INSTRUCTION MANUAL

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CCVT Coupling Capacitor Voltage Transformers

CC Coupling Capacitors

TRENCH®

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Introduction

Trench Limited manufactures a comprehensive range of capacitor voltage transformers (CVT's) and coupling capacitors (CC's). All basebox types utilize the same design principles and manufacturing techniques, the information detailed in this manual is applicable in general, except where noted.

The circuit diagrams, drawings and other data in this manual may vary in minor details, from the equipment supplied. In all cases the diagrams supplied by the factory and identified with the equipment will be correct in all details.

The contents of this manual are designed to cover most situations, which may occur in practice. If any additional information is required, please contact Trench Limited.

Construction and Types

Fig. 1 shows detailed cross sectional views of a typical capacitor voltage transformer. All Trench Instrument Transformer Products contain oil, which has less than 2-PPM PCB considered as non-detectable amount.

Capacitor Voltage Transformers

Types TCVT, TEVF, TEMF, TEVP, TEMP, TETP, TERP, TEIRF, TEIMF, TEHMF and TEHMP are capacitor voltage transformers (CVT's) for use with PLC coupling schemes, protective relaying and metering applications. They comprise of an assembly of one or more capacitor units mounted on oil filled aluminum basebox or electromagnetic unit (EMU), which contains the intermediate transformer, series reactor and auxiliary components.

A low voltage terminal box houses the secondary terminals and auxiliary components.

Coupling Capacitors

Types TECF, TECP, TEICF, TEHCF and TEHCP are coupling capacitors (CC's) for use in power line carrier (PLC) coupling schemes. They consist of an assembly of one or more capacitor units of a flat base design with no carrier accessories or mounted on an air-filled aluminum basebox complete with carrier accessories.

The film/paper/PXE fluid insulation system represents a premium system of a low dielectric loss design and outstanding stability performance.

Heaters

Note that Trench oil filled EMU's do not require heaters. In the low voltage terminal box, heaters may be installed to prevent condensation during long storage periods in very humid environments. Power rating of heaters could be up to 15 watts and dual voltages 120/240V or 240/480V. Once the CVT is in service it is not recommended to keep the heater on especially when ambient temperature exceeds 40°C.

Inspection

All shipments should be inspected upon arrival for chipped or damaged porcelains, metallic parts and oil leaks. The LV terminal box should be opened and examined for loose components or broken wiring. If transit damage has been found, file a claim with the Transit Company and notify Trench Limited immediately.

Shielding Ring

When a shielding ring is supplied, refer to the outline drawing regarding the way the shielding ring should be mounted on the unit. Check the shielding ring for any scratches or sharp points, which may have been caused during transit and file smooth before installation.

Storage & Transportation

Units may be safely stored upright only on level ground, outdoors for a reasonable period of time. Multiple capacitor units are shipped with the upper capacitor units removed and bolted to the skid alongside the basebox. The top ends of the capacitors exposed by the removal of the upper units are protected from the weather by temporary plastic bag covers, which should be examined when equipment is placed in storage, and adjusted if found to be damaged or loosened.

Units must be only transported in the upright position preferably with their original packaging.

Installation

Erection

CC's or CVT's with more than one capacitor unit are shipped with the units disassembled. They are crated in sets with all components required to assemble one CVT unit in one crate. Capacitor units must not be interchanged with capacitors from different CVT's.

Assembling of CVT's can be performed with assistance of a lifting crane. The use of rope slings with a choker-type hitch arranged to bear on the upper metal flange is an effective way of lifting the capacitor units.

<u>Assembling can be carried out as follows:</u>
Mount the basebox and bottom capacitor assembly on its pedestal and prepared foundation and assemble subsequent capacitor units on top in accordance with the instructions detailed below.

Capacitor Assembling Instructions

Electrical connection between capacitor sections is done by direct mounting of the upper capacitor section onto the lower capacitor section. The capacitors are secured by axial bolts around the capacitor flange that must be tightened to 20 ft. lb. (27 Nm). For easy reference, the individual nameplates should be aligned with each other during assembling. Fig.2 shows details of the assembly and connection procedure.

For high seismic areas, the use of damping pads may be required. Please refer to the contract drawings supplied with the equipment.

<u>Caution:</u>
It is essential that the capacitor unit serial numbers shown on the main nameplate of the CVT match the actual serial numbers of the capacitor units installed on the device.

<u>Note:</u>
Accuracy performance may be severely affected if capacitor units are interchanged between CVT's.

Fig. 1 Sectioned Perspective View of a Typical Capacitor Voltage Transformer

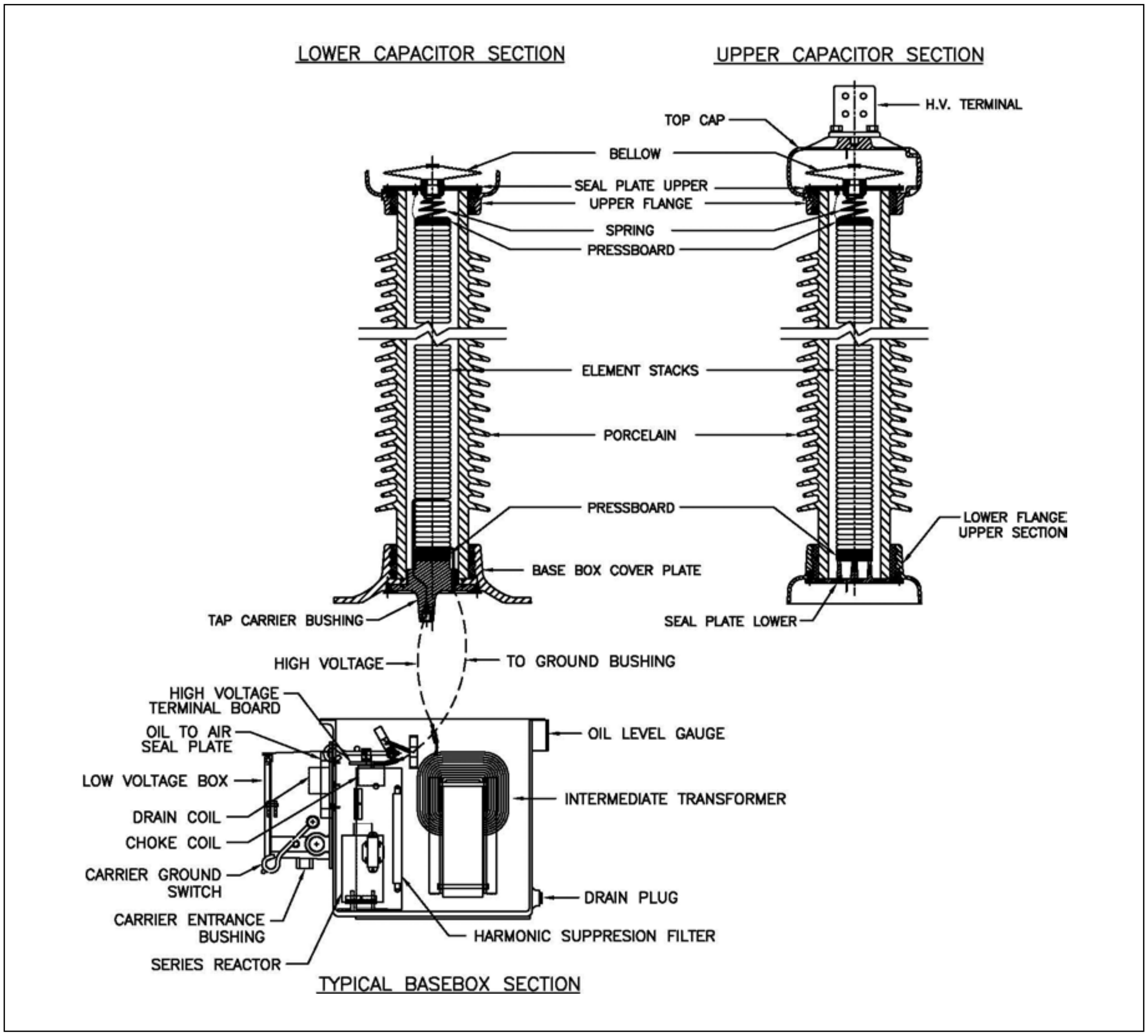
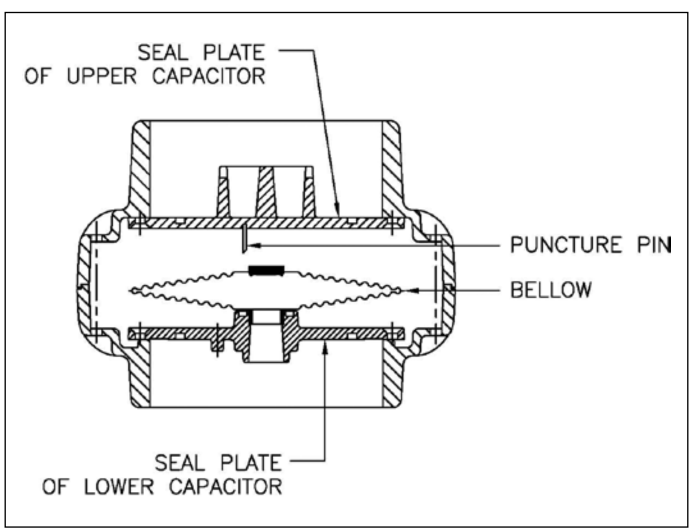


Fig. 2 Capacitor unit’s assembly and connection



Connections

The basebox should be solidly grounded by means of a grounding cable connected to the aluminum ground pad located on the side of the basebox.

All low voltage and carrier terminals are in the air-filled low voltage terminal box located on the front side of the basebox (Fig. 3).

Low voltage secondary terminals are provided in the oil/air seal plate assembly (Fig. 3). Secondary wiring entrance to the low voltage box is by 4” x 5” (102 x 127 mm) gland plate with provision for 1¼” (32 mm) knock out conduit entry by bosses. Carrier entrance to the low voltage box is by 5/8” (16mm) internal diameter entrance bushing, with customer connection directly on the carrier terminal stud.

DANGER

HAZARD AND BODILY INJURY OR EQUIPMENT DAMAGE

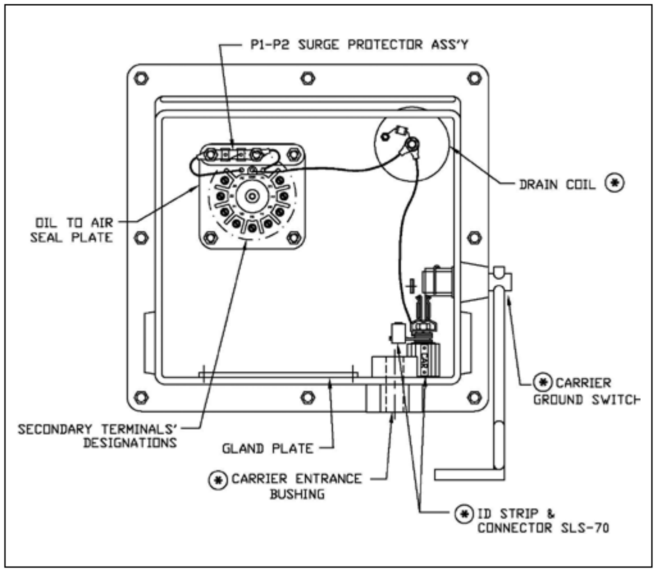
- Only qualified maintenance personnel should operate, service or maintain this equipment. This document should not be viewed as sufficient for those who are not otherwise qualified to operate, service, or maintain the equipment discussed. This bulletin is intended to provide accurate and authoritative information only. Trench Limited assumes no responsibility for any consequences arising out of the use of this bulletin.
- The successful operation of this equipment depends upon proper handling and installation. Neglecting fundamental installation requirements can lead to personal injury as well as damage to electrical equipment or other property.
- Before servicing equipment, disconnect all sources of electrical power. Assume that all circuits are live until they have been completely de-energized, tested, grounded, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.
- Carefully inspect the area around the transformer for tools and objects left near the unit.
- For safety, at least two qualified individuals must be present during installation.

Failure to observe these precautions may result in equipment damage, severe personal injury, or death!

Caution (refer to Fig. 3)

- **The ground connection for the surge protective device (P_2 terminal) must never be removed during normal service conditions. This provides the ground for the magnetic unit.**
- **The carrier terminal must always be connected to ground, either directly, if no carrier is required, or via the drain coil.**

Fig. 3 Low Voltage Terminal Box for CVT



Commissioning and Routine Maintenance

During a regular maintenance program, perform a regular visual inspection of the following:

- Chipped porcelain
- Abnormal pollution accumulation
- Oil leaks
- Check oil level of the basebox by means of the oil gauge.

It is recommended to check the protective gap annually. The life of this device depends on the frequency and duration of system switching. Unless specified otherwise in the connection diagram of the CVT, the protective device across P_1 and P_2 is a Siemens gas-filled surge protector type SI-A 350 with a.c. sparkover voltage of 250 volts rms and a tolerance of +/-20%. If the sparkover voltage of the device is outside this range, it needs a replacement. When this protective device is installed, it is important to make sure the metallic ends make good contact in the holder.

If a preventive maintenance program calls for regular electrical tests, the following procedures may serve as a guide for tests on a routine basis as governed by your usual practice. If it is the practice of your utility to conduct a check at the time of commissioning, then these same procedures may be followed at this time.

If the CVT is utilized for PLC only, the potential ground switch must remain in the open position.

Electrical Tests

See precautions for HV testing on page 8 before doing the tests.

Measure capacitance and dissipation factor of each capacitor unit.

It is important to use equipment with a capacitance measurement error of less than 0.5% in order to detect a capacitor element failure. This can be achieved by the use of Low Voltage Capacitance Bridge. All measurements taken should be corrected to 20°C using Fig. 4.

As there will always be differences between the calibrations of various capacitance measuring equipment, the initial capacitance readings on installation should be recorded and used as a basis for comparison with subsequent measurements made with the same test equipment.

- Measure the transformation ratio of the unit (CVT's only). The purpose of this test is to verify the continuity of the CVT circuit only. The use of Doble Test equipment as a power supply to the HV terminal and measurement of secondary voltage is a convenient method of doing this measurement.

Capacitance Bridge Testing

It is possible, but not likely, for a damaged capacitor element to recover after de-energisation and the unit capacitance appear to be normal when measured at a low voltage, using a low voltage capacitance bridge. Factory measurements are made at normal operating voltage.

Measure upper units by attaching the test leads directly to the joining bolts.

For CVT's, the presence of the intermediate transformer connected to the tapping point on the bottom unit requires special consideration. Refer to the connection diagram and low voltage terminal box and follow the procedure described below:

- Close voltage tap ground switch and measure "C_1", (HV terminal to basebox with ground switch closed). Compare to value marked on main nameplate or measurements taken in previous tests.
- With ground switch still closed, measure "C_2". Remove ground connection at "CAR" terminal and measure between this terminal and basebox. Compare to C_2 value marked on main nameplate or previous measurements.
- Measure "C total", from HV terminal to "CAR" terminal with ground switch open and grounding links removed from "P_2" and "CAR" terminals. Depending on the type of bridge used, there may be difficulties in obtaining a balance for DF as leakage currents through the insulation of the transformer windings will cause apparent DF readings below the true value or even to be negative, although capacitance value obtained will be correct. A change of measurement "C" total from one routine test to another would be an indicator that additional investigation is required.

Note that, on the bottom capacitor unit, the lower end plate is isolated from the capacitor electrodes and cannot be used as a connection point.

Capacitance and Dissipation Factor Measurements

The procedures outlined below are operating instructions for the use with Doble M4000 equipment.

The power factor reading from the capacitance and dissipation factor (DF) test corresponds to the DF shown on the nameplate of each capacitor unit. The DF reading depends upon good solid test connections being established and care must therefore be taken to obtain valid test results. The capacitance data obtained at commissioning stage may differ from the nameplate values and therefore the capacitance measurement done at commissioning should be used as a reference for future comparison. A capacitor element failure will result in an increase in the total capacitance in proportion to the original number of elements and those remaining in operating condition. Generally, an increase of 1% in capacitance from the reference data obtained during commissioning would be significant. The capacitance of the capacitor unit should be preferably measured with the same equipment and compared to the commissioning data to ensure good working condition of the capacitor assembly.

Capacitance and dissipation factor test can be carried out on all ratings of Trench Limited coupling capacitors and capacitor voltage transformers.

For coupling capacitors, the carrier bushing is accessible and tests can be done by energizing either top or bottom end of the capacitor as required.

For capacitor voltage transformers, the HV terminal must be disconnected from the HV bus for accurate measurements.

If solidly bolted bus connections are to be used, it is recommended that suitable insulating supports be installed to isolate the CVT for test purposes. Shorting links normally used across these insulating supports may then be easily removed during tests and replaced afterwards.

The test methods for assemblies which have 1, 2, 3 or 4 capacitor units, are detailed below and from page 11 to 17.

- Remove carrier ground connection for the duration of the capacitance and dissipation factor test
- Ground the basebox solidly to the test set
- Close the voltage tap ground switch

> - **IMPORTANT: Replace carrier connection immediately after test, before energizing.**

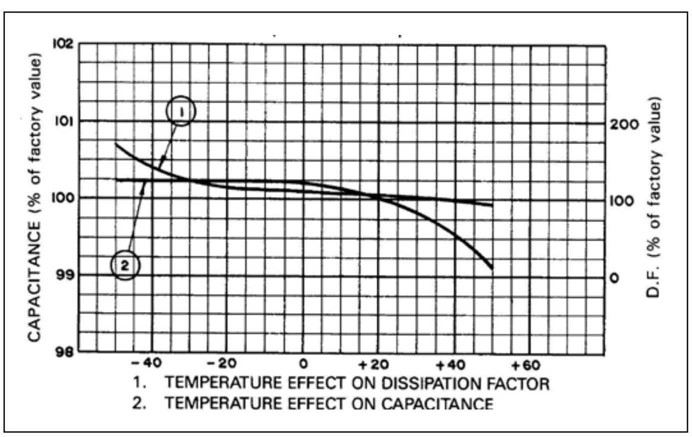
NOTE: It is not unusual for dissipation factor (DF) measurements made at 10kV or below to exceed factory values, which are measured at operating voltage. If DF exceeds 0.4 %, consult Trench Limited.

Example for use of Fig. 4

1. Make measurement at field temperature. Example:
   Temperature = -10°C
   Capacitance = 10050 pF
   Dissipation Factor = 0.065%
2. Find our factory values from test report. Example:
   Capacitance = 10 000 pF
   Dissipation Factor = 0.055%
3. Calculate predicted values at field temperature. Example:
   Capacitance at -10°C = 100.25% of factory value
   = 10025 pF
4. Dissipation Factor at -10°C = 113% of factory value
   = 0.062%

Compare values from 1 and 4.

Fig. 4 Capacitance and Dissipation Factor Temperature Correction Curves for Paper-Film/PXE Capacitor



Note: Measurement is done at normal operating voltage. Significant error on dissipation factor may result if measurement performed at low voltage (1-10kV).

Precautions for High Voltage Testing

If HV testing methods are employed on complete CVT's, the following precautions should be taken:

- Do not energize the HV terminal above the normal rated line-to-ground voltage of the unit. The terminals "P_2" and "P_1" are connected to the high voltage side of the electromagnetic unit of the CVT which is subsequently connected to the tap capacitance "C_2". If "P_2" is not properly grounded and the CVT is energized with the potential ground switch in open position, a voltage of 5 to 11 kV will appear at "P_2" and "P_1" terminals (Refer to Fig. 5).
- The normal operating voltage of the tapping point is approximately 5 kV (TEVF), 11 kV (TEMF, TEMP and TEHMF), 5 to 11 kV (TCVT). It is recommended that capacitance measurements be taken at voltages below the normal rated voltage of the unit, so that the voltage appearing on "P_1" and "P_2" terminals during the measurement will be proportionately reduced.
- Extreme care must be taken to ensure that connections to the "CAR" terminal are completely away from the "P_1" and "P_2" terminals, because of the high voltage which will appear at these terminals.
- Qualified personnel only, who fully understand the circuit involved, should make measurements.
- Maximum test voltage to "P_1" and "P_2" and "CAR" terminals with respect to grounds should not exceed 2 kV.

WARNING
HAZARD OF ELECTRIC SHOCK.

During storage, ensure that all capacitor insulator assemblies are shorted.

Failure to observe these precautions can result in personal injury or product damage.

Connection of a Non-Linear (Magnetic) Burden

Caution must be used when using non-linear (or magnetic) burdens with CVT's. Non-linear burdens connected to the CVT may cause harmonics in the output voltage and current within the electromagnetic components of the CVT, which, in turn, may cause variation in ratio and phase angle errors as well as increasing the voltage across the protective gaps. During momentary overvoltage conditions, the effects of a non-linear burden may cause P_1 - P_2 flashover and, thereby, interfere with the operation of the relaying systems.

Most relays, synchroscopes, voltmeters and other generally used instruments are essentially linear burdens up to twice the normal voltage. Burdens with closed magnetic circuits such as auxiliary potential transformers may not have linear characteristics over the entire voltage range.

If such devices are used in the secondary circuits, these should be selected so that the iron core is operating at not more than one-half the flux density required to reach the knee of the magnetization curve. For example, it is desirable to use a 230-230 volt auxiliary potential transformer in the 115-volt circuit instead of one having a 115-115 volt rating. The same precaution should be taken for relay coils.

CVT Principle of Operation

Main Components

The main components are the capacitor divider, the intermediate step-down transformer and the series reactor, as shown in Fig. 5.

The step-down transformer and series reactors are connected to the intermediate voltage tap between C_1 & C_2. The series reactor is manufactured so its impedance cancels the impedance of the capacitor; therefore, the full intermediate voltage is delivered to the terminals of the step-down transformer, in phase with the primary line voltage. The series reactor and primary winding of the step-down transformer are manufactured with taps to enable ratio and phase angle adjustment. These are factory preset and do not require alteration after delivery unless a capacitor unit is changed.

Auxiliary Components

All items referred to are identified on the connection diagram.

The choke coil assembly prevents the grounding of the carrier signal when the voltage tap ground switch is closed.

The harmonic suppression filter prevents sustained ferroresonance oscillations. It consists of a resistor in series with a saturable reactor and a parallel resistor. The reactor is designed to saturate above the highest over-voltage rating to form a loading circuit, which will dampen sub-harmonic ferroresonant oscillations.

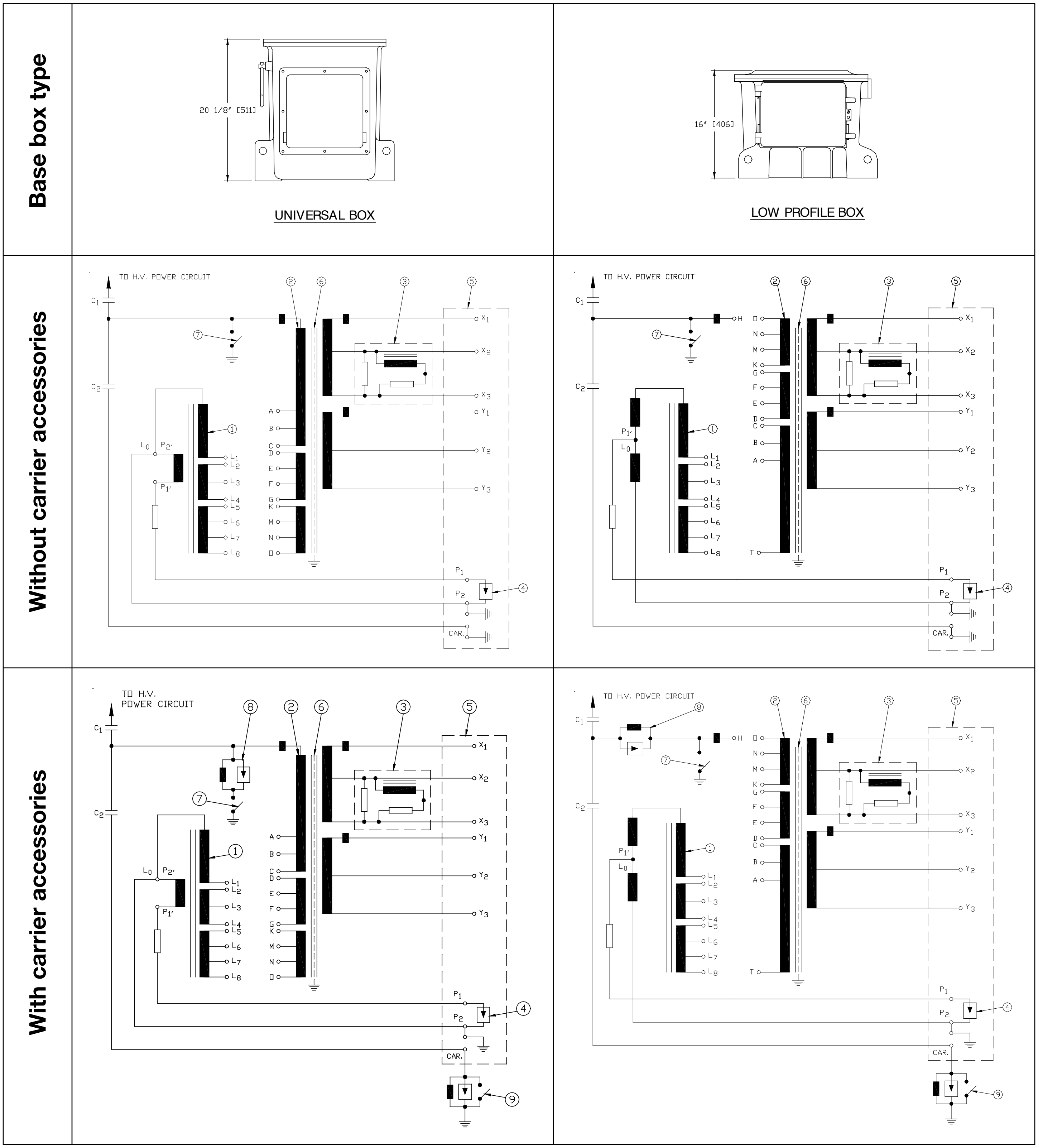
The protective gap (item 4 Fig. 5) is a voltage sensitive device wired in series with a loading resistor on a secondary winding of the series reactor. The protective gap is normally open circuit, but goes in short circuit mode when the intermediate voltage exceeds the overvoltage factor of the CVT, or when the secondary current causes the thermal burden rating (shown in Table V) to be exceeded. This has the effect of de-tuning the CVT and limiting the secondary current available during overvoltage and external short circuit conditions. The protective gap also serves to further limit ferroresonance oscillations. If the fault condition persists for more than about thirty seconds, the protective gap will not reset from the short circuit mode and must be replaced. Its location inside the low voltage terminal box facilitates replacement.

The drain coil, gap and carrier ground switch are supplied if the CVT is to function as a coupling capacitor for power line carrier.

CAUTION on operation of potential ground switch:

The potential ground switch position (see Fig. 5, item 7) is provided for maintenance purposes only. It is not meant to be closed on permanent basis, due to increased stress of C_1 capacitor elements. Closing the potential ground switch for more than 8 hours is not recommended.

Fig. 5 Schematic Diagram of a typical CVT



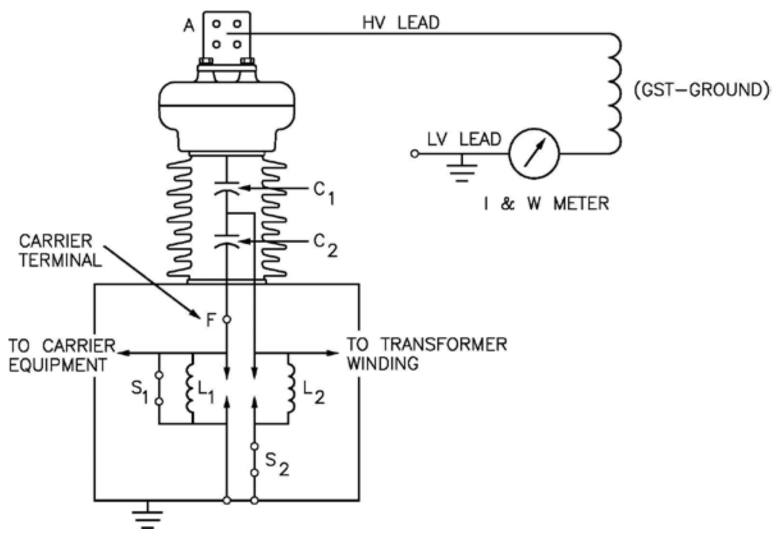
Legend:

① Series Reactors
② Intermediate Voltage Transformer
③ Harmonic Suppression Filter
④ Sealed Protective Gap
⑤ Secondary Terminal Board
⑥ Faraday Field
⑦ Potential Ground Switch
⑧ Choke Coil & Gap Assembly
⑨ Drain Coil, Gap & Carrier Ground Switch Assembly

Note: connection between internal terminals L1…L8 and A, D…O are made at the factory as required for each unit.

Fig. 6 Capacitor Voltage Transformer with One Capacitor Section (Test 1 to 2)

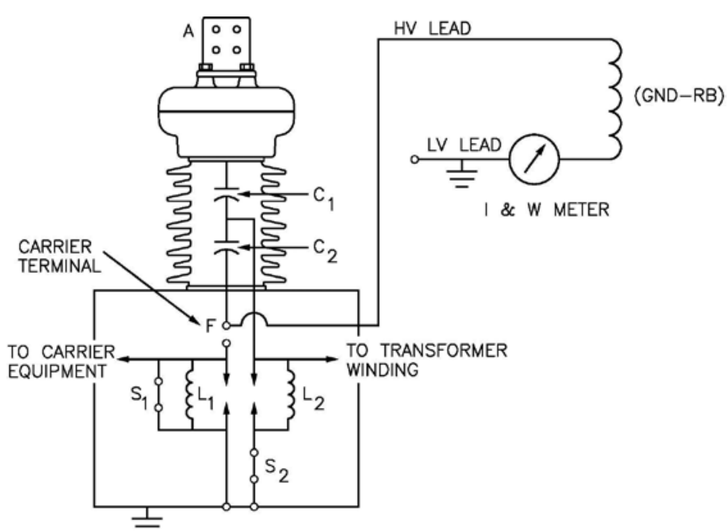
- <u>Test 1 - one capacitor section</u>



Test Procedures	
Measure:	C_1
Test Voltage:	10kV
Circ. Desc.:	GST-GROUND
HV Lead:	A
LV Lead:	-
F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

- <u>Test 2 - one capacitor section</u>

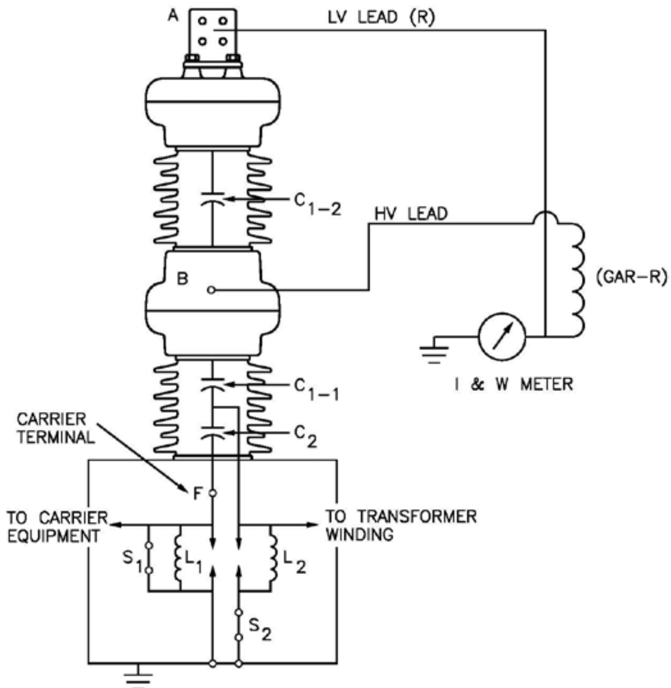


Test Procedures	
Measure:	C_2
Test Voltage:	2kV
Circ. Desc.:	GND-RB
HV Lead:	F
LV Lead:	-
F:	Disconnected (carrier lead)
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

Fig. 7 Capacitor Voltage Transformer with Two Capacitor Sections (Test 1 to 3)

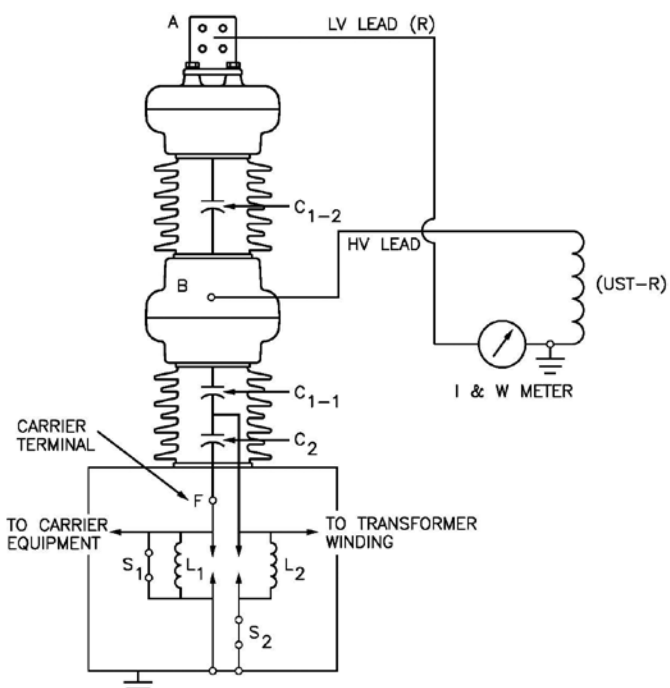
- Test 1 - two capacitor sections



Test Procedures	
Measure:	C_{1-1}
Test Voltage:	10kV
Circ. Desc.:	GAR-R
HV Lead:	B
LV Lead:	A
F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

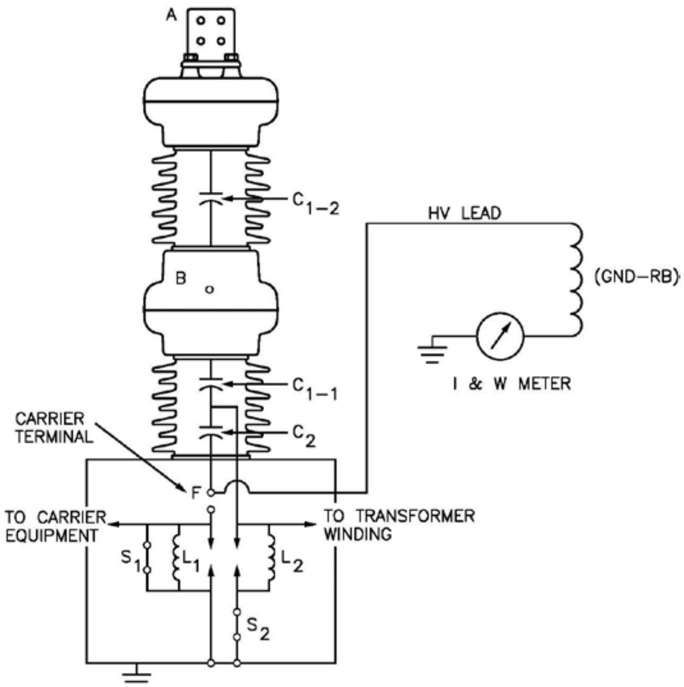
- Test 2 - two capacitor sections



Test Procedures	
Measure:	C_{1-2}
Test Voltage:	10kV
Circ. Desc.:	UST-R
HV Lead:	B
LV Lead:	A
F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

- Test 3 - two capacitor sections



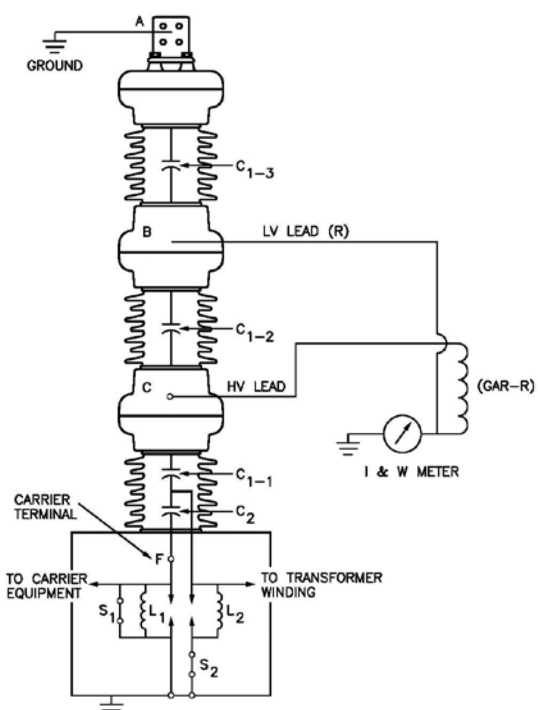
Test Procedures

Measure:	C_2
Test Voltage:	2kV
Circ. Desc.:	GND-RB
HV Lead:	F
LV Lead:	-
F:	Disconnected (carrier lead)
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

Fig. 8 Capacitor Voltage Transformer with Three Capacitor Sections (Test 1 to 4)

- Test 1 - three capacitor sections

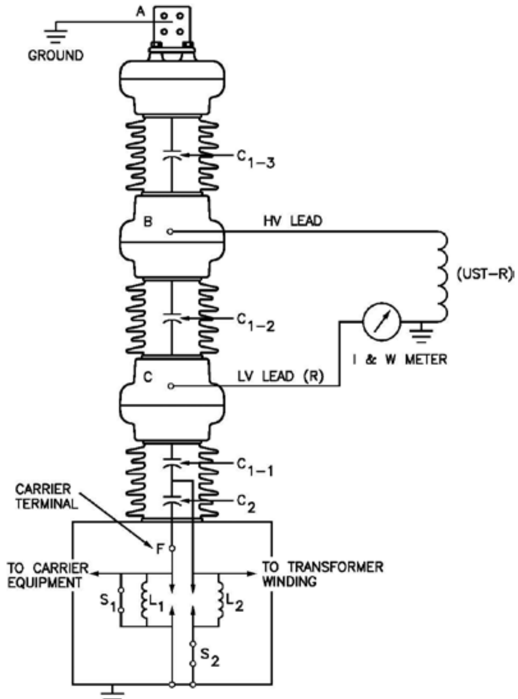


Test Procedures

Measure:	C_{1-1}
Test Voltage:	10kV
Circ. Desc.:	GAR-R
HV Lead:	C
LV Lead:	B
A, F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

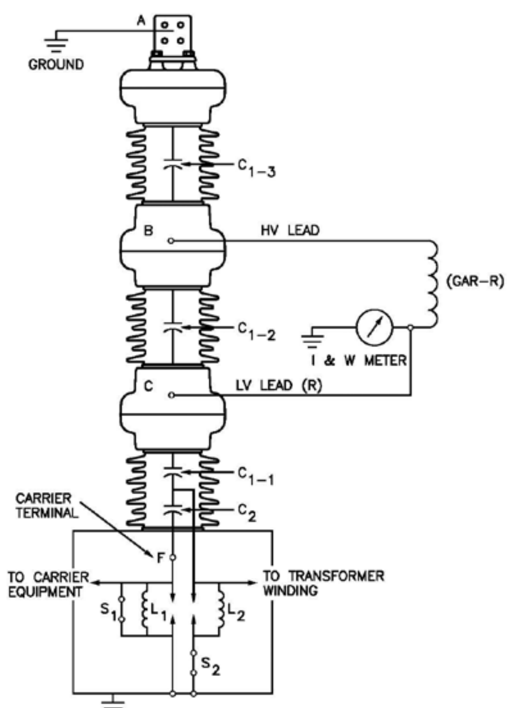
- Test 2 - three capacitor sections



Test Procedures	
Measure:	$C_{1\text{-}2}$
Test Voltage:	10kV
Circ. Desc.:	UST-R
HV Lead:	B
LV Lead:	C
A, F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

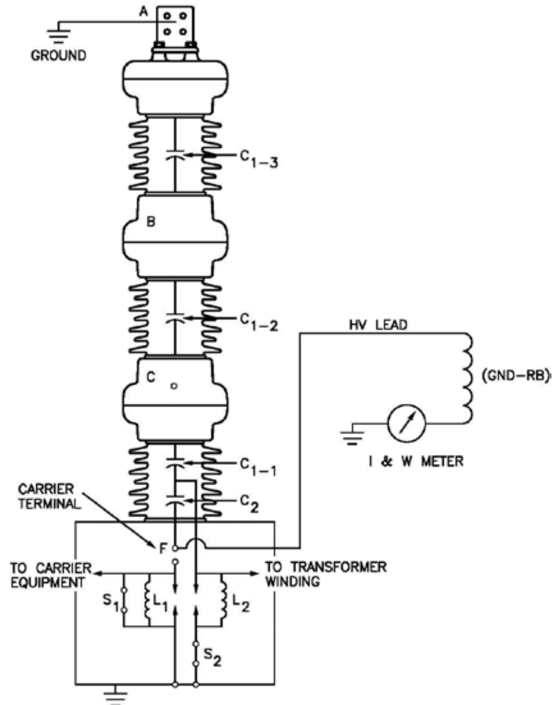
- Test 3 - three capacitor sections



Test Procedures	
Measure:	$C_{1\text{-}3}$
Test Voltage:	10kV
Circ. Desc.:	GAR-R
HV Lead:	B
LV Lead:	C
A, F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

- Test 4 - three capacitor sections



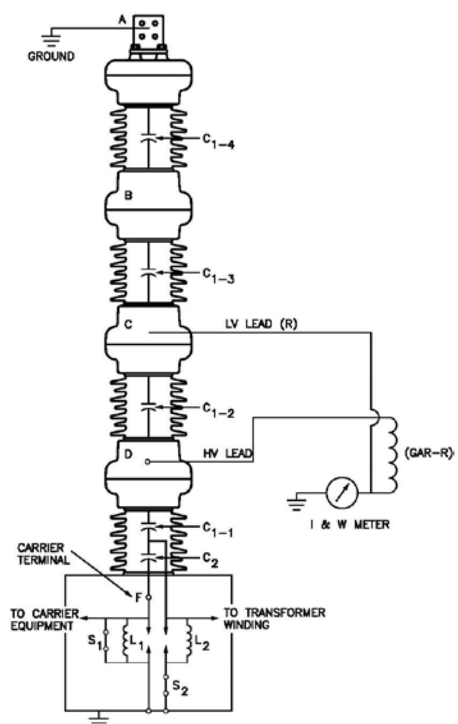
Test Procedures

Measure:	C_2
Test Voltage:	2kV
Circ. Desc.:	GND-RB
HV Lead:	F
LV Lead:	-
A:	Grounded
F:	Disconnected (carrier lead)
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

Fig. 9 Capacitor Voltage Transformer with Four Capacitor Sections (Test 1 to 5)

- Test 1 - four capacitor sections

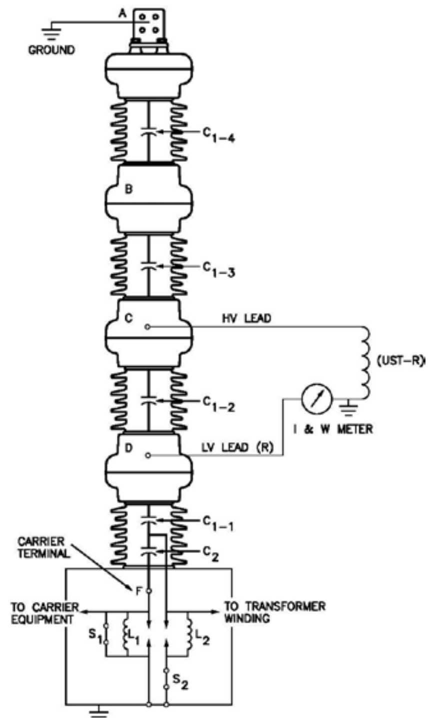


Test Procedures

Measure:	C_{1-1}
Test Voltage:	10kV
Circ. Desc.:	GAR-R
HV Lead:	D
LV Lead:	C
A, F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

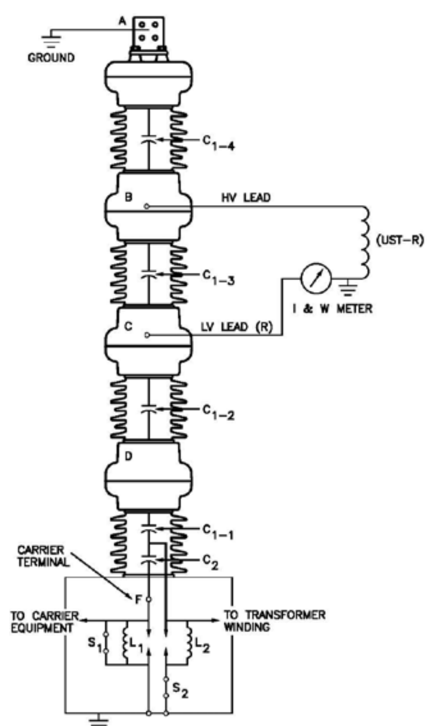
- <u>Test 2 - four capacitor sections</u>



Test Procedures	
Measure:	C_{1-2}
Test Voltage:	10kV
Circ. Desc.:	UST-R
HV Lead:	C
LV Lead:	D
A, F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

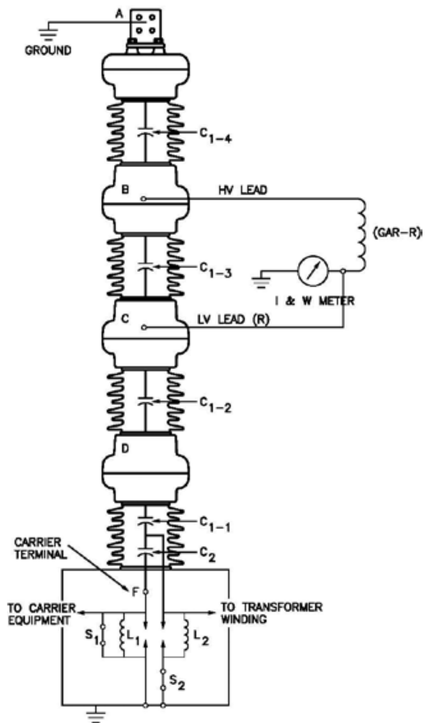
- <u>Test 3 - four capacitor sections</u>



Test Procedures	
Measure:	C_{1-3}
Test Voltage:	10kV
Circ. Desc.:	UST-R
HV Lead:	B
LV Lead:	C
A, F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

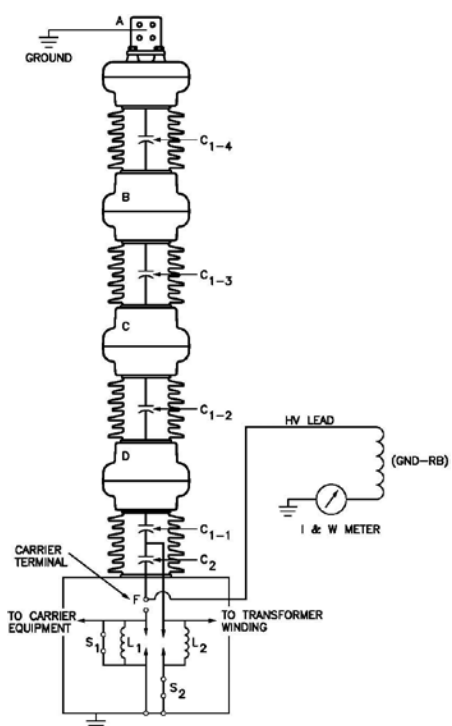
- <u>Test 4 - four capacitor sections</u>



Test Procedures	
Measure:	$C_{1\text{-}4}$
Test Voltage:	10kV
Circ. Desc.:	GAR-R
HV Lead:	B
LV Lead:	C
A, F:	Grounded
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

- <u>Test 5 - four capacitor sections</u>



Test Procedures	
Measure:	C_2
Test Voltage:	2kV
Circ. Desc.:	GND-RB
HV Lead:	F
LV Lead:	-
A:	Grounded
F:	Disconnected (carrier lead)
S_1 Switch:	Grounded
S_2 Switch:	Grounded

Note:
S_1: Carrier ground switch
S_2: Voltage tap ground switch
L_1: Drain coil
L_2: Choke coil

Table I Troubleshooting

The following is a list of possible problems and their solutions. If difficulty is encountered at any stage, please contact Trench Limited.

Problem		Possible Cause	Procedures
Zero Secondary Output	1.1	Volt tap ground switch closed	Open volt tap ground switch (up position)
	1.2	Short circuit on secondary connections	Remove external wiring and measure output voltage at terminals. If there is still no voltage, then proceed as follows: 1. Megger X and Y windings to tank should read 50 meg ohms or more. 2. Remove P2 ground link. 3. Open ground switch. 4. Megger P2 to tank should read 50 meg ohms or more.
	1.3	Open circuit on intermediate transformer	Remove P2 connection. Close volt tap ground switch. 1. Measure resistance from P2 connection to tank, should read less than 1000 ohms. Remove carrier ground connection and close volt tap ground switch. 2. Measure capacitance between CAR connection and basebox. This gives C2 value. 3. Measure capacitance from top of capacitor to basebox. This gives C1 value. Either of above tests will confirm integrity of tap lead from lower capacitor unit. 4. Measure P1 - P2, should read less than 75 ohms
	1.4	No connection between units	Confirm as per test 1.3.2 and 1.3.3.
	1.5	Broken connection inside capacitor unit	As per test 1.3.2 and 1.3.3. If no continuity, confirm that connections between capacitor units are made. If still no continuity, change capacitor unit.
Low Secondary Output	2.1	Poor secondary connection	Check all connections.
	2.2	Failure of a C2 capacitor element	Check C2 value as per test 1.3.2.
	2.3	Extreme load on secondary	Remove external wiring to substation and re-check secondary output at terminals.
High Secondary Output	3	Failure of one or more C1 capacitor elements	Remove unit from service immediately for evaluation. Check C1 per 1.3.3 Replace capacitor unit if capacitance is more than 1% high.
Fluctuating Secondary Output	4	Loose intermediate or secondary connections	Check all connections.
High Dissipation Factor in Capacitor Unit(s)	5	Oil contamination due to capacitor element arcing/failure	Remove unit from service immediately. Replace capacitor unit.
High Capacitance Values	6	Capacitor element failure	As above (5)
Low Capacitance Values	7	Possible measurement error	Check measurement equipment.
Waveform Distortion	8.1	Malfunction of harmonic suppression filter	Check harmonic suppression filter wiring and components, replace as necessary.
	8.2	Use of non linear (saturable) burden	See further section “Connection of saturable (non-linear) burden”.
Low Secondary Output and Phase Angle Error	9.1	P1 - P2 surge protector shorted	Replace surge protector.
	9.2	Faulty harmonic suppression filter	As above (8.1).
High Oil Level in Basebox	10.1	Extremely high ambient temperature	In no case should oil be more than 10 mm (3/8”) above mark.
	10.2	Oil leak in lower capacitor unit tap or carrier bushing	Check expansion chamber on top of lower capacitor unit. Consult factory immediately.
Low Oil Level in Basebox	11.1	Extremely low ambient temperature	In no case should oil level be more than 10 mm (3/8”) below mark. Top up if necessary.
	11.2	Basebox leaking oil	Check for leaks around tank and report to factory if necessary.
Sign of Oil on Porcelains	12.1	Oil leak of expansion chamber	Replace expansion chamber.
	12.2	Capacitor failure causing expansion chamber to puncture	Inspect expansion chamber. If punctured, remove unit from service immediately. Consult factory.

CAUTION: BEFORE PERFORMING ANY TESTS ENSURE THAT UNIT HAS BEEN COMPLETELY DE-ENERGIZE

Table II Types: TCVT, TECF, TECP, TEVF, TEMF, TEVP, TERP, TEMP & TETP

PARAMETER	UNIT	72.5	123	145	170	245	300	362	420	550
Maximum System Voltage	kV	72.5	123	145	170	245	300	362	420	550
*Rated Secondary Voltage	V	115 & 67.08	115 & 69	115 & 67.08	115 & 65.7	115 & 69	69	115 & 69	115 & 63.9	(1) 115 & 69 (1) 115 & 63.9
*Transformation ratio		350-600:1	600-1,000:1	700-1,200:1	800-1,400:1	1,200-2,000:1	2,500:1	1,800-3,000:1	2,000-3,600:1	(1) 2,700-4,500:1 (1) 2,500-4,500:1
Total capacitance TECF, TCVT, TEVF, TEMF	pF	10,000	6,000	5,000	4,300	3,000	2,500	2,150	1,650	1,430
TECP, TCVT, TEVP, TEMP, TETP	pF	20,800	12,500	10,400	8,300	6,200	5,200	4,100	3,500	2,800
Power frequency withstand (Hipot) - dry 1 min. - wet 10 sec.	kV	165 140	265 230	320 275	370 325	525 460	640 570	785 680	785 680	900 780
Full wave withstand (BIL) 1.2 x 50 microsecond	kV	350	550	650	750	1,050	1,300	1,550	1,550	1,800

Dimensions TCVT, TECF, TEVF & TEMF (with Low Profile Base Tank)

Number of capacitor units		1	1	1	1	1	2	2	3	2
Overall Height	in. mm	54 5/8 1388	66 7/16 1688	74 5/16 1888	82 5/8 2098	105 11/16 2684	130 3/4 3321	147 5/16 3741	188 3/8 4784	193 3/4 4921
Total Section Height	in. mm	40 1/4 1022	52 1/16 1322	59 15/16 1522	68 1/4 1734	91 5/16 2319	116 3/8 2956	132 15/16 3376	174 4420	179 3/8 4556
Creepage Distance	in. mm	71.7 1820	124.0 3150	147.6 3750	180.4 4583	248.0 6300	295.3 7500	360.9 9166	442.9 11250	496.1 12600
Strike Distance	in. mm	27 3/4 705	39 9/16 1005	47 7/16 1205	55 11/16 1415	78 15/16 2005	94 7/8 2410	111 7/16 2830	142 5/16 3615	157 7/8 4010
*Weight	lb. kg	410 185	450 203	475 215	505 229	590 267	670 303	730 331	855 387	895 406
Max. Horizontal terminal pull in 80 mph (130 km/h) wind referring to capacitor porcelain strength	lb. kN	1394 6.2	1057 4.7	899 4.0	787 3.5	562 2.5	427 1.9	360 1.6	259 1.15	247 1.1
Shielding ring		No	No	No	No	Yes	No	Yes (1)	No	Yes

Dimensions TCVT, TECP, TEVP, TERP, TETP (with Low Profile Base Tank) & TEMP (with Universal Base Tank)

Number of capacitor units		1	1	1	1	1	2	2	3	2
Overall Height (Add 5 in./130 mm for TEMP)	in. mm	55 3/8 1406	67 3/16 1706	75 1906	83 5/16 2116	106 9/16 2706	132 3/8 3363	148 15/16 3783	189 3/4 4820	195 3/8 4963
Total Section Height	in. mm	41 1041	52 13/16 1341	60 5/8 1540	68 15/16 1751	92 3/16 2342	118 2997	134 9/16 3418	175 3/8 4455	181 4597
Creepage Distance	in. mm	71.7 1820	124.0 3150	147.6 3750	180.4 4583	248.0 6300	295.3 7500	360.9 9166	442.9 11250	496.1 12600
Strike Distance	in. mm	27 3/4 705	39 9/16 1005	47 7/16 1205	55 11/16 1415	78 15/16 2005	94 7/8 2410	111 7/16 2830	142 5/16 3615	157 7/8 4010
*Weight (add 69 kg/150lbs. for TEMP)	lb. kg	490 223	550 249	585 266	620 281	720 326	815 369	880 399	1040 472	1080 490
Max. Horizontal terminal pull in 80 mph (130 km/h) wind referring to capacitor porcelain strength	lb. kN	1641 7.3	1236 5.5	1079 4.8	922 4.1	764 3.4	495 2.2	427 1.9	292 1.3	292 1.3
Shielding ring		No	No	No	No	Yes	No	Yes (1)	No	Yes

1. 345 kV, 1300 kV BIL designs available without shielding rings

* Not applicable to TECF, TECP

Table III Types: TCVT, TEICF, TEIRF & TEIMF

PARAMETER	UNIT	123	145	170	245	362	420	550	765 / 800
Maximum System Voltage	kV	121	145	170	170	362	420	550	800
*Rated Secondary Voltage	V	115 & 69	115 & 67.08	115 & 65.7	115 & 69	115 & 69	115 & 63.9	(1) 115 & 69 (1) 115 & 63.9	115 & 69
*Transformation ratio		600-1,000:1	700-1,200:1	800-1,400:1	1,200-2,000:1	1,800-3,000:1	2,000-3,600:1	(1) 2,700-4,500:1 (1) 2,500-4,500:1	3,750-6,250:1
Total capacitance	pF	20,000	16,500	15,000	10,000	7,500	5,500	5,000	4,000
Power frequency withstand (Hipot) - dry 1 min. - wet 10 sec.	kV	265 230	320 275	370 325	525 460	785 680	785 680	900 780	1,200 1,050
Full wave withstand (BIL) 1.2 x 50 microsecond	kV	550	650	750	1,050	1,550	1,550	1,800	2,425
Number of capacitor units		1	1	1	1	2	3	2	3
**Overall Height	in. mm	76 1/4 1936	84 1/8 2136	92 3/8 2346	115 9/16 2936	162 1/16 4116	206 3/4 5251	208 3/8 5293	301 3/16 7650
Total Section Height	in. mm	56 3/4 1441	64 5/8 1641	72 7/8 1851	96 1/16 2440	142 9/16 3621	187 1/4 4756	188 7/8 4797	281 11/16 7155
Creepage Distance	in. mm	124.0 3150	147.6 3750	180.4 4583	248.0 6300	360.9 9166	442.9 11250	496.1 12600	744 18900
Strike Distance	in. mm	39 9/16 1005	47 7/16 1205	55 11/16 1415	78 15/16 2005	111 7/16 2830	142 5/16 3615	157 7/8 4010	236 13/16 6015
*Weight	lb. kg	840 382	915 416	985 446	1135 515	1450 657	1715 778	1755 795	2365 1075
Max. Horizontal terminal pull in 80 mph (130 km/h) wind referring to capacitor porcelain strength	lb. kN	1861 8.3	1637 7.3	1435 6.4	1083 4.83	695 3.1	493 2.2	493 2.2	247 1.1
Shielding ring		No	No	No	No	Yes	No	No	Yes

* Not applicable to TEICF ** Not applicable to TEICF with flat base

Table IV Types: TEHCF, TEHCP, TEHMF & TEHMP

PARAMETER	UNIT	115	138	161	230	345	400	500	765 / 800
Maximum System Voltage	kV	121	145	170	245	362	420	550	800
*Rated Secondary Voltage	V	115 & 69	115 & 67.08	115 & 65.7	115 & 69	115 & 69	115 & 63.9	(1) 115 & 69 (1) 115 & 63.9	115 & 69
*Transformation ratio		600-1,000:1	700-1,200:1	800-1,400:1	1,200-2,000:1	1,800-3,000:1	2,000-3,600:1	(1) 2,700-4,500:1 (1) 2,500-4,500:1	3,750-6,250:1
Total capacitance TEHMF, TEHCF	pF	20,000	16,500	15,000	10,000	7,500	5,500	5,000	4,000
Total capacitance TEHMP, TEHCP	pF	47,500	38,100	30,500	22,800	15,200	12,700	10,100	6,200
Power frequency withstand (Hipot) - dry 1 min. - wet 10 sec.	kV	265 230	320 275	370 325	525 460	785 680	785 680	900 780	1,200 1,050
Full wave withstand (BIL) 1.2 x 50 microsecond	kV	550	650	750	1,050	1,550	1,550	1,800	2,425
Number of capacitor units		1	1	1	2	2	3	3	4
**Overall Height	in. mm	71 1/4 1810	79 3/4 2026	88 1/4 2242	121 3/4 3092	155 1/2 3950	197 3/4 5023	223 5664	290.1/2 7379
Total Section Height	in. mm	53 1346	61 1/2 1562	70 1778	103 1/2 2629	137 1/4 3486	179 1/4 4553	204 1/2 5194	271 3/4 6902
Creepage Distance	in. mm	112 2850	139 3530	165 4190	224 5700	330 8380	417 10590	495 12570	660 16760
Strike Distance	in. mm	37 940	46 1160	54 1370	74 1880	108 2740	138 3480	162 4110	216 5480
*Weight	lb. kg	1100 499	1175 533	1300 590	1650 748	1975 896	2350 1066	2700 1225	3425 1554
Max. Horizontal terminal pull in 80 mph (130 km/h) wind referring to capacitor porcelain strength	lb. kN	4750 21.13	4250 18.9	3850 17.12	2750 12.23	2100 9.34	1600 7.12	1375 6.12	900 4.00
Shielding ring		No	No	No	No	Yes	No	No	Yes

* Not applicable to TEHCF, TEHCP ** Not applicable to TEHCF with flat base

Table V Electrical Performance

CHARACTERISTICS	TEVF/TEVP/TCVT	TEMF/TCVT	TETP/TCVT	TEIRF/TCVT	TEMP/TCVT	TCVT, TEHMF, TEHMP, TEIMF
Accuracy class(1) ANSI	200VA (0.6class)	200VA (0.3class)	200VA (0.6class)	200VA (0.3class)	400VA (0.3class) 200VA (0.15class)	400VA (0.3class), 400VA (0.15) 200VA (0.15class)
Each main winding (2)	0.6 MWXYZ 1.2Z, ZZ	0.3 MWXYZ	0.6 MWXYZ	0.3 MWXYZ	0.3 MWXYZ, ZZ, 0.15 MWXYZ	0.3 MWXYZ, ZZ 0.15 MWXYZ 0.15 MWXYZ and ZZ (3)
Auxiliary Winding	1.2Y	1.2Y	1.2Y	1.2Y	1.2Y	1.2Y
IEC(2)						
Each main winding						
cl 0.1, 50 Hz					100VA	100VA
cl 0.2, 50 Hz					225VA	250VA
cl 0.2, 60 Hz					250VA	300VA
cl 0.5, 50 Hz	150VA	250VA	150VA	350VA	500VA	600VA
cl 0.5, 60 Hz	200VA	300VA	200VA	400VA	550VA	700VA
cl 1.0, 50 Hz	300VA	500VA	300VA	600VA	700VA	1000VA
cl 1.0, 60 Hz	400VA	600VA	400VA	700VA	700VA	1000VA
Auxiliary Winding	Class 3P, 50 VA	Class 3P, 50 VA	Class 3P, 50 VA	Class 3P, 50 VA	Class 3P, 50 VA	Class 3P, 50 VA
Transient response	Less than % (of crest) residual voltage in 1 cycle @ burden:					
	ZT (200 VA)	ZT (200 VA)	ZT (200 VA)	ZT (200 VA)	ZZT (400 VA)	ZZT (400 VA)
	10%	10%	6%	5%	10%	5%
Ferroresonance suppression	Less than 10 % (of crest) in 200 milliseconds at 120% of rated voltage					
Thermal rating	1000 VA	1000 VA	1000 VA	1500 VA	1000 VA	1500 VA

Notes: (1) Two main windings are supplied as standard, with a third auxiliary winding available as an optional extra.
(2) The accuracy class for total simultaneous loading is equal to the values given for each main winding.
(3) On special demand

For after sales assistance:

Please contact Trench Limited and provide the following information for the unit in question:

- Type of unit
- Serial number
- Trench shop order number

Note all this information is available from the main nameplate. Please supply the information regarding the problems or questions you may have.

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