, selectivity and full sensitivity to all types of line fault. The general concept for

- 1) 400kV and 220kV levels is to have primary and back-up protection systems having equal performance requirement especially in respect of time as would be provided by two Main protections called **Main-I** and **Main-II**. It is desirable that Main-I and Main-II protection should work on two different principles of operation and one back up dir O/C & E/F protn is envisaged.

- 2) For 132 kV level the concept of one main distance protection and one backup directional O/C and E/F protection is envisaged.

- 3) For 33 kV level, the requirement is that of modular directional O/C and E/F protection.

The protection requirements are summarised below, and illustrated in the single line diagrams in the schedules.

- **400kV and 220kV lines**
  - Main I Numerical non switched distance protection meeting performance levels.
  - Main II Numerical non switched phase comparison, carrier aided or of numerical distance using a different principle of operation
  - Phase segregated teleprotection facility
  - Power swing detection blocking and tripping



- Synchronising.
- Line overvoltage ( Only for 400kV and 220kV line  $\geq$  200kM long )
- Autoreclosure
- Numerical directional overcurrent and earth fault
- Three phase to ground
- Numerical local breaker back up
- Pole discrepancy protection

### **6.5.1 Distance Protection Relay (Numerical IEC-61850 Protocol compliance)**

The relay shall:

1. Be static and modular in construction
2. Have high speed phase segregated non switched distance relays for three phase systems to clear all type of line faults within the set reach of the relay.
3. Cover at least two line sections with 15% in hand margin.
4. Measure all type of faults without the need to switch the measuring elements to the faulty phase or phases. Zone switching to extend the reach of the measuring elements is not allowed. The reach of each zone shall be independently and individually adjustable and shall have settings in steps of 1%. Memory circuits with defined characteristics shall be provided in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions. Independent zero sequence compensation shall be provided for each zone.
5. Have reverse reaching zone operating times as given in Table. The Carrier transmission time has been considered as 20 ms.
6. Have stepped time-distance characteristics and at least two directional and one non-directional independently variable time graded distance protection zones to cover two adjacent line sections.
7. Have a maximum Zone 1 operating time from fault initiation to trip impulse from relay (complete protection time excluding applicable carrier time) under source to line impedance ratios and under all possible combinations of fault with CVT being used on the line (with all filters included) and at 50% of Zone I reach as follows:
  - For S.I.R. 0.01 to 4: 30 ms at the nearest end and 50 ms at far end.
  - For S.I.R. 4 to 15: 30 ms at the nearest end and 50 ms at far end.

Carrier transmission time is considered as 20 ms. Any reduction in carrier transmission time shall be reflected in the reduction of maximum operating time.

The trip times should not be affected by DC offset and under frequency up to 47Hz.

8. Have a reach for Zones 1,2 and 3 to cover line length as per 3 above. The relay shall have an adjustable characteristic angle setting range of 30 to 75 degree, preferably adjustable dynamically following the load conditions of the power system. It should be ensured that this long coverage is consistent with limitations imposed by heavy loading and sound phase component of fault current. If so characterised by system requirements, it shall be possible to have circular characteristics of offset

Mho type & Quadrilateral shaped. If the characteristics of starting relays are such that it cannot pick-up because of very low infeed, under voltage relays may also be used as supplementary relays.

9. Have two independent continuously variable time setting range of 0-3 seconds for Zone 2 and 0-5 seconds for Zone 3.
10. Have a maximum resetting time of less than 35 milliseconds.
11. Have facilities for offset features with adjustment of at least 20% of Zone 3 setting.
12. Have automatic residual compensation capabilities variable from 30-150%.
13. Be such that the setting / reach should not be affected by mutual coupling effect of double circuit line or nearby paralleled circuits. The proof of compensation should be given if provided.
14. Operate instantaneously when circuit breaker is closed to zero volt 3 phase fault.
15. Be suitable for single and three phase tripping.
16. Have a continuous current rating of twice rated current. The voltage circuit shall be capable of continuous operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of one second.
17. Be selective between internal and external faults.
18. Incorporate three separate high speed trip relays for single phase faults and a fourth high speed trip relay for multi phase faults. Each of these shall have adequate contacts to meet the complete scheme requirements. The relay shall conform to the requirements for tripping relays specified in this specification.
19. Include power swing blocking protection which shall:
  - be of triple pole type
  - have suitable setting range to encircle the distance protection described above.
  - have a continuously adjustable time delay on pick up of setting range 0-2 seconds.
  - block tripping during power swing conditions.
20. Include fuse failure protection which shall:
  - monitor all the three fuses of CVT and associated cable against open circuit.
  - inhibit trip circuits on operation and initiate annunciation.
  - have an operating time less than seven milliseconds.
  - remain inoperative for system earth faults.
21. Have integrated two stage over voltage protection facilities.
22. Shall have comprehensive self test feature including diagnostics at power up.
23. Broken conductor detection facility.
24. Distance to fault locator

## 6.5.2 Distance to fault locator

### General

Distance to fault locators shall be the inbuilt features of the distance relay for both Main I and Main II, shall be capable of locating phase to phase and phase to earth faults. They shall also preferably be capable of locating open circuit faults.

1. Have built-in display feature.
2. Display directly in percent of line length or kilometres without the requirement for further calculation.
3. Have an accuracy of 3% or better for all types of faults and fault levels. This level of accuracy should not be impaired under the following conditions:
  - presence of remote end infeed
  - predominant DC component in fault current
  - high fault arc resistance
  - severe CVT transients
4. Have facility for remote data transmission
5. Meet IEC 255 Part IV or other equivalent internationally recognised standard.
1. Have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line.

**Table 16.3.2 Operating Times for Distance Protection**

Operating Time (ms)	SIR = $Z_s/Z_L$	Fault Position % of Impedance Setting
≤ 20	10	5 to 20
≤ 30	30	10 to 60
≤ 50	60	1 to 95

SIR = System Impedance ratio.  $Z_s$  = Source impedance.  $Z_L$  = Relay setting impedance

### 6.5.3 Line over voltage protection relay

The line over voltage protection (59L) relay shall:

1. Monitor all three phases
2. Have two independent (59L1 and 59L2) stages
3. Have an adjustable setting range of 100-170% of rated voltage with an adjustable time delay range of 1 to 60 seconds for the first stage. (59L1)
4. Have an adjustable setting range of 100-170% of rated voltage with an adjustable time having setting range 100-200 seconds for the second stage. (59L2)
5. Be tuned to power frequency
6. Be provided with separate operation indicators (flag target) for each stage relays. (59L1 and 59L2)
7. Have a drop-off to pick-up ratio greater than 95%. Integral of overvoltage feature is also acceptable.

#### **6.5.4 Auto reclosing relay**

The auto reclosing relay shall:

1. Have single phase and/or three phase reclosing facilities. ( Single /three phase reclosure shall be adapted for 400kV/220kV systems and 3pole trip/ reclosure for 132kV system)
2. Have a continuously variable single phase dead time range of 0.1-2 seconds in steps of 0.1 second.
3. Have a continuously variable three phase, one shot dead time range of 0.1-5 seconds in steps of 0.1 seconds.
4. Have a continuously variable reclaim time range of 5- 50 seconds.
5. Incorporate a four-position selector switch from which single phase/three phase/single and three phase auto reclosure and non-auto reclosure mode can be selected.
6. Have facilities for selecting check synchronising or dead line charging features. It shall be possible at any time to change the required feature by connection of links.
7. Be of single shot type.
8. Include check synchronising relay which shall
  - Have a time setting continuously variable between 0.5-5 seconds.
  - Have a response time within 200 milli seconds with the timer disconnected.
  - Have a phase angle setting not exceeding 35 degree.
  - Have a voltage difference setting not exceeding 10%
9. Include dead line charging Relay which shall
  - Have two sets of relays and each set shall be able to monitor the three phase voltage.
  - Have one set connected to the line CVT's with a fixed setting of 20% of rated voltage.
  - Incorporate necessary auxiliary relays and timers to give comprehensive scheme.

The scheme shall be such as to have Main I and Main II fully segregated such that shutdown and testing on one main protection should not affect the other main protection. The auto reclosure should then be connected to one protection. Integrated auto-reclosure feature as part of both Main I and Main II is also acceptable.

The scheme shall have check synchronous and voltage check interlocks (25, 27). These interlocks are supplementary to all other decision interlocks that may be required or specified in order to ensure correct operation of the scheme.

#### **6.6 Local Breaker Back-up protection relay (50 LBB) for circuit breakers**

The local breaker backup protection relay shall:

1. Be of triple pole type
2. Have an operating time of less than 15 milliseconds.
3. Have a resetting time of less than 15 milliseconds.

4. Have three over current elements. Each element shall be arranged to get individual initiation from the corresponding phase of line protection.
5. Be of solid-state type having a setting range of 5-80% of rated current
6. Have a continuous thermal withstand twice the rated current irrespective of the setting.
7. Have three separate timers, one for each phase with continuously adjustable setting range of 0.1-1 seconds.
8. Have necessary auxiliary relays to make a comprehensive scheme.

## **Protective system**

### **6.7 Unit and backup protection**

Power system elements and the network shall be provided with independent high speed discriminative protection systems. Duplicate schemes (Main I and Main II) shall be provided for all 400kV and 220kV systems. For all other systems up to 132kV, the protection equipment shall be divided into 'Main' and 'Backup' systems.

Protection schemes of different philosophy (Main I and Main II or Main and Back-up) shall preferably be fed from different DC supplies when available in the substation. This shall include energisation of trip coil circuits in case of 400 kV and 220 kV breakers. However in case of 132kV system where a duplicate DC source is available, the two trip coils shall be energised from the different sources.

Protection equipment shall not initiate a trip signal following the normal and correct discharge operation of one or more surge arresters.

Measurement functions relays must be achieved through electronic circuits. Auxiliary relays, repeat relays, trip relays and any other simple auxiliary or contact multiplication function may be based on standard attracted armature or other electromechanical techniques.

Relays based on numerical design technique shall constitute all primary protections. The Employer intends to avail the improved benefits in the functionality, design, reliability and cost effectiveness of integrated substation control systems in future for which relays with numeric design only shall be required. It is the responsibility of the Contractor to demonstrate that all relay equipment offered has a reasonable level of in-service experience. For numerical relays, the following conditions apply :

1. The Bidder must be able to demonstrate that a minimum of 10 relays of each type offered have been in full service without relay failures for a minimum of three years in two different countries, one of which may be the country of manufacture. Experience involving trial installations is not acceptable.
2. The Bidder must include a statement of the number of years of guaranteed manufacturing and parts support which will be provided for the relays offered.
3. The Bidder is be required to state the full firmware version together with the version of relays for which experience records are offered.

For relays which are provided with communication facilities, the communications facility should allow all information which is available locally at the relay front panel to be accessed remotely. It should also be possible to carry out bulk transfer of settings and fault record information using the appropriate PC based software.

## **6.8 Protection discrimination**

On the occurrence of a fault on the power system network the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted electrical element from the network.

Protection equipment associated with adjacent electrical elements may detect the fault, but must be able to discriminate between an external fault and a fault on the electrical element which it is designed to protect. Sequential time delayed tripping is not permitted except in the following specific circumstances:

- Protection for short connections between post current transformer housings and circuit breakers when the technical advantages of complete overlapping of the protection are outweighed by economic considerations, (i.e. short-zone protection)
- Operation of time graded back-up protection takes place as a result of either the complete failure of the communication links associated with the main protection systems, or the fault resistance is substantially greater than a value which can be detected by main protection systems.
- Operation of line back-up protection to disconnect primary system faults in the case of a circuit breaker failing to operate, (i.e. circuit breaker failure protection)
- All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the transmission system.

### **6.8.1 Codes and Standards**

The equipment supplied shall generally comply with the codes and standards indicated in relevant sections of this specification. Additionally the equipment shall also conform the requirements of this specification.

### **6.8.2 Environmental requirement**

The protection, control and metering equipment shall operate satisfactorily under the various atmospheric, mechanical, electrical and environmental conditions as stipulated in the relevant sections of this Specification. The equipment shall conform to EMC Class III.

### **6.8.3 Future network scada system**

At some time in the future the Employer intends to introduce a network SCADA system. All equipment to be installed under this Specification shall be suitable for future remote operation and remote data acquisition.

The limit of responsibility with regard to this contract shall be to provide equipment suitable for future connection to and communication with a SCADA system, either by means of RTU or modem. Neither the RTU nor the modems form part of the scope of this Specification.

The proposed protocol for the SCADA system is IEC 61850 compliance. Equipment necessary to interface the Integrated Substation Control System with the SCADA system are part of the scope of this Specification.

#### **6.8.4 Control and monitoring levels**

The substation control and monitoring system shall allow for three levels of man machine interface. The number of levels initially employed will be limited to one i.e. substation levels. Provision shall be made for the future implementation of the second and third level of network control and monitoring from a system control centre via SCADA.

Selection of substation control shall be from the individual equipment basis i.e., from the control panels.

At the station level, control panels should be located in the main control room.

A mimic diagram representing the substation lay-out in single line diagram form should be provided. The mimic board is intended to give operating personnel an overall view of the switchgear state. It shall be made up from the individual circuit control panels mounted side by side. The arrangement should correspond to the primary equipment layout.

Alarm annunciation equipment should be mounted adjacent to the mimic diagram, or form an integral part of the control panel. Operation of an alarm should cause the appropriate window to flash and sound an audible warning. Operation of an accept button will silence the audible warning, steady the flashing window and prepare the annunciation to respond to subsequent initiation. A reset button should be provided to extinguish alarms which have reset.

A lamp test button shall be provided which will initiate steady state illumination of all alarm windows. Trip or protection initiated alarms should have windows distinct from others (e.g. red display instead of white). Control and selector switches should be of approved types complying with accepted standards such as IEC 337. Control switches shall have two independent motions or two handed operation to effect operation. Indicating instruments should be of approved types complying with accepted standards such as IEC 5 1.

#### **6.9 Enclosures**

Protection systems shall preferably be accommodated in rack or hinged rack cubicles and be of modular construction with factory assembled and tested wiring. Conventional analogue relays may be mounted on conventional relay panels which must be mounted to allow access to the front and rear of the panel. Relays mounted on such panels shall be flush mounted. The construction method shall offer the benefits of minimum site construction times and circuit outage requirements.

Interconnections shall be identified in accordance with the requirements for dependent local end marking as specified in IEC Publication 391 Sections 3.4.1.a.1 and 5.1.2. The interconnections shall be recorded on an appropriate schedule or diagram.

For modular protection systems, means shall be provided to lock positively each withdrawable module or unit in the “service” position. It shall not be possible to remove any module without first short-circuiting all associated current transformer circuits.

#### **6.10 Operator interface**

##### **6.10.1 General**

All numerical protection systems shall be provided with an integral local operator interface facility to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be an additional feature to the local operator interface. No exceptions to this requirement shall be accepted.

### **6.10.2 Identification**

Each protection system shall have a unique identifier which is clearly visible. If the protection system is software operated the software reference and issue level shall be identified.

### **6.10.3 Settings**

Each protection system shall provide a means by which the user can easily access the protection system to apply the required settings. This facility shall be secure from inadvertent operation. A display of the selected settings shall be provided on the protection system.

### **6.10.4 Indications**

Each relay or protection scheme shall be provided with an adequate number of indications to ensure that the appropriate faulted phase, zone, etc. can be easily identified after a fault condition. Each indicator shall be visible and capable of being reset without removing the relay cover.

For relays based upon numerical techniques, indication shall be provided for failures detected in the protection relay or communications equipment. The indications provided shall be designed to allow the defective item to be quickly identified. The status of the DC power supplies shall be permanently indicated.

Details of the indication required for specific types of relay are provided in the individual parts of this section of the specification covering particular types of relay.

## ***6.11 Protection system output contacts***

All protection systems shall be provided with an adequate number of contacts of suitable rating to carry out the required tripping functions, alarm indications, fault recorder functions and such supplementary signalling functions as may be necessary for initiation of automatic switching control, inter tripping etc. In all cases contacts intended for tripping duty shall be designed such that they cannot inadvertently interrupt trip coil current.

## ***6.12 Testing and isolating facilities***

Each functional protection system shall be so arranged that operational and calibration checks can be carried out with the associated primary circuit(s) in service.

Adequate test facilities shall be provided within the protection system to enable the protection and auto-reclosing equipment to be tested from the front of the protection equipment panel with the primary circuit(s) in service. The test points shall be clearly identified and labelled.

Relays based on digital and numerical design techniques shall include supervision facilities which provide a periodic self check of the key elements within the relay and also provide continuous self monitoring of all internal power supplies and microprocessor operation. A defect in any of the self supervision facilities shall not cause maloperation of the protection relay internal self-test facilities and shall give an alarm should an internal fault occur.

Adequate facilities shall be provided, preferably at the front of each protection equipment panel, to isolate all DC and AC incoming and outgoing circuits so that work may be carried out on the equipment with complete safety for personnel and without loss of security in the operation of the switching station. The isolation points shall be clearly identified and labelled. The labels on the isolation points shall either describe the function or be uniquely numbered.

The Contractor shall provide a list of all of the protection and auto-reclose equipment being offered under the contract.



The Contractor shall also provide a list of all of the test and ancillary equipment required for commissioning and routine testing of all protection and auto-reclose equipment.

### **6.13 Service life and support**

The protection systems shall be designed for a service life of at least 15 years, and preferably 20 years, given that normal maintenance in accordance with manufacturers recommendations is carried out during the lifetime of the protection system.

The Contractor shall state the service life of the protection system equipment in relation to that of the main HV plant and apparatus so that Employer can assess the cost of any replacement during the life of the substation.

The Contractor shall state the period for which lifetime support will be provided for the protection system equipment and shall make recommendations for the provision of spare parts.

The Contractor shall supply circuit diagrams for each protection system and the associated tripping system(s). The diagrams shall provide sufficient information to enable fault finding and maintenance to be carried out and shall not consist solely of information used for equipment manufacture.

When the Contractor has been notified of incorrect operation, or failure to operate when required, of any protection system supplied under the contract, the Contractor shall investigate the incident and inform Employer of any such incidents if they result in the necessity to modify the equipment. The Contractor shall also inform Employer of the details of the modifications required to prevent such incidents re-occurring.

The Contractor shall offer a service to enable any faulty item of protection equipment to be rectified or replaced within a stated period of the fault being reported. The Contractor shall state the repair/replacement period.

The Contractor shall, when requested, offer the Employer a maintenance contract for the protection equipment supplied under the contract. The Contractor shall supply details of the cost of the maintenance contract and information on test procedures and test frequencies that would be supplied under the maintenance contract.

The Contractor shall offer training for Employer's personnel in the operation and maintenance of the protection equipment.

### **6.14 Thermal rating of equipment**

Relay equipment intended to perform a current measurement function shall be capable of continuous operation at a current of not less than 2.4 times the nominal rating or twice the setting value, whichever is the more onerous.

Relay equipment intended for use in a normally quiescent mode and having a short time rating - for example, high impedance differential protection - shall be rated in accordance with the intended function and taking account of such inherent protective devices as may be incorporated in the design. The short time rating for all protection relaying schemes shall be 100 times the nominal relay rating for a duration of one second.

Voltage sensitive equipment intended for use on effectively earthed networks shall have a continuous withstand of not less than 1.2 times nominal voltage and a short duration withstand of not less than 1.5 times nominal phase-to-ground voltage for 30 s.

## **6.15 Insulation**

The rated insulation voltage of circuits connected to current transformers of high impedance relays shall be 1000 V. All other circuits shall have an insulation voltage of 2500V.

All open contacts of the protection system shall withstand a voltage of 1000V. The protection system shall comply with the dielectric test requirements of IEC 255-5. The test voltage shall be selected according to the rated insulation voltage of the circuits being tested form SeriesC of Table1 of IEC 255-5. The protection system shall comply with the impulse test requirements of IEC 255-5 with test voltage of 5kV.

## **6.16 Test requirements**

### **6.16.1 General requirements**

The Contractor shall supply test results and/or in service operating evidence to confirm compliance with the general and performance requirements as detailed in this Specification.

### **6.16.2 Pre-commissioning and energisation tests**

The Contractor shall submit details of all pre-commissioning and energisation tests to the Project Manager for approval prior to the tests, and shall provide the Project Manager with the opportunity to witness the commissioning tests.

### **6.16.3 Testing, inspection and test certificates**

The Bidder shall enclose with his bid the reports of type and routine tests conducted on similar equipment earlier as a proof of designing and developing similar equipment. Bid documents, furnished without these test reports shall be considered as incomplete and shall be liable for rejection.

All equipment furnished shall conform to the type tests and shall be subject to routine tests in accordance with the requirements stipulated for control and relay panel equipment. The Project Manager reserves the option to call for any or all the type tests to be repeated on the equipment. The Project Manager further reserves the option to intimate the type tests to be carried out on the equipment up to six months after the award of contract. Payments would be made for the type tests actually carried out in accordance with the rates given in the Bid Price Schedule.

The Project Manager will have the right to call for any other tests of reasonable nature to be carried out at the Contractor's premises or at site or in any other place, in addition to the aforesaid type and routine tests, to satisfy that the materials comply with the Specification.

The Contractor shall advise the Project Manager three months in advance of the type tests to be conducted on the finished equipment giving a programme for conducting the tests and shall proceed to test the equipment only after approval of the Project Manager. All type tests shall be performed in presence of Project Manager should he so desire.

The Contractor shall give one months notice of routine tests and inspection to be carried out on the finished equipment. A programme for conducting the tests shall be furnished and the Contractor shall proceed to test the equipment after approval of the Project Manager. The tests shall be witnessed by the Project Manager should he so desire.

All inspections, type tests and routine tests shall be carried out after approval of all the relevant drawings required under the contract.

None of the equipment to be furnished or used in connection with this contract shall be despatched until factory tests are satisfactorily completed. Such factory tests on the equipment shall not however

relieve the Contractor from full responsibility for furnishing equipment conforming to the requirements of this contract, nor prejudice any claim right or privilege which the Employer may have because of the use of defective or unsatisfactory equipment. Should the Project Manager waive the rights to inspect and test any equipment, such a waiver shall not relieve the Contractor, in any way, of his obligations under this contract.

Six (6) copies of test reports of successful tests shall be submitted by the Contractor to the Project Manager for approval before shipment of equipment.

For equipment tests for which IEC recommendations or Indian Standards are available, test reports confirming that the equipment has passed the specified type and routine tests shall be furnished for the approval of the Project Manager by the Contractor before shipment of the equipment.

For equipment/tests for which IEC/IS specifications do not exist, the Contractor shall propose a test procedure for the approval of the Project Manager before conducting tests. Test certificates for tests carried out shall be submitted for approval of the Project Manager before shipment of the equipment. Failure of any equipment to meet the requirements of tests carried out at works or at site shall be sufficient cause for rejection of the equipment. Rejection of any equipment will not be held as a valid reason for delay in the completion of the works in accordance with the agreed programme.

The Employer reserves the right to call for field tests on the completely assembled equipment at site. The price for conducting all the type tests in accordance with relevant standards and specifications shall be indicated in Bid Price Schedule and these would be considered for bid evaluation. The break-up price of type tests shall be given in the relevant price schedule for payment purpose only. In case Bidder does not indicate charges for any of the type tests or does not specifically identify any test in the price schedules, it will be assumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to rejection.

Six (6) copies of all test reports shall be supplied for approval before shipment of equipment. The reports shall indicate clearly the standard values specified for each test, to facilitate checking of the test reports. Fourteen (14) bound copies of test reports shall be submitted along with the equipment after approval of test results.

#### **6.16.4 Soak test**

All solid state equipment/system panels shall be subject to the Hot Soak Test as a routine test in accordance with the procedure detailed in the following paragraph.

All solid state equipment shall be burn-in tested for minimum of 120 hours continuously under operational conditions. During the last 48 hours of testing, the ambient temperature of the test chamber shall be 50C. Each panel shall be complete with all associated sub-systems and the same shall be in operation during the above test. During the last 48 hours of the above test, the temperature inside the panel shall be monitored with all the doors closed. The temperature of the panel interior shall not exceed 65C.

#### **6.16.5 Type tests**

Impulse voltage withstand test as per Clause 6.1 of IS 8686 (for a test voltage appropriate to Class III as per Clause 3.2 of IS-8686)

High Frequency Disturbance test as per Clause 5.2 of IS 8686 (for a test voltage appropriate to Class III as per Clause 3.2 of IS 8686)

Type tests listed under IEC-Technical Committees recommendation `TEC-57' and functional type tests listed under **CIGRE Study Committee 34** (Protection) Report on simulator, Network analyser or PTL as applicable.

### **6.16.6 Routine tests**

Contact insulation resistance test as per Clause 10.5 of IS-3231.

Insulation withstand capability as per Clause 10.5 of IS-3231 on all AC/DC relays.

## **7.0 Protection Schemes**

### **7.1 General**

The following sections of this specification identify the protection requirements for specific schemes. Drawings showing single line diagrams for each type of circuit are included in this Specification. The arrangements shown on these drawings represent the minimum requirements. Other protection arrangements may be provided but the Bidder must clearly state the reasons for offering supplementary protection schemes.

### **7.2 Technical requirements**

Technical requirements of the protection and auxiliary relays, recorders and meters to be provided as part of the scope are detailed in the following sub clauses.

The setting ranges of the equipment offered, if different from that specified shall be acceptable if they meet the functional requirements. The Bidder shall quote for protection equipment meeting the requirements given in these sub clauses.

The Bidder may also quote alternative or additional protections or relays considered necessary by him for providing an effective and reliable protection scheme. These equipments shall be quoted separately as an alternative or addition to the main offer. The Employer reserves the right to accept or otherwise such equipment.

### **7.3 400kV Reactor protection**

#### **Protection requirement**

The 400 kV reactors provided with the lines shall have the following protections.

- Differential protection.
- Restricted earth fault protection.
- Backup impedance protection.

#### **7.3.1 Differential protection relay (87R)**

This relay shall :

1. Be triple pole type
2. Have operation time less than 25 milliseconds at five times setting.
3. Be tuned to system frequency.
4. Have three instantaneous high set units to ensure rapid clearance of heavy faults with saturated CT's.

5. Have current setting range of 10 to 40% of 1 Amp.
6. Be Low impedance type.
7. Be stable for all external faults.
8. Be provided with suitable non-linear resistors to limit the peak voltage to 1000 volts.

### **7.3.2 Restricted earth fault protection relay (64 R)**

This relay shall:

1. Be single pole type
2. Be of current/voltage operated high impedance type
3. Have a current setting of 10-40% of 1A and a suitable voltage setting range.
4. Be tuned to system frequency.
5. Be fitted with suitable non-linear resistors to limit the peak voltage to 1000 volts.

### **7.3.3 Back up impedance protection relay (21 R)**

This relay shall:

1. Be triple pole type
  2. Be single step polarised 'mho' distance relay or impedance relay suitable for measuring phase to ground and phase to phase faults.
  3. Have an ohmic setting range of 20-320 ohms and shall be continuously variable.
  4. Have an adjustable characteristic angle of 30 to 80 degree.
  5. Have a definite time delay with a continuously adjustable setting range of 0.2 - 2.0 seconds.
- Shall initiate three phase tripping

## **7.4 Transformer protection**

The following protection shall be provided for all 315MVA 400/220kV and 220/132/33 KV,160 or 100MVA autotransformers(33 kv side is delta winding and is a loaded winding), and 220/33kV and 132/33kV double wound transformers: **All the relay shall be latest numerical version having IEC 61850 protocol compliance**

1. Transformer differential protection (87AT)
2. Over fluxing protection (99AT)
3. Restricted earth fault protection (64AT)
4. Back-up directional over current protection (67/51/50) on HV side
5. Back-up directional earth fault protection (67N/51N/50N) on HV side
6. Back-up directional over current protection (67/51/50) on LV side
7. Back-up directional earth fault protection (67N/51N/50N) on LV side
8. Restricted earth fault protection (64R)
9. Transformer over load protection (51OL)

10. LBB for 400kV, 220kV and 132kV sides.

#### **7.4.1 Transformer differential protection relay (87AT)**

This relay shall :

1. Be triple pole type, with faulty phase identification/indication
2. Have an operating time not greater than 30 milliseconds at five times setting.
3. Have three instantaneous high set units to ensure rapid clearance of heavy faults with saturated CT's.
4. Have an adjustable dual slope bias setting range of 10%-50%.
5. Be suitable for rated current of 1A.
6. Have second harmonic and fifth harmonic restraint feature and also be stable under normal over fluxing conditions and inrush of current during charging.
7. Have at least three bias winding per phase.
8. Have an operating current setting adjustable between 10% and 50%
9. Should not require interposing transformers and the relay should correct the vector group difference and CT primary/load current difference.

#### **7.4.2 Over fluxing protection relay (99AT)**

This relay shall :

1. Operate on the principle of voltage to frequency ratio and have two settings - for alarm and trip.
2. Have inverse time characteristics, matching with transformer over fluxing withstand capability curve.
3. Provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of " $v/f$ " between 100% to 130% of rated values.
4. Have a set of characteristics of various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at " $v/f$ " values of 1.4 and 1.5 times, the rated values, respectively.
5. Have a tripping time governed by " $v/f$ " Vs. time characteristics of the relay.
6. Have an accuracy of operating time better than  $\pm 10\%$ .
7. Have a resetting ratio of 98% or better.

#### **7.4.3 Restricted earth fault protection relay (64AT)**

This relay shall:

1. Be single pole type.
2. Be of current/voltage operated high/low impedance type.
3. Have a current setting range of 10-40% of 1A and a suitable voltage setting range.
4. Be tuned to the system frequency

5. Have suitable non-linear resistor in case required to limit the peak voltage to 1000 Volts.

#### **7.4.4 Transformer overload protection feature**

The transformer overload protection shall:

1. Be a single pole type
2. Be a definite time overcurrent type
3. Have two separate sets of overcurrent relay elements, each with continuously adjustable setting range of 50-200% of rated current independently.
4. Have two separately adjustable time delay relays, one for alarm having setting range of 1 to 10.0 seconds, continuously. The second time delay relay should have continuously adjustable setting range of 1.0 to 10.0 minutes for tripping.
5. Have a drop-off/pick-up ratio greater than 95%.

#### **7.4.5 HV /LV side back-up directional over current protection**

This relay shall:

1. Be single pole type.
2. Have IDMT characteristics with a definite minimum of three seconds at ten times the setting.
3. Have a variable setting range of 50% to 200% of rated current.
4. Have a characteristic angle of 45 degrees, a directional controlled, low transient over reach, high set instantaneous unit of continuously variable setting range of 500- 2000% of rated current.
5. Provision of highest setting in two stages.

#### **7.4.6 HV/LV side back-up directional earth fault protection**

This shall also have identical specification as at clause above excepting that the adjustable setting range shall be 20-80%.

### **7.5 TEE protection differential relays (87 TT1,87TT2) (applicable for 5 CT scheme)**

Where a Tee Protection for a five CT system is provided the following shall be applicable.

#### **7.5.1 First set of differential relays**

One set of differential protection relays (87 TT1) shall

1. Be triple pole type.
2. Have an operating time less than 30 milliseconds at five times setting
3. Have three instantaneous high set over current units.
4. Have an adjustable bias setting range of 20% to 50%
5. Be suitable for rated current of 1A.
6. Have three bias windings.
7. Have an operating current setting of 15% or less.

## **7.5.2 Second set of differential relays.**

The second set of Differential relay (87 TT2) shall:

1. Be triple pole type.
2. Have operating time less than 25 milliseconds at five times setting.
3. Be tuned to system frequency
4. Have current setting range of 20 to 80% of 1A.
5. Be voltage operated, high impedance type
6. Be stable for all external faults.
7. Be provided with suitable non linear resistors across the relay to limit the peak voltage to 1000 volts.

## **7.6 BUS BAR PROTECTION:**

Bus bar protection schemes shall be provided for each main and transfer bus of 400 KV and 200 KV provided in the switch yard. This shall constitute main and check features. The overall scheme shall be engineered such that operation of both main and check features connected to the faulty bus shall result in tripping of the same. The scheme shall be provided with necessary expansion capacity and interfaces for adding features when the switch yard is extended in future to its ultimate capacity. The bus bar relay shall be of latest numerical relay having IEC protocol 61850 compliance.

### ***7.6.1 Busbar protection (Latest version numerical having IEC-61850 protocol compliance)***

Bus bar protection schemes shall be provided for each main bus of 400kV and 220kV switchyard. The overall scheme shall be engineered so as to ensure that operation of any one out of two schemes connected to main faulty bus shall result in tripping of the same. However in case of transfer bus, where provided, only one busbar protection scheme shall be required.

Each busbar protection scheme shall

1. Be of modular construction and have features of self monitoring facility to ensure maximum availability of scheme. The scheme shall be static/ microprocessor/ Numerical based.
2. Have maximum operating time up to trip impulse to trip relay for all types of faults of 15 milli seconds at 5 times setting value.
3. Operate selectively for each busbar.
4. Give hundred percent security up to 40kA fault level.
5. Incorporate a check feature.
6. Incorporate continuous supervision for CT secondaries against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate alarm.
7. Not give false operation during normal load flow in busbars.
8. Incorporate clear zone indication.



9. Be of phase segregated and triple pole type and provide independent zones of protection for each bus (including transfer bus if any). If a bus section is provided then each side of the bus section shall have separate busbar protection scheme.
10. Include individual high speed hand reset tripping relays for each feeder, including future ones.
11. Be of low/medium impedance biased differential type and have operate and restraint characteristics.
12. Be transient free in operation
13. Include continuous DC supplies supervision.
14. Shall include multitap auxiliary CT's for each bay including future bays as per SLD and also include necessary CT switching relays wherever CT switching is involved.
15. Include protection 'in/out' switch for each zone with at least six contacts for each switch.
16. Shall have CT selection incomplete alarm wherever CT switching is involved.
17. Have necessary auxiliary relays to make a comprehensive scheme.

At existing substations busbar scheme with independent zones for each bus will be available. All necessary co-ordination for 'CT' and 'DC' interconnections between existing schemes (panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relays, trip relays, flag relays required to facilitate the operation of bays covered under this contract shall be fully covered in the scope of the bidder.

The Contractor shall offer all equipment to meet the requirements as above to make the scheme full and comprehensive.

### **7.6.2 Weatherproof relay panels**

Where required these panels shall be provided for busbar differential protection. The panels shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contact multiplication and for changing the CT and DC circuits to relevant zone of protection.

The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 3.0 mm thick and properly braced to prevent movement. The enclosures of the panel shall provide a degree of protection of not less than IP55 (as per IS 2147). The constructional requirements shall comply with the relevant section of this Specification.

Two test terminal blocks required for bus coupler bay CT connection shall be supplied and mounted inside the panel of adjacent bay.

The test terminal blocks shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. Such blocks shall have washer and binding screws for external circuit wire connections, a white marking strip for circuit identification and moulded plastic cover. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

## **7.7 Tripping relay (86)**

High speed tripping relay shall:

1. Be instantaneous (operating time not to exceed 10 milliseconds).
2. Reset within 20 milliseconds. Not self resetting.
3. Be DC operated
4. Have adequate contacts to meet the requirement of scheme, other functions such as auto-reclose relay, LBB relay as well as cater to associated equipment such as event logger, disturbance recorder, fault locator, etc.
5. Be provided with operation indicators for each element/coil.

## **7.8 Flag relays**

These shall have:

1. Hand reset flag indication
2. Two elements
3. Four contacts (NO or NC or combination as required), for each element/coil.

## **7.9 Trip circuit supervision relay**

The relay shall be capable of monitoring the healthiness of each 'phase' trip coil and associated trip circuit of circuit breaker during 'ON' and 'OFF' conditions. The relay shall have adequate contacts for providing connections to alarm and event logger. The relay shall have time delay on drop-off of not less than 200 milliseconds and be provided with operation indications for each phase.

## **7.10 Supply supervision relay**

The relay shall be capable of monitoring the DC supply to which it is connected and indicating failure. It shall have adequate potential free contacts to meet the scheme requirement. The relay shall have a 'time delay on drop-off' of not less than 100 milliseconds and be provided with operation indicator/flag.

## **7.11 Bus coupler / transfer bus coupler protection**

The protection scheme for the above are to be provided with directional numerical over current and earth fault protection scheme . The relay shall be latest version numerical and IEC 61850 compliant for future SCADA purpose. The details as indicated under unit back up protection relay.

All 220 kV substations shall be of Double Main (DM) or Double Main and Transfer (DMT) busbar configuration and shall be provided with a single bus coupler circuit breaker. In addition 220 kV DMT busbar configurations shall be provided with a transfer bus coupler circuit breaker. The required protection equipment for these breakers comprises overcurrent and earth fault relays. These relays shall comply with the requirements for backup over current and earth fault protection as described elsewhere in this section, except that the relays shall not be directional. The earth fault element shall have a current setting range of at least 20 - 80 per cent in six equal steps.

All 132 and 33 kV substations shall be of Single Main and Transfer (SMT) busbar configuration and a bus section isolator. Overcurrent and earth fault protection, complying with the requirements as given elsewhere in this section but without directional feature, shall be provided.

In DMT/SMT configurations, whenever the main breaker of a feeder or transformer is substituted by the bus coupler or transfer bus coupler breaker, a facility for switching over of the trip function of the feeder or transformer relays from the main breaker to the bus coupler or transfer bus coupler breaker, shall be provided through provision of a lockable protection transfer switch. The provision of a key interlock on the above switch is to be so arranged that at one time only one feeder or transformer can be taken to transfer mode.

### **7.12 Circuit breaker monitoring auxiliary relays**

All circuit breakers shall be provided with several relay contacts for annunciation of circuit breaker conditions such as :

- Low air/hydraulic oil/gas pressure.
- Lockout conditions due to abnormally low air/hydraulic oil/gas pressure.
- Pole discrepancy trip.
- Compressor/hydraulic pump trouble.

The exact requirements for this shall be available in the circuit breaker drawings to be provided by the manufacturer. The programmable Inputs/Outputs of the numeric relays shall be used as much as possible for providing annunciation in the control room for such cases. In case this is found inadequate, suitable auxiliary flag relays may be provided in the relay panels to provide annunciation.

### **7.13 Disturbance recorder (Required for 400 and 220 KV sub-station)**

#### **7.13.1 General**

Where required disturbance recorders shall be provided separately. Integrated out put from the relays memory is also acceptable.

Disturbance recorders shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage and neutral current, open or closed position of relay contracts and breakers during system disturbances.

Necessary auxiliary VT's, to generate open delta voltage, shall be supplied by the Bidder. The Bidder shall furnish along with the offer a typical printout for simulated conditions, on original paper.

The disturbance recorder shall be an individual acquisition unit, one for each feeder, and shall have at least 8 analogue and 16 event channels for acquisition of fault data and events. The restitution unit, printer, EGA/VGA screen and key board shall be common for the entire substation. The acquisition unit shall acquire fault data and store either on portable magnetic cassettes or floppy discs, or instantaneously transfer data to the restitution unit for storage in solid state non-volatile memory.

The restitution unit shall be capable of reading fault data from the magnetic cassettes or floppy discs or from its own memory, as the case may be, and controlling the printer to give the graphic form whenever desired by the operator. The acquisition units shall be located in the protection panels of the respective feeders and the restitution unit along with the printer shall be located suitably within

the substation control room. Only one printer for the entire substation is required for disturbance recording purposes. The disturbance recorder system shall have non-volatile memory of the last ten faults of at least 1.6 second duration each.

### **7.13.2 Features of the disturbance recorder.**

The disturbance recorder shall incorporate the features as described below:

#### **7.13.3 Software stability**

The operation of the equipment shall be based on programme stored in non-volatile solid state memory. The programme shall be stable and no inadvertent change of programme shall occur.

#### **7.13.4 Reliability**

Large scale integrated circuits shall be used as far as possible to reduce the number of components and interconnections and the amount of wiring. The components used shall be subjected to strict quality control which shall include screening of components by heat soaking and testing their functioning prior to assembly.

#### **7.13.5 Simplicity of maintenance and repair**

The number and type of modules employed shall be minimised. The modules shall be of plug-in type and shall be easily accessible for maintenance and repair wherever required.

#### **7.13.6 Immunity from the effects of hostile environment**

The equipment shall be designed to operate satisfactorily even when subject to the effects of severely hostile electrical environment such as interference signals arising from switching transients. The equipment shall be mounted in self contained, free standing cubicles and shall be of dust, vermin and rodent proof construction. Ventilation arrangements shall be provided if warranted by power dissipation level of the equipment.

#### **7.13.7 Interface with PC**

The disturbance recorder should have an interface arrangement for the transfer and storage of data to PC through its serial port. Necessary PC, software, special cables etc. shall be part of the disturbance recorder and should be included in the Bid.

PC based user friendly, disturbance recorder evaluation software shall be provided for the analysis and evaluation of the record data made available in the PC under WINDOWS environment. The software features shall include:

- Repositioning of analogue and digital signals
- Selection and amplification of time and amplitude scales of each analogue and digital channel
- Calculation of MAX/MIN frequency and phase difference values
- Recording of MAX/MIN values etc. of analogue channels
- Grouping of signals to be drawn on the same axis etc.,

- Listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping.

### **7.13.8 Power supply**

Disturbance recorder equipment shall be suitable for operation from 220V DC or 110V DC supplies as available at substation. Voltage variation of +10% and -20% can be expected. Any other power supply that may be required for proper functioning of the equipment including the printer shall be derived by the Bidder from his own equipment and shall form an integral part of the disturbance recorder system.

### **7.13.9 Alarms and indications**

All external and internal faults in the disturbance recorder equipment such as power supply fail, printer faulty, paper exhausted, processor/memory fail etc. are required to be indicated by means of light emitting diodes on the front of panels of the equipment if type 2 disturbance recorders are offered, or on the front of panel of the restitution unit if type 1 disturbance recorders are offered.

### **7.13.10 Scan rate**

The frequency response shall be DC on lower side and 250 Hz or better on upper side. The acquisition unit shall have a scan rate of 1000 Hz/channel or better.

The equipment shall have as an inherent part of it, starting sensors based on over voltage, rate of change of current, and rate of change of frequency. These starting sensors, when picked up, shall start the disturbance recorders to give out the graphic form of analogue and event signals, in the case of type 2 disturbance recorders. If type 1 disturbance recorders are offered the starting sensors, on pick up, shall preserve the fault data acquired during the period of system disturbance, including pre-fault and post fault time, on magnetic cassettes, floppy disks, CD or solid state memory of restitution unit, as the case may be. Preserved fault data shall not be erased other than by the operator. Erasing arrangement shall be provided in the restitution unit.

### **7.13.11 Starting sensors**

The equipment shall have inherent to it starting sensors based on over voltage, rate of change of current and rate of change of frequency. The starting sensors on pick-up shall preserve the fault data acquired during the period of system disturbance including pre-fault and post fault time on magnetic cassettes, CD or floppy diskettes or solid state restitution unit as the case may be.

### **7.13.12 Pre-fault and post-fault time**

Pre-fault time shall not be less than 160 ms and the post fault time adjustable at a minimum of two seconds and a maximum of not less than five seconds. If another system disturbance occurs during one post-fault time, the recorder shall also be able to record the same.

### **7.13.13 Amplitude and event resolution**

Amplitude resolution shall not be less than eight bit. Event resolution shall be 2 ms or better.

### **7.13.14 Print out**

The print out shall contain the following:

1. Feeder identity.
2. Date and time (in hour, minute and second up to 100th of a second).
3. Identity of trigger source.
4. Graphic form of analogue and event signals of all the channels.

The print out shall be clear and legible without the help of looking glass or any such device.

Minimum acceptable paper width shall be 8-1/2 inches. (216 mm approx.)

### **7.13.15 Type and quantity of paper**

Printer shall use plain paper. The Bidder shall provide as part of his scope of supply sufficient consumable for 6 months operation. The arrangement of feeding and removing paper rolls shall be quick and simple.

### **7.13.16 Time generator**

Each disturbance recorder shall have its own time generator. The facility shall exist to synchronise the time generator from station time synchronisation equipment having output of following types at 30 min interval

1. Voltage signal - 3 to 50V continuously settable, with 50 ms minimum pulse duration.
2. Potential free contact (Minimum pulse duration of 50 ms.)
3. IRIG-B
4. RS232C

At substations where station time synchronisation equipment is not available, time generator of any one of the disturbance recorders can be taken as master. The facility shall exist to synchronise the time generators of other disturbance recorders and event loggers in that station with respect to it. The recorder shall give annunciation in case of absence of 'Sync'. pulse within a specified time. The clock of the time generator shall be such that, the drift is limited to  $\pm 0.5$  seconds per day, if allowed to run without synchronisation. Facility shall exist to display the time in hours, minutes and seconds on the front of panel.

### **7.13.17 Inputs**

The equipment shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make them compatible to the equipment shall form an integral part of the equipment. However, such processing of input signals shall in no way distort its wave form. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. The input circuits shall withstand the following tests.

- 5kV impulse test in accordance with IEC 225 Part-IV.
- High frequency disturbance test in accordance with IEC 255 Part-IV).

## **8.0 Event logger (\*\*)**

\*\*As per the customers requirement

All 400 and 220 KV sub-station shall have separate Event Logger panel provision.

### **8.1 General**

The event logger shall be used to record the open and close states of switch yard equipment, relays and changes of alarms.

The function of the equipment should be based on programmes stored in it. The stored programmes should permit some degree of flexibility of operation. Facility should be provided to erase the existing programme and reprogram allowing changes to be made very easily.

The number of modules and different types of modules should be minimised. The modules should be of plug-in type and should be easily accessible to simplify maintenance and repair.

The equipment should be designed to operate satisfactorily in severely hostile electrical environment such as in 400kV/220kV switchyard which are prone to various interference signals, typically from large switching transients.

The equipment should be carefully screened, shielded, earthed and protected.

Input/ Output circuits should withstand the following tests:

- Impulse test in accordance with IEC 255, Part-IV.
- High frequency disturbance test in accordance with IEC 255, Part-IV.

Since the equipment will be used in dedicated non-attended situations, programme stability is vitally important. Programme must not be capable of being changed unintentionally during normal operation.

### **8.2 Construction**

The equipment should be constructed in clearly defined plug-in modules. A monitor module should be provided for indicating internal faults such as processor failure, memory failure, other internal hardware failures, and also external plant failures. These failures should be displayed on the LED's mounted on the monitor module. The equipment is used to record changes in digital points, i.e. operations and resetting of alarms and switching of primary equipment within a substation. Approximately 500 points should be accommodated in a single equipment. When such changes occur, a print out on a local teletype writer, which forms a part of this contract, should result.

The date and time should be printed to the nearest 10 ms followed by a message describing the point which has operated. Such messages may be abbreviated or in full English forms. Events occurring whilst a previous event is in process of being printed are to be stored to await printing. Over 100 such events must be stored. Facility shall exist to synchronise the internal clock system which will give a pulse output every half an hour with a pulse duration of at least 50 milliseconds through potential free contacts. However, if master clock system is not available, time generator of any one of the disturbance recorder shall be taken as master and event logger(s) in that station will be synchronised with it. The event logger shall give annunciation in case of absence of synchronising pulse within a specified time window. The internal clock of the event logger shall be such that the drift is limited to  $\pm 0.5$  seconds per day, if allowed to run without time synchronisation. The print out of current alarm and plant stages must be available on request by the operator. the operator should also be able to enter the date and time from the key board.

### **8.3 Technical requirements**

The event recorder shall record all changes of alarms and plant states of switchyard equipment, along with the date and time of all alarms and plant state changes to the nearest 10 ms.

Facility shall be provided to commit 50 points of sequential memory or 25% of alarm whichever is the greater. In addition the unit shall be capable of handling up to 40 changes in any one 10 ms interval and 500 alarms and changes of state of switchyard equipment.

On receipt of an alarm the equipment must:

- Print out a message on Printer
- Set off an audible alarm.
- Set off a beacon.

Allow normal inputs of

- Accept
- Alarm demand log
- Plant state demand log
- Date and time

The Bidder shall furnish along with the offer a two copies on original paper typical print out for simulated conditions.

Only plain paper readily available in India shall be used for the printer. The arrangement of feeding and removing paper rolls or stacks shall be quick and simple. The width of paper shall be 216 mm approximately. The Bidder shall provide as part of his scope of supply, consumables for up to six months operation.

Event printout of the shall contain as a minimum the following:

- Station identification.
- Date and time (in hour, minutes, seconds and milliseconds).
- Event number.
- Event description (at least 40 characters).

The auxiliary power supply required for the event logger, VDU and printer shall be either 220V DC or 110V DC (as available in the station) with voltage variation of + 10% to -20%. Any other power supply that may be required for proper functioning of the equipment has to be derived by the Bidder from his own equipment which shall form an integral part of the event logger station.

Bidder shall supply VDU, printer and keyboard arrangement.

At existing substations where an event logger is provided, Bidder shall provide necessary potential free contacts of various relays/equipment for plant and alarm states and shall co-ordinate with existing event logger for proper logging of events.

A combined solution of disturbance recorder and event logger function with a VDU, key board and a printer is also acceptable.

### **9.0 Synchronising equipment**

Where required synchronising equipment shall be provided along with this Contract.

The synchronising instruments shall be mounted on a synchronising trolley. The trolley shall be equipped with double voltmeter, double frequency meter, synchroscope and lamps fully wired. The



trolley shall be of mobile type with four rubber padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two metre long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

Synchronising check relay with necessary ancillary equipment shall be provided. This shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have a continuously adjustable time setting range of 0.5-3 seconds. A guard relay shall be provided to prevent a closing attempt by means of synchronising check relay when control switch is kept in closed position before the two systems are in synchronism.

Suitable auxiliary voltage transformers, wherever necessary, shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.

Each circuit for which a synchronous closure is required shall be provided with a lockable synchronising selector switch which shall be used to select the voltage signals (incoming and running voltage) appropriate for that circuit. The provision of a key interlock shall ensure that at any one time only one feeder / transformer can be synchronised.

### **10.0 Time synchronisation equipment for substation**

The Bidder shall offer necessary time synchronisation equipment complete in all respects including antenna, all cables, processing equipment etc. required to receive co-ordinated universal time (UTC), transmitted through GEO Positioning Satellite System (GPS).

The time synchronising system should be compatible for synchronisation with event loggers, disturbance recorders, relays, computer systems and all other equipment provided in the protection, control and metering system of the substation wherever required.

Equipment should operate up to an ambient temperature of 50C and 100% humidity. The synchronisation equipment shall have two microsecond accuracy. Equipment should give real time corresponding to IST (taking into consideration all factors such as voltage and temperature variations, propagation and processing delays etc).

Equipment should meet the requirement of IEC 255 for storage and operation. The system should be able to track the satellites to ensure no interruption of synchronisation signal.

The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

The equipment offered shall have six output ports. Various combinations of output ports shall be selected by the Project Manager, during detailed engineering, from the following:

1. Voltage signal : 0-5V continuously settable, with 50 ms. minimum pulse duration.
2. Potential free contact : minimum pulse duration of 50 ms
3. IRIG-B & SNTP

#### 4. RS232C

The equipment should have a periodic time correction facility of one second periodicity.

Time synchronisation equipment shall be suitable for operation from 220V DC as available at substation with a voltage variation of +10% and -20%. Any other power supply that may be required for proper functioning of the equipment shall be derived by the Bidder from his own equipment which shall form an integral part of the system.

Equipment shall have real time digital display in hour, minute, second (24 hour mode) and have a separate time display unit to be mounted on the top of control panels having display size of approximately 100 mm height.

Bidder shall quote unit rates for each type of output port for the purpose of addition/deletion.

Schedule of Quantities

### 11.0 General

Protection, control, metering panels and associated equipment to be located in switchyard control rooms at various substations shall be offered as panels/systems/modules of following description.

The quantities are given at the end of this section.

Sl. No.	Description of Panels	Relay Panels type and designation	
1	Line protection panel:		
1.1	400kV line-4CT,5CT ( 1 ½ breaker scheme)	RPF4H	
1.2	220kV line-DMT	RPF2D	
1.3	132kV line—MT	RPF1M	
1.4	33kV line—MT	RPF0M	
2	Transformer protection panel:		
2.1	400/220kV Auto-Transformer	RPH4H	
		RPL2D	
2.2	220/132kV Auto-Transformer	RPH2D	
		RPL1M	
2.3	220/33kV power Transformer	RPH2D	
		RPL0M	
2.4	132/33kV power Transformer	RPH1M	
		RPL0M	
3	Reactor protection panel:		
3.1	Bus reactor	RPR4H	
3.2	Line reactor	RPS4H	
4.1	Transfer bus coupler		
		220kV line-DMT	RPT2D
		220kV line-T	RPT2T
4.2	Bus coupler		
		220kV line-DMT	RPB2D
		132kV line—MT	RPB1M
	33kV line—MT	RPB0M	
4.5	Bus sectionaliser	RPZ2D	

### 11.1 Type designations for the various panels

The panels are designated by an alpha-numeric code consisting of five characters (AAANA) throughout this schedule in this specification to represent their use for various applications. Their representation shall be as here under:

### 11.2 Bill of quantities for individual panels

Each panel described above shall constitute the equipment as detailed here under. The quantities of each type of equipment are minimum. The bidder may include additional devices in the panels depending upon the design and requirements as per stipulations of the specification.

### 11.3 Line protection panel (RPLNA)

The line protection panel or panels may be a single panel or more panels to accommodate all the equipments listed below. However, for bay extension, new panels must match the existing panels in all respect.

Sl. No	Equipment	Quantities required			
		400kV RPL3H	220kV RPL2 A	132kV RPL1 A	33kV RPL0A
1	Main-I protection scheme (composite numerical distance protection relay with auto reclosing and check synchronising facility)	1 set	1 set	1 set	Not required
2	Main-II protection scheme (composite numerical distance protection or phase comparison relay with auto reclosing and check synchronising facility)	1 set	1 set	Not required	Not required
3	Composite numerical directional over current and earth fault relay, with under/over frequency protection. (selectable Features Dir & Non Dir)	1 set	1 set	1 set	1 set
4	Over voltage/ Under voltage protection scheme (if not available in the main-I protection module)	1 set	1 set	1 set	Not required
5	Selector switch for carrier in/out for main-I and main-II protection scheme	2 Nos.	2 Nos.	1 No.	Not required
7	Disturbance recorder (if not available in the distance protection or main protection module)	1 set	1 set	1 set	Not required
8	Distant-to-fault locator for phase and earth faults (if not available in the distance protection or main protection module)	1 set	1 set	1 set	Not required
9	CVT selecting relays or switches	1 set	1 set	1 set	Not

	(depending on switching scheme)				required
10	Test terminal blocks for Main-I/ Main II/other protection relay	1 set for each module	1 set for each module	1 set for each module	1 set for each module
11	Auxiliary relays for carrier supervision of Main-I and Main II protection relays (depending on its application)	1 set	1 set	1 set	Not required
12	Carrier receive lockout relay (depending on its application)	1 set	1 set	1 set	Not required
13	Breaker failure protection scheme	1 set	1 set	1 set	1 set
14	Trip circuit pre and post supervision relays for trip coil I and II	1 set	1 set	1 set	1 set
15	DC supply supervision relay	1 set	1 set	1 set	1 set
16	Flag relays for circuit breaker trouble shooting	1 set	1 set	1 set	1 set
17	Trip relays single/three phase for group-A	1 set	1 set	1 set	1 set
18	Trip relays single/three phase for group-B	1 set	1 set	1 set	1 set
19	Trip relays single/three phase for LBB	1 set	1 set	1 set	1 set
20	Under Frequency Relay			1 set	1 set

#### 11.4 Transformer protection panel(RPHNA and RPLNA)

The transformer protection panel or panels may be a single panel or more panels to accommodate all the equipments listed below. However, for bay extension, new panels must match the existing panels in all respect.

Sl. No	Equipment	Quantities required		
		For each High Voltage panel of 400/220kV and 220/132kV transformers	For each High Voltage panel of 220/33kV and 132/33kV transformers	For each Low Voltage Panel of transformers
1	Main-I Transformer composite numerical protection comprising of the following: <ul style="list-style-type: none"> <li>Differential protection</li> <li>Restricted earth fault protection</li> </ul>	1 set	1 set	Not required

	• Over fluxing protection			
2	Main-II Duplicated numerical protection as Main-I	1 set	Not required	Not required
3	Composite numerical directional over current and earth fault protection relay(selectable Features Dir & Non Dir)	1 set	1 set	1 set
4	Over load protection ( if not included in sl.no. 1 and 2 above)	1 set	1 set	1 set
5	Over voltage/ Under voltage protection scheme (if not available in the main protection module)	1 set	1 set	Not required
6	Flag relays for thermal imaging, MOG, WTI, OTI, Bucholz, PRV,OSR and status indication etc.. (1.MOG-AI,2.WTI,BUCH,OTI – AI & Trip,3. PRV,OSR – Trip)	1 set	1 set	Not required
7	Solid state trivector type energy meters for measurement of export/ import of MWH, MVA and MVARH with MDI.	1 set	1 set	1 set
8	CVT/PT selection relays (depending upon the the switching scheme of the system)	1 set	1 set	1 set
9	Breaker failure protection scheme	1 set	1 set	1 set
10	Trip circuit pre and post supervision relays for trip coil I and II.	1 set	1 set	1 set
11	DC supply supervision relay	1 No for each panel	1 set	1 set
12	Flag relays for circuit breaker trouble shooting	1 set	1 set	1 set
13	Trip relays three phase for group-A	1 set	1 set	1 set
14	Trip relays three phase for group-B	1 set	1 set	1 set
15	Test terminal blocks for all protection relays	1 set for each module	1 set for each module	1 set for each module

## 11.5 Transfer bus coupler (RPT2D) / Bus coupler and Busbar (RPBNA) protection panel

Bus bar protection panel shall be equipped to accommodate all present and future bays.

Sl. No	Equipment	Quantities required			
		RPB4H	RPB2A	RPB1A/ RPB0A	RPT2D
1.	Composite numerical Directional Over current and earth fault protection (selectable Features Dir & Non Dir)	1 set	1 set	1 set	1 set
2.	Test terminal block for all protection relays	1 set for each module	1 set for each module	1 set for each module	1 set for each module
3.	Trip circuit pre and post supervision relays for trip coil I and II	Not required	1 set	1 set	1 set
4.	DC supply supervision relay	Not required	1 set	1 set	1 set
5.	Flag relays for circuit breaker trouble and status indication etc.	Not required	1 set	1 set	1 set
6.	Breaker failure protection scheme	Not required	1 set	1 set	1 set
7.	Trip relays single/three phase for group-A	Not required	1 set	1 set	1 set
8.	Trip relays single/three phase for group-B	Not required	1 set	1 set	1 set
9.	Bus bar differential relay for Bus-I	1 set	1 set	Not required	Not required
10.	Bus bar differential relay for Bus-II	1 set	1 set	Not required	Not required
11.	CT switching/selection relays(if required)	1 set	1 set	Not required	Not required
12.	Bus bar differential relay for Check Zone	1set	1set	Not required	Not required

At existing substations, necessary trip relays and auxiliary relays required shall be included in the offer to accommodate the new bays for existing bus bar protection schemes.

### 11.6 Common equipment (RPKNA)

Sl. No	Equipment	Quantities required
1.	Bus-I voltage recorder	1 No.
2.	Bus-II voltage recorder	1 No.
3.	Bus-I frequency recorder	1 No.
4.	Bus-II frequency recorder	1 No.
5.	Bus-I & Bus-II Digital Volt meter	1 Set
6.	Bus-I & Bus-II Digital Frequency meter	1 Set
7.	Event logger(Separate panel)	1 No.

### 11.7 Bus sectionalizer protection panel

Sl. No	Equipment	Quantities required
1.	Composite numerical directional Over current and earth fault protection relay(selectable Features Dir & Non Dir)	2 sets
2.	Test terminal block for all protection relays	1 set
3.	Trip circuit pre and post supervision relay for trip coil I and II	2 No
4.	DC supply supervision relay	1 No
5.	Flag relays for circuit breaker trouble and status indication etc.	2 No
6.	Breaker failure protection scheme	2 set
7.	Trip relays three phase for group-A	2 set
8.	Trip relays three phase for group-B	2 set
9.	Bus bar differential relay for Bus-I (numerical type- IEC -61850)	1 set
10.	Bus bar differential relay for Bus-II (numerical type- IEC -61850)	1 set
11.	CT switching/selection relays	1 set

12.	Bus bar differential relay for Check Zone (numerical type- IEC -61850)	1set
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### 11.8 Synchronising panel

Synchronisation panels are required for new substations and addition of new voltage ( 132kV and above) to existing substation.

Sl. No	Equipment	Quantities required
1	Double Voltmeter (0-150v range)	1 no for each panel
2	Double Frequency meter (45-55Hz)	1 no for each panel
3	Synchroscope	1 no for each panel
4	Synchronising relay	1 set for each panel

**\*\* ALL THE RELAYS SHALL BE OF NUMERICAL VERSION HAVING IEC 61850 PROTOCOL COMPLIANCE.ALL CARE SHALL BE TAKEN IN DESIGNING THE PROTECTION SYSTEM FOR FUTURE SCADA PROVISION. THERE SHALL BE ADEQUATE NO OF INPUT AND OUT PUT CONTACTS FOR USE. SHALL HAVE SELF SUPERVISING AND INTERNAL FAULT DETECTING/DIAGNOSING FACILITY. SUFFICIENT FAULT /DISTURBANCE RECORDING FACILITIES.**

#### 12.0 ERECTION AND MAINTENANCE TOOL EQUIPMENT:

All special testing equipment required for the installation and maintenance of the apparatus,instruments devices shall be furnished . The testing plug shall be supplied along with the panels for conducting testing of relays. These testing plug should be suitable for test terminal box provided in the panel.

#### 12.1 TROPICALISATION:

Control room will be normally air-conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot,humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring,equipment and accessories shall be protected against fungus growth,condensation,vermin and other harmful effects due to tropical environment.

#### 12.2 RELAY TEST KIT

One relay test kit shall comprise of the following equipment as detailed hereunder.

1. ONE No. universal relay testing kit for testing of all type of relays metering system.
2. Relay tools kits: 3 Sets
3. Test plugs: 2 Nos
4. Special type test plugs for using with modular type cases(if applicable): 1 No

### 13.0 ADDITIONAL INFORMATION ON PROTECTION RELAYS, SWITCHES ETC.

#### 13.1 RELAYS:



1. All relays shall conform to the requirements of IS: 3231/IEC-60255 and IEC-61850 protocol compliance. Relay shall be suitable for flush or semi-flush mounting on the front with connections from the rear.
2. Shall be draw out or plug in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied, which is in the scope of this contract.
3. The protective relay shall be suitable for efficient and reliable operation of the protection scheme as indicated in the specification. Necessary auxiliary relays etc for interlocking scheme, for multiplying contacts suiting for the scheme and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme, contacts shall be silver faced with spring action. It shall have adequate numbers of terminals for making potential free external connection to the relay coils and contacts, including spare contacts. All the contacts of the auxiliary relays and timers except lock out type relays shall have self reset type contacts
4. No control relay which shall trip the power circuit breaker when the relay is deenergised shall be employed in the circuit.
5. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
6. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
7. The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.
8. The numerical relays shall include the followings:
  - i) Necessary software and hardware to up/down load the data's to/from the relay from/to the personal computer ( supply is in the scope of this contract.).
  - ii) The relay shall have suitable communication facilities for future connectivity to SCADA. The relay shall be capable of supporting IEC 870-5-103 protocol. Neither the interface hardware nor the software for connectivity to SCADA will form part of the scope of this specification.
  - iii) In the numerical relays the features like disturbance recorder and event logging function as available in these relays shall be supplied.

#### 13.2 A) Transmission Line protection:

The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines.

1. The maximum fault current could be as high as 40 KA and minimum fault current could be as low as 20% of rated current of the CT secondary. The starting and measuring relay characteristics should be satisfactory under these extremely varying conditions.
2. The protective relays shall be suitable for use with capacitor voltage transformer having non-electronic damping and transient response as per IEC.
3. Disturbance recorder, Distance to fault locator, over voltage, auto reclose functions are integral functional part of the relay.
4. The following protection for line protection shall be provided.

### 13.3 For 400 KV & 220 KV

- Main – I** Numerical distance protection scheme.
- Main – II** Numerical distance protection scheme of a make different from that of Main – I.
- Back up:** Directional Over current and Earth fault protection.
- For 132 KV.**
- Main-** Numerical distance protection scheme.
- Back up:** Directional over current and Earth fault protection.

### 13.4 MAIN-I & MAIN-II:

1. Shall be numerical type and shall be continuous self monitoring and diagnostic feature.
2. Shall be non-switched type with separate measurements for all phase to Phase & phase to ground faults.
3. Shall have stepped time distance characteristics and a minimum of three independent zones & a zone for reverse reach..
4. Shall have mho & quadrilateral (with site selection facilities) characteristics or other suitable characteristics for the above mentioned zones.
5. Shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

13.4.1 For 400,220 KV	400KV	220KV
Source to Impedance ratio:	4	15
Relay setting (ohms)	10/20	22
Fault locations (as % of Relay settings)	50	50
Fault resistance (ohms)	0	0
Maximum operating time	40ms	45ms for Phase faults
	For all faults	60ms for all other faults

#### 13.4.2 For 132 KV line:

Data's as indicated for 200 KV line

Shall remain same except maximum

Operating time: 5ms relaxation in the above timings

6. Relay shall have independent setting of "R" and "X" and also an adjustable relay characteristic angle having setting range from 30 -75 degree.
7. Shall have independent continuously variable time settings from 0 to 5 seconds.
8. Shall have resetting time of less than 55 milliseconds (including the reset time of the trip relays)
9. Shall have offset features with adjustable 10 – 20% of zone setting.
10. Shall have variable residual compensation.

11. Shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close up 3-phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero volts three phase fault.
12. Shall have week end in-feed features.
13. Shall be suitable for single and three phase tripping.
14. Shall have a continuous current rating of two times of rated current. The voltage circuits shall be capable of operation at 1.2 times rated voltage. The relay shall have the capability to carry a short circuit current of 70 times the rated current without damage for 1second.
15. Shall be provided with necessary self reset type trip duty contacts for completion of the scheme.(a minimum number of such contacts shall be 4 per phase). The making capacity of the contacts shall be 30 amps for 0.2 seconds with an inductive load of  $L/R > 10\text{ms}$ .
16. Shall have permissive under reach/over reach/blocking communication mode.
17. Shall have sufficient number of potential free contacts for carrier aided tripping, Auto reclosing, Event logger, Disturbance recorder & Data acquisition system.
18. Shall have power swing blocking protection (i) suitable setting range to encircle the distance protection (ii) block tripping during power swing conditions.
19. Include fuse failure protection (i) monitor all three fuses of CVT and associated cable against open circuit(ii) inhibit trip circuits on operation and initiate annunciation(iii)have an operating time less than 7ms(iv)remain inoperative for system earth faults.
20. Shall have directional back up Inverse Definite minimum Time earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature.
21. Shall have broken wire features having option for tripping/ annunciation.

### **13.5 BACK UP DIRECTIONAL O/C & E/F PROTECTION SCHEME.**

1. Shall have three over current and one earth fault elements.
2. Shall be numerical type.
3. Shall have suitable VT fuse failure for relay alarm purpose.

#### **O/C features:**

4. Shall have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting.
5. Shall have variable setting range up to 200% of rated current.
6. Shall have relay characteristic angle of 30/45 deg lead.
7. LED indications for different type faults.

#### **E/F features:**

8. Shall have IDMT characteristics with a definite minimum time of 3.0 seconds at 10 times setting.
9. Shall have variable setting range up to 80% of rated current.
10. Shall have characteristic angle of 45/60 deg lag.
11. LED indications for all type of faults

12. **Include necessary separate interposing voltage transformers or have internal features in the relay for open delta voltage to the relay.**
13. **Shall have continuous self monitoring and diagnostic feature.**

#### **13.6 AUTO RECLOSING RELAY:**

1. **Shall have single phase and three phase reclosing facilities.**
2. **Shall have continuously variable single phase dead time range of 0.1 – 2 sec**
3. **Shall have continuously variable reclaim time range 5 – 25 sec.**
4. **Shall have provision of selection with single phase//three phase//single and three phase auto reclosure and non auto reclosure mode (can be selected through programming).**
5. **Shall have provision of selecting check synchronizing or dead line charging.**
6. **Shall be single shot type.**
7. **Shall have priority circuit to closing of both circuit breakers incase one and half breaker arrangements to allow sequential closing of breakers.**
8. **Include check synchronizing relay which shall**
  - I) **Have a time setting variable from 0.5 – 5 sec with a facility of additional 10 sec.**
  - II) **Have a response time within 200 ms with the timer disconnected.**
  - III) **Have a phase angle setting not exceeding 35 deg.**
  - IV) **Have voltage difference setting not exceeding 10%**
  - V) **Include dead line charging relay.**

#### **13.7 TRANSFORMER PROTECTION:**

**Transformer differential protection scheme shall be of numerical relay.**

1. **Shall be triple pole type with faulty phase identification/indication.**
2. **Shall have an operating time not greater than 30ms at 5 times the rated current.**
3. **Shall have three instantaneous high set over current units.**
4. **Shall have an adjustable bias setting range of 10 – 50%.**
5. **Suitable for rated 1 amp current.**
6. **Shall have 2<sup>nd</sup> harmonics or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof features shall not be achieved any intentional time delay.**
7. **Shall have an operating current setting of 15% or less.**
8. **Shall have an internal feature of the relays to take care of the angle and ratio correction.**
9. **Shall have provision of self monitoring and diagnostic feature.**
10. **Shall have provision of recording features to record graphic from of instantaneous values during faults and disturbances for the pre and post fault period and during running conditions.**
11. **Current in all the windings in separate analog channels and voltage in one channel. The disturbance recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay.**
  - a) **REF protection operated.**

- b) HV breaker status (suitable for 1&1/2 breaker system also)
- c) IV & LV breaker status.
- d) Bucholtz /OLTC Bucholtz /PRV alarm/trip.
- e) WTI/OTI alarm/trip
- f) MOG alarm

Necessary hardware and software for automatic up-loading the data captured by disturbance recorder to the personal computer.

12. Shall have built in features of definite time over load protection (alarm) relay.
  - a) Shall be single pole type.
  - b) Shall have definite time O/C.
  - c) Shall have one set of O/C relay element, with continuously adjustable setting up to 200%(50% -200%) of rated current.
  - d) Shall have adjustable time delay alarm having setting range of 1 to 10.0 sec continuously.
  - e) Shall have a drop-off/pick-up ratio greater than 95%
13. Shall have feature of REF protection for three winding transformers.
  - a) Shall have current setting (continuously variable) range from 10%- 40% of 1 Amp.
  - b) Shall be tuned to the system frequency.
  - c) Shall have provision of for limiting the peak voltage (>1000Volts) during fault condition.
14. Shall be numerical type and shall have continuous self monitoring and diagnostic feature.

### 13.8 OVER FLUXING PROTECTION:

1. Shall be latest version numerical relay.
2. Shall have the principle of voltage to frequency ratio and shall be phase to phase connected.
3. Shall have inverse time characteristics, matching with transformer over fluxing withstand capability curve.
4. Provide an independent alarm with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of v/f, from 100% to 130% of rated values.
5. Shall have tripping time to be governed by v/f Vs time characteristics of the relay.
6. Shall have a set of characteristics for various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at v/f values of 1.4 and 1.5 times, the rated values, respectively.
7. Shall have resetting ratio of 95% or better.
8. Shall be numerical type and shall have continuous self monitoring and diagnostic feature.
9. Shall have fault recording feature.

### 13.9 LOCAL BREAKER BACKUP PROTECTION SCHEME:

1. Shall have triple pole type.

2. Shall be of numerical type and shall have continuous self monitoring and diagnostic feature.
3. Shall have an operating time of less than 15ms
4. Shall have resetting time of less than 15ms.
5. Shall have three over current elements.
6. Shall be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element.
7. Shall have setting range of 20-80% of rated current.
8. Shall have continuous thermal withstand two times rated current irrespective of the setting.
9. Shall have a timer with continuously adjustable setting range of 0.1 – 1 sec.
10. Shall have necessary auxiliary relays to make a comprehensive scheme.

#### **13.10 TRIPPING RELAY:**

1. High speed tripping relay.
2. Instantaneous operation(time not to exceed 10ms)
3. Reset within 20ms
4. Shall be DC operated.
5. Shall have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, disturbance recorder, fault locator etc.
6. Shall have provision of operation indicators for each element/coil.

#### **13.11 TRIP CIRCUIT SUPERVISION RELAY:**

1. The relay shall be capable of monitoring the healthiness of each “phase” trip coil and associated circuit of circuit breaker during ON and OFF conditions.
2. Shall have adequate contacts for providing connection to alarm and event logger.
3. Shall have time delay on-drop-off of not less than 200ms and be provided with operation for each phase.

#### **13.12 DC SUPERVISION RELAY:**

1. Shall be capable of monitoring the failure of DC supply to which it is connected.
2. Shall have adequate potential free contacts to meet the scheme requirement.
3. Shall have a time delay drop-off of not less than 100ms and be provided with operational indicator/flag.