INSTRUCTION MANUAL NUMBER MI-ITR103

CAPACITOR VOLTAGE TRANSFORMER
MODEL OTCF

VOLTAGE LEVEL: 72,5kV TO 800kV

GE Grid Solutions
Av. Nossa Senhora da Piedade, 1021
37504-358 Itajuba - MG – Brazil

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Attention!

Anyone involved in the transportation, installation, commissioning, operation, and maintenance of OTCF Capacitor Voltage Transformers (CVT) should read these instructions before taking any action.

Never work on high voltage equipment without first having grounded its metallic parts, since it is inherent to capacitances the possibility of electric charges accumulated with voltages at lethal levels. In addition, an earth rod must remain connected to the line terminal while an operator works on these transformers.

When an electrical test is going to be performed, the person responsible for supervising the test assumes responsibility for carrying out the test in a safe manner in accordance with current legislation. After the test, the operator must remove the ground rod so that the equipment is ready for operation.

Note: To discharge high voltage equipment effectively proceed as follows:

A) Connect the ground rod to the line terminal (this will short circuit the entire unit and place the line terminal in the ground potential) and,

B) Use other(s) ground rod connected to any intermediate metal part for a minimum of 30 seconds to make sure there is no residual electrical load on the unit.

This transformer is manufactured with controlled process which guarantees the highest level of Quality. To maintain this high-Quality level throughout the service life of the CVT it is of the utmost importance that all instructions in this manual be read and understood.

THE VERSIONS OF OTCF TRANSFORMERS TRANSPORTED IN VERTICAL POSITION CANNOT BE STORED IN THE HORIZONTAL POSITION. DEPENDING ON THE PRODUCT VERSION, OTCF-245, OTCF-420 AND OTCF-550 MAY BE TRANSPORTED AT HORIZONTAL POSITION. EVEN FOR THESE CASES, THE TRANSFORMERS CAN NOT BE STORED IN A HORIZONTAL POSITION FOR MORE THAN FOUR MONTHS. IF THE TIME OF TRANSPORTION AND STORAGE EXCEEDS THIS PERIOD, IT IS MANDATORY TO UNPACK AND PUT THE TRANSFORMER INTO A VERTICAL POSITION, ANCHORING ITS BASETANK TO THE GROUND. DO NOT ENERGIZE A TRANSFORMER IF IT HAS BEEN KEPT IN HORIZONTAL POSITION DURING MORE THAN FOUR MONTHS.

Preliminary remarks

During receipt of the CVT, it is important to check the unpacking carefully to control the packaging conditions and the CVT itself. Any irregularity must be noted on the transportation documents and communications with responsible persons should be made shortly.
The insulator may be delivered in porcelain, avoid fast movements that may cause shocks and / or blows.

Index

1. SCHEMATIC DIAGRAM

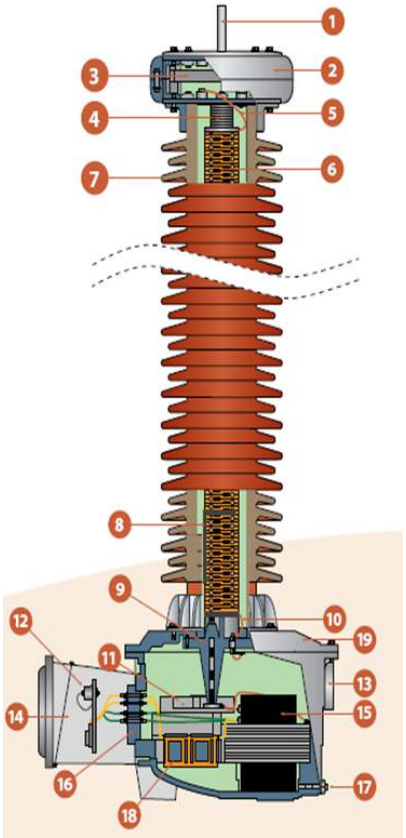
The OTCF Capacitor Voltage Transformer (CVT) is an assembly of a capacitive voltage divider (CD) and an electromagnetic unit (EMU). Depending on the rated voltage, the CD may contain of one or more capacitive modules with an intermediate voltage terminal through a medium voltage bushing which feeds the EMU.

Each capacitive module contains capacitive elements impregnated with synthetic oil and is hermetically sealed, a metallic bellows works as expansion chamber to compensate variation of volume of oil due to ambient temperature changing.

When specified, each capacitive module can be supplied with a manometer for indication of internal pressure of oil.

The EMU is mounted in a tank filled with mineral oil and is hermetically sealed through an air cushion.

Figure below shows a typical cross-sectional view of an OTCF:



1- Primary terminal
2- Top cover to protect metallic bellows
3- Metallic bellows
4- Compression spring
5- Wire for voltage connection
6- Capacitive elements
7- Insulator: porcelain or composite
8- Voltage divider
9- Bushing
10- Voltage divider LV connection
11- Ferroresonance suppression device
12- Secondary terminals
13- EMU oil level indicator
14- Secondary box
15- Intermediate transformer
16- Oil / air block
17- Oil sample plug
18- Compensation reactor
19- EMU top cover

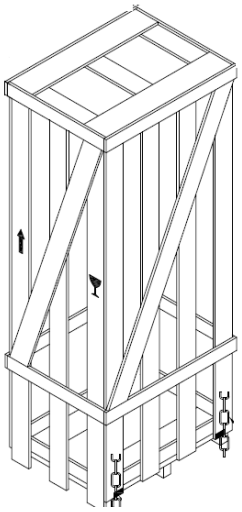
2. TRANSPORT, RECEPTION, UNPACKING AND STORAGE

2.1. Transport

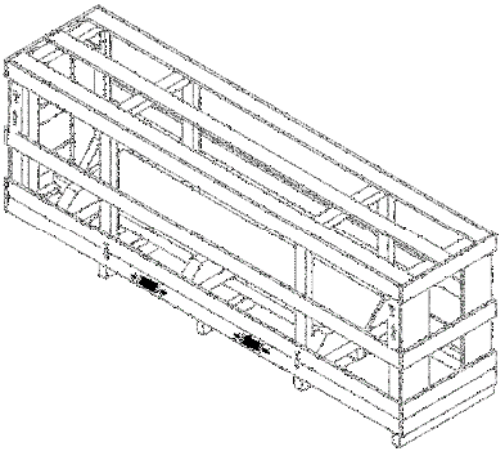
The transformer shall be transported in the position indicated by the manufacturer in an appropriate packaging.

In general, the CVT with maximum voltage up to **245 kV** is transported in a wooden box containing the assembled base unit (EMU and CD). For CVT above **245 kV**, the equipment is transported in such a way that the upper modules of the CD are separated from the lower module and EMU but transported in the same package together with all the necessary hardware for the assembly of the complete unit (see 5.1). **The CD modules must be placed in an upright position. Depending on the product version, OTCF-245, OTCF-420 and OTCF-550 may be transported at horizontal position. Even for these cases, the units cannot be stored in a horizontal position for more than 4 months. It the time of transportation and storage exceeds this period, it is mandatory to unpack and put the transformer in a vertical position, anchoring its basetank to the ground.**

The user must carry and handle the CVT carefully. The correct shipping position is marked on the packaging as shown in the following examples.



Example of vertical packaging



Example of horizontal packaging

IMPORTANT: The OTCF must always be transported with the top modules disassembled from the EMU. **When originally it was transported in horizontal position, all components in an upright position, apart from versions that are transported in a horizontal position**. Also, it shall be transported in its original packaging or in an appropriate packaging.

OTCF vertical packages cannot be stacked. For horizontal packages, the stack limit is one.

ATTENTION! The CVT has fragile parts (insulator, bellows, etc.) that can be damaged during transportation, by sea, air or by road (being the road paved or not). The transportation and handling shall be made with care. Sudden movements can cause impact and damage to the equipment.

2.2. Reception

Whether the shipment is on manufacturer's or customer's responsibility, the customer inspector or the service agent has to check the following on receipt of delivery:

If the crates show any signals of impact, blows or fractures, or if the transformers have any signal of damage, or oil leakage, the customer inspector or the service agent in charge of receipt shall make a written remark on shipment documents. The receipt control, mainly for the porcelain insulators and the secondary terminal box, shall be done in the presence of the forwarding agent, if possible. The remarks regarding the condition of the goods shall clearly state details of the damages found at the time of reception.

In case of damages, the customer inspector in charge of receipt shall notify GE and the insurance representative. All contact information shall be indicated on shipment insurance documents. This declaration shall be made within maximum of eight days after receipt of the material.

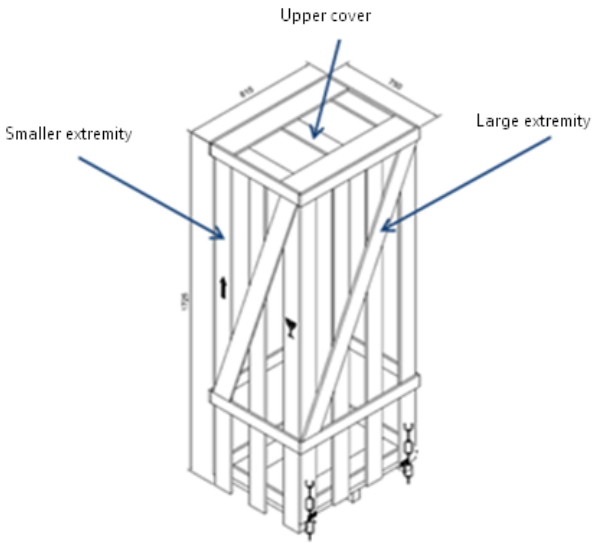
2.3. Unpacking

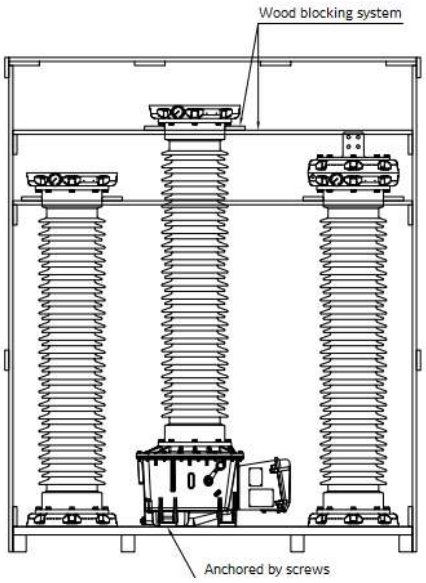
Material required for unpacking, lifting and put the transformer into service:

Qty Description
2 Crane, munck or hoist.
1 Contact grease type PENETROX or equivalent.
1 Graphite grease MOLYKOTE type P37 or equivalent.
4 Slings of 4,5m of length (capacity 10.000 N)
1 Sling of 1,5m of length (capacity 1.000 N), for cases with equipment packaged at horizontal position only.

Unpacking of the transformer should be made with care.

Vertical packaging
1) Remove upper cover.
2) Remove the smaller extremities.
3) Remove the wood blocking pieces.
4) Remove the larger extremities
5) Remove the four screws at the equipment feet and, when applicable, screws that anchor the modules to the package
6) Lift each part of the CVT

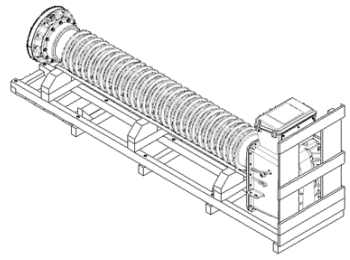


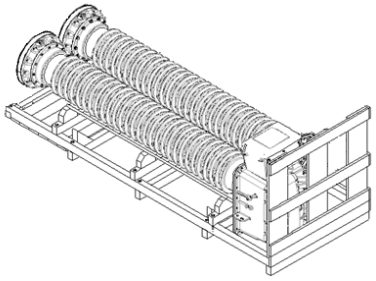


Example of wood blocking pieces

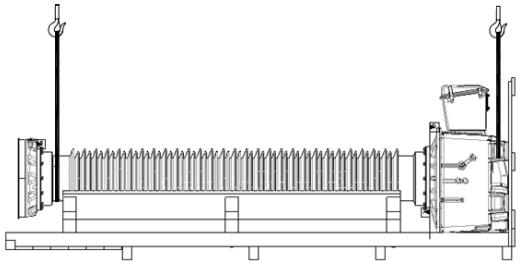
NEVER lift a transformer by its primary terminal. Always lift it by the four lifting holes on the bottom tank and as per indicated in the next pictures.

Horizontal packaging
1) Remove the upper cover.
2) Remove 3 side covers (except the side on which the basetank is fixed with screws)

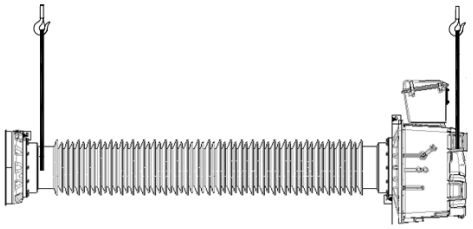


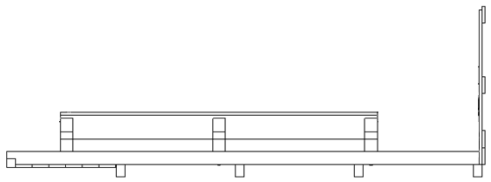


3) Remove the four screws at the equipment feet.
4) Remove the green nylon slings
5) Remove the CVT and lift it following the next steps:
- Use two slings, one at the neck of the insulator and other at the lifting holes of the basetank.

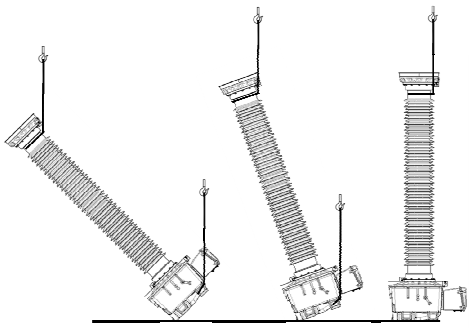


- Remove the CVT keeping it in horizontal position

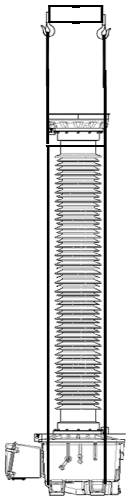




- Gradually put the CVT in vertical position by lifting the sling placed in the neck of the insulator. Keep always the sling in vertical position. Handle with care in order do not damage the bellow flange.

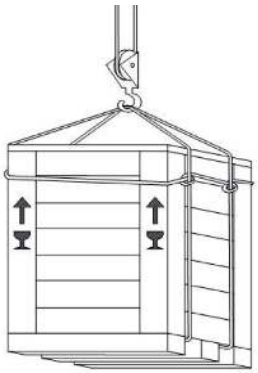


- After confirming the CVT is in vertical position and supported in the ground, change the lift system by four slings placed at the four lifting holes of the basetank. Use a 1.5m sling to connect the other slings at the height of the insulator neck to guarantee the CVT will not move horizontally when lifting.



•CVT handled with its package:

To lift the packaged transformer with crane or munck follow the marks on the wood crate, once it indicates the right position for the slings (nylon belts reinforced) and avoid blows and vibrations. Handle with care!



Example of lifting the CVT on its packing

• Placing the CVT on the pedestal:

The use of lifting slings or steel cables with a chocker type hitch arranged to support the upper metal flange is an effective way to lift the upper modules of the CD.

Avoid sudden CVT movements when lifting. To avoid CVT tipping, it is recommended to use a sling passed around the upper flange of the insulator and attached to other slings (one on each side - see figure below).

If the CD of the CVT has more than one section, the top and bottom modules must be joined using the supplied material:

- Eight or twelve sets of bolts, nuts and washers for each CD.

For OTCF having manometer in the CD:

The display box of the manometer used in the sections of the CD are partially filled with liquid glycerin in order to avoid any damage due to impact during transportation. The glycerin is not necessary after transportation.

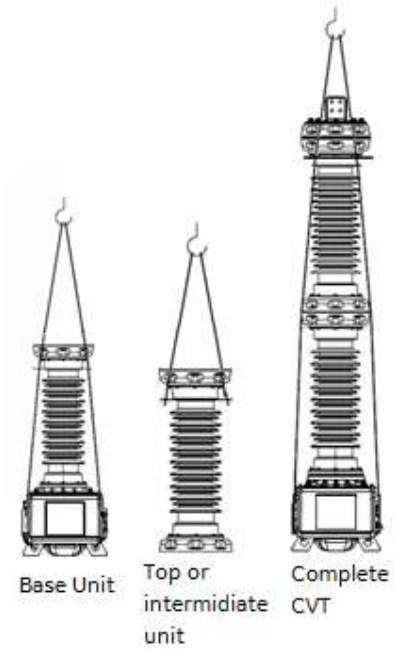
On the top of manometer, there is rubber cover with a small protrusion. **For**

all OTCF models, this small protrusion needs to be cut after the transportation. For the cases when CD units are transported at horizontal position, cut the protrusion only after putting the CD at vertical position.

Follow the steps below for mounting on the pedestal:

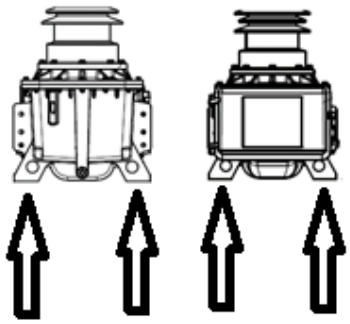
- Place the CD top modules with their nameplates aligned to the main nameplate, installed on the secondary terminal box cover in the base tank.
- Place each module slowly, one at a time, with a crane.
- Place the bolts in the upper unit flange holes.
- Fasten the bolts with an appropriate torque (3 kgf.m).
- Repeat the same procedure for all subsequent upper modules.

ATTENTION! It is mandatory for the serial numbers of the CD modules to match the serial number shown on the CVT main nameplate. Accuracy and ferroresonance performance will be affected if incorrect capacitive modules are assembled together.
The serial reactance and transformer ratio are adjusted and tuned during the factory routine tests to meet the specified accuracy class. Each EMU is tuned to a CD. In this way, **it is not allowed** to exchange any CD module or even a complete CD from one EMU to another.

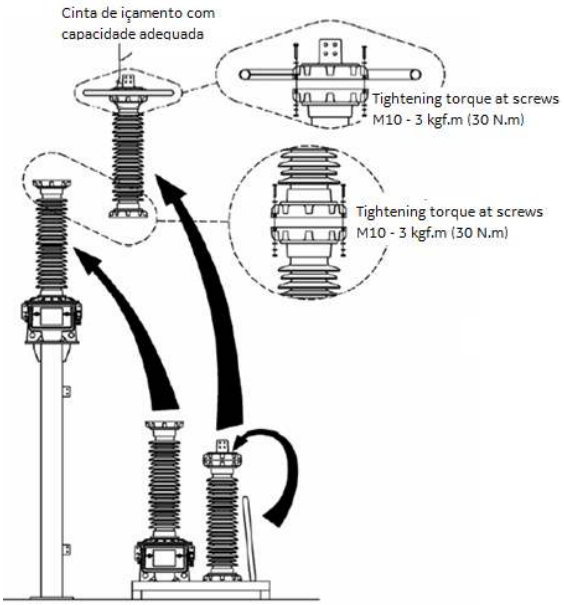


Example of lifting

The base unit (or unit with only 1 module) must be handled using the 04 lifting holes available in the base tank. **The use of the 04 lifting holes is mandatory.**



4 lifting eyes



Mounting on the pedestal

2.4. Storage

Transformers can be stored packed vertically on a homogeneous surface.

NOTE: Equipment stored vertically exposed to the environment, without packaging, must be screwed to the ground (flat and stable surface), even if the storage is of short duration.

- It is not allowed to store equipment horizontally.

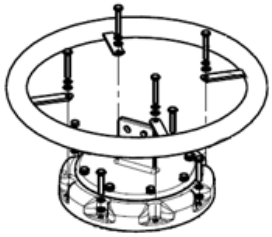
3. ANCHORING

The transformers must be energized in an upright position. It is important to confirm that the surface on which the CVT is to be fixed is flat (tolerance at most 1mm). Check that all four feet are fully supported on the frame. If not, insert shims before fastening the screws.

Tank anchoring to the pedestal must be done using 4 (four) screws. The dimensions of the holes and the thickness of the anchoring point can be found in the dimensional drawing.
When a complementary base is supplied, the tank must be mounted on this base and the base anchored to the pedestal.

IMPORTANT: Never support ladders on the equipment for interventions at heights. Use appropriate equipment that provides safety to the user.

Anti-corona rings are provided only for certain BIL values and radio interference voltage requirements. When supplied, it is necessary to mount the corona-ring above the flange of the upper module as shown in the figure below. The anti-corona ring is transported in the same package as the CVT. Confirm in the set of CVT drawings if anti-corona ring is applicable or not. Applicable bot torque: 3,5 kgf .m (35 Nm).



4. CONTACT SURFACES PREPARATION

It is recommended to clean all aluminum contact surfaces with sandpaper 150 grain to eliminate the oxidation layer. Scrub the contact surfaces with a metallic brush (diameter of the thread 0,3mm) and impregnate with grease of the type “PENETROX” or equivalent. All the surfaces must be completely covered with grease.

For silver or tinned contacts, only clean (do not use sandpaper) and polish the side of the aluminum. Cleaning silver or tinned surfaces

with sandpaper could cause damage to the protection layer.

5. CONNECTIONS AND ACCESORIES

ATTENTION: Never work on a CVT without first:

-Ground all metallic parts (top, intermediate and bottom CD) for at least 30 seconds using an appropriate grounding rod.

-Confirm that all low voltage terminals intended to be grounded (N or H2, HF, 1n, 2n, 3n or X3, Y3, Z3) are effectively grounded.

Before to reconnect voltage, confirm that there are no short-circuited secondary terminals.

5.1. Primary terminals

Connect the high voltage cable or high voltage tube to the primary terminal of the CVT with an appropriate connector to ensure good contact. Check item 4 of this manual for the preparation of the contact surface.

When the line connectors are supplied, the screws to connect the connector with the cable or tube are not included in the scope of supply.

M12 or ½" bolts shall be used at the primary terminals and flanges where a minimum tightening torque of 5,4 kgf.m (54 N.m) must be applied.

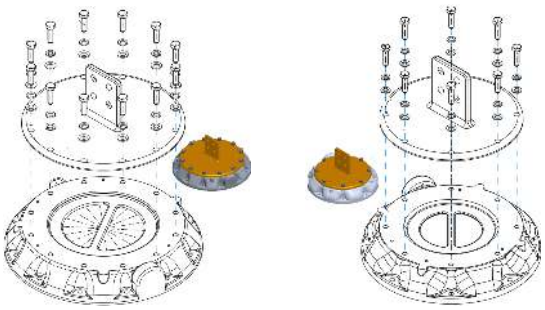
Note: The screw threads must be covered with MOLYCOTE P37 grease (or equivalent). Do not apply this grease to contact surfaces.

If the transport height allows, the CVT is transported with the high voltage terminal installed at the top of the upper CD.

The orientation of the terminal can be adjusted by moving screws that fix primary terminal to the bellows flange of the upper capacitive module.

If the high voltage terminal is not installed due to transport height limitations, the terminal must be attached to the unit using the supplied material:

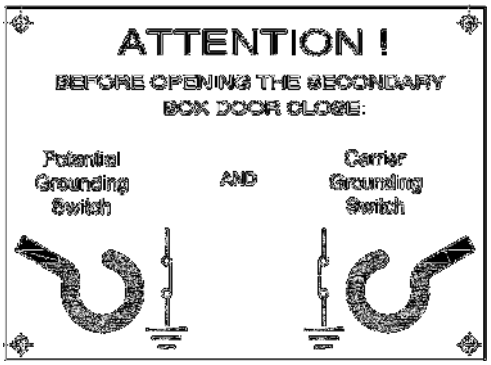
- Eight or twelve sets of bolts, nuts and washers for each CD.



In this case, there will be a metallic cover to protect the metallic cell during transportation. This protection shall be removed for the primary terminal installation. Use the bolts that are available inside the terminal box to attach the top flange and primary terminal.

5.2. Secondary terminal box

Before opening the secondary terminal box, check the position of the EMU and carrier grounding switches. A warning plate is supplied with the CVT and is placed on the secondary terminal box on the side of the potential grounding switch.



5.3. Secondary terminals

Look for the set of drawings of the CVT to verify the type of connection to the secondary terminal and acceptable cables for the connection.

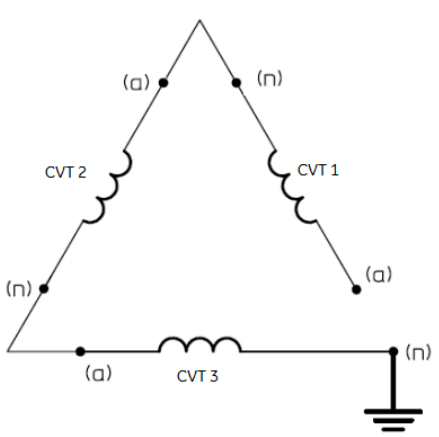
Use proper connectors to ensure a good connection. Tightening torque is indicated on the secondary terminal box drawing.

One point of each secondary should be connected to the ground terminal inside the secondary terminal box, in order to obtain a ground point for the potential reference.

Unused secondary terminals must remain open circuit and one point of the unused secondary terminal must be connected to the ground terminal.

This grounding should be done at one point only, as far away as possible from the CVT, preferably in the control room. Multiple grounding points may cause transient voltage difference that can cause circulation of surge currents between windings, rather than flowing from the windings to the earth.

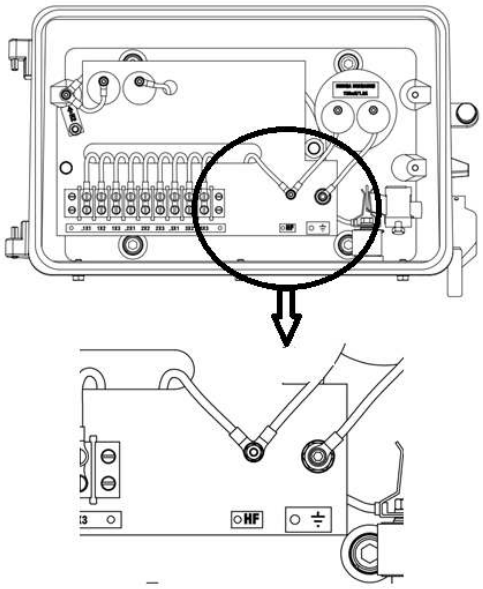
When a secondary winding is used in a broken delta connection with secondary windings of CVT from other phases, ensure that there is only one grounding point on the broken delta connection as shown below.



NEVER SHORT CIRCUIT THE SECONDARY TERMINAL OF A CVT.

5.4. HF terminal

When available, for connection to the carrier system, connect the lead-in cable through the removable undrilled gland plate of the secondary terminal box to the 'HF' terminal. The figure below shows the typical position of the 'HF' terminal. Confirm the position of this terminal in the CVT secondary terminal box.



If the carrier system is not connected to the HF terminal during operation, the carrier grounding switch must remain at the "Closed" position. See item 5.9.

5.5. Terminal marking

The marking of the primary and secondary terminals is done according to the specified standard for the project. Check the markings on the set of approved drawings.

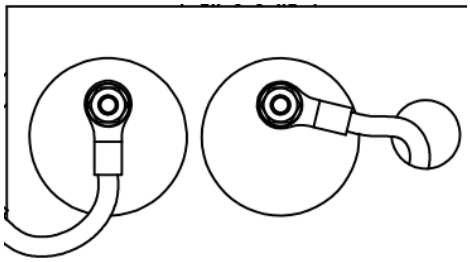
The wiring diagram for the secondary terminals are those shown on the drawings.

5.6. Protection of compensation reactor and drain coil

To provide protection against overvoltages arising from voltage fluctuations in the CVT, protection sparkers are supplied to the compensation reactor and the drain coil and are located in the secondary terminal box.

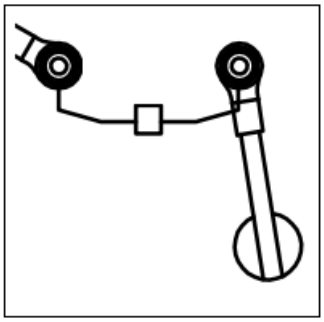
These sparkers may be of two types:

- Spark gap: Air insulation with preset factory setting. Refer to the CVT secondary terminal box drawing for more details.
  This setting cannot be modified on-site.



Spark gap type example

- Encapsulated: Gas insulation with pre-set operating voltage. Refer to the CVT secondary terminal box drawing for more details on which type is used.

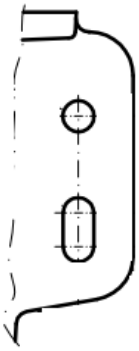


Encapsulated type example

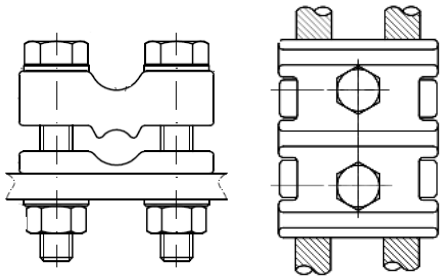
5.7. CVT grounding

The CVT tank has two grounding points located on the tank's own body. At least one of the points must be connected to the substation earthing system using appropriate cables.

When required, earthing connectors are provided (check set of drawings to see the type of the connector and the range of cables it can receive). Tightening torque of 5.4 kgf.m on screw M12.



Example of earthing terminal

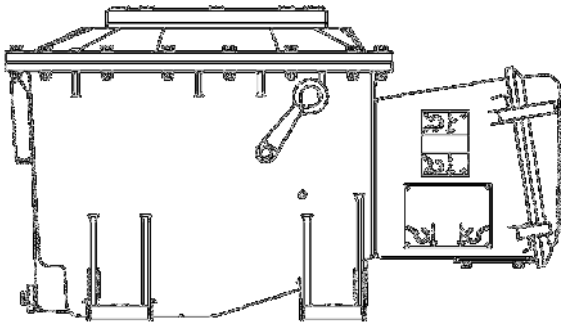


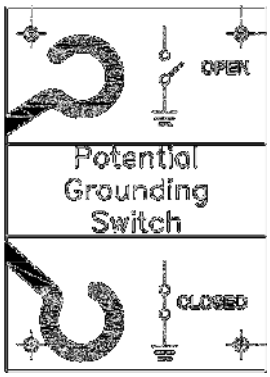
Examples of earthing connectors

5.8. EMU potential grounding switch

When required, a potential grounding switch is supplied with the CVT. It is located on the side of the tank.

Figure below shows the position of the potential grounding switch of the EMU.



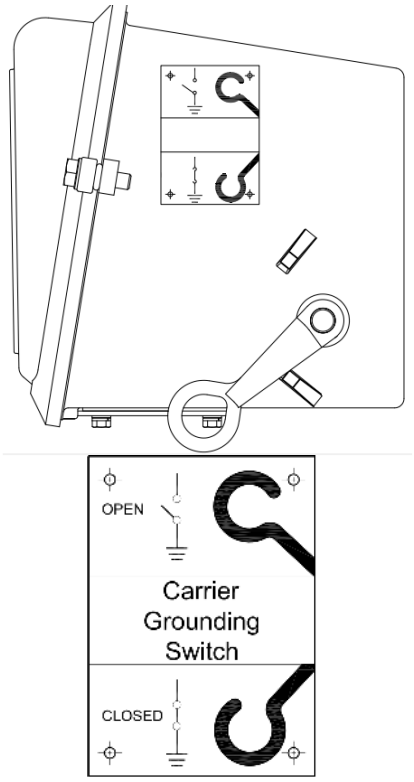


The operation time with the potential grounding switch must be kept to a minimum, since in this condition the CD is subjected to a higher dielectric stress by eliminating the insulation of the capacitance C2.

It is not recommended to remain with the potential grounding switch closed with the CVT energized for a long time (more than 6 hours).

5.9. Carrier grounding switch

If the carrier system is not connected to the HF terminal while the CVT is energized, the carrier grounding switch located on the side of the secondary terminal box should remain in the "Closed" position as shown in the figure below.



5.10. Line trap assembly

If the CVT is used to support a line trap, refers to the dimensional drawing for more details.

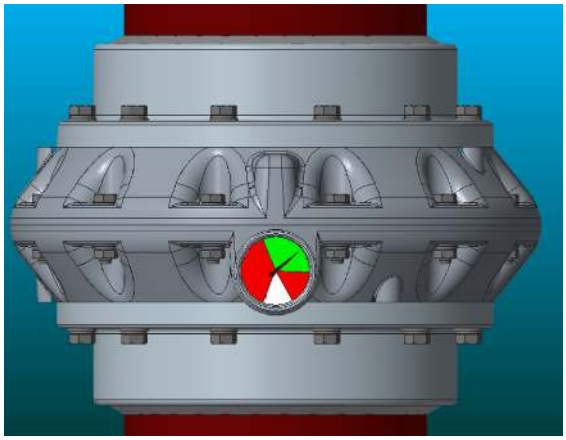
An adapter plate to fix line trap must be specified according to the application.

Verify dimensional drawing to ensure that the mechanical load imposed by the line trap, including the forces due to short circuit and wind, will not exceed the values used at design stage.

6. OIL LEVEL INDICATOR

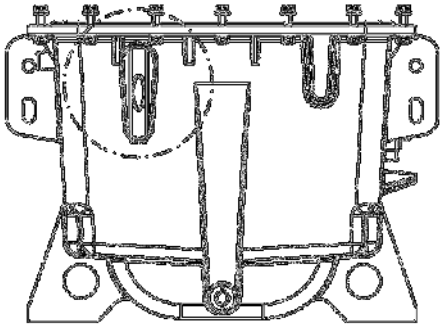
For capacitive modules or CD, when required, oil level indicators are provided. These indicators are manometer type.

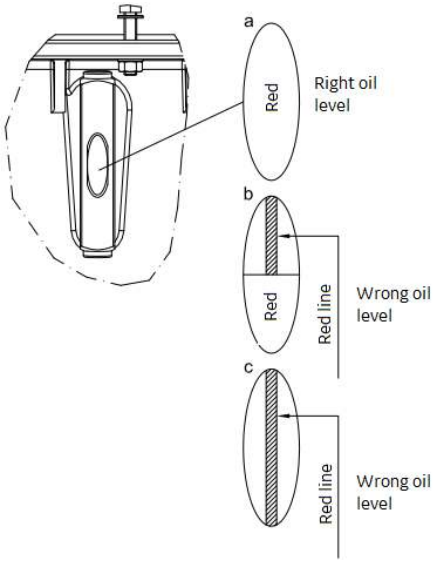
Figure below represents the operating positions of the indicator. If the indicator (pointer) is in the green range the CVT can remain, or enter, in operation. If the indicator (pointer) is in both red ranges, it is an incorrect operation condition for the CVT and it must be removed from operation and GE must be informed immediately.



Oil level indicator – type manometer

For EMU it is standard to provide an oil level indicator. It is located on the back of the tank (opposite side of the secondary terminal box).





EMU oil level indicator

7. INSPECTION BEFORE FIRST ENERGIZING

• Confirm the terminal connections to ensure correct tightening torque on the fastening screws.
• Confirm that there are no short-circuited secondary terminals. If there are left open circuits and a point connected to the grounding terminal.
• Confirm the connection to the substation earthing system.
• Confirm that oil level indicator is in the green area of the display.
• Confirm the protrusion on the top on manometer has been cut as explained in 2.3.

The CVT is tested at factory according to the standard and does not require the repetition of electrical tests. Check routine test reports for more details. However, if it is desired to carry out some measurements, check item 08 of this manual.

Although all care is taken at the factory during oil filling, the surface around the bellows and top cover screws can, without risks, show small oil stains. These stains should not be confused with oil leakage if the level indicator pointer is positioned in the green area of the display. Clean those stains with alcohol and confirm that there is no oil leakage.

DO NOT REMOVE OIL SAMPLES FROM THE CAPACITIVE DIVIDER.

NO REMOVAL OF OIL SAMPLES FOR ANALYSIS IS NECESSARY FOR THE EMU. CVT IS HERMETICALLY SEALED.

If necessary, EMU oil samples, small quantities may be taken. Always check the oil level indicator before taking the samples.

Never refill oil without consulting GE.

8. ON-SITE TESTS

If customer uses a periodic maintenance program that includes electrical measurements, the following tests are recommended as a guide.

It is important to use capacitance meters that can perform readings with a minimum accuracy of 0.5%.

The nominal values of the capacitances expressed in pF (pico-Farad) are recorded on the nameplate of the CVT.

Measurements performed during commissioning should be kept as a reference for subsequent measurements.

An increase of about 1% in the capacitance values should be carefully checked, as it may be an indication of failure of insulation of a capacitive element.

Important notes: During the commissioning tests, the record of the values found for each type of test performed shall be made for comparisons with the results that will be measured during the lifetime of the CVT. The values measured in the factory tests are important, but also important are the results of the commissioning, for each CVT. The comparisons between the results of the tests make sense for the data measured in the field, since they determine the monitoring and evolution of the values and the performance of each CVT, when a history of their lifetime can be obtained.

8.1. On-site test methods

In general, on-site test equipment can provide a test voltage of up to 10 kV for measurement purposes. The procedures and techniques are not the same for different test equipment. Check the operating manual of the test system. The precautions and test principles given below are for reference.

8.2. Care and precaution

- Before handling capacitive units, short circuit and ground them for at least 30 seconds to avoid any possibility of stored loads.
- The maximum voltage that can be applied to the carrier terminal cable after removal from the "HF" terminal (CD low voltage terminal) is 2 kV.
- The maximum voltage that can be applied to the ground terminal of the EMU ("N" or "H2") after removing it is 2 kV.
- The nominal voltage of the intermediate voltage terminal (or nominal voltage of the EMU) is indicated on the nameplate of the CVT. It is recommended that the lower capacitor capacitance measurement be performed at a voltage less than 10% of the rated voltage of the lower CD.
- After removing the "HF" and "N" or "H2" terminal connections, do not energize the unit at rated voltage.
- Apply the voltage in a controlled manner.
- Redo any connection that has been removed during the on-site tests.

8.3. Capacitance measurement

The following figures show how to connect typical insulation measurement equipment for the measurement of each capacitance of an OTCF CVT.

Since the intermediate voltage terminal of the lower capacitive module for accessing the capacitances C1-1 and C(2) is not directly accessible, the user can determine the total capacitance from the measured values of C1-1 and C2.

The presence of the internal chock coil does not influence the measurements for frequencies of 50Hz or 60Hz.

- **CVT with capacitive divisor in a single module**

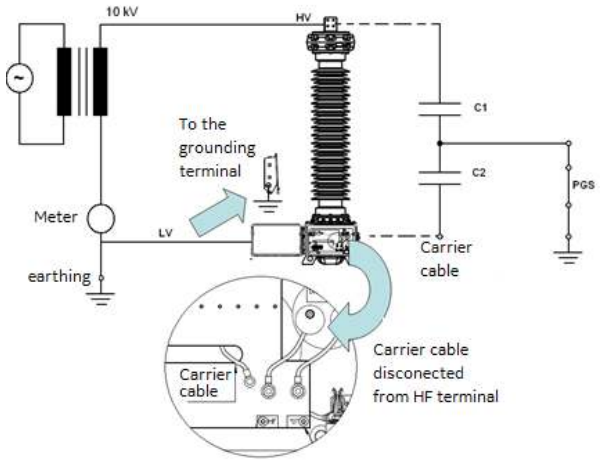


Figure 1 – Capacitance measurement of C1 – OTCF single module (Mode GST/Ground)

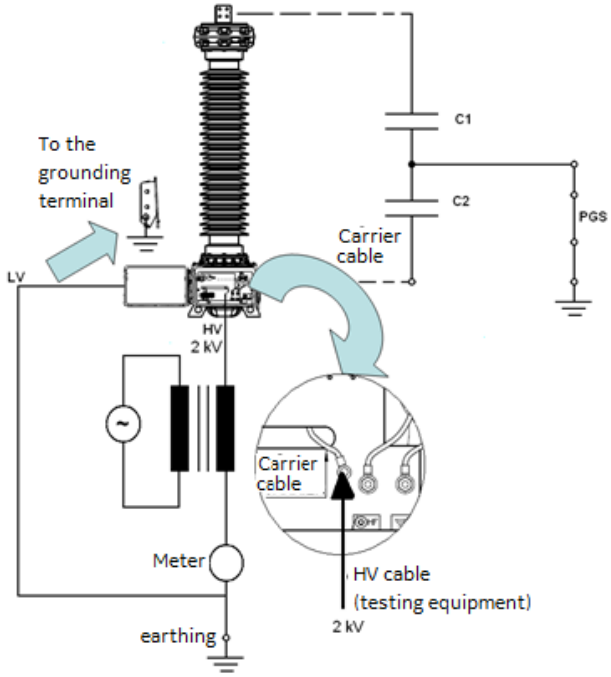


Figure 2 - Capacitance measurement of C2 – OTCF single module (Mode GST/Ground)

➢CVT with capacitive divider with two modules

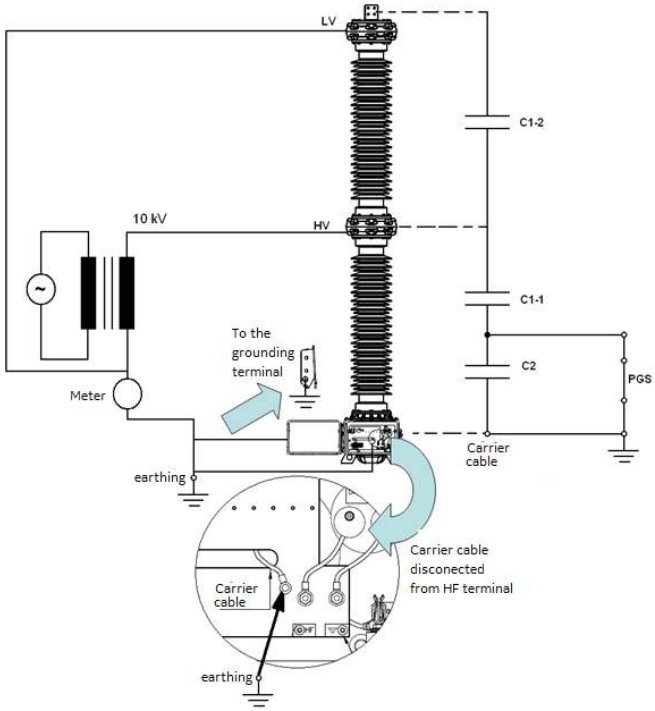


Figure 3 - Capacitance measurement of C1-1 – OTCF two modules (Mode GST/Guard)

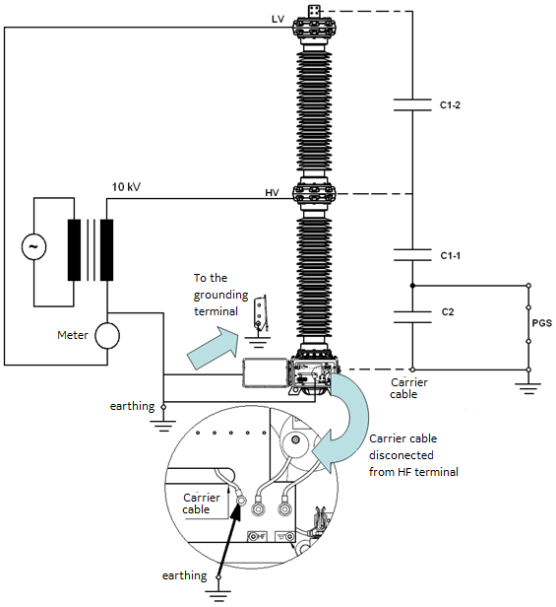


Figure 4 - Capacitance measurement of C1-2 – OTCF two modules (Mode UST)

➢CVT with capacitive divider with three modules

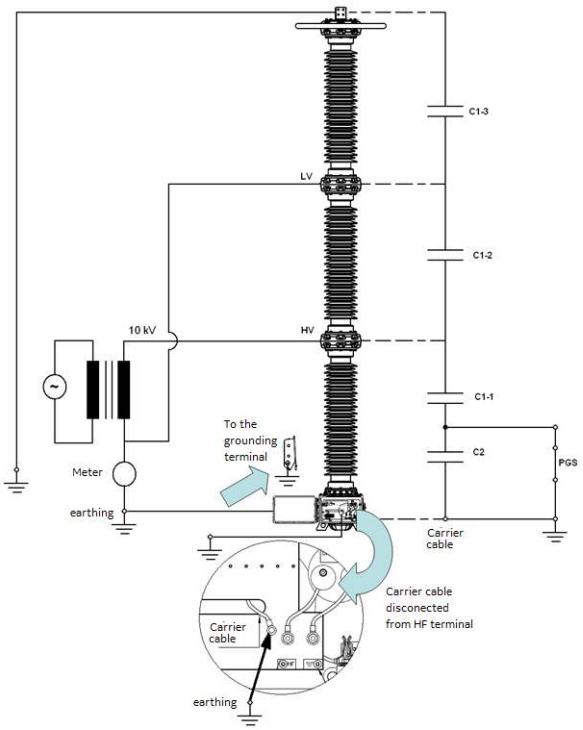


Figure 5 - Capacitance measurement of C1-1 – OTCF three modules (Mode GST/Guard)

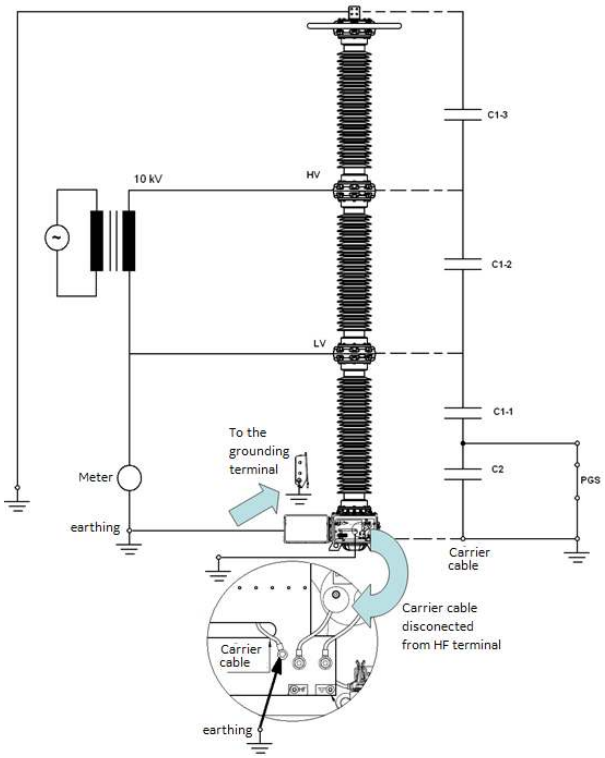


Figure 7 - Capacitance measurement of C1-3 – OTCF three modules (Mode GST/Guard)

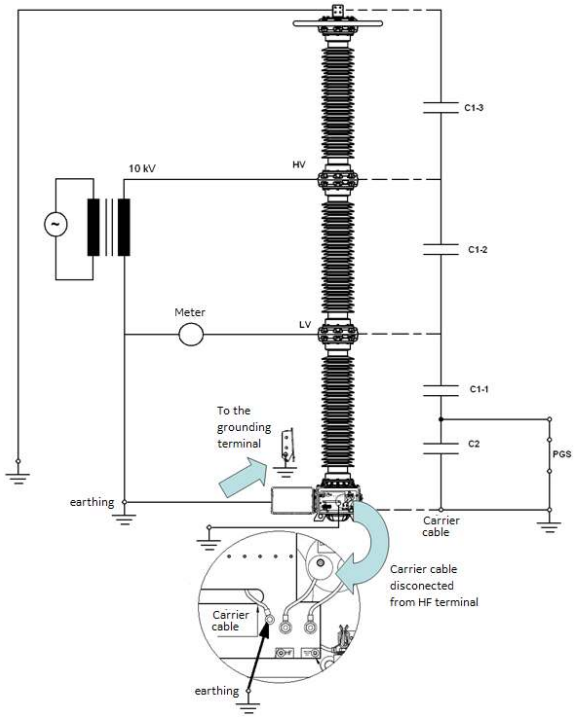


Figure 6 - Capacitance measurement of C1-2 – OTCF three modules (Mode UST)

➢**CVT with capacitive divider with four modules**

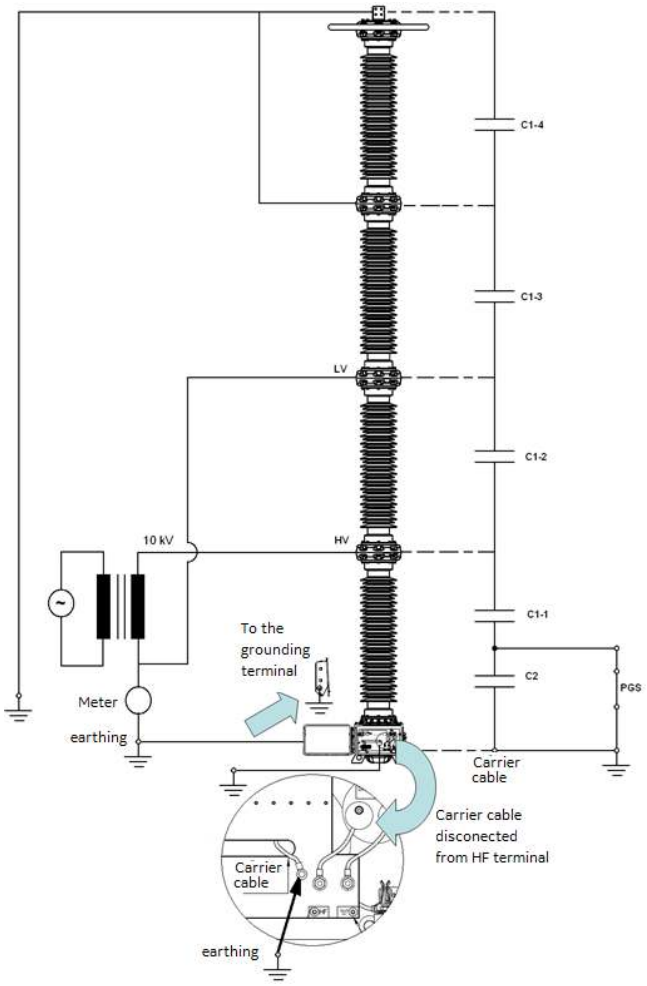


Figure 8 - Capacitance measurement of C1-1 – OTCF four modules (Mode GST/Guard)

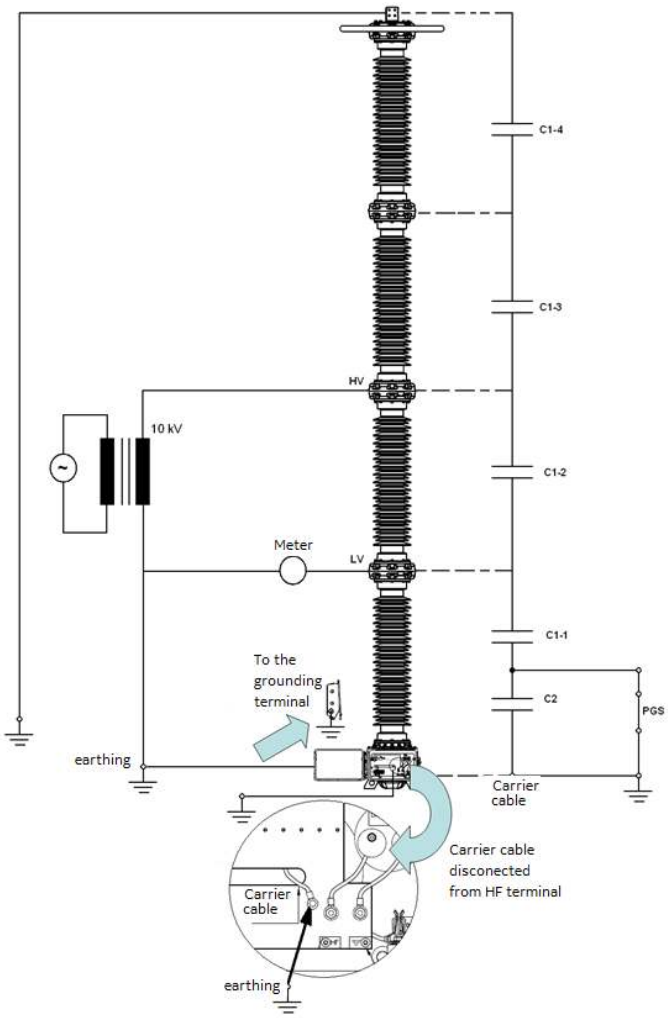


Figure 9 - Capacitance measurement of C1-2 – OTCF four modules (Mode UST)

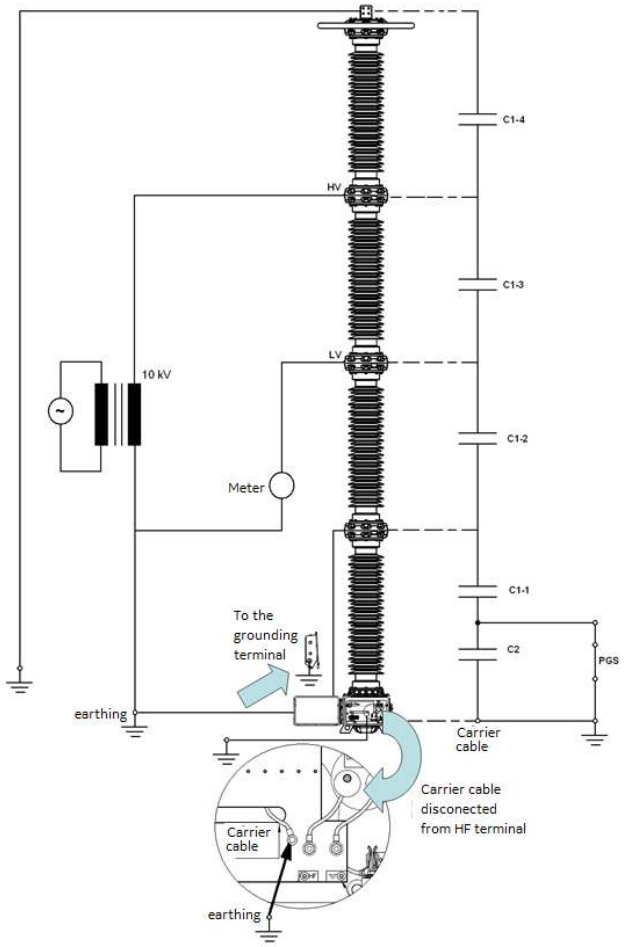


Figure 10 - Capacitance measurement of C1-3 – OTCF four modules (Mode UST)

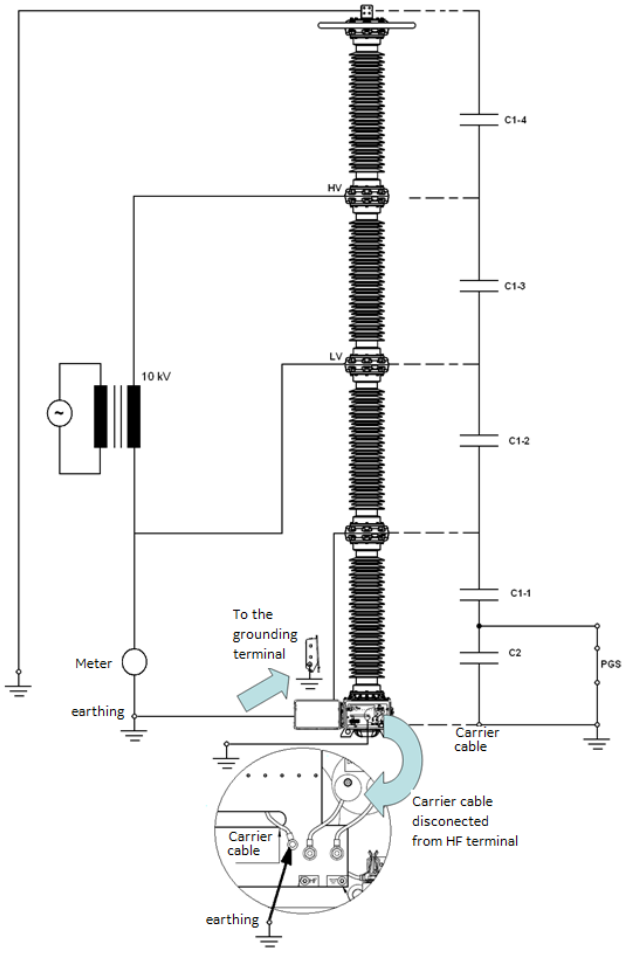


Figure 11 - Capacitance measurement of C1-4 – OTCF four modules (Mode GST/Guard)

➢Summary of capacitance measurement

Capacitance	CVT Single module	CVT two modules
C1	See Figure 1	$C_1 = \frac{C_{1-1} \cdot C_{1-2}}{C_{1-1} + C_{1-2}}$
C2	See Figure 2	See Figure 2
C1-1	NA	See Figure 3
C1-2	NA	See Figure 4
C1-3	NA	NA
C1-4	NA	NA
Cn	$Cn = \frac{C_1 \cdot C_2}{C_1 + C_2}$	

Capacitance	CVT Three modules	CVT four modules
C1	$C_1 = \frac{C_{1-1} \cdot C_{1-2} \cdot C_{1-3}}{C_{1-1} \cdot C_{1-2} + C_{1-1} \cdot C_{1-3} + C_{1-2} \cdot C_{1-3}}$	$Cn = \frac{C_{1-1} \cdot C_{1-2} \cdot C_{1-3} \cdot C_{1-4}}{C_{1-1} \cdot C_{1-2} \cdot C_{1-3} + C_{1-1} \cdot C_{1-2} \cdot C_{1-4} + C_{1-1} \cdot C_{1-3} \cdot C_{1-4} + C_{1-2} \cdot C_{1-3} \cdot C_{1-4}}$
C2	See Figure 3	See Figure 3
C1-1	See Figure 5	See Figure 8
C1-2	See Figure 6	See Figure 9
C1-3	See Figure 7	See Figure 10
C1-4	NA	See Figure 11
Cn	$Cn = \frac{C_1 \cdot C_2}{C_1 + C_2}$	

ATTENTION! After the test, connect again "HF" to the carrier system or close carrier grounding switch and open the potential ground switch.

8.4. Voltage ratio measurement

The voltage ratio can be verified by applying voltage to the bellows flange of the lower capacitive module with the tank grounded. For CVT with more than one capacitive module, it is recommended to perform the test on the base unit (tank + lower capacitive module) by applying the voltage to the bellows flange of the lower capacitive module for results with greater sensitivity.

The formula for determining the expected voltage at the secondary terminals is given below:

$$U_S = n \cdot \frac{V}{R}$$

Where:
n: Number of capacitive modules of the complete CVT
V: Applied voltage
R: Voltage ratios stated at nameplate
Us: Expected voltage at secondary terminals.

Example:
The capacitive divider of a standard OTCF-362 consists of 2 capacitive modules. Considering that the informed voltage ratio on the nameplate is 1800: 1, the expected voltage between the secondary terminals when 10 kV is applied between the lower capacitive and the grounded tank will be 10 V, ie, 2x10,000 / 1800.
If the values obtained are different than expected, contact the factory, informing the serial number of the equipment.

8.5. GARTON effect

Since the synthetic oil used by GE in the capacitive modules is a powerful solvent, it is inevitable that the oil dissolves some material on the capacitive elements or insulator forming ions.

This fact tends to increase the dissipation factor when measured at reduced voltage values (ie, values equal to or less than 10% of rated voltage).

For new capacitors, the influence of the Garton effect, in any case, should not result in dissipation factor values equal to or greater than 0.3% with application of 10% of the rated voltage.

Measurements above this value may be indicative of poor oil quality. In this case, the user must consult the factory, always informing the serial number of the unit.

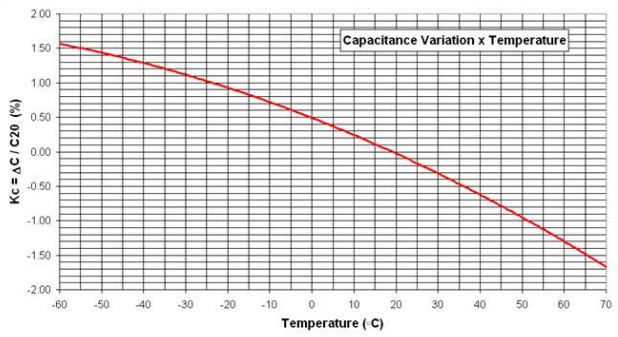
When performing dissipation factor measurements on capacitors that are in operation for some time, it is recommended that the measurement be performed within 48 hours after removing it from operation.

Measurements performed after 3 days from operation can result in high values, of the order of 1%, due to the following phenomena:

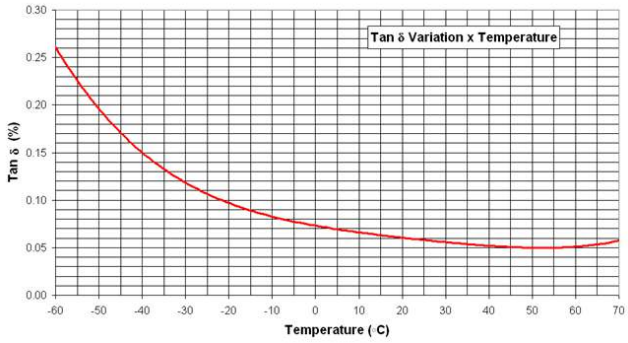
- Ionic concentration in the system, due to the circulation of oil inside the capacitor in operation has become uniform and complete.
- The ions are distributed more evenly in the thin film of oil between elements than at the time they were manufactured.

8.6. Capacitance and dissipation factor with temperature variation

The curves for the variation of the capacitance and the dissipation factor with temperature are presented in the following figures:



Capacitance variation with temperature



Dissipation factor(Tg) variation with temperature

9. MANTENANCE AFTER ENERGIZING

After installation and energizing, the CVT should not require any further intervention. However, it is suggested to perform a visual inspection during the first weeks of service to:

•Confirm the position of oil level indicator. If the indicator is significantly below or above the green range, in comparison with other CVT, it is recommended to check that there is no oil leakage and, if an oil leakage is discovered remove the CVT from operation and inform GE.
•With an infrared device, check if connections are not overheating. Compare with other CVT from the same circuit.

After one year of operation, it is recommended a detailed inspection of tightening torques and oil leakage and thereafter twice per year according to the substation maintenance contract.

If possible, GE suggests disconnecting the CVT and to perform the following examination:

•Insulator: Depending on the pollution level it is necessary to clean the porcelain.
•Metallic components: check for corrosions.
•Tightening torque of primary and secondary connections. Any adjustments should be carried out.
•Secondary terminal box: If necessary clean inside the terminal box.
•Confirm oil level indicator and if there is oil leakage.
•Access to the bellows and confirm if there is an oil leakage near the fixation of the bellows and / or if the bellows is in good condition (no deformations)

10. FINAL DISPOSAL OF THE TRANSFORMER PARTS AFTER LIFE TIME

The high voltage instruments transformers are made of the following components, which after life time require a properly disposal to prevent environmental contamination:

Components	Recommended Disposal
Metallic materials	Metal recycling company
Resin and materials saturated with resin	Industrial landfill, properly licensed by the state's responsible agency.
Oil (PCB-free) – classified as Class I hazardous residue	Oil refinery at a company which is properly licensed to perform such an activity
Material contaminated with oil	Co-processing or incineration at a company which is properly licensed by the state's responsible agency.
Porcelain insulator	Industrial landfill, properly licensed by the state's responsible agency.
Other materials	Industrial landfill, properly licensed by the state's responsible agency.

The disposal of oil and components contaminated with oil directly into the soil or water is **prohibited**.

For further information or clarifications, contact GE environment department: +55 35 36297112.