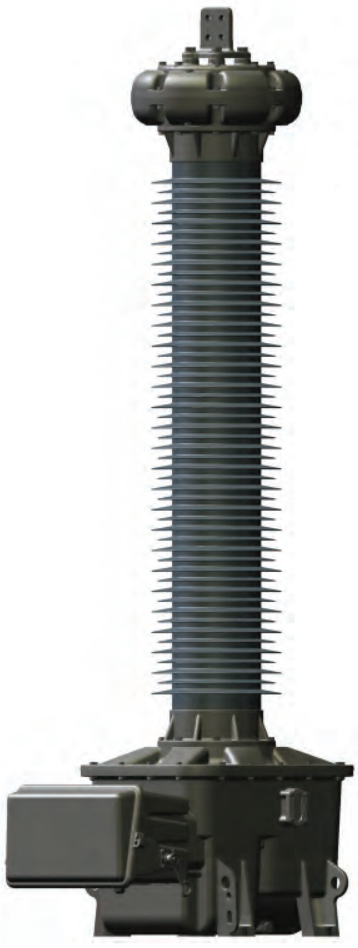
Instruction Manual

Ritz Type CVO
Coupling Capacitor Voltage Transformer



Instruction Manual IM-001-R0
August 2018

Ritz Instrument Transformers, Inc.
25 Hamburg Avenue
Lavonia, Georgia USA 30553
706-356-7180
sales@ritzusa.com
www.ritzusa.com

READ THIS INSTRUCTION MANUAL <u>BEFORE</u>
INSTALLATION AND OPERATION OF THE UNIT

Acronyms:

CCVT – Coupling Capacitor Voltage Transformers
CVD – Capacitor Voltage Divider
PGS – Potential Grounding Switch
CGS – Carrier Grounding Switch
EMU – Electromagnetic Unit
FSD – Ferroresonance Suppression Device

******WARNING******

DE-ENERGIZED HIGH VOLTAGE EQUIPMENT MAY CONTAIN TRAPPED CHARGES

Read this instruction manual **<u>before</u>** installation and operation of the unit.
<u>Never</u> work on CCVTs without first having short-circuited and grounded all terminals and metallic housings, as the inherent capacitance may have electric charges with voltage at a lethal level. In addition, a ground rod should stay on the line terminal as long as the unit is being worked on.
In the event an electrical test is to be performed, the person supervising the test assumes responsibility for performing the test in a safe manner under all local, state, and federal regulations. After the test, the operator should put the ground rod back to the line terminal until the unit is ready to return to service.

Note: To effectively discharge the CCVT, do the following:

(a) Put the ground rod onto the line terminal with the base tank grounded (Such action will short-circuit the entire unit and put the line terminal to the ground potential), and
(b) Use another ground rod to attach to any intermediate metallic housing on top of each insulator for a duration of 10 – 15 seconds to be certain that there is no residual electrical charge within the unit.

Table of Contents

1.0 Description, Circuit Diagram and Nameplates

1.1 Design

The Ritz CCVT is comprised of a CVD and an EMU. Depending on the voltage rating, the CVD can be a multi-capacitor unit stack with the intermediate voltage tap brought out through a bushing from the bottom capacitor unit. Ritz individually and hermetically seals these capacitor units in the insulator housings which contain the capacitor elements impregnated with synthetic oil. In addition, Ritz hermetically seals the EMU in a cast aluminum base tank filled with mineral oil (See Figure 2).

1.2 General Principle of Operation

CCVTs are used to transform the voltage of the transmission line, through the device shown on the schematic (Figure 1) to a value suitable for metering and relaying applications. The CVD (C_N) is comprised of a high voltage capacitor (C_1) in series with an intermediate voltage capacitor (C_2). The EMU, in parallel with C_2, contains the following items:
Note: For the temperature correction factor for both the capacitance and dissipation factor, refer to Figure 3.

A. **Series Reactance** [5] tuned, at rated frequency, to the sum of C_1 and C_2
B. **Intermediate Transformer** [7] with one or more secondary windings
C. **FSD** [8], with item D to provide stabilized secondary voltage
D. **Protective device** [3] to protect against excessive voltage

Ritz provides a carrier terminal "HF' in the terminal box for carrier coupling, if required.
The rating plate on the outside of the terminal box door shows the serial number and ratings of the CCVT. A wiring diagram plate, mounted on the inside of the terminal box door, provides details of the device.
Bracketed numerals are item numbers in Figure 1.

1.3 Normal Ambient Conditions

Ritz CCVTs are suitable for outdoor operation.
Ambient temperature: -50° to +45° C
Altitude: Up to 3,300 feet (1,000m) above sea level
Wind Velocity: Up to 100 mph (45 km/h)
Ritz shows the deviations from the above in the customer drawings.

2.0 Packing, Transport and Storage

2.1 General Information

In general, CCVTs with ratings up to 170 kV are delivered on wooden skids containing the base unit assembly (base tank and bottom capacitor). Units rated above 170 kV are delivered with the upper capacitor unit(s) removed and bolted to the skid alongside the base unit assembly. Top ends of the capacitor units are protected from the weather with temporary covers, which the user should examine when storing the equipment. Additional protection, e.g., tarp, is recommended for extended periods of storage.

The bottom capacitor is mounted on the base tank. Lifting holes are provided on the base tank. A crane may be used to lift the upper capacitor units. The use of rope slings with choker-type hitch arranged to bear on the upper metal flange is an effective way to lift the capacitor units or the base unit assembly (See Figure 4). The insulator sheds/skirts should not be used for lifting. Avoid jarring the load when starting to lift. The user may store units outdoor on level ground in a well-drained area. Blocks should be placed underneath the skids to prevent the base of the units from being submerged in water during storage.

**The user should use slings with strength ratings of at least twice the lifting weight.

3.0 Assembly and Erection

3.1 Pre-Assembly Checks

The packing-material remnants should be cleaned off all components, especially underneath insulator sheds. Check the oil level indicator on the base tank. All sealed joints, such as fittings, covers, oil-level indicator, and oil drain valve should be inspected for oil leakage. Ritz should be consulted on any apparent leak prior to installation and energization.

3.2 Erection of the CCVT

The user should adhere to the transport instructions (see sec 2). Uncrate the units carefully and inspect for oil leak and physical damage.

3.2.1 Base Unit Assembly

The base tank should be secured to the supporting structure with 4 mounting bolts (generally not included with CCVT). See outline drawing for the size of holes and thickness of the pad.

3.2.2 Upper Capacitor Assembly (If Applicable)

The upper and bottom capacitor units should be joined together with the hardware as follows:
Eight sets of bolts, washers, and nuts, as supplied, per upper capacitor unit. (Figure 5)

3.2.3 Assembly Procedure for Two or More Capacitor Units

Position the upper unit with reference to the alignment of the unit above the lower one with a crane, insert the bolts into the upper unit mounting holes, lower the upper unit onto the lower one and tighten the bolts. Repeat the same procedure for the subsequent unit(s).
CAUTION!: It is essential that the capacitor unit serial numbers shown on the main nameplate match the actual serial numbers of the capacitor units shown on the capacitor unit nameplate. Accuracy performance may be impacted if the user uses the wrong capacitor units.

3.2.4 High Voltage Terminal

If shipping height permits, Ritz provides the CCVT with the high voltage terminal installed on the uppermost capacitor. If not installed on the upper capacitor unit, the user shall install the high voltage terminal to the unit (See Figure 5). Note the permissible cantilever load specified on the outline drawing when making the connection to the line.

3.2.5 Electrical Shield (Corona Ring)

If supplied, the user should assemble the shield over the flanges with the bolts provided on to the high voltage terminal assembly as illustrated in Figure 5.

4.0 Electrical Connections

4.1 Ground and Carrier Terminal Connections

CAUTION! Never work on a CCVT without first having short-circuited and grounded all terminals and intermediate flanges.
Connect the ground terminal [4] of the base tank to the station grounding system. Before commissioning the CCVT, the user should check whether he has grounded the carrier terminal 'HF' [13] via the carrier drain coil [11] or grounding link.
For a CCVT with carrier accessories, the user should bring the lead-in cable through the carrier entrance bushing at the bottom of the terminal box and connect to the "HF" terminal.
[Bracketed numerals are item numbers in Figure 1.]

4.2 Connection of the Secondary Terminals

The secondary wiring should be connected as specified on the wiring diagram plate located on the back of the terminal box door.

4.3 Secondary Cables and Wiring

Experiences indicate that high frequency surge currents of a few kA flow through the C_1 during line switching operations and lightning disturbances. Unless the user takes precaution to reduce the coupling between high voltage loops, large induced voltages can occur in the secondary circuit, which may cause them to malfunction. In extreme cases damage to the secondary insulation including the potential device may occur. To minimize the induced voltages, the secondary cables should follow as closely as possible the ground conductor between the base tank ground terminal and the point the ground conductor attaches to the ground grid.
For single-phase secondary connection, it is a common practice that the user grounds the non-polarity secondary terminal of each secondary winding. This connection to ground should be at one point only, as remote from the CCVT as possible and preferably in the control room. Multiple grounding tends to impress transient potential differences in ground potential across the secondary winding rather than from winding to ground. The same practices should be followed in 3-phase secondary connections, such as in grounding the common neutral of a wye-connection or on one corner of a broken delta connection. The user should ground the non-polarity terminal of any unused secondary windings. All secondary windings should always have a reference to ground.

5.0 Effect of Non-Linear Burden

Caution must be taken when applying non-linear (or magnetic) burdens with CCVTs. The effect of a non-linear burden on the CCVT is to cause harmonics in the output voltage current, which, in turn, adversely effects accuracy as well as increasing the voltage across the protective device. During momentary over-voltage conditions, these effects of a non-linear burden may cause gap flashover and, thereby, interfere with the operation of the relaying system.

Most relays, synchroscopes, voltmeters, and other generally used instruments are essentially linear burdens up to twice normal voltage. Burdens with closed magnetic circuits, such as auxiliary potential transformers and isolation transformers, may not have linear characteristics over the entire voltage range. If such devices are connected to the secondary circuits, they should be designed such that the operating flux density is less than one-half the knee-point flux density. For example, it is desirable to use a 240:240-V transformer in the 115-V circuit. The same should apply to relay coils.

6.0 Special Designs

6.1 Line Trap Mounting

The high voltage terminal is removable to expose an adapter plate suitable for mounting a line trap. Consult the outline drawing for further detail.

6.2 Suspension Mounting

This manual also applies to CCVTs designed for suspension mounting. Suspension mounting terminals and base adapters are included by special order. Reference the outline drawing to make sure the pull applied does not exceed the rating.

7.0 Preventive Maintenance and Repairs

Ritz CVTs do not require any programmed maintenance. However, it is recommended to perform an annual inspection for oil teaks, oil level of the tank, and condition of protective gaps during other substation routine checks. If desired, some of the tests outlined in Section 12 and 13 may be performed. Leaks or cracks during transport, or in operation, should be reported to Ritz. The hermetic seals of the unit must not be broken without the consent of Ritz.

8.0 Proper Use of PGS

The PGS [10] is provided for safety purposes. When the secondary terminal box is to be accessed while the unit is energized, the PGS should be moved to the closed position, which grounds out the primary side of the intermediate voltage transformer, which effectively removes voltage from the secondary terminal box. The PGS should not be closed for a longer time then necessary[1] because the CVD is subjected to higher stress (closing the PGS eliminates the effectiveness of the C_2 capacitors). The PGS should not be closed for more than 6 hours.

9.0 Performance

The unit is adjusted for accuracy performance as shown on the rating plate. Field adjustment is, therefore, unnecessary.
The user should refer to the rating plate for the thermal burden rating of the CCVT.

9.1 Unused Secondary Windings

If one or more secondary windings are not used, it is recommended to ground only the non-polarity terminal of each unused secondary winding. The other terminals of unused winding(s) shall remain unconnected. For example: If the Y winding is not needed: ground Y3 and leave Y1 and Y2 unconnected.

[1] For CCVT of 48 kV or below system voltage, Ritz forbids the closing of PGS, while the unit remains energized at rated voltage, for more than 3 hours.

10.0 Fuse Assembly

If the user requires fuse protection, Ritz suggests the following fuses:

CVO…	~69-V (or Tap Winding)	115-V (or Full Winding)
IR/II/ER/EI	20 A	10 A
IM/EM	25 A	15 A

11.0 Heater

The use of a heater in the terminal box is not necessary as the heat generated within the base tank during service will prevent condensation. However, during periods of extended storage in humid environments, the use of a heater of a rating ranging from 6 to 12 W may reduce surface condensation and mildew build-up. Ritz does not recommend keeping a heater on when the unit is in service particularly when the ambient temperature exceeds 40º C.

12.0 Electrical Measurements[2]

If the user's maintenance program calls for periodic electrical measurements, Ritz recommends the following as a guide. It is important to use capacitance measurement equipment that can provide readings with a minimum 0.5% accuracy. The user should note that the nameplate is marked with the capacitance taken at rated voltages and rounded off to the hundreds of pico-farads. The user should keep readings taken during the commission as a reference for subsequent measurements. A capacitance increase of 1% (or higher) should be addressed to the manufacturer immediately since this could potentially be an indication of an internal insulation failure.

12.1 Field Test Set Method

In general, a test set that is capable of generating a voltage up to 10 kV or higher for measurement purposes should be used. For different test sets, the procedure and techniques are not the same. The user should refer to the manual of the test set. The precautions and principle of the test outlined below are for reference only.

12.1.1 Precautions

A. Re-install any connection undone for field tests.
B. The maximum voltage applied to the "HF" (Low-voltage) terminal of the lower capacitor unit is 2 kV.
C. The maximum voltage applied to the "P2" (Low–voltage) of the EMU is 2 kV.
D. The rated voltage of the intermediate voltage terminal is ~7.0 kV for IR, ER, EI and ER units and ~12.5 kV for IM and EM units. Ritz recommends the capacitance CB reading of the bottom capacitor taken at voltage below 10% of the rated (of the bottom capacitor) so that the voltage developed across P1 and P2 terminals (if left floating) is below the rating of the protective gap.
E. After the removal of the connection at "HF" and "P2" terminals, do not energize the unit with rated voltage.
F. Apply the test voltage in a controlled manner. Shut off the power, as the conditions require, such as noise and flashover coming from the CCVT.
G. Before handling the capacitor units, short-circuit the units for 10 seconds minimum to drain off any possible stored charges.

[2] The user may contact Ritz for a copy of the field test procedure of CCVT using Doble Test Set

12.1.2 The Principle of the Test

Since the intermediate-voltage terminal of the bottom capacitor unit [comprising C_{1-1} and C_2] is inaccessible, the user can only determine the capacitance C_B based on the measured value of C_{1-1} and C_2. The presence of the choke coil has insignificant effect on the result at power frequency.

A. The user can measure the capacitance of the upper capacitor units with the test sets (See Figure 7).

B. In order to measure (C_{1-1}) and (C_2), close the PGS and disconnect the low-voltage lead[3] from the "HF" terminal.

C. Measure the capacitance C_{1-1} with the test set connected to the bellow housing (of the bottom capacitor-unit) and the tank. For C_{1-1} measurement, the applied voltage should be 10 kV or less. Measure the capacitance C_2 with the test set connected to the Low-voltage lead and the tank. The applied voltage for the C_2-measurement must not exceed 2 kV (See Figure 6).

The rated capacitance C_{B1} can be calculated as follows:

$$C_B = (C_{1-1} * C_2) / (C_{1-1} + C_2)$$

D. After the test, re-install the connections at the "HF" terminal and open the PGS.

E. Verify the voltage transformation ratios of the secondary windings with voltage applied to the bellow housing of the bottom capacitor unit and with the tank grounded. For multi-capacitor CCVTs, it is recommended that the test be carried out for the base unit assembly. In this way, more sensitive results should be obtained than the test performed on a unit assembly. The following gives the expected voltage of the secondary winding:

$$n*V/R$$

Where:

N: Number of capacitor units of the CVD[4]
V: Applied voltage
R: Transformation ratio shown on the rating plate

The user can measure the voltage across all secondary terminals, e.g., voltage across

a) X_1-X_3 b) Y_1-Y_3
c) X_2-X_3 d) Y_2-Y_3

Reading of a) should match that of b) and reading of c) should match that of d) if the ratio of both windings is the same. The test voltage divided by the rating plate ratio should give the reading obtained during the test.
Example: A standard CVO245IR comprises 2 IHC capacitors. The voltage transformation ratio for X_2-X_3 is 2 000:1. The expected voltage across X_2-X_3 with 10 kV applied voltage is 10,000/ (2 000/2) = 10 V. If the readings are not as expected, notify Ritz.

12.2 Capacitance Bridge Method

The user can perform the test on the CCVT supplied without the choke coil assembly, with a bridge at a voltage less than 1.0 kV and at a frequency less than 1.0 kHz. For units supplied with a choke coil assembly (standard), the user should be critical about the readings because the error due to the choke coil at a frequency of 1.0 kHz or higher could be significant.

A. The capacitance of the upper capacitors can be obtained directly with the test leads across the unit (See Figure 7).

[3] The lead connects to the low voltage end of the bottom capacitor unit. Ritz brings the lead to the "HF" terminal of the terminal board.

[4] The expression is valid assuming the capacitor units of the CVD are of the same rating.

B. For the base unit assembly, the user should follow the procedure provided below (See Figure 6)
(i) With the PGS closed and the ground low-voltage lead[5] removed from "HF" terminal, measure the capacitance C_{1-1} with the leads of the bridge attach to the bellow housing and the tank.
(ii) Measure the capacitance C_2 between the Low-voltage lead and the tank with the PGS still closed. Use the formula, given in paragraph 12.1.2, for C_B to determine the capacitance of the bottom capacitor unit.

12.3 Ionic (Garton) Effects

Since the synthetic capacitor oil used by Ritz is a powerful solvent, it is unavoidable that the oil dissolves some foreign materials on the capacitor elements and insulators with the formation of ions. This increases the dissipation factor when measured at reduced voltage (i.e. at 10% rated). For brand new capacitors of mixed dielectrics, the Garton effect should not result in a dissipation factor of 0.30% or higher at 10% rated voltage. High readings would indicate poor oil quality and the user should consult Ritz.
For capacitors that have been in service for some time, (if the user decides to check the power factor[6]), it is recommended to perform the measurement within 48 hours after removal from service. If the measurement of power factor is performed after a longer waiting time, the power factor can be as high as 1.0% due to the chemical transport phenomena which causes non-uniform ionic concentration in the capacitors which can result in insulation power factor readings much higher than expected.

12.4 Correction Factors for Capacitance and Dissipation Factor

Curves of temperature correction factor[7] for capacitance and dissipation factor are provided for reference (See Figure 3).

13.0 Other Pertinent Tests

The tests outlined below are for checking if the CCVT is in proper working condition. The user may consider incorporating such tests in both the commissioning and scheduled maintenance program.

13.1 Inductive Reactance Test

To check if the reactor is working properly, apply a short circuit across one of the secondary windings and connect a voltmeter across P1 and P2 terminal. Set the voltmeter at the highest scale. Raise the voltage applied to the high voltage terminal of the CCVT. If the voltage across the P1 and P2 increases quickly with the applied voltage, the reactor is in satisfactory condition. Conversely, if the voltage across P1 and P2 does not respond to the applied voltage, the reactor may be defective. In this case, report the findings to the Ritz. (The user may perform this test on the base unit assembly.)

13.2 Low Voltage Test / Backfeed Test

The application of household power source protected with a series resistor of 10-Ω is adequate as the main for the following tests.

A. Connect the main supply to the secondary terminals X_1 and X_3 as shown in Figure 8 with the ground connection at the "HF" terminal temporarily removed. Make sure the PGS is in the "Open" position. (See Figure BF-1)

---

[5] The lead connects to the low voltage end of the bottom capacitor unit. Ritz brings the lead to the "HF" terminal of the terminal board.

[6] The term power factor is used in the field test, which is essentially of the value as dissipation factor.
[7] Ritz recommends the application of the correction factor only under unusual ambient temperature conditions.

B. Raise the voltage up slowly to approximately 30 V and take corresponding reading of the ammeter A, [I_1] which is essentially the exciting current of the transformer. Check if the voltage across Y_1 and Y_3 is the same as the applied voltage. Bring the tests voltage back to zero.

C. Close the PGS and repeat step B for the measured current, which is the load current for reactance. The supply current will increase rapidly with the test voltage, as the series reactance is load across the intermediate transformer. The protective gap for the reactance will spark over at a certain supply current level [I_2]. Reduce the test voltage as soon as the protective gap sparks over. (See Figure BF-2)

C. After grounding both the line terminal and "HF" terminal, perform the test with the PGS open. Bring up the voltage slowly. The supply current will increase rapidly with the test voltage as the intermediate voltage side is a series-tuned circuit and the protective gap for the reactance will spark over at a certain supply current level [I_3]. Reduce the test voltage as soon as the protective gap sparks over. (See Figure BF-3)

D. Under normal conditions, the measured current I_3 should be higher than I_2, which should be, in turn, higher than I_1 at a given voltage. [Alternatively, the user can determine the corresponding impedances, Z_1, Z_2, and Z_3. For a normal CCVT, $Z_3 < Z_2 < Z_1$]. If the reactor is not working properly, the results will indicate otherwise. Notify Ritz if the secondary voltages across X_1-X_3 and Y1-Y_3 are dissimilar, or if the reactor is defective.

13.3 Ferroresonance Test Procedure

1. With the unit assembled on the pedestal, disconnect the burden by the removal of fuses or links at the junction box. Connect a recorder of a voltmeter on one of the secondary windings (at the fuse-blocks). Ensure the scale is at least 4 times the secondary voltage of the recorder.
2. Energize the unit with the PGS closed.
3. With the hook stick operate the PGS for a couple of times and record the voltage trace simultaneously (or observe the response of the voltmeter). Close the PGS at the end of this test. Examine the voltage trace to see if the voltage recovers its normal pattern after each opening of the PGS. If not, de-energize the unit and consult with Ritz regarding the next step of action.
4. If the voltage trace is satisfactory, repeat the test 6 or 8 times. If the voltage trace confirms previous results, the unit is ready to put in service. Close the PGS and reconnect the burdens[8] by reinstalling the fuses and links in the junction box. Open the PGS.
5. The user may check if his burden could cause problem by repeating the above PGS operation test to check the performance. If the results are satisfactory, the user can put the CCVT in service.

13.4–PGS Operation

After the user has inspected and tested the unit to be in satisfactory conditions, one last test which should be carried out is the PGS operation test before putting the unit in service. Such test will serve the following purposes of making sure that:

A. The ferro-resonance suppression device is working properly, and
B. The components within the CCVT are in satisfactory condition.

[8] Ritz assumes that the user has checked the burden to be linear and not short circuit.

Annex 1 Ionic (Garton) Effect for Capacitors

The ionic effect for capacitors was discovered in the 50's by the team of Electrical Research Association (ERA) U.K. led by C.G. Garton. The capacitors of that era were of mineral oil impregnated kraft paper (MOP) material. The dissipation factor (DF) of MOP capacitors is in the range of 0.40%. If the capacitors are poorly processed or contaminated, ionis will be present within the system. The ionics can be detected with examining the DF profile (DF vs test voltage). The contaminated capacitors exhibit DF peaking at approximately 10% rated voltage (for the typical designs).

These capacitors are thermally unstable because the DF may climb to higher levels at elevated temperature due to the ionic presence.

Another point of interest is the DF of these capacitors, after a long resting time, are test voltage-sensitive, i.e., the DF varies hysteresis with applied voltage. Furthermore, it can be stabilized with extended memorization. This is due to the chemical transport phenomena.

The mixed dielectric/ synthetic oil capacitors are with much lower DF values (~0.080%)[9] compared with MOP units. Unlike power capacitors with much larger elements housed in cases of limited cooling surface, the probability for cooling capacitors with mixed dielectric/ synthetic oil to get into thermal instability is extremely low. However, the exhibit of high DF at 10 kV during the field test is a concern to the utilities because of the lesson leant from the past.

The latest synthetic oil is with an additive which significantly reduces the ionic effect. This helps capacitor manufacturers to build a better product for the customer.

[9] Power capacitors with plypropylene film impregnated with synthetic oil is even lower DF because film is non-polar while kraft paper is polar martial which is the major contributor of the dielectric loss of MOP and mixed dielectric systems.

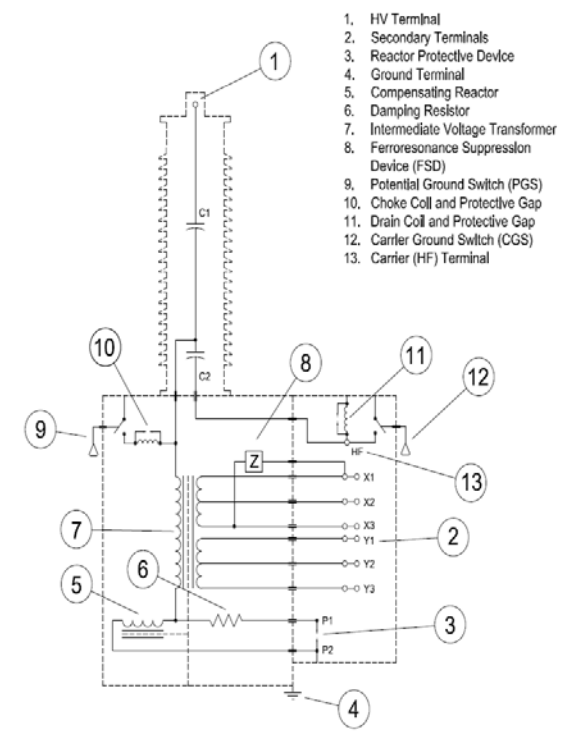


Figure 1

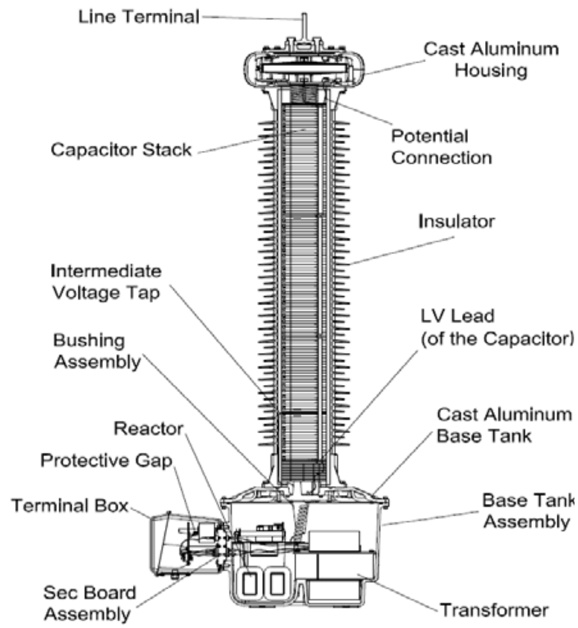


Figure 2

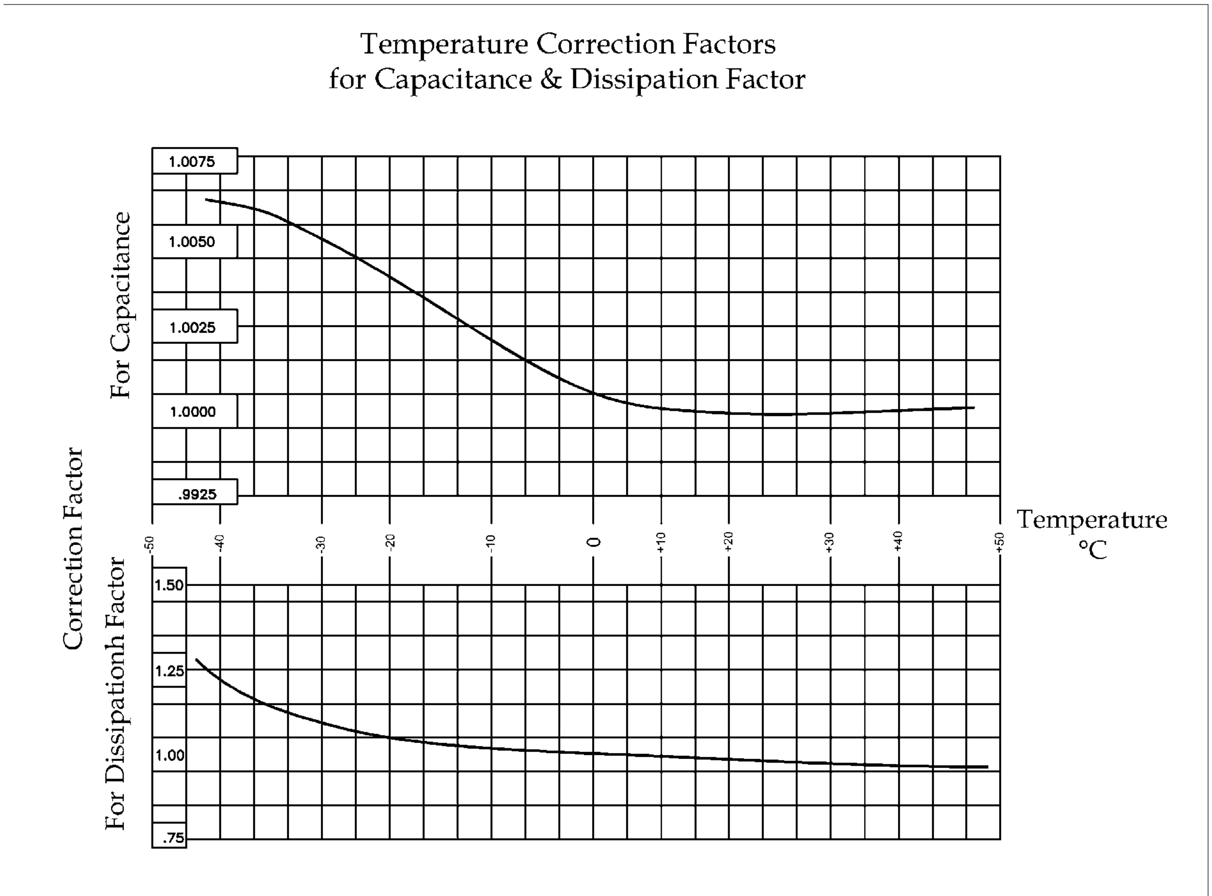


Figure 3

Figure 4

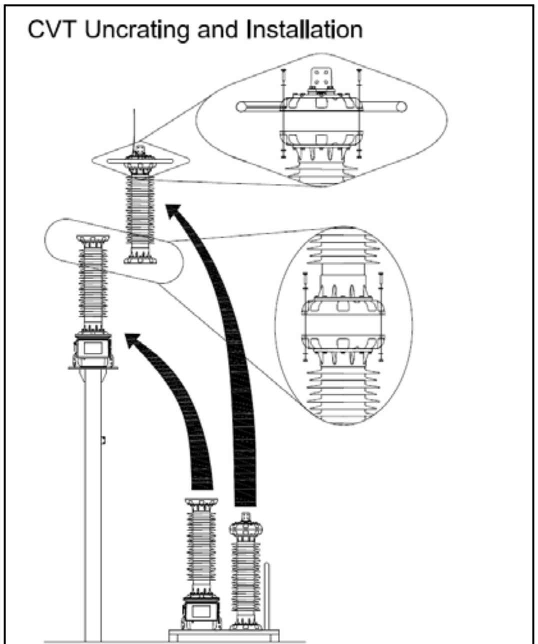


Figure 5

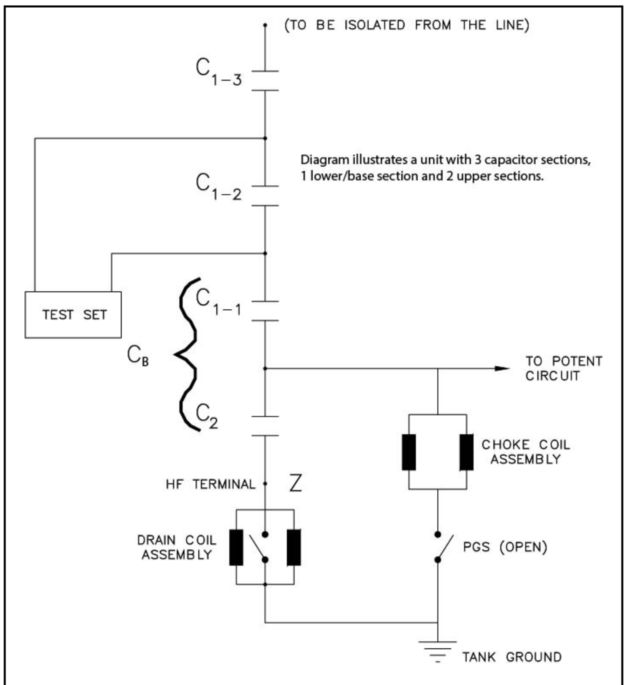


Figure 7

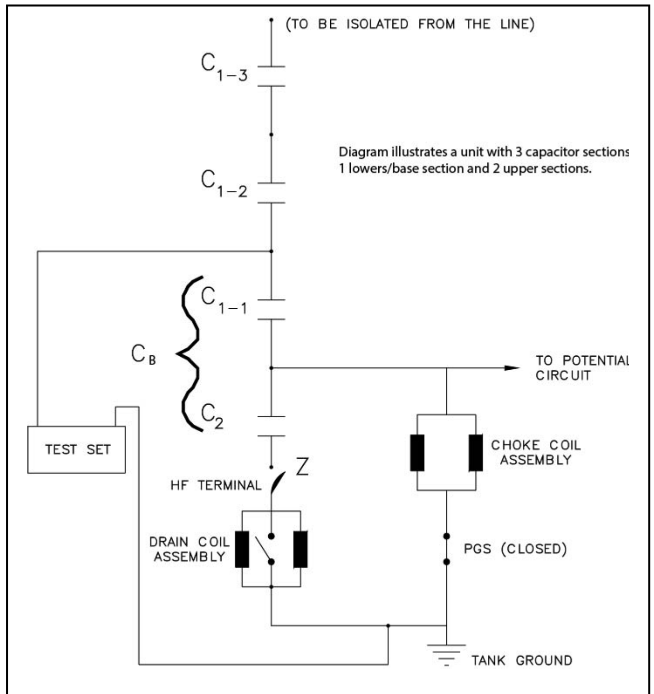


Figure 6

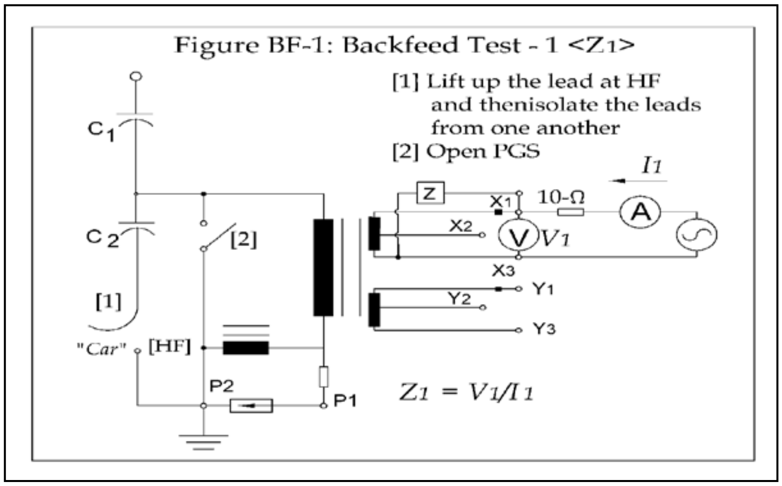


Figure BF-1: Backfeed Test - 1 <Z1>
[1] Lift up the lead at HF and thenisolate the leads from one another
[2] Open PGS
I1
C1
C2
[1]
[2]
"Car"
[HF]
Z
X1
X2
X3
10-Ω
A
V
V1
Y1
Y2
Y3
P2
P1
Z1 = V1/I1

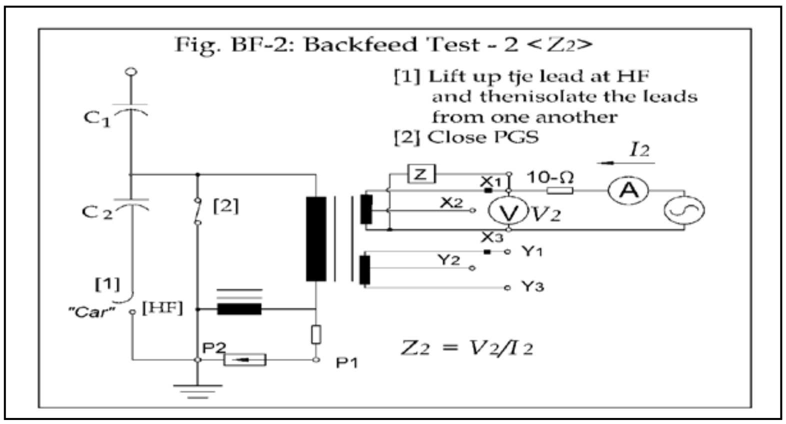


Fig. BF-2: Backfeed Test - 2 <Z2>
[1] Lift up tje lead at HF and thenisolate the leads from one another
[2] Close PGS
I2
C1
C2
[1]
[2]
"Car"
[HF]
Z
X1
X2
X3
10-Ω
A
V
V2
Y1
Y2
Y3
P2
P1
Z2 = V2/I2

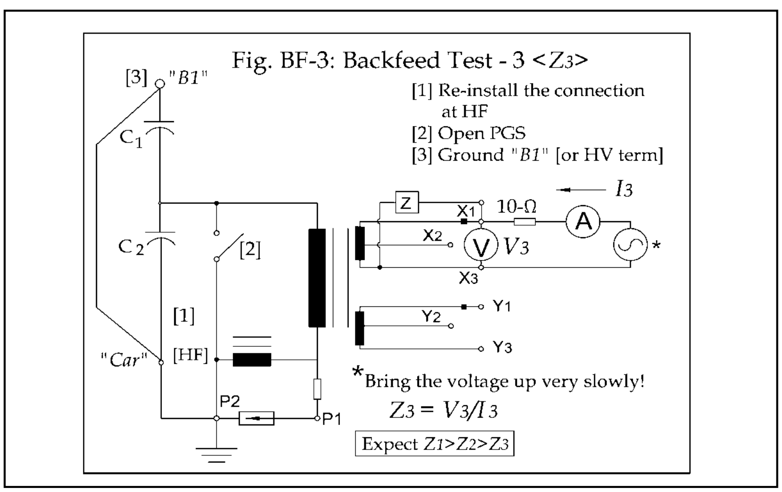


Fig. BF-3: Backfeed Test - 3 <Z3>
[1] Re-install the connection at HF
[2] Open PGS
[3] Ground "B1" [or HV term]
[3]
"B1"
I3
C1
C2
[1]
[2]
"Car"
[HF]
Z
X1
X2
X3
10-Ω
A
V
V3
Y1
Y2
Y3
P2
P1
*Bring the voltage up very slowly!
Z3 = V3/I3
Expect Z1>Z2>Z3