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IEC 61869-11: 2017

INSTRUMENT TRANSFORMERS –

Part 11: Additional requirements for low-power passive voltage transformers

ICS 17.220.20

Saudi Standards, Metrology and Quality Org (SASO)

Foreword

The Saudi Standards ,Metrology and Quality Organization (SASO) has adopted the International standard No. IEC 61869-11: 2017 “INSTRUMENT TRANSFORMERS –Part 11: Additional requirements for low-power passive voltage transformers” issued by the international Electrotechnical Commission(IEC). The text of this international standard has been translated into Arabic so as to be approved as a Saudi standard without introducing any technical modification.

CONTENTS

INTRODUCTION

Low-power passive voltage transformers are based on the voltage divider principle. They can be built for example as resistive dividers, capacitive dividers or resistive-capacitive dividers. Annex 11C shows the schematic diagram of the different dividers.

According to a general block diagram given in Figure 601 of IEC 61869-6:2016, the low-power passive voltage transformers do not use an active primary converter (i.e. without any active electronic component); therefore, there is no need for primary power supply. Additionally, neither the secondary converter nor the secondary power supply is used.

The general block diagram of a low-power passive voltage transformer is given in Figure 1101.

The applied technology decides which part is necessary for the realization of a low-power passive voltage transformer, i.e. it is not necessary that the transmitting cable or primary converter described in Figure 1101 be included in the low-power passive voltage transformer.

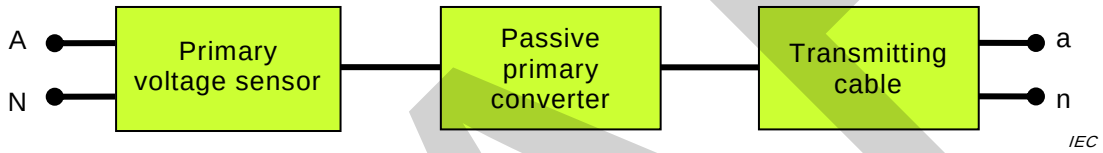

Figure 1101 – General block diagram of a single-phase low-power passive voltage transformer

INSTRUMENT TRANSFORMERS –

Part 11: Additional requirements for low-power passive voltage transformers

1 Scope

This part of IEC 61869 is a product standard and covers only additional requirements for low-power passive voltage transformers (passive LPVT). The product standard for low-power passive voltage transformers is composed of IEC 61869-1, along with IEC 61869-6 and this document with specific requirements.

This document is applicable to newly manufactured low-power passive voltage transformers with analogue output having rated frequencies from 15 Hz to 100 Hz for use with electrical measuring instruments or electrical protective devices.

This document covers low-power passive voltage transformers used for measurement or protection and low-power passive voltage transformers used for both measurement and protection.

Low-power passive voltage transformers have analogue output only (for digital output or for technology using any kind of active electronic components refer to future IEC 61869-7[1]). Such low-power passive voltage transformers can include the secondary signal cable (transmitting cable). The secondary voltage of the low-power passive voltage transformer is proportional to the primary voltage. Derivative output signals are not within the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Clause 2 of IEC 61869-6:2016 is applicable with the following additions:

IEC 61869-6:2016, *Instrument transformers – Part 6: Additional general requirements for low-power instrument transformers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61869-1 and IEC 61869-6 apply with the following additions and modifications:

3.1 General definitions

3.1.613
transmitting system
Definition 3.1.613 of IEC 61869-6:2016 is applicable with the following addition:

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1 Under preparation.

Note 1101 to entry: For low-power passive voltage transformers the transmitting system is just a transmitting cable.

3.1.621
output signal
Definition 3.1.621 of IEC 61869-6:2016 is applicable with the following modification:

Note 1 to entry: In an electrically steady-state condition, the output signal is defined by the following equation:

$$u_s(t) = U_s \sqrt{2} \sin(2\pi f t + \varphi_s) + u_{sres}(t)$$

where

$u_s(t)$ is the output signal in steady state condition;

U_s is the RMS value of secondary voltage, when $u_{s\,res}(t) = 0$;

f is the fundamental frequency;

φ_s is the secondary phase;

$u_{s\,res}(t)$ is the secondary residual voltage including harmonic, sub-harmonic and interharmonic components;

t is the instantaneous value of the time;

f, U_s, φ_s are constant for steady-state condition.

3.1.1101
voltage divider
device comprising resistors, inductors, capacitors (or a combination of these components) such that, between two points of the device, a desired fraction of the voltage applied to the device as whole can be obtained

[SOURCE: IEC 60050-312:2001, 312-02-32, modified – transformer deleted]

3.1.1102
high-voltage resistor
R_1
resistor connected between the high-voltage terminal and the intermediate-voltage secondary terminal of a voltage divider

3.1.1103
high- voltage capacitor
C_1
capacitor connected between the high-voltage terminal and the intermediate-voltage secondary terminal of a voltage divider

[SOURCE: IEC 60050-436:1990, 436-02-12]

3.1.1104
low- voltage resistor
R_2
resistive part of an R- or RC-divider between the secondary terminals

3.1.1105
low-voltage capacitor
C_2
capacitive part of a C- or RC-divider between the secondary terminals

3.1.1106
voltage limitation device
device connected in parallel to the secondary terminals to limit overvoltage

3.2 Definitions related to dielectric ratings and voltages

3.2.1101
rated voltage factor
F_V
multiplying factor to be applied to the rated primary voltage to determine the maximum voltage at which a transformer must comply with the relevant thermal requirements for a specified time and with the relevant accuracy requirements

[SOURCE: IEC 60050-321:1986, 321-03-12]

3.4 Definitions related to accuracy

3.4.3
ratio error
ε
Definition 3.4.3 of IEC 61869-1:2007 is applicable with the following addition:

Note 1101 to entry: The ratio error, expressed in percent, is given by the following formula:

$$\varepsilon = \frac{K_r \cdot U_s - U_p}{U_p} \times 100\ \%$$

where

K_r is the rated transformation ratio;

U_p is the RMS value of the primary voltage;

U_s is the RMS value of the secondary voltage.

This definition is only related to the rated frequency component of both the primary and secondary signal.

3.4.602
rated delay time
t_{dr}
Not applicable.

3.4.1101
ratio correction factor
CF_U
factor by which the rated transformation ratio evaluated at rated burden and rated frequency of an individual passive LPVT is to be multiplied to achieve the specified accuracy class

3.4.1102
corrected transformation ratio
K_{cor}
individual transformation ratio of a passive LPVT

Note 1 to entry: The relationship between the corrected transformation ratio and the rated ratio correction factor is:

$$K_{cor} = CF_U \cdot K_r$$

3.4.1103
phase offset correction
$\varphi_{o\,cor}$
value to be added to the rated phase offset evaluated at rated burden and rated frequency of an individual passive LPVT to achieve the specified accuracy class

3.4.1104
corrected phase offset

$\varphi_{cor\ \varphi o}$
individual phase offset of a passive LPVT

Note 1 to entry: The relationship between corrected phase offset and phase offset correction is:

$$\varphi_{cor_{\varphi o}} = \varphi_{o_{cor}} + \varphi_{or}$$

3.4.1105
corrected ratio error

$\varepsilon_{cor\ U}$
ratio error of an individual passive LPVT corrected by the factor defined in 3.4.1102

Note 1 to entry: The corrected ratio error is calculated by the formula:

$$\varepsilon_{cor_U}(\%) = \frac{CF_U \cdot K_r \cdot U_s - U_p}{U_p} \times 100$$

where

CF_U is the ratio correction factor of the individual passive LPVT.

3.4.1106
corrected phase error

$\varphi_{e\ cor}$
phase error of an individual passive LPVT corrected by the value defined in 3.4.1104

Note 1 to entry: The corrected phase error is given by the formula:

$$\varphi_{e_{cor}} = \varphi_s - \varphi_p - \varphi_{cor_{\varphi o}}$$

3.7 Index of abbreviations and symbols

Subclause 3.7 of IEC 61869-1:2007 is replaced by the following:

C_1	high-voltage capacitor of a divider
C_2	low-voltage capacitor of a divider
CF_U	correction factor
F	mechanical load
f_r	rated frequency
F_V	rated voltage factor
K	actual transformation ratio
K_{cor}	corrected transformation ratio
K_r	rated transformation ratio
LPIT	low-power instrument transformer
LPVT	low-power voltage transformer
R_1	high-voltage resistor of a divider
R_2	low-voltage resistor of a divider
R_{br}	rated burden

U_m	highest voltage for equipment
U_{pr}	rated primary voltage
U_{sr}	rated secondary voltage
U_{sys}	highest voltage for system

ε	ratio error
$\varepsilon_{cor\ U}$	corrected ratio error
$\varepsilon_U(t)$	instantaneous voltage error for transient conditions

φ_e	phase error
φ_o	phase offset
$\varphi_{o\ cor}$	phase offset correction
φ_{or}	rated phase offset
$\Delta\varphi$	phase displacement
$\varphi_{e\ cor}$	corrected phase error
$\varphi_{cor\ \varphi o}$	corrected phase offset

5 Ratings

5.3 Rated insulation levels and voltages

5.3.5 Insulation requirements for secondary terminals

Subclause 5.3.5 of IEC 61869-6:2016 is applicable with the following addition:

For rated secondary voltage > 10 V the test voltage is 3 kV regardless of the cable length.

5.3.601 Rated auxiliary power supply voltage (U_{ar})

Not applicable.

5.5 Rated output

5.5.601 Rated burden (R_{br})

Subclause 5.5.601 of IEC 61869-6:2016 is applicable with the following addition:

The cable included in the LPVT shall not be changed/modified in order to preserve the specified characteristics of the device.

5.5.602 Standard values for rated delay time (t_{dr})

Not applicable.

5.6 Rated accuracy class

5.6.1101 Accuracy based on the rated transformation ratio and rated phase offset

Ratio error ε is calculated according to the formula in Note 1101 of definition 3.4.3. No correction for individual characteristics of the passive LPVT is done.

5.6.1102 Accuracy based on individual corrected transformation ratio and corrected phase offset

As alternative to the accuracy based on the rated transformation ratio and rated phase offset, for passive LPVT the compliance to the accuracy class can be based on the individual corrected transformation ratio or individual ratio correction factor and the individual corrected phase offset or individual phase offset correction.

Corrected ratio error $\varepsilon_{\text{cor U}}$ is calculated according to the formula in Note 1 of definition 3.4.1105. The correction factor CF_{U} shall be in the range of 0,900 to 1,100 and specified with the suitable accuracy and number of decimals according to the relevant accuracy class (with a minimal resolution of 0,001).

The corrected phase error is calculated according to the formula in Note 1 of definition 3.4.1106. For passive LPVT the individual corrected phase offset $\varphi_{\text{cor φo}}$ replaces the rated phase offset φ_{or}. Since rated delay time for passive LPVT is not applicable, φ_{tdr} is zero. The phase offset correction shall be in the range of ± 300 min and specified with the suitable accuracy and number of decimals according to the relevant accuracy class (with a minimal resolution of 1 min).

If the accuracy is based on the individual correction, the correction factors or the corrected transformation ratio and the corrected phase offset shall be indicated on the rating plate. Additional information on the designation of the accuracy class using the corrected transformation ratio and the ratio correction factor is given in Annex 11B.

5.6.1103 Accuracy requirements for measuring low-power passive voltage transformer

5.6.1103.1 Accuracy class designation

For measuring passive LPVT, the accuracy class is designated by the highest permissible percentage of the ratio error at rated primary voltage and with rated burden.

5.6.1103.2 Standard accuracy classes

The standard accuracy classes for metering low-power passive voltage transformers are:

0,1 – 0,2 – 0,5 – 1,0 – 3,0

5.6.1103.3 Limits of ratio error and phase error

The ratio error and phase error shall not exceed the values given in Table 1101 for the appropriate accuracy class at any voltage between 80 % and 120 % of the rated voltage and at any value of temperature and frequency within the reference ranges and connected to a burden within the range of:

– ± 5 % of the resistive part of rated burden, and
– between 0 % and 100 % of the capacitive part of the rated burden.

Table 1101 – Limits of ratio error and phase error for measuring LPVT

Accuracy class	Percentage ratio error ε, $\varepsilon_{cor\ U}$ ± %			Phase error φ_e, $\varphi_{cor\ \varphi o}$ ±					
				Minutes			Centiradians		
	at voltage (% of rated)			at voltage (% of rated)			at voltage (% of rated)		
	80	100	120	80	100	120	80	100	120
0,1	0,1	0,1	0,1	5	5	5	0,15	0,15	0,15
0,2	0,2	0,2	0,2	10	10	10	0,3	0,3	0,3
0,5	0,5	0,5	0,5	20	20	20	0,6	0,6	0,6
1,0	1,0	1,0	1,0	40	40	40	1,2	1,2	1,2
3,0	3,0	3,0	3,0	Not specified			Not specified		

5.6.1103.4 Accuracy requirements on harmonics

If there are requirements for harmonics, the accuracy requirements on harmonics, given in Annex 6A of IEC 61869-6:2016, are applicable even though the improvement of the relevant test procedures given there is under consideration by IEC TC38.

5.6.1104 Accuracy requirements for protective and multipurpose low-power passive voltage transformers

5.6.1104.1 Accuracy class designation

The accuracy class for a protective and multipurpose low-power passive voltage transformer is designated by the highest permissible percentage of the ratio error specified for the accuracy class concerned, from 2 % of rated voltage to a voltage corresponding to the rated voltage factor (see 5.1102) followed by the letter “P”.

5.6.1104.2 Standard accuracy classes

The standard accuracy classes for:

– multipurpose low-power passive voltage transformers are "0,1P", "0,2P”, "0,5P" and "1P"

– protective low-power passive voltage transformers are "3P" and "6P“.

Multipurpose low-power voltage transformers with their extended range of accuracy are generally suitable for residual voltage measurement based on the sum of the three-phase voltages.

5.6.1104.3 Limits of ratio error and phase error

The ratio error and phase error shall not exceed the values given in Table 1102 for the appropriate accuracy class at any value of temperature and frequency within the reference ranges and connected to a burden within the range of:

– ± 5 % of the resistive part of rated burden, and

– between 0 % and 100 % of the capacitive part of the rated burden.

Table 1102 – Limits of ratio error and phase error for protection and multipurpose LPVT

U		Phase error φ_e, $\varphi_{cor\ \varphi o}$						
		± minutes						
ed)		at voltage (% of rated)						
100	F_v x100	2	20	80	100	F_v x100	2	
0,1	0,1	20	10	5	5	5	0,6	
0,2	0,2	40	20	10	10	10	1,2	
0,5	0,5	80	40	20	20	20	2,4	
1	1	160	80	40	40	40	4,8	
3	3	240	120	120	120	120	7	
6	6	480	240	240	240	240	14	

's sizing rules and application requirements. LPVT accuracy class 0,1P could be recommended for power systems earthed with Petersen coil while LPVT

5.1101 Standard values of rated voltages

5.1101.1 Rated primary voltages U_{pr}

The standard values of the rated primary voltage of a low-power passive voltage transformer connected between one line of a three-phase system and earth shall be $1/\sqrt{3}$ times the values of the rated system voltage.

Preferred values are given in IEC 60038.

A range of rated primary voltages can be assigned to an LPVT. In this case the accuracy specification is applicable to the assigned primary voltage range, and the voltage factor F_V is applied to the highest value of this range.

NOTE The performance of a low-power passive voltage transformer as a measuring or protection transformer is based on the rated primary voltage U_{pr} whereas the rated insulation level is based on the highest voltages for equipment U_m.

5.1101.2 Rated secondary voltages U_{sr}

The standard RMS values of rated secondary voltage U_{sr} are:

$$3{,}25/\sqrt{3}\ \text{V},\ 100/\sqrt{3}\ \text{V}$$

For LPVT used for a range of rated primary voltages, the rated secondary voltage has to correspond to one of the rated primary voltages, or alternatively a rated transformation ratio (e.g. 10'000/1) may be used.

5.1102 Standard values of rated voltage factor F_V

The voltage factor is determined by the maximum operating voltage which, in turn, is dependent on the system earthing conditions.

The standard voltage factors appropriate to the different earthing conditions are given in Table 1103, together with the permissible duration of maximum operating voltage (i.e. rated time).

Table 1103 – Standard values of rated voltage factors

Rated voltage factor F_V	Rated time	Method of connecting the primary terminal and system earthing conditions
1,2	Continuous	Between phase and earth in an effectively earthed neutral system (3.2.7 a) of IEC 61869-1:2007)
1,5	30 s	
1,2	Continuous	Between phase and earth in a non-effectively earthed neutral system (3.2.7 b) of IEC 61869-1:2007) with automatic earth-fault tripping.
1,9	30 s	
1,2	Continuous	Between phase and earth in an isolated neutral system (3.2.4 of IEC 61869-1:2007) without automatic earth-fault tripping or in a resonant earthed system (3.2.5 of IEC 61869-1:2007) without automatic earth-fault tripping.
1,9	8 h	
Reduced rated times are permissible by agreement between manufacturer and user. The maximum operating voltage of an LPVT shall be lower than or equal to the highest voltage for equipment $U_m/\sqrt{3}$ or the rated primary voltage U_{pr} multiplied by the rated voltage factor 1,2 for continuous service, whichever is the lowest.		

6 Design and construction

6.11 Electromagnetic compatibility (EMC)

6.11.3 Requirements for immunity

Not applicable.

6.11.601 Emission requirements

Subclause 6.11.601 of IEC 61869-6:2016 is applicable with the following additions:

As a consequence, no further emission requirement is specified for passive LPCT in addition to Radio Interface Voltage (RIV) test and Transmitted Overvoltage (TOV) test.

6.13 Markings

6.13.1101 Terminal markings – General rules

The markings shall identify

a) the primary and secondary terminals;

b) the relative polarities of terminals.

6.13.1102 Method of marking

The primary terminals shall be marked clearly and indelibly, either on their surface or in their immediate vicinity. If possible, the secondary terminals shall be identified clearly and indelibly, either on the surface of the passive LPVT or in case of integrated cable with connector, in the immediate vicinity of the connector. If not possible, the manufacturer shall in any case provide relevant information in the product documentation.

The marking shall consist of letters followed or preceded, where necessary, by numbers.

6.13.1103 Terminal markings

Terminal markings shall be in accordance with Figure 1102.

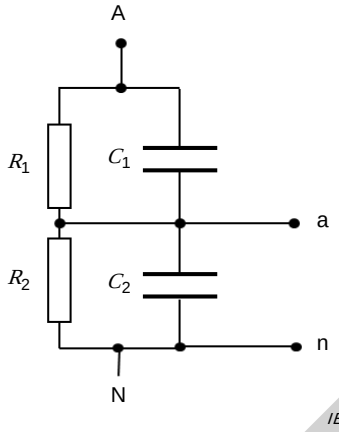


Figure 1102 – Terminal markings for passive LPVT

NOTE For other types of LPVT, see Annex 11C.

6.13.1104 Rating plate markings

In addition to those markings defined in IEC 61869-1:2007, 6.13, and IEC 61869-6:2016, 6.13, all low-power passive voltage transformers shall carry the following rating plate markings:

a) the rated primary and secondary voltage (e.g. 20/√3 kV / 3,25/√3 V) or if applicable the rated transformation ratio (e.g. 10 000/1);

b) the range of rated primary voltages if applicable (e.g. 10/√3 kV to 30/√3 kV);

c) the rated voltage factor and corresponding rated time (e.g. F_V = 1,9 /8 h);

d) the serial number of capacitor units if applicable (e.g. in high-voltage application);

e) primary and secondary resistance and capacitance (for U_m ≥ 72,5 kV);

f) rated burden and accuracy class based on the rated and the corrected transformation ratio, if applicable;

EXAMPLE 1 2 MΩ/50 pF class 0,2 for measuring passive LPVT.

EXAMPLE 2 2 MΩ/50 pF class 3P for protective passive LPVT.

g) the ratio correction factor or the corrected transformation ratio, if needed for the declared accuracy class (e.g. CF_U = 0,965 or K_{cor} = 10 005 V/V);

h) rated phase offset (e.g. φ_{or} = 0°);

i) the phase offset correction, or the corrected phase offset if needed for the declared accuracy class (e.g. $\varphi_{o\ cor}$ = 52 min or $\varphi_{cor\ \varphi o}$ = 52 min).

6.601 Requirements for optical transmitting system and optical output link

Not applicable.

6.602 Requirements for electrical transmitting system and electrical wires for output link

6.602.1 Connectors

Subclause 6.602.1 of IEC 61869-6:2016 is applicable with the following addition:

Pin assignment for passive LPVT using connector type RJ45 is given in Table 1104.

Table 1104 – Pin assignment for RJ45 connectors used in passive LPVT

RJ 45 connector for:	Pin:	1	2	3	4	5	6	7	8
Passive LPVT								a	n
Reserved for LPCT		S1	S2						
Reserved for TEDS				+			-		
Reserved for power supply					+	-			

For secondary voltages > 10 V the following connections shall be used:

– screwed terminals

– coaxial or triaxial connector plugs or sockets, with terminal “a” in the central conductor

NOTE In case of more than one secondary output each output signal is connected with a separate cable and connector.

6.603 Signal-to-noise ratio

Not applicable.

6.604 Failure detection and maintenance announcement

Not applicable.

6.605 Operability

Not applicable.

6.606 Reliability and dependability

Not applicable.

6.1101 Transient response requirements

6.1101.1 General

The transient response performance for passive LPVT is based on Annex 6C in IEC 61869-6:2016.

A primary short-circuit test gives information on low frequency behaviour and the step response test gives information on high frequency behaviour. Depending on the application and the available test facility, one or the other test can be performed to show the transient behaviour.

6.1101.2 Primary short-circuit

Following a short-circuit of the primary voltage, the secondary voltage of the passive LPVT shall decay, within 500 µs, to a value of less than 10 % of the peak value before short-circuit.

6.1101.3 Step response

The step response time shall be lower than 500 µs.

The test procedures are given in 7.4.1102.3.

6.1102 Voltage limitation device requirements

The passive LPVT may include voltage limitation devices (e.g. spark-gaps or other kind of surge arresters, etc.).

The lightning impulse breakdown voltage of a spark-gap or the protection level of surge arresters has to be lower than 5 kV.

The AC breakdown voltage of a spark-gap or the protection level of surge arresters has to be higher than 3 times the rated secondary voltage times the voltage factor F_V of the passive LPVT.

7 Tests

7.1 General

7.1.2 List of tests

Subclause 7.1.2 of IEC 61869-6:2016 is applicable with the following modified Table 10:

Table 10 – List of tests

Tests	Clause/subclause
Type tests	**7.2**
Temperature-rise test	7.2.2
Impulse voltage withstand test on primary terminals	7.2.3
Wet test for outdoor type transformers	7.2.4
Electromagnetic compatibility tests (RIV test)	7.2.5
Test for accuracy	7.2.6
Verification of the degree of protection by enclosures	7.2.7
Enclosure tightness test at ambient temperature	7.2.8
Pressure test for the enclosure	7.2.9
Low-voltage component voltage withstand test	7.2.601
Chopped impulse voltage withstand test on primary terminals	7.4.1
Routine tests	**7.3**
Power-frequency voltage withstand tests on primary terminals	7.3.1
Partial discharge measurement	7.3.2
Power-frequency voltage tests on secondary terminals	7.3.4
Test for accuracy	7.3.5
Verification of markings	7.3.6
Enclosure tightness test at ambient temperature	7.3.7
Pressure test for the enclosure	7.3.8
Measurement of capacitance and dissipation factor at power frequency	7.3.1101
Resistance measurement	7.3.1102
Special tests	**7.4**
Multiple chopped impulse test on primary terminals	7.4.2
Transmitted overvoltage test	7.4.4
Mechanical tests	7.4.5
Internal arc fault test	7.4.6

Enclosure tightness test at low and high temperatures	7.4.7
Gas dew point test	7.4.8
Corrosion test	7.4.9
Fire hazard test	7.4.10
Vibration tests	7.4.601
Tests for accuracy versus harmonics and low frequencies	Annex 6A, 6A.5
Frequency response measurements	7.4.1101
Transient response test	7.4.1102
Sample tests	**7.5**

7.1.1101 Passive LPVT integrated in other equipment

For specific application where the passive LPVT is integrated in other equipment (such as separable connectors, bushings, terminations, etc.) test voltages and procedures of the relevant standards for this equipment shall be taken into account. This topic is under consideration in TC 38.

7.2 Type tests

7.2.2 Temperature-rise test

7.2.2.1101 General

The test shall be performed on the complete low-power passive voltage transformer. The temperature-rise test shall be performed with the rated burden. The temperature shall be recorded. If a range of rated primary voltage is assigned to the LPVT then the higher range value shall be considered for the temperature-rise test.

The test site ambient temperature shall be between +10 °C and +30 °C.

7.2.2.1102 Test procedure

The low-power passive voltage transformers shall be tested in accordance with item a) and in combination with item b) or item c) as described below.

a) All low-power passive voltage transformers irrespective of rated voltage factor and time rating shall be tested at 1,2 times the rated primary voltage. The test shall be continued until the temperature of the divider has reached a steady state. The low-power passive voltage transformer is considered to be in steady state condition when the rate of temperature rise does not exceed 1 K/h.

b) Low-power passive voltage transformers, having a rated voltage factor of 1,5 for 30 s or 1,9 for 30 s, shall be tested at their respective rated voltage factor for 30 s starting immediately after a).

c) Low-power passive voltage transformers, having a rated voltage factor of 1,9 for 8 h, shall be tested at 1,9 times the rated voltage for 8 h starting immediately after a).

The ambient temperature (reference) shall be measured by thermometers or thermocouples immersed in equivalent insulation material, so that the reference and the test object have a similar thermal time constant.

The temperature shall be measured on different locations of the equipment, including surfaces and, if necessary, non-accessible parts (the choice of the locations shall be made according to the manufacturer indication, for example considering LPVT thermal model, measurements, etc.).

NOTE Other methods to measure the temperature (for instance pressure variation, capacitance variation) which give an average temperature value can be defined between purchaser and manufacturer.

For all three items (a, b, c), the acceptance criterion is that the temperature rise shall not exceed the values given in Table 5 of IEC 61869-1:2007.

7.2.5 Electromagnetic compatibility tests

7.2.5.2 Immunity test

Not applicable.

7.2.5.601 EMC emission tests

Not applicable.

7.2.6 Test for accuracy

7.2.6.601 General

Subclause 7.2.6.601 of IEC 61869-6:2016 is applicable with the following addition:

The correction factor and phase offset declared in the rating plate shall be used for all accuracy tests. CF_U = 1 is considered if it is not declared on the rating plate.

In case the input impedance of the reference measuring equipment is not considered as being part of the rated burden used for accuracy verification, the variation of the total burden impedance caused by the reference measuring equipment shall be within ± 0,5 % of the rated burden.

7.2.6.602 Basic accuracy tests

Subclause 7.2.6.602 of IEC 61869-6:2016 is replaced by the following:

To prove compliance with the specified accuracy class, tests shall be made at each value of the input signal given in 5.6 at the rated frequency and at ambient temperature, unless otherwise specified.

The tests shall be made with each burden listed in Table 1105:

Table 1105 – Burden values for basic accuracy tests

Resistance	Capacitance
Rated value	0[a)]
Rated value	Rated value
Rated value +5 %	Rated value
Rated value –5 %	Rated value

NOTE The burden values during test include the impedance of the test equipment.

[a)] Only inherent capacitance of test equipment which shall be not more than 10 pF.

In a first step, the accuracy shall be measured in a short time (less than 0,05 times the thermal time constant) at ambient temperature with increasing voltages according to values in Tables 1101 and 1102.

Then the voltage is set to the rated primary voltage U_{pr} and maintained up to the thermal stabilization and then the accuracy is measured again. In case of a defined range of primary voltage the highest level shall be used.

The errors shall be within the limits of the relevant accuracy class both at the time of applying the test voltage and after thermal stabilization.

The accuracy variation between the two measurements shall be noted in the type test report, as a characteristic of the passive LPVT.

NOTE 1101 The stability is considered after a delay of 3 times the thermal time constant which is defined by the manufacturer or determined during the temperature-rise test.

NOTE 1102 This test can be performed in combination with the temperature-rise test, or can be combined with the temperature cycle accuracy test in 7.2.6.603

7.2.6.605 Test for accuracy in relation to replacement of components

Not applicable.

7.2.6.1101 Test for impact of electric field from other phases

The purpose of this test is to verify the influence of the electric fields at rated frequency emitted by other phases.

The test shall be performed in a configuration representing the real installation. The test can be performed in three-phase or single-phase. Test arrangement and procedure are given in Annex 11A.

7.2.601 Low-voltage component voltage withstand test

Subclause 7.2.601 of IEC 61869-6:2016 is replaced by the following:

A low-voltage component of passive LPVT is the low-voltage part of RC-dividers or C-dividers with U_m > 72,5 kV when placed outside the main housing (external low-voltage part) as shown in Figure 1103.

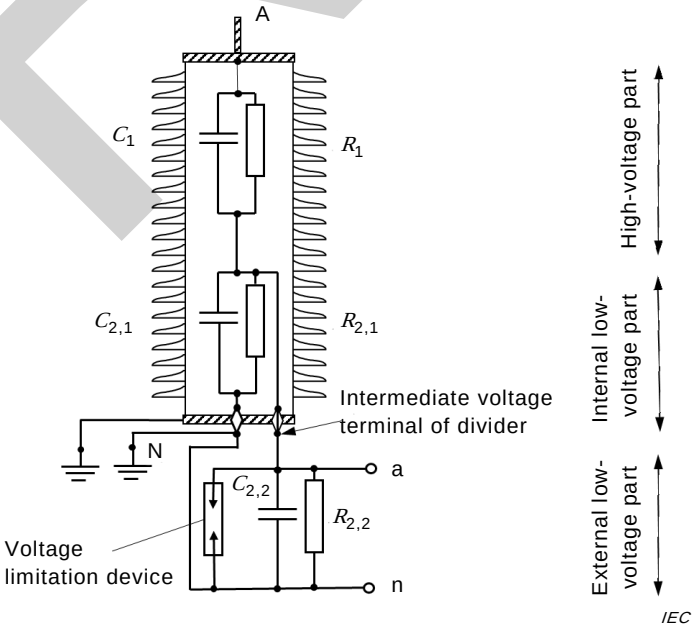


Figure 1103 – RC-divider with external low-voltage part outside the main housing

To test this external secondary part, five positive and five negative lightning impulses of 1,2/50 µs, with the test value according to 5.3.5, shall be applied as shown in Figure 1104. The voltage limitation device shall be disconnected. This test verifies the voltage withstand of the complete external low-voltage part to earth.

No insulation breakdown is permitted.

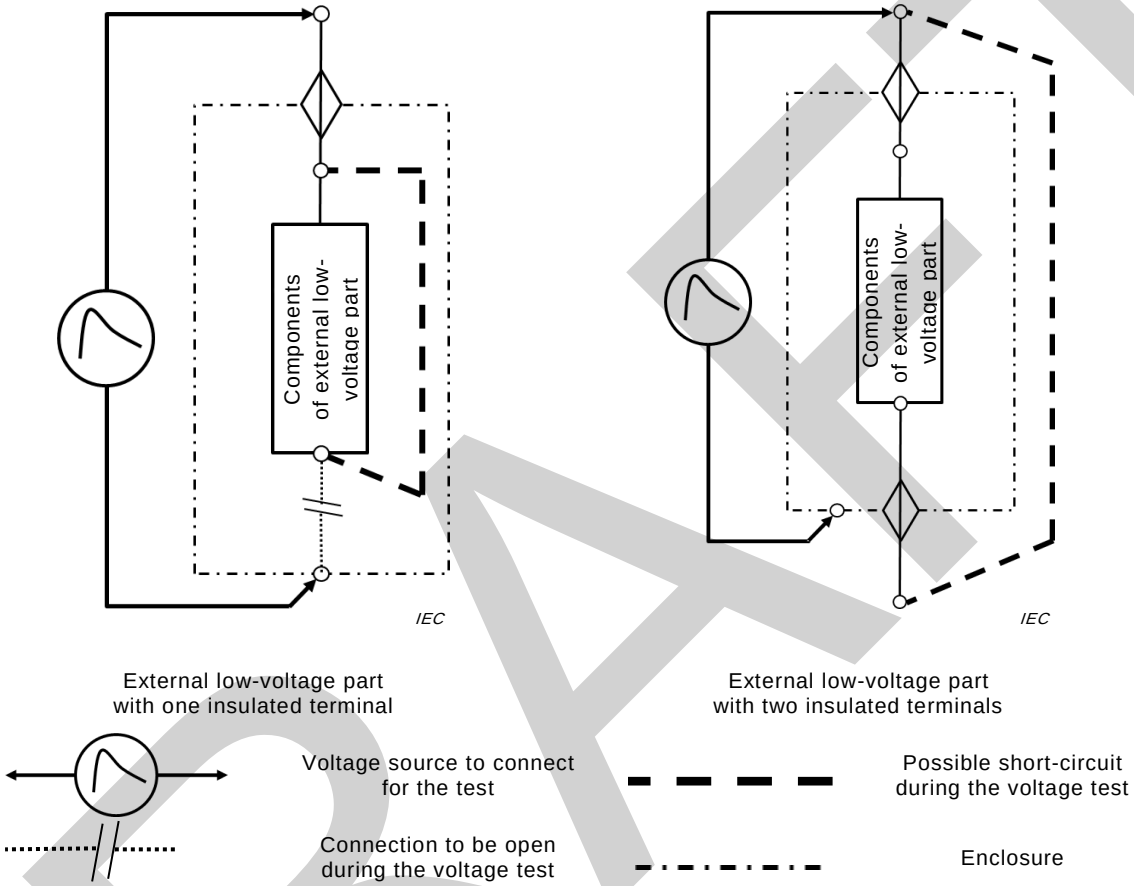


Figure 1104 – Connection for voltage withstand test of the external low-voltage part of a divider

7.3 Routine tests

7.3.3 Power-frequency voltage withstand tests between sections

Not applicable.

7.3.4 Power-frequency voltage withstand tests on secondary terminals

Subclause 7.3.4 of IEC 61869-6:2016 is applicable with the following addition:

If a low-voltage limitation device is connected to earth it shall be disconnected during this test.

For medium voltage (U_m < 72,5 kV) application and when there is an internal galvanic link between the secondary terminal n and ground this test is required only as type test. In this case the connection between the secondary terminal n and ground shall be opened for the test.

7.3.5 Test for accuracy

Subclause 7.3.5 of IEC 61869-6:2016 is applicable with the following addition:

Routine tests for accuracy shall be made at rated burden and ambient temperature only. The accuracy shall be measured in a short time (less than 0,05 times the thermal time constant) and the measurement shall be adjusted with the corrections for the warm up evaluated during the type test in 7.2.6.602.

Both the measured errors and the adjusted errors shall be within the limits of the relevant accuracy class.

NOTE When the temperature coefficient of the primary and the secondary elements are different the accuracy after warming up the LPVT in service can change

7.3.1101 Measurement of capacitance and dissipation factor

For passive LPVT having U_m ≥ 72,5 kV, capacitance C and tanδ at 10 % and 100 % of U_{pr} shall be measured before and after the dielectric test at 10 % and 100 % of U_{pr} in order to reveal any change in capacitance due to the puncture of one or more elements. They shall be measured at rated frequency.

The capacitance shall be measured using a method that excludes errors due to harmonics and to accessories in the measuring circuit.

NOTE 1101 When there is an intermediate-voltage terminal which is still accessible when the equipment is completely assembled the following are measured:

a) the capacitance between line and low-voltage terminal or line and earth terminal,

b) the capacitance between the intermediate and low-voltage terminals or intermediate and earth terminal.

NOTE 1102 For R- and RC-dividers only capacitance is measured.

NOTE 1103 Capacitance change with temperature is covered by the temperature cycle accuracy test in IEC 61869-6:2016, 7.2.6.603.

7.3.1102 Resistance measurement

For passive LPVT having U_m ≥ 72,5 kV, in case of resistive voltage dividers or RC-dividers, the resistance R_1 of the primary part shall be measured at 1 000 V DC (± 10 %) before and after the dielectric tests.

The resistance of the secondary part R_2 shall be measured after the dielectric tests. The test voltage in DC shall have at least the same value as the rated secondary voltage, but not be higher than twice the rated secondary voltage.

7.4 Special tests

7.4.3 Measurement of capacitance and dielectric dissipation factor

Subclause 7.4.3 of IEC 61869-1:2007 is not applicable, as for passive LPVT this measurement is a routine test (see 7.3.1101).

7.4.1101 Frequency response measurements

The frequency response of the low-power passive voltage transformer shall be evaluated in the frequency range according to the application reported in Annex 6A of IEC 61869-6:2016. The ratio error and the phase error are recorded. The amplitude of the test voltage shall be not lower than

– 2,5 % of the rated primary voltage for U_m < 72,5 kV

– 1 000 V for U_m ≥ 72,5 kV.

Acceptance criteria in the ratio error and phase error shall be in accordance with Annex 6A of IEC 61869-6:2016.

For measuring accuracy classes (Table 6A.2 of IEC 61869-6:2016) the test shall be made between the 2nd and the 13th harmonic.

7.4.1102 Transient response test

7.4.1102.1 General

To comply with the requirements in 6.1101 one of the following tests shall be performed.

7.4.1102.2 Primary short-circuit test

For the protective low power passive voltage transformer, the secondary output is measured with a transient recorder. After application of a primary voltage of F_V x U_{pr} the primary voltage is short-circuited. The peak of the output voltage shall be lower than required in 6.1101.2.

7.4.1102.3 Measurement of step response time

The test shall be performed on the complete low-power passive voltage transformer. The step response measurement shall be performed with the rated burden and the original transmission cable, if it exists.

The primary test voltage should be $U_{pr} \times \sqrt{2}/\sqrt{3}$ with accuracy of ± 3 % and represents an impulse voltage characteristic. The step voltage can be generated by an impulse voltage generator.

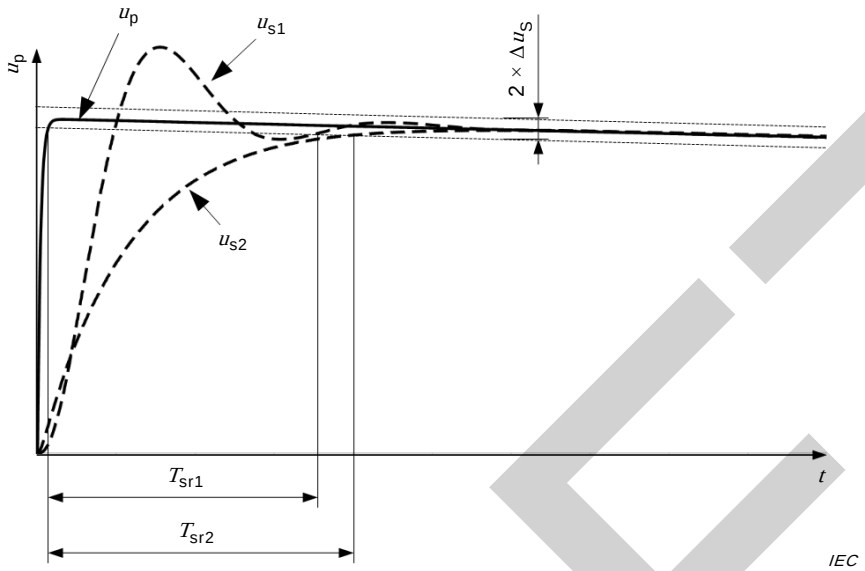
The front time of 1,2 µs, ± 30 % shall correspond to the standard lightning impulse as defined in 7.2.1 of IEC 60060-1:2010.

The time to half value of 2 500 µs, ± 60 % shall correspond to the standard switching impulse as defined in 8.2.1 of IEC 60060-1:2010.

The test has to be performed one time for each polarity. Each test has to be recorded with the reference curve together with the step response curve of the test object.

The primary voltage is measured with a wide band reference divider. The output of this reference divider and the output voltage of the passive LPVT are measured with a transient recorder.

The step response time of the low-power passive voltage transformer is reached if the secondary signal stays within the tolerance band Δu_s = 6 % (see Figure 1105). The step response time should be lower than the value given in 6.1101.3.



Key

u_P	Input voltage
u_{S1}	Output voltage of test object, periodic function
u_{S2}	Output voltage of test object, aperiodic function
$2 \times \Delta u_S$	Specified tolerance limit
T_{sr1}	Step response time, periodic function
T_{sr2}	Step response time, aperiodic function

Figure 1105 – Step response time of a passive LPVT

601 Information to be given with enquiries, tenders and orders

601.1 Designation

Subclause 601.1 of IEC 61869-6:2016 is applicable with the following additional table:

Table 1106 – Designation of a passive LPVT

Rating	Abbreviation	Definition	Clause or sub-clause
Highest voltage for equipment	U_m	3.2.2	5.2
Rated insulation level		3.2.3	5.3
Service conditions			4
Rated frequency	f_r	3.5.1	5.4
Rated primary voltage (range of primary voltage if applicable)	U_{pr}	3.2.601	5.1101.1
Rated secondary voltage	U_{sr}	3.1.623	5.1101.2
Rated voltage factor	F_V	3.2.1101	5.1102
Rated burden	R_{br} (resistance/capacitance)	3.4.7	5.5.601
Accuracy class		3.4.5	5.6.1101 5.6.1102
Application (for example, free-standing, GIS, suspended on busbar, breaker-mounted)			
Ratio correction factor	CF_U	3.4.1101	
Phase offset	φ_o	3.4.603	
Phase offset correction	$\varphi_{o\ cor}$	3.4.1103	
The user shall declare whether the correction factor and/or phase offset correction are accepted in order to reach the accuracy class.			

601.2 Dependability

Not applicable.

NOTE Subclause 601.2 in IEC 61869-6:2016 refers to subclause 6.606 which is not applicable in this part of IEC 61869 because the passive LPCT has no components that will be replaced during maintenance.

Annex 11A
(normative)

Tests for impact of electric field from other phases

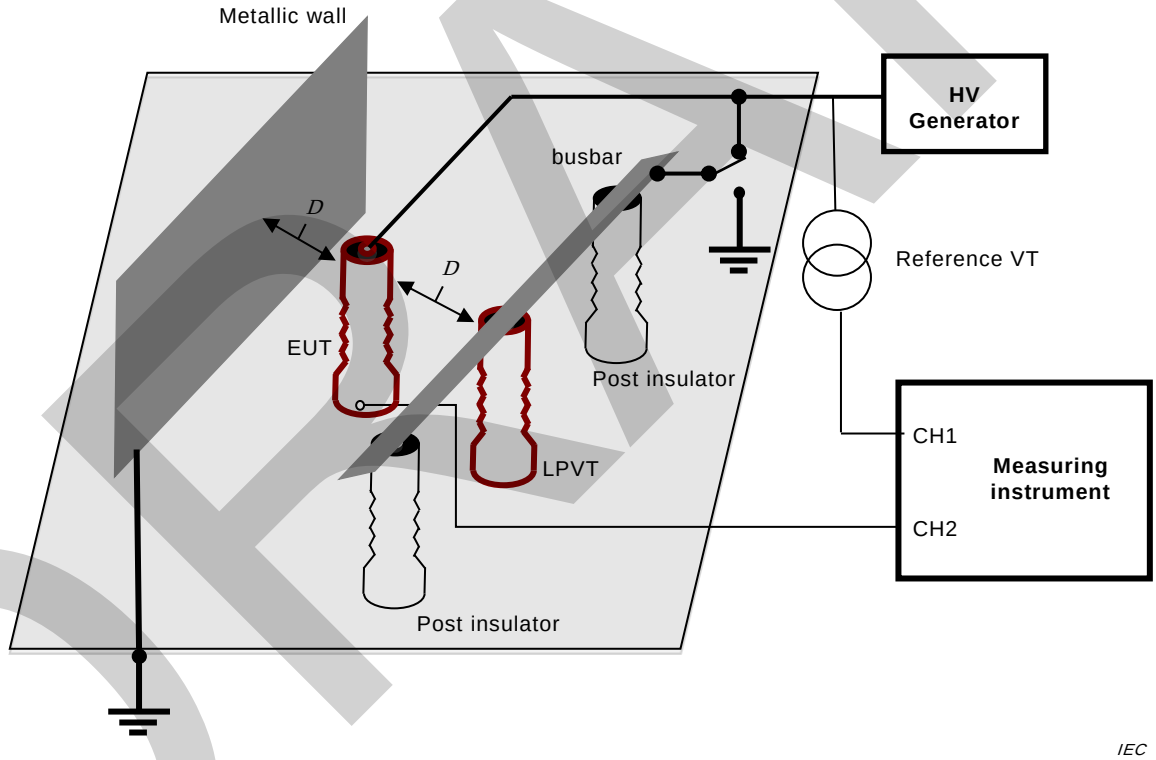
11A.1 General

Adjacent phases in a three-phase power system can influence the accuracy of passive LPVT. To evaluate the impact of electric field effects at rated frequency generated by adjacent phases in the power system the following test shall be performed.

11A.2 Test setup

Passive LPVT for GIS shall be tested in the real configuration for which the LPVT is designed.

Passive LPVT for air-insulated substations shall be tested in the real three-phase configuration in the substation. If it is not possible to test in the real configuration Figure 11A.1 shows the test setup to be used for LPVT for air-insulated substations.



Key
D distance between phases

Figure 11A.1 – Test setup for LPVT used in air-insulated substations

The LPVT under test is placed in the test field at a distance from a grounded wall equal to the distance between phases of a power system operating at U_m of the LPVT under test. The length of the wall shall be at least equal to the distance between the two LPVT and the height of the wall shall be at least 1,5 times the height of the LPVT.

A second LPVT of the same type is placed at a distance equal to the distance between the phases of a power system operating at U_m of the LPVT under test. A metallic bar with a length equal to the distance between the two LPVTs is mounted on the second LPVT.

In case the LPVT is designed for operation in conjunction with other parts (such as plug-in connectors, inside bushings, terminations, etc.) the shield for assuring the immunity to the external electric field at rated frequency could be inside or provided by such parts. In the case of an embedded LPVT in other devices the equipment under test is the complete device with the embedded LPVT.

11A.3 Test procedure

For the following two-step test procedure the rated value of the burden for the LPVT shall be used.

– Step 1:

  The rated primary voltage is applied to the LPVT under test. The second LPVT and the metallic bar are grounded. A measuring equipment made by a reference voltage divider and a measuring instrument is used to measure the phasors of both the output voltage of the reference divider and of the LPVT under test. The actual transformation ratio as well as the phase displacement of the LPVT are evaluated.

– Step 2:

  The rated primary voltage is applied to both LPVTs and the metallic bar. The measuring instrument measures the phasors of both the output voltage of the reference divider and of the LPVT under test. The actual transformation ratio as well as the phase displacement of the LPVT are evaluated.

  The transformation ratios as well as the phase displacements evaluated in step 1 and in step 2 are then compared. The difference between the actual transformation ratios, evaluated in step 1 and step 2 divided by the actual transformation ratio evaluated in step 1, shall be lower than or equal to 1/5 of the ratio error associated with the accuracy class specified by the manufacturer for the LPVT under test. The difference between the phase displacements shall be below 1/3 of the phase displacement associated with the accuracy class specified by the manufacturer for the LPVT under test. For instance, for an LPVT of a specified accuracy class 0,5 and according to the accuracy specifications reported in Table 1101, the difference between the two transformation ratios shall be lower than 0,1 % and the difference between the two phase displacements shall be lower than 7 min/0,2 centirad.

Annex 11B
(informative)

Designation of accuracy class when using corrected transformation ratio and ratio correction factor

11B.1 General

Annex 11B provides an explanation for the defining accuracy class of low-power passive voltage transformers (passive LPVT) using individual ratio correction factor CF_U, where U is the designation for voltage. The advantage of defining accuracy class by using the individual ratio correction factor instead of traditional rated transformation ratio (K_r) is that a higher accuracy class can be designated for a passive LPVT. Designation of the accuracy class in IEC 61869-6:2016 is based on the rated transformation ratio. To clarify this, ratio error was defined, which is an error that an instrument transformer introduces into the measurement of a voltage and which arises from the fact that the transformation ratio of individual instrument transformers is not equal to the rated transformation ratio. Traditional metering and protection devices were not designed flexibly enough to accept the transformation ratio of individual instrument transformers. Therefore, a rated transformation ratio was used that represented a whole group of instrument transformers classified with the same accuracy class. Because the transformation ratio was slightly different for each instrument transformer, the accuracy class had to be designated so as to cover all instrument transformers of the same class, resulting in reduced accuracy class designation. Today's technology makes it possible to effectively use the individual transformation ratio of passive LPVTs in protection, metering, and control devices. This is possible by using the ratio correction factor CF_U combined with the rated transformation ratio or by using the corrected transformation ratio K_{cor}. Designation of the accuracy class based on the ratio correction factor and corrected transformation ratio is next explained based on actual accuracy tests performed on passive LPVT of the same design. However, this method can be applied to any type of instrument transformers.

The ratio correction factor CF_U is defined by the formula:

$$CF_U = \frac{1}{1 - \frac{x}{100}}$$

where x is error in per unit between the rated transformation ratio and actual transformation ratio at rated voltage.

The corrected transformation ratio is defined by the formula:

$$K_{cor} = CF_U \cdot K_r$$

In actual applications, protective relays can be designed to separately accept the rated transformation ratio (K_r) and the ratio correction factor CF_U or the corrected transformation ratio K_{cor} as one number that combines both K_r and CF_U.

Figure 11B.1 illustrates the accuracy class designation improvement for three passive LPVT using ratio correction factor CF_U. In Figure 11B.1 F_v is the rated voltage factor.

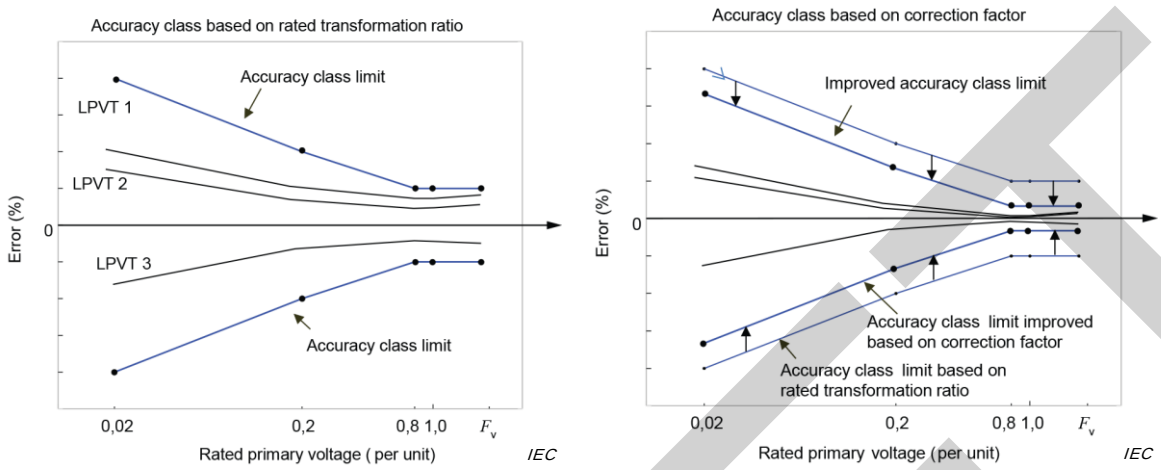


Figure 11B.1 – Accuracy class designation improved, based on individual ratio correction factor CF_U

11B.2 Designation of accuracy class based on rated transformation ratio

Subclause 3.4.3 defines ratio error ε for analogue output by the formula:

$$\varepsilon = \frac{K_r \cdot U_s - U_p}{U_p} \times 100\ \%$$

where

K_r is the rated transformation ratio;

U_p is the RMS value of the primary voltage;

U_s is the RMS value of the secondary voltage.

11B.3 Designation of accuracy class based on individual ratio correction factor

The error based on the ratio correction factor (CF_U) is called corrected ratio error ($\varepsilon_{cor\ U}$) and is defined in 3.4.1105 by the formula:

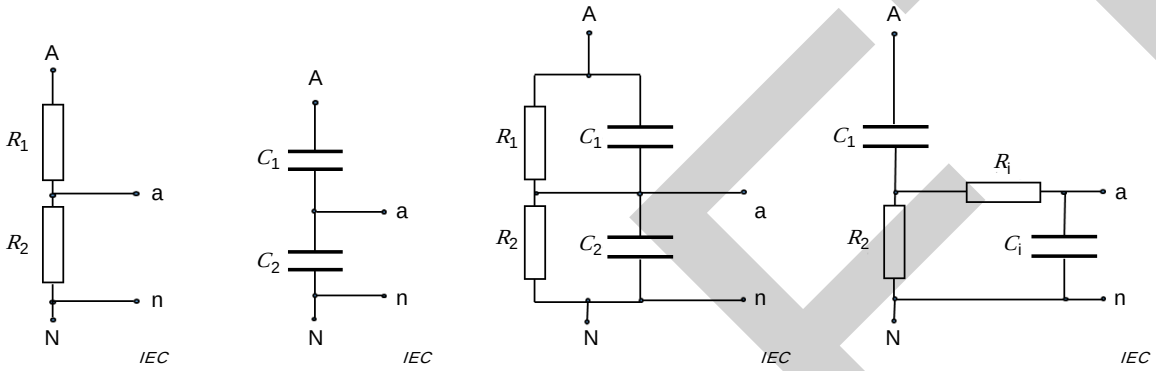
$$\varepsilon_{corU} = \frac{CF_U \cdot K_r \cdot U_s - U_p}{U_p} \times 100\ \% = \frac{K_{cor} \cdot U_s - U_p}{U_p} \times 100\ \%$$

The difference from the formula in Clause 11B.2 is that the rated transformation ratio K_r here is multiplied by the ratio correction factor CF_U.

Annex 11C
(informative)

Types of divider principles covered by this part of IEC 61869

The following Figure 11C.1 shows the types of divider principles covered by this part of IEC 61869.



R-divider C-divider RC-divider CR-divider with passive integrator

Figure 11C.1 – Divider principles

Bibliography

IEC 60038, *IEC Standard Voltages*

IEC 60358-1, *Coupling capacitors and capacitor dividers – Part 1: General rules*

IEC 60358-4[2], *Coupling capacitors and capacitor dividers – Part 4: DC or AC single-phase capacitor-dividers*

IEC 61869-3, *Instrument transformers – Part 3: Additional requirements for inductive voltage transformers*

IEC 61869-5, *Instrument transformers – Part 5: Additional requirements for capacitor voltage transformers*

IEC 61869-7, *Instrument transformers – Part 7: Additional requirements for electronic voltage transformers*[3]

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2 To be published. Stage at the time of publication: IEC ADIS 60358-4:2017.

3 Under preparation.