Приложение 15

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RITZ

Instrument Transformers

Medium Voltage Instrument Transformers

RITZ HAMBURG
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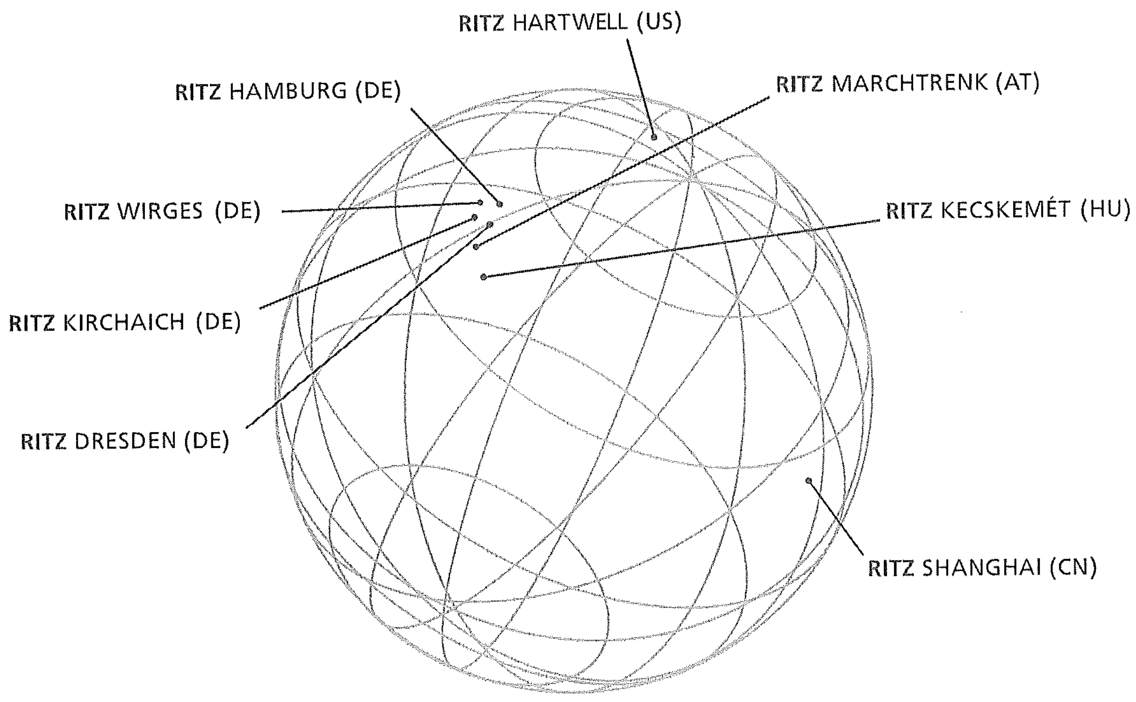
RITZ Instrument Transformers GmbH – Core competency

Under the trading name „RITZ Instrument Transformers GmbH" RITZ has been pooling its activities to gather new strengths since 01.08.2007.

The tradition and knowledge of the parent company „RITZ Messwandler Hamburg" and the subsidiary „RITZ Messwandler Dresden (TuR)" has been united with the companies "Wandler- und Transformatoren-Werk Wirges (WTW) and "Messwandlerbau Bamberg (MWB)" under this name. This merger unites a total of more than two hundred years of know-how in instrument transformers production.

In addition, RITZ has decided to concentrate on the core business of medium voltage and low voltage transformers in which the high voltage division is sold. The resources gained through this shall now be applied for additional innovations and quality standards in the medium and low voltage products. RITZ is therefore securing its position on the global market.

The overseas corporations of RITZ Instrument Transformers GmbH in Austria (Marchtrenk), Hungary (Kecskemét), China (Shanghai) and USA (Hartwell) strengthen the company's position on the international market.



Contents

Introduction 2

1.0 Medium Voltage Instrument Current and Voltage Transformers 4

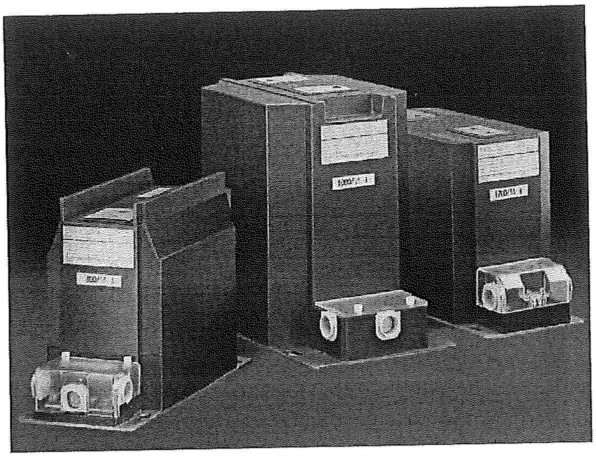
1.1 General 5
1.2 Design 6
1.3 Current Transformer 7
1.3.1 Choice limitations of the Rated Burden 7
1.3.2 Definitions 8
1.3.3 Metering Current Transformer 9
1.3.4 Protective Current Transformer 9
1.3.5 Reconnection of Current Transformer 9
1.3.6 Over Current Range 10
1.3.7 Service and Grounding 10
1.3.8 Capacitive Divider 11
1.4 Voltage Transformer 11
1.4.1 V-Connection of Two Double Pole Insulated Voltage Transformer 11
1.4.2 General Design 12
1.4.3 Definitions 13
1.4.4 Service and Grounding 13
1.4.5 Ferroresonances 14
1.5 Service Conditions 14
1.5.1 Altitude 14
1.6 Test Voltages and Insulation Levels for Instrument Transformers 14s
1.7 Insulation Class 15
1.8 Partial Discharge Test 15
1.9 Standards

2.0 Products
Product Selection List 16 - 17
2.1 Current Transformer Indoor up to 72,5 kV
2.1.1 Support Type Current Transformer Indoor Block-Type (narrow type) ASS 12 | 17,5 | 24 | 36 | 40,5 18
2.1.2 Support Type Current Transformer Indoor Block-Type GSW 12/0 19
2.1.3 Support Type Current Transformer Indoor Block-Type ASN 12 | 17,5 | 24 | 36 20
2.1.4 Current Transformer Indoor GI 52 | 72,5 21
2.1.5 High Current Transformer Indoor GSSO 12 | 17,5 | 24 22
2.1.6 Bushing Current Transformer with Fixed Bars Indoor GDS 12 | 17,5 | 24 | 36 23
2.2 Current Transformer Outdoor up to 72,5 kV
2.2.1 Support Type Current Transformer Outdoor Compact GIFK 12 | 17,5 | 24 | 36 24
2.2.2 Support Type Current Transformer Outdoor Standard GIFS 12 | 17,5 | 24 | 36 25
2.2.3 Current Transformer Outdoor Head Type GIF 10 | 17,5 | 20 | 30 | 36 | 52 | 72,5 26
2.3 Voltage Transformer Single Pole up to 72,5 kV
Indoor
2.3.1 Voltage Transformer Indoor VES 12 | 17,5 | 24 | 36 27
2.3.2 Voltage Transformer Indoor GSE 12/0 28
2.3.3 Voltage Transformer Indoor VEN 12 | 17,5 | 24 | 36 | 52 | 72,5 29
Outdoor
2.3.4 Voltage Transformer Outdoor VEF 12 | 17,5 | 24 | 36 30
2.3.5 Voltage Transformer Outdoor Head Type VEF 52 | VEF 72,5 31
2.4 Voltage Transformer Double Pole up to 36 kV
Indoor
2.4.1 Voltage Transformer Indoor VZS 12 | 17,5 | 24 32
2.4.2 Voltage Transformer Indoor GSZ 12/0 33
2.4.3 Voltage Transformer Indoor VZN 12 | 17,5 | 24 | 36 34
Outdoor
2.4.4 Voltage Transformer Outdoor VZF 12 | 17,5 | 24 | 36 35
Low Voltage Instrument Transformers 36
Cast Resin Insulated Bus Bar Systems up to 72,5 kV, 6500 A 37
Cast Resin Insulated Power Transformers up to 40,5 kV, 25 MVA 38
Electronic Instrument Transformers & Sensors | Customised Cast Resin Parts 39

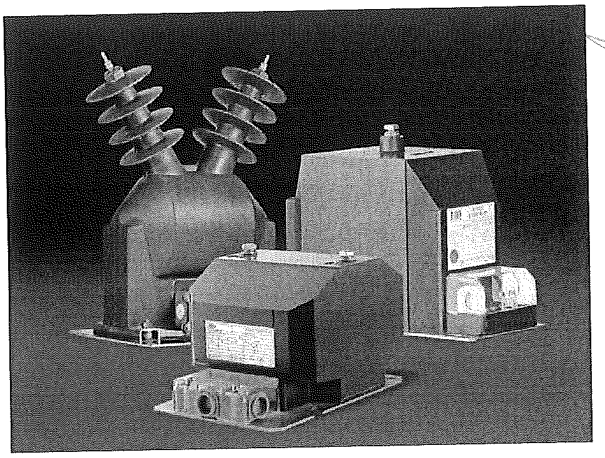
1.0. Medium Voltage Current and Voltage Transformers

1.1 General

Instrument transformers are transformers, which convert high currents or voltages into measurable and standardized currents or voltages, which are proportional and in-phase to the primary signal. They are intended to supply electrical measuring instruments, meters, relays or other electrical devices.



CT according to DIN-Design



PT according to DIN-Design

Current Transformer

A current transformer is designed to convert the primary rated current which flows through the primary winding.

The secondary winding must generally be short circuited at any time, otherwise dangerous high voltages can occur at the secondary terminals.

The secondary connected devices are connected in series.

Current Transformers can be equipped with one or more independent magnetic cores with equal or different characteristics for measuring, metering and/or protective purposes.

Voltage Transformer

Voltage transformers have only one iron core with attached secondary winding (s).

If an open delta circuit (da-dn) is necessary, an additional winding can be provided for single pole insulated transformers.

It is extremely dangerous to short circuit a voltage transformer.

For single pole insulated transformers the end of the primary winding is grounded as "N" inside of the secondary terminal box, and must not be removed during operation.

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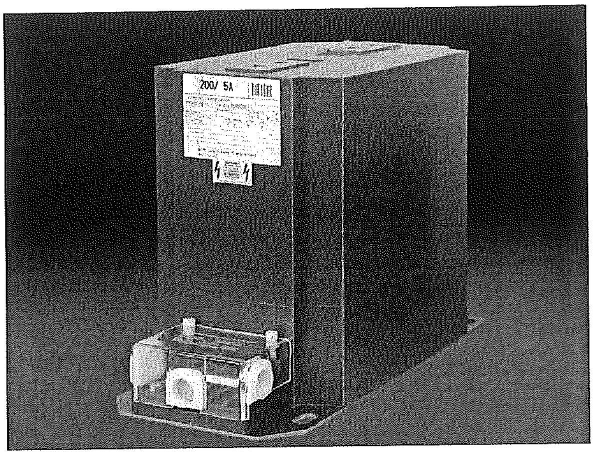
278

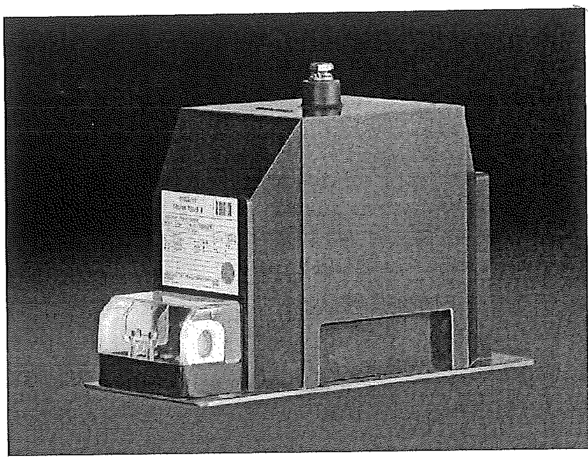
1.2 Design

Instrument transformers can be differentiated into different designs through their specification and application. The following basic designs exit:

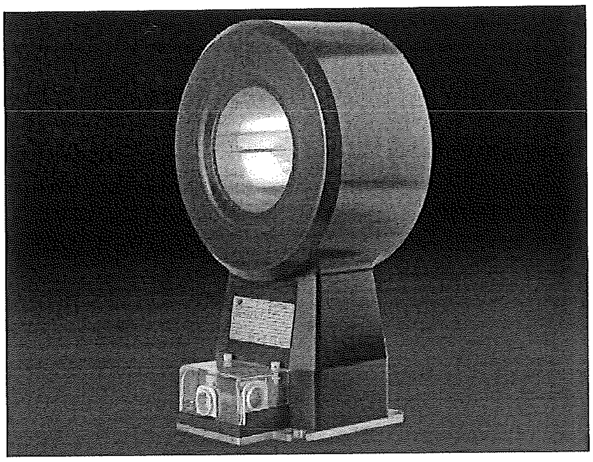
- Supporting types according to DIN 42600 (only for indoor use) or designed according to customer requirement for indoor and outdoor application
- Bushing types for indoor and outdoor application
- Voltage transformers, single or double pole insulated, for indoor and outdoor application.



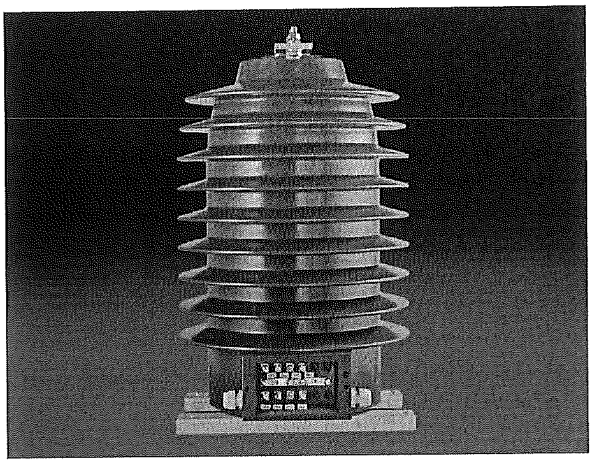
Support type current transformers for indoor applicationss



Single pole voltage transformer for indoor applications



High current bushing type current transformer



Outdoor voltage transformer with characteristic shields to extend the creepage distance

ВЯРНО С ОРИГИНАЛА

229

1.3 Current Transformer

Current transformers are transformers which convert high currents into measurable and standardized currents proportional and in-phase to the primary signal.

A current transformer can be equipped with one or more independent ferromagnetic cores made of silicon or nickel iron steel.

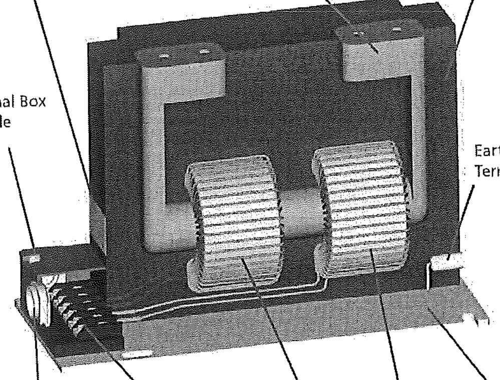
The secondary winding (W2) is symmetrically wound around the iron core. This causes a very intensive magnetic coupling of the primary to the secondary winding. The number of turns of the secondary winding depends on the ratio between the primary and the secondary rated current. The iron core(s) and the secondary winding must be grounded.

Depending on the primary rated current and the short time current (Ith), the primary winding (W1) consists of one solid winding (primary conductor) or a number of turns.

The primary winding is designed for the full rated current and has the same potential as the busbar.

The highest system voltage (phase to phase voltage) has to be considered for the design of the transformer with respect to its insulation between the primary and the secondary winding.

The windings W1 and W2 as well as the iron core(s), together with the secondary winding(s) are completely resin-embedded and casted in a single production step by using a pressure gelation casting process.



General design sample of a current transformer

The resin body is mounted on a metal plate. The secondary terminals are embedded in the resin body and protected by a plastic box. The cover of the box is removable and can be sealed. Each secondary terminal can be separately grounded inside the secondary terminal box. The grounding screw is connected to the bottom plate. The terminal box is equipped with two or three removable cable plugs, which makes wiring easy.

The ends of the primary winding are provided with flat terminals ("P1/P2"), made of copper or brass alloy, and located at the top of the resin body.

A M8 grounding screw is available on the bottom plate for grounding the current transformer. Grounding can take place directly on the frame of the switchgear or on a separate grounding bar.

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1.3.1 Choice Limitations of the Rated Burden

Especially for small rated primary currents, and high rated short time thermal currents (Ith), the rated burden of a current transformer is limited due to the maximum permissible kAW-value (ampere turns). In this case, information should be requested from the manufacturer.

If the rated burden of a current transformer is calculated according to the formula

$$P_N = \frac{(AW)^2 \cdot Q_{Fe} \cdot K}{l_{Fe}} \; [VA]$$

AW	primary ampere turns
Q_{Fe}	iron cross section (mm2)
K	constant
l_{Fe}	ferromagnetic circuit (cm)

it becomes evident that, if the ampere turns (AW) can be doubled, a burden which is four times higher can be achieved. Physically speaking, however, this is not always feasible, because the ampere turns are limited by the rated dynamic current (Idyn). The reason for this is the force of the magnetic field intensity which, in case of a short circuit, attempts to mutually balance the individual primary windings. Furthermore, the maximum rated burden depends on the size of the resin body.

1.3.2 Definitions

1.3.2.1 Rated Primary and Secondary Current

The value of the primary and secondary current indicates the performance rating of the transformer. A common practice is to use a secondary rated current of 1 or 5 A. The primary rated current depends on the network and is defined by the end user.

Economically speaking, a secondary rated current of 1A should be chosen in order to keep the rated burden low, especially for long wiring distances.
$P_N = I^2 \cdot R + P_B$

1.3.2.2 Rated Continuous Thermal Current

This is the value of the current which can be permitted to flow continuously through the primary winding while the secondary winding is connected to the rated burden, without the rise in temperature exceeding the values specified.

It is common practice that the rated continuous thermal current is equal to the rated current but a higher current can also be defined.

1.3.2.3 Rated Short Time Thermal Current

The r.m.s value of the primary current is the value which a transformer will withstand for one or three seconds without suffering harmful effects, should the secondary wiring be short circuited.

1.3.2.4 Rated Dynamic Current

The peak value of the primary current is the value which a transformer will withstand, without being damaged electrically or mechanically by the resulting electromagnetic forces, should the secondary winding be short circuited.

1.3.2.5 Burden

Burden is the impedance of the secondary circuit and power factor in ohms. The burden is usually expressed as the apparent power in volt amperes (VA) at a specified power factor and at the rated secondary current.

1.3.2.6 Rated Burden

The value of the burden is based on the accuracy requirements of this specification.

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1.3.2.7 Error Limits

The composite error for metering cores has to be higher than 10% to protect the connected metering devices in case of over currents. In the opposite the composite error for protection cores at the rated accuracy limit of the primary current should be smaller or equal 5% (5P) or 10% (10P) to secure a proper tripping of the connected protection devices.

1.3.2.8 Instrument Security Factor

In the event of a system fault when a current is flowing through the primary winding of a current transformer, the apparatus is offered the highest level of protection by the transformer when the security factor value (FS) of the rated instrument is small.

1.3.3 Metering Current Transformer

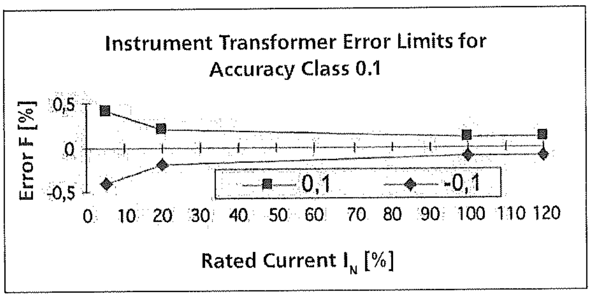
This is a current transformer intended to supply indication instruments, integrating meters and similar apparatus.

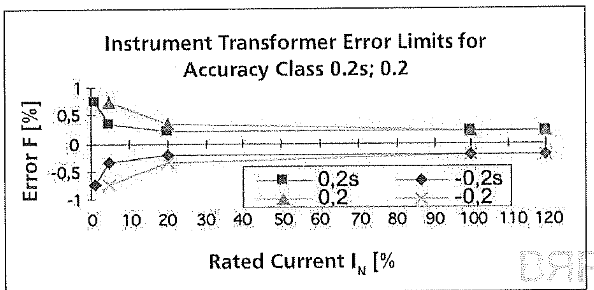
1.3.3.1 Accuracy Class

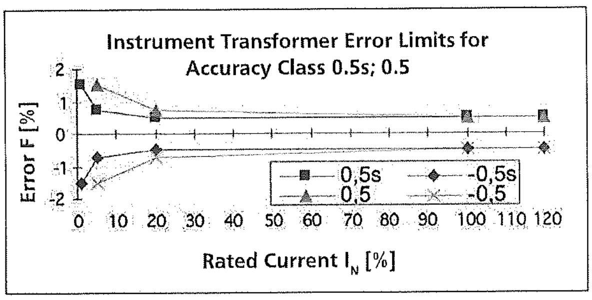
This is the limit of the permissible percentage of current error at the rated current. In general, the limits of current error are calculated for a range between 1% up to 120% of rated current.

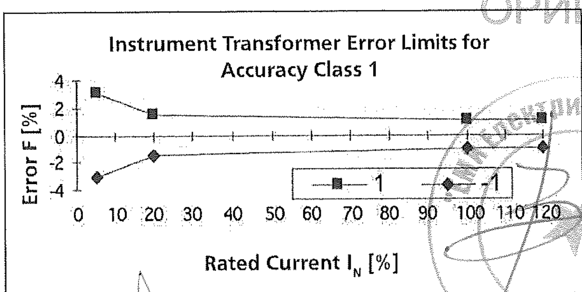
Permissible limits for current error (F_i) and phase displacement (δ_i) according to IEC 60044-1

Accuracy Class	± percentage of current error at percentage of rated current					± phase displacement in minutes at percentage of rated current				
	1	5	20	100	120	1	5	20	100	120
Measuring Current Transformers										
0,1	-	0,4	0,2	0,1	0,1	-	15	8	5	5
0,2S	0,75	0,35	0,2	0,2	0,2	30	15	10	10	10
0,2	-	0,75	0,35	0,2	0,2	-	30	15	10	10
0,5S	1,5	0,75	0,5	0,5	0,5	90	45	30	30	30
0,5	-	1,5	0,75	0,5	0,5	-	90	45	30	30
1	-	3,0	1,5	1,0	1,0	-	180	90	60	60
Protective Current Transformers										
5P	-	-	-	1	-	-	-	-	60	-
10P	-	-	-	3	-	-	-	-	-	-









1.3.4 Protective Current Transformer

A current transformer intended to supply protective relays. Protective current transformers are marked with the letter "P".

1.3.4.1 Special Request

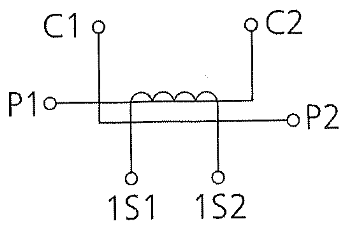
On request current transformers can be designed for higher extended current ratings than the standard value of 120%. Additional typical values are for example 150% and 200%. This means that accuracy is guaranteed at 150% or 200% of the rated primary current.

1.3.5 Reconnection of Current Transformer

In case of changeable ratios, for example extension of nominal rated current, it is possible to design the transformer with primary reconnection or secondary tapping.

1.3.5.1 Primary Reconnection

The primary reconnection can only be used for primary currents up to 2 x 600A and for current transformers which have a primary winding consisting of several primary turns. The ratio of the reconnection is always 1:2.



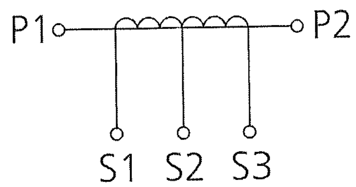
C1 – C2 low rated current P1/C1 – P2/C2 high rated current
Circuit Diagram Primary Reconnection

For primary reconnection, the primary winding consists of two winding sections (P1-C2 & C1-P2) which can either be connected in series or parallel. The changeover will be done at the primary side by using joint bars. In case of primary reconnection the rated burden, the accuracy, and the instrument security factor remains unchanged.

1.3.5.2 Secondary Tapping

For secondary tapping the secondary winding is wound on the iron core in two or more separate sections. The ends of these are connected to the secondary terminals. Changeover will be performed at the secondary side. In the case that the primary rated current should be changed to the lower current, the accuracy class between 0.2 and 3 will decrease at approximately the square value of the reduction in primary current. The ratings of the protective cores of class 5P or 10P decrease almost proportionally to the reduction of the primary current.

The values of the rated short time thermal current, as well as the dynamic current, remains the same at all ratios.

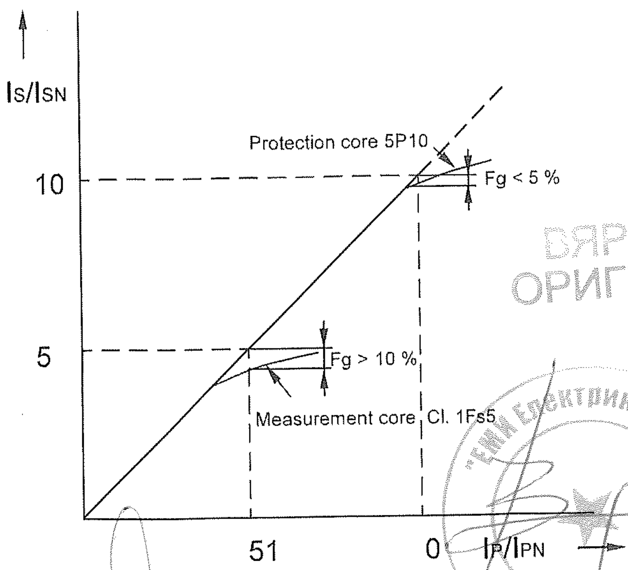


S1 – S3 high rated current S1 – S2 low rated current
Circuit Diagram Secondary Tapping

1.3.6 Over Current Range

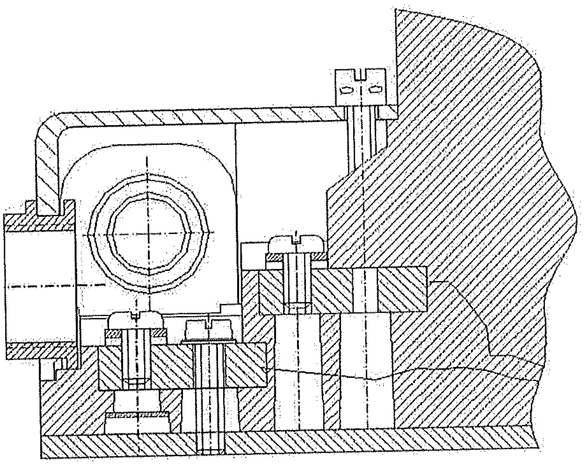
In the event of a system fault, the secondary rated current increases in proportion to the primary rated current up to the limit of the primary current.

The error limits will only be observed of the secondary burden is equal to the rated burden. If the burden is different to the rated burden, the instrument security factor will be changed.



1.3.7 Service and Grounding

The secondary winding must generally be connected to a burden or be short circuited at all times; otherwise dangerous high voltages can occur in the secondary terminals. One end of the secondary winding as well as all other metal parts of the transformer must be grounded.



Secondary terminal with grounding screw of a current transformer type ASS.

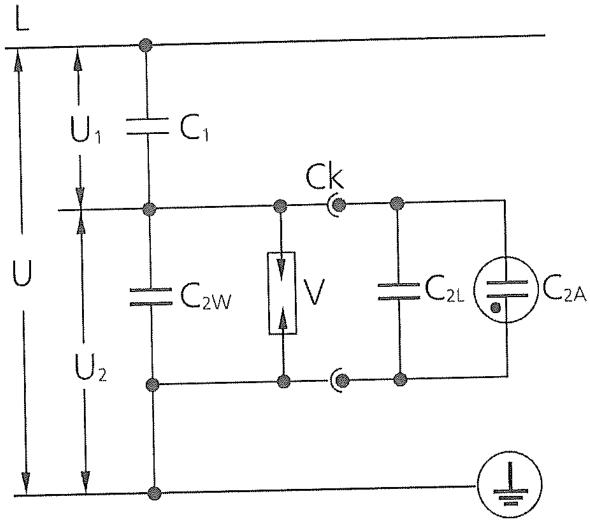
1.3.8 Capacitive Divider

With reference to the guidelines of the modern switch gear it is required, and it is common practice with respect to safe handling of the switch gear, that the doors and all coverings can only be opened after the panel is de-energized. This will be achieved by using a voltage indicator which is mounted in the front door of the panel.

The voltage indicator consists of a capacitive divider splitting the voltage U between phase and ground into two voltages, namely U1 and U2. An indicating device, which is connected between the terminal CK inside of the secondary terminal box and earth.

Indication range:
Smaller than 0,1 x U_N no indication
Equal or greater than 0,4 x U_N safe indication

All supporting type current transformers can be equipped with a capacitive divider.
The capacitive divider is embedded in the resin body. The capacity C_{2W} is connected to the terminal CK inside of the secondary terminal box. A surge arrester is connected between the terminals CK and earth and is intended to limit the output voltage.



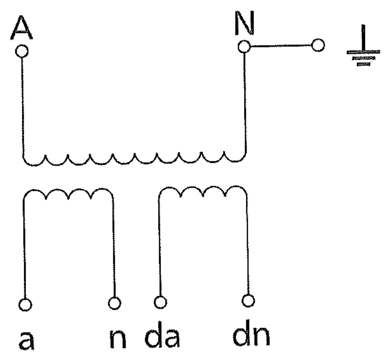
Circuit diagram capacitive divider

C_{2A}	voltage indicator
C_1	upper capacity
C_{2W}	lower capacity
C_{2L}	lead capacity
Ck	terminal
L	high voltage
U	line to ground voltage
U_1	partial voltage at C_1
U_2	partial voltage at C_2 (C_{2W} + C_{2L}+ C_{2A})
V	surge arrester

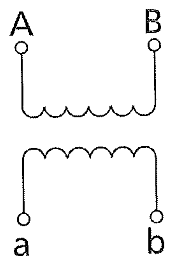
284

1.4 Voltage Transformer

Voltage transformers are transformers which convert high voltages into measurable and standardized voltages proportional and in-phase to the primary signal.
Voltage transformers have only one magnetic iron core with attached secondary winding (s).
Voltage transformers can be provided either as single pole or double pole insulated designs. An additional winding can be provided for single pole insulated transformers (da-dn) if necessary for an open delta circuit.



Schematic single pole insulated voltage transformer with an open delta winding



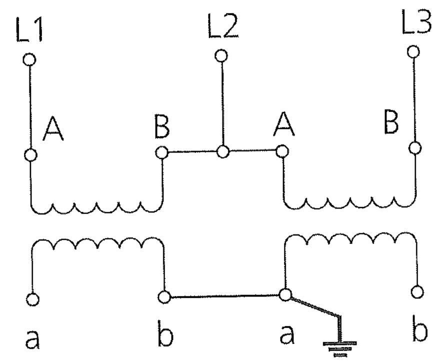
Schematic double pole insulated voltage transformer

It is extremely dangerous to short circuit a voltage transformer.

The end of the primary winding in single pole insulated transformers is grounded as „N" inside of the secondary terminal box, and must not be removed during operation.

1.4.1 V-Connection of Two Double Pole Insulated Voltage Transformers

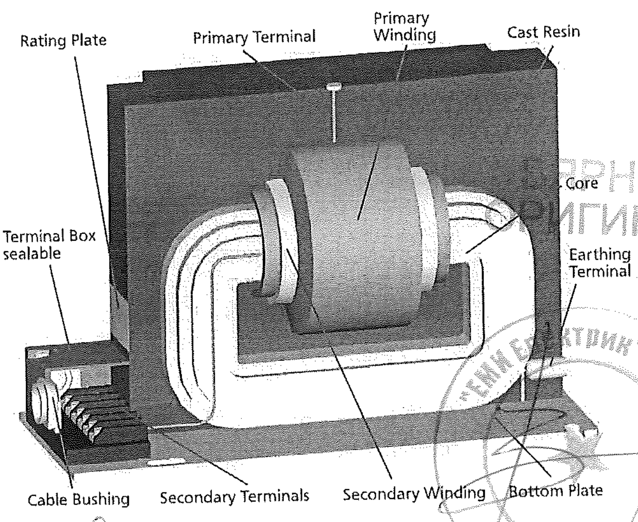
When using two double pole insulated transformers connected in „V-connection", it must be strictly observed that the secondary winding(s) of only one of the two transformers is grounded. This is in order to avoid a short circuit between these two transformers.



Schematic V-connection

1.4.2 General Design

Voltage transformers have only one magnetic iron core.
For single pole insulated voltage transformers the secondary winding(s) are attached directly to the grounded iron core.
In single pole insulated transformers the secondary winding(s) are directly attached to the grounded iron core. In double pole insulated voltage transformers the insulation between primary and secondary winding(s) has to be designed for one half of the phase to ground voltage.
The secondary windings are designed to withstand a test voltage of 3 kV against each other.



General design sample of a single pole voltage transformer

The high voltage winding as well as the secondary winding(s) are completely embedded in resin and casted in a single production step by using a pressure gelation casting process.

The resin body is mounted on a metal plate. The secondary terminals are embedded in the resin body and protected by a plastic box. The cover of the box is removable and can be sealed. Each secondary terminal can be separately grounded inside the secondary terminal box. The grounding screw is connected to the bottom plate. The terminal box is equipped with two or three removable cable plugs, which makes wiring easier.

The end(s) of the primary winding are provided with inserts (M10) made of copper or brass alloy, and located at the top of the resin body.

A M8 grounding screw is available on the bottom plate for grounding the voltage transformer. Grounding can take place directly on the frame of the switchgear or on a separate grounding bar.

1.4.3 Definitions

1.4.3.1 Highest Voltage for Equipment

The highest r.m.s. phase to phase voltage for which a transformer is designed with respect to its insulation.

1.4.3.2 Rated Primary and Secondary Voltage

The value of the primary and secondary voltage, which appears in the designation of the transformer, and on which its performance is based. The values are indicated in the transformer rating plate.

1.4.3.3 Rated Transformation Ratio

The ratio of the rated primary voltage to the rated secondary voltage.

1.4.3.4 Limits of Voltage Error and Phase Displacement

The voltage error (Fu) and phase displacement (δu) at the rated frequency shall not exceed the values given in the following table at any voltage between 80% and 120% of rated voltage, and with burdens between 25% and 100% of the rated burden and a power factor of 0.8.

accuracy class	± voltage error (%)	± phase displacement (minutes)
0,2	0,2	10
0,5	0,5	20
1	1	40

1.4.3.5 Rated Output

The value of the apparent power (in VA at a specified power factor), which the transformer is intended to supply to the secondary circuit at the rated secondary voltage, and with rated burden connected to it.

1.4.3.6 Rated Burden

The apparent resistance of the connected burden including the wiring on which the accuracy requirements are based.

1.4.3.7 Thermal Limiting Output

The value of the apparent power with reference to the rated voltage, which can be taken from a secondary winding at the applied rated primary voltage, without exceeding the limitations of the rise in temperature.

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286

1.4.3.8 Rated Thermal Limiting Output of the Residual Voltage Winding

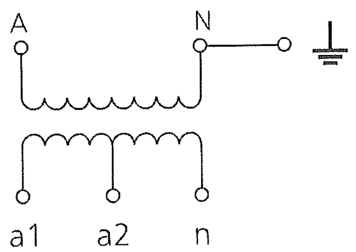
The thermal limiting output of the residual winding shall be specified in volt ampere (VA) in relation to the secondary voltage with the unit power factor. The preferred values are given in the IEC-Standard.
Since the residual windings are connected in an open delta circuit, these windings are only loaded under fault conditions. Therefore, a maximum duration of 8 hours for example, can be chosen.

1.4.3.9 Rated Voltage Factor

The rated voltage factor is determined by the maximum operating voltage depending on the system grounding conditions. In single pole insulated transformers, it is common practice to use a rated voltage factor of 1,9 x the rated voltage for a load duration of 8 hours. The rated factor is defined as 1,2 · UN for all other types.

1.4.3.10 Reconnection of Voltage Transformer

Due to dielectric reasons the reconnection of a voltage transformer is only possible by secondary tapping.

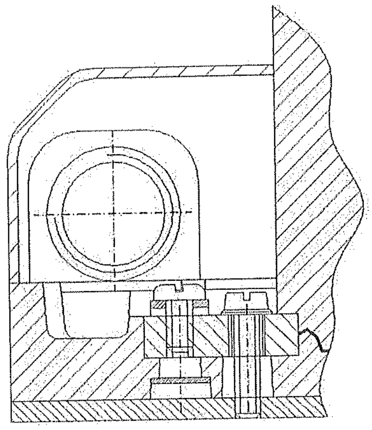


The ends of the winding are connected to the secondary terminals. Changeover will be performed at the secondary side. In the case that the primary rated voltage is to be changed to the lower voltage, the accuracy class remains unchanged. The rated burden decreases at approximately the square value of the reduction in the primary voltage.

1.4.4 Service and Grounding

Contrary to current transformers, voltage transformers must never be short circuited to the secondary side. The "N" terminal is grounded to the bottom plate in the secondary terminal box and may never be removed when in service.

Each secondary terminal can be grounded inside the secondary terminal box.



Secondary part with earthing terminal of the voltage transformer types VES/VEN

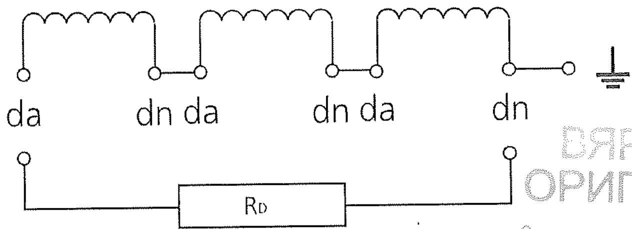
1.4.5 Ferroresonances

In electrical installations ferroresonances can occur if the following criteria are present:

- Use of single pole insulated voltage transformer
- The network is ungrounded (insulated neutral starpoint)
- Voltage surges caused by prior switching operations

In such a case an oscillating circuit between the earth capacity (C_e) and the transformer inductance (L_w) will occur, which will lead to a very intensive voltage increase and subsequently, saturation of the iron core of the transformer. Overheating of the iron core as well as the materials used inside the primary winding is the consequence. The high temperature leads to the destruction of the resin matrix. Flashover of the high voltage to the grounded iron core and the secondary winding will occur. The resulting pressure increase inside the resin body leads to bursting of the resin body.

To avoid such damage the transformers can be equipped with a residual winding connected in an open delta circuit and equipped with a dumping device (resistor, reactor or a combination of the two). The design of this device depends on the thermal limiting output of the residual winding.



Attention: To avoid a secondary short circuit it must be strictly observed that the open delta circuit is only grounded once.

1.5 Service Conditions

All current and voltage transformers are designed in accordance with the conditions described in the international standards.

The transformers are classified in two categories as given in the following table.

Transformers for indoor applications

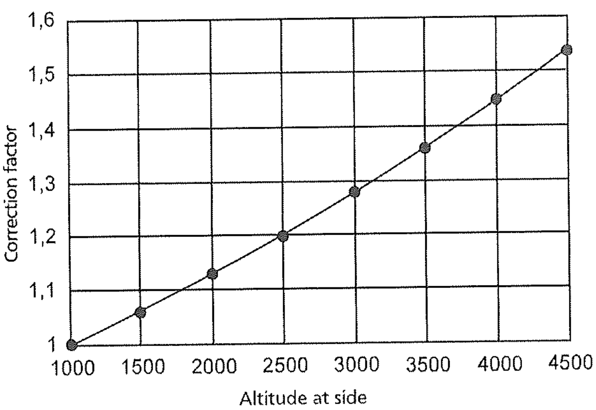
- Lowest temperature - 5°C
- Highest temperature + 40°C
- Relative humidity/24 hours 95%
- Relative humidity/months 90%

Transformers for outdoor applications

- Lowest temperature -25/-40°C
- Highest temperature + 40°C
- Relative humidity 100%

1.5.1 Altitude

For an installation at an altitude higher than 1000 meters the arcing distance under the standardized reference atmospheric conditions shall be determined by multiplying the withstand voltages required at the service location by a factor „K_a" in accordance with the following table.



Altitude correction factor

Formula

$$U_k \geq U \cdot K_a$$

U BIL under atmospheric reference

U_k BIL under service location

K_a altitude correction factor according to the above graph

Example:

For a BIL of 75 kV (1,2/50 µs) at 2500 meters above sea level a corrected value of 90 kV must be chosen. (75 kV · 1,2 = 90 kV)

1.6 Test Voltages and Insulation Levels for Instrument Transformers

In order to guarantee safe operation of an instrument transformer throughout its designed lifetime, the following test must be carried out during type tests and routine tests.

- Rated lightning impulse withstand voltage test (type test)
- Power frequency withstand voltage test on primary and secondary windings (routine test)
- Partial discharge test (routine test)
- Determination of errors (routine test)

Highest voltage for equipment [kV]	Power frequency voltage [kV]	Lightning impulse voltage [kV]
7,2	20	60
12	28	75
17,5	38	95
24	50	125
36	70	170

1.7 Insulation Class

Most of the instrument transformers are designed for the insulation class „E" as described in the IEC-standard, whereby the absolute maximum temperature is 115 °C.

The maximum temperature increase must not exceed 75° K at an ambient temperature of 40 °C.

ВЯРНО С ОРИГИНАЛА

На основание чл.36а ал.3 от ЗОП