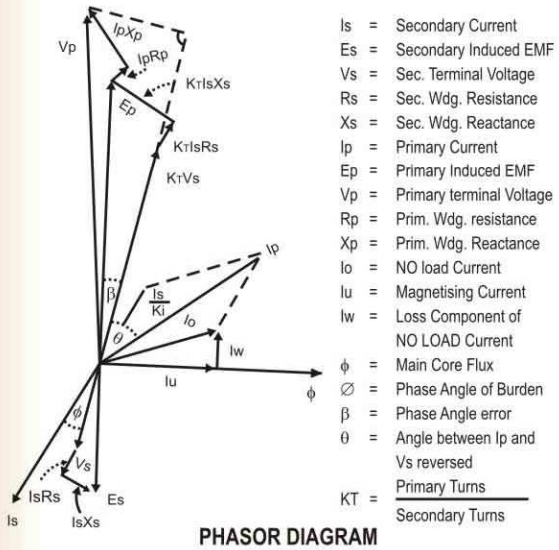
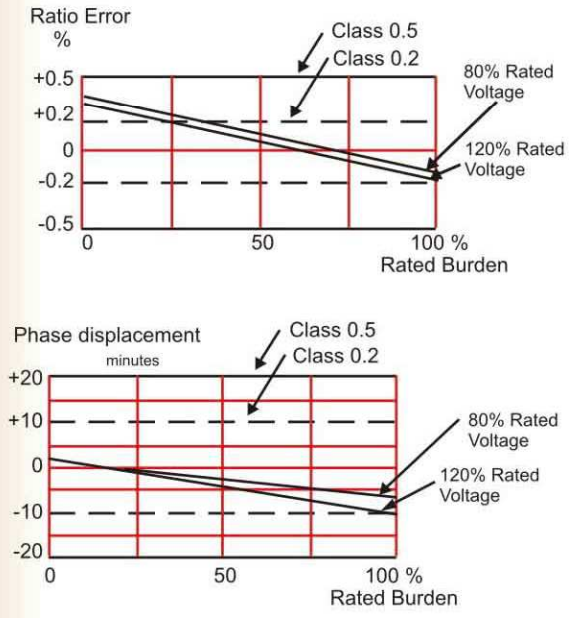
Voltage Transformer

Instrument Transformer
Division



PHASOR DIAGRAM

Fig. No.1



TYPICAL ERROR CURVES & LIMITS FOR CLASSES 0.2 & 0.5 I.S. 3156 / IEC 60044-2

Fig. No.2

Standard Voltage Transformer with standard burden

GENERAL

AUTOMATIC ELECTRIC LTD. introduced their indigenously developed INSTRUMENT TRANSFORMERS in the year 1968. Since then 'AE' are one of the leading Manufacturers in the Country for quality instrument Transformers.

'AE' manufactures OUTDOOR OIL COOLED VOLTAGE TRANSFORMERS ranging from 11kv to 220kv. The Modern Plant situated at Ambernath is equipped with full range of testing equipments, plant & machinery to manufacture INSTRUMENT TRANSFORMERS. 'AE' have supplied thousands of these transformers to almost all the STATE ELECTRICITY BOARDS and utilities in the Country. These INSTRUMENT TRANSFORMERS are working satisfactorily under different service conditions at the sites. 'AE' are also EXPORTING transformers. The instrument transformers are fully type tested in accordance with latest I.S. /I.E.C. Specifications.

APPLICATION

Direct measurement of voltage in High Voltage System is not possible because of insulation problem of measuring instruments. It is also not possible to use direct voltage for the system protection purpose due to its high value and high insulation problem of protective relays. Therefore, voltage transformers are used to step-down the high system voltage to low standard value accurately in proportion to their ratio.

BASIC FUNCTIONS OF VOLTAGE TRANSFORMERS ARE:

1. To reduce the line voltage to a value which is suitable for standard measuring instruments, relays etc.
2. To isolate the measuring instruments, meters relays etc. from high voltage side of an installation.
3. To sense abnormalities in voltage and give voltage signals to protective relays to isolate the defective system.

THEORY

General principle of power transformer design also apply to the voltage transformers but there are certain considerations of performance which are of particular importance. In the electromagnetic voltage transformers, accuracy depends on leakage reactance and winding resistance. These determine how the phase error and voltage error vary as the burden on secondary increases (Refer Fig.2) The permeability and power dissipation of core material affects the exciting current and thus the error at zero burden.

To comply with the requirement of I.S. 3156/IEC 60044-2, Flux density employed in voltage transformer is much less than the value generally used in power transformer. The turn ratio and voltage drop due to leakage reactance and the winding resistance must be carefully determined, in order that the permissible error is not exceeded.

Theory of voltage transformer can be established more clearly with the help of phasor diagram as given in FIG.1

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DESIGN

Single phase Electromagnetic voltage transformer (EMV) is manufactured in two types (i) single pole (To connect between lines & earth) (ii) Both pole (to connect between Line-to-Line) 3 phase voltage transformers are of star/star connected or star/open delta connected (residual Voltage Transformer) type. Single phase voltage transformers are manufactured for 11kv to 220 kv system voltage. whereas 3 phase voltage transformers are manufactured for 11kv to 33kv system voltage.

CONSTRUCTION : VOLTAGE TRANSFORMER MAINLY CONSISTS OF:

1. Primary & Secondary Winding
2. Electromagnetic Core
3. Bottom Tank & Oil Expansion Chamber
4. Porcelain Bushing

PRIMARY & SECONDARY WINDING

Copper enameled wire is used for winding. Primary is wound with multilayer and graded insulation. The diameter and length of each layer is selected such that surge voltage is distributed equally in all layers of the Winding. Multilayer Kraft Paper insulation is provided between winding layers. Stress equalising shield is provided on last layer of the winding. H.T. Connection is brought out through metallic pipe.

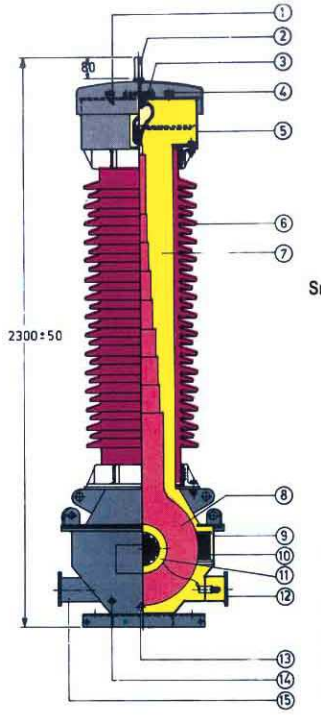
Secondary is separately wound and inserted in the primary winding as per the requirement. Winding and tapping of V.T. is done in dust-free atmosphere.

ELECTROMAGNETIC CORE

C.R.G.O. Silicon Steel is used for building up Electromagnetic core. Shell type construction is used to minimise leakage reactance.

BOTTOM TANK & OIL EXPANSION CHAMBER

Bottom tank and oil expansion chamber are made of M.S. Sheet. All tanks and chambers are painted with Oven baked paint, after cleaning by seven tank process. All surface which come in contact with oil are painted with oil insoluble paint. M.S. parts can be hot dip galvanised on request



Sr. No.	DESCRIPTION
1	OIL FILLING PLUG
2	H.T. TERMINAL
3	PRESSURE RELEASE DEVICE
4	NITROGEN VALVE
5	OIL EXPANSION CHAMBER
6	PORCELAIN BUSHING
7	OIL
8	H.T. COIL
9	OIL TANK
10	CORE LAMINATION STACK
11	L.T. COIL
12	EARTHING TERMINAL BOX
13	OIL DRAIN PLUG
14	EARTHING TERMINALS
15	SECONDARY TERMINAL BOX

CONSTRUCTION DETAILS OF 132 kV V.T.

Fig. No. 3

Taping of PT Coil

11 KV CTPT

25 KVPT

33 KV CTPT

33 KVPT

150 KV HV Transformer

Voltage Transformer

Instrument Transformer
Division

PORCELAIN BUSHING

Brown Glazed Porcelain bushing with different shed profiles to suit different pollution conditions is used. These bushings are Hollow Cylindrical Type conforming to I.S. 5621/I.E.C.815 . Bushing with collar at both the ends is clamped using Aluminium Flanges. Nitrile and Neoprene Gaskets are used at both sides of collar to form flexible joint. This joint can sustain vibrations without damaging bushing. Bushings with Cemented flanges are also used.

INSULATION

High quality electrical grade kraft paper and crepe paper is used for insulating primary and secondary winding of V. T. The high voltage connection is brought out through paper condenser formed on metallic pipe using fine grading of insulation. Semiconducting shield is used to give linear distribution of electric stress along the length of the bushing. The paper insulation is dried in over under very high vacuum and strictly controlled conditions. Filtered and de-aerated EHV grade oil is filled in V.T. while V.T. is under vacuum. To seal it, the space left for expansion on the top is filled with dry and pure nitrogen through non-returnable valve at pre-determined pressure.

Oil Filtration Machine

Oil Testing Kit

Testing Laboratory

TESTING

AE testing Lab is equipped with modern test facilities to carry out all routine tests, including Temperature Rise Test. Partial discharge Measurement plays a vital role in quality control of insulation. All our V.Ts. are tested for Partial Discharge on most modern bridge type Partial Discharge Test Set.

All the V.Ts. pass though a standardized quality assurance plan to ensure requisite top quality at every stage and in the final product.

PACKING & TRANSPORTATION

All V.Ts. are packed with strong jungle wood to take care of most adverse conditions of transportation all over the country. Special sea-worthy packing is done for the V.Ts. for Export. V.Ts. upto 132kv class are transported vertically. 220 kv. V.Ts. are transported horizontally.

MAINTENANCE

V.Ts. do not require maintenance apart from occasional cleaning of Bushing and checking of Nitrogen Pressure. For more details refer Instruction Manual supplied with the V.T.

HOW TO SELECT THE V.T.

It is Important to specify correct parameters of V.T. while ordering for optimum design.

Following are main factors for selecting Voltage Transformer.

1. **Service Voltage**

   System Voltage in which V.T is to be installed e.g. 11kv, 22kv, 33kv etc.

2. **Installation**

   Whether OUTDOOR or INDOOR

3. **Atmospheric Conditions**

   Such as condition of Pollution, Altitude, Ambient Temperature etc.

4. **Insulation Level**

   If insulation level other than associated with service voltage is required, it should be specifically mentioned.

5. **Rated Primary Voltage**

   Rated primary voltage is generally rated system voltage for unearthed type V.Ts. and rated system voltage divided by square root of three for earthed type V.Ts. The V.Ts. can be manufactured suitable for more than one system voltage. In such cases, different primary voltages required may be indicated.

6. **Rated Secondary Voltage**

   Standard Values of Secondary voltages are 110v or 110v/√3 depending on application of the secondary winding. V.Ts. with different secondary voltages other than those mentioned above can be manufactured and supplied.

7. **Voltage Factor**

   All V.Ts. are manufactured suitable for continuous voltage factor of 1.2. As per I.S. / L.E.C. Specifications, short time voltage factor is different for different earthing systems. Therefore appropriate system earthing conditions may be specified.

8. **Number of secondary windings. Their burdens & accuracy classes**

   Number of secondary windings, their burdens and accuracy classes are selected on the basis of application. Two types of classes are available, one for metering and other for protection. Unlike current transformers, accuracy of one winding is influenced by loading of other winding. Due to this reason burden of each winding should be correctly mentioned. Accuracy of V.T. is guaranteed at the secondary terminals of the V.T. The impedance of cable connecting secondary terminal to load (Relay or Meter) offers series drop in output voltage. This causes additional errors in secondary winding at the measuring end of cable and is proportional to the load on the secondary. Therefore, it is advisable to select separate metering and protection winding. Alternatively, single winding can be used for metering and protection if separate cables are used for connections. (Cable of 4 sq. mm. cross section offer 2% voltage drop at 100 metres distance will 100 VA burden for secondary voltage of 110v/√3).

VT-Coil winding unit

Ct's & PT's

Vacuum Drying Oven

EPOXY Casting Plant

Induced Generator Set for Voltage Transformer Testing

Core Testing Unit

RESIDUAL VOLTAGE TRANSFORMER

RESIDUAL VOLTAGE TRANSFORMER is used to detect unbalanced voltage in three phase system and to supply voltage to directional earth-fault relay.

For directional earth-fault relay. It is necessary that the voltage applied to voltage coil of the relay corresponds in phase to that of the current in current coil. Such voltage will be the Residual voltage of the system and will be the phasor sum of the three line-to-earth voltages.

Residual voltage can be achieved by connecting secondaries of three single phase V.Ts. connected in three phase in open-delta fashion. It is, however, economical to use three phase V.Ts. instead of Three nos. single phase V.Ts. 'AE' manufactures three phase R.V.Ts. suitable upto 33kV system voltage.

In normal three phase limb V.T. when one phase experiences earth fault, the resultant flux due to two healthy lines returns through transformer limb of faulty line, inducing a heavy short circuit current in the winding on the limb. Also voltage induced in secondary open-delta winding is not true residual voltage. To overcome this difficulty two separate limbs are provided in the magnetic circuit of three phase Voltage Transformer to form Five limb Voltage Transformer as shown in Fig. No. 4

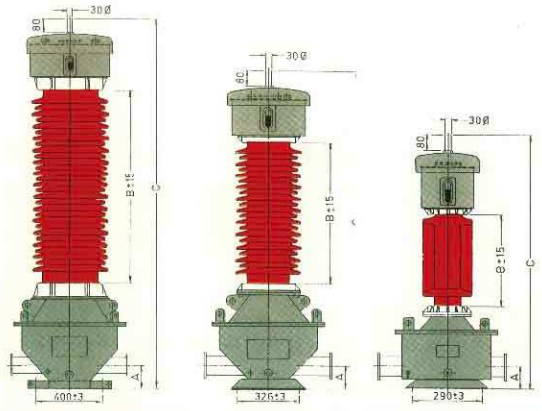
The use of an open-delta connected winding to give true residual voltage in demonstrated in Fig. No. 5 with three cases:

5A) Under healthy condition all three phases will be balanced and hence residual voltage VR will be zero.

5B) In system with unearthed neutral. if here is earth fault on one line, neutral of V.T. will be shifted, such that each healthy phase winding will have line-to-line voltage with 60° phase difference. The resultant open-delta voltage shall be therefore three times phase voltage (VR = 3 VS)

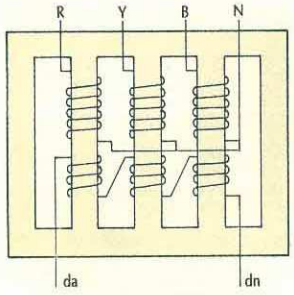
5C) In Solidly earthed system, neutral of the V.T. does not get shifted due to earth-fault one line. Therefore, the resultant open-delta residual voltage remains phase voltage only (VR = VS)

Primary winding of R.V.T. is connected in star. The secondary winding is connected in open-delta. Sometimes additional secondary winding is provided in R.V.T. for measuring purpose and is connected in Star. Ratio of R.V.T. is generally specified as line-to-line primary voltage to open-delta residual voltage. It, therefore, becomes necessary to mention system neutral condition so as to select phase voltage of the open-delta winding correctly. When R.V.Ts. are used along with Capacitor Bank capacitor bank gets discharged through primary winding 'AE' make R.V.Ts. are suitable for such applications also.



TYPE	VOLTAGE CLASS	DIMENSIONS IN mm			MOUNTING	TOTAL CREEPAGE IN mm	TOTAL WEIGHT IN kg (Approx.)
		A	B	C			
OP AS 132	132 / 110 / 100kV	145	1215	2300 ±50	400 X 400	3625	600
OP AS 66	66 kV	120	805	1710 ±50	326 X 390	2310	300
OP HP 33/1	32 / 22 kV	115	450	1275 ±35	230 X 290	900	130
OP HP 33/2		85		1180 ±35	200 X 305		
OP NP 33/1		115	310	1135 ±35	230 X 290	820	120
OP NP 33/2		85		1040 ±35	200 X 305		
OP AS 33/1		115	450	1275 ±35	230 X 290	1320	130
OP AS 33/2		85		1180 ±35	200 X 305		

Principle Dimensions of Oil Cooled Voltage Transformers



5 LIMB CONSTRUCTION OF RVT.

Fig. No. 4

TYPICAL R.V.T.

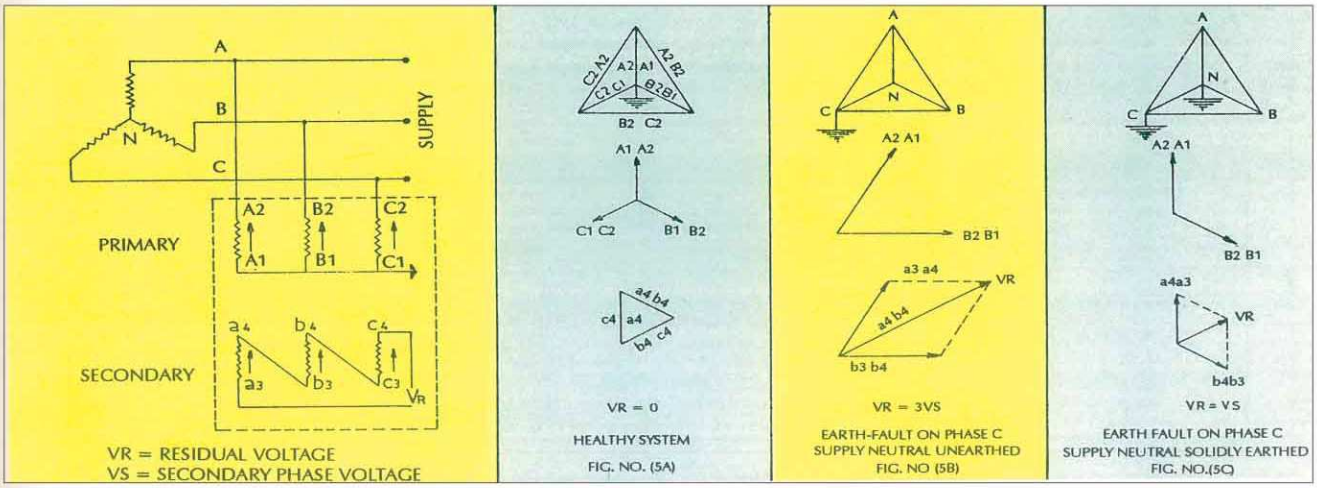


Fig No. 5 Principle of the Residual Voltage Transformer