BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION PROJECTS ENGINEERING MANAGEMENT

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TYPE OF DOC.	TECHNICAL SPECIFICATION			NAME	AA	SKS	AG
TITLE	765KV CURRENT TRANSFORMER			SIGN			
				DATE	02/08/19	02/08/19	3/8/19
				GROUP	TBEM	W.O. No	
CUSTOMER	POWERGRID						
PROJECTS	Substation Package SS-19 : Extn of 765kV Solapur, 765kV Aurangabad, 765kV Wardha , 400kV Khandwa, 400kV Rajgarh, 400kV Champa, 400/220kV Itarsi, 400/220kV Jabalpur.						

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SECTION 1

SCOPE, SPECIFIC TECHNICAL REQUIREMENTS AND QUANTITIES

1.0 SCOPE

This technical specification covers the requirements of design, manufacture, testing at works, packing, dispatch to sites and supervision of erection, testing & commissioning at each site of 765kV Current Transformers complete with accessories as listed in clause 4.0 below. This section covers the specific technical requirements of 765KV CT.

The specification comprise of following sections:

Section-1:	Scope, Specific Technical Requirements & Bill of Quantities
Section-2:	Detailed Technical Requirement - Equipment Specification
Section-3:	Project Details & General Technical Requirements
Section-4:	Guaranteed Technical Particulars **(NOT APPLICABLE)**
Section-5:	Checklist

In case of any conflict between various sections, order of precedence shall be - Section-1 shall precede Section-2, Section-2 shall precede Section-3

Note: The terms used in this specification namely,"Employer/Purchaser" refers to Powergrid, "Contractor " refers to BHEL & "Sub-contractor" refers to successful bidder.

1.1 The equipment is required for the following Projects.

Name of Customer : Power Grid Corporation of India Ltd.

Name of the Project : Substation Package SS-19 : Extn of 765kV Solapur, 765kV Aurangabad, 765kV Wardha, 400kV Khandwa, 400kV Rajgarh, 400kV Champa, 400/220kV Itarsi, 400/220kV Jabalpur.

Refer Section - 3 for Project Details and General Specifications.

2.0 SPECIFIC TECHNICAL PARTICULARS

a) Technical Parameters of 765KV CT:

S.No.	Description of parameters	Data
1.	Max. System Voltage	800KV
2.	Rated frequency	50 Hz

S.No.	Sub-Station	System Fault Level	Min. Creepage Distance
1.	765kV Solapur	40kA for 1sec	25mm/kV
2.	765kV Aurangabad	40kA for 1sec	25mm/kV
3.	765kV Wardha	40kA for 1sec	25mm/kV
4.	400kV Khandwa	40kA for 1sec	25mm/kV
5.	400kV Rajgarh	40kA for 1sec	25mm/kV
6.	**400kV Champa**	**50kA for 1sec**	**25mm/kV**
7.	400/220kV Jabalpur	40kA for 1sec	25mm/kV
8.	400/220kV Itarsi	40kA for 1sec	25mm/kV

For detailed Technical requirement of 765kV Current transformer refer Section-II of the technical Specification.

b) Refer Section-III for general technical requirements for the project.
c) The offered current transformer shall conform to the latest version of IEC 61869-1 & 61869-2 or IS:2705 Part -1 to 4.
d) 765kV CT shall be with Polymer insulator.
e) If SF6 gas filled CT is offered , it shall be with suitable SF6 gas density monitoring device with NO & NC contacts for remote annunciation and tripping in case of SF6 gas leakage.
f) The common CT junction box for set of three (3) CTs are not in scope of supply of bidder.
g) Terminal connectors are not in bidder's scope of supply.
h) The supervision of Erection, testing & commissioning (including pre- & Post commissioning testing) of the offered CTs is in scope of bidder.
    - Document No. CF/CT/04/R-4 dtd 01.04.2013 under POWERGRID document D-2-01-03-01-04 to be referred for pre-commissioning procedures and formats. The same will be available at respective sites.
    - All tests as per document above including tests after commissioning/ charging shall be in scope of bidder.
    - Any additional test based on specialty of the item as per field Q.P / instruction of the equipment supplier or customer shall be performed, the cost of same shall be included in quoted price , no additional price implication will be entertained during contract stage.
    - Arranging instruments for conducting tests shall be in BHEL Scope. However arranging any product specific or proprietary tools, tackles, instruments required for conducting the tests on offered CT shall be in bidder's scope and shall be listed out during detailed engineering.
    - Arranging oil sampling device, bottle, syringe etc for DGA test of oil of the offered CTs as per above mentioned document shall be the responsibility of bidder (including DGA test after one month of charging and before completion of one year of charging). The oil samples from CTs shall be taken by ETC contractor of BHEL under supervision of bidder using oil sampling devices brought by bidder (on returnable basis). The collected oil samples shall be handed over to BHEL/Customer for testing. Charges for testing are not in scope of bidder. Successful testing of the supplied CTs is the responsibility of bidder. Repetition of oil sampling till successful testing and replenishment of oil after sampling if required shall be in scope of bidder. Price for the same shall be included in quoted price. No additional implication in this regard will be entertained during detailed engineering.
    - Supervision of erection, testing & commissioning of the offered CTs shall include ensuring that the CTs have been installed & terminated in all respect.
      If any fault/damage to CT occurs due to the installation/hotspot/clearance issues etc in the CT, then the repair, refurbishment, replacement of the damaged CT including to and fro transportation from manufacturer's works and respective site shall be carried out by bidder without any price or project time implication to BHEL during contract stage. The replaced/repaired/refurbished CT (or part of the CT) shall have additional two(2) year warranty without prejudice to contractual warranty period.
i) The respective dates of commencement of erection, pre-commissioning, commissioning (including tests after charging as per pre-commissioning document referred above) and trial – run activity by BHEL will be intimated to the equipment manufacturer from time to time , so that arrangements for supervising the activity can be made accordingly by the manufacturer.(however, the travel, lodging and boarding expenses for each visit of the bidder's engineers shall be borne by the bidder.)

j) Bidder shall supply 2 Nos oil sampling device for every 20 Nos. of oil filled CT supplied, with a minimum of 2 Nos oil sampling device for each substation.

k) Please refer clause 10.0 and Annexure-V of Section-II for defect liability requirement.

3.0 TECHNICAL QUALIFYING REQUIREMENTS:

Please refer Annexure -A of Section-1 for Technical Qualifying requirement of the project.

4.0 SITE WISE BILL OF QUANTITY:

S. No.	Description	Unit	Total Quantity
I a.	**For 765kV Solapur S/s (Extn) :** 765KV, 3000A, 40kA with 120% extended current rating, 1-Phase Current Transformer along with mounting hardware complete in all respect excluding support structure, clamps & connectors and common Junction Box.	No.	3
I b.	**For 765kV Solapur S/s (Extn) :** **Mandatory Spares**: 765KV, 3000A, 40kA with 120% extended current rating, 1-Phase Current Transformer along with mounting hardware complete in all respect excluding support structure, clamps & connectors and common Junction Box.	No.	1
I c.	**For 765kV Solapur S/s (Extn) :** Supervision of Erection.	Lot	1
I d.	**For 765kV Solapur S/s (Extn) :** Supervision of Testing. (including Pre/Post commissioning tests as per TS)	Lot	1
I e.	**For 765kV Solapur S/s (Extn) :** Supervision of Commissioning.	Lot	1
II a.	**For 765kV Aurangabad S/s (Extn):** 765KV, 3000A, 40kA with 120% extended current rating, 1-Phase Current Transformer along with mounting hardware complete in all respect excluding support structure, clamps & connectors and common Junction Box.	No.	3
II b.	**For 765kV Aurangabad S/s (Extn):** **Mandatory Spares** : 765KV, 3000A, 40kA with 120% extended current rating, 1-Phase Current Transformer along with mounting hardware complete in all respect excluding support structure, clamps & connectors and common Junction Box.	No.	1
II c.	**For 765kV Aurangabad S/s (Extn):** Supervision of Erection.	Lot	1
II d.	**For 765kV Aurangabad S/s (Extn):** Supervision of Testing. (including Pre/Post commissioning tests as per TS)	Lot	1

II e.	**For 765kV Aurangabad S/s (Extn):** Supervision of Commissioning.	Lot	1

S. No.	Description	Unit	Total Quantity
III a.	**For 765kV Wardha (Extn) S/s :** 765KV, 3000A, 40kA with 120% extended current rating, 1-Phase Current Transformer along with mounting hardware complete in all respect excluding support structure, clamps & connectors and common Junction Box.	No.	3
III b.	**For 765kV Wardha (Extn) S/s :** **Mandatory Spares** : 765KV, 3000A, 40kA with 120% extended current rating, 1-Phase Current Transformer along with mounting hardware complete in all respect excluding support structure, clamps & connectors and common Junction Box.	No.	1
III c.	**For 765kV Wardha (Extn) S/s :** Supervision of Erection.	Lot	1
III d.	**For 765kV Wardha (Extn) S/s :** Supervision of Testing. (including Pre/Post commissioning tests as per TS)	Lot	1
III e.	**For 765kV Wardha (Extn) S/s :** Supervision of Commissioning.	Lot	1

Note : a) Total contract value may vary upto ±30% at contract stage.
b) The price quoted against supervision of Erection, testing and commissioning shall include to & fro travel charges and charges for lodging & boarding.

5.0 QUALITY ASSURANCE, TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

Please refer clause 8.0, 9.0 & 10.0 of Section –III.

6.0 ANNEXURES TO SECTION-1

Annexure-A : Technical Qualifying Requirements for 765kV Current Transformer.
Annexure-B : Pre-commissioning checks (ONLY FOR REFERENCE)
Annexure-C : Pre-commissioning Formats (ONLY FOR REFERENCE)

ANNEXURE-A

TECHNICAL QUALIFYING REQUIREMENTS

For 765kV Current Transformer

The manufacturer shall meet the following technical requirement as stipulated here-

(i) The manufacturer(s) whose 765kV equipment(s) are offered, must have, manufactured, type tested (as per IEC/IS or equivalent standard) and supplied 715kV or higher voltage class equipment(s), which are in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India for the offered equipment and not meeting the requirement stipulated in (i) above, can also be considered provided that-

a) 715kV or higher Voltage class equipment(s) must have been manufactured in the above Indian works & type tested (as per IEC/IS standard) and supplied as on the date of NOA.

b) Contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipments(s) and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.

Note:

a) # - Satisfactory operation means certificate issued by the Employer/Utility Certifying the operation without any adverse remark

b) NOA stands for Notification of Award issued by Powergrid to BHEL for referenced project. Date of NOA is 29/07/2019.

Prepared

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Checked

Approved

ANNEXURE - B

[FOR REFERENCE ONLY]

PRE-COMMISSIONING CHECKS/TESTS FOR OTHER SWITCHYARD EQUIPMENTS

Once erection is completed, various pre-commissioning checks/ tests are performed to ensure the healthiness of the switchyard equipments prior to their energisation. Various major electrical tests to be performed and their significance are given below:

Sr. No.	Name of Test / Check point	Purpose of test/ check
6.1	Tan δ & Capacitance measurement of CT, each stack of CVT & total capacitance, CB voltage grading capacitor & each stack of Surge Arresters	The purpose of the dissipation factor measurement of high voltage insulation is to detect incipient weaknesses in HV insulation. The most important benefit to be gained from this measurement is to obtain a "benchmark reference reading" on costly and high voltage equipment when the equipment is new and insulation is clean, dry and free from impurities. Tan delta & Capacitance values shall be comparable with factory test results and in no case shall be more than 0.5 %.
6.2	**Checks/ Tests applicable for CTs**	
6.2.1	Polarity test for CT	To ascertain whether the polarity markings are correct or not as per drawing.
6.2.2	Magnetization characteristics of CT	To prove that the turns of CTs secondary windings are not short circuited and to check healthiness of CT cores. The magnetizing currents at KPV (Knee point voltage) shall be less than the specified value. The ratio of secondary and primary voltage shall also be measured.
6.2.3	Ratio test for CT	The ratio errors of the primary to the secondary currents should within specified ratio errors.
6.2.4	IR measurement of CT (Primary & Secondary windings)	Changes in the normal IR value of CT indicate abnormal conditions such as presence of moisture, dirt, dust, crack in insulator of CT and degradation of insulation.
6.2.5	DGA test of CT oil	This test shall be conducted after 30 days of commissioning. The purpose is to identify evolving faults in the CT and DGA values shall be comparable with factory values (if available)
6.3	**Checks/ Tests applicable for Circuit Breakers**	
6.3.1	Dew point measurement of SF6 gas	Dew point of SF6 gas is to measure moisture content in SF6 gas which shall indicate whether CB evacuation is done properly or not. This test shall be carried out preferably at rated pressure of SF6 gas.
6.3.2	Measurement of Circuit	To measure closing/ tripping/ CO timings. These timings

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Sr. No.	Name of Test / Check point	Purpose of test/ check
	Breaker Operating Timings including PIR Timings	should be within permissible limits and shall be comparable with factory values. Pole discrepancies and Break to Break discrepancies shall be less than specified values.
6.3.3	DCRM Contact Travel Measurement / DC injected currents and trip/ close coil currents.	DCRM is the technique for measuring Contact Resistance during operation (Close/ Trip) of a circuit breaker with a delay Tco of 300ms. A DC current of at least 100 Amp is injected through the circuit breaker. The current and voltage drop are measured and resistance is calculated. The resistance and travel versus time data provides useful information on the condition of the circuit breaker contacts and is used as a diagnostic tool. DCRM test signatures shall be approved by Corporate OS.
6.3.4	Operational lockout checking for EHV Circuit Breakers	To ensure various lockout operation of CB by simulating the actual conditions at the specified pressure of oil/ air/ operating medium.
6.3.5	Measurement of static contact resistance	This test is conducted to evaluate healthiness of Main contacts. 100 Amp DC is injected and voltage drop is measured across each CB contact to compute contact resistance.
6.3.6	Checking the Anti-Pumping feature	By giving simultaneous close/ trip commands, CB hunting shall not take place by operation of Mechanical/ Electrical anti pumping feature.
6.3.7	Checking the Anti-Condensation Heaters	To check correct operation of Thermostat provided for anti condensation heaters.
6.3.8	Pole discrepancy relay testing	To test tripping of CB in case of pole discrepancy more than 2.5 seconds or specified value.
6.3.9	Checking the N2 priming pressure	This test is to check healthiness of N2 accumulators provided in Hydraulic drive mechanisms. N2 priming pressure shall be as per the rated pressure.
6.4	**Checks/ Tests applicable for CVTs**	
6.4.1	CVT polarity, Ratio test	This test is conducted in the same manner as for CT to determine correct CVT polarity, ratio and phasor group.
6.4.2	Insulation resistance measurement of Primary & secondary winding	Changes in the normal IR value of CVT indicate abnormal conditions such as presence of moisture, dirt, dust, crack in insulator of CVT and degradation of insulation.
6.5	**Checks/ Tests applicable for Isolators**	
6.5.1	MILLIVOLT Drop test	The voltage drop gives a measure of resistance of current carrying part and contacts by injecting minimum 100 A DC current.

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Sr. No.	Name of Test / Check point	Purpose of test/ check
6.5.2	50 operation tests	To test operation of contacts etc with jumpers connected and contact resistance to be measured after 50 operations. There shall not be any change from the previous value.
6.6	**Checks/ Tests applicable for Surge Arrestors**	
6.6.1	Third Harmonic Resistive Current (THRC) for surge arrestors	To monitor healthiness of Surge arrestors by monitoring third harmonic resistive current from the leakage current. This test is to be conducted after charging of Las. The value of THRC shall be less than 30 µA.
6.6.2	IR measurement of each stack of LA	Changes in the normal IR value of LA indicate abnormal conditions such as presence of moisture, dirt, dust, crack in insulator of LA and degradation of insulation.
6.6.3	Checking of operation of LA counter	This test is done to check the healthiness of LA counter.
6.7	**Checks/ Tests for other areas/ equipments**	
6.7.1	Earth resistance measurement	To ensure value of earth resistance is below 1 ohm.
6.7.2	Secondary current injection test	Conducted for testing of protecting devices, circuit breakers, trip coils, motor overloads etc.
6.7.3	Contact Tightness check of Bay contacts by Primary injection method	Since complete bay contact resistance measurement is practically not possible because DC current may not be injected in CT primary, hence contact tightness check by primary injection method has been introduced to check overall contact tightness.
6.7.4	Stability check for Bus Bar	This test is performed to check the proper operation of Bus Bar protection by simulating actual conditions. Any problem in CT connection, wrong cabling, relay setting can be detected by this test.

6.1 TAN DELTA & CAPACITANCE MEASUREMENT OF CT, CVT, CB VOLTAGE GRADING CAPACITORS AND LA STACKS

To measure dissipation factor/loss factor (Tan delta) and Capacitance measurement of EHV class CTs, CVTs, CB Voltage Grading Capacitors & LA stacks by applying test voltages up to 10kV.

A) CURRENT TRANSFORMERS

CTs with test taps

1. Tan delta tap to be disconnected from ground.
2. High voltage lead from tan delta kit to be connected to primary(HV) Terminal and LV lead to be connected to the Tan delta test tap.
3. P1 and P2 to be shorted
4. Porcelain surface to be thoroughly cleaned.
5. Measurements have to be taken in UST mode with fully automatic test kit.
6. Standard procedure(as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/induced voltage conditions should be followed for measurement of capacitance and tan delta values.
7. It is to be ensured to connect the test tap to ground terminal after carrying out the test.

B) CB VOLTAGE GRADING CAPACITOR

1. Connect LV cable to the middle of the double interrupter.
2. Connect HV cable to the other end of the Grading capacitor to be tested.
3. The opposite end of the grading capacitor has to be grounded using earth switch.
4. Measurements have to be taken in UST Mode with fully automatic test kit.
5. Disconnect the HV cable and connect the same to the other grading capacitor and ground the previous grading capacitor. Now the second grading capacitor is ready for testing.
6. Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/induced voltage conditions should be followed
7. Measurements are to be carried out at 10 kV/ 12 KV.

C) CAPACITOR VOLTAGE TRANSFORMERS

1. Testing procedure for Top and Middle Stacks:
   (a) Apply 10 KV between flanges of Top/Middle stacks (whichever is being tested)
   (b) Carry out measurements in UST mode at 10.0 KV
   (c) While measuring Middle/ Bottom stacks, Top/ middle stacks to be shorted.

2. Testing procedure for Bottom Stack connected to EMU PT
   (a) Connect HV of the test kit at the top flange of bottom stack. HF point to be grounded. Earth connection of the neutral of the PT to be opened/ isolated from ground.
   (b) Top of CVT to be guarded. LV lead of the kit to be connected at the top of the CVT for guarding.

(c) Carry out measurements in GSTg mode at 10.0 KV
(d) Repeat the Test with neutral of PT connected to ground.
(e) In case Tan delta value is negative or erratic, only capacitance values are to be monitored.
(f) Measurement to be carried out using fully automatic kit.

3. Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/ induced voltage conditions should be followed.

~~D) SURGE ARRESTERS~~

~~1. Testing procedure for Top, Middle and Bottom Stacks:~~
~~(a) Apply 10 KV between flanges of Top/Middle/ Bottom stacks (whichever is being tested)~~
~~(b) Carry out measurements in UST mode at 10.0 KV with fully automatic test kit.~~
~~(c) While measuring Middle/ Bottom stacks, the stacks above the HV lead to be shorted.~~

~~2. Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/ induced voltage conditions should be followed.~~

~~3. While doing measurement of bottom stack the earth connection to be removed.~~

6.2 CHECKS/TESTS APPLICABLE FOR CTs

6.2.1 POLARITY TEST FOR CT

A centre zero voltmeter is connected across CT secondary. A 1.5 Volt battery is touched to primary of CT. The deflection of pointer should be similar in case of each CT core.

At any instant current entering the primary from P1 the current should leave secondary from the terminal marked S1. A setup shown in the Figure 9 can show whether the polarity markings are correct or not.

When the key is pressed, current enters the primary through terminal P1, the voltmeter connected as shown, should read positive. A general arrangement of polarity test setup is indicated in Fig. 10.

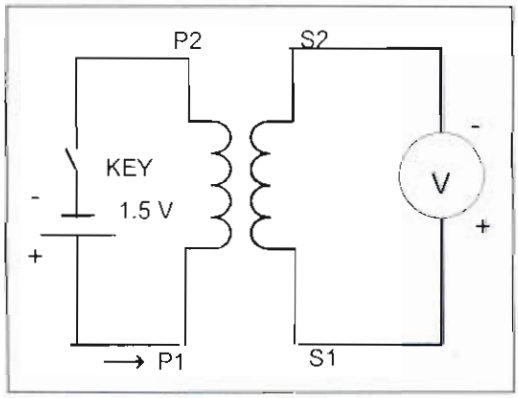

Figure - 9

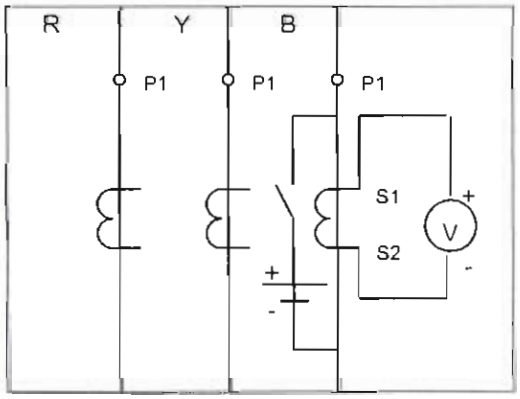

Figure - 10

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6.2.2 MAGNETIZATION CHARACTERISTICS OF CTs

PRECAUTIONS

a) There should be no joints in testing leads/cables.
b) It should be ensured that whole testing equipment along with testing procedures are available at testing site. Testing must be carried out in presence of testing personnel only.

Test Equipment: Voltage source of 5 kV, Voltmeter of range 0 to 5 kV, Ammeter of range 0 to 500 Amps, testing leads/cables etc.

Test Procedure: Make connections as per diagram shown below (Fig- 11). After making proper connections, applied voltage is increased from zero to rated Knee Point Voltage in steps of 25%, 50%, 75% and 100%. Measure the current drawn by the CT secondary core at respective applied voltages and record the test results

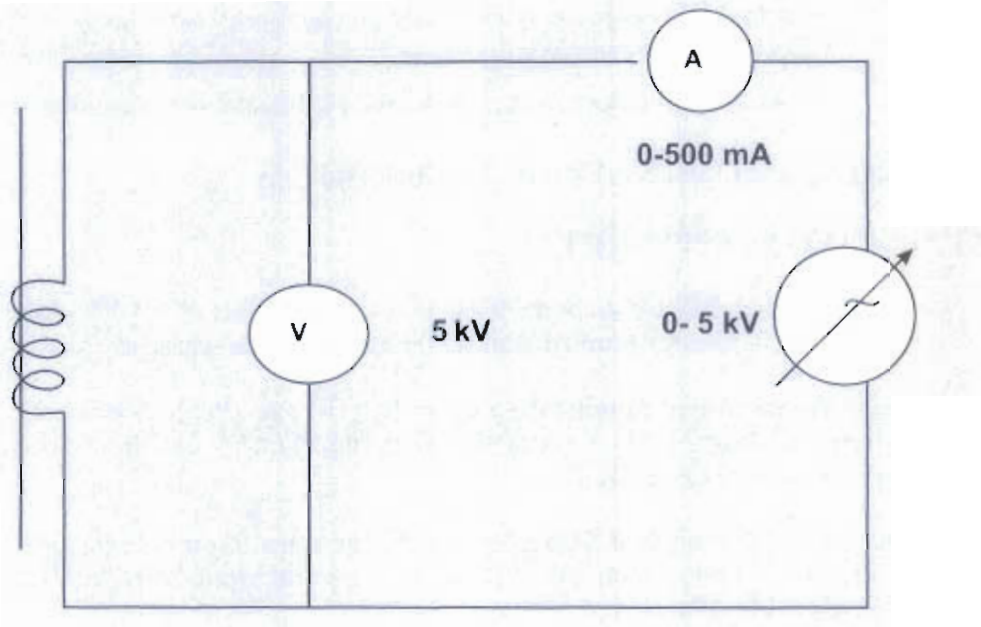

Figure - 11

Knee Point Voltage is normally defined as the voltage at which 10% increase in the applied voltage causes 30 to 50% increase in secondary current. The magnetization current at rated Knee Point Voltage should not be more than the specified/designed value. A curve can be drawn between applied voltage and magnetizing current. Typically, the curve drawn should be like the one given below in Fig.-12.

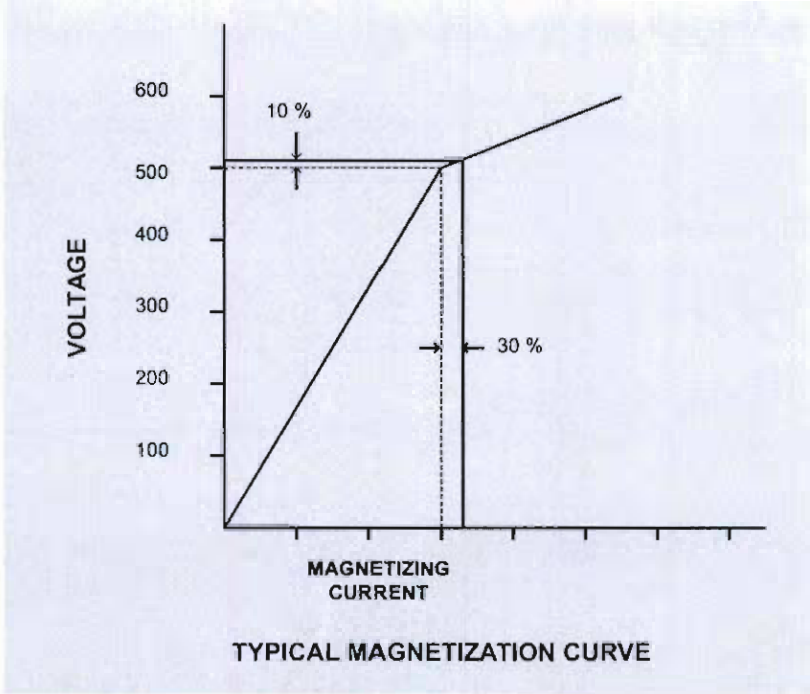

Figure - 12

From the curve it can be implied that up to rated KPV (Knce Point Voltage), the VI curve should be almost a straight line. However, if this line is not linear, this indicates that the magnetizing characteristics are not desirable. If the slop of the curve starts increasing, it indicates that magnetizing induction becomes low and total primary current is utilized in exciting the core alone. Consequently, out put of CT secondary disappears.

6.2.3 RATIO TEST FOR CURRENT TRANSFORMER

The ratio check has to be carried out as indicated in Fig-13 below.

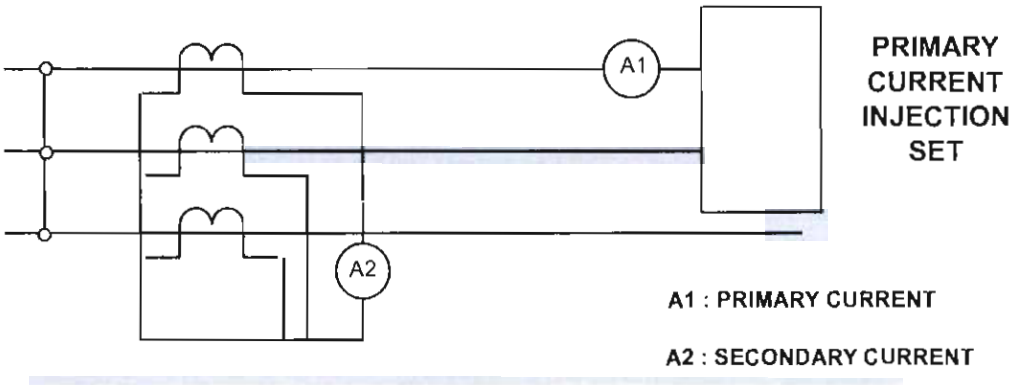

Figure - 13

It is customary to conduct this in conjunction with the primary injection test. Current is passed through the primary circuit with the secondary winding circuit to its normal circuit load. The ratio of the primary to the secondary currents should approximate closely to that stamped under CT identification plate.

Alternatively, ratio test is to be conducted as per the following method (Fig-14).

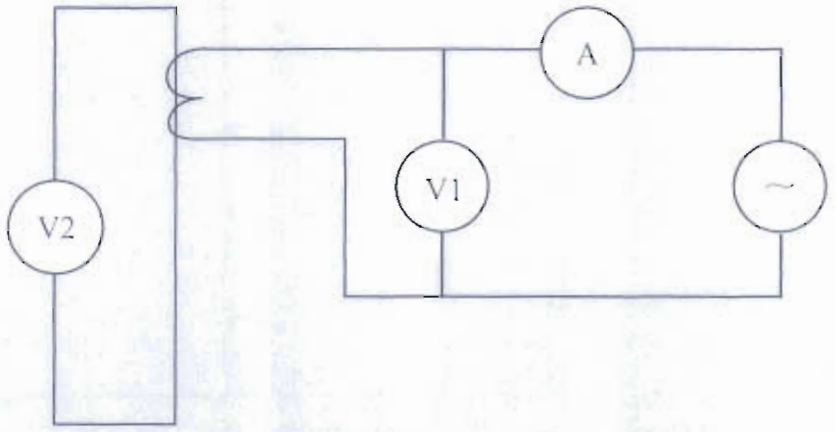

Figure - 14

Apply voltage from secondary of the CT and measure voltage in primary winding. Increase voltage in secondary up to rated KPV/ ISF and by recording Primary Voltage, compute ratio of V1/ V2. The ratio should match with the specified value.

6.2.4 INSULATION RESISTANCE MEASUREMENT OF CURRENT TRANSFORMER

PRECAUTIONS

a) There should be no joints in testing cables.

b) Test leads should not touch any live part.

c) Megger body should be earthed (if separate terminal is provided).

d) Surface/terminals should be cleaned.

e) IR measurement should be carried out preferably in dry and sunny weather.

f) Never connect the test set to energized equipment.

g) The ground terminal must be connected first and removed at last.

h) High voltage plugs should be free from moisture during installation and operation.

i) If oil traces are found on the surface of CT, the same should be cleaned by Methyl Alcohol only. Petrol or diesel should never be used.

j) It should be ensured that whole testing equipment along with testing procedures are available at testing site. Testing must be carried out in presence of testing engineer only.

k) After testing with high voltage, test terminals must be grounded before being touched by any personnel.

l) Test leads should be properly screened/ shielded.

Connect the Megger as per figure-15 given below. Connect the HV terminal to the Primary terminal of CT by using crocodile clip for firm grip

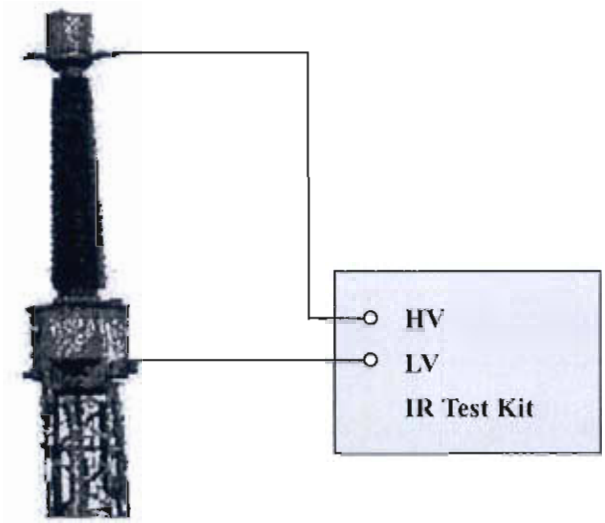

Figure-15 Typical Arrangement for IR measurement

Carry out the measurement as per standard procedure given by the kit supplier.

A test voltage as specified is applied as per the above connections and successive readings are taken. Values of IR should be recorded after 15 seconds, 60 seconds and 600 seconds. Ambient temperature and weather conditions are to be recorded.

6.2.5 DGA Test of CT Oil: Oil samples to be collected in 300ml bottles and to be sent to CIOTL Hyderabad for testing. Test results should be comparable to factory values. In case of any deviation, test results to be forwarded to CC-OS for approval.

~~6.3 CHECKS/TESTS APPLICABLE FOR CIRCUIT BREAKERS~~

~~6.3.1 DEW POINT MEASUREMENT OF SF6 GAS FOR CIRCUIT BREAKER~~

~~Dew Point is the temperature at which moisture content in SF6 gas starts condensing.~~

~~**Dew Point at rated pressure of CB**: Dew Point when measured keeping regulating valve in service at the outlet of dew point kit to allow required flow rate of gas, is called at rated pressure of CB. Inlet valve is opened completely.~~

~~**Dew Point at atmospheric pressure** : Dew Point when measured by regulating the gas flow at the inlet of dew point kit and keeping outlet regulating valve (if provided) in fully open condition so that flow rate of gas is maintained as required, is called at atmospheric pressure.~~

~~**TESTING PROCEDURE**~~

~~a) Make the connections to the kit from CB pole ensuring that regulating valve is fully closed at the time of connections of the Dew Point kit.~~

~~b) By regulating the flow rate of SF6 gas (0.2 liter/min to 0.5 liter/min - ref. IEC 60480), the value of dew point is observed till it becomes stable.~~

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c) If the regulating valve is provided at outlet of the dew point kit then values as given in Doc. no. for rated pressures are to be monitored.

Dew Point of SF6 gas varies with pressure at which measurement is being carried out. This is due to the fact that Saturation Vapour Pressure decreases with increase in Pressure of the SF6 gas. Hence, dew point of SF6 gas at higher pressure is lower than dew point at atmospheric pressure Therefore, it is to be ensured that if measurement has been done at a pressure other than the atmospheric pressure, same is to be converted to the atmospheric pressure as given in the table below used at the time of commissioning for various CB manufacturers: Method for converting dew point at different gas pressures, is given/described in IEC-60480.

Sl. No.	Make of CB	Dew point at rated pressure	Dew point at Atmospheric Pressure (Limit)
1	BHEL	(-) 15° C	-36° C
2	M & G	-	-39° C
3	CGL	(-) 15° C	-35° C
4	ABB	(-) 15° C	-35° C
5	NGEF	(-) 15° C	-36° C

6.3.2 MEASUREMENT OF CIRCUIT BREAKER OPERATING TIMINGS INCLUDING PRE INSERTION RESISTOR TIMINGS

PRECAUTIONS

a) There should not be any joint in testing cables.
b) Test leads should not touch any live part.
c) Never connect the test set to energised equipment.
d) The ground cable must be connected first and removed at last.
e) High voltage plugs should be free from moisture during installation and operation.
f) Circuit Breaker Analyser body should be earthed (if separate earth is provided).
g) It should be ensured that whole testing equipment along with testing procedures are available at testing site. Testing must be carried out in presence of testing personnel only.
h) Surface/terminals should be cleaned where the connections for testing are to be made.
i) Clean earth point with sand paper/wire brush where earth terminal is to be provided.
j) Ensure that all the poles trip simultaneously through single close/trip command.

TESTING PROCEDURE

a) Make connections as shown in the figure-16 below. It is to be ensured that R, Y, B phase marking cables are connected with the proper place in the CB analyser and colour codes are to be maintained for all the three poles of CB.
b) Make connections for recording operating timings of Auxiliary contacts.
c) Extend power supply to Circuit Breaker Analyzer.
d) Give closing command to closing coil of CB and note down the PIR and main contact closing time. Take the print out from the Analyzer.

e) Give tripping command to trip coil-I of CB & note down the main contact tripping time.

f) Give tripping command to trip coil-II of CB & note down the main contact closing time.

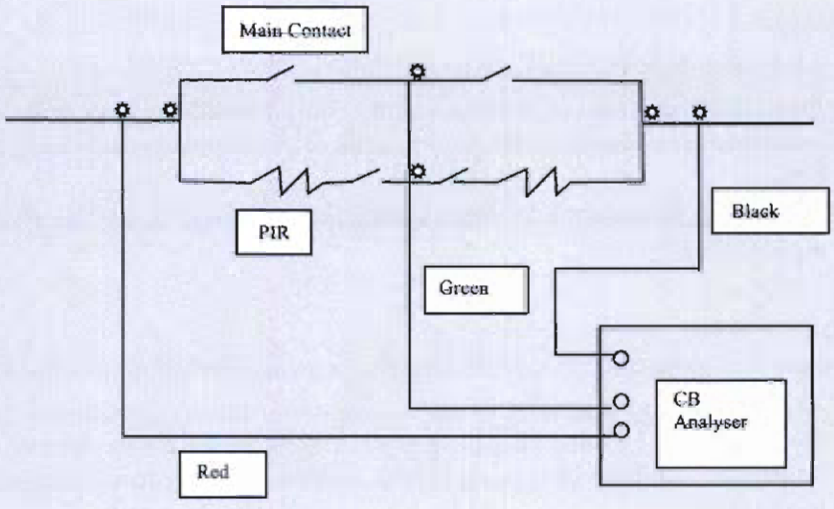
g) Note down the timings for 'CO', and 'OCO' by giving respective commands. CO command to be given without time delay but 300ms time delay to be given between O and CO operation in testing for OCO.

h) To find out opening time of PIR contacts, PIR assembly has to be electrically isolated from Main contacts and then PIR contacts are to be connected to separate digital channels of the Analyzer.

EVALUATION OF TEST RESULTS

A) CLOSING TIMINGS

Closing timings and Discrepancy in operating times of PIR and main contacts should not exceed the permissible limits as specified in the DOC NO: D-5-02-XX-01-03. In any case, main contacts should not close prior to closing of PIR contacts and PIR contacts should not open prior to closing of main contacts. In case, contact bouncing is observed in operating timings for PIR and main contacts, same should be rectified by tightening the cable connections.



Typical Arrangement for Operating Timings Measurement of CB

Figure - 16

B) TRIPPING TIMINGS

Trip time and pole discrepancy in operating timings should not exceed beyond permissible value given in Doc. No. D-5-02-XX-01-03. In case of ABB, NGEF and CGL make CBs, while tripping, PIR contacts should not open after opening of main contacts.

C) 'CO' TIMINGS

CO timings should be within permissible limits as specified by different manufacturers. If operating timings of CB poles are not within limits, same may be corrected by:

1. Equalizing the SF6 gas pressure in all the poles
2. Adjusting plunger movement of trip/ close coils
3. Adjustment in operating mechanism
4. Changing of trip/ close coils (if required)

It is also important to measure timings of auxiliary contacts from the point of view of variations w.r.t. the main contacts.

6.3.3 DYNAMIC CONTACT RESISTANCE MEASUREMENT (DCRM) AND CONTACT TRAVEL MEASUREMENT OF EHV CIRCUIT BREAKERS

Test Equipment: 100 Amp. DCRM kit with CB operational analyzer with 10k Hz sampling frequency.

Isolation Required

a) CB should be in open position.

b) Isolator of both sides of CB should be in open position.

c) Earth switch of one side of CB should be in open position.

Precautions

a) There should be no joints in testing leads/cables.

b) It should be ensured that whole testing equipment along with testing procedures are available at testing site. Testing must be carried out in presence of testing personnel only.

c) Current leads should be connected such that voltage leads are not outside area of current flow.

Testing Procedure

1. Follow the standard procedure as given in instruction manual of DCRM kit.
2. The tightness of connections at CB flanges is most important to ensure error free measurement. CB during CO operation generates lot of vibrations and failure of connections during this period can dramatically change the dynamic signature of CB resistance.
3. DCRM signatures should be recorded for CO operation. Open command should be extended after 300 ms from the close command.
4. Clean portions of incoming and outgoing flanges of CB with polish paper to remove paint, oxidation etc, at points where Current clamps are mounted.
5. Select this point of connection, as close as possible to the end of porcelain insulator to ensure that minimum resistance is offered by flanges, bolts, terminal connectors etc.
6. It should be ensured that Travel Transducers are properly fitted.
7. Sampling frequency during measurement should be 10 KHz.
8. Resistance, travel, injected current and Trip/ Close coil currents are to be recorded.

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The variations in the measured resistance versus time will be seen as a finger print for the breaker contacts and can be used as a bench mark for comparing with future measurements on the same breaker. This provides information on the condition of the breaker contacts, driving mechanism, operating levers etc.

Dynamic Contact Resistance Measurement for CB healthiness

By application of Dynamic Contact Resistance Measurement, condition of arcing contact, main contact, operating levers, driving mechanism can be predicted. If DCRM signature shows vide variations and also there is change in arcing contact insertion time, it indicates erosion of the arcing contacts to main contacts and subsequent failure.

Contact Travel Measurement

Transducers are attached to the operating rod or interrupting chamber in order to record the contact travel. When CB closes, contact travel is recorded. Contact bounces or any other abnormality is also clearly indicated by the Contact Travel Measurement.

If contact travel, contact speed and contact acceleration signature are compared with the original signatures, then it may indicate problems related with the operating mechanism, operating levers, main/ arcing contacts, alignments etc.

DCRM along with Contact Travel measurement is useful in monitoring length of Arcing contacts. Erosion of Arcing contacts may lead to commutation failures and current may get transferred to Main contacts. Due to heat of arc, main contacts may get damaged.

6.3.4 OPERATIONAL LOCKOUT CHECKING FOR EHV CIRCUIT BREAKERS

6.3.4.1 TESTING PROCEDURE:

A. SF6 GAS PRESSURE LOCKOUT

a) LOW PRESSURE ALARM

Close Isolation Valve between CB Pole(s) and density monitor. Start releasing SF6 gas from density monitor till the low pressure gas alarm contacts are actuated which is detected by Multimeter. Note down the pressure and temperature at which the contacts get actuated.

b) OPERATIONAL LOCKOUT:

Continue releasing SF_6 gas from isolated zone till the operational lockout Alarm Contacts are actuated which are detected by Multimeter. Note down the pressure and temperature at which the contacts get actuated. This is called operational lockout pressure.

B. PNEUMATIC OPERATING SYSTEM LOCKOUT

a) COMPRESSOR START/STOP SWITCH

Close the isolating valve of CB. Release air into atmosphere from the compressor. Note down the value of pressure at which Compressor starts building up air pressure and pressure at which Compressor stops.

b) CB AUTO RECLOSE LOCKOUT

Close isolation valve between pneumatic system and pressure switches. Release air from the isolated zone to atmosphere. Note down pressure at which A/R L/O contacts of pressure switch get actuated which are detected by Multimeter. The leads of the Multimeter should be connected to the contactor where the AR L/O of CB are made.

c) CB CLOSING LOCKOUT

Release air from the isolated zone to atmosphere. Note down pressure at which CB Closing L/O contacts of pressure switch get actuated which are detected by Multimeter.

d) CB OPERATIONAL LOCKOUT

Release air from the isolated zone to atmosphere. Note down pressure at which CB Operational L/O contacts of pressure switch get actuated which are detected by Multimeter.

e) MECHANICAL CLOSING INTERLOCK (FOR ABB & BHEL CBs ONLY)

CB should be in closed position. Release air from pneumatic system of CB to atmosphere and observe whether CB poles start opening, if so, note down the pressure at which tie rod starts coming down. In such case the closing interlock is to be opened for inspection and if required, replace the closing interlock.

C. HYDRAULIC OPERATING SYSTEM LOCKOUT

a) Pump START/STOP

By opening pressure release valve, note down the pressure at which Pump starts building up oil pressure and pressure at which pump stops.

b) CB AUTO RECLOSE LOCKOUT

Close Isolation valve between hydraulic system and pressure switches. Release oil from the isolated zone to oil tank. Note down pressure at which A/R L/O contacts of pressure switch get actuated which are detected by Multimeter.

c) CB CLOSING LOCKOUT

Release oil from the isolated zone to oil tank. Note down pressure at which CB Closing L/O contacts of pressure switch get actuated which are detected by Multimeter.

d) CB OPERATIONAL LOCKOUT

Release oil from the isolated zone to container. Note down pressure at which CB Operational L/O contacts of pressure switch get actuated which are detected by Multimeter.

D. OPERATING PRESSURE DROP TEST:

For Pneumatic/ Hydraulic operating system, operating pressure drop test to be performed during OCO operation of CB, keeping AC supply of Hydraulic pump/ Compressor in off condition. Hydraulic/ Pneumatic pressure drop should be within limits (as recommended by Manufacturer)

6.3.4.2 EVALUATION OF TEST RESULTS

A. SF6 GAS PRESSURE LOCKOUT

All the SF6 gas pressure switches settings should be checked and corrected with ambient temperature. Settings of SF6 gas pressure switches should be within ± 0.1 bar/ Kg/cm² of the set value (after taking into account the temperature correction factor).

B. AIR PRESSURE LOCKOUT

All the air pressure switches settings should be checked and corrected and should be within ± 0.3 bar/ Kg/cm² of the set value.

C. OIL PRESSURE LOCKOUT

All the oil pressure switches settings should be checked and corrected and should be within ± 0.3 bar/ Kg/cm² of the set value.

6.3.5 MEASUREMENT OF STATIC CONTACT RESISTANCE

The Static contact resistance of main circuit of each pole of a circuit breaker is of the order of a few tens of micro ohms. 100 A DC is injected and milli volt drop is measured across each CB contact to compute contact resistance. The values should be within specified limits.

6.3.6 CHECKING THE ANTI-PUMPING FEATURE

When the breaker is in open position and closing and opening commands are given simultaneously the breaker first closes and then opens, but does not reclose even though the closing command is maintained.

6.3.7 CHECKING THE ANTI-CONDENSATION HEATERS

Check the supervisory circuit of the anti-condensation heaters for correct functioning. With the heaters switched ON, measure their current output.

6.3.8 POLE DISCREPANCY RELAY TESTING

Pole Discrepancy is defined as the difference in closing & opening timings of different poles of CB.

A. WHEN CB IN OPEN POSITION

Closing Command is extended to close one pole, say R-Pole, of CB. After closing R-Pole of CB, this Pole should automatically open after 2.5 seconds (as per pole discrepancy timer settings). Repeat the test for remaining two poles of CB.

B. WHEN CB IN CLOSED POSITION

Tripping Command is extended to trip one pole, say R-Pole, of CB. Remaining Y and B- Poles of CB should automatically open after 2.5 seconds. Repeat the same test for remaining two poles of CB.

C. EVALUATION OF TEST RESULTS

Permissible value of pole discrepancy between two poles of CB is 3.33 msec. from system point of view and it should not be confused with the setting of pole discrepancy timer which is generally 1.0 or 2.5 sec. depending on Auto-reclose scheme.

6.3.9 CHECKING THE NITROGEN PRIMING PRESSURE

Close the pressure release valve. Shortly after the oil pump starts, the priming pressure (200 bar at 20 °C) in the accumulator can be read. The relationship between the pressure and temperature is indicated in Fig. 17.

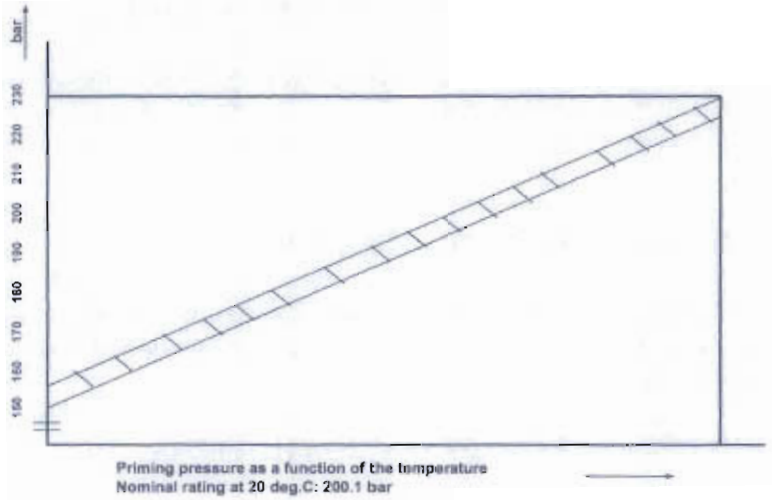

Figure - 17

6.4 CHECKS/ TESTS APPLICABLE FOR CVTs

6.4.1 CVT POLARITY, RATIO TEST

CVT polarity is checked in the same manner as for CT, taking care to ensure that the battery is connected to the primary winding. In case of star/star winding configuration care has to be taken to ensure that the primary and secondary neutral points are not connected together. It is necessary to verify that the phase rotation sequence of the 3 phase CVT is correct. The secondary voltage between phases and neutral are measured and then phase rotation meter is connected across the three phase terminal.

6.4.2 INSULATION RESISTANCE MEASUREMENT OF PRIMARY & SECONDARY WINDING

6.5 CHECKS/TESTS APPLICABLE FOR ISOLATORS

6.5.1 MILLI VOLT DROP TESTS

The milli volt drop across the isolator is measured using DC current. The voltage drop gives a measure of resistance of current carrying part and contacts.

The DC current should be equal to or more than 100 A. The resistance of isolator should be measured at ambient air temperature. The temperature of specimen/environmental temperature should be recorded. The value of measured resistance should be converted to the value of temperature at which factory test results are taken. Temperature corrected value of resistance should be comparable to the factory value.

6.5.2 50 OPERATION TESTS

6.6 CHECKS/TESTS APPLICABLE FOR SURGE ARRESTERS

6.6.1 MEASUREMENT OF THIRD HARMONIC RESISTIVE CURRENT FOR SURGE ARRESTERS

Testing Procedure

a. Make the connections as per the diagram given below (Fig.18)
b. The kit should be properly earthed.
c. Clamp On type CT should be placed above the surge monitor to pick up the total leakage current.
d. Carryout the measurements as per standard procedure supplied by the test kit manufacturer.
e. Note down the system voltage and ambient temperature along with the test current value.
f. Avoid measurement during monsoon.

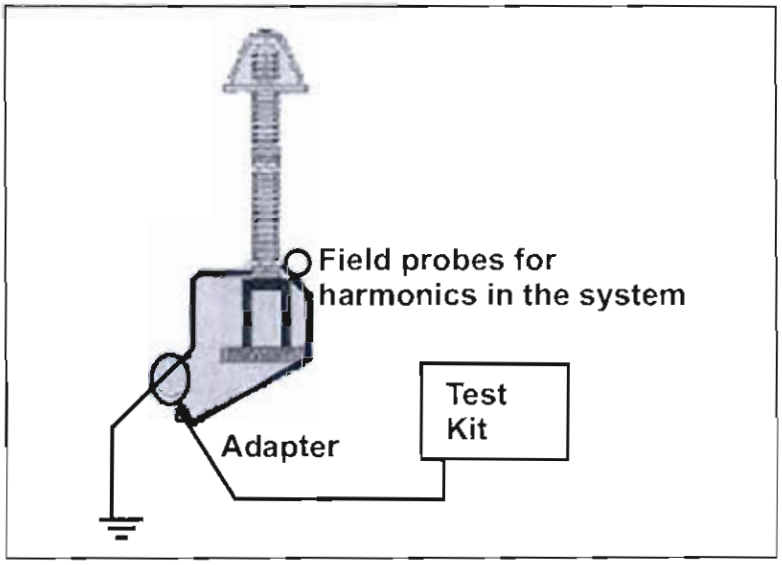

Figure- 18 Typical arrangement for THRCM Test

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EVALUATION OF TEST RESULTS

A. ZnO Surge Arrester continuously conducts a small leakage current (Fig.19). The resistive component of this leakage current may increase with time due to different stresses causing ageing and finally cause arrester failure.

B. If Harmonics are present in the system voltage, it affects the value of measured third harmonic current. Compensating device provided to be used to nullify the effect. The value of Third Harmonic Resistive current shall be less than 30 μA

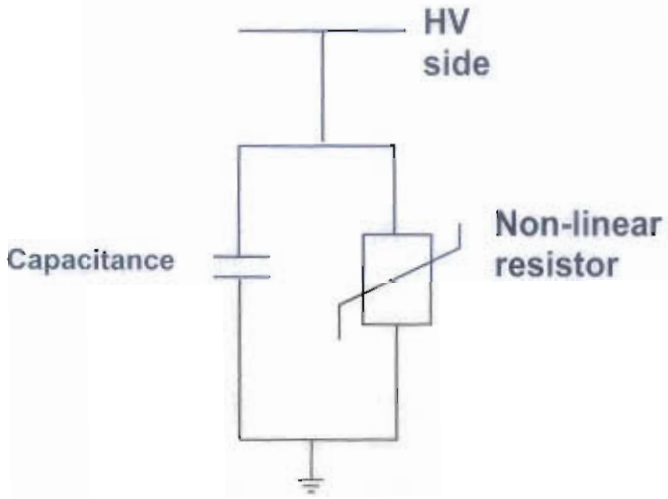

Figure-19 Arrester equivalent circuit

6.7 CHECKS/TESTS FOR OTHER AREAS/ EQUIPMENTS

6.7.1 EARTH RESISTANCE MEASUREMENT

Normally Earth tester is used for measuring

(a) Soil resistivity

(b) Earth resistance

a. Prior to the testing of soil resistivity and earth resistance the operation manual of the testing instrument available at site may be referred for procedures to be adopted for measurement of soil resistivity and earth resistance.
A typical earth tester has 4 terminals. C1, P1, C2, P2 and 4 similar electrodes are driven in the ground at equal distances and connected to the instruments in the order of C1, P1 and P2, C2. Then the handle is rotated or button is pressed and the reading of the resistance is read on the scale of the instrument. If R is the resistance measured then

Specific Resistivity = $2\pi a R$

Where 'a' is the distance between the electrode

And R is the resistance in ohms measured on the earth tester.

b. In order to measure earth resistance of the electrode of the substation, it could be connected to C1 and the value of R could be read in the scale with the rotation of the handle of the Insulation tester. This will give the earth resistance. The value as far as possible should be around 1 ohm. To improve the value, water should be spread at the earth pit.

6.7.2 SECONDARY CURRENT INJECTION TEST SETS

The primary test is essential when commissioning and new installation as a test the whole protection system and will detect current transformers connected with incorrect polarity or relays that have been set in the wrong sequence in differential system. Secondary current injection sets are very useful for conducting these tests. The standard secondary current injection test equipment consists of a 1/5 A current injection set, separate wave form filter unit and a digital counter. The equipment is designed in a portable kit for on site testing of protecting devices, circuit breakers, trip coils, motor overloads, and similar apparatus. The filter unit should be used when testing saturating core type relays to ensure that the test current has a substantially sinusoidal waveform. The typical test setup is shown in fig. 20. Details of the testing will be elaborated in the relay testing.

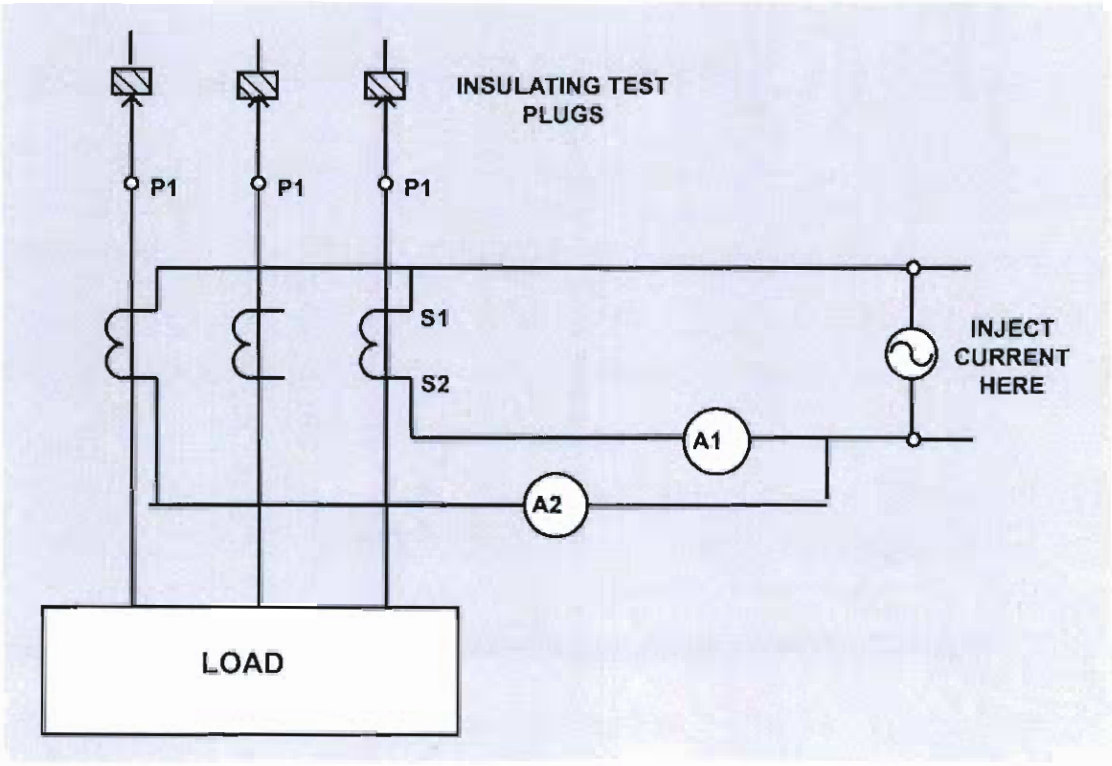

Figure - 20

6.7.3 CONTACT TIGHTNESS TEST OF BAY CONTACTS:

a. Isolate the Bay from Bus –Side and line side as shown in Fig.-21.

b. Ensure that all the secondary cores are connected or short if not in use.

c. Inject the Current at Point 1 (200A) from primary injection kit (w r t earth) and return current via earth point at 2 as shown in Fig.-21.

d. Check that we are able to inject current at point 1 and measure the current at point 2.

e. Injection of current is the indication of contact tightness.

f. Repeat the procedure for point 1 & 3

g. Repeat the procedure for point 1 & 4

Note: Above tests can be aborted if individual contact resistances are within satisfactory limit and physical phase checking is satisfactory.

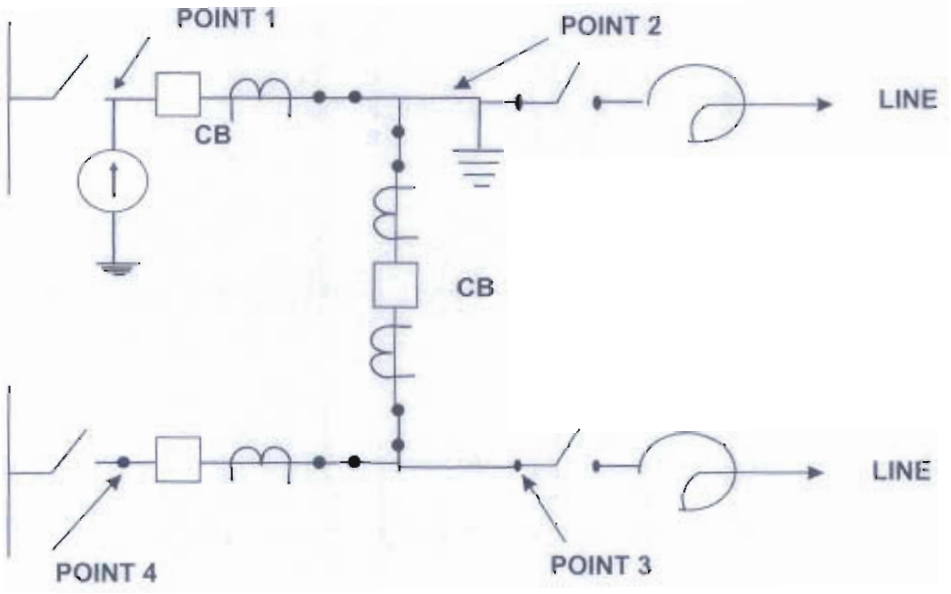

Figure-21 : Primary injection test to check contact tightness of Bay/ feeders

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ANNEXURE – C

PRE-COMMISSIONING FORMATS FOR CURRENT TRANSFORMER

I. General Details

DETAILS	
Region:	Sub-Station:
LOA No. :	Make:
Sr. No.: R Ø:- YØ:- BØ:-	Type:
Year of Manufacture: R Ø:- YØ:- BØ:-	Rating:
Date of Receipt at site: R Ø:- YØ:- BØ:-	Date of Erection: R Ø:- YØ:- BØ:-
Date of energisation	

II. Rated Data And Duty

Core	Ratio	Class	Burden	KVp	Protection / Metering
Winding I					
Winding II					
Winding III					
Winding IV					
Winding V					

KVp: Knee Point Voltage In Volts

III. Pre-Commissioning Checks:

Sl. No	Description	Status		Remark
		Yes	No	Record Deficiencies, If Any
1	Equipment is cleaned and free from dust / dirt foreign materials etc.			
2	Equipment is free from all visible defects on physical inspection			
3	Check ct tank has been provided with double earthing (dead tank CT's)			
4	Check that ct junction box is earthed.			
5	All nuts and bolts are tightened correctly as per specified torque			
6	Check tightness of terminal connector			
7	All fittings as per out line general arrangement drawing.			
8	Leveling and alignment of structure and base frame is checked			
9	Erection completion certificate along with list of outstanding activities reviewed			
10	Any paint removed / scratched in transit has been touched up			
11	Check primary polarity of CTs erected as per relevant drawing.			
12	Check hermetically sealing is intact			
13	Check the oil level and leakage through any joints / sec. Terminals			
14	Check oil drain valve is properly closed and locked.			
15	Oil level & oil sampling			
16	N2 pressure checked (wherever applicable)			
17	Oil level on top chamber gauge glass			
18	BDV of oil sample taken from tank bottom drain valve (only if Nitrogen pressure is measured zero)			
19	All the cable identification tags provided and all cores are provided with identification ferrules at MB.			
20	Check secondary cable end box is properly fixed and ensure cable entry at the bottom and unused holes sealed			
21	Ensure interpole cabling is completed and check the continuity.			
22	Check the ir value of secondary cable			
23	Check external cabling from junction- box to relay / control panel completed			
24	Ensure unused secondary cores, if any, has been shorted and earthed			
25	Check star point has been formed properly and grounded at one end only			
26	Check spark gap setting in p1 terminal (wherever provided/ possible) permanent Pole leveling and identification markings made			
27	Check tan delta test tap is properly earthed			
28	Check that lugs used in secondary circuit are of ring type			
29	Check direction of primary (P1/ P2) w.r.t. Bus/ line on erection			
30	Provision of bimetallic strips (cu +al) ensured wherever applicable			
31	Physically open the bellow cover and check the oil in bellow			
32	Ensure the proper sealing of the CT MB against moisture ingress			

IV. Insulation Resistance Measurement

a) **Insulation Resistance Measurement (Using 5000Volt Megger)**

Make & Sl. No of testing kit _____

Date of last calibration of the kit _____

Ambient temp in ° C _____

Remove the connected earthing to system involving ct under test and disconnect the connected terminals of ct marshalling box.

Core	Unit	Phase		
		R	Y	B
PRIMARY - CORE I	M Ω			
PRIMARY - CORE II	M Ω			
PRIMARY - CORE III	M Ω			
PRIMARY - CORE IV	M Ω			
PRIMARY - CORE V	M Ω			
PRIMARY - CORE VI	M Ω			
PRIMARY - EARTH	M Ω			

* **Permissible limit of IR value should be > 1000 M Ω**

b) **Insulation Resistance Measurement in MΩ (Using 500 V Megger)**

Make & Sl. No of testing kit _____

Date of last calibration of the kit _____

Ambient temp in ° C _____

Between	Unit	Phase		
		R Ø	Y Ø	B Ø
SECONDARY CORE I - EARTH	M Ω			
SECONDARY CORE II - EARTH	M Ω			
SECONDARY CORE III - EARTH	M Ω			
SECONDARY CORE IV - EARTH	M Ω			
SECONDARY CORE V - EARTH	M Ω			
SECONDARY CORE V - EARTH	M Ω			

***Permissible limit of IR value should be > 50 M Ω**

c)

Between	Unit	Phase		
		R Ø	Y Ø	B Ø
CORE I - CORE II	M Ω			
CORE I - CORE III	M Ω			
CORE I - CORE IV	M Ω			
CORE I - CORE V	M Ω			
CORE I - CORE VI	M Ω			
CORE II - CORE III	M Ω			
CORE II - CORE IV	M Ω			
CORE II - CORE V	M Ω			
CORE II - CORE V	M Ω			
CORE III - CORE IV	M Ω			
CORE III- CORE V	M Ω			
CORE III- CORE VI	M Ω			
CORE IV - CORE V	M Ω			
CORE IV - CORE VI	M Ω			
CORE V- CORE VI	M Ω			

d) **Check IR value between tan delta point and earth at 1 kv in secondary box**

R Ø	Y Ø	B Ø

V. Measurement Of Secondary Winding Resistance (In Ohm)

Make of testing kit _____

Date of calibration _____

Ambient temperature _____

Core	Terminal	Unit	R Ø		Y Ø		B Ø	
			Factory	Site	Factory	Site	Factory	Site
CORE I	1S1 - 1S2	Ω						
	1S1 - 1S3	Ω						
	1S1 - 1S4	Ω						
CORE II	2S1 - 2S2	Ω						
	2S1 - 2S3	Ω						
	2S1 - 2S4	Ω						
CORE III	3S1 - 3S2	Ω						
	3S1 - 3S3	Ω						
	3S1 - 3S4	Ω						
CORE IV	4S1 - 4S2	Ω						
	4S1 - 4S3	Ω						
	4S1 - 4S4	Ω						
CORE V	5S1 - 5S2	Ω						
	5S1 - 5S3	Ω						
	5S1 - 5S4	Ω						
CORE VI	6S1 - 6S2	Ω						
	6S1 - 6S3	Ω						
	6S1 - 6S4	Ω						

VI. POLARITY TEST

With 1.5 Volt connect +ve at P1 and –ve at P2

Core	Between		Phase		
			R Ø	Y Ø	B Ø
CORE I	1S1 (+VE)	1S2 (-VE)			
	1S1 (+VE)	1S3 (-VE)			
	1S1 (+VE)	1S4 (-VE)			
CORE II	2S1 (+VE)	2S2 (-VE)			
	2S1 (+VE)	2S3(-VE)			
	2S1 (+VE)	2S4 (-VE)			
CORE III	3S1 (+VE)	3S2(-VE)			
	3S1 (+VE)	3S3(-VE)			
	3S1 (+VE)	3S4(-VE)			
CORE IV	4S1 (+VE)	4S2(-VE)			
	4S1 (+VE)	4S3(-VE)			
	4S1 (+VE)	4S4(-VE)			

Core	Primary Current		Secondary Current	Theoret-ical Ratio	Actual Ratio	% Of Error
	%	ACTUAL				
CORE III (3S1 - 3S2)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S2)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S2)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S2)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S3)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S3)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S3)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S3)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S3)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S3)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S4)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S4)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S4)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S4)	20 %					
	40 %					
	80 %					

Core	Between		Phase		
			R Ø	Y Ø	B Ø
CORE V	5S1 (+VE)	5S2(-VE)			
	5S1 (+VE)	5S3(-VE)			
	5S1 (+VE)	5S4(-VE)			
CORE VI	6S1 (+VE)	6S2(-VE)			
	6S1 (+VE)	6S3(-VE)			
6S1	(+VE)	6S4(-VE)			

VII. Tan Delta And Capacitance Measurement

Make of testing kit _____

Date of calibration _____

Ambient temperature _____

Capacitance

Across Stack	Pre Commissioning Values			Factory Values			% Deviation		
	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø
2kV									
10 kV									

Tan Delta

Across Stack	Pre Commissioning Values			Factory Values			% Deviation		
	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø
2kV									
10 kV									

Permissible Limits Tan δ 0.005 (max.) and Rate of rise in Tan Delta 0.001 per year (max)
Deviation of Capacitance value from factory value should be within ± 5% of the rated value

Factory Test Report Ref. No: _____

VIII. Current Ratio Test

Make of testing kit _____

Date of calibration _____

Primary Injection through Primary Injection Kit at Primary Terminal P1 – P2
Measure the current on the secondary Terminals

R Phase-

Core	Primary Current		Secondary Current	Theoret-ical Ratio	Actual Ratio	% Of Error
	%	ACTUAL				
CORE I (1S1 - 1S2)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S2)	20 %					
	40 %					
	80 %					

Core	Primary Current %	Primary Current ACTUAL	Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
CORE V (5S1 - 5S4)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S4)	20 %					
	40 %					
	80 %					
Y Phase						
CORE I (1S1 - 1S2)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S2)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S2)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S2)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S2)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S2)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S3)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S3)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S3)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S3)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S3)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S3)	20 %					
	40 %					
	80 %					

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Core	Primary Current		Secondary Current	Theoret-ical Ratio	Actual Ratio	% Of Error
	%	ACTUAL				
CORE I (1S1 - 1S4)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S4)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S4)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S4)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S4)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S4)	20 %					
	40 %					
	80 %					

B Phase

CORE I (1S1 - 1S2)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S2)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S2)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S2)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S2)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S2)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S3)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S3)	20 %					
	40 %					
	80 %					

Core	Primary Current		Secondary Current	Theoret-ical Ratio	Actual Ratio	% Of Error
	%	ACTUAL				
CORE III (3S1 - 3S3)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S3)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S3)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S3)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S4)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S4)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S4)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S4)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S4)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S4)	20 %					
	40 %					
	80 %					

Note: Primary current to be injected as per given % or 1500 Amps whichever is maximum

IX. Magnetising Curves Performance

Knee Point Voltage (KVp) = ...Volt

R – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 4S1-4S2	CORE – IV 5S1-5S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

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Y – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 4S1-4S2	CORE – IV 5S1-5S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

B – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 4S1-4S2	CORE – IV 5S1-5S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

X. Contact Resistance Measurement

Make of testing kit _____

Date of calibration _____

Contact Resistance	Units	R - Ø	Y - Ø	B - Ø
Across Terminal P1	μ Ω			
Across Terminal P2	μ Ω			

The value of Contact Resistance should not be more than 10 Micro – ohms per Joint / Connector

XI. Dissolve Gas Analysis

Duration	H2	CH4	C2H4	C2H6	C2H2	CO	CO2	O2	N2	TCG
After one month of charging										
Before completion of one year of charging										

XII. SF6 Gas and Density Monitor Test

In Case of SF6 gas filled CT

	Set Value			Measured		
	R	Y	B	R	Y	B
Loss of SF6 Alarm						
SF6 lockout/ trip						

a) **Measurement of dew point of sf6 gas**

Phase	Measured Value	Measurement Pressure
R Phase		
Y Phase		
B Phase		

XIII. Shock Indicator impact values (in G)

R Phase	
Y Phase	
B Phase	

Note : Shock recorder value to be filled in case digital recorder or in case of mechanical indicator type shock recorder OK/Not OK to be mentioned.

XIV. Check of SF6 gas purity

R Phase	
Y Phase	
B Phase	

XV. Final Documentation Review

i. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

ii. Document regarding spares equipment, O&M manuals etc available at site for O&M purpose

Yes	No

iii. After modification, if any, "As built Drawings" are available at site

Yes	No

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning. Team) Members: 1. 2. 3. 4.

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PRE-COMMISSIONING FORMATS FOR CAPACITIVE VOLTAGE TRANSFORMER

I. General Details

DETAILS	
Region:	**Sub-Station:**
Feeder name	**LOA No. :**
Make:	**Type:**
Sr. No.: **R Ø:-** **YØ:-** **BØ:-**	**Primary Voltage rating**
Secondary Voltage rating: **Winding-I** **Winding-II** **Winding III**	**Secondary Voltage Burden:** **Winding-I** **Winding-II** **Winding III**
Voltage Class: **Winding-I** **Winding-II** **Winding III**	**Purpose of** **Winding-I** **Winding-II** **Winding III**
Rating:	**Feeder name:**
Year of Manufacture: **R Ø:-** **YØ:-** **BØ:-**	**Date of Receipt at site:** **R Ø:-** **YØ:-** **BØ:-**
Date of Erection: **R Ø:-** **YØ:-** **BØ:-**	**Date of energisation**

II. Pre-Commissioning Checks:

Sl. No	Description	Status		Remarks Record Deficiencies, If Any
		YES	NO	
1	Equipment is cleaned and free from dust / dirt foreign materials etc.			
2	Equipment is free from all visible defects on physical inspection			
3	Check CVT tank has been provided with double earthing			
4	Check that CVT marshalling box is earthed correctly as per specified torque			
5	All nuts and bolts are tightened			
6	Check tightness of terminal connector			
7	All fittings as per outline general arrangement drawing.			
8	Labeling and identification marking is carried out			
9	Leveling and alignment of structure and base frame is checked			

Sl. No	Description	Status		Remarks Record Deficiencies, If Any
		YES	NO	
10	Erection completion certificate along with list of outstanding activities reviewed			
11	Any paint removed / scratched in transit has been touched up			
12	Sl. No of HV capacitor identical to the sl.no mentioned on rating & dig. Plate			
13	Ensure brass vent plug between stacks of CVT's is removed			
14	Check the oil level and leakage through any joints / sec. Terminals			
15	Check oil drain valve is properly closed and locked.			
16	Oil level on tank gauge glass			
17	BDV of oil sample taken from tank bottom drain valve			
18	Check secondary cable end box is properly fixed and ensure cable entry at the bottom.			
19	Ensure HF terminal of unused phases has been earthed and no load on HF terminal bushing			
20	Check rating / healthiness of fuses at CVT marshaling.b and CVT terminal box.			
21	Check that the neutral point is earthed			
22	Ensure interpole cabling is completed and check the continuity.			
23	Check the IR value of secondary cable (> 50 m ohms for control cables)			
24	Check external cabling from m.b to relay / control panel completed			
25	All the cable identification tags provided and all cores are provided with identification ferrules at m.b.			
26	Check all the fuse/ MCB			

III. Continuity Of Winding
(After removing Earth Link 1, 2 & 3)

i. Between terminals 1a - 1n

Yes	No

ii. Between terminals 2a - 1n

Yes	No

iii. Between terminals 3a - 1n

Yes	No

IV. Insulation Resistance Measurement

USING A MEGGER OF 5KV/ 10 KV

Between	Unit	Measured Value		
		R Ø	Y Ø	B Ø
Primary - secondary core 1	MΩ			
Primary - secondary core 2	MΩ			
Primary - secondary core 3	MΩ			
Primary - earth Ω	M			

Permissible Limit should be MIN 1000 MΩ

V. Secondary Winding Resistance

Phase	Core 1		Core 2		Core 3		Remarks
	Factory	Site	Factory	Site	Factory	Site	
R Ø							
Y Ø							
B Ø							

Factory test report ref. No _____

VI. INSULATION RESISTANCE MEASUREMENT

Using A Megger Of 500 Volt

Between	Unit	Measured Value		
		R Ø	Y Ø	B Ø
Secondary core 1 - earth	MΩ			
Secondary core 2 - earth	MΩ			
Secondary core 3 - earth	MΩ			
Core 1 - core 2	MΩ			
Core 1 - core 3	MΩ			
Core 2 - core 3	MΩ			

Permissible Limit should be MIN 50 MΩ

VII. VOLTAGE RATIO TEST

Phase	Primary Voltage	Secondary Voltage		Theoretical Ratio	Actual Ratio		%
		Between	Value		Factory	Site	Error
R		1a – 1 n					
		2a – 2 n					
		3a – 3 n					
Y		1a – 1 n					
		2a – 2 n					
		3a – 3 n					
B		1a – 1 n					
		2a – 2 n					
		3a – 3 n					

Permissible Limit should be min ± 5 % for protection cores and ± 0.5 % for metering cores

Note:-

a) Apply voltage of the order of 10 kV across line capacitor (top flange) to earth link
b) Ensure all earth links connected

VIII.

i. All terminal blocks closed in the secondary after all testing

Yes	No

ii. Phasing (phase relationship) of CVT by measuring voltage between R-phase, Y-phase and B-phase at incoming terminal in control cubicle, for one circuit of the checked CVT and output terminals R-phase, Y-phase and B-ph of a reference circuit (existing CVT) with known phasing

Reference Circuit	Measured Value		
	R Ø	Y Ø	B Ø
R Ø			
Y Ø			
B Ø			

IX. TAN δ AND CAPACITANCE MEASUREMENT

Make of testing kit _____

Date of calibration _____

Ambient temperature _____

Capacitance

Across Stack	Pre Commissioning Values			Factory Values			% Deviation		
	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø
TOP									
MIDDLE 1									
MIDDLE 2									
MIDDLE 3									
BOTTOM									
TOTAL									

TAN δ

Across Stack	Pre Commissioning Values			Factory Values			% Deviation		
	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø
TOP									
MIDDLE 1									
MIDDLE 2									
MIDDLE 3									
BOTTOM									
TOTAL									

Permissible Limits Tan δ 0.005 (max.)
Deviation of Capacitance value from factory value should be within ± 5% of the rated value
For bottom stack, the measured values shall be considered as base value and may not match factory test results.

Factory Test Report Ref. No: _____

X. Final Documentation Review

		Yes	No
i.	Final documents of Pre- Commissioning checks reviewed and approved		
ii.	Document regarding spares equipment, O&M manuals etc available at sit for O&M purpose		
iii.	After modification, if any, "As built Drawings" are available at site		

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning Team] Members: 1. 2. 3. 4.

SECTION-II

DETAILED TECHNICAL REQUIREMENT

OF 765KV CURRENT TRANSFORMER

MODEL TECHNICAL SPECIFICATION

SECTION-SWITCHGEAR-INST

(INSTRUMENT TRANSFORMERS)

(REV. NO. 11)

Following are the major changes made in the Technical specification, Section-Switchgear-INST, Rev. 11:

Clause No.	Major Modification
1.	**New IEC-61869 referred. IEC-60044 is superseded by IEC-61869**
2.	**245kV and above rating CT are acceptable with Polymer Insulator**
3.	**Cantilever strength for 72.5kV Instrument Transformer specified**
4.	**Live Tank CT shall be preferably of Bar primary design with SS Bellow**
5.	**Type test & Special test requirements mentioned in line with IEC-61869**
6.	**DGA sampling after commissioning elaborated**
7.	**Requirement of Oil sampling device added**
8.	**Defect liability clause added for actions required in case of defects observed during warrantee period**
9.	**Protection class of CT mentioned as "PX class" in line with IEC-61869**

Note: The above is the list of major changes with respect to previous revision (Rev. 10). However, the bidders are advised to read the entire section/chapter for other changes and quote accordingly.

SECTION-SWITCHGEAR–INST

INSTRUMENT TRANSFORMERS

CONTENTS

NOTE: "CONTRACTOR" REFERS TO SUCCESSFUL BIDDER.

SECTION-SWITCHGEAR-INST

INSTRUMENT TRANSFORMERS

1.0 GENERAL:

1.1 The instrument transformers and accessories shall conform to the latest version of the standards specified below except to the extent explicitly modified in this specification and shall be in accordance with the requirements in Section- III

Current Transformers (CT): IEC: ***61869-1 & 61869-2*** or IS: 2705 ***Part-1 to 4***

Capacitive Voltage Transformers (CVT): IEC: ***61869-1, 61869-5*** & IEC-60358 ***or IS-3156 Part-1 to 4***

Inductive Voltage Transformers (IVT): IEC: ***61869-1 & 61869-3 or IS-3156 Part-1 to 3***

1.2 The instrument transformers shall be designed for use in geographic and meteorological conditions as given in Section- III **and Section-** I

2.0 CONSTRUCTION FEATURES:

The features and constructional details of instrument transformers shall be in accordance with requirements stipulated hereunder:

a) Instrument transformers of **800kV/420kV/245kV/145kV/72.5** kV class, shall be oil filled/SF_6 gas filled, suitable for outdoor service and upright mounting on steel structures. **245kV, 420kV and** 800kV CT shall be with polymer insulator.

b) Bushings/Insulators shall conform to requirements stipulated in Section- . The bushing/insulator for CT shall be one piece without any metallic flange joint.

c) Oil filling and drain plugs, oil sight glass shall be provided for CT & IVT. Oil sight glass shall be provided for electromagnetic unit of CVT. ***The Instrument transformer shall have cantilever strength of not less than 500 kg, 500 kg, 350 kg, 350 kg and 250 kg respectively for 800kV, 420kV, 245kV, 145kV and 72.5kV Instrument Transformers.*** For CVT/IVT with polymer housing, the cantilever strength shall not be less than 150kg. Oil filling and drain plugs are not required for SF_6 gas filled CT/IVT.

d) Instruments transformers shall be hermetically sealed units. The details of the arrangements made for the sealing of instrument transformers shall be furnish during detailed engineering.

e) Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

f) SF_6 gas filled CT/IVT shall be provided with a suitable SF_6 gas density monitoring device, with NO/NC contacts to facilitate the remote annunciation and tripping in case of SF_6 gas leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

g) The instrument transformers shall be complete with its terminal box and a common marshalling box for a set of 3 instrument transformers.

h) The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted as per Section- III. External surface of aluminum can have natural finish.

i) The impregnation details alongwith tests/checks to ensure successful completion of impregnation cycle shall be furnished for approval.

2.2 **Terminal box/Marshalling Box:**

Terminal box/**Marshalling Box** shall conform to the requirements of Section- III

2.3 **Insulating Oil/Gas:**

a) Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IS-335/IEC-60296 (required for first filling). Non–PCB based synthetic insulating oil conforming to IEC 60867 **shall** be used in the capacitor units of CVT.

b) The SF_6 gas shall comply with IEC-60376, 60376A, 60376B **& IEC-60480** and shall be suitable in all respects for use in the switchgear under operating conditions.

2.4 **Name Plate:**

Name plate shall conform to the requirements of IEC incorporating the year of manufacture. The rated current **&** extended current rating in case of current transformers and rated voltage, voltage factor **& intermediate voltage** in case of voltage transformers shall be clearly indicated on the name plate.

3.0 CURRENT TRANSFORMERS:

a) Current transformers shall have single primary either ring type or hair pin type and suitably designed for bringing out the secondary terminals

in a weather proof (IP-55) terminal box at the bottom. PF **(Tan delta)** terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box.

In case of inverted type **(Live Tank)** current transformers, the manufacturer shall meet following additional requirements:

(i) **The primary conductor shall preferably be of bar type meeting the desired characteristics.**

(ii) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly **i.e. insulation at neck** shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) **Bellows made of stainless steel shall be used at the top for hermetic sealing of CT.**

(v) Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

b) Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

c) Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. μ metal or nano-crystalline core can also be used for metering cores.

d) The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

e) Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

f) Current Transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

g) The rated extended currents for 800kV and 420kV class Current transformers shall be as given below:

Tap Ratio	800kV, 3000A	400kV, 3000A
	Rated extended currents in % of rated current	
500/1	200	200
1000/1	---	---
2000/1	180	180
3000/1	120 (200 for 15 min)	120

h) The secondary winding shall be rated for 2A continuously.

Further, the intermediate tapping at 3000-2000 of metering core of 3000 A rated 400kV and 800kV CTs shall be suitable for using as 1000/1 ratio **also**. The Auxiliary reactor, **if used,** as referred at wiring diagram No.0000-000-T-E-L-028 shall be suitable for connecting to the selected taps. The requirements of 3000A CTs are given at TABLE II-A.

For 245/145/**72.5**kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs.

h) For 800/420/245/145/**72.5**kV Current Transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120% (or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

i) The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing **and transportation** design to the Employer for review.

j) For 800kV CTs, the instrument security factor at all ratios shall be less than ten (10) for metering core. For 420/245/145/**72.5**kV CTs, the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

k) The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box. A typical

wiring diagram no. 0000-000-T-E-L-028 (Sh.1 & 2) is enclosed herewith at Annexure-III **of this specification**.

l) The Current Transformers should be suitable for mounting on lattice structure (for 800 kV) or pipe structure (for 420 kV and below) to be provided by the Contractor in accordance with stipulations of Section-I/III /**Section-Structures.**

m) The CT shall be designed so as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

n) 800/420/245/145kV Current Transformers shall be suitable for high speed auto reclosing.

4.0 VOLTAGE TRANSFORMERS:

a) 800/420/245/145kV Voltage Transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling.

b) Voltage transformers secondaries shall be protected by HRC cartridge type fuses or MCBs for all the windings. In addition, fuses/MCBs shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VTs shall be terminated to the stud type non-disconnecting terminal blocks in the individual phase secondary boxes via the fuse/MCBs.

c) CVTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e. 40 to 500 KHz. H.F. terminal of the CVT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilized. Further, earthing link with fastener to be provided for HF terminal.

d) The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.

e) The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferroresonance oscillations.

f) The accuracy of 0.2 on secondary III for all CVTs/IVTs should be maintained through out the entire burden range upto 50 VA on all the windings without any adjustments during operation.

g) **The Voltage Transformers shall be suitable for mounting on lattice structure (for 800kV) or Pipe structure (for 420kV and below) to be provided by the Contractor in accordance with stipulations of Section-Project/Section-Structures.**

h) It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

i) A protective surge arrester shall be provided, if required, to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit in transformer secondaries. **Alternate arrangement shall also be acceptable**.

j) The wiring diagram for the interconnection of the three single phase CVTs/IVTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time. Wiring diagram no.: 0000-000-T-E-L-029 enclosed herewith at Annexure-IV **of this specification shall be** followed.

5.0 TERMINAL CONNECTORS: (NOT IN SCOPE OF SUPPLY)

The terminal connectors shall meet the requirements as given in Section-GTR **and technical parameters for the respective equipment as per Annexure-I and Annexure-II of this specification.**

6.0 TESTS:

6.1 In accordance with the requirements in Section-III, Current Transformer and Voltage Transformer should have been type tested and shall be subjected to routine tests in accordance with **relevant IEC**.

6.2 The test reports of type tests, **as applicable, as per IEC-61869-2 for CT, IEC-61869-5/IEC-60358 for CVT, and IEC-61869-3 for IVT** and following additional tests shall be submitted for the Employer's review. **The type tests for which the procedure is under consideration as per abovesaid IEC is not required to be considered.**

a) Current Transformers (CT):

i) Corona test as per Annexure-A of Section-III **for 420kV and above voltage rating.**

ii) **RIV test as per IEC-61869 or as per Annexure-A of Section-III . for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.**

iii) Seismic withstand test as per Annexure-B of Section- III **or IEC-62271-2 (with Seismic acceleration requirement as per Annexure-I of this specification/Section- I / III)** for 145kV and above voltage rating.

iv) Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit **for 145kV and above voltage rating** (not applicable for SF_6 filled CT).

v) Thermal co-efficient test i.e. measurement of tan-delta as a function of temperature (at ambient and between 80°C & 90°C) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/√3) **for 145kV and above voltage rating** (not applicable for SF_6 filled CT).

vi) Multiple chopped impulse test (not applicable for SF_6 filled CT) with the application of 600 chopped impulses **for 145kV and above voltage rating**.

vii) Transmitted over voltage test for 145kV and above voltage rating

viii) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 145kV and above voltage rating

ix) Internal Arc fault test for 145kV and above voltage rating (not applicable for CT with Polymer Insulator)

x) Enclosure tightness test at low & high temperature for SF_6 filled CT of 145kV and above voltage rating

xi) Gas dew point test for SF_6 filled CT

xii) Corrosion test for 145kV and above voltage rating

b) Capacitive Voltage Transformers (CVT):

i) High frequency capacitance and equivalent series resistance measurement (as per IEC-60358)

ii) Seismic withstand test (as per Annexure-B of Section- III) ***or IEC-62271-2*** **(with Seismic acceleration requirement as per Annexure-II of this specification/Section- I / III) for 145kV and above voltage class.**

iii) Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC-60358)

iv) Corona test as per Annexure-A of Section- III for 420kV and above voltage rating.

v) RIV test as per IEC-61869 or as per Annexure-A of Section- III for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.

vi) Transmitted over voltage test for 145kV and above voltage rating

vii) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 72.5kV and above voltage rating

viii) Determination of Temperature coefficient for 145kV and above voltage rating

ix) Tightness design test of capacitor units for 145kV and above voltage rating

x) Corrosion test for 145kV and above voltage rating

c) Inductive Voltage Transformers (IVT):

i) Seismic withstand test (as per Annexure-B of Section- III) *or IEC-62271-2* (with Seismic acceleration requirement as per Annexure-II of this specification/Section- I/III) for 145kV and above voltage rating.

ii) Corona test as per Annexure-A of Section- I/III for 420kV and above voltage rating.

ii) RIV test as per IEC-61869 or as per Annexure-A of Section- III for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.

iii) Multiple chopped impulse test with application of 600 chopped impulses for 145kV and above voltage rating (not applicable for SF_6 filled CT).

iv) Transmitted over voltage test for 145kV and above voltage rating

v) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 72.5kV and above voltage rating

vi) Enclosure tightness test at low & high temperature for SF_6 filled CT of 145kV and above voltage rating

vii) Gas dew point test for SF_6 filled CT

viii) Corrosion test for 145kV and above voltage rating

ix) Measurement of Capacitance and Dielectric dissipation factor for 145kV and above voltage rating

6.3 The current and voltage transformer shall be subjected to the following routine tests in addition to routine tests as per ***relevant*** IEC:

a) CURRENT TRANSFORMERS:

ROUTINE TESTS:

For Oil filled CT:

i) Measurement of Capacitance.

ii) Oil leakage test.

iii) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/√3.

For SF_6 filled CT:

i) Dew point measurement

ii) SF_6 alarm/ lockout check.

iii) SF_6 gas leakage test: Gas leakage rate shall be maintained within 0.2% per annum.

b) VOLTAGE TRANSFORMERS:

Routine tests on CVT/IVT shall be done in line with IEC-61869-3/61869-5.

7.0 MANDATORY SPARES:

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

8.0 MAJOR TECHNICAL PARAMETERS:

Major technical parameters for 800kV/420kV/245kV/145kV/72.5kV Instrument Transformers are enclosed at Annexure-I and Annexure-II to this specification.

9.0 PRE-COMMISSIONING TESTS

9.1 An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Supplier or Employer without any extra cost to the Employer. **The Contractor shall arrange all instruments**

required for conducting these tests alongwith calibration certificates at his own cost.

9.2 **Current Transformers**

(a) Insulation Resistance Test for primary and secondary

(b) Polarity test

(c) Ratio identification test - checking of all ratios on all cores by primary injection of current

(d) Dielectric test of oil (wherever applicable)

(e) Magnetizing characteristics test

(f) Tan delta and capacitance measurement

(g) Secondary winding resistance measurement

(h) Contact resistance measurement (wherever possible/accessible)

(i) Test for SF_6 (for SF_6 filled CTs) – Dew point measurement, SF_6 alarm/ lockout check

(j) DGA test of oil

Dissolved Gas Analysis (DGA) shall be carried out twice within the first year of service, first within the first month of commissioning/charging and second between six months to one year from the date of commissioning/charging.

CTs/IVTs must have adequate provision for taking oil samples from the bottom of the CT/IVT without exposure to atmosphere. Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. ~~Bidder/~~Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary.

Bidder shall supply 2 nos. oil sampling device for every 20 nos. oil filled CT supplied with a minimum of 2 nos. oil sampling device for each substation.

9.3 **Inductive Voltage Transformers/Capacitive Voltage Transformers**

(a) Insulation Resistance test for primary (if applicable) and secondary winding
(b) Polarity test
(c) Ratio test
(d) Dielectric test of oil (wherever applicable)

(e) Tan delta and capacitance measurement of individual capacitor stacks
(f) Secondary winding resistance measurement

For pre-commissioning procedures and formats for Current Transformers, Doc.No.: CF/CT/04/R-4 dtd-01.04.2013 and for Voltage Transformers, CF/CVT/05/R-4 dtd-01.04.2011 under POWERGRID document no. D-2-01-03-01-04 will be the reference document. **This document will be available at respective sites and shall be referred by the contractor.**

10.0 Defect Liability

The actions required to be taken by contractor in case of defects observed in CT/CVT of ratings 145kV & above during the warranty period (defect liability period) shall be as per enclosed Annexure-V of this specification. Further, the replaced/repaired/refurbished equipment (or part of equipment) shall have Two (2) years warranty without prejudice to contractual warranty period (defect liability period).

TABLE - IA

REQUIREMENTS OF 800 KV CAPACITIVE VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	800		
2.	Type	Single phase Capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	± **10 minutes** (For metering core)		
6.	Capacitance (pf)	4400/8800* (+10% /- 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	0.5&3P	0.5&3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - IB

REQUIREMENTS OF 420 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	420		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	4400/8800* (+10% / - 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	0.5&3P	0.5&3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - IC

REQUIREMENTS OF 245 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	245		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3 cores		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	4400/8800* (+10% / - 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	3P	3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - ID

REQUIREMENTS OF 145 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	145		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3 cores		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	8800 (+ 10% / -5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{132/\sqrt{3}}{0.11/\sqrt{3}}$	$\frac{132/\sqrt{3}}{0.11/\sqrt{3}}$	$\frac{132/\sqrt{3}}{0.11/\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	3P	3P	0.2
	d) Min. Output burden (VA)	50	50	50

TABLE - IE

REQUIREMENTS OF 72.5 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR		
1.	Rated primary voltage (kV rms)	72.5	
2.	Type	Single phase Electro-magnetic or Capacitive VT	
3.	No. of secondaries	2 cores	
4.	Rated Voltage Factor	1.2 continuous 1.5 – 30 seconds	
5.	Phase angle error	+ 20 minutes (For metering core)	
6.	Core details	**Core-1**	**Core-2**
	a) Voltage ratio	**For 66 kV feeder application** 66/√3 /0.11/√3	66/√3 /0.11/√3
		For tertiary loading (of ICT) application 33/√3 /0.11/√3	33/√3 /0.11/√3
	b) Application	Protection	Metering
	c) Accuracy	3P	0.5
	d) Output Burden (VA) (minimum)	10	10

TABLE-IIA

REQUIREMENTS FOR 800 KV CURRENT TRANSFORMER

No. of Cores.	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class	Min. Knee Pt. Voltage (Vk)	Max. CT Sec. wdg. Resistance (in Ω)	Max. Excit. Current at Vk (in mA)
6	1	BUS DIFF. CHECK	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	2.	BUS DIFF. MAIN	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	3.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	4.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	5.	TRANSF DIFF./ LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	6	LINE PROTN/LBB PROTN.	3000- 2000- 500/1	-	**PX**	3000/ 2000 500	15/10/2.5	20 on 3000/1 Tap,30 on 2000/1 Tap,120 on 500/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-IIB

REQUIREMENTS FOR 420 KV CURRENT TRANSFORMER

No. of cores	Core No.	Application	Ratio	Output Burden	Accuracy Class	Min. Knee Pt. Voltage (Vk)	Max. CT Sec. wdg. Resistance (in Ω)	Max. Excit. Current at Vk (in mA)
6	1	BUS DIFF. CHECK	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	2.	BUS DIFF. MAIN	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	3.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	4.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	5.	TRANS. BACK UP/LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	6.	TRANS. DIFF. /LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - IIC

REQUIREMENTS FOR 245 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age (Vk)	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	2	BUS DIFF MAIN	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap: 50 on 800/1 Tap
	3	METERING	1600-800/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap: 50 on 800/1 Tap
	5	TRANS. DIFF/LINE PROTN	1600-800/1	-	PX	1600/800	8/4	25 on 1600/1 Tap: 50 on 800/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - IID

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	2	BUS DIFF MAIN	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	3	METERING	800-400/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	5	TRANS. DIFF/LINE PROTN	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE – IIE

REQUIREMENTS FOR 145 kV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap
	2	BUS DIFF MAIN	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; on 300/1 Tap
	3	METERING	300-150/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap
	5	TRANS. DIFF/LINE PROTN	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE – IIF

REQUIREMENTS FOR 72.5 kV CURRENT TRANSFORMER (FOR TERTIARY LOADING OF ICT)

No. of Cores	Core No.	Application	Current Ratio	Output burden (VA)	Accuracy class & ALF
2	1	O/C & E/F	50/1	10	5P10
	2	Metering	50/1	10	0.5

Annexure-I

MAJOR TECHNICAL PARAMETERS FOR CT

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for Tertiary loading)
1	Rated voltage, U_m (kVrms)	800	420	245	145	72.5
2	Rated frequency (Hz)	50	50	50	50	50
3	No. of Poles	1	1	1	1	1
4	Design ambient temperature (°C)	50	50	50	50	50
5	Rated Primary Current (A)	3000	3000	1600	800/600	50
6	Rated extended primary current	120%	120%	120%/150%	120%/150 %	120%
7	Rated short time thermal withstand current	40kA/50kA (as applicable) for 1 sec	40kA/50kA/63kA (as applicable) for 1 sec	40kA/50kA (as applicable) for 1 sec	31.5kA for 1sec	25kA for 3sec
8	Rated dynamic current	100kAp/125kAp (as applicable)	100kAp/125kAp/ 157.5kAp (as applicable)	100kAp/125kAp (as applicable)	80kAp	63kAp
9	Temperature rise over design ambient temperature	As per IEC				
10	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsecond)					
i)	between line terminals and ground(kVpeak)	±2100	±1425	±1050	±650	±325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)					
i)	between line terminals and ground (kVpeak)	± 1550	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)					
i)	between line terminals and ground (kVrms)	975 (dry only)	630 (dry only)	460	275	140
d)	One minute power frequency withstand voltage between secondary terminals & earth (kVrms)	5kV				

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for Tertiary loading)
11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts)	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms	-NA-
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-	-NA-
13	Seismic acceleration (Horizontal)	0.3g	0.3g	0.3g	0.3g	-NA-
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBs.				
16	Minimum Creepage distance (mm) *	20000	10500	6125	3625	1813
17	System neutral earthing	Effectively Earthed				

*The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV is specified, the Minimum Creepage distance values shall be considered proportionately.

For other parameters, refer respective Table for the applicable voltage class of CTs.

Annexure-II

MAJOR TECHNICAL PARAMETERS FOR CVT/IVT

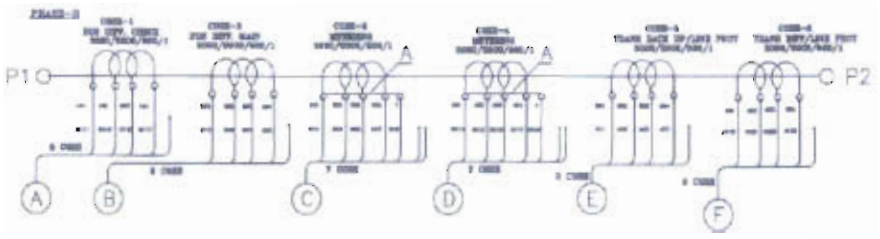
S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for tertiary loading)
1	Type (CVT/IVT)	CVT	CVT/IVT	CVT/IVT	CVT/IVT	CVT/IVT
2	Rated voltage, U_m (kVrms)	800	420	245	145	72.5
3	Rated frequency (Hz)	50	50	50	50	50
4	No. of Poles	1	1	1	1	1
5	Design ambient temperature (°C)	50	50	50	50	50
6	System fault level (kA)	40kA/50kA (as applicable) for 1 sec	40kA/50kA/63kA (as applicable) for 1 sec	40kA/50kA (as applicable) for 1 sec	31.5kA for 1sec	25kA for 3sec
6	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement				
7	High frequency capacitance for entire carrier frequency range (for CVT only)	Within 80% to 150% of rated capacitance				-
8	Equivalent series resistance over entire carrier frequency range (for CVT)	Less than 40 Ohms				-
9	Stray capacitance and stray conductance of HF terminal over entire carrier frequency range (for CVT)	As per IEC-60358				-
10	Temperature rise over design ambient temperature	As per IEC				
11	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsecond)					
i)	between line terminals and ground (kVpeak)	±2100	±1425	±1050	±650	±325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)					

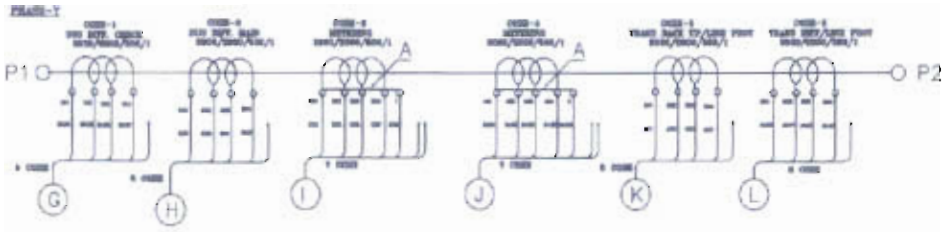
S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for tertiary loading)
i)	between line terminals and ground (kVpeak)	± 1550	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)					
i)	between line terminals and ground (kVrms)	975 (dry only)	630 (dry only)	460	275	140
d)	One minute power frequency withstand voltage between secondary terminals & earth					
i)	between LV (HF) terminal and earth terminal (kVrms)	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box				
ii)	For secondary winding	3kVrms				
11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts)	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms	-NA-
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-	-NA-
13	Seismic acceleration (Horizontal)	0.3g	0.3g	0.3g	0.3g	-NA-
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBs.				
16	Rated Total Thermal Burden (VA)	300 VA (100VA/winding)				20VA
17	System neutral earthing	Effectively Earthed				
	Minimum Creepage distance (mm) *	20000	10500	6125	3625	1813

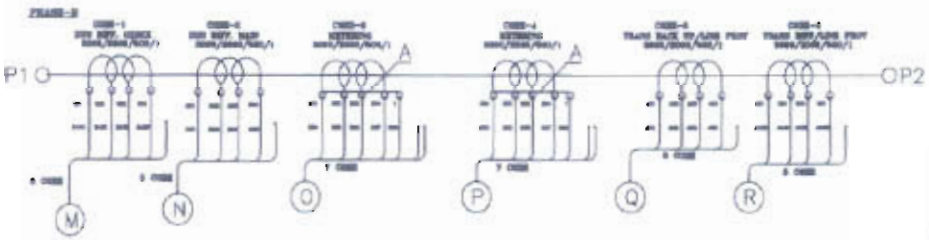
*The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV is specified, the Minimum Creepage distance values shall be considered proportionately.

For other parameters, refer respective Table for the applicable voltage class of CVTs/IVTs.

Annexure-III: Wiring Diagram of CT







NOTE

1. INTERPOLE CABLING (A) TO (N) 3.5 SQ.MM STRANDED FLEXIBLE ARMOURED COPPER CABLE OF 1100V GRADE (FROM CT SEC TO MARSHALLING BOX).

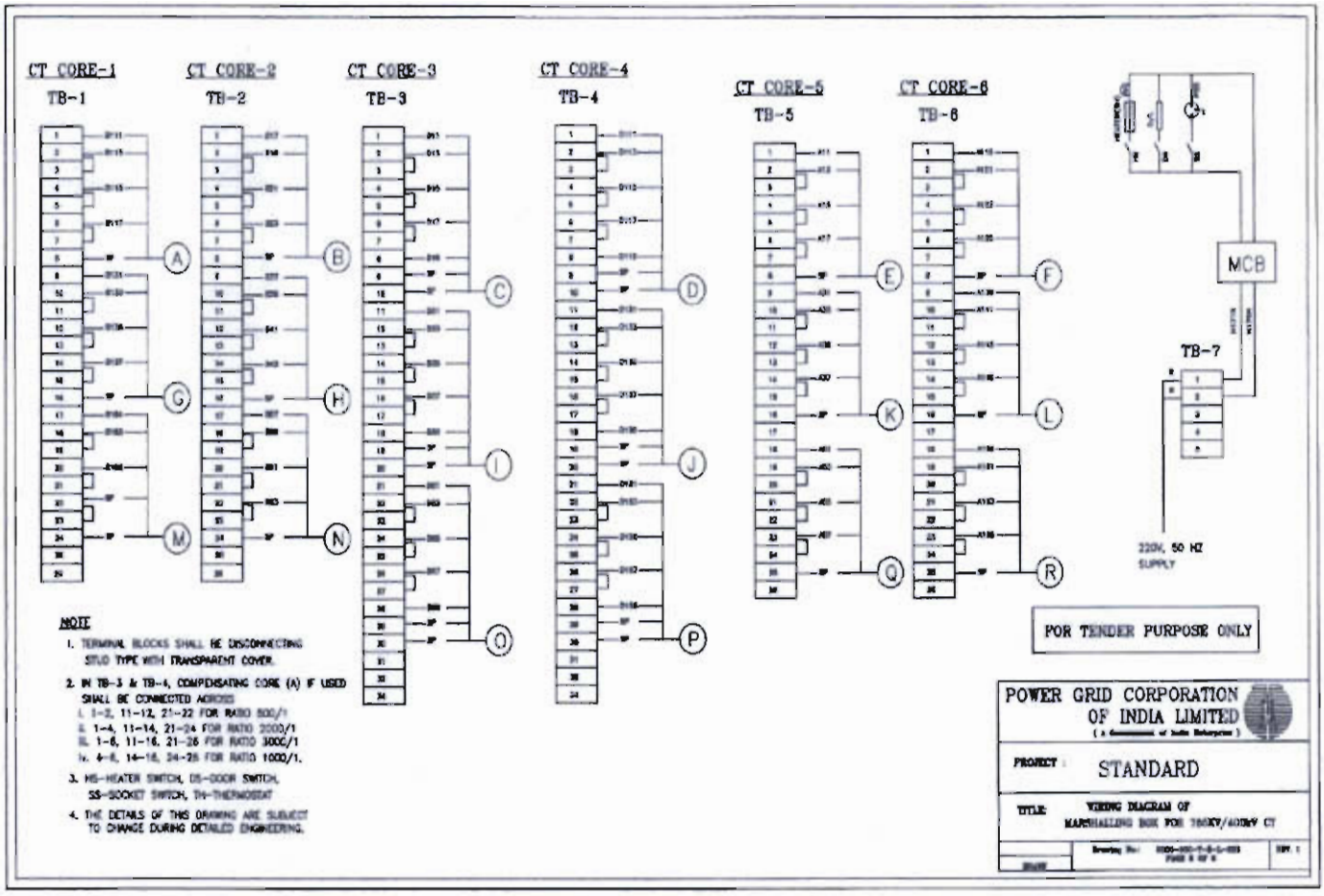
FOR TENDER PURPOSE ONLY

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

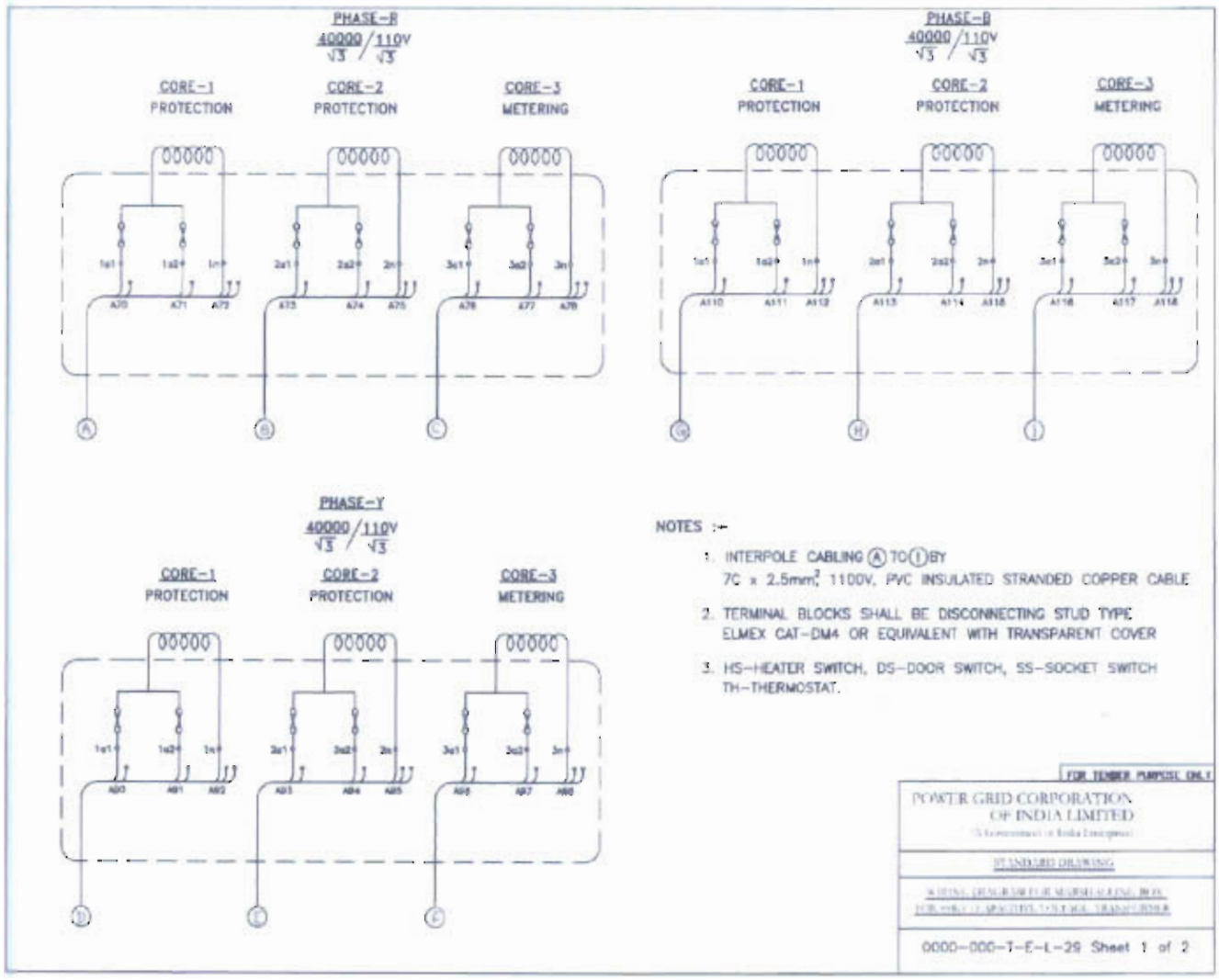
PROJECT : STANDARD

TITLE: WIRING DIAGRAM OF MARSHALLING BOX FOR 765KV/400KV CT

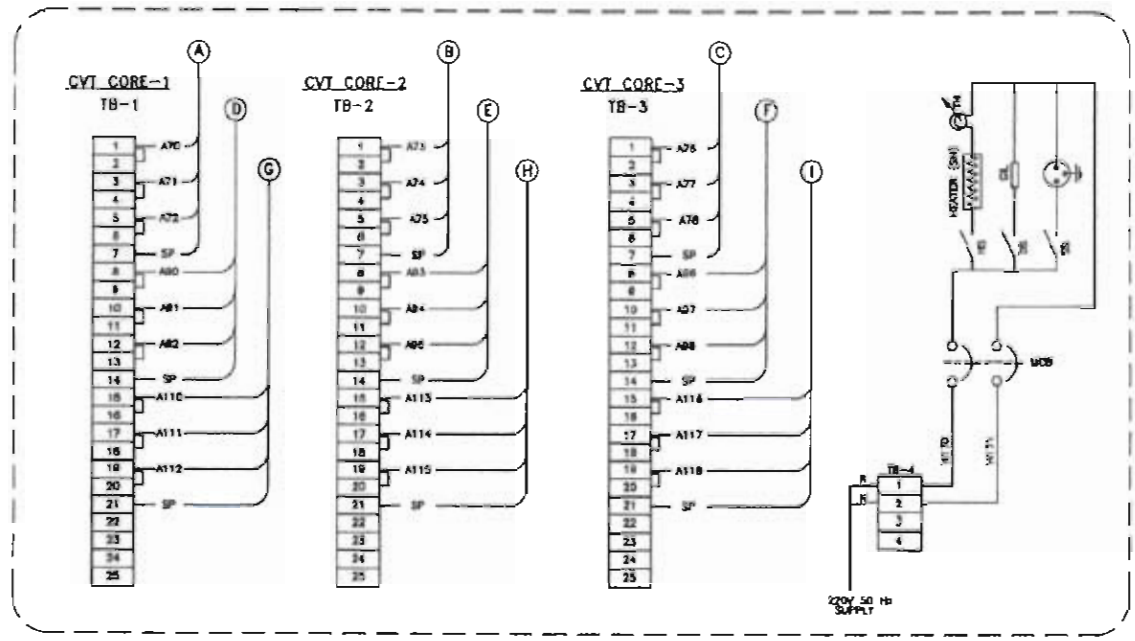
Annexure-III: Wiring Diagram of CT



Annexure-IV: Wiring Diagram of VT



Annexure-IV: Wiring Diagram of VT



CVT MARSHALLING BOX

NOTES :-

1. INTERPOLE CABLING (A) TO (I) BY
   7C x 2.5mm, 1100V, PVC INSULATED STRANDED COPPER CABLE
2. TERMINAL BLOCKS SHALL BE DISCONNECTING STUD TYPE
   ELMEX CAT-DM4 OR EQUIVALENT WITH TRANSPARENT COVER
3. HS-HEATER SWITCH, DS-DOOR SWITCH, SS-SOCKET SWITCH
   TH-THERMOSTAT.

POWER GRID CORPORATION OF INDIA LIMITED

STANDARD DRAWING

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Annexure-V: Actions required in case of defects observed during warrantee period

Equipment	Nature of problem	Corrective measures to be taken by contractor
CT (Oil filled)	**DGA Violation** H2 > 300 ppm C2H2> 2 ppm	CT to be **refurbished** or replaced
CT (SF_6 filled)	a) SF6 gas leakage b) High Dew point of SF6 gas (> -36 deg C at atm press)	a)Repair/ replacement b)Re-processing of gas and replacement of Gas in case of no improvement
CT (Oil filled)	**Violation of Tan delta** Tan Delta: >0.5%(during pre-commisioning) >0.7% (in operation) or change w.r.t. to previous **year** value > 0.1%	Replacement of CT
CT & CVT	- Oil leakage - Low Oil level -Sec winding problem leading to open/ short circuit, saturation etc	Replacement or repair as per repair procedure approved by QA.
CVT	Secondary voltage drift: Upto ± 0.5 volts Healthy a) ± 0.5 **or beyond**	a) CVT to be replaced

***Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.**