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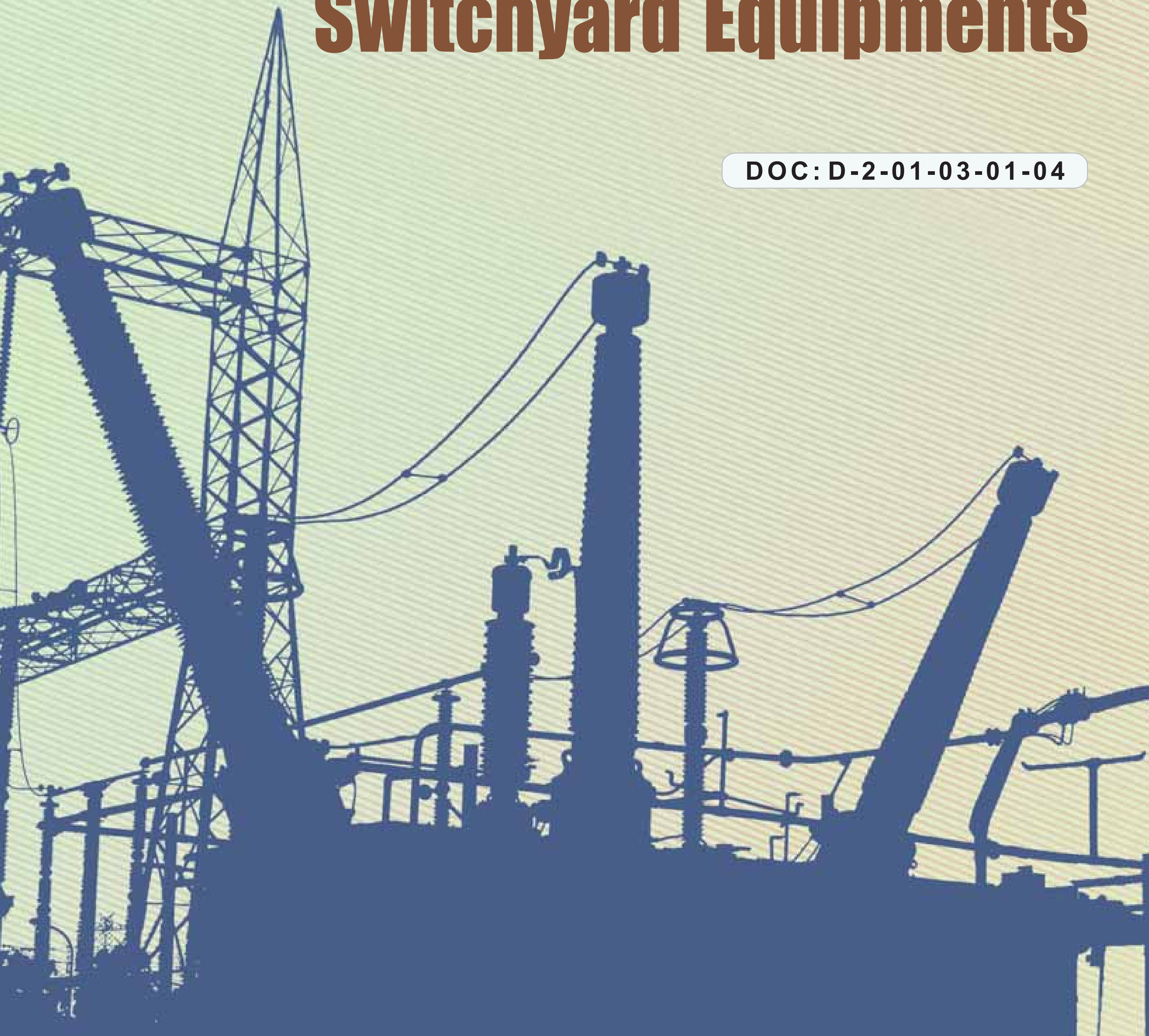
पावरग्रिड

Pre-Commissioning Procedures and Formats for Switchyard Equipments

DOC: D-2-01-03-01-04



CONTENTS

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

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.

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.

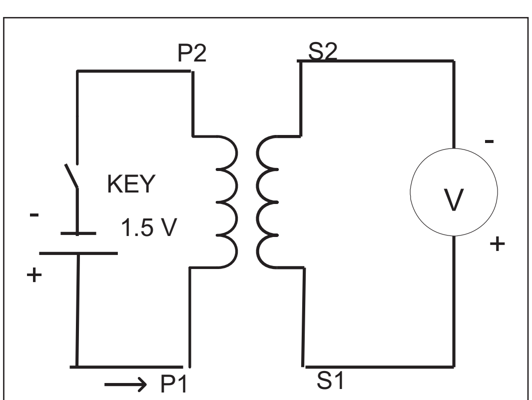


Figure - 9

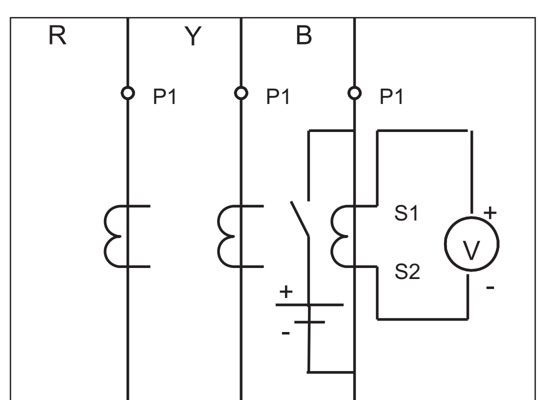


Figure - 10

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

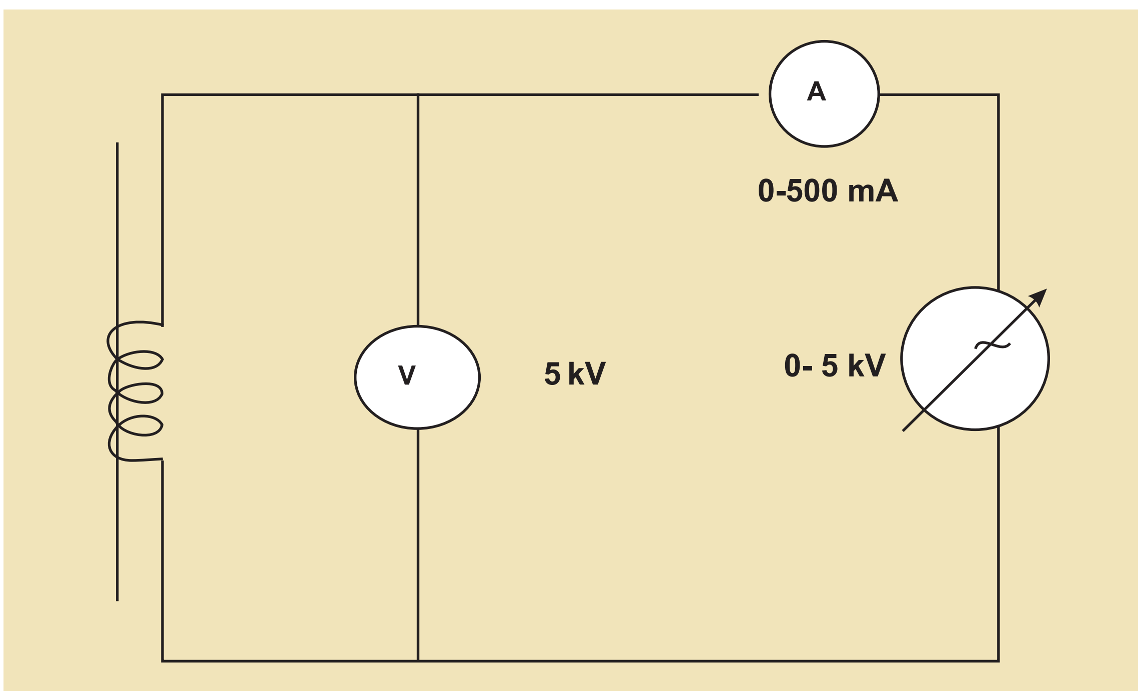


Figure - 11

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.

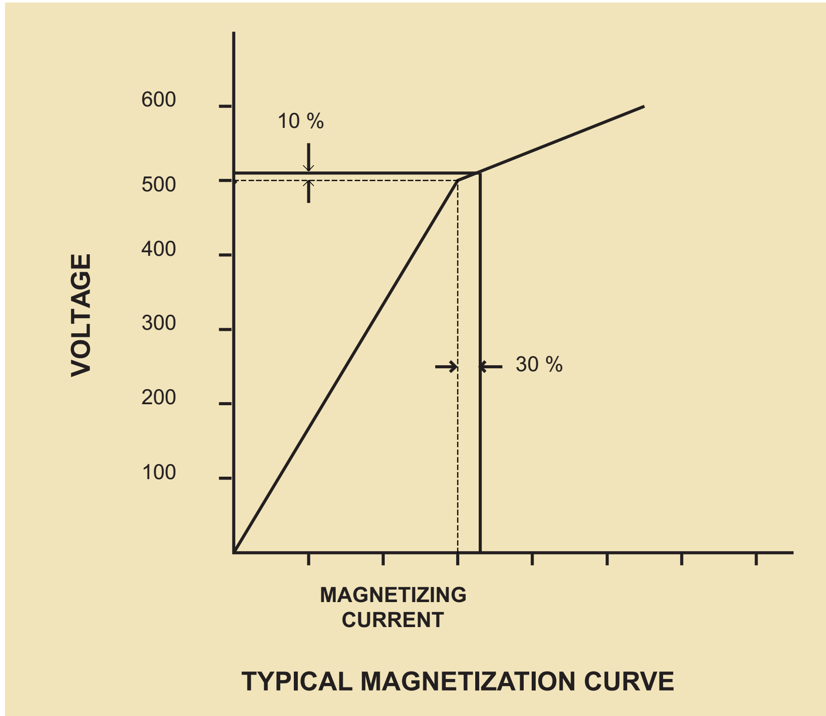


Figure - 12

From the curve it can be implied that up to rated KPV (Knee 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.

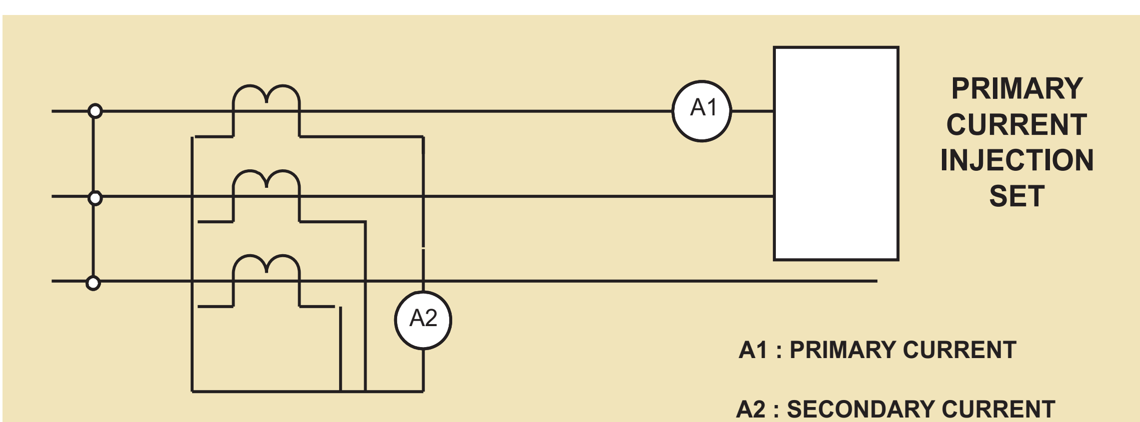


Figure - 13

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).

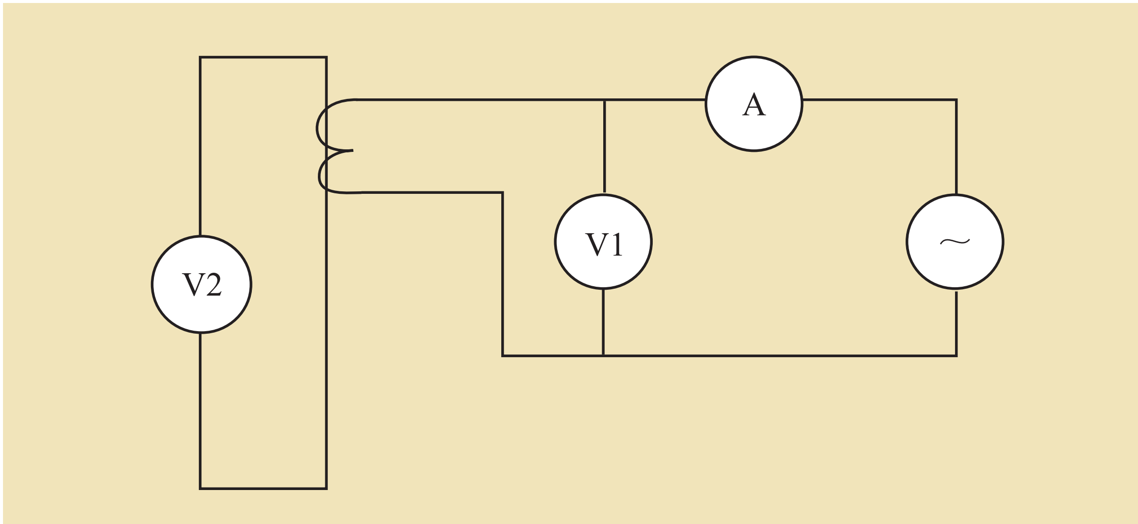


Figure - 14

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

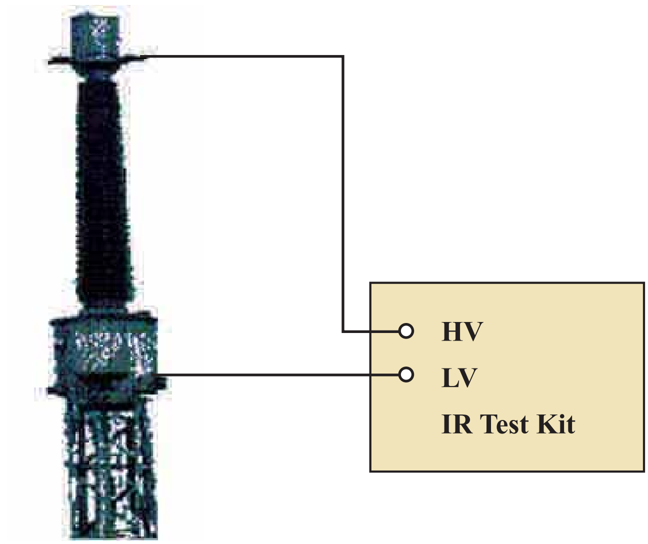


Figure-15 Typical Arrangement for IR measurement

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.

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.

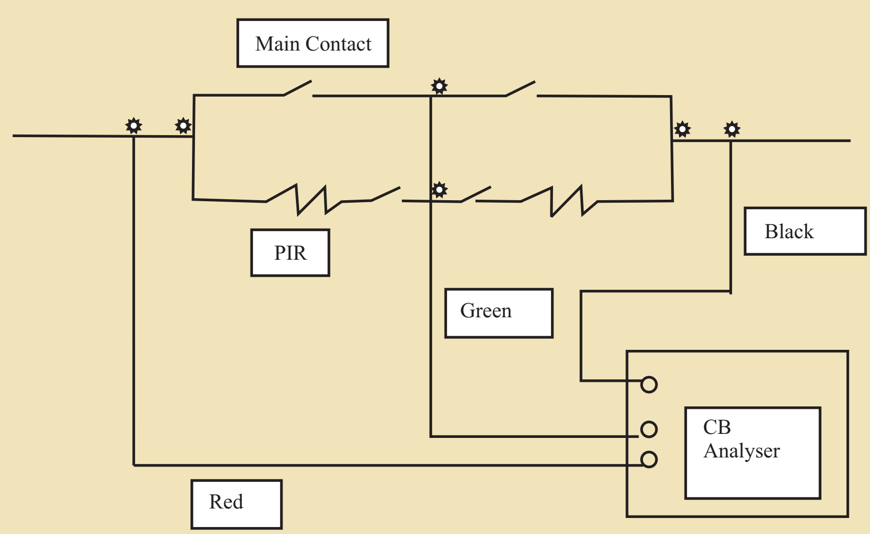
g) Note down the timings for `CO', and `OCO' by giving respective commands. CO command to be given without time delay but 300ms time delay to be given between O and CO operation in testing for OCO.

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.

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/cm^2 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/cm^2 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/cm^2 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.

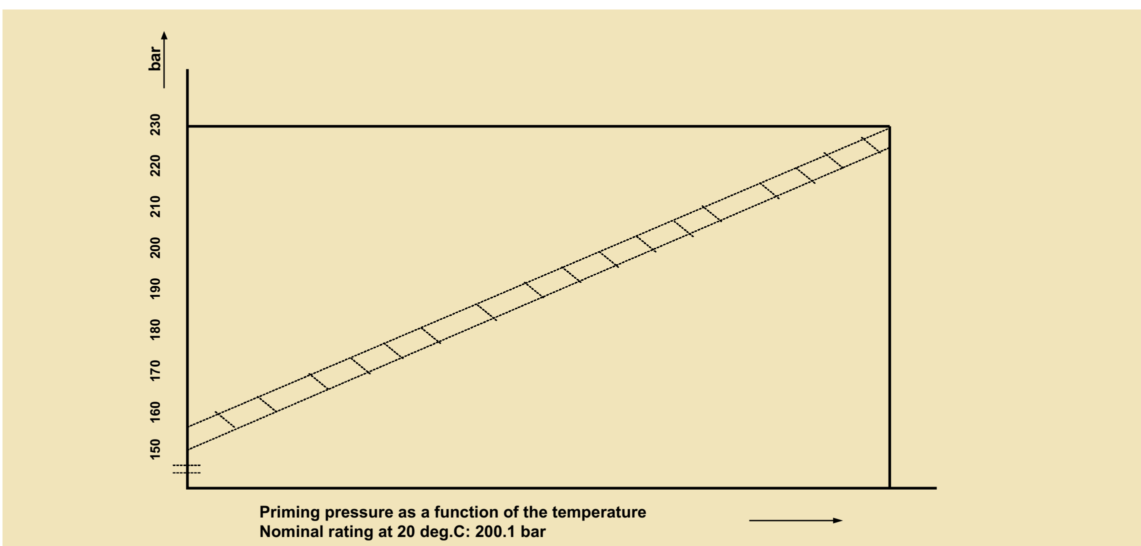


Figure - 17

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.

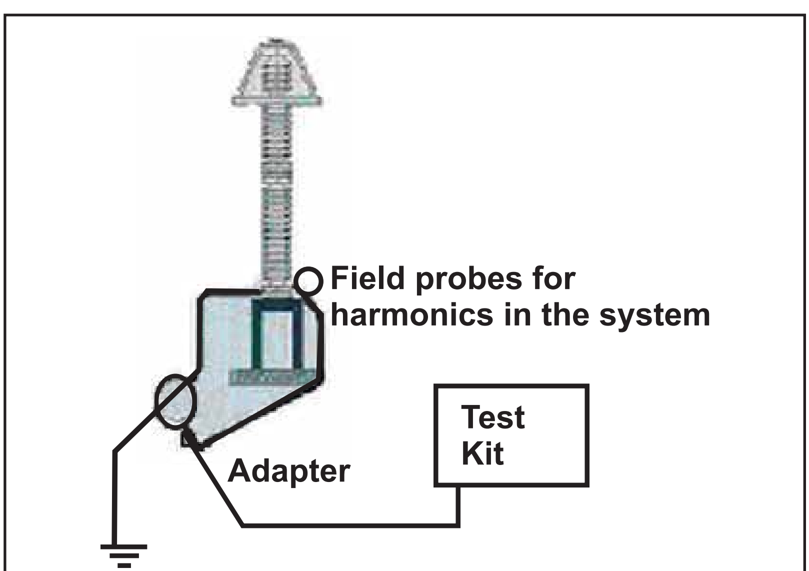


Figure- 18 Typical arrangement for THRCM Test

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

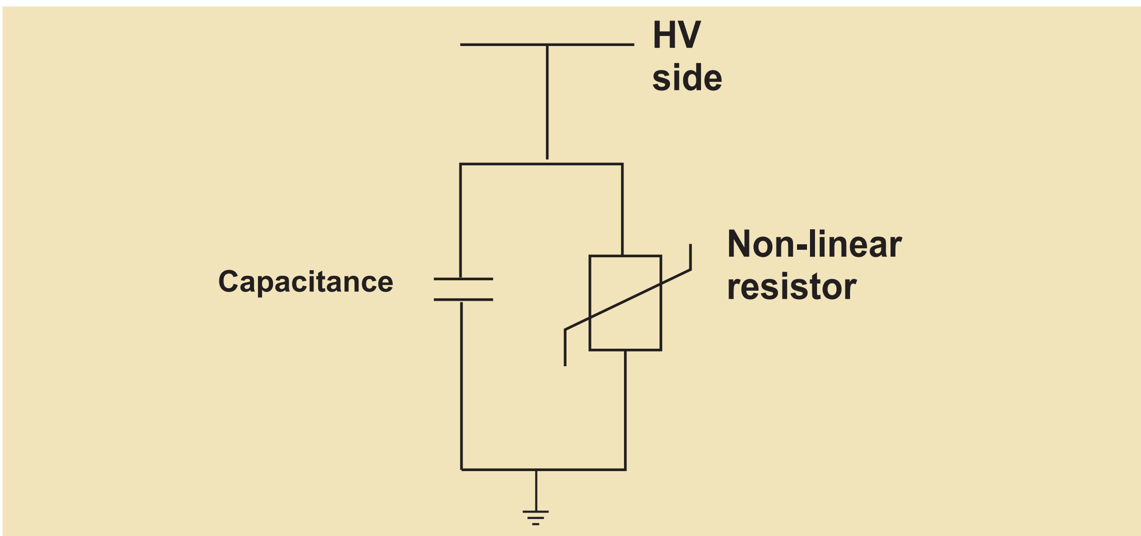


Figure-19 Arrester equivalent circuit

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.

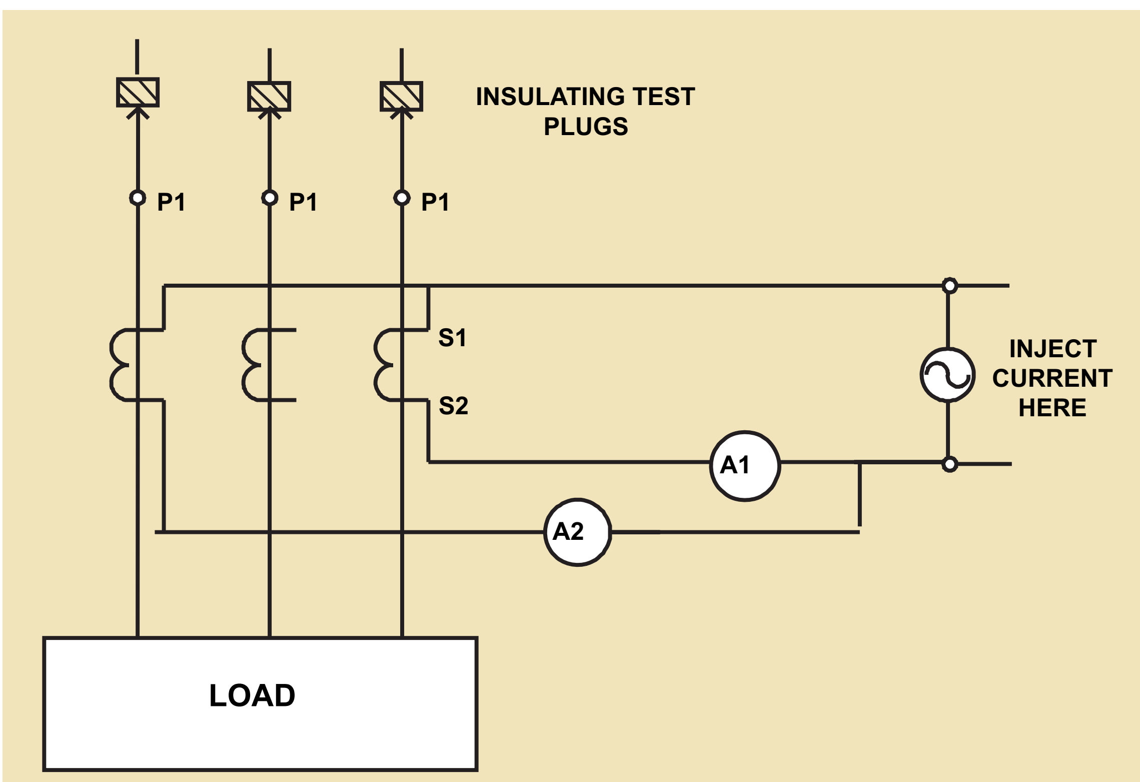


Figure - 20

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.

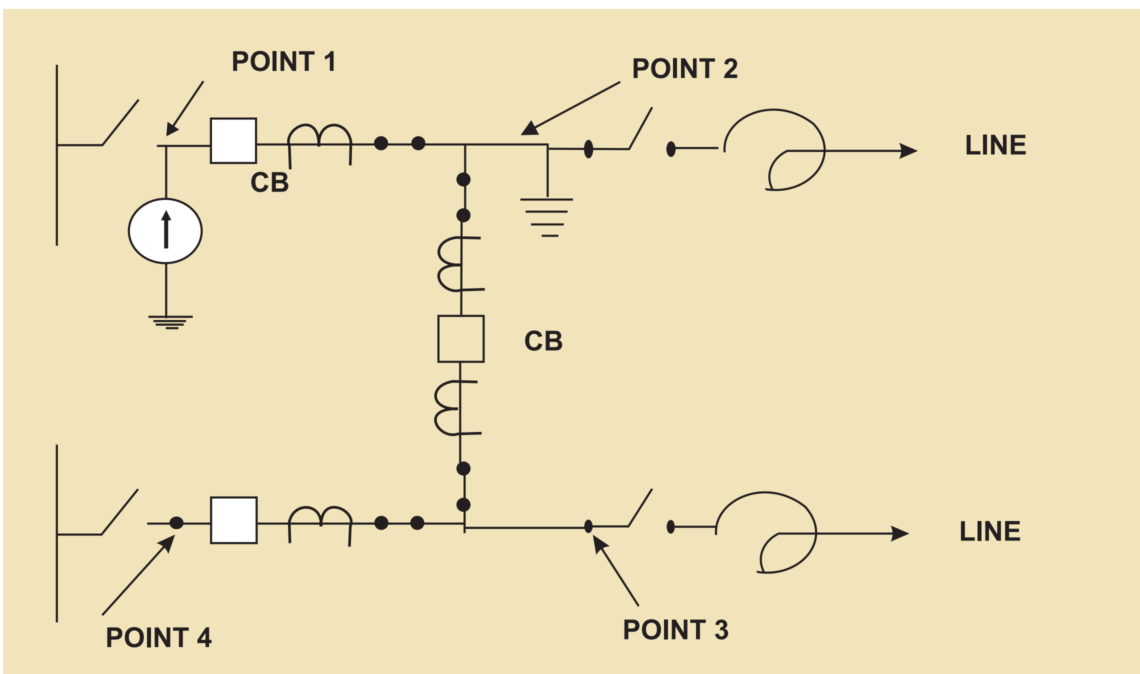


Figure-21 : Primary injection test to check contact tightness of Bay/ feeders

CHECKS/TESTS FOR BUS BAR PROTECTION

Types of bus bar protection

a) High impedance

b) Low impedance

7.1 High Impedance protection

The High-impedance protection scheme, is a good solution for single busbar arrangements, 1 ½ breaker systems or ring Busbars, provided that appropriate dedicated CT cores are available for this use alone.

Sensitive, stable and fast protection for single busbar arrangements and 1 ½ breaker systems.

Eg: RADHA (ABB), FAC 34 (EE), PBDCB (EE), PBLSB (EE)

7.1.1 Types of High impedance protection schemes

Two main protections with CT supervision feature

Main & check zone scheme

a) Two main protections

Generally used where direct measurement is possible without switching of the CT circuits

Trip command will be issued on operation of any one of the main protection.

b) Main & check zone scheme

Have highest degree of security in the form of check zone, generally used where CT switching is required through auxiliary contacts of isolator (like 220kV DMT scheme)

For a double busbar arrangement, two different high impedance units are required. In this case, the current must be switched between the two different measuring units by connecting auxiliary switches to the busbar isolator contacts.

In some cases the auxiliary switches did not operate correctly. This caused the busbar Protection to trip the busbar. For this reason, a safety precaution was introduced: An overall Check-Zone unit, fed from individual CT cores. This overall scheme does not include any switching of CT and therefore is more secure.

The TRIP command is only issued when both a discriminating and check-zone system Operates.

The relay coil will be designed as voltage measuring device consuming negligible current.

$V_f = I_f (Rct+2.Rl)$

$V_k = 2V_f$

Paralleling CT current should be done at CT marshalling boxes.

7.1.2 CT requirements for High impedance protection system

- **Knee point voltage requirement of the CT will be high**
- CT core shall be dedicated to the High-impedance Busbar Protection Scheme (i.e. cannot be shared with other protection relays)
- CT Must have identical turns-ratio (CT Ratio) (Aux.CT for ratio corrections not acceptable)
- Shall have a low resistance of the secondary windings
- Shall have a minimum knee-point voltage of approx. 300-500V.
- Should have a low magnetising current (few milliamps)

7.1.3 Supervision of the CT circuits

Any interruption of CT currents up to the point of parallel connection can cause instability during external faults even though their degree of unbalance is with in the limits during normal operation. Hence supervision scheme for CT wire are required.

Supervision relay should be provided across each phase for each zone.

It will block the current passing through the differential relay by shorting the CT terminals

General setting of the CT supervision relay is 10% of the lowest circuit rating.

Calculation of typical settings for bus bar differential protection

CT ratio:	: 2000/1
CT resistance:	: 10 Ohms
Max. bus fault MVA	: 10000 MVA
Max. fault current	: $10000x10^6/1.732*400000 = 14434$ A
Fault current in secondary	: 7.217A
Voltage setting of the relay	: V_f or $V_S = I_f(R_{ct}+2R_L)$

Lead resistance of 1000m, 2.5sq.mm copper wire is 7.28 ohms

Assume 500m of lead length

Vs= 7.217* (10+2*7.28/2) =124.7V

Nearest available setting can be adopted for the relay

7.2 Low Impedance bus bar scheme

The most suitable protection scheme for Double and multiple busbar Systems (with or without transfer bus) with feeders being switched between sections of the busbar, which operates with full selectivity for all possible busbar configurations.

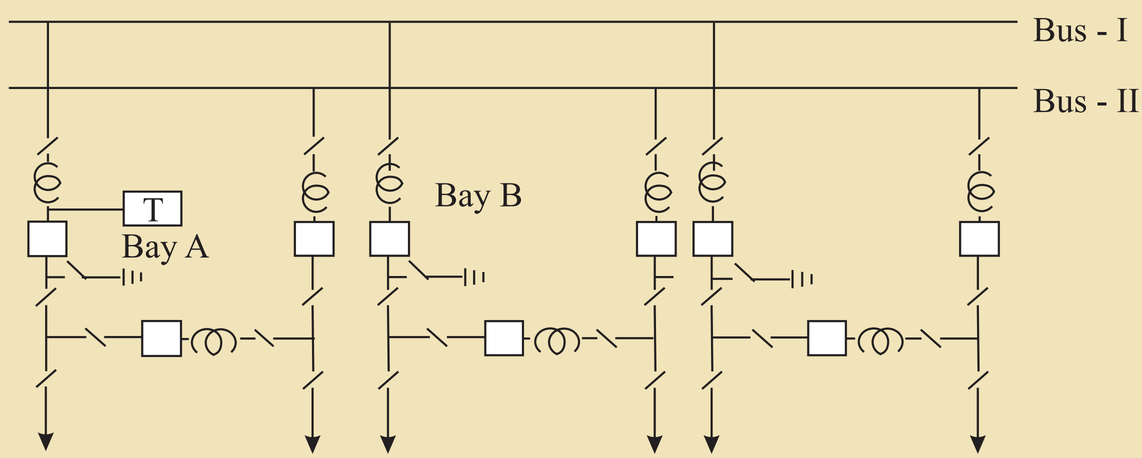
Free of any need for matched CT characteristic or ratios, low leakage reactance or resistance.

Other protective relays can be included in the same circuit.
Stable for infinite fault level.
Insensitive to CT saturation.

All the CT wiring will be routed to relay either directly or through aux. relay.

Eg: RADSS (ABB), MBCZ (EE)

7.3. Primary injection and bus bar differential stability test (New Substation)



T - Primary current injection text kit

1. Take one of the bays (A) as the reference

2. Select other bay (B) for testing the differential stability. Inhibit the tripping of the breaker in bay **B** from control room due to operation of distance or over current protection caused by primary current injection, if the earthing has been made after the breaker by using earth switch.

3. Earth the bus bar after CT using local earth or nearby earth switch on bay **B** to provide return path for the current.

4. Ensure bus bar is earthed only at bay **B**

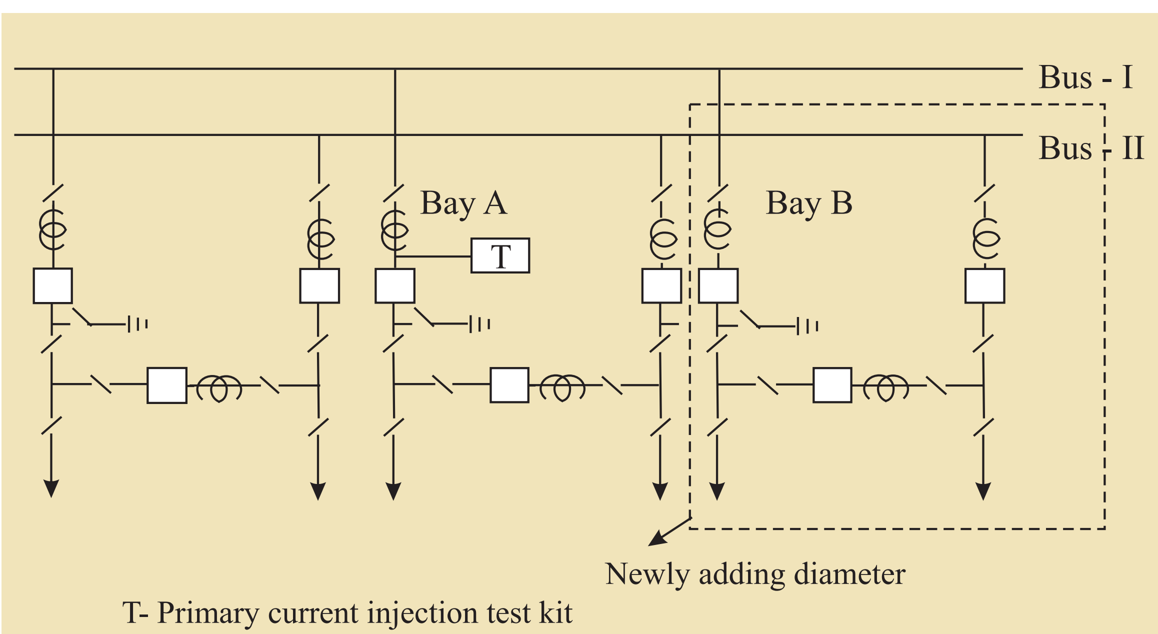
5. Inject primary current using primary current injection test kit across one phase (e.g.R Phase) and ground; don't use other phase as return path for the current.

6. Measure the current at both CT marshalling boxes and voltage across differential relay terminals incase of high impedance differential protection.

7. Measure currents before and after aux. CTs and at relay terminals, incase of low impedance differential protection is being installed.

8. The measured spill voltage/current at relay terminals should not be more than 2%.
9. If the spill voltage/current is more (almost twice the CT secondary current) at the relay terminals, stop injecting the primary current and then reverse the secondary terminals of CT at bay **B.**
10. Start injecting primary current and measure the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage magnitude less than 2%.
11. Stop injecting primary current and then create in-zone fault on primary side (by providing earthing between the two CTs) and start injecting primary current and Measures the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current. (a pictorial example is attached herewith at Annexure)
12. After ensuring the above stop injecting the current. The CT connection should be as per polarity thus proved.
13. Repeat the test for other two phases.
14. Repeat the same procedure for other bays of the same bus bar by taking adjacent bus bar stability checked bay as the reference bay in order to inject max. possible current in the primary using primary injection test kit.
15. Repeat the above procedure for other bus bars also.
16. Above said procedure shall be carried out between Phase-Phase (R-Y &Y-B) by injecting in one phase and joining with other phase for using it as return path instead of earth return for one set of CTs (Two bays).

7.4. Primary injection and bus bar differential stability test (Bay Extension in the old substation):



1. Arrange the shutdown of the bus barunder test
2. Consider one of the existing bays (A) as the reference
3. Short the CT cores used for the other protections (like LBB, distance or differential or O/C or metering, etc), at CT MB itself, no CT core shall be in open condition.
4. Select one of new bays (B) for testing the differential stability and inhibit the tripping of the breaker from control room due to operation of distance or over current caused by primary current injection.
5. Earth the bus bar after CT using local earth or nearby earth switch on bay **B**.
6. Ensure bus bar is earthed only at bay **B**
7. Inject primary current using primary current injection testing kit across one phase (eg.R Phase) and ground; don't use other phase as return path for the current.
8. Measure the current at both CT marshalling boxes and voltage across differential relay terminals incase of high impedance differential protection.
9. Measure currents before and after aux. CTs and at relay terminals, incase of low impedance differential protection is being installed.
10. The measured spill voltage/current at relay terminals should not be more than 2%.
11. If the spill voltage/current is more (almost twice the CT secondary current) at the relay terminals, stop injecting the primary current and then reverse the secondary terminals of CT at bay **B.**
12. Start injecting primary current and measure the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/voltage magnitude less than 2%.
13. Stop injecting primary current and then create in-zone fault on primary side (by providing earthing between the two CTs) and start injecting primary current and measure the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current. (a pictorial example is attached herewith at Annexure)
14. After ensuring the above stop injecting the current. The CT connection should be as per polarity thus proved.
15. Repeat the test for other two phases.
16. Repeat the same procedure for other bays of the same bus bar by taking adjacent bay (whose stability check completed) as the reference in order to inject max. possible current in the primary using primary injection test kit.
17. Repeat the above procedure for other bus bars also.
18. Restore the system to normal conditions.

7.5 Scheme Checking of bus bar protection & DC trip logic. (New substation & Bay extension)

7.5.1 Two Main protection philosophy

1. Test the relay by secondary injection.
2. Check the tripping of the corresponding breakers and non tripping of other bus breakers and tie breakers.
3. Check initiation of LBB relays of the breakers corresponding to particular bus.
4. Check blocking of the bus bar protection on operation of CT supervision relay.
5. Ensure that operation of CT supervision relay should not initiate bus bar tripping.
6. Check initiation of bus bar tripping by operation of corresponding breaker LBB relays.(Back Trip feature)
7. a. Check the direct tripping scheme on operation of bus bar protection (only if tie breaker is in open condition)

   b. Direct trip signal should not go on operation of Bus bar protection if the Tie CB is in close condition.
8. Test CT supervision relays and ensure for triggering control panel annunciation and event logger triggering as per approved scheme.
9. Check bus bar IN/OUT switch for correctness of wiring as per the drawing.

7.5.2 Main and Check zone philosophy

1. Test the both main and check zone relays by secondary injection.
2. Ensure bus bar should not initiate tripping for operation of either main or check zone alone.
3. For checking the tripping scheme, bypass the check zone contact.
4. Check the tripping of the corresponding breakers and non tripping of other bus breakers and tie breakers.
5. Check initiation of LBB relays of the breakers corresponding to particular bus.
6. Check blocking of the bus bar protection on operation of CT supervision relay.
7. Ensure operation of CT supervision relay should not initiate bus bar tripping.
8. Check initiation of bus bar tripping by operation of corresponding breaker LBB relays.(Back Trip feature)
9. a. Check the direct tripping scheme on operation of bus bar protection (only if tie breaker is in open condition)

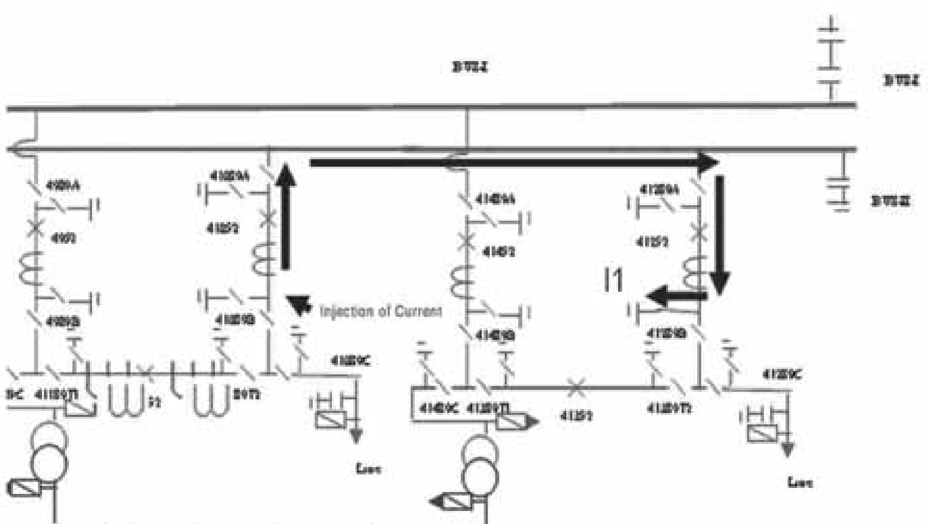
   b. Direct trip signal should not go on operation of Bus bar protection if the Tie CB is in close condition.
10. Test CT supervision relays and ensure for triggering control panel annunciation and event logger triggering as per approved scheme.
11. Check bus bar IN/OUT switch for correctness of wiring as per the drawing.
12. Repeat the above for check zone and CT supervision schemes.

7.6 AMP Testing of bus bar protection and scheme

1. Arrange bus bar shutdown for off line testing. Preferably the bus bar isolation should done through bus bar protection trip relay.
2. Insert the test block after shorting the incoming current terminals for on line testing.
3. Test the relays.
4. For off line testing:
   - i. Check tripping scheme of bus bar (2 main/ main and check scheme), in case of main and check scheme, operation of one relay should not initiate bus bar trip.
   - ii. Check initiation from LBB of corresponding bays of bus bar
   - iii. Check initiation of LBB of corresponding bays of bus bar
   - iv. Check annunciations and DR triggering as per the drawings
5. After completion of the above checks, normalise the connections and take bus bar into service.

CHECKING OF BUS BAR STABILITY

CONDITION 1- BUS –II EARTH SWITCH OPEN



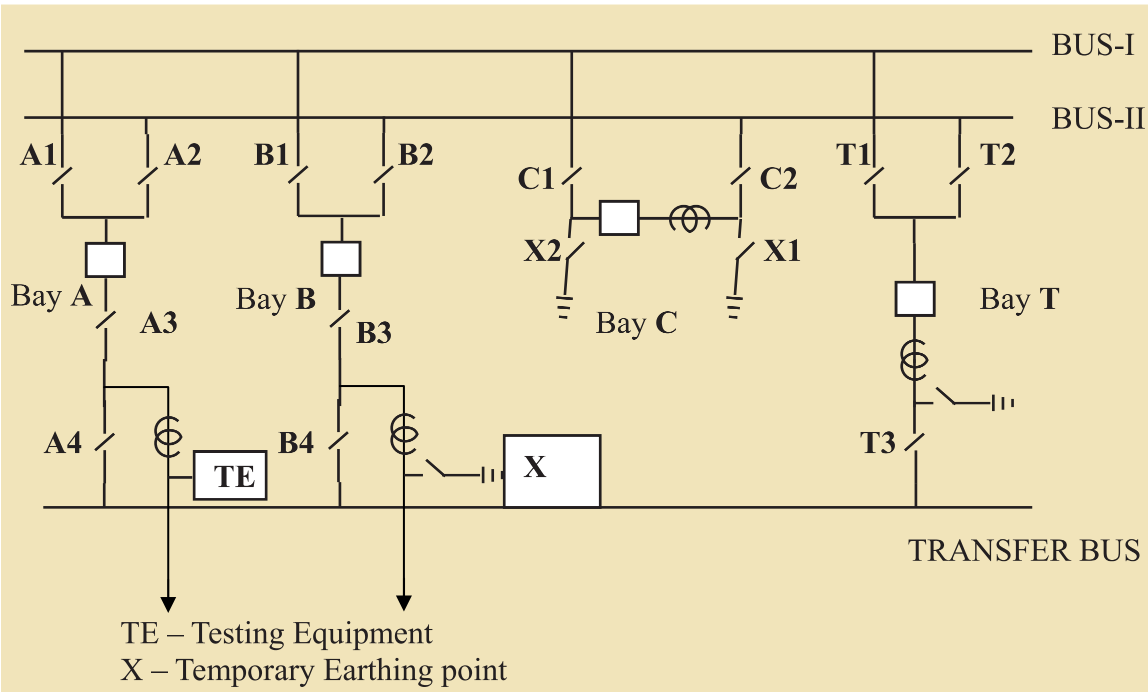
MEAUREMENT OF CURRENT

- Primary injected current = I 1(on single ph basis only)
- Secondary current for 410 CT for Ph & Neutral at
  - CT MB
- Secondary current for 412 CT for Ph & Neutral at
  - CT MB
- Relay diff current
  - As Summation of current is almost zero (Idiff= I1'-I1'),at relay current value should not more than spill

7.7 Double main transfer scheme (400kV/220kV):

For the double main transfer scheme, bus bar protection shall preferably be Main and check zone scheme because of dependency on CT switching between BUS-I & II bus bar protections.

7.7.1 Primary injection and bus bar differential stability test (New Substation):



1. Take one of the bays (**A**) as the reference

2. Select other bay (**B**) for testing the differential stability. Inhibit the tripping of the breakers in bay **A** and **B** from control room due to operation of distance or over current protection caused by primary current injection.

3. Earth the bus bar after CT at X using earth rods on bay **B**.

4. Preferably connect the primary injection testing kit to the CT terminal pad of reference bay (A) after opening the jumper from line side.

5. Ensure that bus or line connected to bay B shall not be earthed other than at X.

6. Close the isolators A1 in bay A, B1 in bay B and Ensure that corresponding CT switching relays operated for checking the bus bar differential stability of BUS-1.

7. Close isolator A3 and breaker in bay A and isolator B3 and breaker in bay B.

8. Measure the resistance of the CT cores (used for main and check zone) towards CT in the CT switching cubicle and it shall be equal to the sum of resistance of the CT core and lead resistance. If the resistance towards CT core is more, then check the CT circuit and corresponding CT switching relay.

9 Inject primary current using primary injection testing kit from bay **A**.

10. Measure the current at both CT marshalling boxes (both cores used for main and check zone) and relay terminals in the control room in case of low impedance protection or measure voltage across cores in CT MB and differential relay terminals incase of high impedance differential protection.

11. The measured spill voltage/current at relay terminals shall be very less compared to the primary current/corresponding voltage (around 2%).

12. If Spill current/voltage is more (almost twice the CT secondary current) at the relay terminals.

    a. Stop injecting the primary current and Check CT paralleling connections after the CT switching relay. If every thing is correct then reverse the secondary terminals of CT at bay **'B'.**

    b. Start injecting primary current and Measures the current/voltage at both CT marshalling boxes and relay terminals at control room and observe the spill current/ voltage magnitude shall be very less compared to the set value (around 2%).

13. Stop injecting primary current and then create in-zone fault in primary side (by providing earthing between two CTs).

14. Start injecting primary current and Measures the current at both CT marshalling boxes (both cores used for main and check zone) and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current.

15. After ensuring the above stop injecting the current and normalize the system.

16. Open isolators A1 on bay A& isolator B1 on bay B and ensure that corresponding CT switching relay got resetted.

17. Close isolators A2 in bay A, B2 in bay B for connecting the feeder to bus-2 and ensure the operation of corresponding CT switching relay for checking the bus bar differential stability of BUS-2.

18. Repeat the above sequence from 9 to 16

19. Open isolators A2 on bay A& isolator B2 on bay B and ensure that corresponding CT switching relays got resetted.

20. Repeat the test for other two phases.

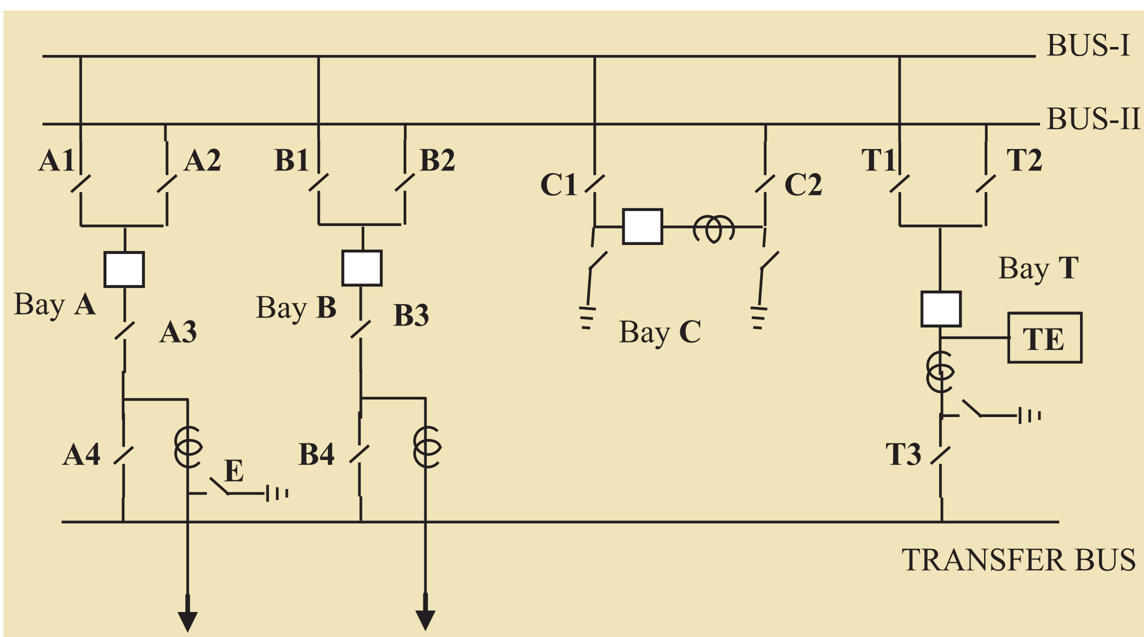
21. Above said procedure shall be carried out between Phase-Phase (R-Y &Y-B) by injecting in one phase and joining with other phase for using it as return path instead of earth return for one set of CTs (Two bays).

22. Repeat the same procedure for other bays including transfer bus coupler bay w.r.t Bus-I & II.

7.7.2 Checking of differential protection stability w.r.t bus coupler:

1. Take one of the bay A as the reference bay
2. Close isolator A1 in bay A to check differential stability of the bus coupler w.r.t Bus-1.
3. Close isolator C1 and breaker in bus coupler bay C and earth at X1 in bay C.
4. Adopt the same procedure as explained above for stability testing of normal bays.
5. Open breaker & isolators A1 in bay **A** and Open breaker & isolator C1 on bay C,
6. Close isolator A2 & breaker in bay **A** and isolator C2 & breaker on bay C to check differential stability of bus coupler CT w.r.t Bus - 2.
7. Earth bay C at X2.
8. Adopt the same procedure as explained above for stability testing of normal bays.
9. Open the breaker and isolator in bay A & bay C and open earthing on bay C and normalize the system.

7.7.3 Checking of differential protection stability w.r.t Transfer bus:



1. Before carrying out this test, ensure that differential protection stability with respect to Bus –I & Bus-II has been carried out on all bays including transfer bus coupler bay.
2. For checking the differential protection stability w.r.t to transfer bus, take one of the bays as reference bay and inject current from transfer bus coupler bay CT.
3. Close isolator T3 and breaker in transfer bus coupler bay T.
4. Close isolator A4 to check stability w.r.t transfer bus and ensure the operation corresponding CT switching relay.
5. Keep the normal/transfer switch of bay A in transfer mode.

6. Measure the resistance of the CT cores towards CT in the CT switching cubicle and it shall be equal to the resistance of the CT core and lead resistance. If the resistance towards CT core is more, then check the CT circuit and corresponding CT switching relay.

7. Inject primary current using primary injection testing kit from bay T.

8. Measure the current at both CT marshalling boxes and relay terminals in the control room in case of low impedance protection or measure voltage across cores in CT MB and differential relay terminals incase of high impedance differential protection.

9. The measured spill voltage/current at relay terminals shall be very less compared to the primary current/corresponding voltage (around 2%).

10. If Spill current/voltage is more (almost twice the CT secondary current) at the relay terminals.

    a. Stop injecting the primary current and Check CT paralleling connections after the CT switching relay. If every thing is correct then reverse the secondary terminals of CT at bay **'T' only while testing first bay.**

    b. Start injecting primary current and Measures the current/voltage at both CT marshalling boxes and relay terminals at control room and observe the spill current/ voltage magnitude shall be very less compared to the set value (around 2%).

11. Stop injecting primary current and then create in-zone fault in primary side (by providing earthing between two CTs)

12. Start injecting primary current and Measures the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current.

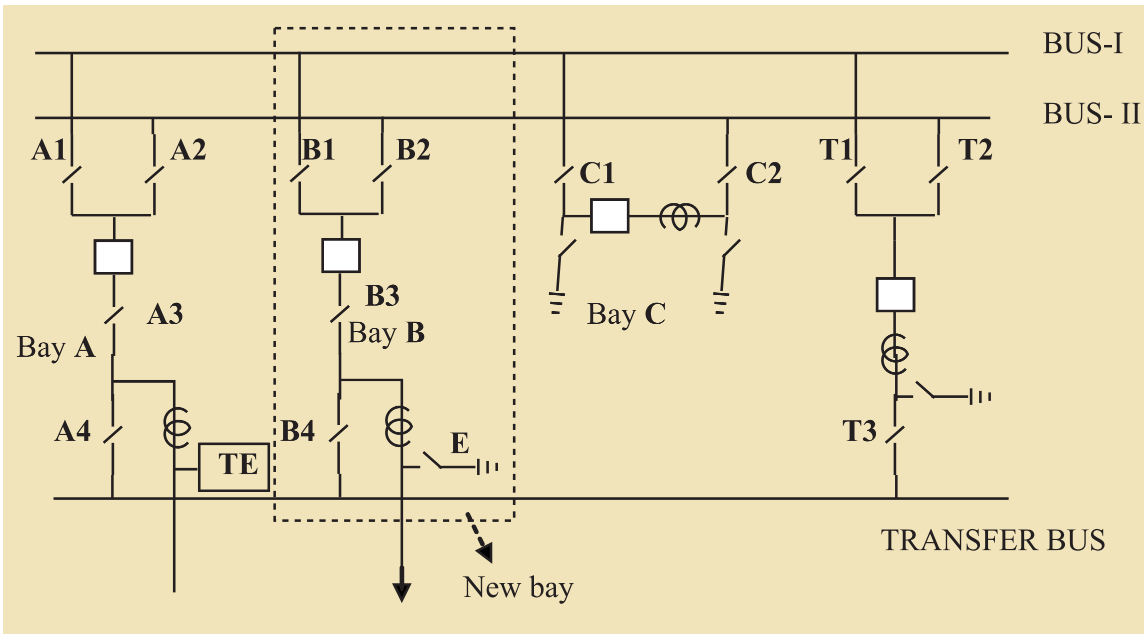
13. After ensuring the above stop injecting the current and normalize the system.

14. Open isolators and earthing which are closed for testing and keep N/T switches in normal position.

15. Repeat the test for other two phases.

16. Repeat the above procedure for other bays to ensure the operation of CT switch relay for transfer bus.

7.7.4 Primary injection and bus bar differential stability test for Bus-I (Bay extension in existing Substation)



1. Arrange the shutdown of the one of the existing feeder or take a bay which is already in out of service as reference bay (A).
2. Arrange shutdown of the bus bar (Bus-I).
3. Close the isolator of new bay B (B1) and ensure the operation of corresponding CT switching relay.
4. Measure the resistance of the CT cores towards CT in the CT switching cubicle and it shall be equal to the resistance of the CT core and lead resistance. If the resistance towards CT core is more, then check the CT circuit and corresponding CT switching relay.
5. Close the isolator B3 and breaker in bay B and isolators A1, A3 and breaker in bay A for connecting the CTs to Bus-I.
6. Inject primary current using primary injection testing kit from bay A.
7. Measure the current at both CT marshalling boxes (both cores used for main and check zone) and relay terminals in the control room in case of low impedance protection or measure voltage across cores in CT MB and differential relay terminals incase of high impedance differential protection.
8. The measured spill voltage/current at relay terminals shall be very less compared to the primary current/corresponding voltage (around 2%).
9. If Spill current/voltage is more (almost twice the CT secondary current) at the relay terminals:

a. Stop injecting the primary current and check CT paralleling connections after the CT switching relay. If every thing is correct then reverse the secondary terminals of CT at bay '**B'.**

b. Start injecting primary current and Measures the current/voltage at both CT marshalling boxes and relay terminals at control room and observe the spill current/ voltage magnitude shall be very less compared to the primary current/corresponding voltage (around 2%).

10. Stop injecting primary current and then create in-zone fault in primary side (by providing earthing between two Cts.

11. Start injecting primary current and Measures the current at both CT marshalling boxes (both cores used for main and check zone) and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current.

12. After ensuring the above stop injecting the current and normalize the system.

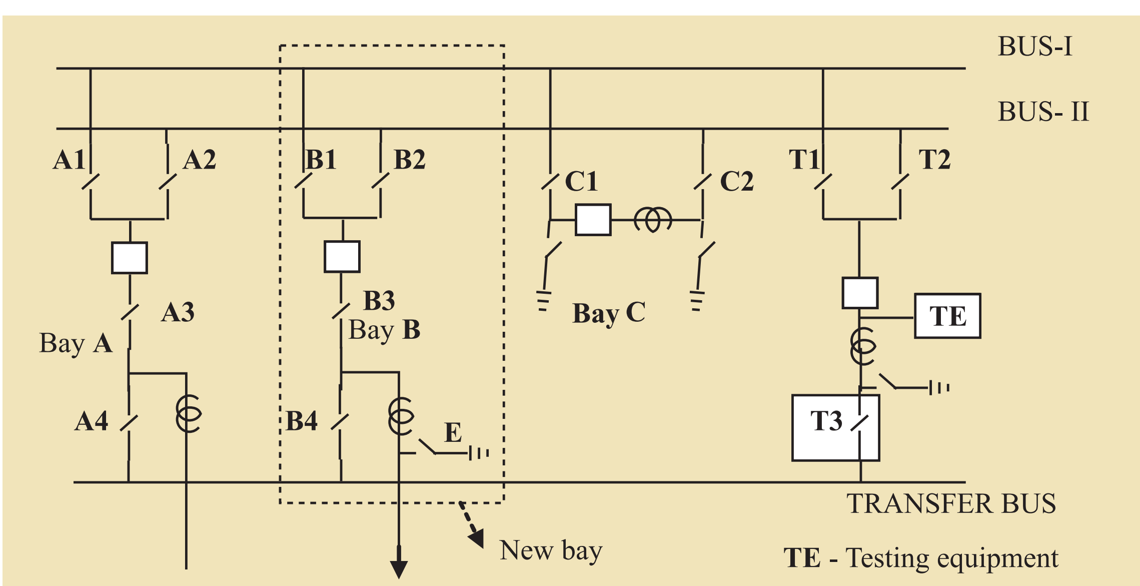
13. Open the breaker and isolator A1 in bay A and breaker and isolator B1 in bay B.

14. Repeat the above procedure for other phases.

15. Repeat the testing of the other newly adding bays (if any) taking this stability tested new bay (B) as the reference bay to avoid outage of old reference bay A for longer periods.

16. Repeat the above procedure of stability testing for new bay w.r.t. Bus-II by selecting of appropriate section (i.e. isolators A2 & B2) with Bus-II shutdown.

7.7.5 Primary injection and bus bar differential stability test w.r.t to transfer bus (Bay extension in existing Substation):



1. Arrange shutdown of transfer bus.
2. Take transfer bus T as reference bus.
3. Close isolator B4 and keep N/T switch in transfer position and ensure the operation of corresponding CT switching relay.
4. Measure the resistance of the CT cores towards CT in the CT switching cubicle and it shall be equal to the resistance of the CT core and lead resistance. If the resistance towards CT core is more, then check the CT circuit and corresponding CT switching relay.
5. Close isolator T3 and breaker in bay T.
6. Inject primary current using primary injection testing kit from bay T.
7. Measure the current at both CT marshalling boxes and relay terminals in the control room in case of low impedance protection or measure voltage across cores in CT MB and differential relay terminals incase of high impedance differential protection.
8. The measured spill voltage/current at relay terminals shall be very less compared to the set value (around 2%).
9. If Spill current/voltage is more (almost twice the CT secondary current) at the relay terminals.
   a. Stop injecting the primary current and Check CT paralleling connections after the CT switching relay.
   b. Start injecting primary current and Measures the current/voltage at both CT marshalling boxes and relay terminals at control room and observe the spill current/ voltage magnitude shall be very less compared to the set value (around 2%).
10. Stop injecting primary current and then create in-zone fault in primary side (by providing earthing between two CTs.
11. Start injecting primary current and Measures the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current.
12. After ensuring the above stop injecting the current and normalize the system.
13. Start injecting primary current and measure the current/voltage at relay terminals and ensure that its magnitude is very less compared to the primary current.
14. Open isolators and earthing which are closed for testing and keep N/T switches in normal position.
15. Repeat the test for other two phases.

7.8 Scheme checking of bus bar protection & DC trip logic. (New substation & Bay extension)

7.8.1 Two Main protection philosophy

1. Test the relay by secondary injection.
2. Check the tripping of the corresponding selected breakers and bus coupler breaker (in case of Bus-I & Bus-II only) and non tripping of other breakers.
3. Check initiation of LBB relays of the selected breakers corresponding to particular bus.
4. Check blocking of the bus bar protection on operation of CT supervision relay.
5. Ensure that operation of CT supervision relay should not initiate bus bar tripping.
6. Check initiation of bus bar tripping by operation of corresponding breaker LBB relays.(Back Trip feature)
7. Check the direct tripping scheme on operation of bus bar protection.
8. Test CT supervision relays and ensure for triggering control panel annunciation and event logger triggering as per approved scheme.
9. Check bus bar IN/OUT switch for correctness of wiring as per the drawing.

7.8.2 Main and Check zone philosophy

1. Test the both main (i.e. Bus-I, Bus-II and Transfer Bus) and check zone relays by secondary injection.
2. Ensure bus bar should not initiate tripping for operation of either main or check zone alone.
3. For checking the tripping scheme, bypass the check zone contact.
4. Check the tripping of the corresponding selected breakers and bus coupler breaker (in case of Bus-I & Bus-II only) and non tripping of other breakers.
5. Check initiation of LBB relays of the breakers corresponding to particular bus.
6. Check blocking of the bus bar protection on operation of CT supervision relay.
7. Ensure operation of CT supervision relay should not initiate bus bar tripping.
8. Check initiation of bus bar tripping by operation of corresponding breaker LBB relays.(Back Trip feature)
9. Check the direct tripping scheme on operation of bus bar protection.
10. Test CT supervision relays and ensure for triggering control panel annunciation and event logger triggering as per approved scheme.
11. Check bus bar IN/OUT switch for correctness of wiring as per the drawing.
12. Repeat the above for check zone and CT supervision schemes.

7.9 AMP testing of bus bar protection and scheme

1. Arrange bus bar shutdown for off line testing and scheme checking.
2. While switching all the loads from one bus to other bus observe the operation and resetting of corresponding CT switching relays in accordance to the operation of isolators.
3. CT switching discrepancy alarm shall not appear in the control panel.
4. Check tripping scheme of bus bar (2 Main/ Main and check scheme), in case of main and check scheme, operation of one relay should not initiate bus bar trip.
5. Check annunciations and DR triggering as per the drawings
6. After completion of the above checks, normalise the connections and take bus bar into service.
7. Insert the test block after shorting the incoming current terminals for on line testing.
8. Test the relays.