Grid Solutions
a GE and Alstom joint venture

INSTRUMENT TRANSFORMERS PRODUCT SOLUTIONS

OTCF

Capacitor voltage transformers 72.5 kV to 765 kV

In high and extra high voltage transmission systems, capacitor voltage transformers (CVTs) are used to provide potential outputs to metering instruments and protective relays. In addition, when equipped with carrier accessories, CVTs can be used for power line carrier (PLC) coupling.

Designed for long service life

Decades of experience have resulted in strong and reliable units, able to meet the highest standards. These units are manufactured using the most modern insulation impregnation technology and equipment.

Grid Solutions CVT's provide excellent reliability because the major insulation of the CVT, the capacitor stack, comprised of homogeneously assembled capacitor elements, is extremely surge resistant irrespective of the waveform of the surge voltage.

CVT insulation integrity is assured by the fact that a metallic bellows assembly hermetically seals the oil from the atmosphere.

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CUSTOMER BENEFITS

- Operational security$_{op}$
- Extensive field experience, including high seismic regions
- Operation as coupling capacitor for power line transmission
- Rugged, leak-proof design: near-zero maintenance
- Easy transport and installation

- **For revenue metering and protection in high voltage networks**
- **PLC application**
- **Performance:**
  Un: 72.5 to 765 kV
  Cn from 1750 to 37500 pF
  Thermal capacity up to 1500 VA
- **Characteristics:**
  High quality film / paper-oil insulation Oil expansion by stainless steel bellows Superior transient response Porcelain or composite insulator
- **Seismic withstand capability:**
  The standard OTCF resists medium intensity seismic events.
  For highly active seismic regions, the design is adapted accordingly.
- **Compliance with IEC, ANSI / IEEE or equivalent standards.**

Reliable design for high life expectancy

INSULATING SYSTEMS

The external insulation is provided by the porcelain housing and coordinated with the capacitor stack, consisting of virtually identical elements so that the axial voltage distribution from the line terminal to ground is essentially uniform.

The capacitor elements have a mixed dielectric material consisting of alternating layers of polypropylene film and kraft paper. The kraft paper layers serve as a wicking agent to ensure homogenous synthetic oil impregnation.

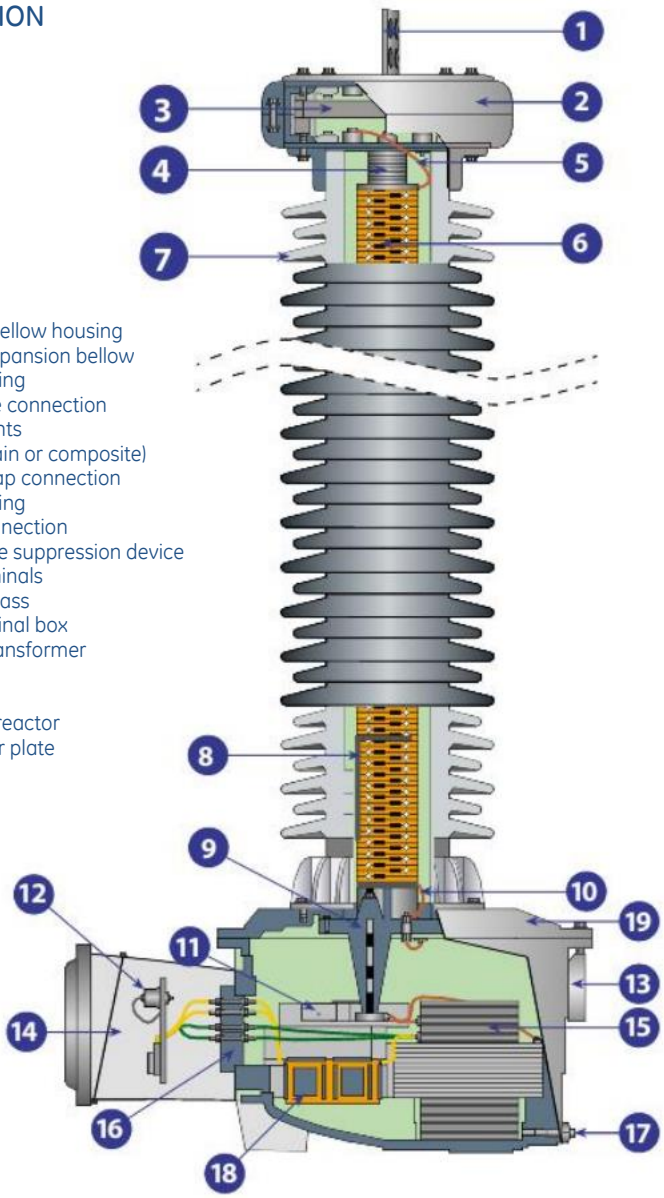
The electromagnetic unit (EMU) is housed in an oil-filled tank at the base of the capacitor stack. Mineral oil is employed as the insulating medium instead of air because of its superior insulating and heat transfer properties. The use of an oil-filled base tank removes the need for space heaters in the secondary terminal box as this area is warmed by heat transfer from the insulating oil. This results in a more reliable and cost effective design.

INSULATING OIL

We use insulating oils with excellent dielectric strength, aging, and gas absorbing properties. The synthetic oil used for the capacitor units possesses superior gas absorption properties resulting in exceptionally low partial discharge with high inception/extinction voltage ratings. The oil used for the EMU is premium naphthenic mineral oil. The oil is filtered, vacuum dried and degassed with in-house processing. It contains no PCB.

TYPICAL SECTION

1 Primary terminal
2 Cast aluminum bellow housing
3 Stainless steel expansion bellow
4 Compression spring
5 Insulated voltage connection
6 Capacitor elements
7 Insulator (porcelain or composite)
8 Voltage divider tap connection
9 Cast-epoxy bushing
10 HF terminal connection
11 Ferro-resonance suppression device
12 Secondary terminals
13 Oil level sight-glass
14 Aluminum terminal box
15 Intermediate transformer
16 Oil/air block
17 Oil drain plug
18 Compensating reactor
19 Aluminum cover plate



CAPACITOR STACK

The capacitor stack is a voltage divider which provides a reduced voltage at the intermediate voltage bushing for a given voltage applied at the primary terminal.

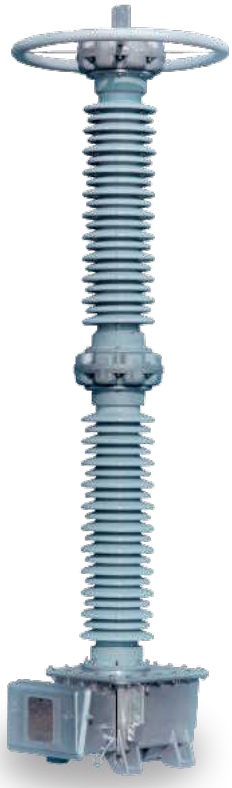
The capacitor stack is a multi-capacitor-unit assembly. Each unit is housed in an individual insulator. A cast aluminium cover is on top of the upper capacitor assembly and is fitted with an aluminum terminal. An adapter for mounting a line trap on top of the CVT can be provided with an optional (and removable) HV terminal.

The capacitor units are mechanically coupled together by means of stainless steel hardware passing through the corrosion resistant cast aluminium housing. The mechanical connection also establishes the electrical connection between capacitor units. This facilitates field assembly of the CVT.

Each capacitor unit is hermetically sealed; a stainless steel diaphragm (expansion bellow) preserves oil integrity by maintaining the hermetic seal while allowing for thermal expansion and contraction of the oil. The capacitor units operate in a practically pressure-free mode over a very wide ambient temperature range.

The capacitor stack consists of a series of capacitor elements. The dielectric spacers are a combination of kraft paper and polypropylene film. The ratio of paper/film is carefully determined to provide constant capacitance for a wide range of operating temperature. The aluminum electrodes are precision wound by microprocessor controlled machinery. The capacitor elements are connected with low inductance tinned copper tabs. The stack assemblies are hydraulically compressed and bound with epoxy fibreglass tape to obtain the optimum space factor for capacitance requirement and oil circulation.

After assembly in the insulator, capacitor units are individually oven dried under vacuum and then impregnated with the processed synthetic oil.



Thousands of installed units to attest to their reliability

ELECTROMAGNETIC UNIT (EMU)

The EMU steps down the intermediate voltage provided by the voltage divider to values suitable for relay and metering applications.

A series reactance cancels the phase shift induced during voltage transformation in the capacitor voltage divider. A set of internal taps is used for factory accuracy and phase angle adjustments to provide optimum performance. Over-voltage protection is provided by a protective gap connected in parallel to the series reactances.

The inherent capacitance and iron-cored EMU of a CVT require the suppression of ferro-resonance.

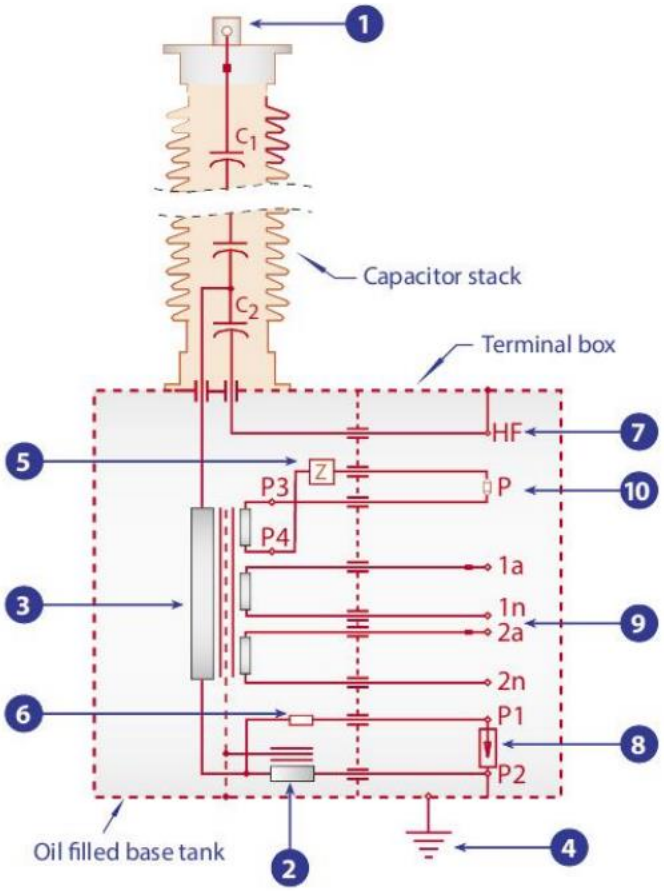
The ferro-resonance suppression device (FSD) contains a saturable reactor, which acts like a switch, presenting a very high impedance under normal conditions and switching on a damping resistor across the secondary at a prescribed voltage, and switching off the damping load when voltage has normalised.

The voltage sensitive switching strategy effectively suppresses ferro-resonance without imposing a heavy permanently connected stabilizing burden on the unit, significantly improving the accuracy and the transient response performance of the CVT.

No field adjustment of the unit is necessary.

The EMU is housed in a cast aluminum base tank with a cast aluminum cover. The base tank is filled with treated mineral oil and hermetically sealed from the environment and from the synthetic oil in the capacitor units. A sight glass at the rear of the tank provides for easy oil level monitoring. No oil maintenance is necessary throughout the service life of the unit. An oil drain plug is provided on the base tank.

PRINCIPAL CIRCUIT DIAGRAM



1 High voltage terminal
2 Compensation reactor
3 Intermediate voltage transformer
4 Ground terminal
5 Ferroresonance suppression device
6 Damping resistor
7 Carrier (HF) terminal (optional)
8 Overvoltage protective device
9 Secondary terminals
10 Link, to be opened for test purposes

CARRIER ACCESSORIES

When the CVT is equipped with carrier accessories for PLC service, an external carrier grounding switch (CGS) and carrier entrance bushing are provided in the terminal box. The carrier accessories include a carrier drain coil with protective spark gap. A choke coil and a protective spark gap are installed in the base tank when a potential ground switch (PGS) is provided to prevent the loss of the carrier signal when the PGS is in the closed position.

SECONDARY TERMINAL BOX

The terminal box is very spacious and can accommodate all required connections. The secondaries of the EMU are brought out of the base tank through an oil/air seal block assembly and terminated on separate terminal blocks. The secondary terminal box area is warmed by heat transfer from the oil filled tank. This prevents condensation in the terminal box and removes the need for a space heater. An aluminum gland plate is provided to accommodate customer conduit hubs.

CORONA SUPPRESSION

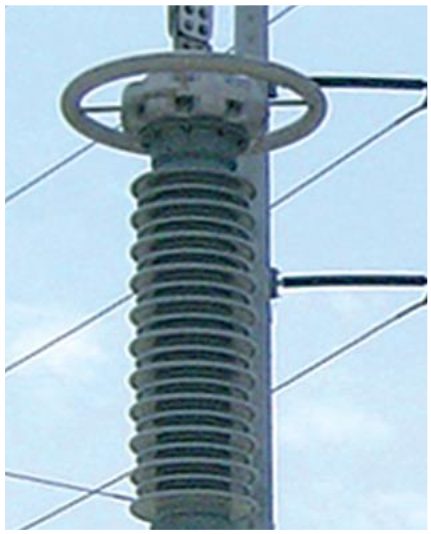
Corona suppression is considered in the design and construction of every part of the CVT. 245 kV units and units above 245 kV are supplied with an aluminum electrode to ensure insulation performance.

Dielectric loss factor	Less than 0.06 % / 0.0006 at rated voltage
Radio Influence Voltage (RIV)	Less than 2,500 uV at 1.1 U_m
Partial discharge	Less than 10 pC at 1.2 U_m
Frequency	50 Hz or 60 Hz
Ambient temperature	50 °C….+45 ° C on a 24h average

Other values on request

SECONDARY WINDINGS

To meet the requirements for measuring and protection, generally two secondary windings are provided with an option of up to four windings, including the earth fault winding. The maximum burdens can be seen on page 7.



INSULATOR

The outer insulation consists of a high-quality porcelain in brown (RAL 8016) or grey (ANSI 70). Standard creepage distances are available according to the dimension tables. Larger creepage distances are available on request.
On special request, Grid Solutions can offer CVTs with a composite insulator consisting of an epoxy resin fiberglass tube with silicone rubber sheds.

SERVICE LIFE AND MAINTENANCE

OTCF have been designed for a 30 year life-time and, thanks to the the robust construction and conservative insulation design, many well out-live this service life. They have near-zero maintenance requirements: the oil is hermetically sealed from the air by a stainless steel diaphragm assembly and all external parts are of corrosion-resistant material.

TESTS

Routine tests are performed in accordance with national and international standards. Each capacitor unit is routine tested for lightning impulse, power-frequency withstand, partial discharge, dissipation factor and capacitance. A routine rest report is provided for each unit. Existing type test reports can be provided on request.

Partial discharges
For the capacitor units, the partial discharge intensity is less than 5 pC at 1.2 times maximum line-to-ground voltage and less than 10 pC at twice the rated voltage after the power frequency voltage test.

Ferro-resonance check
After routine accuracy tests, the unit is checked for ferro-resonance suppression by applying secondary short-circuits. The secondary voltage is monitored with an oscilloscope to ensure that the recovery of normal waveform is satisfactory.

Dissipation factor or Tan δ
Dissipation factor measured at the rated voltage is less than 0.06 %.

INQUIRY CHECK LIST

- Applicable standards
- Rated frequency
- Highest system voltage
- Power-frequency withstand test voltage
- Lightning impulse test voltage
- Switching impulse test voltage, if applicable
- Rated capacitance Cn in pF
- Overvoltage factor (ex. 1.5 Un 30 s)
- Voltage ratio
- Number of secondaries
- Accuracy class and rated burden for each secondary winding
- Environmental conditions (altitude, temperature, site pollution, seismic conditions...)
- Required leakage path in mm or in mm/kV
- Options as required:
  HV terminal (material and dimensions)
  Carrier accessories (1 voltage limiter, 1 HF disconnecting switch, 1 draining coil)
  Composite insulator (light grey).

If a line trap is to be mounted on the CVT, please specify the weight and overall dimensions.

EASY TRANSPORT AND INSTALLATION

CVTs must be transported and stored in the upright position. Multi capacitor unit assemblies are delivered with the upper capacitor units packed in the same crate.

The base unit and upper stack elements can easily be assembled by following the instruction manual. No special tools are required.

DESIGNATION

OTCF ... SR	Standard high capacitance Relay accuracy
OTCF ... SI	Standard high capacitance Intermediate accuracy
OTCF ... SM	Standard high capacitance Meter accuracy
OTCF ... IR	Intermediate high capacitance Intermediate relay accuracy
OTCF ... IM	Intermediate high capacitance High burden meter accuracy
OTCF ... ER	Extra high capacitance Relay accuracy
OTCF ... EM	Extra High Capacitance High burden meter accuracy

RATINGS

Capacitive voltage transformers can be rated for metering and/or protection purposes.

The following burdens (as a sum of all windings except the ground fault winding) can be achieved.

TYPE OTCF		SR ER	SI	SM	IM	EM
FREQ.		CLASS	RATED BURDEN (VA) ACCORDING TO IEC			
50Hz	0.2	25	50	100	200	230
	0.5	60	120	250	500	580
	1.0	120	250	500	800	1000
60Hz	0.2	30	60	120	250	280
	0.5	80	150	300	600	700
	1.0	150	300	600	1000	1200

THERMAL BURDEN (VA)

60Hz	1.2 Z	0.6 Z	0.3 Z	0.3 ZZ	0.3 ZZ

TRANSIENT RESPONSE

50 Hz	800	800	800	800	1200
60 Hz	1000	1000	1000	1000	1500

The following capacitances are standard for the various voltage levels:

Type (Um [kV])	... SR ... SI	... IM	... ER ... EM
CAPACITANCE (pF)*			
OTCF 72.5	12500	16700	37500
OTCF 123	7500	10000	22500
OTCF 145	6250	8300	18800
OTCF 170	5250	6700	16200
OTCF 245	3750	5000	11300
OTCF 362	2630	3350	8100
OTCF 420	2080	2870	6250
OTCF 550	1750	2250	5400
OTCF 765			4000

*other values on request

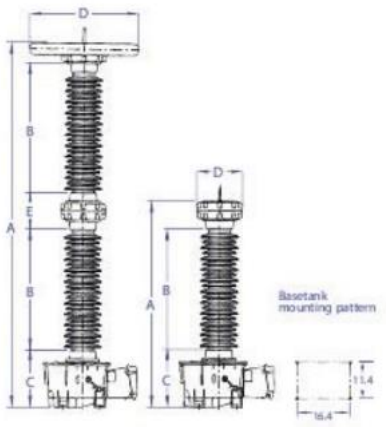
DIMENSIONS

The following dimensions refer to standard versions. Other U_m values affect other dimensions.

DIMENSIONS

Highest system voltage (V_m)	kV	72.5	123	145	170	245	362	420	550	765
Impulse test voltage (BIL)	kV	350	550	650	750	1050	1175	1425	1800	2100
OTCF Creepage distance	mm	1620	2945	3535	4335	5890	8670	10605	13005	-
... SR Dimensions mm	A	1285	1650	1858	2088	2882	3758	4738	5428	-
... SI	B	580	945	1153	1383	945	1383	1153	1383	-
... SM	C	485	485	485	485	485	485	485	485	-
	D	356	356	356	356	648	864	864	864	-
	E	-	-	-	-	287	287	2x287	2x287	-
Total weight (approx.)	kg	185	225	229	246	334	368	459	489	-
Volume of oil (approx)	l	30	31	33	34	40	45	54	57	-
OTCF Creepage distance	mm	1620	2945	3535	4335	5890	8670	10605	13005	-
... IM Dimensions mm	A	1321	1686	1894	2124	2918	3794	4774	5464	-
	B	580	945	1153	1383	945	1383	1153	1383	-
	C	521	521	521	521	521	521	521	521	-
	D	356	356	356	356	648	864	864	864	-
	E	-	-	-	-	287	287	2x287	2x287	-
Total weight (approx.)	kg	261	303	307	323	411	445	536	566	-
Volume of oil (approx.)	l	45	49	50	51	57	62	71	74	-
OTCF Creepage distance	mm	1600	2755	3420	4370	5510	8740	10260	13110	17480
... ER Dimensions mm	A	1318	1683	1886	2153	2955	3894	4836	5636	7378
	B	580	945	1148	1415	926	1415	1148	1415	1415
	C	514	514	514	521	514	514	514	514	514
	D	446	446	446	446	648	864	864	864	1016
	E	-	-	-	-	327	327	2x327	2x327	3x327
Total weight (approx.)	kg	238	277	322	375	440	628	737	878	1130
Volume of oil (approx.)	l	38	44	48	53	66	84	99	114	145
OTCF Creepage distance	mm	1600	2755	3420	4370	5510	8740	10260	13110	17480
... EM Dimensions mm	A	1354	1719	1922	2189	2991	3930	4872	5672	7413
	B	580	945	1148	1415	945	1415	1148	1415	1415
	C	549	549	549	549	549	549	549	549	549
	D	446	446	446	446	864	864	864	864	1016
	E	-	-	-	-	327	327	2x327	2x327	3x327
Total weight (approx.)	kg	315	354	399	452	517	705	814	955	1207
Volume of oil (approx.)	l	55	61	65	70	83	101	116	131	162

Indicatives value only - All indicated dimensions must be confirmed with order.



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