

INTERNATIONAL STANDARD



Electrical measuring transducers for converting AC and DC electrical quantities to analogue or digital signals

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRICAL QUANTITIES TO ANALOGUE OR DIGITAL SIGNALS****FOREWORD**

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IEC 60688 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) updating normative references;
- b) additional requirements for specific transducers used for LV monitoring applications;
- c) creation of interface coding to ease selection by the end-user.

The text of this International Standard is based on the following documents:

CDV	Report on voting
85/748/CDV	85/781/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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INTRODUCTION

New transducers can now be equipped with microprocessors that utilise digital data processing, communication methods and auxiliary sensors. This makes them more complex than conventional analogue transducers and gives them considerable added value.

The class index system of classification used in this document is based upon IEC 60051 (all parts). Under this system, the permitted variations of the output signal due to varying influence quantities – ambient temperature, voltage, frequency, etc. – are implicit in the classification.

For those unfamiliar with the class index system, a word of warning is necessary. If, for example, a transducer is classified as class 1, it does not mean that the error under practical conditions of use will be within ± 1 % of the actual value of the output or ± 1 % of the full output value. It means that the error should not exceed ± 1 % of the fiducial value under closely specified conditions. If the influence quantities are varied between the limits specified by the nominal ranges of use, a variation of amount comparable with the value of the class index may be incurred for each influence quantity.

The permissible error of a transducer under working conditions is the sum of the permissible intrinsic error and of the permissible variations due to each of the influence quantities. However, the actual error is likely to be much smaller because not all of the influence quantities are likely to be simultaneously at their most unfavourable values and some of the variations may cancel one another. It is important that these facts be taken into consideration when specifying transducers for a particular purpose.

Furthermore, some of the terms used in this document are different from those used in IEC 60051 (all parts) due to the fundamental differences between indicating instruments and measuring transducers.

All statements of performance are related to the output which is governed by two basic terms:

- "the nominal value", which may have a positive or a negative sign or both;
- "the span", which is the range of values of the output signal from maximum positive to maximum negative, if appropriate.

ELECTRICAL MEASURING TRANSDUCERS FOR CONVERTING AC AND DC ELECTRICAL QUANTITIES TO ANALOGUE OR DIGITAL SIGNALS

1 Scope

This document applies to transducers with electrical inputs and outputs for making measurements of AC or DC electrical quantities. The output signal ~~may~~ can be in the form of an analogue direct current, an analog direct voltage or in digital form. ~~In this case, that part of the transducer utilized for communication purposes will need to be compatible with the external system.~~

This document applies to measuring transducers used for converting electrical quantities such as

- current,
- voltage,
- active power,
- reactive power,
- power factor,
- phase angle,
- frequency,
- harmonics or total harmonic distortion, and
- apparent power

to an output signal.

This document is not applicable for

- instrument transformers that comply with ~~IEC 60044 series~~ IEC 61869 (all parts);
- transmitters for use in industrial process application that comply with IEC 60770 (all parts), and
- performance measuring and monitoring devices (PMD) that comply with IEC 61557-12:2018.

Within the measuring range, the output signal is a function of the measurand. An auxiliary supply ~~may~~ can be needed.

This document applies

- a) if the nominal frequency of the input(s) lies between 0 Hz and 1 500 Hz,
- b) ~~if a measuring transducer is part of a system for the measurement of a non-electrical quantity, this standard may be applied to the electrical measuring transducer, if it otherwise falls within the scope of this standard~~
to the electrical measuring transducer if it is part of a system for the measurement of a non-electrical quantity, and if it otherwise falls within the scope of this document, and
- c) to transducers for use in a variety of applications such as telemetry and process control and in one of a number of defined environments.

This document is intended:

- to specify the terminology and definitions relating to transducers whose main application is in industry,

- to unify the test methods used in evaluating transducer performance, and
- to specify accuracy limits and output values for transducers.

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.

~~IEC 60051-1:1997, Direct acting indicating analogue electrical measuring instruments and their accessories – Part 1: Definitions and general requirements common to all parts~~

IEC 60068-2-6, *Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27, *Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock*

IEC 60255-151, *Measuring relays and protection equipment - Part 151: Functional requirements for over/under current protection*

~~IEC 60417, Graphical symbols for use on equipment~~

IEC 61010 (all parts), *Safety requirements for electrical equipment for measurement, control and laboratory use*

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements*
IEC 61010-1:2010/AMD1:2016

IEC 61010-2-030:2017, *Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 2-030: ~~Special~~ Particular requirements for equipment having testing and or measuring circuits*

~~IEC 61326 (all parts), Electrical equipment for measurement, control and laboratory use – EMC requirements~~

IEC 61326-1:2020, *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements*

IEC 61557-12:2018, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC - Equipment for testing, measuring or monitoring of protective measures - Part 12: ~~Performance measuring~~ Power metering and monitoring devices (PMD)*

IEC 61558-1:2017, *Safety of transformers, reactors, power supply units and combinations thereof - Part 1: General requirements and tests*

~~NOTE – Please refer to the Bibliography for the list of informative references.~~

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>

- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 General terms

3.1.1

electrical measuring transducer

TRD

device for converting an AC or DC measurand to a direct or alternating current, a direct or alternating voltage or a digital signal for measurement purposes

3.1.2

electrical measuring transducer type 1

transducer type 1

TRD1

conventional transducer

Note 1 to entry: Transducers type 1 use conventional interface outputs and are generally single-function devices.

3.1.3

electrical measuring transducer type 2

transducer type 2

TRD2

single-function transducer used in low voltage (LV) monitoring applications

Note 1 to entry: Transducers type 2 are using specific interface outputs and are generally more accurate than transducers type 1.

3.1.4

single-function device

device performing the measurement of a single electrical quantity (e.g. current, power factor, THD) in a single form (e.g. RMS or peak or average) but not both

3.1.5

analogue transducer

device for converting an AC or DC measurand to a direct or alternating current, a direct or alternating voltage for measurement purposes

3.1.6

digital transducer

device for converting an AC or DC measurand to a digital signal for measurement purposes

3.1.7

auxiliary supply

AC or DC electrical supply, other than the measurand, which is necessary for the correct operation of the transducer

3.1.8

auxiliary circuit

circuit which is usually energized by the auxiliary supply

Note 1 to entry: The auxiliary circuit is sometimes energized by one of the input quantities.

~~**transducer with offset zero**~~

~~transducer that gives a predetermined output signal other than zero when the measurand is zero~~

3.1.9**transducer with suppressed zero**

transducer for which zero output signal corresponds to a measurand greater than zero

~~**total distortion factor**~~~~ratio of the r.m.s. value of the total distortion content to the r.m.s. value of an alternating quantity~~~~Note 1 to entry: The total distortion factor depends on the choice of the fundamental component. If it is not clear from the context which one is used, an indication should be given.~~**3.1.10****output load**

<analogue signal> total resistance of the circuits and apparatus connected externally across the output terminals of the transducer

3.1.11**ripple content**

<analogue output signal> ratio of the peak-to-peak value of the fluctuating component of an analogue output signal, expressed in percentage, to the fiducial value, with steady-state input conditions

3.1.12**output signal**

analogue or digital representation of the measurand

3.1.13**output power**

power at the transducer output terminals

~~**output current**~~~~**output voltage**~~~~for analogue signals, the current (voltage) produced by the transducer which is an analogue function of the measurand~~**3.1.14****output current**

<analogue signal> current produced by the transducer which is an analogue function of the measurand

3.1.15**output voltage**

<analogue signal> voltage produced by the transducer which is an analogue function of the measurand

~~**reversible output current**~~~~**reversible output voltage**~~~~for analogue signals, the output current (voltage) that reverses polarity in response to a change of sign or direction of the measurand~~**3.1.16****measuring element**

<transducer> unit or module of a transducer that converts the measurand, or part of the measurand, into a corresponding signal

~~**single-element transducer**
transducer having one measuring element~~

multi-element transducer
transducer having two or more measuring elements

Note 1 to entry: The signals from the individual elements are combined to produce an output signal corresponding to the measurand.

~~**combined transducer**
transducer having two or more measuring circuits for one or more functions~~

3.1.18

response time

time from the instant of application of a specified change of the measurand until the output signal reaches and remains at its final steady value or within a specified interval centred on this value

3.1.19

compliance voltage

accuracy limiting output voltage

<variable output load transducers having a current output> value of the voltage appearing across the output terminals up to which the transducer complies with the requirements of this document

~~**output series mode interference voltage**~~

~~unwanted alternating voltage appearing in series between the output terminals and the load~~

~~**output common mode interference voltage**~~

~~unwanted alternating voltage that exists between each of the output terminals and a reference point~~

~~**storage conditions**~~

~~conditions, defined by means of the ranges of the influence quantities, such as temperature or any other special condition, within which the transducer may be stored (non-operating) without damage~~

3.1.20

stability

ability of a transducer to keep its performance characteristics unchanged during a specified time, all influence quantities remaining within their specified ranges

~~**3.1.22.1**~~

~~**short-term stability**~~

~~stability over a period of 24 h~~

~~**3.1.22.2**~~

~~**long-term stability**~~

~~stability over a period of one year~~

3.1.21

usage group

group of transducers capable of operating under a specified set of environmental conditions

3.1.22**pulse density output**

digital representation of the measurand, where the relative density of the output pulses corresponds to the analog signal amplitude

3.2 Terms describing transducers according to the measurand**3.2.1****voltage transducer**

transducer used for the measurement of AC or DC voltage

3.2.2**current transducer**

transducer used for the measurement of AC or DC current

3.2.3**apparent power transducer**

transducer that is used for the measurement of the apparent power

3.2.4**active power transducer**

transducer used for the measurement of active electrical power

3.2.5**reactive power transducer**

transducer used for the measurement of reactive electrical power

3.2.6**frequency transducer**

transducer used for the measurement of the frequency of an AC electrical quantity

3.2.7**phase angle transducer**

transducer for the measurement of the phase angle between two AC electrical quantities having the same frequency

3.2.8**power factor transducer**

transducer used for the measurement of the power factor of an AC circuit

3.2.9**harmonics transducer**

transducer that is used for the measurement of the harmonics or the total harmonic distortion of an AC circuit

3.2.10**TRD2-PFA**

power factor (arithmetic method) transducer for LV monitoring applications

3.2.11**TRD2-PFV**

power factor (vector method) transducer for LV monitoring applications

3.2.12**TRD2-THDU**

voltage THD transducer for LV monitoring applications

3.2.13

TRD2-THDI

current THD transducer for LV monitoring applications

3.2.14

TRD2-UAC

voltage transducer for LV monitoring applications that is used for the measurement of AC voltage

3.2.15

TRD2-UDC

voltage transducer for LV monitoring applications that is used for the measurement of DC voltage

3.2.16

TRD2-IAC

current transducer for LV monitoring applications that is used for the measurement of AC current

3.2.17

TRD2-IDC

current transducer for LV monitoring applications that is used for the measurement of DC current

3.3 Terms describing transducers according to their output load

3.3.1

fixed output load transducer

transducer that complies with this document only when the output load is at its nominal value, within specified limits

3.3.2

variable output load transducer

transducer that complies with this document when the output load has any value within a given range

3.4 Nominal values

3.4.1

nominal value

value, or one of the values, indicating the intended use of a transducer

Note 1 to entry: The lower and upper nominal values of the measurand are those which correspond to the lower and upper nominal values of the output signal.

3.4.2

span

output span

algebraic difference between the upper and lower nominal values of the output signal

3.4.3

fiducial value

value to which reference is made in order to specify the accuracy of a transducer

Note 1 to entry: The fiducial value is the span, except for transducers having a reversible and symmetrical output signal when the fiducial value may be half the span if specified by the manufacturer.

circuit insulation voltage

highest circuit voltage to earth of a transducer that determines its voltage test

nominal power factor

factor by which it is necessary to multiply the product of the nominal voltage and nominal current to obtain the nominal power

$$\text{Nominal power factor} = \frac{\text{nominal power}}{\text{nominal voltage} \times \text{nominal current}}$$

Note 1 to entry: When the current and voltage are sinusoidal quantities, the nominal power factor is $\cos \varphi$ where φ is the phase difference between the current and the voltage. For reactive power transducers, the nominal power factor is $\sin \varphi$.

~~**maximum permissible values of input current and voltage**~~

~~values of current and voltage assigned by the manufacturer as those which the transducer will withstand indefinitely without damage~~

3.4.5**limiting value of the output signal**

<current or voltage> upper limit of output signal which cannot, by design, be exceeded under any conditions

3.4.6**measuring range**

range defined by two values of the measurand within which the performance complies with the requirements of this document

~~(SOURCE: IEC 60051-1:1997, 2.4.3, modified – the wording of the definition has been changed.)~~

Note 1 to entry: See 3.4.3 of IEC 60051-1:2016.

3.4.7**nominal value of the measured voltage**

nominal value of the voltage of the external circuit (e.g. the secondary winding of a voltage transformer) to which the voltage input circuit of the transducer is to be connected

3.4.8**nominal value of the measured current**

nominal value of the current in the external circuit (e.g. the secondary winding of a current transformer) to which the current input circuit of the transducer is to be connected

~~**nominal value of the measurand**~~

~~for active power and reactive power transducers, the value of the measured quantity corresponding to the nominal values of the measured voltage and current, and the power factor~~

3.5 User adjustment Terms describing transducers with provisions to be adjusted by users

~~Transducers can be supplied with provision to be adjusted by the user. (It should be noted that power sources and measuring equipment having adequate stability and accuracy are required). The following definitions apply to these transducers~~

calibration value

value of a quantity to which the nominal value is changed by user adjustment for a specific application

~~calibration value of the measured voltage~~

~~value of the voltage applied to the voltage input circuit of the transducer~~

~~calibration value of the measured current~~

~~value of the current applied to the current input circuit of the transducer~~

~~calibration value of the measurand~~

~~value of the measurand resulting from user adjustment~~

~~calibration value of the output signal~~

~~value of the output signal of the transducer corresponding to the calibration value of the measurand after adjustment~~

3.5.2

adjustment range

possible range of adjustment values of the measured current or voltage

~~conversion coefficient~~

~~relationship of the value of the measurand to the corresponding value of the output signal~~

3.6 Influence quantities and reference conditions

3.6.1

influence quantity

quantity (other than the measurand) that may affect the performance of a transducer

3.6.2

reference conditions

specified conditions under which the transducer complies with the requirements concerning intrinsic errors

Note 1 to entry: These conditions may be defined by either a reference value or a reference range.

3.6.2.1

reference value

specified single value of an influence quantity at which the transducer complies with the requirements concerning intrinsic errors

3.6.2.2

reference range

specified range of values of an influence quantity within which the transducer complies with the requirements concerning intrinsic errors

nominal range of use

specified range of values over which it is intended that an influence quantity can assume without the output signal of the transducer changing by amounts in excess of those specified

3.7 Errors and variations

error

actual value of the output signal minus the intended value of the output signal, expressed algebraically

~~error expressed as a percentage of the fiducial value~~
~~one hundred times the ratio of the error and the fiducial value~~

intrinsic error

error determined when the transducer is under reference conditions

variation due to an influence quantity

difference between the two values of the output signal for the same value of the measurand when an influence quantity assumes successively two different specified values

3.7.4**variation due to an influence quantity**

<expressed as a percentage of the fiducial value> one hundred times the ratio of the variation due to an influence quantity and the fiducial value

3.8 Accuracy, accuracy class, class index**accuracy**

~~value~~ accuracy of a transducer is defined by the limits of intrinsic error and by the limits of variations

3.8.2**accuracy class**

class of transducers for which the accuracy of all can be designated by the same number if they comply with all the requirements of this document

3.8.3**class index**

number which designates the accuracy class

Note 1 to entry: The class index is applicable to the intrinsic error as well as to the variations.

Note 2 to entry: Throughout this document, the phrase "x % of the class index" denotes "x % of the limits of error relating to the class index".

4 ~~Class index, permissible limits of intrinsic error, auxiliary supply and reference conditions~~ General**4.1 Transducer general architecture**

Organisation of the measurement chain: the electrical quantity to be measured may be either directly accessible, as it is generally the case in low-voltage systems, or accessible via measurement sensors like voltage sensors (VS) or current sensors (CS).

Figure 1 shows the common organisation of a transducer (TRD).

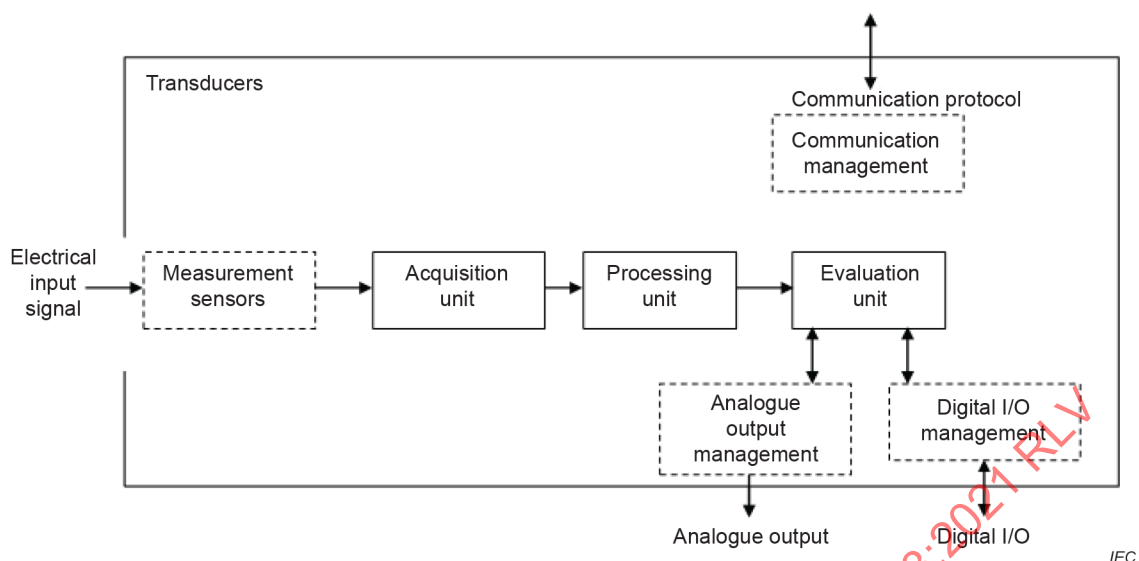


Figure 1 – Transducer (TRD) architecture

4.2 Classification of transducers (TRD)

Transducers are classified according to the applications as defined in Table 1.

Table 1 – Functional classification of transducers with minimal required functions

Requirements	Transducers type	
	TRD1 (transducer type 1)	TRD2 (transducer type 2)
See Clause 5	■	
See Annex A		■
NOTE For more information about differences between TRD1 and TRD2, see also Annex B		

5 Requirements for TRD1

5.1 Safety requirements: clearances and creepage distances

Transducers shall comply with safety requirements of IEC 61010 (all parts), and in addition with the following requirements of:

Clearances and creepage distances shall be selected at least in accordance with

- pollution degree 2,
- measurement category III for measuring input circuits, and
- overvoltage category III for mains circuits.

NOTE Measurement category is defined in IEC 61010-2-030.

5.2 EMC requirements

5.2.1 Immunity

For high frequency disturbance test, see IEC 61326 (all parts).

If, by agreement, other tests are required, then TRD1 with active electronic components may comply with Clause 6 of IEC 61326-1:2020.

NOTE These requirements are consistent with those of 6.21 and 6.23.

5.2.2 Emission

If, by agreement, other tests are required, then TRD1 with active electronic components may comply with either class A or class B limits as defined in Clause 7 of IEC 61326-1:2020.

NOTE This requirement is consistent with the one of 6.23.

5.3 Class index requirements

5.3.1 Class index

The class index for a transducer shall be chosen from those given in Table 2.

This class index definition only applies for the analogue output of the transducers.

Table 2 – Relationship between the limits of intrinsic error, expressed as a percentage of the fiducial value, and the class index

Class index	0,2	0,5	1	2	2,5	3	5	10	20
Limits of error	±0,2 %	±0,5 %	±1 %	±2 %	±2,5 %	±3 %	±5 %	±10 %	±20 %
NOTE — Class indices of 0,3 and 1,5, although non-preferred, may can be used.									

5.3.2 Class index for transducer used with sensors

If the transducers are used with sensors, the manufacturer shall specify the accuracy class of the whole system transducer and sensor.

In some cases when a transducer does not include the sensors, their associated uncertainties are not considered. When a transducer includes the sensors, their associated uncertainties are considered.

5.3.3 Intrinsic error

When the transducer is under reference conditions, the error at any point between the upper and lower nominal values of the output signal shall not exceed the limits of the intrinsic error given in Table 2 expressed as a percentage of the fiducial value.

Values stated in a table of corrections, if any, supplied with the transducer shall not be taken into account in determining the errors.

5.4 Conditions for the determination of intrinsic error

Prior to pre-conditioning and before determination of the intrinsic error, preliminary adjustments shall be carried out in accordance with the manufacturer's instructions. The transducer shall be at the reference temperature.

The transducer shall be left in circuit under the conditions specified in Table 3.

Table 3 – Pre-conditioning

Conditions	Values
Voltage (including any auxiliary supply)	Nominal value
Current	Nominal value
Frequency	Reference value
Power factor	Reference value
Time between connection into circuit and start of determination of errors	30 min

After the specified pre-conditioning, transducers having adjustments available to the user shall be adjusted in accordance with the manufacturer's instructions.

The reference conditions relative to each of the influence quantities are given in Table 4. The reference conditions relative to the measurand are given in Table 5.

Table 4 – Reference conditions of the influence quantities and tolerances or testing purposes

Influence quantity	Reference conditions unless otherwise marked	Tolerances permitted for testing purposes applicable to a single reference value ^a
Ambient temperature	To be marked in the type test report	±1 °C
Usage group (see 6.1.2)		
I	K55	–
II	K70	–
III	Kx ^b	–
Frequency of the input quantity		
Non-frequency sensitive	Nominal value	±2 %
Frequency sensitive	To be marked in the type test report	±0,1 %
Waveform of the input quantity	Sinusoidal, except for harmonics transducers	The distortion factor × 100 shall not exceed the class index, unless otherwise specified by the manufacturer
Output load		
Fixed output load transducers	Nominal value	±1 %
Variable output load transducers	Mean value of the nominal range	±1 %
Auxiliary supply		
Voltage AC	Nominal value	±2 %
Voltage DC	Nominal value	±1 %
Frequency	Nominal value	±1 %
Distortion factor	0,05 maximum	–
Magnetic field of external origin	Total absence	40 A/m at frequencies from DC to 65 Hz in any direction ^c
^a When a reference range is marked, no tolerance is allowed. ^b "Kx" stands for extended conditions. ^c 40 A/m is approximately the highest value of the earth's magnetic field.		

Table 5 – Reference conditions relative to the measurand

Measurand	Reference conditions		
	Voltage	Current	Power factor, active or reactive
Apparent power	Nominal voltage $\pm 2\%$	Any current up to the nominal current	$ \cos \varphi $ or $ \sin \varphi = 1,0$ to $0,8$ lagging or leading
Active power	Nominal voltage $\pm 2\%$	Any current up to the nominal current	$ \cos \varphi = 1,0$ to $0,8$ lagging or leading
Reactive power	Nominal voltage $\pm 2\%$	Any current up to the nominal current	$ \sin \varphi = 1,0$ to $0,8$ lagging or leading ^a
Phase angle or power factor	Nominal voltage $\pm 2\%$	40 % to 100 % of the nominal current	–
Frequency	Nominal voltage $\pm 2\%$	–	–
Polyphase quantities	Symmetrical voltages ^b	Symmetrical currents ^b	–
^a Apparent, active power and reactive power transducers are normally used together and are connected to the same current and voltage transformers. It must be noted that $\sin \varphi = 1,0$ to $0,8$ is used here for ease of testing only. ^b The difference between any two line-to-line voltages and between any two line-to-neutral voltages shall not exceed 1 % of the average (line-to-line and line-to-neutral voltages respectively). Each of the currents in the phases shall differ by not more than 1 % from the average of the currents. The angles between each of the currents and the corresponding phase-to-neutral (star) voltages shall differ by not more than 2° . Where interactions between the separate measuring elements of a multi-element transducer are adequately characterized, single-phase testing of the transducer is acceptable.			

5.5 Auxiliary supply

5.5.1 General

Some transducers dealt with in this document may need an auxiliary supply. This is specified in two separate categories, DC and AC supplies.

5.5.2 DC supply

- The value of the voltage of the DC supply shall be as specified in 5.6.3.
- The battery supply may be earthed or floating. Suitable means shall be provided in the transducer to ensure isolation between the power supply and the input/output circuits of the transducer (for details of voltage tests, see 6.19).
- The transducer shall withstand any voltage ripple up to a maximum of 10 % peak to peak superimposed on the DC power supply.
- The noise fed back to the battery from the transducer shall be limited to 100 mV peak to peak when measured with a specified source resistance at all frequencies up to 100 MHz.

In addition, when the battery feeding the transducer is also used for telephone equipment, the noise shall not exceed 2 mV psophometric.

NOTE The psophometric weighting characteristic is specified in ITU-T Recommendation O.41.

5.5.3 AC supply

For the nominal value of the voltage of the AC supply, see 5.6. This voltage may be provided by a separate supply or may be derived from the measured voltage or current.

5.6 Input values

5.6.1 General

The nominal values of voltage, current, frequency and auxiliary supply shall be specified by the manufacturer.

5.6.2 Adjustment ranges

Adjustment range for transducers that can be adjusted by the user:

- a) for the input voltage: 80 % to 120 % of the nominal value;
- b) for the input current: 60 % to 130 % of the nominal value.

This means that the nominal value of the output signal can be obtained for any adjusted value of the measurand within the ranges given above.

5.6.3 Preferred nominal values

The preferred nominal value of DC auxiliary supplies shall be 24 V, 48 V or 110 V.

5.7 Analogue output signals

5.7.1 General

The lower and upper nominal values of the output signal and the compliance voltage shall be chosen from those given in 5.7.2 and 5.7.3 or 5.7.6.

5.7.2 Output current

The signal 4 mA to 20 mA is preferred.

NOTE The condition "0 mA" has a special meaning (IEC 60381-1).

Other permissible values are

- 0 mA to 20 mA,
- 0 mA to 1 mA,
- 0 mA to 10 mA,
- –1 mA to 1 mA,
- –5 mA to 5 mA,
- –10 mA to 10 mA, and
- –20 mA to 20 mA.

5.7.3 Compliance voltage

- 10 V;
- 15 V.

5.7.4 Maximum output voltage

The manufacturer shall state the maximum value of the output voltage occurring under any conditions of output load and input. This voltage shall not exceed the limit of safety extra-low voltage.

5.7.5 Interference risk of output current

Attention is drawn to the interference problems which may result if the output current has a low value.

5.7.6 Output voltage

- 0 V to 1 V;
- 0 V to 10 V;
- –1 V to 1 V;
- –10 V to 10 V.

NOTE Transducers having a voltage output are non-preferred.

5.8 Output transfer function

For analogue transducers, the used transfer function shall be one of the following curves.

For analogue transducers, variables x , y , y_1 , y_2 can be adjustable.

Curve A is described in Figure 2.

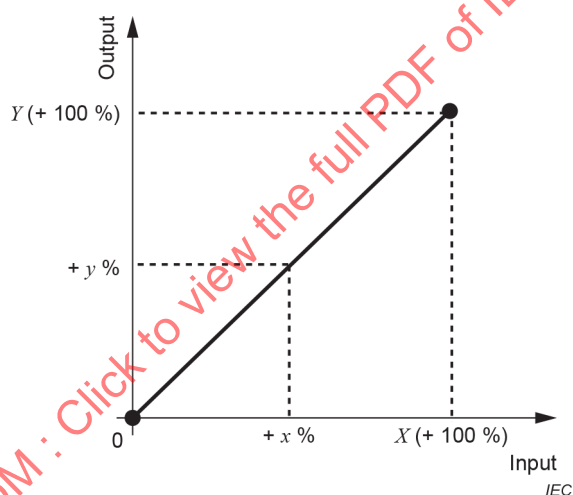


Figure 2 – Transfer function curve A

Curve B is described in Figure 3.

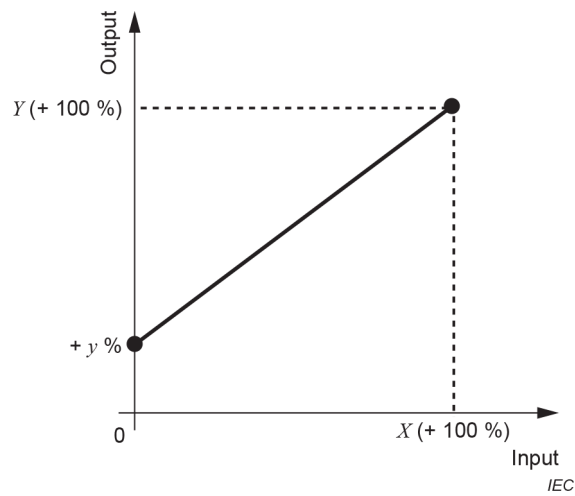


Figure 3 – Transfer function curve B

Curve C is described in Figure 4.

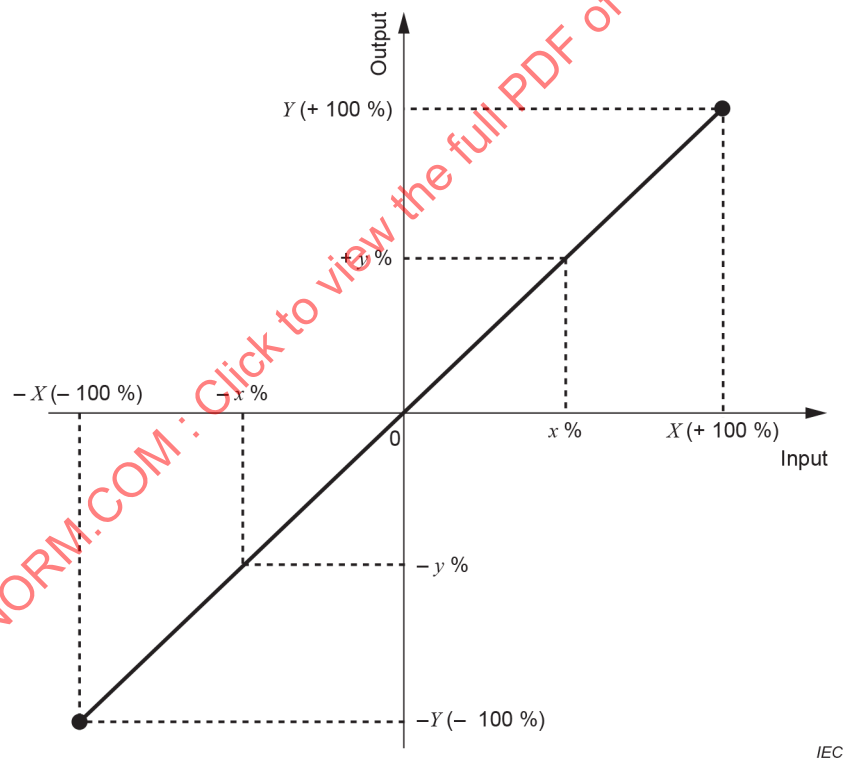


Figure 4 – Transfer function curve C

Curve D is described in Figure 5.

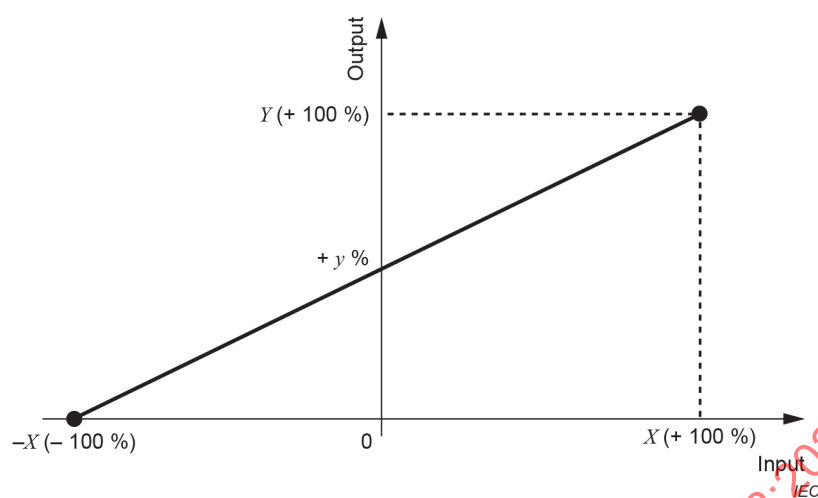


Figure 5 – Transfer function curve D

Curve E is described in Figure 6.

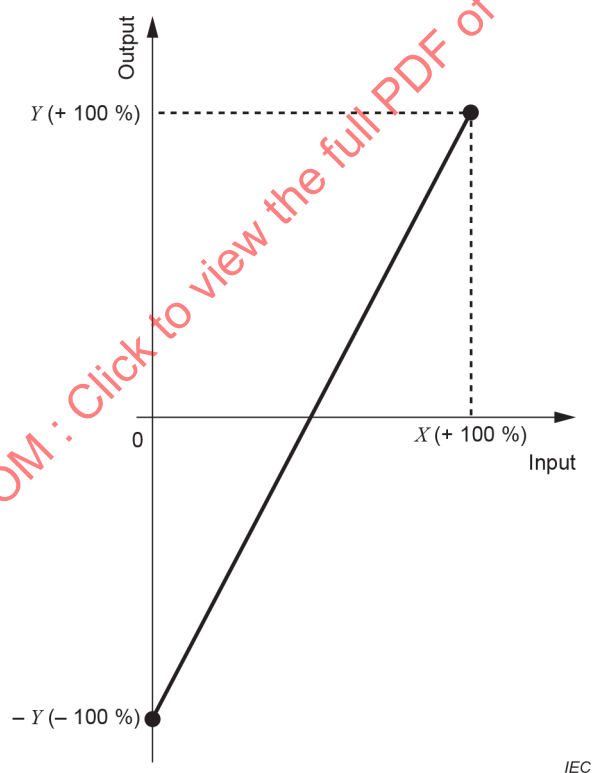


Figure 6 – Transfer function curve E

Curve F (all other kind of curves):

The accuracy class ~~has to~~ shall be checked for each point of the transfer function according to the formula:

$$\frac{Y - R}{R} \times 100$$

where

R is the value of the output signal under reference conditions;

Y is the value of the output signal measured at one extreme of the influence quantity.

NOTE For the curves F, replace in 6.1 to 6.23 F by R .

5.9 Digital output signals

The digital output signals chosen shall correspond with the requirements for transducers concerning accuracy and response time as well as with the requirements of the communication system.

For the digital output, the class index shall be in conformity with the performance class described in IEC 61557-12:2018.

If outputs relays are provided, they shall comply with IEC 60255-151.

5.10 Ripple (for analogue outputs)

The maximum ripple content in the output signal shall not exceed twice the class index.

5.11 Response time

5.11.1 Before determining the response time, the transducer shall be under reference conditions and the auxiliary circuit shall be energized for at least the pre-conditioning time unless it is energized from one of the input quantities and is not separately accessible.

5.11.2 The response time shall be stated by the manufacturer and shall be determined for an input step such that it would produce a change in output signal from 0 % to 90 % of the fiducial value.

5.11.3 If a test for decreasing input is required, the input step should produce a change in output signal from 100 % to 10 % of the fiducial value.

5.11.4 The interval (see 3.1.24) shall be ± 1 % of the upper nominal value of the output signal.

5.11.5 Methods of test for frequency transducers and transducers with suppressed zero shall be stated by the manufacturer.

5.12 Variation due to over-range of the measurand

If, by agreement, a transducer is required to operate with an input up to 150 % of the nominal value, the difference between the intrinsic error at 100 % and the error at 150 % (under reference conditions) of the nominal value of the input shall not exceed 50 % of the class index.

For active power and reactive power transducers, 150 % of the nominal value is achieved by increasing the current while retaining the voltage at the nominal value.

5.13 Limiting value of the output signal

The output signal shall be limited to a maximum of twice the upper nominal value.

When the measurand is not between its lower and upper nominal values, the transducer shall not, under any conditions, for example over-current or under-voltage, produce an output having a value between its lower and upper nominal values.

5.14 Limiting conditions of operation

The limits of the nominal ranges of use given in Clause 6 are those within which the transducer will comply with the requirements of this document. It is possible to operate transducers beyond these limits but the user should note that

- the accuracy may not be maintained, and/or
- the designed operational lifetime may be reduced.

As an example, many transducers will operate in ambient temperatures as low as -25 °C and as high as $+70\text{ °C}$ but the manufacturer should be consulted as to the degradation to be expected in both accuracy and operational lifetime.

5.15 Limits of the measuring range

When the limits of the measuring range do not coincide with the lower and upper nominal values of the output, the limits of the measuring range shall be marked – see 7.1 i).

5.16 Limiting conditions for storage and transport

Unless otherwise stated by the manufacturer, transducers shall be capable of withstanding, without damage, exposure to temperatures within the range -40 °C to $+70\text{ °C}$.

After returning to reference conditions, they shall meet the requirements of this document.

The manufacturer shall specify any additional limiting condition required to ensure the integrity of the transducer.

5.17 Sealing

When the transducer is sealed to prevent unauthorized adjustment, access to the internal circuit and to the components within the case shall not be possible without destroying the seal.

5.18 Stability

Transducers shall comply with the relevant limits of intrinsic error specified for their respective accuracy classes for a period specified by the manufacturer, provided that the conditions of use, transport and storage specified by the manufacturer are complied with.

NOTE Usually, the period will be below one year.

6 Tests for TRD1

6.1 General

6.1.1 Determination of variations

The variations shall be determined for each influence quantity. During the tests, all other influence quantities shall be maintained at reference conditions.

All the influence quantities are given in 6.1 to 6.23, together with the appropriate testing procedure, computations and the permissible variations for each usage group expressed as a percentage of the class index. None of the variations determined shall exceed the permissible values.

Variations shall be determined at the upper nominal value of the output and, at least, at one other point. For apparent power, active power and reactive power transducers, these values shall be obtained by maintaining the voltage and power factor at their reference conditions and varying the value of the current.

When a reference range is specified, the influence quantity shall be varied between each of the limits of the reference range and any value in that part of the nominal range of use which is adjacent to the chosen limit of the reference range.

6.1.2 Environmental conditions

The conditions of temperature and humidity are classified according to the severity dictated by the usage group in accordance with Table 6.

Table 6 – Usage groups

	K55 class of transducer	K70 class of transducer	Kx^b class of transducer
Usage group	I	II	III
Rated operating range (with specified uncertainty)	–5 °C to +55 °C	–25 °C to +70 °C	Above +70 °C and/or under –25 °C ^a
Limit range of operation (no hardware failures)	–5 °C to +55 °C	–25 °C to +70 °C	Above +70 °C and/or under –25 °C ^a
Limit range for storage and shipping	–25 °C to +70 °C	–40 °C to +85 °C	According to manufacturer specification ^a
^a Limits ~~are to~~ shall be defined by manufacturer according to the application.			
^b Kx stands for extended conditions.			

For the purpose of this document, ambient temperature shall be the temperature measured at a single representative point with the transducer operating normally. This measuring point shall be adjacent to the transducer, exposed to free air circulation and not significantly affected by heat from the transducer or by direct solar radiation and other sources of heat.

Humidity is not considered to be an influence quantity provided that the environmental conditions are within the limits specified.

6.1.3 Computations

In 6.2 to 6.22, a computation is required according to a formula. The terms in the formulae follow a general principle:

- R is the value of the output signal under reference conditions;
- X (or Y) is the value of the output signal measured at one extreme of the influence quantity;
- F is the fiducial value.

NOTE For curves F (see 5.8) replace in all the following formula F by R .

6.2 Variations due to auxiliary supply voltage

6.2.1 Application

All transducers requiring a DC or an AC auxiliary supply except where this is obtained from the input voltage or current and the connections cannot be separated for testing purposes.

6.2.2 Procedure

Apply the nominal value of auxiliary supply voltage and record the value of the output signal (R).

At a constant value of the measurand, reduce the auxiliary supply voltage to the lower limit given in 6.2.4 and record the value of the output signal (X). Increase the auxiliary supply voltage to the upper limit given in 6.2.4 and record the value of the output signal (Y).

6.2.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

Permissible variations

For AC auxiliary supplies, Table 7 applies.

Table 7 – Permissible variations due to AC auxiliary supply

Usage group	Nominal range of use %	Variation % of class index
I	90 to 110	50
II	80 to 120	50
III	80 to 120	50

For DC auxiliary supplies, Table 8 applies.

Table 8 – Permissible variations due to DC auxiliary supply

Usage group	Nominal range of use %	Variation % of class index
I	85 to 125	50
II	85 to 125	50
III	85 to 125	50

6.3 Variations due to auxiliary supply frequency

6.3.1 Application

All transducers requiring an AC auxiliary supply except where this is obtained from the input voltage or current and the connections cannot be separated for testing purposes.

6.3.2 Procedure

Apply the nominal value of auxiliary supply frequency and record the value of the output signal (R). At a constant value of the measurand, reduce the auxiliary supply frequency to the lower limit given in 6.3.4 and record the value of the output signal (X).

Increase the auxiliary supply frequency to the upper limit given in 6.3.4 and record the value of the output signal (Y).

6.3.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and:
$$\frac{Y-R}{F} \times 100$$

6.3.4 Permissible variations

Table 9 applies.

Table 9 – Permissible variations due to auxiliary supply frequency

Usage group	Nominal range of use	Variation
	%	% of class index
I	90 to 110	50
II	90 to 110	50
III	90 to 110	50

6.4 Variations due to ambient temperature

6.4.1 Application

All transducers.

6.4.2 Procedure

At a constant value of the measurand and at reference temperature, record the value of the output signal (R).

Increase the ambient temperature to the upper limit given in 6.4.4 and allow sufficient time for conditions to stabilize (30 min is usually adequate). Record the value of the output signal (X).

Reduce the ambient temperature to the lower limit given in 6.4.4 and allow the same stabilization to take place. Record the stabilization time and the value of the output signal (Y).

6.4.3 Computation

The variations are:
$$\frac{X-R}{F} \times 100$$

and:
$$\frac{Y-R}{F} \times 100$$

6.4.4 Permissible variations

Table 10 applies.

Table 10 – Permissible variations due to ambient temperature

Usage group	Nominal range of use	Variation
	°C	% of class index
I	10 to 35	100
II	0 to 45	100
III	–10 to 55	100

6.5 Variations due to the frequency of the input quantity(ies)

6.5.1 Application

All transducers except frequency transducers. Frequency sensitive transducers (e.g. those employing phase shifting circuits) are exceptions and the nominal range of use shall always be marked.

6.5.2 Procedure

Apply the nominal value of the input frequency and record the value of the output signal (R).

At a constant value of the measurand, reduce the frequency to the lower limit given in 6.5.4 and record the value of the output signal (X).

Increase the frequency to the upper limit given in 6.5.4 and record the value of the output signal (Y).

6.5.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.5.4 Permissible variations

Table 11 applies.

Table 11 – Permissible variations due to the frequency of input quantity

Usage group	Nominal range of use %	Variation % of class index
I	90 to 110	100
II	90 to 110	100
III	90 to 110	100
Frequency sensitive	As marked	100

6.6 Variations due to the input voltage

6.6.1 Application

All transducers except voltage and current transducers.

6.6.2 Procedure

Apply the nominal value of the input voltage and record the value of the output signal (R).

At a constant value of the measurand, reduce the voltage to the lower limit given in 6.6.4 and record the value of the output signal (X).

Increase the voltage to the upper limit given in 6.6.4 and record the value of the output signal (Y).

6.6.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.6.4 Permissible variations

Table 12 applies.

Table 12 – Permissible variations due to the input voltage

Usage group	Nominal range of use %	Variation % of class index
I	90 to 110	50
II	80 to 120	50
III	80 to 120	50

6.7 Variations due to the input current

6.7.1 Application

Phase angle and power factor transducers.

6.7.2 Procedure

Apply the nominal value of the input current and record the value of the output signal (R).

At a constant value of the measurand, reduce the input current to the lower limit given in 6.7.4 and record the value of the output signal (X).

Increase the input current to the upper limit given in 6.7.4 and record the value of the output signal (Y).

6.7.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.7.4 Permissible variations

Table 13 applies.

Table 13 – Permissible variations due to the input current

Usage group	Nominal range of use %	Variation % of class index
I	20 to 120	100
II	20 to 120	100
III	20 to 120	100

6.8 Variations due to power factor

6.8.1 Application

Apparent, active and reactive power transducers.

6.8.2 Procedure

Apply respectively 50 % (5 %) of the nominal value of the input current at a power factor of 1,0 and record the two values of the output signal (R). At a constant value of the measurand, increase the input current to 100 % (10 %) of the nominal value and reduce the power factor to 0,5 lag/lead, respectively. Record the two values of the output signal (X).

For convenience, when testing the reactive power transducers, it is usual to apply the equivalent values of $\sin \varphi$.

Active power transducers shall also be tested for error at a power factor of zero and reactive power transducers at a $\sin \varphi = 0$.

6.8.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.8.4 Permissible variations

Table 14 applies.

Table 14 – Permissible variations due to power factor

Usage group	Nominal range of use	Variation % of class index
I	$\cos(\sin) \varphi = 0,5 \dots 1 \dots 0,5$	50
II	$\cos(\sin) \varphi = 0,5 \dots 1 \dots 0,5$	50
III	$\cos(\sin) \varphi = 0,5 \dots 1 \dots 0,5$	50

For all transducers, the error at a power factor of zero (or $\sin \varphi = 0$) shall not exceed 100 % of the class index.

6.9 Variation due to output load

6.9.1 Application

All variable output load transducers.

6.9.2 Procedure

Apply a value of output load equal to the mean value of the nominal range and record the value of the output signal (R).

At a constant value of the measurand, reduce the resistance of the output load to the lower limit given in 6.9.4 and record the value of the output signal (X).

Increase the resistance of the output load to the upper limit given in 6.9.4 and record the value of the output signal (Y).

6.9.3 Computation

The variations are: $\frac{X - R}{F} \times 100$

and: $\frac{Y - R}{F} \times 100$

6.9.4 Permissible variations

Table 15 applies.

Table 15 – Permissible variations due to output load

Usage group	Nominal range of use %	Variation % of class index
I	10 to 100	50
II	10 to 100	50
III	10 to 100	50

6.10 Variations due to distortion of the input quantity(ies)

6.10.1 Application

All transducers characterized by the manufacturer for use on systems having distorted waveforms, except harmonics transducers.

6.10.2 Procedure

Apply the chosen value of input quantity with no distortion and record the value of the output signal (R). Introduce third harmonic distortion at the level given in 6.10.4, maintaining the RMS values constant, and record the value of the output signal (X). The phase relationship between the harmonic and the fundamental should be varied so as to determine the most unfavourable conditions.

For apparent, active and reactive power transducers, the test is performed with distorted current waveform and then repeated with distorted voltage waveform.

For apparent active and reactive power transducers not employing phase shifters, the permissible variations are given in 6.10.4.

For reactive power transducers employing phase shifters, the permissible variations shall be specified by the manufacturer.

6.10.3 Computation

The variation is: $\frac{X-R}{F} \times 100$

6.10.4 Permissible variations

Table 16 applies.

Table 16 – Permissible variations due to distortion of input quantities

Usage group	Nominal range of use	Variation % of class index
I	Distortion factor 0,2	200
II	Distortion factor 0,2	200
III	Distortion factor 0,2	200

6.11 Variation due to magnetic field of external origin

6.11.1 Application

All transducers.

6.11.2 Procedure

The transducer is placed in the centre of a coil of 1 m mean diameter, of square cross section and of radial thickness small compared with the diameter ~~(see Note)~~. Other devices which produce an adequate homogeneous magnetic field in the absence of the transducer under test are also permissible. 400 ampere-turns in this coil will produce, at the centre of the coil, in the absence of the transducer under test, a magnetic field strength of 0,4 kA/m. The magnetic field shall be produced by a current of the same kind and frequency as that which energizes the measuring circuit and shall be such as to have the most unfavourable combination of phase and orientation. The values of AC fields are expressed in RMS values.

Any transducer having an external dimension exceeding 250 mm shall be tested in a coil of mean diameter not less than four times the maximum dimensions of the transducer. The magnetic field strength being the same as that given above.

~~NOTE – Other devices which produce an adequate homogeneous magnetic field in the absence of the transducer under test are also permissible.~~

In the absence of the external field, record the value of the output signal (R).

At a constant value of the measurand, apply the external field and record the value of the output signal (X).

6.11.3 Computation

The variation is: $\frac{X-R}{F} \times 100$

6.11.4 Permissible variations

Table 17 applies.

Table 17 – Permissible variations due to magnetic field of external origin

Usage group	Variation % of class index
I	100
II	100
III	100

6.12 Variation due to unbalanced currents

6.12.1 Application

Multi-element apparent, active and reactive power transducers.

6.12.2 Procedure

The currents shall be balanced and adjusted so that the output signal is approximately in the middle of the span or, if zero output signal is within the span, half-way between zero and the upper nominal value of the output signal. Record the value of the output signal (R).

Disconnect one current, maintaining the voltages balanced and symmetrical, and adjust the other currents, maintaining them equal, so as to restore the initial value of the measurand.

Record the value of the output signal (X).

6.12.3 Computation

The variation is: $\frac{X - R}{F} \times 100$

6.12.4 Permissible variations

Table 18 applies.

Table 18 – Permissible variations due to unbalance currents

Usage group	Variation % of class index
I	100
II	100
III	100

6.13 Variation due to interaction between measuring elements

6.13.1 Application

All multi-element apparent, active power and reactive power transducers except those employing two measuring elements for measuring three-phase four-wired unbalanced power with three current circuits (sometimes known as "two and a half elements") and those reactive power transducers using cross-connection methods.

6.13.2 Procedure

The voltage input of one measuring circuit alone shall be energized at nominal voltage. The current input of each of the other measuring circuits shall be energized in turn at nominal current. The maximum departure of the output signal (X) from that corresponding to zero of the measurand shall be noted whilst the phase angle between the voltage and currents is changed through 360°.

If the auxiliary supply is common to one of the voltage input circuits, this circuit shall be the one to which the voltage is applied.

6.13.3 Computation

The variation is: $\frac{X}{F} \times 100$

6.13.4 Permissible variations

Table 19 applies.

Table 19 – Permissible variations due to interactions between measuring elements

Usage group	Variation % of class index
I	50
II	50
III	50

6.14 Variation due to self-heating

6.14.1 Application

All transducers.

6.14.2 Method

The transducer shall be at ambient temperature and shall have been disconnected for at least 4 h. Energize the transducer in accordance with ~~4.5.4 (except for the condition of "30 min" as specified in Table 2)~~ reference conditions defined in Table 4 and Table 5.

After 1 min and before the third minute, determine the value of the output signal (X). Repeat this procedure between the 30th and 35th minute after energization (R).

6.14.3 Computation

The variation is: $\frac{X - R}{F} \times 100$

6.14.4 Permissible variations

Table 20 applies.

Table 20 – Permissible variations due to self-heating

Usage group	Variation % of class index
I	100
II	100
III	100

6.15 Variation due to continuous operation**6.15.1 Application**

All transducers.

6.15.2 Procedure

Energize the transducer under reference conditions for at least the preconditioning period. Record the value of the output (R). After a convenient period of continuous operation, for example 6 h, note the value of the output (X).

6.15.3 Computation

The variation is: $\frac{X-R}{F} \times 100$

6.15.4 Permissible variation

A variation is allowed but the transducer shall continue to comply in all respects with the requirements appropriate to its accuracy class.

6.16 Variation due to common mode interference**6.16.1 Application**

All transducers having an analogue output signal.

6.16.2 Procedure

At a constant value of the measurand near the upper nominal value, record the value of the output signal (R). Apply a voltage of 100 V RMS, at 45 Hz to 65 Hz, between either output terminal and earth. Record the value of the output signal (X).

6.16.3 Computation

The variation is: $\frac{X-R}{F} \times 100$

6.16.4 Permissible variations

Table 21 applies.

Table 21 – Permissible variations due to continuous operation

Usage group	Variation % of class index
I	100
II	100
III	100

6.17 Variation due to series mode interference

6.17.1 Application

All transducers having an analogue current output signal.

6.17.2 Procedure

At a constant value of the measurand near the upper nominal value and with the compliance voltage at 80 % of the maximum value, record the value of the output signal (R).

Apply a voltage of 1 V RMS at 45 Hz to 65 Hz, in series with the output signal. Record the value of the output signal (X).

NOTE The internal DC resistance of the source of the series-mode interference, if excessive, ~~may~~ can influence the test results, especially for the fixed output load transducers.

6.17.3 Computation

The variation is:
$$\frac{X - R}{F} \times 100$$

6.17.4 Permissible variations

Table 22 applies.

Table 22 – Permissible variations due to series mode interference

Usage group	Variation % of class index
I	100
II	100
III	100

6.18 Permissible excessive inputs

6.18.1 General

After completion of the tests described in 6.18.2 and 6.18.3 and after having regained equilibrium with the reference value of the ambient temperature, the transducer shall comply with the requirements appropriate to its class index.

6.18.2 Continuous excessive inputs

The transducer shall withstand the application of excessive inputs simultaneously for 24 h.

- Voltage inputs, including auxiliary supplies, shall be subjected to 120 % of the nominal value of the voltage.

b) Current inputs shall be subjected to 120 % of the nominal value of the current.

6.18.3 Excessive inputs of short duration

The tests shall be made under reference conditions. The excessive input amplitudes of short duration which shall be applied to transducers are:

- a) for voltage inputs: 200 % of the nominal value of the measured voltage applied for 1 s and repeated 10 times at 10 s intervals;
- b) for current inputs: 20 times the nominal value of the measured current applied for 1 s and repeated 5 times at 300 s intervals.

The test circuit shall be substantially non-reactive.

After testing, the intrinsic characteristics of the transducer shall be unchanged.

6.19 Voltage test, insulation tests and other safety requirements

The requirements for the voltage test and other safety requirements are included in IEC 61010-1:2010 to which reference shall be made.

6.20 Impulse voltage tests

6.20.1 A peak test voltage of 5 kV in both positive and negative senses, having the standardized impulse waveform of 1,2/50 μ s, shall be applied to transducers as follows:

- between the earth terminal and all the other terminals connected together;
- between the terminals of each circuit in turn, all other circuits being earthed.

Three positive and three negative impulses shall be applied at intervals of not less than 5 s. Any flashover (capacitance discharge) shall be considered a criterion of failure unless occurring in a component designed for such.

For further details of the impulse voltage test, reference ~~shall~~ should be made to IEC 61010-1:2010 and IEC 61010-2-030:2017.

6.20.2 After completion of the impulse voltage test, the transducer shall comply with the requirements appropriate to its class index.

6.20.3 Auxiliary circuits with a reference voltage of over 40 V shall be subjected to the impulse voltage test under the same conditions as those already given for the other circuits.

6.21 High frequency disturbance test

See IEC 61326 (all parts).

6.22 Test for temperature rise

The transducer shall be energized as follows:

- each current circuit shall carry a current of 1,1 times the nominal current;
- each voltage circuit shall be supplied with a voltage of 1,2 times the nominal voltage.

These conditions shall be maintained for at least 2 h. During the test, the transducer shall not be exposed to forced ventilation nor to direct solar radiation.

The temperature rise of the following parts of the transducer shall not exceed:

- for input circuits: 60 K;

- for the exterior surface: 25 K.

6.23 Other tests

If, by agreement, other tests are required, ~~refer to~~ the following publications shall apply:

- for vibration: IEC 60068-2-6;
- for shock: IEC 60068-2-27;
- for electromagnetic compatibility: IEC 61326-1:2020.

7 Marking and information for TRD1

7.1 Marking on the case

Transducers shall bear, on (or visible through) one of the external surfaces of the case, the markings listed below. The markings shall be legible and indelible. The symbols referred to below are specified in Table 24.

- Manufacturer's name or mark.
- Manufacturer's type designation.
- Serial number or date code.
- Software version (version of software that reside in the transducer – if any for digital transducers only).
- Class index (symbol E-10 or E-11).
- Nature of the measurand and number of circuits (symbol B-2, B-4 or B-6 to B-10).
- Lower and upper nominal values of the measurand.
- Ratios of current transformers and voltage transformers, if any, with which the transducer is intended to be used.
- Range of values of the output current (voltage) and output load within which specified operation is obtained (analogue signals only).
- Limits of the measuring range, if appropriate (see 5.9).
- Serial number(s) of the associated equipment, if applicable.
- Value(s) of the auxiliary supply, if relevant.
- Symbol showing that some other essential information is given in a separate document (symbol F-33).
- Space for adjustment data (if appropriate).
- Nominal range of use for temperature, symbolized as usage group I, II or III.
- Common mode voltage.
- Overvoltage category (see IEC 61010 (all parts).
- Pollution degree according to IEC 61010 (all parts).
- Other required safety symbols according to IEC 61010-1:2010.

If the markings and symbols are on an easily removable part, such as a cover, the transducer shall have a serial number which shall also be marked on the body of the transducer.

Transducers having a non-linear relationship between input and output shall be marked with the symbol F-33, and actual relationship between input and output shall be given in a separate document.

NOTE To be given if there is sufficient space on the case, otherwise to be given in a separate document.

7.2 Markings relating to the reference conditions and nominal ranges of use for transducers

7.2.1 The reference values (or ranges) and nominal ranges of use, if different from those given in Table 3 and Table 4 and Clause 6, shall be marked on the transducer or given in a separate document.

7.2.2 When a reference value or a reference range is marked, it shall be identified by underlining.

Table 23 shows the significance of the various markings, for example for temperature.

Table 23 – Examples of marking relating to the reference conditions and nominal range of use for temperature

Example	Meaning
-5 ... <u>23</u> ... 55 °C	Conforms to group I
-25 ... <u>15</u> ... <u>30</u> ... 70 °C	Conforms to group II
-35 ... <u>0</u> ... <u>45</u> ... 75 °C	Conforms to group III
0 ... <u>25</u> ... 40 °C	Reference value: 25 °C Nominal range of use: 0 °C to 40 °C
-5 ... <u>20</u> ... <u>30</u> ... 35 °C	Reference range: 20 °C to 30 °C Nominal range of use: -5 °C to 35 °C
Three or four numbers shall always be used.	

7.3 Identification of connections and terminals

If so required for the correct use of the transducer, a diagram or table of connections shall be supplied and the terminals shall be clearly marked to show the proper method of connection.

If a terminal of a measuring circuit is intended to be kept at, or near to earth (ground) potential (for example, for safety or functional reasons), it shall either be marked with a capital N if it is intended to be connected to the neutral conductor of an AC supply circuit, or it shall be marked with symbol F-45 (see Table 24) in all other circumstances.

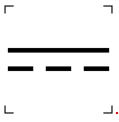
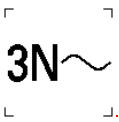
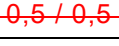
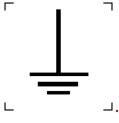
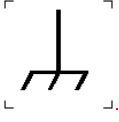
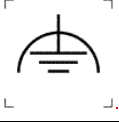
The earthing terminal(s) shall be marked using symbol(s) F-31 and/or F-42 to F-45, as appropriate.

7.4 Information to be given in a separate document

The following information shall be given in the document supplied with the transducer:

- response time;
- the variation due to a magnetic field of external origin;
- the actual relationship between input and output (see required indications according type of curves given in 5.3 for output current transfer functions).

Table 24 – Symbols for marking transducers

No.	Item	Symbol
B Nature of input quantity(ies) and number of measuring circuits		
B-1	~~IEC 60417-5031: Direct current;~~ D.C. circuit (for auxiliary supply only)	
B-2	~~IEC 60417-5032: Alternating current;~~ A.C. circuit (single phase)	
B-3	~~D.C. and a.c. circuit~~	
B-4	~~IEC 60417-5032-1: Three phase alternating current;~~ ~~Three phase a.c. circuit (general symbol)~~	
B-6	One measuring element for three wire network	
B-7	~~IEC 60417-5032-2: Three phase alternating current with neutral conductor;~~ One measuring element for four wire network	
B-8	~~Two measuring elements for three wire network with unbalanced load~~	
B-9	~~Two measuring elements for four wire network with unbalanced load~~	
B-10	~~Three measuring elements for four wire network with unbalanced load~~	
C Safety (see IEC 61010-1)		
E Accuracy class		
E-10	Class index (e.g. 1) when the fiducial value corresponds to the span	
E-11	Class index (e.g. 0,5) when the fiducial value corresponds to half the span	
F General symbols		
F-31	~~IEC 60417-5017: Earth; ground;~~ Earth (ground) terminal (general symbol)	
F-33	~~ISO 7000-0434A: Caution; Caution;~~	
F-42	~~IEC 60417-5020: Frame or chassis;~~ Frame or chassis terminal	
F-43	~~IEC 60417-5019: Protective earth; protective ground;~~ Protective earth (ground) terminal	
F-44	~~IEC 60417-5018: Functional earthing; functional grounding (US);~~ Functional earth terminal	
F-45	Measuring circuit earth (ground) terminal	

F-46	~~IEC 60417-5005: Plus; positive polarity; Positive terminal~~	
F-47	~~IEC 60417-5006: Minus; negative polarity; Negative terminal~~	

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No.	Item		Symbol
B Nature of input quantity(ies) and number of measuring circuits			
B-1	DC circuit (for auxiliary supply only)	IEC 60417-5031 (2002-10)	
B-2	AC circuit (single phase)	IEC 60417-5032 (2002-10)	
B-3	DC and AC circuit	IEC 60417-5033 (2002-10)	
B-4	Three-phase AC circuit (general symbol)	IEC 60417-5032-1 (2002-10)	3
B-6	One measuring element for three-wire network	IEC 60417-5032-1 (2002-10)	3 1E
B-7	One measuring element for four-wire network	IEC 60417-5032-2 (2002-10)	3N 1E
B-8	Two measuring elements for three-wire network with unbalanced load	IEC 60417-5032-1 (2002-10)	3 2E
B-9	Two measuring elements for four-wire network with unbalanced load	IEC 60417-5032-2 (2002-10)	3N 2E
B-10	Three measuring elements for four-wire network with unbalanced load	IEC 60417-5032-2 (2002-10)	3N 3E
C Safety (see IEC 61010-1:2010)			
E Accuracy class			
E-10	Class index (e.g. 1) when the fiducial value corresponds to the span	---	1
E-11	Class index (e.g. 0,5) when the fiducial value corresponds to half the span	---	0,5 / 0,5
F General symbols			
F-31	Earth (ground) terminal (general symbol)	IEC 60417-5017 (2006-08)	
F-33	Caution, (refer to a separate document)	ISO 7000-0434B (2004-01)	
F-42	Frame or chassis terminal	IEC 60417-5020 (2002-10)	
F-43	Protective earth (ground) terminal	IEC 60417-5019 (2006-08)	
F-44	Functional earth terminal	IEC 60417-5018 (2006-08)	
F-45	Measuring circuit earth (ground) terminal	IEC 60417-5073 (2006-08)	
F-46	Positive terminal	IEC 60417-5005 (2006-08)	
F-47	Negative terminal	IEC 60417-5006 (2006-08)	

Annex A (normative)

Requirements for TRD2

A.0 General

Clause A.1 to Clause A.3 follow the numbering of those in the main part of the document.

A.1 Scope

Clause 1 applies, with the following addition:

Nominal voltage is limited to 1 000 V AC and 1 500 V DC.

A.2 Normative references

Clause 2 applies.

A.3 Terms and definitions

Clause 3 applies.

A.4 Environmental conditions

A.4.1 General

TRD2 are used in the environmental conditions of measuring equipment such as PMD complying with IEC 61557-12:2018 or PQI complying with IEC 62586-1:2017.

A.4.2 Normal environmental conditions

Various environments, such as electrical distribution systems or supply grids, can be considered as normal environments.

Normal environmental conditions have been translated in ratings in Clause A.5.

A.4.3 Special environmental conditions

There might be specific or more severe environmental conditions.

A.5 Ratings for TRD2

A.5.1 General

The basic ratings of TRD2 shall include the following items (as applicable).

1) Input ratings

- rated frequency (f_r);
- rated input voltage (U_{pr}).

The ratings for a TRD2 having a current monitoring input shall include, in addition,

- rated input current (I_{pr}),
- rated extended input current factor (K_{epcr}),
- rated continuous thermal current (I_{cth}),
- rated short-time thermal current (I_{th}), and
- rated dynamic current (I_{dyn}).

2) Output ratings

- rated output current (I_{sr}), for TRD2 delivering a current output;
- rated output voltage (U_{sr}), for TRD2 delivering a voltage output;
- rated output frequency (f_{sr}), for TRD2 delivering a frequency output;
- rated burden Z_{br} .

3) General ratings

- rated accuracy class;
- rated temperature class;
- rated humidity class;
- rated auxiliary power supply, if any;
- overvoltage category;
- measurement category, if any.

NOTE See guidance in IEC 61010-2-030:2017.

A.5.2 Input ratings

A.5.2.1 Rated frequency

For AC applications, the standard values of the rated frequency are 16,7 Hz, 50 Hz, 60 Hz and 400 Hz.

A.5.2.2 Input voltage ratings

The rated input voltage shall be specified by the manufacturer, taking into account Annex I of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016.

A.5.2.3 Input current ratings

A.5.2.3.1 Rated input current

The rated input current value shall be specified by the manufacturer.

A.5.2.3.2 Rated extended input current factor

A value for the rated extended input current factor may be assigned to the TRD2 by the manufacturer.

A K_{epcr} shall be assigned to the TRD2; the minimum value allowed is 1,2.

NOTE The selection of proper input and output rated values is supposed to be consistent with input limits of the associated measuring equipment.

A.5.2.3.3 Rated continuous thermal current (I_{cth})

The standard value for the rated continuous thermal current of the TRD2 is the rated input current.

When a rated continuous thermal current greater than the rated input current is specified, the preferred values are 120 %, 150 % and 200 % of rated input current.

A.5.2.4 Short-time current ratings

A.5.2.4.1 Rated short-time thermal current (I_{th})

A rated short-time thermal current (I_{th}) shall be assigned to the equipment.

If the duration is not specified, the value of the duration of the rated short-time thermal current is 1 s.

A.5.2.4.2 Rated dynamic current (I_{dyn})

If not otherwise specified, the standard value of the rated dynamic current (I_{dyn}) is 2,5 times the rated short-time thermal current (I_{th}).

A.5.3 Output ratings

A.5.3.1 Rated output interfaces

Rated output interfaces are defined through interface coding, as defined in Annex B.

NOTE Annex B provides also most common output interfaces.

Output ratings are defined at I_{pr} for TRD measuring current, and at U_{pr} for TRD2 measuring voltage.

A.5.3.2 Rated burden

A.5.3.2.1 Rated burden for TRD2 with an AC or DC voltage output, or a frequency output

The preferred value of rated burden is defined by a resistance in parallel with a capacitance according to Table A.1.

Table A.1 – Rated burden for TRD2 with an AC or DC voltage output, or a frequency output

Burden	Resistance	Capacitance
$Z_{br} U$	2 MΩ	50 pF

The impact of the total burden impedance range on accuracy is covered under accuracy clauses.

Attention should be paid to the parallel capacitance of instruments. If the transmitting cable is not part of the TRD2, the capacitance of the cable shall be considered as part of the burden.

NOTE Typical cable capacitance is in the range from 15 pF/m to 100 pF/m.

If a cable is factory mounted, it shall not be changed/modified in order to preserve the specified characteristics of the device, except if special considerations are undertaken to take into account the modified characteristics of the TRD2 based on manufacturer's information.

A.5.3.2.2 Rated burden for TRD2 with an AC or DC current output

The preferred value of rated burden is defined by the impedance in parallel according to Table A.2.

Table A.2 – Rated burden for TRD2 with an AC or DC current output

Burden	Resistance	Power factor
$Z_{br} I1$	1 Ω	1
$Z_{br} I2$	2,7 Ω	1

Other values of rated burden may be chosen with output power up to 0,05 VA.

A.5.3.3 Power supply

Rated external power supply and power supply provided by measuring equipment connected to TRD2 output are defined in Annex B.

A.5.4 General ratings

A.5.4.1 Accuracy classes

The standard accuracy classes for TRD2 are defined in Table A.7, Table A.8, Table A.9 and Table A.10.

A.5.4.2 Rated temperature classes

The standard temperature classes K40, K45, K55, K70 and Ks for TRD2 are defined in the below Table A.3.

Table A.3 – Rated temperatures for TRD2

	K40 temperature class	K45 ^d temperature class	K55 ^d temperature class	K70 ^d temperature class of TRD2	Ks ^{b d} temperature class of TRD2
Rated operating range^c (with specified uncertainty)	–5 °C to +40 °C	–10 °C to +45 °C	–5 °C to +55 °C	–25 °C to +70 °C	According to manufacturer's specification ^a
Limit range of operation (no hardware failures)	–10 °C to +55 °C	–25 °C to +55 °C	–5 °C to +55 °C	–25 °C to +70 °C	
Limit range for storage and shipping	–25 °C to +70 °C	–25 °C to +70 °C	–25 °C to +70 °C	–40 °C to +85 °C	

^a Limits shall be defined by the manufacturer according to the application.

^b Ks stands for special temperature class.

^c An operating temperature is the highest temperature of the air in close proximity to TRD2.

^d K45 temperature class corresponds to FI1 of IEC 62586-1:2017 and "indoor use" condition of IEC 62052-11:2020.

K55 temperature class corresponds to K55 class of IEC 61557-12:2018.

K70 temperature class corresponds to K70 class of IEC 61557-12:2018.

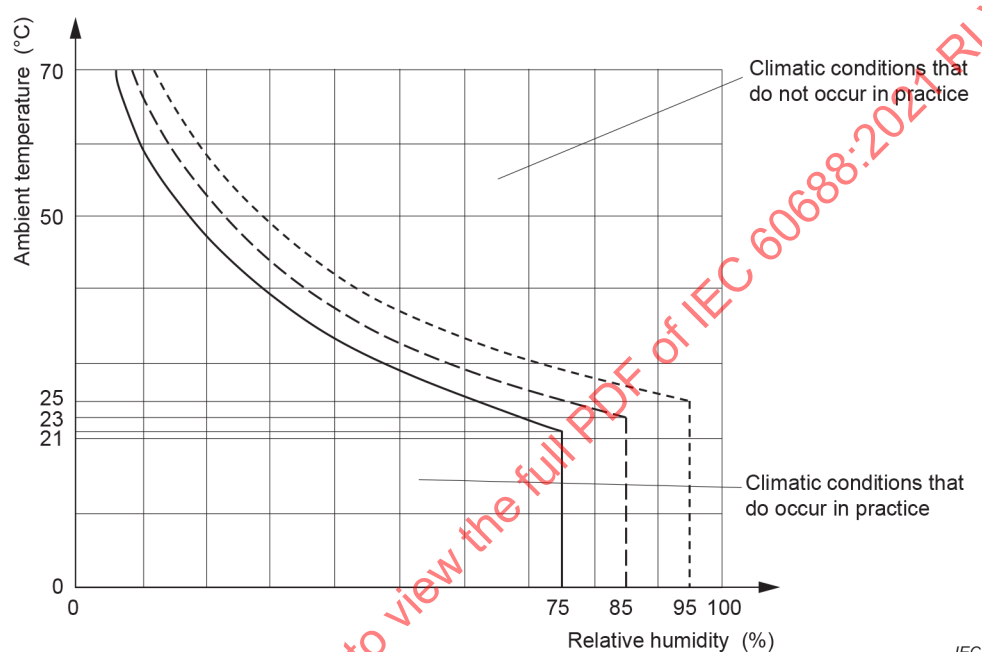
Ks temperature class corresponds to any other temperature class, e.g. Kx class of IEC 61557-12:2018, or FI2 or FO classes of IEC 62586-1:2017.

A.5.4.3 Rated humidity classes

Table A.4 provides the rated humidity classes (standard humidity class and extended humidity class) for TRD2. See Figure A.1.

Table A.4 – Rated humidity classes

	Standard humidity class	Extended humidity class
Rated operating range (with specified uncertainty)	0 % to 75 % RH ^b	0 % to above 75 % RH ^{a b}
Limit range of operation for 30 days/year	0 % to 90 % RH ^b	0 % to above 90 % RH ^{a b}
Limit range for storage and shipping	0 % to 90 % RH ^b	0 % to above 90 % RH ^{a b}
^a Limits shall be defined by manufacturer according to the application.		
^b Relative humidity values are specified without condensation.		

**Figure A.1 – Relationship between ambient air temperature and relative humidity**

A.6 Requirements for design of TRD2

A.6.1 General

If a TRD2 is specified for both AC and DC measuring applications, both AC and DC requirements apply.

However, if a TRD2 is specified for DC measuring with AC components (AC ripples), only DC requirement apply.

Unless otherwise specified, all the requirements of A.6.1 to A.6.9 apply for TRD2 measuring AC or DC applications.

A.6.2 Safety requirements

A.6.2.1 General

Two classes of TRD2 are defined.

- Class F: TRD2 shall fully comply with the safety requirements of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 and IEC 61010-2-030:2017, with additional requirements specified in A.6.2.2 to A.6.2.13. Class F is recommended for new designs.

- Class D: TRD2 shall mostly comply with the safety requirements of IEC 61010-1:2010 and IEC 61010-2-030:2017, with additional requirements specified in A.6.2.2 to A.6.2.13, but with some deviations compared to class F. In such a case, compliance to IEC 61010-1 cannot be claimed.

A.6.2.2 Protection against electric shocks

A.6.2.2.1 General

For TRD2 class F, Clause 6 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 and IEC 61010-2-030:2017 applies with the below additional requirements.

Clearances and creepage distances as well as solid insulation shall be selected at least in accordance with

- pollution degree 2,
- measurement category III, for measuring circuits, and
- overvoltage category III, for other circuits, if any.

For TRD2 class D, levels of insulations can be either identical to those defined for class F or be based on IEC 60664-1:2020, with the below additional requirements.

Clearances and creepage distances as well as solid insulation shall be selected at least in accordance with

- pollution degree 2, and
- overvoltage category III.

NOTE General information is provided in Annex G.

A.6.2.2.2 Accessible parts

A.6.2.2.2.1 Output terminals of TRD2

Output terminals of transducers to be connected to the measuring equipment shall generally be considered as accessible parts.

This is especially true for terminals equipped with an information technology connector (e.g. RJ45, DB9, or similar plug-in connectors) or with stranded wire, where skilled or unskilled people do not expect a hazardous voltage.

Some exemption may apply on condition they are based on a risk analysis, in which case the related mitigation measures shall be documented.

A.6.2.2.2.2 Outer surfaces of TRD2

Outer surface of transducers intended to be installed outside a cabinet, a panel or a cubicle shall generally be considered as accessible parts.

Some exemption may apply on condition they are based on a risk analysis, in which case the related mitigation measures shall be documented.

A.6.2.2.3 Insulation provided by cables, busbars and bushings

Manufacturers shall specify in the technical documentation

- the kind of insulation requested on the cables or busbars or bare conductors to measure, and
- the kind of bushings to use, if any.

NOTE Guidance on insulation of cables or bushings is provided in Annex F.

A.6.2.2.4 Insulation within a panel

Manufacturers shall specify in the technical documentation if a minimum distance needs to be maintained between outer surfaces of the TRD2 (or its output circuits) and other equipment such as metallic parts or another TRD2 in its proximity.

A.6.2.2.5 Automatic disconnection

TRD2 class F shall comply with the requirements of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 related to automatic disconnection.

TRD2 class D shall either comply class F requirements or comply with the requirements of Clause 15 of IEC 61558-1:2017 related to automatic disconnection.

A.6.2.3 Protection against mechanical hazards

Clause 7 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 applies.

A.6.2.4 Resistance to mechanical stress

Clause 8 of IEC 61010-1:2010 applies with the below additional requirements.

Outer surface of transducers intended to be installed outside a cabinet, a panel or a cubicle shall meet, except for terminals and cords,

- IK07 (2 J) for indoor use, and
- IK08 (5 J) for outdoor use.

Outer surfaces of transducers intended to be installed exclusively inside a cabinet, a panel or a cubicle shall meet, except terminals and cords, at least IK02 (0,2 J) requirements.

A.6.2.5 Protection against the spread of fire

Clause 9 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 applies.

A.6.2.6 Equipment temperature limits and resistance to heat

Clause 10 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 applies with the below additional requirements.

Manufacturers shall declare for TRD2 intended to monitor currents

- if the TRD2 is intended to be used with integral means to avoid any (thermal) contact with conductor (cable or busbar) or if it is intended to be used in (thermal) contact with the conductor,
- if two TRD2, put side by side, can be continuously in (thermal) contact during service, and
- if a TRD2 can be continuously in (thermal) contact during service with another cable or busbar in the vicinity.

NOTE Guidance on temperature of cables and busbars is provided in Annex F.

A.6.2.7 Protection against hazards from fluids

A.6.2.7.1 General

Clause 11.6 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 applies with the additional requirements of A.6.2.7.2 and A.6.2.7.3.

A.6.2.7.2 Degrees of protection for indoor use

For indoor use, outer surface of transducers intended to be installed outside a cabinet, a panel or a cubicle shall meet IP40 requirements.

For indoor use, outer surface of transducers intended to be installed inside a cabinet, a panel or a cubicle shall meet IP2X requirements.

This requirement is not applicable to installations where personnel cannot gain access to the transducer without firstly de-energising the transducer and making it safe through some controlled means (i.e. interlocking, documented operating instructions, etc.). In this case, the need for such external safety measures to the transducer should be clearly stated in the product documentation.

A.6.2.7.3 Degrees of protection for outdoor use

The recommended minimum degree of protection for enclosures for outdoor TRD2 is IP44 according to IEC 60529.

For TRD2 with lower IP index or for higher installation needs, additional protection features against rain and other weather conditions shall be specified by means of the supplementary letter W placed after the second characteristic numeral, or after the additional letter, if any.

A.6.2.8 Protection against radiation, including laser sources, and against sonic and ultrasonic pressure

Clause 12 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016, if relevant, applies.

A.6.2.9 Protection against liberated gases and substances, explosion and implosion

Clause 13 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016, if relevant, applies.

A.6.2.10 Components and subassemblies

Clause 14 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016, if relevant, applies.

A.6.2.11 Protection by interlocks

Clause 15 of IEC 61010-1:2010, if relevant, applies.

A.6.2.12 Hazards resulting from application

Clause 16 of IEC 61010-1:2010, if relevant, applies.

A.6.2.13 Risk assessment

Clause 17 of IEC 61010-1:2010, if relevant, applies.

A.6.3 EMC requirements

A.6.3.1 General

A.6.3 applies only to TRD2 with active electronic components.

TRD2 shall comply with the immunity requirements of A.6.3.2 and the emission requirements of A.6.3.3.

They shall also comply with the requirements of IEC 61326-1:2020 in regard to

- test plan,
- test,
- test report, and
- instructions of use.

A.6.3.2 Immunity requirements

TRD2 transducers covered by A.6.3 shall comply with IEC 61326-1:2020, Table 2, with

- the ports as defined in Table A.5, below,
- the performance criteria of 6.4 of IEC 61326-1:2020 replaced by those defined in the below Table A.6, and
- the recommendation that devices are tested at 5 kHz for IEC 61000-4-4, instead of 100 kHz.

Table A.5 – Definition of ports

Port	Items related to transducers
Enclosure	Inner surface and outer surface of the transducer, including outer surface of connection cable and connectors, if any.
I/O signal/control	Output terminals Power supply terminals when provided by the measuring equipment connected to the TRD2 output via the connector, if any Memory management terminals when provided by the measuring equipment connected to the TRD2 output via the connector, if any Functional earth, if any.
DC power ^a	Protective earth, if any. Power supply port, when supplied from an external power supply source, if any.
AC power	Protective earth, if any. Power supply port, when supplied from an external power supply source, if any.
^a Power supply terminal intended to be connected to a low voltage DC supply (≤ 60 V) where the power ports are isolated from the AC mains are not subject to transient overvoltages (i.e. reliably grounded, capacitively filtered DC output circuits) and shall be regarded as I/O signal/control ports.	

Table A.6 – Performance criteria for EMC immunity tests

Assessment criteria	Conditions for acceptance
A	Normal performance within the accuracy specification limits during and after the test. No change in the operating state is allowed nor is loss of data. For transducers with digital output signal, this includes the state of quality and sync bits. During the tests, no individual sampled value error shall exceed 10 % of the rated value. A reset or restart is not allowed.
B	Normal performance after the tests, within the accuracy specification limits for transducers. An unintended change of the operating state is allowed if self-recoverable. A temporary degradation of the performance is permitted during the tests, provided the function is self-recoverable, i.e. without user intervention, if this is described in the EMC test plan and if the information is provided to the end user. During the tests, no loss of stored data is allowed, and no individual sampled value error shall exceed 100 % of the nominal RMS value. A reset or restart is not allowed.
C	Temporary loss of function is permitted, provided the function is self-recoverable or can be restored by the operation of controls. A reset or restart is allowed, provided that, during this cycle, the output signal is either zeroed or the validity bit is set to invalid until the transducer is again within the normal performance limits. The recovery procedure shall be provided to the end user. No permanent damage to the equipment is allowed. After a reset or restart: normal performance within the accuracy specification limits

A.6.3.3 Emission requirements

TRD2 covered by A.6.3 shall comply with the requirements of 7.2 of IEC 61326-1:2020 for class A or class B equipment.

A.6.4 Climatic requirements**A.6.4.1 Temperature requirements**

TRD2 shall comply with one of the temperature classes defined in A.5.4.2.

A.6.4.2 Corrosion requirements

Risks of corrosion should to be considered during design according to TRD2 intended use.

A.6.5 Mechanical requirements**A.6.5.1 Vibration requirements**

No additional requirements to the safety requirements.

A.6.5.2 IP requirements

No additional requirements to the safety requirements.

A.6.6 Interface requirements

A.6.6.1 Input interface requirements

Input terminals, if any, shall be secure and reliable. Screw or screwless terminals are allowed.

A.6.6.2 Output interface requirements

Output terminals, if any, shall be secure and reliable.

For output terminals connection, one the following 4 options is possible:

- integral wire with flying leads, provided marking complies with A.6.8.3.4;
- terminal for wires (e.g. spring terminals, screw or screwless terminals, terminal block);
- a RJ45 connector as described in Table A.7 may be used for short distances (< 10m);
- a special connector, according to manufacturer specification.

Table A.7 – RJ45 connector pinout

Pin:	1	2	3	4	5	6	7	8
Function:	S1	S2	T1+	V+	V-	T2-	a	n

S1, S2: transducer output terminals, for transducers issuing a current output signal
a, n: transducer output terminals, for transducers issuing a voltage output signal
T1+, T2-: reserved for future use of TEDS connection (transducer electronic data sheet, ISO/IEC/IEEE 21451-4:2010).
The voltage level delivered to the transducer shall not exceed 5 V DC.
V+, V-: power supply
NOTE RJ45 cord can be shielded or not depending on the length of the cord.

A.6.7 Accuracy requirements

A.6.7.1 Accuracy classes for TRD2 monitoring power factor with arithmetic method (TRD2-PFA)

Accuracy classes shall align with performance classes defined in 4.8.8 of IEC 61557-12:2018 for power factor, arithmetic method.

A.6.7.2 Accuracy classes for TRD2 monitoring power factor with vector method (TRD2-PFV)

Accuracy classes shall align with performance classes defined in 4.8.8 of IEC 61557-12:2018 for power factor, vector method.

A.6.7.3 Accuracy classes for TRD2 monitoring voltage THD (TRD2-THDU)

Accuracy classes shall align with performance classes defined in 4.8.14 of IEC 61557-12:2018 for voltage THD.

A.6.7.4 Accuracy classes for TRD2 monitoring current THD (TRD2-THDI)

Accuracy classes shall align with performance classes defined in 4.8.16 of IEC 61557-12 for current THD.

A.6.7.5 Accuracy classes for TRD2 monitoring AC current (TRD2-IAC)

A.6.7.5.1 Limits of error (ϵ) and phase error

The limits for the error on the magnitude and phase (as applicable) at the rated frequency shall not exceed the values given in Table A.8 for the specified accuracy class at the rated burden.

Table A.8 – Limits for error and phase error for TRD2-IAC

Accuracy class	Error (as applicable)					Phase error (as applicable)									
	$\pm\%$					$\pm\text{min}$					$\pm\text{Centiradians}$				
	at current (times rated input current)					at current (times rated input current)					at current (times rated input current)				
	0,01	0,05	0,2	1,0	K_{epcr}	0,01	0,05	0,2	1,0	K_{epcr}	0,01	0,05	0,2	1,0	K_{epcr}
0,1	-	0,4	0,2	0,1	0,1	-	15	8	5	5	-	0,45	0,24	0,15	0,15
0,2	-	0,75	0,35	0,2	0,2	-	30	15	10	10	-	0,9	0,45	0,3	0,3
0,2S	0,75	0,35	0,2	0,2	0,2	30	15	10	10	10	0,9	0,45	0,3	0,3	0,3
0,5	-	1,5	0,75	0,5	0,5	-	90	45	30	30	-	2,7	1,35	0,9	0,9
0,5S	1,5	0,75	0,5	0,5	0,5	90	45	30	30	30	2,7	1,35	0,9	0,9	0,9
1	-	3,0	1,5	1,0	1,0	-	180	90	60	60	-	5,4	2,7	1,8	1,8
3			4,5	3,0	3,0										

A.6.7.5.2 Accuracy class for selectable-ratio TRD2 with taps on the output

For all accuracy classes, the accuracy requirements refer to the highest transformation ratio, unless specified otherwise.

The manufacturer shall give information about the accuracy performance at lower ratios.

A.6.7.5.3 Influence of temperature on accuracy

The accuracy of the TRD2 shall remain within the specified accuracy limits specified in Table A.7 over their operating ambient temperature range.

A.6.7.5.4 Anti-aliasing requirements

Annex C applies.

A.6.7.5.5 Requirements for the measurement of harmonics and low frequencies monitoring

Annex D applies.

A.6.7.6 Accuracy classes for TRD2 monitoring DC current

A.6.7.6.1 General

The ratio error for the DC component, at a burden equal to or higher than the rated burden, shall not exceed the values given in Table A.9, expressed as a percentage of the measured current. A graphical representation of error limits is shown in Figure A.2.

The accuracy shall be guaranteed for the whole range of temperature, for both polarities.

Table A.9 – Limits of ratio error for TRD2-IDC

Accuracy class	Error (as applicable) $\pm\%$				
	at current (times rated current)				
	0,05	0,2	1	K_{epcr}	
0,05	0,5	0,13	0,05	0,05	
0,1	1	0,25	0,1	0,1	
0,2	2	0,5	0,2	0,2	
0,5	3,5	1	0,5	0,5	
1	5	2	1	1	

For current lower than 5 % of the rated current, the absolute error ε_A shall not increase above the value at 5 %.

NOTE The purpose of A.6.7.6 is to consider a minimum value of error due to offset voltage and noise.

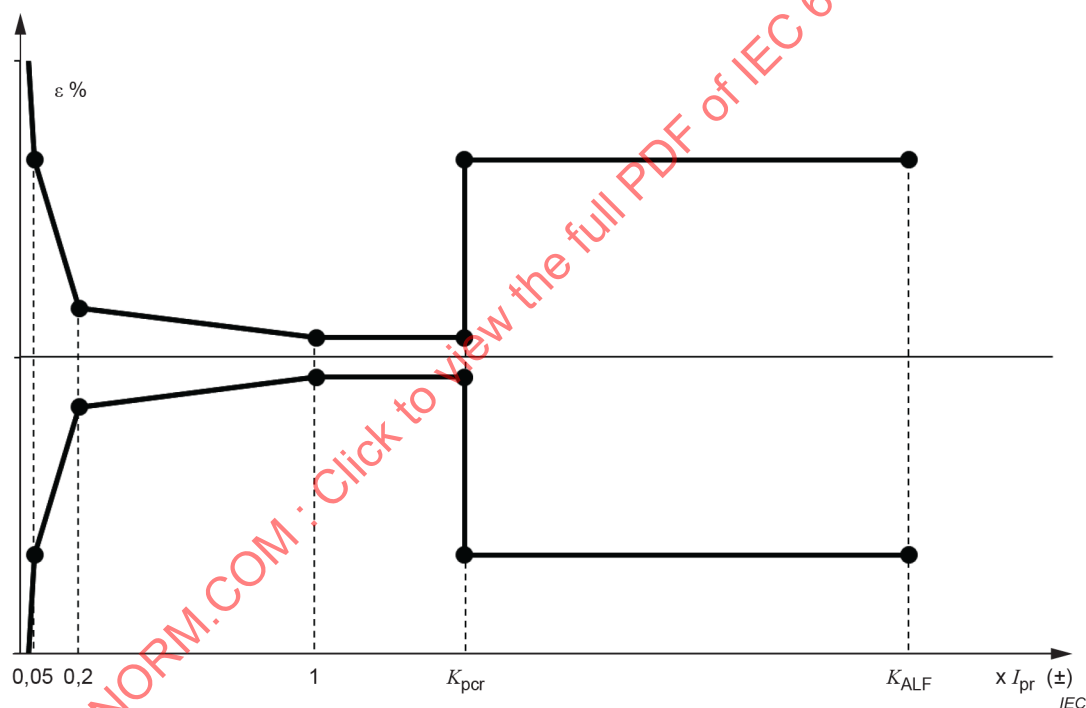


Figure A.2 – Accuracy limits of a TRD2-IDC

A.6.7.6.2 Step response time

A value for the step response time T_{sr1} shall be specified.

A.6.7.6.3 Frequency bandwidth

A cut-off frequency shall be specified for an amplitude error of 3 dB.

A.6.7.6.4 Maximum amplitude of input current over frequency

If the rated input current cannot be sustained over the specified frequency bandwidth, a derating shall be specified.

A.6.7.6.5 Noise

A RMS value referenced to input and a frequency band shall be specified. Alternatively, values for spectral noise density shall be specified at discrete frequencies.

Preferred values are under consideration.

A.6.7.7 Accuracy classes for TRD2 monitoring AC voltage

The voltage error and phase displacement at rated frequency shall not exceed the values given in Table A.10 at any voltage between 80 % and 120 % of rated voltage.

The errors shall be determined at the terminals of the TRD2 and shall include the effects of any fuses or resistors as an integral part of the TRD2.

For TRD2 with tapplings on the output circuit, the accuracy requirements refer to the highest transformation ratio, unless otherwise specified.

Table A.10 – Limits of ratio error for TRD2-UAC

Accuracy Class	Error (as applicable) ±%			Phase error (as applicable)					
				±min			±Centiradians		
	At % of rated voltage			At % of rated voltage			At % of rated voltage		
	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		

A.6.7.8 Accuracy classes for TRD2 monitoring DC voltage

The voltage error shall not exceed the values given in Table A.11.

Table A.11 – Limits of ratio error for TRD2-UDC

Accuracy class	Error (as applicable)					
	±%					
	at % of rated voltage					
	5	20	40	70	100	120
0,1	1	0,2	0,1	0,1	0,1	0,1
0,2	2	0,4	0,2	0,2	0,2	0,2
0,5	3,5	1	0,4	0,4	0,4	0,4
1	5	2	1	1	1	1
3	10	5	3	3	3	3

A.6.7.9 Requirements for short-time currents

The specified ratings shall be confirmed by a test specified in Clause A.7.

A.6.7.10 Requirements for inter-turn overvoltage

For inductive TRD2 with mA outputs, the rated withstand voltage for inter-turn insulation of output circuits shall be 2 kV peak according to a test specified in Clause A.7.

A.6.8 Marking requirements

A.6.8.1 Safety markings

Marking and operating instructions shall comply with IEC 61010-1:2010 unless otherwise specified.

A.6.8.2 General markings

All transducers shall carry at least the following markings:

- a) name or trademark of the manufacturer or supplier;
- b) a model number, name or other means to identify the equipment;
- c) rated frequency(ies) or declared rated frequency range;
- d) highest voltage of equipment.
- e) other ratings defined in A.5.1:
 - input ratings;
 - output ratings.

If there is not enough room on the TRD2 to write all the required markings, a) and b) shall be present on the product and symbol 14 in Table 1 of IEC 61010-1:2010 shall be added (if not otherwise specified). Items c), d) and e) shall be provided in the documentation.

A.6.8.3 Markings of terminals

A.6.8.3.1 General

The terminal markings shall identify, as applicable,

- the input and output terminals,
- the relative polarities, if any,
- the intermediate taps, if any, and
- terminals for other purposes, for example auxiliary power supply, earth connection, inputs, outputs, communication ports.

A.6.8.3.2 Markings to be used

All TRD2 shall comply with requirements provided in Annex E.

A.6.8.3.3 Indication of relative polarities

For TRD2 monitoring current, all the terminals marked P1, S1 and C1 shall have the same polarity at the same instant.

For TRD2 monitoring voltage, terminals having corresponding capital and lower-case markings shall have the same polarity at the same instant.

A.6.8.3.4 Method of marking

The terminals shall be marked clearly and indelibly, either on their surface or marked (or provided by others means) in their immediate vicinity.

The marking shall consist of letters (in block capitals) followed by numbers, (or preceded where necessary, e.g. for 2 output circuits), or with an arrow pointing from the P1 toward P2.

If possible, the output terminals shall be identified clearly and indelibly, either on the surface of the transducer or, in case of an 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.

A.6.9 Documentation requirements

A.6.9.1 General

The manufacturer shall make available to the purchaser the technical documentation, which is necessary for the installation, use and maintenance of the TRD2.

The following information shall either be marked on the transducer or specified in the documentation:

- mass in kg (if > 25kg);
- all measuring characteristics and all markings.

The following information shall be specified in the documentation:

- safety instructions (see 5.4 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 and see A.6.2);
- identification of connections and colour code in case of flying leads connection;
- instructions for transportation and storage;
- instructions for assembly, installation, connection and maintenance;
- instructions for dismantling and disposal;
- noise spectral information for specific transducers;
- ratings defined in A.5.1:
 - input ratings;
 - output ratings;
 - general ratings.
- EMC emission class A or class B ;
- safety class: class F or class D;
- limits of environment use and mitigation measures:
 - indoor or outdoor use;
 - installation inside cabinets (or panels or cubical) with or without locking means;
 - kind of bushings or other means for additional insulation.

A.6.9.2 Information for selection of TRD2

In order to facilitate the selection of transducers compatible with the instrument interface, an interface code, as specified in Annex B, shall be documented by manufacturers.

A.7 Tests for TRD2

A.7.1 Type tests

A.7.1.1 General

A.7.1.1.1 Selection of test specimens

All the type tests shall be carried out on a set of identical specimens.

A type test may also be considered valid if it is made on a TRD2 that has minor constructional deviations from the TRD2 under consideration.

All the type tests shall be carried out at ambient temperature between 10 °C and 30 °C.

A.7.1.1.2 Sequence of tests

No specific sequence of test is requested.

A.7.1.2 Safety tests

All relevant clauses related to test in IEC 61010:2010 and IEC 61010-1:2010/AMD1:2016 apply.

A.7.1.3 Electromagnetic compatibility tests

A.7.1.3.1 General

Test shall be conducted according to IEC 61326-1:2020.

The measurements shall be made in the operating mode in accordance with the EMC test plan (arrangements, including cabling, representative of normal installation conditions, etc.).

A.7.1.3.2 Immunity tests

Tests shall be conducted according to requirements specified in A.6.3.2 with the following additions.

- The output equipment, and the auxiliary power supply if any, shall not be subjected to the test stress.
- During the immunity tests, the length of cable connections between the EUT and the output equipment used as auxiliary test equipment shall be the maximum allowed according to the manufacturer's specifications.
- The TRD2 shall be subjected, during the test, to the nominal input signal for which it is rated. However, for ease of testing, in case of TRD2 monitoring current, it is allowed to reduce the input current value, with a minimum of 10 % of the rated value or 10 A, whichever is greater.

A.7.1.3.3 Emission tests

Tests shall be conducted according to requirements specified in A.6.3.3 with the following additions: TRD2 needs not to be loaded.

A.7.1.4 Climatic tests

Tests shall be conducted according to requirements specified in A.6.4.

A.7.1.5 Mechanical tests

Tests shall be conducted according to requirements specified in A.6.5.

A.7.1.6 Accuracy tests

A.7.1.6.1 General

Tests shall be conducted according to requirements specified in A.6.7.

The limits of error shall be tested at ambient temperature and at the rated frequency(ies).

A.7.1.6.2 Accuracy tests for TRD2 measuring AC currents

Accuracy measurements shall be made at each value of current given in the tables of A.6.7 for the declared accuracy class and the rated frequency relevant to the type of transducer. Measurements shall be made at the highest and at the lowest value of the specified burden range.

If a security factor FS is declared, the following test applies in addition.

With the input circuit open-circuited, the output circuit is energized at rated frequency by a substantially sinusoidal voltage. The voltage shall be increased until the exciting current I_e reaches $I_{Sr} \times FS \times 0,1$.

The RMS value of the obtained terminal voltage shall be less than the output limiting EMF E_{FS} .

The exciting voltage shall be measured with a transducer which has a response proportional to the average of the rectified signal, but calibrated in RMS. The exciting current shall be measured using an RMS measuring transducer having a minimum crest factor of 3.

A.7.1.6.3 Accuracy tests for TRD2 measuring DC currents

Tests shall be made at each value of current given in the tables of A.6.7 for the declared accuracy class relevant to the type of transducer, at rated burden, and at ambient temperature, unless otherwise specified.

The test shall be made up to the rated input current (I_{pr}).

For input current equal to zero, the measured absolute error shall not exceed the value of the absolute error allowed at $0,05 \times I_{pr}$.

For the test at accuracy limit input current, the DC current source might not be available. The accuracy of the whole system may be tested using an alternating DC signal input method. The manufacturer shall supply all necessary information for the calculation of the accuracy at the specified input level.

For some technologies, instead of applying the input current on the input terminals, an auxiliary test circuit may be used to supply a corresponding test current.

A.7.1.6.4 Accuracy tests for TRD2 measuring AC voltages

Tests shall be made at each value of the input signal given in A.6.7.7 at the rated frequency and at ambient temperature, unless otherwise specified.

The tests shall be made with each burden listed in Table A.12.

Table A.12 – 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.

Then the voltage is set to the rated input voltage U_{pr} and maintained up to the thermal stabilization and then the accuracy is measured again. In case of a defined range of input 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.

NOTE 1 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 2 This test can be performed in combination with the temperature-rise test, or can be combined with the temperature cycle accuracy test.

A.7.1.6.5 Accuracy tests for TRD2 measuring DC voltages

Tests shall be made at each value of voltage given in the tables of A.6.7 for the declared accuracy class relevant to the type of transducer, at rated burden, and at ambient temperature, unless otherwise specified.

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.

Then the voltage is reduced to U_{pr} and maintained up to the thermal stabilization. The accuracy is measured and the accuracy variation at U_{pr} is determined.

From this result, the accuracy variation at intermediate voltages and maximum voltage is estimated according to the thermal characteristics of the resistors.

The errors shall be within the limits of the relevant accuracy class, both at the time the test voltage is applied and after the correction of the accuracy variation.

The stability is considered after a period of 3 times the time constant, which shall be defined by the supplier.

For input voltage equal to zero, the measured absolute error shall not exceed the value of the absolute error allowed at $0,05 \times U_{pr}$.

NOTE This test can be performed together with the temperature-rise test.

A.7.1.6.6 Tests of the step response time (T_{sr}) for TRD2 measuring DC current or voltage

A.7.1.6.6.1 Test setup for TRD2 measuring DC currents

The determination of the step response time requires a current generator and instruments to measure the input signal and the output signal. The rise time of the generated signal shall be less than $0,2 \times T_{sr}$ (see Figure A.3).

The input current step-up may be replaced by a current step-down. The rise time is then replaced by the fall time. The positive current polarity generates a negative step-down and vice versa.

The step response time of the signal measurement systems shall be lower than $0,05 \times T_{sr}$.

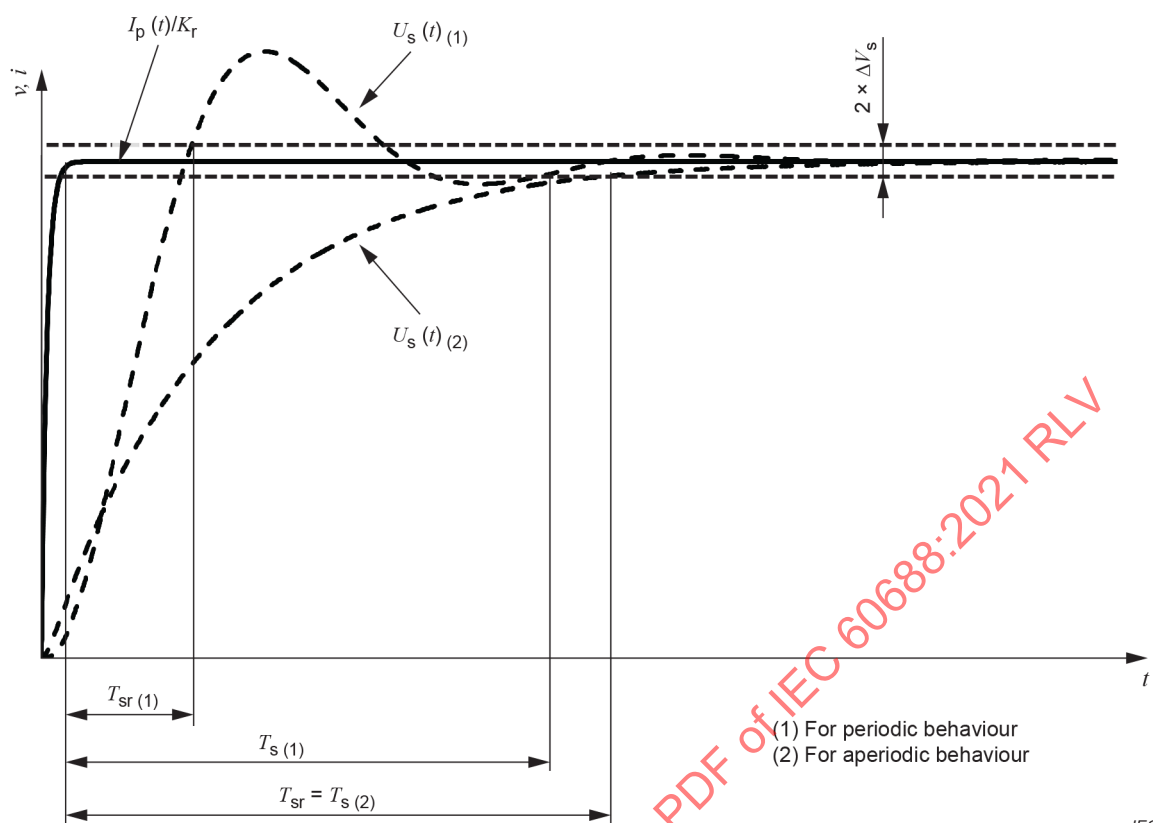
The test shall be performed with input current of positive and negative polarity. A test current value equal to the rated current shall be used.

A step current will be applied and both input current and output signal will be recorded simultaneously.

The tolerance limit ΔV_S is defined as 5 % of the steady-state value of the output signal V_{∞} .

NOTE A reduced tolerance limit can be defined by agreement between the purchaser and the manufacturer.

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IEC

$I_{p(1)}$ input current for periodic behaviour

$I_{p(2)}$ input current for aperiodic behaviour

$U_{s(1)}$ output signal of test object for periodic behaviour

$U_{s(2)}$ output signal of test object for aperiodic behaviour

$T_{sr(1)}$ measured step response time for periodic behaviour

$T_{sr(2)}$ measured step response time for aperiodic behaviour

$T_s(1)$ settling time for periodic behaviour

$T_s(2)$ settling time for aperiodic behaviour

Figure A.3 – Measurement of the step response time

In case of difficulties to generate the input signal with the specified rise time, the test procedure may be adapted as follows.

- Inject an equivalent sensor signal on the input of the input converter. The supplier shall supply necessary information for the calculation of the step response time at the input level.
- For some technologies, instead of applying the input current on the input terminals, an auxiliary test circuit may be used to supply a corresponding test current. The supplier shall supply information for the calculation of the step response time at the input level.

Test results: see A.7.1.6.6.3.

A.7.1.6.6.2 Test setup for TRD2 measuring DC voltages

The input test voltage should be the rated input voltage and represents an impulse voltage characteristic with an accuracy of $\pm 3\%$. The step voltage can be generated by an impulse voltage generator. In case of difficulties in generating the input signal with the specified rise time, the test procedure may be adapted, using a reduced input voltage signal, provided that the linearity of the system is proven, and the output signal level permits an accurate measurement (see Figure A.3).

The front time corresponds to the definitions of lightning impulse definition with a front time of $1,2\ \mu\text{s}$, with a relative tolerance of $\pm 30\%$.

The time to half value corresponds to the definitions of switching impulse definition with a time to half value of $2\ 500\ \mu\text{s}$, with a relative tolerance of $\pm 60\%$.

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

The input voltage is measured with a reference divider. The output of the reference divider and the output voltage of the transducer is measured with a transient recorder (see Figure A.3).

The tolerance limit ΔV_S is defined as 5% of the steady-state value of the output signal V_∞ .

NOTE A reduced tolerance limit can be defined by agreement between the purchaser and the manufacturer.

Test results: see A.7.1.6.6.3.

A.7.1.6.6.3 Test results

The TRD2 is considered to have passed the test if

- the measured step response time T_{sr} is lower than the rated value, and
- the settling time is less than $10 \times T_{sr}$.

A.7.1.6.7 Temperature cycle accuracy test

This test is intended to show compliance with the accuracy requirements under rated conditions the rated temperature categories is given in Table A.3.

If it can be proven with general engineering practices that the transducer under its normal conditions according to Clause A.4 and for its declared ratings will remain within its accuracy limits over its complete temperature range, this test may not to be performed.

The temperature rise test of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016, 10.4, shall be performed prior to this test. From the temperature rise test, the thermal time constant (τ) and the temperature rise (ΔT) shall be determined at the rated continuous thermal current for TRD2 measuring currents or, for TRD2 measuring voltages, at the rated voltage factor multiplied by the rated input voltage. Temperature rises may be negligible for some technologies. Thus, temperature rise tests may not be conducted for those transducers.

The temperature cycle accuracy test shall be performed under the following conditions:

- at rated frequency;
- at rated burden (external burdens may be kept outside the chamber);
- active electronic components and the transmitting system may be exposed in the same chamber or, to their specified minimum and maximum operating ambient temperature if different from the temperatures of the transducer. Other components such as auxiliary power supply may be kept at room temperature.

TRD2 are subjected to a temperature cycle in accordance with Figure A.4.

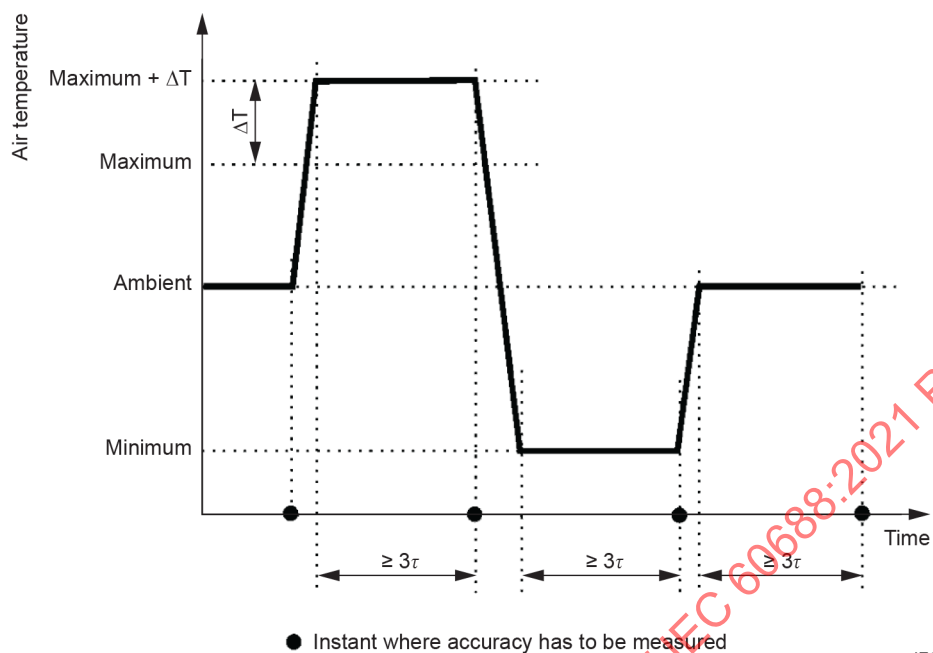


Figure A.4 – Temperature cycle accuracy test

The ambient air temperature at the start and at the end of the test shall be between 10 °C and 30 °C.

The minimum and maximum air temperatures correspond to the specified minimum and maximum operating ambient temperatures.

The acclimatization before the accuracy test for maximum ambient temperature shall be performed with the air temperature equal to the maximum operating ambient temperature increased by the established temperature rise ΔT .

The test is performed without input signal. When a input signal is required for powering the transducer or its associated equipment, the input may be energized.

The temperature variation part of the test is when the air temperature in the climate chamber is changed; this can be either a positive or a negative change. The minimum temperature variation rate is 20 K/h. Condensation shall be avoided. The temperature variation rate shall preferably be noted in the report.

After each temperature variation, the transducer shall enter a stabilizing period with a duration of at least three times the thermal time constant τ .

At the end of each stabilizing period, the accuracy of the transducer shall be measured. After the stabilizing period, measures shall be taken to avoid cooling or heating other than caused by the accuracy measurement itself.

Measured values at every point of the test shall be within the limits of the specified accuracy class. The accuracy measurement at the start of the temperature cycle may be omitted if the accuracy at ambient temperature is known from previous tests.

For TRD2 with multiple rated frequencies, accuracy class measurements may be done at one rated frequency only.

A.7.1.7 Verification of markings and documentation

Conformity of markings and documentation is checked by inspection. Legibility of markings is checked by the tests defined in IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016.

A.7.1.8 Short-time currents tests

A.7.1.8.1 General

The following tests apply as far as possible depending on the kind of device under test and its technology. Thus, if the tests described in this clause cannot be applied, manufacturers should reference in their documentation the product standard used for the tests.

However, short time current tests may not apply to some specific technologies.

A.7.1.8.2 For TRD2 measuring AC currents

The thermal test shall be made at a current I' for a time t' , so that:

$$I'^2 \times t' \geq I_{th}^2 \times t$$

where

t is the specified duration of the short-time thermal current;

t' shall have a value between 0,5 s and 5 s.

The dynamic test shall be made with an input current the peak value of which is not less than the rated dynamic current (I_{dyn}) for at least one peak.

The dynamic test may be combined with the thermal test above, provided the first major peak current of that test is not less than the rated dynamic current (I_{dyn}).

For TRD2 with mA output, the tests shall be made with the output circuit(s) short-circuited.

For TRD2 with mV output, the output terminals shall be left open or connected to the rated burden.

A.7.1.8.3 For TRD2 measuring DC currents

Tests should be applied as stated in A.7.1.8.2 but with a single test at a value of test current as declared by the manufacturer. The value of the test current should be at least equal to either

- ten times the rated current, or
- five times the rated current multiplied by K_{epcr} .

If there is no limitation of use of transducer, then above limit of time applies. If the use is limited to specific applications, then the time limit can be reduced according to manufacturer specification.

A.7.1.8.4 Test results

The device is deemed to have passed these tests if, after cooling to ambient temperature, it satisfies the following requirements:

- it is not visibly damaged;
- its errors after demagnetization do not differ from those recorded before the tests by more than half the limits of error appropriate to its accuracy class;

- it withstands the dielectric tests specified in IEC 61010-1:2010 but with test voltages reduced to 90 % of those given;
- examination of the insulation next to the surfaces of the conductors does not show significant deterioration (e.g. carbonization).

The examination is not required if the current density in the input and output circuits, corresponding to the rated short-time thermal current (I_{th}), does not exceed

- 180 A/mm² where the circuit is of copper of conductivity not less than 97 % of the value given in IEC 60028, or
- 120 A/mm² where the circuit is of aluminium of conductivity not less than 97 % of the value given in IEC 60121.

A.7.1.9 Inter-turn overvoltage tests

Tests shall be performed at the full circuit in accordance with one of the following procedures A or B.

NOTE 1 Due to the test procedure, the wave shape can be highly distorted.

NOTE 2 Tests can result in voltage values lower than specified in A.6.7.

- **Procedure A**

With the output circuit open-circuited (or connected to a high impedance device which reads peak voltage), a substantially sinusoidal current at some suitable test frequency between rated frequency and 400 Hz and of RMS value equal to the rated input current (or rated extended input current if specified) shall be applied for 60 s to the input circuit.

Test results:

- The applied current shall be limited if the test voltage for inter-turn insulation is obtained before reaching the rated input current (or rated extended input current).
- If the test voltage for inter-turn insulation is not reached at maximum input current, the obtained voltage shall be regarded as the test voltage.

- **Procedure B**

With the input circuit open-circuited, the test voltage for inter-turn insulation (at some suitable test frequency) shall be applied for 60 s to the terminals of each output circuit.

Test results:

- The RMS value of the output current shall not exceed the rated output current (or the appropriate extended value if specified).
- If the test voltage for inter-turn insulation is not reached at maximum output current and maximum test frequency, the obtained voltage shall be regarded as the test voltage.

The inter-turn overvoltage test is not a test carried out to verify the suitability of a transducer to operate with the output circuit open-circuited. Transducers should not be operated with the output circuit open-circuited because of the potentially dangerous overvoltage and overheating which can occur.

A.7.1.10 Anti-aliasing tests

This test addresses anti-aliasing requirements defined in Annex C, when applicable.

The attenuation is calculated, and above limits are checked. Where agreed to by the user and manufacturer, injection may be into the output converter.

The magnitude of the input signal shall be at least 1 % of the rated input signal.

NOTE Due to the fact that aliasing occurs, the input signal and the output signal do not have the same frequencies. Therefore, test arrangements using bridge configurations cannot be used. The easiest way to do the test is to calculate or measure the RMS values for input and output separately using a digital system or a simple multi-meter for analogue systems.

Test results: see Annex C.

A.7.1.11 Test with harmonics and at low frequencies

This test addresses requirements for the measurement of harmonics and low frequencies defined in Annex D when applicable.

In an ideal case, tests on harmonics should be made with the rated input signal at the rated frequency plus a percentage of the rated input signal at each considered harmonic frequency. Such an input signal should provide a realistic image of the dynamic requirements on the transducer and will yield a good image of some non-linear phenomena which can happen in the transducer (intermodulation, for example).

However, it can be difficult to achieve a test circuit which generates such a input input signal. For practical considerations, it is accepted that the accuracy tests be made with only one single harmonic frequency applied at the input side for each measurement.

Frequency response requirements defined in Table E.1 are very important for achieving device interoperability. Verification of these requirements may, however, be quite difficult and requires intimate knowledge of physical properties and limitations of the tested device's technology. Frequency response testing shall fulfil the harmonics requirement described in Table E.1.

The use of a suitable test setup is required.

Transducers susceptible to saturation cannot in general be tested at low frequencies using full voltage/current levels. For these devices, measurements at frequencies below the nominal system frequency should be performed with test signal magnitude reduced in inverse proportion with the frequency:

$$I_{\text{test}} = I_{\text{pr}} \times \frac{f_{\text{test}}}{f_{\text{r}}}$$

To avoid measurement circuit clipping, testing of transducers with output signals increasing with frequency should be performed with test signal magnitude reduced in proportion with the frequency

$$I_{\text{test}} = I_{\text{pr}} \times \frac{f_{\text{r}}}{f_{\text{test}}}$$

In case of difficulties or limitations of the laboratory capabilities, it is also accepted to reduce the input test current of TRD2 measuring current to a value not lower than 10 % of the rated value or 10 A, whichever is greater.

Test results: see Annex D.

A.7.2 Routine tests

A.7.2.1 General

Routine tests shall be conducted on 100 % of manufactured TRD2.

Except otherwise specified, TRD2 may be in any position for routine tests as long it does not influence the test results.

Except otherwise specified, accessories and other optional parts may be omitted for routine tests as long it does not influence the test results.

A.7.2.2 Accuracy tests

Accuracy of TRD2 shall be verified in order to verify that the TRD2 complies with its assigned accuracy class. Conformity is checked by any relevant means, under the responsibility of the manufacturer.

Routine test is performed at room temperature at routine test location and at rated frequency only.

A.7.2.3 Verification of markings

It shall be verified that the markings are clearly readable. Conformity is checked by inspection.

A.7.2.4 Safety tests

TRD2 class F shall comply with Annex F of IEC 61010-1:2010.

A.7.2.5 Inter-turn overvoltage tests

No requirements.

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Annex B (normative)

Interface coding

B.1 General

Annex B provides a way to specify an interface coding, aiming at facilitating the selection of transducers compatible with the equipment interface.

This interface coding includes

- the characteristics of connection between the output of transducers and the instrument,
- the rated output value at the output of the transducer,
- the rated power supply at the output of the transducer, in case an auxiliary power supply is supplied from a standardized connector, and
- the rated transfer curve.

This interface coding shall be described in the manufacturer technical literature, in order to ease the selection of the relevant transducer by the customer before ordering.

This interface code is not supposed to be marked on the transducer name plate, because this name plate is visible by the customer once the transducer has been delivered, that is too late.

B.2 Characteristics of interface connection

Table B.1 provides options for connections, either through wires or through a standardised connector.

Table B.1 – Coding of interface connection

Connector specification	Code letter
RJ45 with pinout as specified in A.6.6.2	R
Wires	W
Terminal for wires	T
Special connectors	S
NOTE 1 Soldered terminals on PCB is an example of special connector.	
NOTE 2 Screw/screwless terminals or spring terminals are examples of wired terminal for wires.	

B.3 Coding of rated output values for transducers

Table B.2, Table B.3, Table B.4, Table B.5, Table B.6, Table B.7 and Table B.8 provide lists of rated values to be used for TRD2, and that may be used for TRD1 if relevant.

Table B.2 – Rated AC RMS voltage output

Kind of output	Rated output value	Code letter ^a	Applicable for	
			TRD1	TRD2
AC voltage output	22,5 mV AC RMS	U1		X
	100 mV AC RMS	U2		X
	150 mV AC RMS	U3		X
	225 mV AC RMS	U4		X
	333 mV AC RMS	U5		X
	1V AC RMS	U6		X
	112,5mV AC RMS	U7		X
	Special value	Ux		X
^a In case the output depends on other items (e.g. configuration, position of transducer, frequency or phase of AC input signal) than the input level, then the curve shall be noted "dU" instead of "U" or "dx" instead of "x"				

Table B.3 – Rated DC voltage output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
DC voltage output	1,66 V DC	U8		X
	3 V DC	U9		X
	4 V DC	U10		X
	5 V DC	U11		X
	Special value	Ux		X

Table B.4 – Rated range of DC voltage output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
Range of DC voltage output	0 V to 1 V DC	U21	X	
	0 V to 10 V DC	U22	X	
	–1 V to 1 V DC	U23	X	
	–10 V to 10 V DC	U24	X	
	Special value	Ux		

Table B.5 – Rated AC RMS current output less than 1A

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
AC current output (less than 1 A)	20 mA AC RMS	I1		X
	50 mA AC RMS	I2		X
	100 mA AC RMS	I3		X
	Special value	Ix		X

Table B.6 – Rated range of DC current output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
Range of DC current output	4 mA to 20 mA DC	I21	X	
	0 mA to 20 mA DC	I22	X	
	0 mA to 1 mA DC	I23	X	
	0 mA to 10 mA DC	I24	X	
	–1 mA to 1 mA DC	I25	X	
	–5 mA to 5 mA DC	I26	X	
	–10 mA to 10 mA DC	I27	X	
	–20 mA to 20 mA DC	I28	X	X
	–50 mA to 50 mA DC	I29		X
	–100 mA to 100 mA DC	I30		X
	–200 mA to 200 mA DC	I31		X
	–500 mA to 500 mA DC	I32		X
	Special value	Ix		X

Table B.7 – Rated frequency output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
Range of frequency output proportional to the input quantity	0 to 20 kHz	F1		X
	Special value	Fx		X

Table B.8 – Rated pulse density output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
Pulse density output proportional to the input quantity	10 MHz	P1		X
	20 MHz	P2		X
	Special value	Px		X

B.4 Coding of auxiliary power supply for transducers

Table B.9 provides possible options for power supplies for transducers supplied from measuring instrument via the connector.

Table B.10 provides possible options for external power supplies for transducers.

Table B.9 – Coding of power supply for transducers supplied from measuring instrument via the connector

Power supply characteristics	Voltage	Code letter
Power supply when provided by the measuring equipment connected to the transducer output via the connector	No need	(blank)
	3,3 V DC	PS1
	5 V DC	PS2
	12 V DC	PS3
	24 V DC	PS4
	48 V DC	PS5
	Special voltage or range of voltage	PSx

Table B.10 – Coding of external power supply for transducers

External power supply characteristics	Voltage	Code letter
Power supplied by external power supply	3,3 V DC	EPS1
	5 V DC	EPS2
	12 V DC	EPS3
	24 V DC	EPS4
	48 V DC	EPS5
	±15V DC	EPS6
	±24V DC	EPS7
	110V AC	EPS8
	230 V AC	EPS9
	Special voltage or range of voltage	EPSx

B.5 Coding of transfer function curves for transducers

Table B.11 provides coding for transfer function curves, if applicable.

Table B.11 – Coding of transfer function curves for transducers

Transfer function curve	Code letter
Transfer function curve A, as defined in Figure 2	A
Transfer function curve B, as defined in Figure 3	B
Transfer function curve C, as defined in Figure 4	C
Transfer function curve D, as defined in Figure 5	D
Transfer function curve E, as defined in Figure 6	E
Transfer function curve F, as defined in 5.8	F

B.6 Interface full coding for output of transducers

B.6.1 General

Table B.12 provides the full coding of the output of transducers.

Table B.12 – Interface full coding for output of transducers

Coding of connectors for the output of transducers	Coding of rated output values	Blank	Coding of auxiliary power supply	Blank	Coding of transfer function curve
Code according to Table B.1	Code according to Table B.2 to Table B.8		Code according to Table B.9 or to Table B.10, if relevant		Optional code according to Table B.11, if relevant

B.6.2 Examples of interface codes and most common interface codes

Table B.13 provides a list of examples, and the most common interface codes for transducers.

Table B.13 – Examples of interface codes and most common interface codes

Kind of transducers	Interface code	Meaning of the interface code	Most common
Transducers delivering an AC RMS voltage output	WU2	Transducer with wires connection, 100 mV AC rated voltage output	
	WU3	Transducer with wires connection, 150 mV AC rated voltage output	
	TU3	Transducer with terminal block connection, 150 mV AC rated voltage output	
	WU5	Transducer with wires connection, 333 mV AC rated voltage output	x
	TU5	Transducer with terminal block, 333 mV AC rated voltage output	x
	WU6	Transducer with wires connection, 1 V AC rated voltage output	
	RU1	Transducer with RJ45 standardised connector, 22,5 mV AC rated voltage output	
	RU7	Transducer with RJ45 standardised connector, 112,5 mV AC rated voltage output	x
	RU5	Transducer with RJ45 standardised connector, 333 mV AC rated voltage output	x
	RdU3	Transducer with RJ45 standardised connector, 150 mV AC rated voltage output depending on other items than the input level	x
	RU4	Transducer with RJ45 standardised connector, 225 mV AC rated voltage output	x
	SU2	Transducer with special connector, 100 mV AC rated voltage output	
	SdU2	Transducer with special connector, 100 mV AC rated voltage output depending on other items than the input level	
	SU5	Transducer with special connector, 333 mV AC rated voltage output	
	Sx	Transducer with special connector, special analog output	
	Sdx	Transducer with special connector, special analog output depending on other items than the input level	
Transducers delivering a DC voltage output	WU8	Transducer with wires connection, 1,66 V rated voltage output	
	WU9	Transducer with wires connection, 3 V DC rated voltage output	
	WU10	Transducer with wires connection, 4 V DC rated voltage output	
	WU11	Transducer with wires connection, 5 V DC rated voltage output	
	RU11	Transducer with RJ45 connection, 5 V DC rated voltage output	x
	SU10	Transducer with special connector, 4V DC analog output	
	Sx	Transducer with special connector, special analog output	

Kind of transducers	Interface code	Meaning of the interface code	Most common
Transducers delivering a DC range of voltage output	WU21	Transducer with wires connection, 0 V DC to 1 V DC rated voltage output	
	WU22	Transducer with wires connection, 0 V DC to 10 V DC rated voltage output	
	WU23	Transducer with wires connection, –1 V DC to 1 V DC rated voltage output	
	WU24	Transducer with wires connection, –10 V DC to 10 V DC rated voltage output	
	Sx	Transducer with special connector, special analog output	
Transducers delivering an AC current output	WI1	Transducer with wires, 20 mA DC rated current output	
	WI2	Transducer with wires, 50 mA DC rated current output	
	WI3	Transducer with wires, 100 mA DC rated current output	x
	Sx	Transducer with special connector, special analog output	
Transducers delivering an AC range of current output	WI21	Transducer with wires, 4 mA DC to 20 mA DC rated current output	x
	WI22	Transducer with wires, 0 mA DC to 20 mA DC rated current output	
	WI23	Transducer with wires, 0 mA DC to 1 mA DC rated current output	
	WI24	Transducer with wires, 0 to 10 mA DC rated current output	
	WI25	Transducer with wires, –1 mA DC to 1 mA DC rated current output	
	WI26	Transducer with wires, –10 mA DC to 10 mA DC rated current output	
	WI27	Transducer with wires, –20 mA DC to 20 mA DC rated current output	
	WI28	Transducer with wires, –50 mA DC to 50 mA DC rated current output	
	WI29	Transducer with wires, –100 mA DC to 100 mA DC rated current output	
	WI30	Transducer with wires, –200 mA DC to 200 mA DC rated current output	
	WI21	Transducer with wires, –500 mA DC to 500 mA DC rated current output	
Range of frequency output	WF1	Transducer with wires, 0 kHz to 20 kHz rated range of frequency	
Pulse density output	WP1	Transducer with wires, 10 MHz pulse output	
	WP2	Transducer with wires, 20 MHz pulse output	

Annex C (informative)

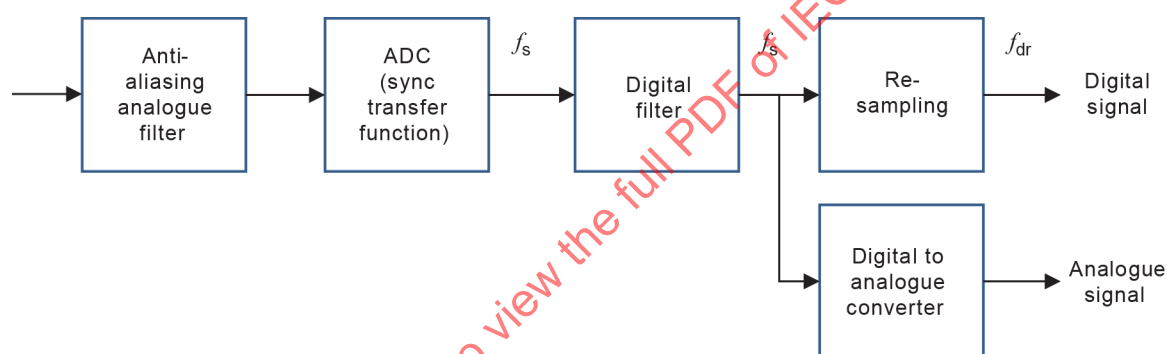
Anti-aliasing requirements

The requirements in Annex C are applicable to transducers with embedded digital data processing or transmission.

Digital and discrete time data processing limits the bandwidth to half the digital sampling rate f_s . If different sampling rates along the signal processing path are used, the lowest rate is the limiting factor. For transducers with digital output, the lowest rate is usually the output sampling rate. Frequencies above $f_s / 2$ are mirrored to frequencies below $f_s / 2$. From the point of view of accuracy, the most critical frequencies are those mapped on to the power system frequency f_r . The first frequency which is mapped on f_r is

$$f_s - f_r$$

Figure C.1 shows an example of a digital data acquisition system.



IEC

Key

f_s ADC sampling rate

f_{dr} digital signal data rate rate

Figure C.1 – Digital data acquisition system example

If f_s is greater than f_{dr} , the maximum signal bandwidth is equal to $f_{dr} / 2$; otherwise, the maximum signal bandwidth is equal to $f_s / 2$.

Hence, a so-called anti-aliasing filter shall be used. Minimum anti-aliasing filter attenuation requirements are specified, as a function of the transducer accuracy class, in Table C.1.

Table C.1 – Anti-aliasing filter

Accuracy class	Anti-aliasing filter attenuation ($f \geq f_s - f_r$)
0,1	≥ 34 dB
0,2	≥ 28 dB
0,5	≥ 20 dB
1	≥ 20 dB
Other classes	≥ 20 dB

Attenuation, expressed in decibels (dB), is calculated according to the following formula (for voltage transducer, replace current I by voltage U):

$$\alpha = 20 \log_{10} \frac{I_p \times Y_{sr}}{Y_s \times I_{pr}} \text{ (dB)}$$

where

α is the attenuation

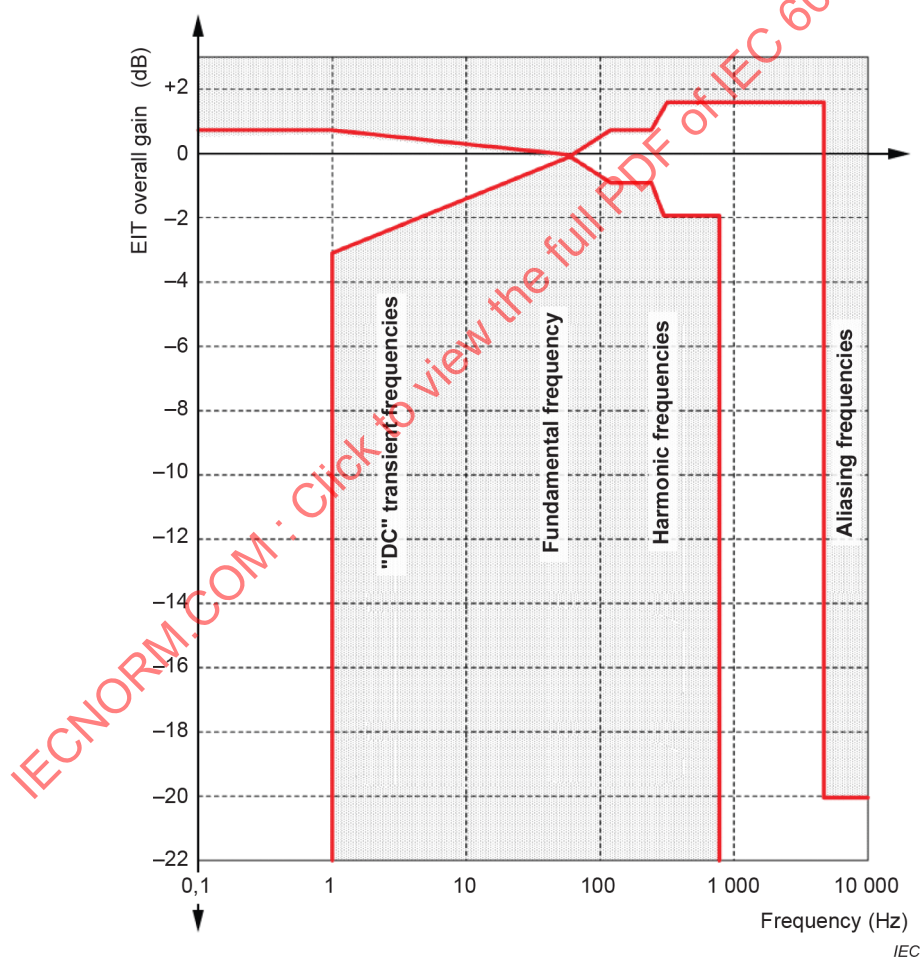
I_p is the RMS value of the input current at frequency f , with $f \geq f_s - f_r$;

Y_s is the RMS value of the output signal at the mirrored frequency, that is, at $f_s - f_r$;

I_{pr} is the rated input current;

Y_{sr} is the rated output signal.

Figure C.2 illustrates an example of harmonic and anti-aliasing frequency response magnitude requirements for metering accuracy class 1, where $f_r = 60$ Hz and $f_s = 4\,800$ Hz.



Key

 Prohibited region for response

Figure C.2 – Frequency response mask for metering accuracy class 1
($f_r = 60$ Hz, $f_s = 4\,800$ Hz)

Annex D (informative)

Requirements for the measurement of harmonics and low frequencies

D.1 General

Annex D may become normative in a future edition.

Due to the use of specific devices (non-linear loads, railway) harmonics can be generated on the network. The amount of harmonics depends on the network and the voltage level.

Harmonics are of interest for monitoring applications, because they may have an impact on all the electrical quantities. Such applications include basic energy management, power metering and monitoring, and power quality monitoring, which require the performance on harmonic measurement to be quantified. Specific accuracy requirements for each class are given in Clause D.2 and Clause D.3.

If harmonics measurement and low frequencies performance is declared by the manufacturer, the requirements for accuracy with harmonics in the next subclauses are applicable as needed.

D.2 Measuring accuracy classes with harmonics

Table D.1 gives the limit of errors on the magnitude and phase (as applicable) for the measuring classes.

Table D.1 – Limits of error for harmonics – Accuracy classes

Accuracy class (at f_r)	Error limit at low frequency		Error limit at harmonics of f_r					Phase error limit at low frequency	Phase error limit at harmonics of f_r			
	%		%					Degrees	Degrees			
	DC ^a	1 Hz	2 nd to 4 th	5 th and 6 th	7 th to 9 th	10 th to 13 th	Above 13 th	1 Hz	2 nd to 4 th	5 th and 6 th	7 th to 9 th	10 th to 13 th
0,1	+1 –100	+1 –30	±1	±2	±4	±8	+8 –100	±45	±1	±2	±4	±8
0,2 and 0,2 S	+2 –100	+2 –30	±2	±4	±8	±16	+16 –100	±45	±2	±4	±8	±16
0,5 and 0,5 S	+5 –100	+5 –30	±5	±10	±20	±20	+20 –100	±45	±5	±10	±20	±20
1	+10 –100	+10 –30	±10	±20	±20	±20	+20 –100	±45	±10	±20	±20	±20
3 and 5	–	–	–	–	–	–	–	–	–	–	–	–

^a –100 % means DC coupling is possible but not required.

The transition between points defined in the above table shall be a straight line when shown in log/log scale.

D.3 Accuracy class extensions of transducers for high bandwidth applications

According to EN 50160 and IEC 61000-4-7, for such purposes, harmonics up to the 40th order (in some cases even to the 50th order) are measured. IEC 61000-4-7 specifies that the relative error (related to the measured value) shall not exceed 5 %.

These extensions can be applied to all accuracy classes to indicate better performances at high frequencies. This performance is indicated by a wide bandwidth (WB) accuracy class extension.

The limits of accuracy for high bandwidth applications are given in Table D.2.

Table D.2 – Limits of error for harmonics – Accuracy class extensions WB1 and WB2

Accuracy classes	Error limits at frequencies shown below			Phase error limits at frequencies shown below		
	±%			± Degrees		
WB1	$0,1 \leq f < 1 \text{ kHz}$	$1 \leq f < 1,5 \text{ kHz}$	$1,5 \leq f < 3 \text{ kHz}$	$0,1 \leq f < 1 \text{ kHz}$	$1 \leq f < 1,5 \text{ kHz}$	$1,5 \leq f < 3 \text{ kHz}$
WB2	$0,1 \leq f < 5 \text{ kHz}$	$5 \leq f < 10 \text{ kHz}$	$10 \leq f < 20 \text{ kHz}$	$0,1 \leq f < 5 \text{ kHz}$	$5 \leq f < 10 \text{ kHz}$	$10 \leq f < 20 \text{ kHz}$
0,1	1	2	5	1	2	5
0,2 and 0,2S	2	4	5	2	4	5
0,5 and 0,5S	5	10	10	5	10	20
1	10	20	20	10	20	20
For DC applications, the phase errors are not applicable.						

The above limits of Table D.2 apply equally to both TRD2 measuring current and TRD2 measuring voltage.

The accuracy classes 0,2S and 0,5S apply only to TRD2 measuring current.

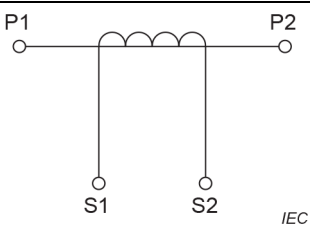
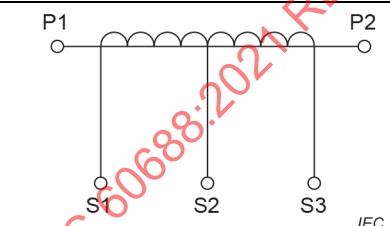
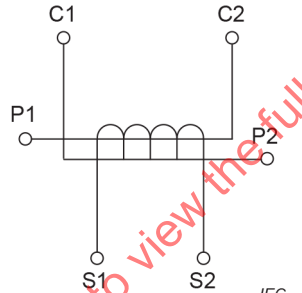
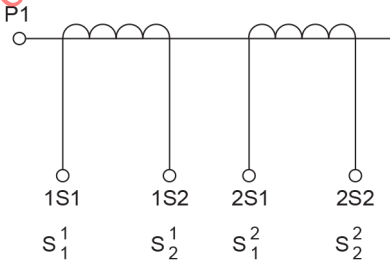
Annex E (normative)

Markings terminals of TRD2

E.1 Marking of terminals for TRD2 monitoring AC current

The markings of TRD2 monitoring AC current shall follow the principles illustrated in the examples in Table E.1.

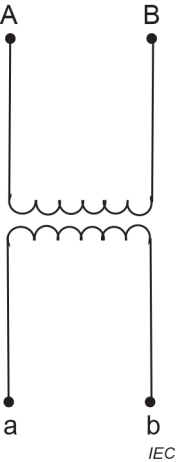
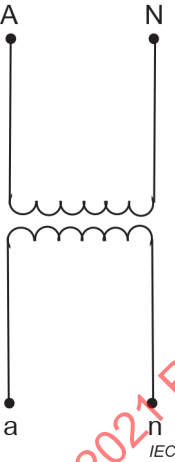
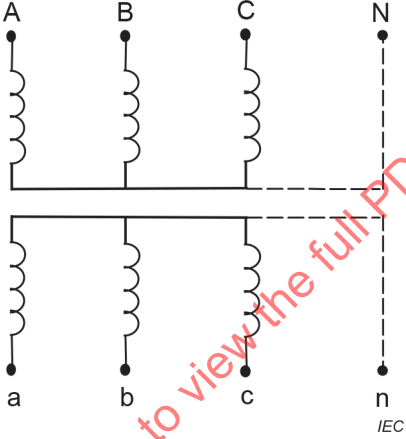
Table E.1 – Marking of terminals for TRD2 monitoring current

Input terminals	 Single-ratio TRD2	 TRD2 with an intermediate tapping on output circuit
Output terminals	 TRD2 with input circuit in 2 sections intended for connections either in series or in parallel	 TRD2 with 2 output circuits; each with its own magnetic core (two alternative markings for the output terminals)
NOTE For TRD2 using curve F_p, S can be replaced by T.		

E.2 Marking of terminals for TRD2 monitoring voltage

The markings of TRD2 monitoring AC voltage shall follow the principles illustrated in the examples in Table E.2.

Table E.2 – Marking of terminals for TRD2 monitoring voltage

Input terminals		
Output terminals	Single-phase TRD2 with a single output LL	Single-phase TRD2 with a single output LN
Input terminals		
Output terminals	Three-phase assembly TRD2 with a single output 3L-N	

Annex F (informative)

Guidance related to cables, busbars and bare conductors within an installation

F.1 Insulation of cables

Cables used in cabinets, panels and cubicles are supposed to provide a basic insulation at the working voltage specified for this cable.

A bushing can provide a supplementary insulation, provided this bushing is specified for at least the same working voltage as for the cable or the same working voltage of the system.

Under some conditions (see installation rules), a cable may be considered to provide a reinforced insulation.

Busbars and bare conductors do not provide any insulation. A bushing can provide a "basic insulation" provided this bushing is specified for at least the same working voltage as for the busbar or the same working voltage of the system.

Under some conditions (see installation rules), a bushing may be considered to provide a reinforced insulation.

Means to avoid contact with cable, busbars or bare conductor (e.g. integral means to avoid contact with cable or busbar) are not supposed to provide any additional insulation to the one provided by bushing, the insulation of cable and insulation of TRD2.

F.2 Temperature of cables and busbars

F.2.1 Cables

According to Table 6 of IEC 61439-1:2020, the maximum temperature-rise limits on terminals for external insulated conductors, for a daily average ambient air temperature up to 35 °C under service conditions, is 70 K.

Therefore, maximum permissible total daily average temperature of cable terminals is 105 °C (35 °C + 70 K).

Considering the usual decrease of cable temperature from terminal, 90 °C can be considered as a common value. This covers copper and aluminium cables.

F.2.2 Busbars

According to Table 6 of IEC 61439-1:2020, the maximum temperature-rise limits on copper busbar, for a daily average ambient air temperature up to 35 °C under service conditions, is 105 K.

Therefore, maximum permissible total daily average temperature of busbar terminals is 140 °C (35 °C + 105 K).

Considering the usual decrease of busbar temperature from terminal, 105 °C can be considered as a common value. This covers copper busbar and also aluminium busbar having lower permissible temperature.

Annex G (informative)

Guidance related to overvoltage categories and measurement categories

G.1 Concept of overvoltage category

The concept of overvoltage categories is defined in 4.3.2 of IEC 60664-1:2020, or IEC 60364-4-44 or IEC 61010-1:2010.

G.2 Approach of IEC 60664-1 for primary circuits of TRD2

G.2.1 General

IEC 60664-1 uses the concept of overvoltage categories (OVC).

G.2.2 Examples with IEC 60664-1:2020, for primary measuring circuits, OVC III, PD 2, altitude under 2 000 m, inhomogeneous field

Two examples are considered below:

- example 1 = 230/400 V network, material group II;
- example 2 = 400/690 V network, material group I

Table G.1 and Table G.2 show clearances and creepage distances, respectively, according to IEC 60664-4.

Table G.1 – Clearances according to IEC 60664-1:2020

Distribution system (LN/LL) V AC	Reference voltage for clearances V	Basic insulation		Reinforced insulation	
		U_{imp}^a kV	Clearance ^b mm	U_{imp}^c kV	Clearance ^b mm
230/400	300	4	3	6	5,5
400/690	600	6	5,5	8	8
NOTE Clearances according to Table F.2 of IEC 60664-1:2020 can be reduced under some circumstances, see IEC 60664-1:2020. However, values of impulse tests cannot be reduced. ^a According to Table F.1 of IEC 60664-1:2020. ^b According to Table F.2 of IEC 60664-1:2020. ^c For reinforced insulation, values are defined one step higher in the preferred list of values in 4.2.2.1 of IEC 60664-1:2020 (see 5.2.3.1 of IEC 60664-1:2020).					

Table G.2 – Creepage distances according to IEC 60664-1:2020

Distribution system (LN/LL) V AC	Voltage rationalized for insulation line to line ^a V	Material Group	Basic insulation	Reinforced insulation
			Creepage distance ^b mm	Creepage distance ^c mm
230/400	400	II	2,8	5,6
400/690	630	I	3,2	6,4

NOTE See 5.3.2.5 of IEC 60664-1:2020 for the relationship of creepage distance to clearance.

^a According to Table F.4 (rationalized voltages) of IEC 60664-1:2020.

^b According to Table F.5 of IEC 60664-1:2020.

^c For reinforced insulation, creepage distance are twice the creepage distance for basic insulation, see 5.3.5 of IEC 60664-1:2020.

G.3 Approach of IEC 61010 for primary circuits of TRD2

G.3.1 General

IEC 61010-1 is the generic standard for safety requirements for electrical equipment for measurement, control, and laboratory use that refers to IEC 61010-2-030 for circuits dedicated to testing or measuring purposes.

IEC 61010-2-030 has introduced a concept of measurement categories (MC, named as CAT II, CAT III, and CAT IV) that replaces the concept of overvoltage categories.

IEC 61010-2-030 applies to testing and measuring circuits.

G.3.2 Example with IEC 61010-2-030:2017, for primary measuring circuits, OVC III, PD 2, altitude under 2 000 m, inhomogeneous field

Two examples are considered below:

- Example 1 = 230/400 V network, material group II,
- Example 2 = 400/690 V network, material group I.

Table G.3 and Table G.4 show clearances and creepage distances, respectively, according to IEC 61010-2-030:2017.

Table G.3 – Clearances according to IEC 61010-2-030:2017

Distribution system (LN/LL) V AC	Reference voltage for clearances V	Basic insulation		Reinforced insulation	
		U_{imp}^a kV	Clearance ^b mm	U_{test}^c kV	Clearance ^b mm
230/400	300	4	3	6,40	5,9
400/690	600	6	5,5	9,50	10,5

NOTE Clearances according to K.101 of IEC 61010-2-030:2017 can be reduced under some circumstances, see IEC 61010 series.

^a According to Table K.16 of IEC 61010-1:2010

^b According to Table K.101 of IEC 61010-2-030:2017.

^c According Table K.16 of IEC 61010-1:2010.

Table G.4 – Creepage distances according to IEC 61010-2-030:2017

Distribution system (LN/LL) V AC	Voltage rationalized for insulation <u>line to line</u> V	Material Group	Basic insulation	Reinforced insulation
			Creepage distance ^a mm	Creepage distance ^b mm
230/400	400	II	2,8	5,6
400/690	690	I	3,5	7,0

^a According to Table K.13 of IEC 61010-1:2010.

^b For reinforced insulation, creepage distance are twice the creepage distance for basic insulation, see IEC 61010-1:2010.

G.4 Approach for secondary circuits of TRD2

Propagation of overvoltage is linked to the "coupling power capability" between primary circuit and secondary circuit. This coupling capability is usually limited for TRD2.

For TRD2 having a current measurement input, the coupling power capability is deemed to be low. Therefore, very low values of transient overvoltages can be expected on the secondary circuit. In case of doubt, a verification by measurement should be performed.

For TRD2 having a voltage measurement input, the coupling power capability is deemed to be limited. Values for clearances can be found in Table K.11 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 or a verification by measurement should be performed in order to determine the remaining value of transient overvoltages on the secondary and to calculate according K.3.2 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016.

Even if transient should not be considered on the secondary (low values for clearance), other safety-related requirements should apply (e.g. creepage distances).

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¹ This document has been withdrawn.

² This document has been withdrawn.

³ This document has been withdrawn.

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Electrical measuring transducers for converting AC and DC electrical quantities to analogue or digital signals

Transducteurs électriques de mesure convertissant les grandeurs électriques alternatives ou continues en signaux analogiques ou numériques

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL MEASURING TRANSDUCERS FOR CONVERTING AC AND DC
ELECTRICAL QUANTITIES TO ANALOGUE OR DIGITAL SIGNALS****FOREWORD**

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IEC 60688 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) updating normative references;
- b) additional requirements for specific transducers used for LV monitoring applications;
- c) creation of interface coding to ease selection by the end-user.

The text of this International Standard is based on the following documents:

CDV	Report on voting
85/748/CDV	85/781/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

In this document, the following print types are used:

- requirements and definitions: in roman type;
- NOTES: in smaller roman type;
- *compliance*: in italic type.

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- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

New transducers can now be equipped with microprocessors that utilise digital data processing, communication methods and auxiliary sensors. This makes them more complex than conventional analogue transducers and gives them considerable added value.

The class index system of classification used in this document is based upon IEC 60051 (all parts). Under this system, the permitted variations of the output signal due to varying influence quantities – ambient temperature, voltage, frequency, etc. – are implicit in the classification.

For those unfamiliar with the class index system, a word of warning is necessary. If, for example, a transducer is classified as class 1, it does not mean that the error under practical conditions of use will be within ± 1 % of the actual value of the output or ± 1 % of the full output value. It means that the error should not exceed ± 1 % of the fiducial value under closely specified conditions. If the influence quantities are varied between the limits specified by the nominal ranges of use, a variation of amount comparable with the value of the class index may be incurred for each influence quantity.

The permissible error of a transducer under working conditions is the sum of the permissible intrinsic error and of the permissible variations due to each of the influence quantities. However, the actual error is likely to be much smaller because not all of the influence quantities are likely to be simultaneously at their most unfavourable values and some of the variations may cancel one another. It is important that these facts be taken into consideration when specifying transducers for a particular purpose.

Furthermore, some of the terms used in this document are different from those used in IEC 60051 (all parts) due to the fundamental differences between indicating instruments and measuring transducers.

All statements of performance are related to the output which is governed by two basic terms:

- "the nominal value", which may have a positive or a negative sign or both;
- "the span", which is the range of values of the output signal from maximum positive to maximum negative, if appropriate.

ELECTRICAL MEASURING TRANSDUCERS FOR CONVERTING AC AND DC ELECTRICAL QUANTITIES TO ANALOGUE OR DIGITAL SIGNALS

1 Scope

This document applies to transducers with electrical inputs and outputs for making measurements of AC or DC electrical quantities. The output signal can be in the form of an analogue direct current, an analog direct voltage or in digital form.

This document applies to measuring transducers used for converting electrical quantities such as

- current,
- voltage,
- active power,
- reactive power,
- power factor,
- phase angle,
- frequency,
- harmonics or total harmonic distortion, and
- apparent power

to an output signal.

This document is not applicable for

- instrument transformers that comply with IEC 61869 (all parts),
- transmitters for use in industrial process application that comply with IEC 60770 (all parts), and
- performance measuring and monitoring devices (PMD) that comply with IEC 61557-12:2018.

Within the measuring range, the output signal is a function of the measurand. An auxiliary supply can be needed.

This document applies

- a) if the nominal frequency of the input(s) lies between 0 Hz and 1 500 Hz,
- b) to the electrical measuring transducer if it is part of a system for the measurement of a non-electrical quantity, and if it otherwise falls within the scope of this document, and
- c) to transducers for use in a variety of applications such as telemetry and process control and in one of a number of defined environments.

This document is intended:

- to specify the terminology and definitions relating to transducers whose main application is in industry,
- to unify the test methods used in evaluating transducer performance, and
- to specify accuracy limits and output values for transducers.

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.

IEC 60068-2-6, *Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27, *Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock*

IEC 60255-151, *Measuring relays and protection equipment - Part 151: Functional requirements for over/under current protection*

IEC 61010 (all parts), *Safety requirements for electrical equipment for measurement, control and laboratory use*

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements*

IEC 61010-1:2010/AMD1:2016

IEC 61010-2-030:2017, *Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 2-030: Particular requirements for equipment having testing or measuring circuits*

IEC 61326-1:2020, *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements*

IEC 61557-12:2018, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC - Equipment for testing, measuring or monitoring of protective measures - Part 12: Power metering and monitoring devices (PMD)*

IEC 61558-1:2017, *Safety of transformers, reactors, power supply units and combinations thereof - Part 1: General requirements and tests*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 General terms

3.1.1

**electrical measuring transducer
transducer**

TRD

device for converting an AC or DC measurand to a direct or alternating current, a direct or alternating voltage or a digital signal for measurement purposes

3.1.2
electrical measuring transducer type 1
transducer type 1
TRD1
 conventional transducer

Note 1 to entry: Transducers type 1 use conventional interface outputs and are generally single-function devices.

3.1.3
electrical measuring transducer type 2
transducer type 2
TRD2
 single-function transducer used in low voltage (LV) monitoring applications

Note 1 to entry: Transducers type 2 are using specific interface outputs and are generally more accurate than transducers type 1.

3.1.4
single-function device
 device performing the measurement of a single electrical quantity (e.g. current, power factor, THD) in a single form (e.g. RMS or peak or average) but not both

3.1.5
analogue transducer
 device for converting an AC or DC measurand to a direct or alternating current, a direct or alternating voltage for measurement purposes

3.1.6
digital transducer
 device for converting an AC or DC measurand to a digital signal for measurement purposes

3.1.7
auxiliary supply
 AC or DC electrical supply, other than the measurand, which is necessary for the correct operation of the transducer

3.1.8
auxiliary circuit
 circuit which is usually energized by the auxiliary supply

Note 1 to entry: The auxiliary circuit is sometimes energized by one of the input quantities.

3.1.9
transducer with suppressed zero
 transducer for which zero output signal corresponds to a measurand greater than zero

3.1.10
output load
 <analogue signal> total resistance of the circuits and apparatus connected externally across the output terminals of the transducer

3.1.11
ripple content
 <analogue output signal> ratio of the peak-to-peak value of the fluctuating component of an analogue output signal, expressed in percentage, to the fiducial value, with steady-state input conditions

3.1.12
output signal
 analogue or digital representation of the measurand

3.1.13**output power**

power at the transducer output terminals

3.1.14**output current**

<analogue signal> current produced by the transducer which is an analogue function of the measurand

3.1.15**output voltage**

<analogue signal> voltage produced by the transducer which is an analogue function of the measurand

3.1.16**measuring element**

<transducer> unit or module of a transducer that converts the measurand, or part of the measurand, into a corresponding signal

3.1.17**multi-element transducer**

transducer having two or more measuring elements

Note 1 to entry: The signals from the individual elements are combined to produce an output signal corresponding to the measurand.

3.1.18**response time**

time from the instant of application of a specified change of the measurand until the output signal reaches and remains at its final steady value or within a specified interval centred on this value

3.1.19**compliance voltage**

accuracy limiting output voltage

<variable output load transducers having a current output> value of the voltage appearing across the output terminals up to which the transducer complies with the requirements of this document

3.1.20**stability**

ability of a transducer to keep its performance characteristics unchanged during a specified time, all influence quantities remaining within their specified ranges

3.1.21**usage group**

group of transducers capable of operating under a specified set of environmental conditions

3.1.22**pulse density output**

digital representation of the measurand, where the relative density of the output pulses corresponds to the analog signal amplitude

3.2 Terms describing transducers according to the measurand**3.2.1****voltage transducer**

transducer used for the measurement of AC or DC voltage

3.2.2

current transducer

transducer used for the measurement of AC or DC current

3.2.3

apparent power transducer

transducer that is used for the measurement of the apparent power

3.2.4

active power transducer

transducer used for the measurement of active electrical power

3.2.5

reactive power transducer

transducer used for the measurement of reactive electrical power

3.2.6

frequency transducer

transducer used for the measurement of the frequency of an AC electrical quantity

3.2.7

phase angle transducer

transducer for the measurement of the phase angle between two AC electrical quantities having the same frequency

3.2.8

power factor transducer

transducer used for the measurement of the power factor of an AC circuit

3.2.9

harmonics transducer

transducer that is used for the measurement of the harmonics or the total harmonic distortion of an AC circuit

3.2.10

TRD2-PFA

power factor (arithmetic method) transducer for LV monitoring applications

3.2.11

TRD2-PFV

power factor (vector method) transducer for LV monitoring applications

3.2.12

TRD2-THDU

voltage THD transducer for LV monitoring applications

3.2.13

TRD2-THDI

current THD transducer for LV monitoring applications

3.2.14

TRD2-UAC

voltage transducer for LV monitoring applications that is used for the measurement of AC voltage

3.2.15**TRD2-UDC**

voltage transducer for LV monitoring applications that is used for the measurement of DC voltage

3.2.16**TRD2-IAC**

current transducer for LV monitoring applications that is used for the measurement of AC current

3.2.17**TRD2-IDC**

current transducer for LV monitoring applications that is used for the measurement of DC current

3.3 Terms describing transducers according to their output load**3.3.1****fixed output load transducer**

transducer that complies with this document only when the output load is at its nominal value, within specified limits

3.3.2**variable output load transducer**

transducer that complies with this document when the output load has any value within a given range

3.4 Nominal values**3.4.1****nominal value**

value, or one of the values, indicating the intended use of a transducer

Note 1 to entry: The lower and upper nominal values of the measurand are those which correspond to the lower and upper nominal values of the output signal.

3.4.2**span****output span**

algebraic difference between the upper and lower nominal values of the output signal

3.4.3**fiducial value**

value to which reference is made in order to specify the accuracy of a transducer

Note 1 to entry: The fiducial value is the span, except for transducers having a reversible and symmetrical output signal when the fiducial value may be half the span if specified by the manufacturer.

3.4.4**nominal power factor**

factor by which it is necessary to multiply the product of the nominal voltage and nominal current to obtain the nominal power

Note 1 to entry: When the current and voltage are sinusoidal quantities, the nominal power factor is $\cos \varphi$ where φ is the phase difference between the current and the voltage. For reactive power transducers, the nominal power factor is $\sin \varphi$.

3.4.5**limiting value of the output signal**

<current or voltage> upper limit of output signal which cannot, by design, be exceeded under any conditions

3.4.6

measuring range

range defined by two values of the measurand within which the performance complies with the requirements of this document

Note 1 to entry: See 3.4.3 of IEC 60051-1:2016.

3.4.7

nominal value of the measured voltage

nominal value of the voltage of the external circuit (e.g. the secondary winding of a voltage transformer) to which the voltage input circuit of the transducer is to be connected

3.4.8

nominal value of the measured current

nominal value of the current in the external circuit (e.g. the secondary winding of a current transformer) to which the current input circuit of the transducer is to be connected

3.5 Terms describing transducers with provisions to be adjusted by users

3.5.1

calibration value

value of a quantity to which the nominal value is changed by user adjustment for a specific application

3.5.2

adjustment range

possible range of adjustment values of the measured current or voltage

3.6 Influence quantities and reference conditions

3.6.1

influence quantity

quantity (other than the measurand) that may affect the performance of a transducer

3.6.2

reference conditions

specified conditions under which the transducer complies with the requirements concerning intrinsic errors

Note 1 to entry: These conditions may be defined by either a reference value or a reference range.

3.6.2.1

reference value

specified single value of an influence quantity at which the transducer complies with the requirements concerning intrinsic errors

3.6.2.2

reference range

specified range of values of an influence quantity within which the transducer complies with the requirements concerning intrinsic errors

3.6.3

nominal range of use

specified range of values over which it is intended that an influence quantity can assume without the output signal of the transducer changing by amounts in excess of those specified

3.7 Errors and variations

3.7.1

error

actual value of the output signal minus the intended value of the output signal, expressed algebraically

3.7.2

intrinsic error

error determined when the transducer is under reference conditions

3.7.3

variation due to an influence quantity

difference between the two values of the output signal for the same value of the measurand when an influence quantity assumes successively two different specified values

3.7.4

variation due to an influence quantity

<expressed as a percentage of the fiducial value> one hundred times the ratio of the variation due to an influence quantity and the fiducial value

3.8 Accuracy, accuracy class, class index

3.8.1

accuracy

accuracy of a transducer is defined by the limits of intrinsic error and by the limits of variations

3.8.2

accuracy class

class of transducers for which the accuracy of all can be designated by the same number if they comply with all the requirements of this document

3.8.3

class index

number which designates the accuracy class

Note 1 to entry: The class index is applicable to the intrinsic error as well as to the variations.

Note 2 to entry: Throughout this document, the phrase "x % of the class index" denotes "x % of the limits of error relating to the class index".

4 General

4.1 Transducer general architecture

Organisation of the measurement chain: the electrical quantity to be measured may be either directly accessible, as it is generally the case in low-voltage systems, or accessible via measurement sensors like voltage sensors (VS) or current sensors (CS).

Figure 1 shows the common organisation of a transducer (TRD).

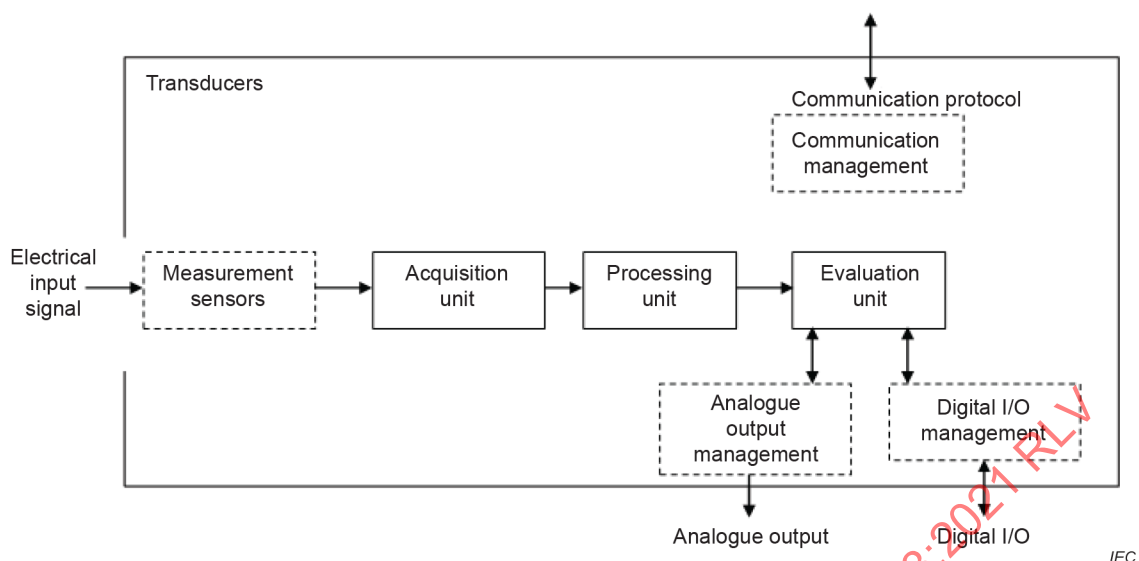


Figure 1 – Transducer (TRD) architecture

4.2 Classification of transducers (TRD)

Transducers are classified according to the applications as defined in Table 1.

Table 1 – Functional classification of transducers with minimal required functions

Requirements	Transducers type	
	TRD1 (transducer type 1)	TRD2 (transducer type 2)
See Clause 5	■	
See Annex A		■
NOTE For more information about differences between TRD1 and TRD2, see also Annex B		

5 Requirements for TRD1

5.1 Safety requirements: clearances and creepage distances

Transducers shall comply with safety requirements of IEC 61010 (all parts), and in addition with the following requirements of:

Clearances and creepage distances shall be selected at least in accordance with

- pollution degree 2,
- measurement category III for measuring input circuits, and
- overvoltage category III for mains circuits.

NOTE Measurement category is defined in IEC 61010-2-030.

5.2 EMC requirements

5.2.1 Immunity

For high frequency disturbance test, see IEC 61326 (all parts).

If, by agreement, other tests are required, then TRD1 with active electronic components may comply with Clause 6 of IEC 61326-1:2020.

NOTE These requirements are consistent with those of 6.21 and 6.23.

5.2.2 Emission

If, by agreement, other tests are required, then TRD1 with active electronic components may comply with either class A or class B limits as defined in Clause 7 of IEC 61326-1:2020.

NOTE This requirement is consistent with the one of 6.23.

5.3 Class index requirements

5.3.1 Class index

The class index for a transducer shall be chosen from those given in Table 2.

This class index definition only applies for the analogue output of the transducers.

Table 2 – Relationship between the limits of intrinsic error, expressed as a percentage of the fiducial value, and the class index

Class index	0,2	0,5	1	2	2,5	3	5	10	20
Limits of error	±0,2 %	±0,5 %	±1 %	±2 %	±2,5 %	±3 %	±5 %	±10 %	±20 %
Class indices of 0,3 and 1,5, although non-preferred, can be used.									

5.3.2 Class index for transducer used with sensors

If the transducers are used with sensors, the manufacturer shall specify the accuracy class of the whole system transducer and sensor.

In some cases when a transducer does not include the sensors, their associated uncertainties are not considered. When a transducer includes the sensors, their associated uncertainties are considered.

5.3.3 Intrinsic error

When the transducer is under reference conditions, the error at any point between the upper and lower nominal values of the output signal shall not exceed the limits of the intrinsic error given in Table 2 expressed as a percentage of the fiducial value.

Values stated in a table of corrections, if any, supplied with the transducer shall not be taken into account in determining the errors.

5.4 Conditions for the determination of intrinsic error

Prior to pre-conditioning and before determination of the intrinsic error, preliminary adjustments shall be carried out in accordance with the manufacturer's instructions. The transducer shall be at the reference temperature.

The transducer shall be left in circuit under the conditions specified in Table 3.

Table 3 – Pre-conditioning

Conditions	Values
Voltage (including any auxiliary supply)	Nominal value
Current	Nominal value
Frequency	Reference value
Power factor	Reference value
Time between connection into circuit and start of determination of errors	30 min

After the specified pre-conditioning, transducers having adjustments available to the user shall be adjusted in accordance with the manufacturer's instructions.

The reference conditions relative to each of the influence quantities are given in Table 4. The reference conditions relative to the measurand are given in Table 5.

Table 4 – Reference conditions of the influence quantities and tolerances or testing purposes

Influence quantity	Reference conditions unless otherwise marked	Tolerances permitted for testing purposes applicable to a single reference value ^a
Ambient temperature	To be marked in the type test report	±1 °C
Usage group (see 6.1.2)		
I	K55	–
II	K70	–
III	Kx ^b	–
Frequency of the input quantity		
Non-frequency sensitive	Nominal value	±2 %
Frequency sensitive	To be marked in the type test report	±0,1 %
Waveform of the input quantity	Sinusoidal, except for harmonics transducers	The distortion factor × 100 shall not exceed the class index, unless otherwise specified by the manufacturer
Output load		
Fixed output load transducers	Nominal value	±1 %
Variable output load transducers	Mean value of the nominal range	±1 %
Auxiliary supply		
Voltage AC	Nominal value	±2 %
Voltage DC	Nominal value	±1 %
Frequency	Nominal value	±1 %
Distortion factor	0,05 maximum	–
Magnetic field of external origin	Total absence	40 A/m at frequencies from DC to 65 Hz in any direction ^c
^a When a reference range is marked, no tolerance is allowed. ^b "Kx" stands for extended conditions. ^c 40 A/m is approximately the highest value of the earth's magnetic field.		

Table 5 – Reference conditions relative to the measurand

Measurand	Reference conditions		
	Voltage	Current	Power factor, active or reactive
Apparent power	Nominal voltage $\pm 2\%$	Any current up to the nominal current	$ \cos \varphi $ or $ \sin \varphi = 1,0$ to $0,8$ lagging or leading
Active power	Nominal voltage $\pm 2\%$	Any current up to the nominal current	$ \cos \varphi = 1,0$ to $0,8$ lagging or leading
Reactive power	Nominal voltage $\pm 2\%$	Any current up to the nominal current	$ \sin \varphi = 1,0$ to $0,8$ lagging or leading ^a
Phase angle or power factor	Nominal voltage $\pm 2\%$	40 % to 100 % of the nominal current	–
Frequency	Nominal voltage $\pm 2\%$	–	–
Polyphase quantities	Symmetrical voltages ^b	Symmetrical currents ^b	–
^a Apparent, active power and reactive power transducers are normally used together and are connected to the same current and voltage transformers. It must be noted that $\sin \varphi = 1,0$ to $0,8$ is used here for ease of testing only. ^b The difference between any two line-to-line voltages and between any two line-to-neutral voltages shall not exceed 1 % of the average (line-to-line and line-to-neutral voltages respectively). Each of the currents in the phases shall differ by not more than 1 % from the average of the currents. The angles between each of the currents and the corresponding phase-to-neutral (star) voltages shall differ by not more than 2°. Where interactions between the separate measuring elements of a multi-element transducer are adequately characterized, single-phase testing of the transducer is acceptable.			

5.5 Auxiliary supply

5.5.1 General

Some transducers dealt with in this document may need an auxiliary supply. This is specified in two separate categories, DC and AC supplies.

5.5.2 DC supply

- The value of the voltage of the DC supply shall be as specified in 5.6.3.
- The battery supply may be earthed or floating. Suitable means shall be provided in the transducer to ensure isolation between the power supply and the input/output circuits of the transducer (for details of voltage tests, see 6.19).
- The transducer shall withstand any voltage ripple up to a maximum of 10 % peak to peak superimposed on the DC power supply.
- The noise fed back to the battery from the transducer shall be limited to 100 mV peak to peak when measured with a specified source resistance at all frequencies up to 100 MHz.

In addition, when the battery feeding the transducer is also used for telephone equipment, the noise shall not exceed 2 mV psophometric.

NOTE The psophometric weighting characteristic is specified in ITU-T Recommendation O.41.

5.5.3 AC supply

For the nominal value of the voltage of the AC supply, see 5.6. This voltage may be provided by a separate supply or may be derived from the measured voltage or current.

5.6 Input values

5.6.1 General

The nominal values of voltage, current, frequency and auxiliary supply shall be specified by the manufacturer.

5.6.2 Adjustment ranges

Adjustment range for transducers that can be adjusted by the user:

- a) for the input voltage: 80 % to 120 % of the nominal value;
- b) for the input current: 60 % to 130 % of the nominal value.

This means that the nominal value of the output signal can be obtained for any adjusted value of the measurand within the ranges given above.

5.6.3 Preferred nominal values

The preferred nominal value of DC auxiliary supplies shall be 24 V, 48 V or 110 V.

5.7 Analogue output signals

5.7.1 General

The lower and upper nominal values of the output signal and the compliance voltage shall be chosen from those given in 5.7.2 and 5.7.3 or 5.7.6.

5.7.2 Output current

The signal 4 mA to 20 mA is preferred.

NOTE The condition "0 mA" has a special meaning (IEC 60381-1).

Other permissible values are

- 0 mA to 20 mA,
- 0 mA to 1 mA,
- 0 mA to 10 mA,
- –1 mA to 1 mA,
- –5 mA to 5 mA,
- –10 mA to 10 mA, and
- –20 mA to 20 mA.

5.7.3 Compliance voltage

- 10 V;
- 15 V.

5.7.4 Maximum output voltage

The manufacturer shall state the maximum value of the output voltage occurring under any conditions of output load and input. This voltage shall not exceed the limit of safety extra-low voltage.

5.7.5 Interference risk of output current

Attention is drawn to the interference problems which may result if the output current has a low value.

5.7.6 Output voltage

- 0 V to 1 V;
- 0 V to 10 V;
- –1 V to 1 V;
- –10 V to 10 V.

NOTE Transducers having a voltage output are non-preferred.

5.8 Output transfer function

For analogue transducers, the used transfer function shall be one of the following curves.

For analogue transducers, variables x , y can be adjustable.

Curve A is described in Figure 2.

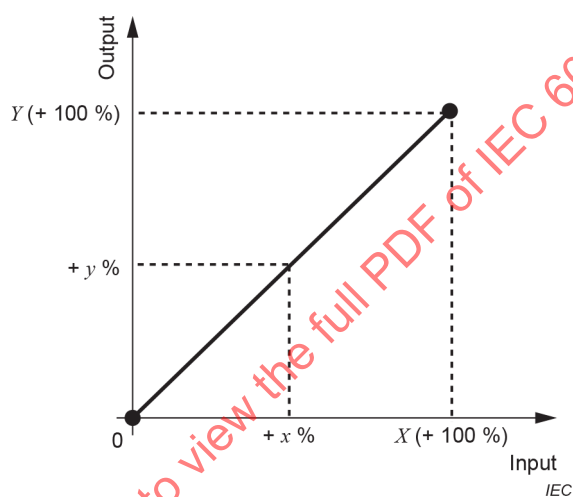


Figure 2 – Transfer function curve A

Curve B is described in Figure 3.

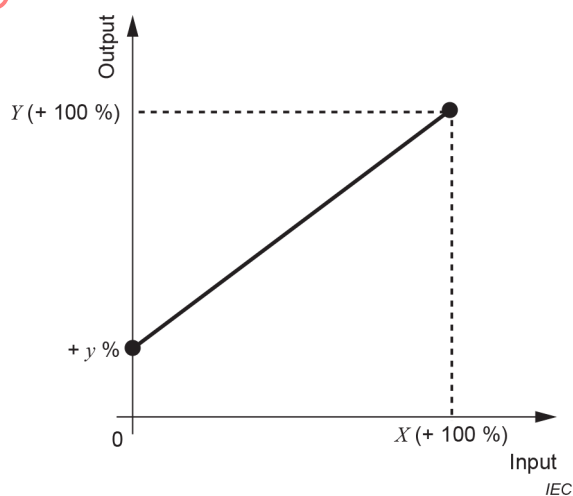


Figure 3 – Transfer function curve B

Curve C is described in Figure 4.

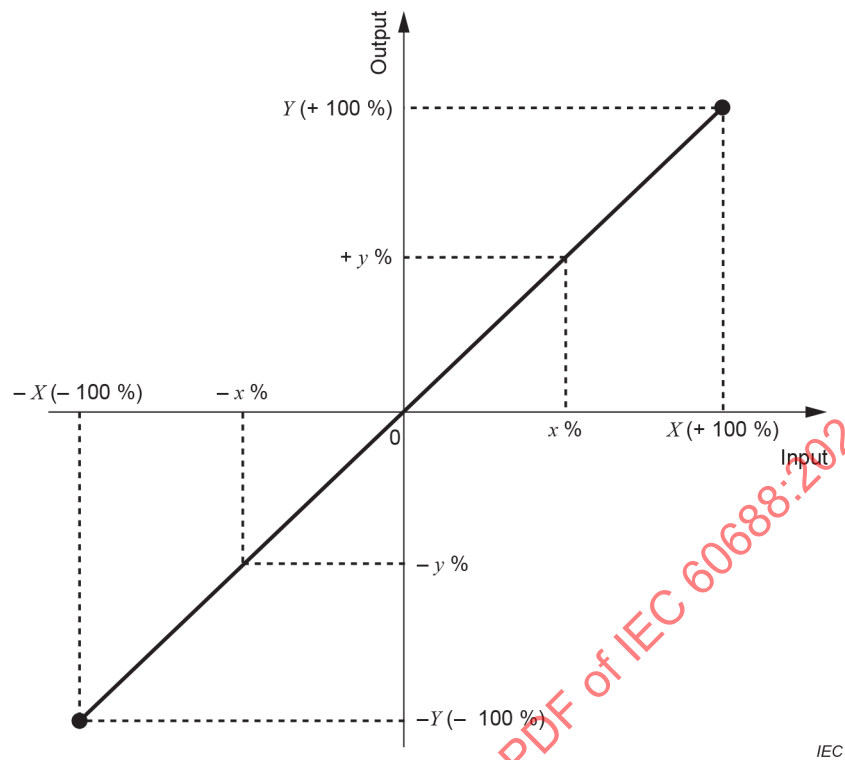


Figure 4 – Transfer function curve C

Curve D is described in Figure 5.

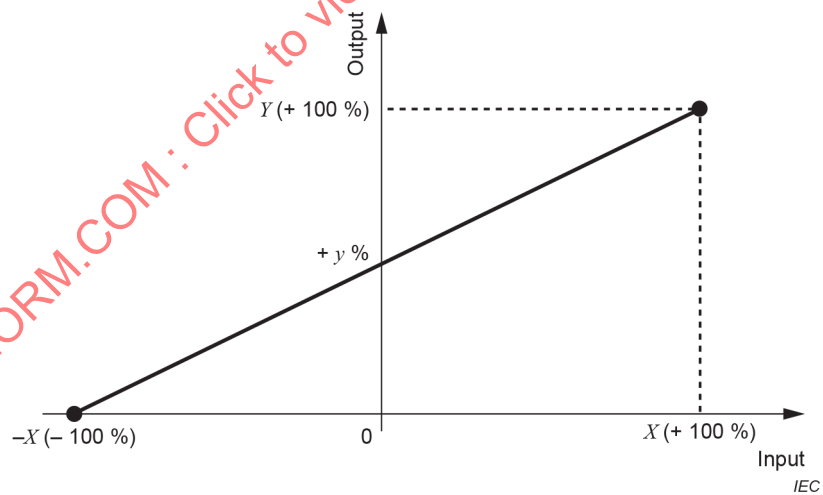


Figure 5 – Transfer function curve D

Curve E is described in Figure 6.

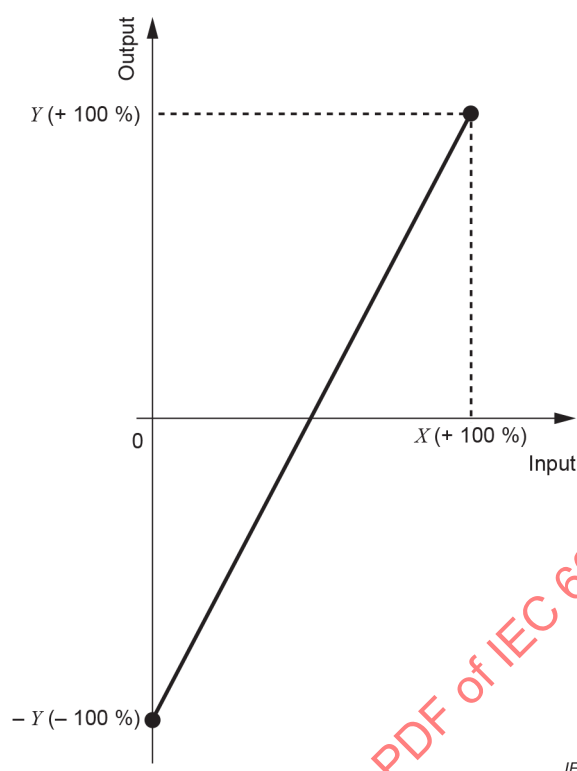


Figure 6 – Transfer function curve E

Curve F (all other kind of curves):

The accuracy class shall be checked for each point of the transfer function according to the formula:

$$\frac{Y - R}{R} \times 100$$

where

R is the value of the output signal under reference conditions;

Y is the value of the output signal measured at one extreme of the influence quantity.

NOTE For the curves F, replace in 6.1 to 6.23 F by R .

5.9 Digital output signals

The digital output signals chosen shall correspond with the requirements for transducers concerning accuracy and response time as well as with the requirements of the communication system.

For the digital output, the class index shall be in conformity with the performance class described in IEC 61557-12:2018.

If outputs relays are provided, they shall comply with IEC 60255-151.

5.10 Ripple (for analogue outputs)

The maximum ripple content in the output signal shall not exceed twice the class index.

5.11 Response time

5.11.1 Before determining the response time, the transducer shall be under reference conditions and the auxiliary circuit shall be energized for at least the pre-conditioning time unless it is energized from one of the input quantities and is not separately accessible.

5.11.2 The response time shall be stated by the manufacturer and shall be determined for an input step such that it would produce a change in output signal from 0 % to 90 % of the fiducial value.

5.11.3 If a test for decreasing input is required, the input step should produce a change in output signal from 100 % to 10 % of the fiducial value.

5.11.4 The interval (see 3.1.24) shall be ± 1 % of the upper nominal value of the output signal.

5.11.5 Methods of test for frequency transducers and transducers with suppressed zero shall be stated by the manufacturer.

5.12 Variation due to over-range of the measurand

If, by agreement, a transducer is required to operate with an input up to 150 % of the nominal value, the difference between the intrinsic error at 100 % and the error at 150 % (under reference conditions) of the nominal value of the input shall not exceed 50 % of the class index.

For active power and reactive power transducers, 150 % of the nominal value is achieved by increasing the current while retaining the voltage at the nominal value.

5.13 Limiting value of the output signal

The output signal shall be limited to a maximum of twice the upper nominal value.

When the measurand is not between its lower and upper nominal values, the transducer shall not, under any conditions, for example over-current or under-voltage, produce an output having a value between its lower and upper nominal values.

5.14 Limiting conditions of operation

The limits of the nominal ranges of use given in Clause 6 are those within which the transducer will comply with the requirements of this document. It is possible to operate transducers beyond these limits but the user should note that

- the accuracy may not be maintained, and/or
- the designed operational lifetime may be reduced.

As an example, many transducers will operate in ambient temperatures as low as -25 °C and as high as $+70$ °C but the manufacturer should be consulted as to the degradation to be expected in both accuracy and operational lifetime.

5.15 Limits of the measuring range

When the limits of the measuring range do not coincide with the lower and upper nominal values of the output, the limits of the measuring range shall be marked – see 7.1 i).

5.16 Limiting conditions for storage and transport

Unless otherwise stated by the manufacturer, transducers shall be capable of withstanding, without damage, exposure to temperatures within the range -40 °C to $+70$ °C.

After returning to reference conditions, they shall meet the requirements of this document.

The manufacturer shall specify any additional limiting condition required to ensure the integrity of the transducer.

5.17 Sealing

When the transducer is sealed to prevent unauthorized adjustment, access to the internal circuit and to the components within the case shall not be possible without destroying the seal.

5.18 Stability

Transducers shall comply with the relevant limits of intrinsic error specified for their respective accuracy classes for a period specified by the manufacturer, provided that the conditions of use, transport and storage specified by the manufacturer are complied with.

NOTE Usually, the period will be below one year.

6 Tests for TRD1

6.1 General

6.1.1 Determination of variations

The variations shall be determined for each influence quantity. During the tests, all other influence quantities shall be maintained at reference conditions.

All the influence quantities are given in 6.1 to 6.23, together with the appropriate testing procedure, computations and the permissible variations for each usage group expressed as a percentage of the class index. None of the variations determined shall exceed the permissible values.

Variations shall be determined at the upper nominal value of the output and, at least, at one other point. For apparent power, active power and reactive power transducers, these values shall be obtained by maintaining the voltage and power factor at their reference conditions and varying the value of the current.

When a reference range is specified, the influence quantity shall be varied between each of the limits of the reference range and any value in that part of the nominal range of use which is adjacent to the chosen limit of the reference range.

6.1.2 Environmental conditions

The conditions of temperature and humidity are classified according to the severity dictated by the usage group in accordance with Table 6.

Table 6 – Usage groups

	K55 class of transducer	K70 class of transducer	Kx^b class of transducer
Usage group	I	II	III
Rated operating range (with specified uncertainty)	–5 °C to +55 °C	–25 °C to +70 °C	Above +70 °C and/or under –25 °C ^a
Limit range of operation (no hardware failures)	–5 °C to +55 °C	–25 °C to +70 °C	Above +70 °C and/or under –25 °C ^a
Limit range for storage and shipping	–25 °C to +70 °C	–40 °C to +85 °C	According to manufacturer specification ^a
^a Limits shall be defined by manufacturer according to the application.			
^b Kx stands for extended conditions.			

For the purpose of this document, ambient temperature shall be the temperature measured at a single representative point with the transducer operating normally. This measuring point shall be adjacent to the transducer, exposed to free air circulation and not significantly affected by heat from the transducer or by direct solar radiation and other sources of heat.

Humidity is not considered to be an influence quantity provided that the environmental conditions are within the limits specified.

6.1.3 Computations

In 6.2 to 6.22, a computation is required according to a formula. The terms in the formulae follow a general principle:

- R is the value of the output signal under reference conditions;
- X (or Y) is the value of the output signal measured at one extreme of the influence quantity;
- F is the fiducial value.

NOTE For curves F (see 5.8) replace in all the following formula F by R .

6.2 Variations due to auxiliary supply voltage

6.2.1 Application

All transducers requiring a DC or an AC auxiliary supply except where this is obtained from the input voltage or current and the connections cannot be separated for testing purposes.

6.2.2 Procedure

Apply the nominal value of auxiliary supply voltage and record the value of the output signal (R).

At a constant value of the measurand, reduce the auxiliary supply voltage to the lower limit given in 6.2.4 and record the value of the output signal (X). Increase the auxiliary supply voltage to the upper limit given in 6.2.4 and record the value of the output signal (Y).

6.2.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.2.4 Permissible variations

For AC auxiliary supplies, Table 7 applies.

Table 7 – Permissible variations due to AC auxiliary supply

Usage group	Nominal range of use %	Variation % of class index
I	90 to 110	50
II	80 to 120	50
III	80 to 120	50

For DC auxiliary supplies, Table 8 applies.

Table 8 – Permissible variations due to DC auxiliary supply

Usage group	Nominal range of use %	Variation % of class index
I	85 to 125	50
II	85 to 125	50
III	85 to 125	50

6.3 Variations due to auxiliary supply frequency

6.3.1 Application

All transducers requiring an AC auxiliary supply except where this is obtained from the input voltage or current and the connections cannot be separated for testing purposes.

6.3.2 Procedure

Apply the nominal value of auxiliary supply frequency and record the value of the output signal (R). At a constant value of the measurand, reduce the auxiliary supply frequency to the lower limit given in 6.3.4 and record the value of the output signal (X).

Increase the auxiliary supply frequency to the upper limit given in 6.3.4 and record the value of the output signal (Y).

6.3.3 Computation

The variations are: $\frac{X - R}{F} \times 100$

and: $\frac{Y - R}{F} \times 100$

6.3.4 Permissible variations

Table 9 applies.

Table 9 – Permissible variations due to auxiliary supply frequency

Usage group	Nominal range of use %	Variation % of class index
I	90 to 110	50
II	90 to 110	50
III	90 to 110	50

6.4 Variations due to ambient temperature

6.4.1 Application

All transducers.

6.4.2 Procedure

At a constant value of the measurand and at reference temperature, record the value of the output signal (R).

Increase the ambient temperature to the upper limit given in 6.4.4 and allow sufficient time for conditions to stabilize (30 min is usually adequate). Record the value of the output signal (X).

Reduce the ambient temperature to the lower limit given in 6.4.4 and allow the same stabilization to take place. Record the stabilization time and the value of the output signal (Y).

6.4.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.4.4 Permissible variations

Table 10 applies

Table 10 – Permissible variations due to ambient temperature

Usage group	Nominal range of use °C	Variation % of class index
I	10 to 35	100
II	0 to 45	100
III	–10 to 55	100

6.5 Variations due to the frequency of the input quantity(ies)

6.5.1 Application

All transducers except frequency transducers. Frequency sensitive transducers (e.g. those employing phase shifting circuits) are exceptions and the nominal range of use shall always be marked.

6.5.2 Procedure

Apply the nominal value of the input frequency and record the value of the output signal (R).

At a constant value of the measurand, reduce the frequency to the lower limit given in 6.5.4 and record the value of the output signal (X).

Increase the frequency to the upper limit given in 6.5.4 and record the value of the output signal (Y).

6.5.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.5.4 Permissible variations

Table 11 applies.

Table 11 – Permissible variations due to the frequency of input quantity

Usage group	Nominal range of use %	Variation % of class index
I	90 to 110	100
II	90 to 110	100
III	90 to 110	100
Frequency sensitive	As marked	100

6.6 Variations due to the input voltage

6.6.1 Application

All transducers except voltage and current transducers.

6.6.2 Procedure

Apply the nominal value of the input voltage and record the value of the output signal (R).

At a constant value of the measurand, reduce the voltage to the lower limit given in 6.6.4 and record the value of the output signal (X).

Increase the voltage to the upper limit given in 6.6.4 and record the value of the output signal (Y).

6.6.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.6.4 Permissible variations

Table 12 applies.

Table 12 – Permissible variations due to the input voltage

Usage group	Nominal range of use %	Variation % of class index
I	90 to 110	50
II	80 to 120	50
III	80 to 120	50

6.7 Variations due to the input current

6.7.1 Application

Phase angle and power factor transducers.

6.7.2 Procedure

Apply the nominal value of the input current and record the value of the output signal (R).

At a constant value of the measurand, reduce the input current to the lower limit given in 6.7.4 and record the value of the output signal (X).

Increase the input current to the upper limit given in 6.7.4 and record the value of the output signal (Y).

6.7.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.7.4 Permissible variations

Table 13 applies.

Table 13 – Permissible variations due to the input current

Usage group	Nominal range of use %	Variation % of class index
I	20 to 120	100
II	20 to 120	100
III	20 to 120	100

6.8 Variations due to power factor

6.8.1 Application

Apparent, active and reactive power transducers.

6.8.2 Procedure

Apply respectively 50 % (5 %) of the nominal value of the input current at a power factor of 1,0 and record the two values of the output signal (R). At a constant value of the measurand, increase the input current to 100 % (10 %) of the nominal value and reduce the power factor to 0,5 lag/lead, respectively. Record the two values of the output signal (X).

For convenience, when testing the reactive power transducers, it is usual to apply the equivalent values of $\sin \varphi$.

Active power transducers shall also be tested for error at a power factor of zero and reactive power transducers at a $\sin \varphi = 0$.

6.8.3 Computation

The variations are:
$$\frac{X - R}{F} \times 100$$

and:
$$\frac{Y - R}{F} \times 100$$

6.8.4 Permissible variations

Table 14 applies.

Table 14 – Permissible variations due to power factor

Usage group	Nominal range of use	Variation % of class index
I	$\cos(\sin) \varphi = 0,5 \dots 1 \dots 0,5$	50
II	$\cos(\sin) \varphi = 0,5 \dots 1 \dots 0,5$	50
III	$\cos(\sin) \varphi = 0,5 \dots 1 \dots 0,5$	50

For all transducers, the error at a power factor of zero (or $\sin \varphi = 0$) shall not exceed 100 % of the class index.

6.9 Variation due to output load

6.9.1 Application

All variable output load transducers.

6.9.2 Procedure

Apply a value of output load equal to the mean value of the nominal range and record the value of the output signal (R).

At a constant value of the measurand, reduce the resistance of the output load to the lower limit given in 6.9.4 and record the value of the output signal (X).

Increase the resistance of the output load to the upper limit given in 6.9.4 and record the value of the output signal (Y).

6.9.3 Computation

The variations are: $\frac{X-R}{F} \times 100$

and: $\frac{Y-R}{F} \times 100$

6.9.4 Permissible variations

Table 15 applies.

Table 15 – Permissible variations due to output load

Usage group	Nominal range of use	Variation
	%	% of class index
I	10 to 100	50
II	10 to 100	50
III	10 to 100	50

6.10 Variations due to distortion of the input quantity(ies)

6.10.1 Application

All transducers characterized by the manufacturer for use on systems having distorted waveforms, except harmonics transducers.

6.10.2 Procedure

Apply the chosen value of input quantity with no distortion and record the value of the output signal (R). Introduce third harmonic distortion at the level given in 6.10.4, maintaining the RMS values constant, and record the value of the output signal (X). The phase relationship between the harmonic and the fundamental should be varied so as to determine the most unfavourable conditions.

For apparent, active and reactive power transducers, the test is performed with distorted current waveform and then repeated with distorted voltage waveform.

For apparent active and reactive power transducers not employing phase shifters, the permissible variations are given in 6.10.4.

For reactive power transducers employing phase shifters, the permissible variations shall be specified by the manufacturer.

6.10.3 Computation

The variation is: $\frac{X-R}{F} \times 100$

6.10.4 Permissible variations

Table 16 applies.

Table 16 – Permissible variations due to distortion of input quantities

Usage group	Nominal range of use	Variation % of class index
I	Distortion factor 0,2	200
II	Distortion factor 0,2	200
III	Distortion factor 0,2	200

6.11 Variation due to magnetic field of external origin

6.11.1 Application

All transducers.

6.11.2 Procedure

The transducer is placed in the centre of a coil of 1 m mean diameter, of square cross section and of radial thickness small compared with the diameter. Other devices which produce an adequate homogeneous magnetic field in the absence of the transducer under test are also permissible. 400 ampere-turns in this coil will produce, at the centre of the coil, in the absence of the transducer under test, a magnetic field strength of 0,4 kA/m. The magnetic field shall be produced by a current of the same kind and frequency as that which energizes the measuring circuit and shall be such as to have the most unfavourable combination of phase and orientation. The values of AC fields are expressed in RMS values.

Any transducer having an external dimension exceeding 250 mm shall be tested in a coil of mean diameter not less than four times the maximum dimensions of the transducer. The magnetic field strength being the same as that given above.

In the absence of the external field, record the value of the output signal (R).

At a constant value of the measurand, apply the external field and record the value of the output signal (X).

6.11.3 Computation

The variation is:
$$\frac{X - R}{F} \times 100$$

6.11.4 Permissible variations

Table 17 applies.

Table 17 – Permissible variations due to magnetic field of external origin

Usage group	Variation % of class index
I	100
II	100
III	100

6.12 Variation due to unbalanced currents

6.12.1 Application

Multi-element apparent, active and reactive power transducers.

6.12.2 Procedure

The currents shall be balanced and adjusted so that the output signal is approximately in the middle of the span or, if zero output signal is within the span, half-way between zero and the upper nominal value of the output signal. Record the value of the output signal (R).

Disconnect one current, maintaining the voltages balanced and symmetrical, and adjust the other currents, maintaining them equal, so as to restore the initial value of the measurand.

Record the value of the output signal (X).

6.12.3 Computation

The variation is: $\frac{X - R}{F} \times 100$

6.12.4 Permissible variations

Table 18 applies.

Table 18 – Permissible variations due to unbalance currents

Usage group	Variation % of class index
I	100
II	100
III	100

6.13 Variation due to interaction between measuring elements

6.13.1 Application

All multi-element apparent, active power and reactive power transducers except those employing two measuring elements for measuring three-phase four-wired unbalanced power with three current circuits (sometimes known as "two and a half elements") and those reactive power transducers using cross-connection methods.

6.13.2 Procedure

The voltage input of one measuring circuit alone shall be energized at nominal voltage. The current input of each of the other measuring circuits shall be energized in turn at nominal current. The maximum departure of the output signal (X) from that corresponding to zero of the measurand shall be noted whilst the phase angle between the voltage and currents is changed through 360°.

If the auxiliary supply is common to one of the voltage input circuits, this circuit shall be the one to which the voltage is applied.

6.13.3 Computation

The variation is: $\frac{X}{F} \times 100$

6.13.4 Permissible variations

Table 19 applies.

Table 19 – Permissible variations due to interactions between measuring elements

Usage group	Variation % of class index
I	50
II	50
III	50

6.14 Variation due to self-heating

6.14.1 Application

All transducers.

6.14.2 Method

The transducer shall be at ambient temperature and shall have been disconnected for at least 4 h. Energize the transducer in accordance with reference conditions defined in Table 4 and Table 5.

After 1 min and before the third minute, determine the value of the output signal (X). Repeat this procedure between the 30th and 35th minute after energization (R).

6.14.3 Computation

The variation is: $\frac{X-R}{F} \times 100$

6.14.4 Permissible variations

Table 20 applies.

Table 20 – Permissible variations due to self-heating

Usage group	Variation % of class index
I	100
II	100
III	100

6.15 Variation due to continuous operation

6.15.1 Application

All transducers.

6.15.2 Procedure

Energize the transducer under reference conditions for at least the preconditioning period. Record the value of the output (R). After a convenient period of continuous operation, for example 6 h, note the value of the output (X).

6.15.3 Computation

The variation is:
$$\frac{X - R}{F} \times 100$$

6.15.4 Permissible variation

A variation is allowed but the transducer shall continue to comply in all respects with the requirements appropriate to its accuracy class.

6.16 Variation due to common mode interference

6.16.1 Application

All transducers having an analogue output signal.

6.16.2 Procedure

At a constant value of the measurand near the upper nominal value, record the value of the output signal (R). Apply a voltage of 100 V RMS, at 45 Hz to 65 Hz, between either output terminal and earth. Record the value of the output signal (X).

6.16.3 Computation

The variation is:
$$\frac{X - R}{F} \times 100$$

6.16.4 Permissible variations

Table 21 applies.

Table 21 – Permissible variations due to continuous operation

Usage group	Variation
	% of class index
I	100
II	100
III	100

6.17 Variation due to series mode interference

6.17.1 Application

All transducers having an analogue current output signal.

6.17.2 Procedure

At a constant value of the measurand near the upper nominal value and with the compliance voltage at 80 % of the maximum value, record the value of the output signal (R).

Apply a voltage of 1 V RMS at 45 Hz to 65 Hz, in series with the output signal. Record the value of the output signal (X).

NOTE The internal DC resistance of the source of the series-mode interference, if excessive, can influence the test results, especially for the fixed output load transducers.

6.17.3 Computation

The variation is:
$$\frac{X - R}{F} \times 100$$

6.17.4 Permissible variations

Table 22 applies.

Table 22 – Permissible variations due to series mode interference

Usage group	Variation % of class index
I	100
II	100
III	100

6.18 Permissible excessive inputs

6.18.1 General

After completion of the tests described in 6.18.2 and 6.18.3 and after having regained equilibrium with the reference value of the ambient temperature, the transducer shall comply with the requirements appropriate to its class index.

6.18.2 Continuous excessive inputs

The transducer shall withstand the application of excessive inputs simultaneously for 24 h.

- Voltage inputs, including auxiliary supplies, shall be subjected to 120 % of the nominal value of the voltage.
- Current inputs shall be subjected to 120 % of the nominal value of the current.

6.18.3 Excessive inputs of short duration

The tests shall be made under reference conditions. The excessive input amplitudes of short duration which shall be applied to transducers are:

- for voltage inputs: 200 % of the nominal value of the measured voltage applied for 1 s and repeated 10 times at 10 s intervals;
- for current inputs: 20 times the nominal value of the measured current applied for 1 s and repeated 5 times at 300 s intervals.

The test circuit shall be substantially non-reactive.

After testing, the intrinsic characteristics of the transducer shall be unchanged.

6.19 Voltage test, insulation tests and other safety requirements

The requirements for the voltage test and other safety requirements are included in IEC 61010-1:2010 to which reference shall be made.

6.20 Impulse voltage tests

6.20.1 A peak test voltage of 5 kV in both positive and negative senses, having the standardized impulse waveform of 1,2/50 μ s, shall be applied to transducers as follows:

- between the earth terminal and all the other terminals connected together;
- between the terminals of each circuit in turn, all other circuits being earthed.

Three positive and three negative impulses shall be applied at intervals of not less than 5 s. Any flashover (capacitance discharge) shall be considered a criterion of failure unless occurring in a component designed for such.

For further details of the impulse voltage test, reference should be made to IEC 61010-1:2010 and IEC 61010-2-030:2017.

6.20.2 After completion of the impulse voltage test, the transducer shall comply with the requirements appropriate to its class index.

6.20.3 Auxiliary circuits with a reference voltage of over 40 V shall be subjected to the impulse voltage test under the same conditions as those already given for the other circuits.

6.21 High frequency disturbance test

See IEC 61326 (all parts).

6.22 Test for temperature rise

The transducer shall be energized as follows:

- each current circuit shall carry a current of 1,1 times the nominal current;
- each voltage circuit shall be supplied with a voltage of 1,2 times the nominal voltage.

These conditions shall be maintained for at least 2 h. During the test, the transducer shall not be exposed to forced ventilation nor to direct solar radiation.

The temperature rise of the following parts of the transducer shall not exceed:

- for input circuits: 60 K;
- for the exterior surface: 25 K.

6.23 Other tests

If, by agreement, other tests are required, the following publications shall apply:

- for vibration: IEC 60068-2-6;
- for shock: IEC 60068-2-27;
- for electromagnetic compatibility: IEC 61326-1:2020.

7 Marking and information for TRD1

7.1 Marking on the case

Transducers shall bear, on (or visible through) one of the external surfaces of the case, the markings listed below. The markings shall be legible and indelible. The symbols referred to below are specified in Table 24.

- a) Manufacturer's name or mark.
- b) Manufacturer's type designation.

- c) Serial number or date code.
- d) Software version (version of software that reside in the transducer – if any for digital transducers only).
- e) Class index (symbol E-10 or E-11).
- f) Nature of the measurand and number of circuits (symbol B-2, B-4 or B-6 to B-10).
- g) Lower and upper nominal values of the measurand.
- h) Ratios of current transformers and voltage transformers, if any, with which the transducer is intended to be used.
- i) Range of values of the output current (voltage) and output load within which specified operation is obtained (analogue signals only).
- j) Limits of the measuring range, if appropriate (see 5.9).
- k) Serial number(s) of the associated equipment, if applicable.
- l) Value(s) of the auxiliary supply, if relevant.
- m) Symbol showing that some other essential information is given in a separate document (symbol F-33).
- n) Space for adjustment data (if appropriate).
- o) Nominal range of use for temperature, symbolized as usage group I, II or III.
- p) Common mode voltage.
- q) Overvoltage category (see IEC 61010 (all parts).
- r) Pollution degree according to IEC 61010 (all parts).
- s) Other required safety symbols according to IEC 61010-1:2010.

If the markings and symbols are on an easily removable part, such as a cover, the transducer shall have a serial number which shall also be marked on the body of the transducer.

Transducers having a non-linear relationship between input and output shall be marked with the symbol F-33, and actual relationship between input and output shall be given in a separate document.

NOTE To be given if there is sufficient space on the case, otherwise to be given in a separate document.

7.2 Markings relating to the reference conditions and nominal ranges of use for transducers

7.2.1 The reference values (or ranges) and nominal ranges of use, if different from those given in Table 3 and Table 4 and Clause 6, shall be marked on the transducer or given in a separate document.

7.2.2 When a reference value or a reference range is marked, it shall be identified by underlining.

u

Table 23 shows the significance of the various markings, for example for temperature.

Table 23 – Examples of marking relating to the reference conditions and nominal range of use for temperature

Example	Meaning
-5 ... <u>23</u> ... 55 °C	Conforms to group I
-25 ... <u>15</u> ... <u>30</u> ... 70 °C	Conforms to group II
-35 ... <u>0</u> ... <u>45</u> ... 75 °C	Conforms to group III
0 ... <u>25</u> ... 40 °C	Reference value: 25 °C Nominal range of use: 0 °C to 40 °C

–5 ... <u>20 ... 30</u> ... 35 °C	Reference range: 20 °C to 30 °C Nominal range of use: –5 °C to 35 °C
Three or four numbers shall always be used.	

7.3 Identification of connections and terminals

If so required for the correct use of the transducer, a diagram or table of connections shall be supplied and the terminals shall be clearly marked to show the proper method of connection.

If a terminal of a measuring circuit is intended to be kept at, or near to earth (ground) potential (for example, for safety or functional reasons), it shall either be marked with a capital N if it is intended to be connected to the neutral conductor of an AC supply circuit, or it shall be marked with symbol F-45 (see Table 24) in all other circumstances.

The earthing terminal(s) shall be marked using symbol(s) F-31 and/or F-42 to F-45, as appropriate.

7.4 Information to be given in a separate document

The following information shall be given in the document supplied with the transducer:

- response time;
- the variation due to a magnetic field of external origin;
- the actual relationship between input and output (see required indications according type of curves given in 5.3 for output current transfer functions).

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Table 24 – Symbols for marking transducers

No.	Item		Symbol
B Nature of input quantity(ies) and number of measuring circuits			
B-1	DC circuit (for auxiliary supply only)	IEC 60417-5031 (2002-10)	
B-2	AC circuit (single phase)	IEC 60417-5032 (2002-10)	
B-3	DC and AC circuit	IEC 60417-5033 (2002-10)	
B-4	Three-phase AC circuit (general symbol)	IEC 60417-5032-1 (2002-10)	3
B-6	One measuring element for three-wire network	IEC 60417-5032-1 (2002-10)	3 1E
B-7	One measuring element for four-wire network	IEC 60417-5032-2 (2002-10)	3N 1E
B-8	Two measuring elements for three-wire network with unbalanced load	IEC 60417-5032-1 (2002-10)	3 2E
B-9	Two measuring elements for four-wire network with unbalanced load	IEC 60417-5032-2 (2002-10)	3N 2E
B-10	Three measuring elements for four-wire network with unbalanced load	IEC 60417-5032-2 (2002-10)	3N 3E
C Safety (see IEC 61010-1:2010)			
E Accuracy class			
E-10	Class index (e.g. 1) when the fiducial value corresponds to the span	---	1
E-11	Class index (e.g. 0,5) when the fiducial value corresponds to half the span	---	0,5 / 0,5
F General symbols			
F-31	Earth (ground) terminal (general symbol)	IEC 60417-5017 (2006-08)	
F-33	Caution, (refer to a separate document)	ISO 7000-0434B (2004-01)	
F-42	Frame or chassis terminal	IEC 60417-5020 (2002-10)	
F-43	Protective earth (ground) terminal	IEC 60417-5019 (2006-08)	
F-44	Functional earth terminal	IEC 60417-5018 (2006-08)	
F-45	Measuring circuit earth (ground) terminal	IEC 60417-5073 (2006-08)	
F-46	Positive terminal	IEC 60417-5005 (2006-08)	
F-47	Negative terminal	IEC 60417-5006 (2006-08)	

Annex A (normative)

Requirements for TRD2

A.0 General

Clause A.1 to Clause A.3 follow the numbering of those in the main part of the document.

A.1 Scope

Clause 1 applies, with the following addition:

Nominal voltage is limited to 1 000 V AC and 1 500 V DC.

A.2 Normative references

Clause 2 applies.

A.3 Terms and definitions

Clause 3 applies.

A.4 Environmental conditions

A.4.1 General

TRD2 are used in the environmental conditions of measuring equipment such as PMD complying with IEC 61557-12:2018 or PQI complying with IEC 62586-1:2017.

A.4.2 Normal environmental conditions

Various environments, such as electrical distribution systems or supply grids, can be considered as normal environments.

Normal environmental conditions have been translated in ratings in Clause A.5.

A.4.3 Special environmental conditions

There might be specific or more severe environmental conditions.

A.5 Ratings for TRD2

A.5.1 General

The basic ratings of TRD2 shall include the following items (as applicable).

1) Input ratings

- rated frequency (f_r);
- rated input voltage (U_{pr}).

The ratings for a TRD2 having a current monitoring input shall include, in addition,

- rated input current (I_{pr}),
- rated extended input current factor (K_{epcr}),
- rated continuous thermal current (I_{cth}),
- rated short-time thermal current (I_{th}), and
- rated dynamic current (I_{dyn}).

2) Output ratings

- rated output current (I_{sr}), for TRD2 delivering a current output;
- rated output voltage (U_{sr}), for TRD2 delivering a voltage output;
- rated output frequency (f_{sr}), for TRD2 delivering a frequency output;
- rated burden Z_{br} .

3) General ratings

- rated accuracy class;
- rated temperature class;
- rated humidity class;
- rated auxiliary power supply, if any;
- overvoltage category;
- measurement category, if any.

NOTE See guidance in IEC 61010-2-030:2017.

A.5.2 Input ratings

A.5.2.1 Rated frequency

For AC applications, the standard values of the rated frequency are 16,7 Hz, 50 Hz, 60 Hz and 400 Hz.

A.5.2.2 Input voltage ratings

The rated input voltage shall be specified by the manufacturer, taking into account Annex I of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016.

A.5.2.3 Input current ratings

A.5.2.3.1 Rated input current

The rated input current value shall be specified by the manufacturer.

A.5.2.3.2 Rated extended input current factor

A value for the rated extended input current factor may be assigned to the TRD2 by the manufacturer.

A K_{epcr} shall be assigned to the TRD2; the minimum value allowed is 1,2.

NOTE The selection of proper input and output rated values is supposed to be consistent with input limits of the associated measuring equipment.

A.5.2.3.3 Rated continuous thermal current (I_{cth})

The standard value for the rated continuous thermal current of the TRD2 is the rated input current.

When a rated continuous thermal current greater than the rated input current is specified, the preferred values are 120 %, 150 % and 200 % of rated input current.

A.5.2.4 Short-time current ratings

A.5.2.4.1 Rated short-time thermal current (I_{th})

A rated short-time thermal current (I_{th}) shall be assigned to the equipment.

If the duration is not specified, the value of the duration of the rated short-time thermal current is 1 s.

A.5.2.4.2 Rated dynamic current (I_{dyn})

If not otherwise specified, the standard value of the rated dynamic current (I_{dyn}) is 2,5 times the rated short-time thermal current (I_{th}).

A.5.3 Output ratings

A.5.3.1 Rated output interfaces

Rated output interfaces are defined through interface coding, as defined in Annex B.

NOTE Annex B provides also most common output interfaces.

Output ratings are defined at I_{pr} for TRD measuring current, and at U_{pr} for TRD2 measuring voltage.

A.5.3.2 Rated burden

A.5.3.2.1 Rated burden for TRD2 with an AC or DC voltage output, or a frequency output

The preferred value of rated burden is defined by a resistance in parallel with a capacitance according to Table A.1.

Table A.1 – Rated burden for TRD2 with an AC or DC voltage output, or a frequency output

Burden	Resistance	Capacitance
$Z_{br} U$	2 MΩ	50 pF

The impact of the total burden impedance range on accuracy is covered under accuracy clauses.

Attention should be paid to the parallel capacitance of instruments. If the transmitting cable is not part of the TRD2, the capacitance of the cable shall be considered as part of the burden.

NOTE Typical cable capacitance is in the range from 15 pF/m to 100 pF/m.

If a cable is factory mounted, it shall not be changed/modified in order to preserve the specified characteristics of the device, except if special considerations are undertaken to take into account the modified characteristics of the TRD2 based on manufacturer's information.

A.5.3.2.2 Rated burden for TRD2 with an AC or DC current output

The preferred value of rated burden is defined by the impedance in parallel according to Table A.2.

Table A.2 – Rated burden for TRD2 with an AC or DC current output

Burden	Resistance	Power factor
$Z_{br} I1$	1 Ω	1
$Z_{br} I2$	2,7 Ω	1

Other values of rated burden may be chosen with output power up to 0,05 VA.

A.5.3.3 Power supply

Rated external power supply and power supply provided by measuring equipment connected to TRD2 output are defined in Annex B.

A.5.4 General ratings

A.5.4.1 Accuracy classes

The standard accuracy classes for TRD2 are defined in Table A.7, Table A.8, Table A.9 and Table A.10.

A.5.4.2 Rated temperature classes

The standard temperature classes K40, K45, K55, K70 and Ks for TRD2 are defined in the below Table A.3.

Table A.3 – Rated temperatures for TRD2

	K40 temperature class	K45 ^d temperature class	K55 ^d temperature class	K70 ^d temperature class of TRD2	Ks ^{b d} temperature class of TRD2
Rated operating range^c (with specified uncertainty)	–5 °C to +40 °C	–10 °C to +45 °C	–5 °C to +55 °C	–25 °C to +70 °C	According to manufacturer's specification ^a
Limit range of operation (no hardware failures)	–10 °C to +55 °C	–25 °C to +55 °C	–5 °C to +55 °C	–25 °C to +70 °C	
Limit range for storage and shipping	–25 °C to +70 °C	–25 °C to +70 °C	–25 °C to +70 °C	–40 °C to +85 °C	

^a Limits shall be defined by the manufacturer according to the application.

^b Ks stands for special temperature class.

^c An operating temperature is the highest temperature of the air in close proximity to TRD2.

^d K45 temperature class corresponds to FI1 of IEC 62586-1:2017 and "indoor use" condition of IEC 62052-11:2020.

K55 temperature class corresponds to K55 class of IEC 61557-12:2018.

K70 temperature class corresponds to K70 class of IEC 61557-12:2018.

Ks temperature class corresponds to any other temperature class, e.g. Kx class of IEC 61557-12:2018, or FI2 or FO classes of IEC 62586-1:2017.

A.5.4.3 Rated humidity classes

Table A.4 provides the rated humidity classes (standard humidity class and extended humidity class) for TRD2. See Figure A.1.

Table A.4 – Rated humidity classes

	Standard humidity class	Extended humidity class
Rated operating range (with specified uncertainty)	0 % to 75 % RH ^b	0 % to above 75 % RH ^{a b}
Limit range of operation for 30 days/year	0 % to 90 % RH ^b	0 % to above 90 % RH ^{a b}
Limit range for storage and shipping	0 % to 90 % RH ^b	0 % to above 90 % RH ^{a b}
^a Limits shall be defined by manufacturer according to the application.		
^b Relative humidity values are specified without condensation.		

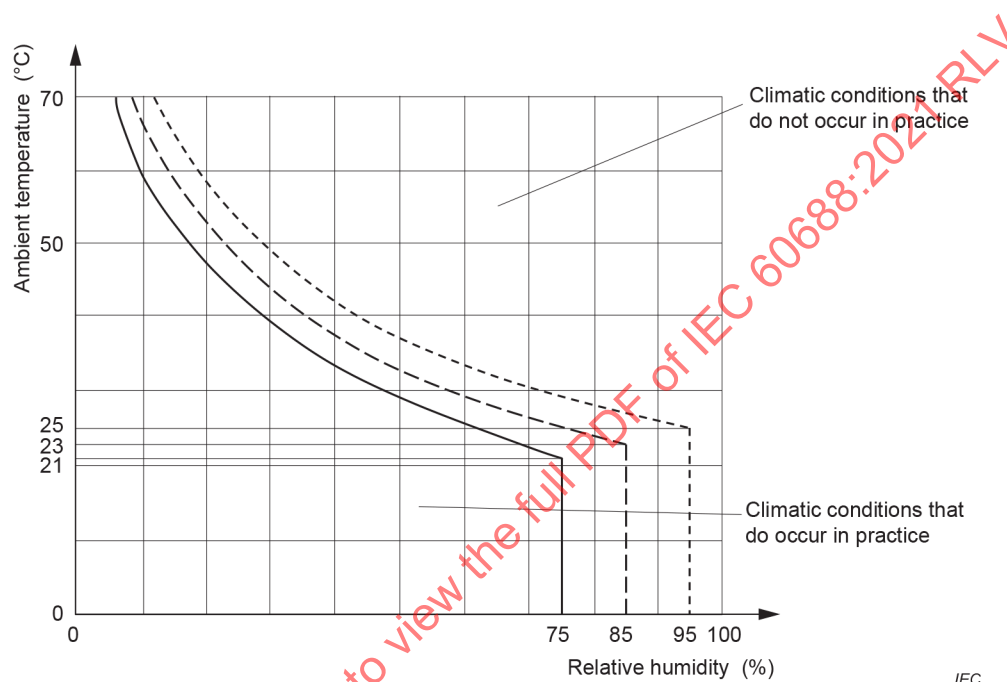


Figure A.1 – Relationship between ambient air temperature and relative humidity

A.6 Requirements for design of TRD2

A.6.1 General

If a TRD2 is specified for both AC and DC measuring applications, both AC and DC requirements apply.

However, if a TRD2 is specified for DC measuring with AC components (AC ripples), only DC requirement apply.

Unless otherwise specified, all the requirements of A.6.1 to A.6.9 apply for TRD2 measuring AC or DC applications.

A.6.2 Safety requirements

A.6.2.1 General

Two classes of TRD2 are defined.

- Class F: TRD2 shall fully comply with the safety requirements of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 and IEC 61010-2-030:2017, with additional requirements specified in A.6.2.2 to A.6.2.13. Class F is recommended for new designs.

- Class D: TRD2 shall mostly comply with the safety requirements of IEC 61010-1:2010 and IEC 61010-2-030:2017, with additional requirements specified in A.6.2.2 to A.6.2.13, but with some deviations compared to class F. In such a case, compliance to IEC 61010-1 cannot be claimed.

A.6.2.2 Protection against electric shocks

A.6.2.2.1 General

For TRD2 class F, Clause 6 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 and IEC 61010-2-030:2017 applies with the below additional requirements.

Clearances and creepage distances as well as solid insulation shall be selected at least in accordance with

- pollution degree 2,
- measurement category III, for measuring circuits, and
- overvoltage category III, for other circuits, if any.

For TRD2 class D, levels of insulations can be either identical to those defined for class F or be based on IEC 60664-1:2020, with the below additional requirements.

Clearances and creepage distances as well as solid insulation shall be selected at least in accordance with

- pollution degree 2, and
- overvoltage category III.

NOTE General information is provided in Annex G.

A.6.2.2.2 Accessible parts

A.6.2.2.2.1 Output terminals of TRD2

Output terminals of transducers to be connected to the measuring equipment shall generally be considered as accessible parts.

This is especially true for terminals equipped with an information technology connector (e.g. RJ45, DB9, or similar plug-in connectors) or with stranded wire, where skilled or unskilled people do not expect a hazardous voltage.

Some exemption may apply on condition they are based on a risk analysis, in which case the related mitigation measures shall be documented.

A.6.2.2.2.2 Outer surfaces of TRD2

Outer surface of transducers intended to be installed outside a cabinet, a panel or a cubicle shall generally be considered as accessible parts.

Some exemption may apply on condition they are based on a risk analysis, in which case the related mitigation measures shall be documented.

A.6.2.2.3 Insulation provided by cables, busbars and bushings

Manufacturers shall specify in the technical documentation

- the kind of insulation requested on the cables or busbars or bare conductors to measure, and
- the kind of bushings to use, if any.

NOTE Guidance on insulation of cables or bushings is provided in Annex F.

A.6.2.2.4 Insulation within a panel

Manufacturers shall specify in the technical documentation if a minimum distance needs to be maintained between outer surfaces of the TRD2 (or its output circuits) and other equipment such as metallic parts or another TRD2 in its proximity.

A.6.2.2.5 Automatic disconnection

TRD2 class F shall comply with the requirements of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 related to automatic disconnection.

TRD2 class D shall either comply class F requirements or comply with the requirements of Clause 15 of IEC 61558-1:2017 related to automatic disconnection.

A.6.2.3 Protection against mechanical hazards

Clause 7 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 applies.

A.6.2.4 Resistance to mechanical stress

Clause 8 of IEC 61010-1:2010 applies with the below additional requirements.

Outer surface of transducers intended to be installed outside a cabinet, a panel or a cubicle shall meet, except for terminals and cords,

- IK07 (2 J) for indoor use, and
- IK08 (5 J) for outdoor use.

Outer surfaces of transducers intended to be installed exclusively inside a cabinet, a panel or a cubicle shall meet, except terminals and cords, at least IK02 (0,2 J) requirements.

A.6.2.5 Protection against the spread of fire

Clause 9 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 applies.

A.6.2.6 Equipment temperature limits and resistance to heat

Clause 10 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 applies with the below additional requirements.

Manufacturers shall declare for TRD2 intended to monitor currents

- if the TRD2 is intended to be used with integral means to avoid any (thermal) contact with conductor (cable or busbar) or if it is intended to be used in (thermal) contact with the conductor,
- if two TRD2, put side by side, can be continuously in (thermal) contact during service, and
- if a TRD2 can be continuously in (thermal) contact during service with another cable or busbar in the vicinity.

NOTE Guidance on temperature of cables and busbars is provided in Annex F.

A.6.2.7 Protection against hazards from fluids

A.6.2.7.1 General

Clause 11.6 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 applies with the additional requirements of A.6.2.7.2 and A.6.2.7.3.

A.6.2.7.2 Degrees of protection for indoor use

For indoor use, outer surface of transducers intended to be installed outside a cabinet, a panel or a cubicle shall meet IP40 requirements.

For indoor use, outer surface of transducers intended to be installed inside a cabinet, a panel or a cubicle shall meet IP2X requirements.

This requirement is not applicable to installations where personnel cannot gain access to the transducer without firstly de-energising the transducer and making it safe through some controlled means (i.e. interlocking, documented operating instructions, etc.). In this case, the need for such external safety measures to the transducer should be clearly stated in the product documentation.

A.6.2.7.3 Degrees of protection for outdoor use

The recommended minimum degree of protection for enclosures for outdoor TRD2 is IP44 according to IEC 60529.

For TRD2 with lower IP index or for higher installation needs, additional protection features against rain and other weather conditions shall be specified by means of the supplementary letter W placed after the second characteristic numeral, or after the additional letter, if any.

A.6.2.8 Protection against radiation, including laser sources, and against sonic and ultrasonic pressure

Clause 12 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016, if relevant, applies.

A.6.2.9 Protection against liberated gases and substances, explosion and implosion

Clause 13 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016, if relevant, applies.

A.6.2.10 Components and subassemblies

Clause 14 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016, if relevant, applies.

A.6.2.11 Protection by interlocks

Clause 15 of IEC 61010-1:2010, if relevant, applies.

A.6.2.12 Hazards resulting from application

Clause 16 of IEC 61010-1:2010, if relevant, applies.

A.6.2.13 Risk assessment

Clause 17 of IEC 61010-1:2010, if relevant, applies.

A.6.3 EMC requirements

A.6.3.1 General

A.6.3 applies only to TRD2 with active electronic components.

TRD2 shall comply with the immunity requirements of A.6.3.2 and the emission requirements of A.6.3.3.

They shall also comply with the requirements of IEC 61326-1:2020 in regard to

- test plan,
- test,
- test report, and
- instructions of use.

A.6.3.2 Immunity requirements

TRD2 transducers covered by A.6.3 shall comply with IEC 61326-1:2020, Table 2, with

- the ports as defined in Table A.5, below,
- the performance criteria of 6.4 of IEC 61326-1:2020 replaced by those defined in the below Table A.6, and
- the recommendation that devices are tested at 5 kHz for IEC 61000-4-4, instead of 100 kHz.

Table A.5 – Definition of ports

Port	Items related to transducers
Enclosure	Inner surface and outer surface of the transducer, including outer surface of connection cable and connectors, if any.
I/O signal/control	Output terminals Power supply terminals when provided by the measuring equipment connected to the TRD2 output via the connector, if any Memory management terminals when provided by the measuring equipment connected to the TRD2 output via the connector, if any Functional earth, if any.
DC power ^a	Protective earth, if any. Power supply port, when supplied from an external power supply source, if any.
AC power	Protective earth, if any. Power supply port, when supplied from an external power supply source, if any.
^a Power supply terminal intended to be connected to a low voltage DC supply (≤ 60 V) where the power ports are isolated from the AC mains are not subject to transient overvoltages (i.e. reliably grounded, capacitively filtered DC output circuits) and shall be regarded as I/O signal/control ports.	

Table A.6 – Performance criteria for EMC immunity tests

Assessment criteria	Conditions for acceptance
A	Normal performance within the accuracy specification limits during and after the test. No change in the operating state is allowed nor is loss of data. For transducers with digital output signal, this includes the state of quality and sync bits. During the tests, no individual sampled value error shall exceed 10 % of the rated value. A reset or restart is not allowed.
B	Normal performance after the tests, within the accuracy specification limits for transducers. An unintended change of the operating state is allowed if self-recoverable. A temporary degradation of the performance is permitted during the tests, provided the function is self-recoverable, i.e. without user intervention, if this is described in the EMC test plan and if the information is provided to the end user. During the tests, no loss of stored data is allowed, and no individual sampled value error shall exceed 100 % of the nominal RMS value. A reset or restart is not allowed.
C	Temporary loss of function is permitted, provided the function is self-recoverable or can be restored by the operation of controls. A reset or restart is allowed, provided that, during this cycle, the output signal is either zeroed or the validity bit is set to invalid until the transducer is again within the normal performance limits. The recovery procedure shall be provided to the end user. No permanent damage to the equipment is allowed. After a reset or restart: normal performance within the accuracy specification limits

A.6.3.3 Emission requirements

TRD2 covered by A.6.3 shall comply with the requirements of 7.2 of IEC 61326-1:2020 for class A or class B equipment.

A.6.4 Climatic requirements**A.6.4.1 Temperature requirements**

TRD2 shall comply with one of the temperature classes defined in A.5.4.2.

A.6.4.2 Corrosion requirements

Risks of corrosion should be considered during design according to TRD2 intended use.

A.6.5 Mechanical requirements**A.6.5.1 Vibration requirements**

No additional requirements to the safety requirements.

A.6.5.2 IP requirements

No additional requirements to the safety requirements.

A.6.6 Interface requirements

A.6.6.1 Input interface requirements

Input terminals, if any, shall be secure and reliable. Screw or screwless terminals are allowed.

A.6.6.2 Output interface requirements

Output terminals, if any, shall be secure and reliable.

For output terminals connection, one the following 4 options is possible:

- integral wire with flying leads, provided marking complies with A.6.8.3.4;
- terminal for wires (e.g. spring terminals, screw or screwless terminals, terminal block);
- a RJ45 connector as described in Table A.7 may be used for short distances (< 10m);
- a special connector, according to manufacturer specification.

Table A.7 – RJ45 connector pinout

Pin:	1	2	3	4	5	6	7	8
Function:	S1	S2	T1+	V+	V-	T2-	a	n

S1, S2: transducer output terminals, for transducers issuing a current output signal
a, n: transducer output terminals, for transducers issuing a voltage output signal
T1+, T2-: reserved for future use of TEDS connection (transducer electronic data sheet, ISO/IEC/IEEE 21451-4:2010).
The voltage level delivered to the transducer shall not exceed 5 V DC.
V+, V-: power supply
NOTE RJ45 cord can be shielded or not depending on the length of the cord.

A.6.7 Accuracy requirements

A.6.7.1 Accuracy classes for TRD2 monitoring power factor with arithmetic method (TRD2-PFA)

Accuracy classes shall align with performance classes defined in 4.8.8 of IEC 61557-12:2018 for power factor, arithmetic method.

A.6.7.2 Accuracy classes for TRD2 monitoring power factor with vector method (TRD2-PFV)

Accuracy classes shall align with performance classes defined in 4.8.8 of IEC 61557-12:2018 for power factor, vector method.

A.6.7.3 Accuracy classes for TRD2 monitoring voltage THD (TRD2-THDU)

Accuracy classes shall align with performance classes defined in 4.8.14 of IEC 61557-12:2018 for voltage THD.

A.6.7.4 Accuracy classes for TRD2 monitoring current THD (TRD2-THDI)

Accuracy classes shall align with performance classes defined in 4.8.16 of IEC 61557-12 for current THD.

A.6.7.5 Accuracy classes for TRD2 monitoring AC current (TRD2-IAC)

A.6.7.5.1 Limits of error (ϵ) and phase error

The limits for the error on the magnitude and phase (as applicable) at the rated frequency shall not exceed the values given in Table A.8 for the specified accuracy class at the rated burden.

Table A.8 – Limits for error and phase error for TRD2-IAC

Accuracy class	Error (as applicable)					Phase error (as applicable)									
	$\pm\%$					$\pm\text{min}$					$\pm\text{Centiradians}$				
	at current (times rated input current)					at current (times rated input current)					at current (times rated input current)				
	0,01	0,05	0,2	1,0	K_{epcr}	0,01	0,05	0,2	1,0	K_{epcr}	0,01	0,05	0,2	1,0	K_{epcr}
0,1	-	0,4	0,2	0,1	0,1	-	15	8	5	5	-	0,45	0,24	0,15	0,15
0,2	-	0,75	0,35	0,2	0,2	-	30	15	10	10	-	0,9	0,45	0,3	0,3
0,2S	0,75	0,35	0,2	0,2	0,2	30	15	10	10	10	0,9	0,45	0,3	0,3	0,3
0,5	-	1,5	0,75	0,5	0,5	-	90	45	30	30	-	2,7	1,35	0,9	0,9
0,5S	1,5	0,75	0,5	0,5	0,5	90	45	30	30	30	2,7	1,35	0,9	0,9	0,9
1	-	3,0	1,5	1,0	1,0	-	180	90	60	60	-	5,4	2,7	1,8	1,8
3			4,5	3,0	3,0										

A.6.7.5.2 Accuracy class for selectable-ratio TRD2 with taps on the output

For all accuracy classes, the accuracy requirements refer to the highest transformation ratio, unless specified otherwise.

The manufacturer shall give information about the accuracy performance at lower ratios.

A.6.7.5.3 Influence of temperature on accuracy

The accuracy of the TRD2 shall remain within the specified accuracy limits specified in Table A.7 over their operating ambient temperature range.

A.6.7.5.4 Anti-aliasing requirements

Annex C applies.

A.6.7.5.5 Requirements for the measurement of harmonics and low frequencies monitoring

Annex D applies.

A.6.7.6 Accuracy classes for TRD2 monitoring DC current

A.6.7.6.1 General

The ratio error for the DC component, at a burden equal to or higher than the rated burden, shall not exceed the values given in Table A.9, expressed as a percentage of the measured current. A graphical representation of error limits is shown in Figure A.2.

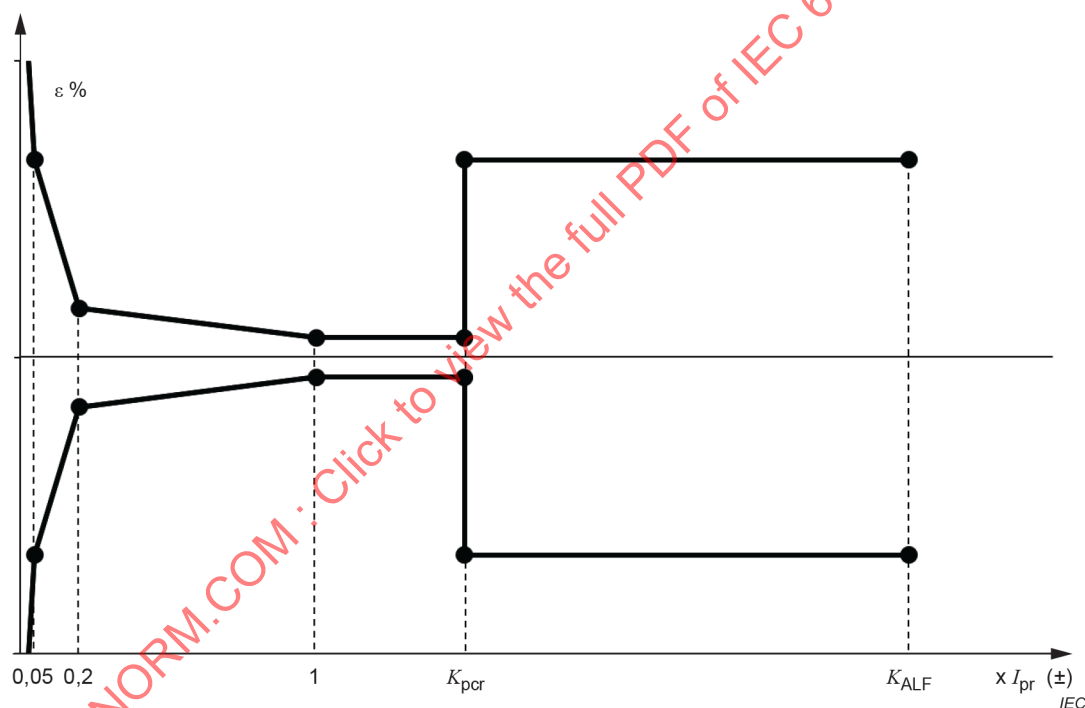
The accuracy shall be guaranteed for the whole range of temperature, for both polarities.

Table A.9 – Limits of ratio error for TRD2-IDC

Accuracy class	Error (as applicable) $\pm\%$				
	at current (times rated current)				
	0,05	0,2	1	K_{epcr}	
0,05	0,5	0,13	0,05	0,05	
0,1	1	0,25	0,1	0,1	
0,2	2	0,5	0,2	0,2	
0,5	3,5	1	0,5	0,5	
1	5	2	1	1	

For current lower than 5 % of the rated current, the absolute error ε_A shall not increase above the value at 5 %.

NOTE The purpose of A.6.7.6 is to consider a minimum value of error due to offset voltage and noise.

**Figure A.2 – Accuracy limits of a TRD2-IDC**

A.6.7.6.2 Step response time

A value for the step response time T_{sr1} shall be specified.

A.6.7.6.3 Frequency bandwidth

A cut-off frequency shall be specified for an amplitude error of 3 dB.

A.6.7.6.4 Maximum amplitude of input current over frequency

If the rated input current cannot be sustained over the specified frequency bandwidth, a derating shall be specified.

A.6.7.6.5 Noise

A RMS value referenced to input and a frequency band shall be specified. Alternatively, values for spectral noise density shall be specified at discrete frequencies.

Preferred values are under consideration.

A.6.7.7 Accuracy classes for TRD2 monitoring AC voltage

The voltage error and phase displacement at rated frequency shall not exceed the values given in Table A.10 at any voltage between 80 % and 120 % of rated voltage.

The errors shall be determined at the terminals of the TRD2 and shall include the effects of any fuses or resistors as an integral part of the TRD2.

For TRD2 with tapplings on the output circuit, the accuracy requirements refer to the highest transformation ratio, unless otherwise specified.

Table A.10 – Limits of ratio error for TRD2-UAC

Accuracy Class	Error (as applicable) ±%			Phase error (as applicable)					
				±min			±Centiradians		
	At % of rated voltage			At % of rated voltage			At % of rated voltage		
	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		

A.6.7.8 Accuracy classes for TRD2 monitoring DC voltage

The voltage error shall not exceed the values given in Table A.11.

Table A.11 – Limits of ratio error for TRD2-UDC

Accuracy class	Error (as applicable)					
	±%					
	at % of rated voltage					
	5	20	40	70	100	120
0,1	1	0,2	0,1	0,1	0,1	0,1
0,2	2	0,4	0,2	0,2	0,2	0,2
0,5	3,5	1	0,4	0,4	0,4	0,4
1	5	2	1	1	1	1
3	10	5	3	3	3	3

A.6.7.9 Requirements for short-time currents

The specified ratings shall be confirmed by a test specified in Clause A.7.

A.6.7.10 Requirements for inter-turn overvoltage

For inductive TRD2 with mA outputs, the rated withstand voltage for inter-turn insulation of output circuits shall be 2 kV peak according to a test specified in Clause A.7.

A.6.8 Marking requirements

A.6.8.1 Safety markings

Marking and operating instructions shall comply with IEC 61010-1:2010 unless otherwise specified.

A.6.8.2 General markings

All transducers shall carry at least the following markings:

- a) name or trademark of the manufacturer or supplier;
- b) a model number, name or other means to identify the equipment;
- c) rated frequency(ies) or declared rated frequency range;
- d) highest voltage of equipment.
- e) other ratings defined in A.5.1:
 - input ratings;
 - output ratings.

If there is not enough room on the TRD2 to write all the required markings, a) and b) shall be present on the product and symbol 14 in Table 1 of IEC 61010-1:2010 shall be added (if not otherwise specified). Items c), d) and e) shall be provided in the documentation.

A.6.8.3 Markings of terminals

A.6.8.3.1 General

The terminal markings shall identify, as applicable,

- the input and output terminals,
- the relative polarities, if any,
- the intermediate taps, if any, and
- terminals for other purposes, for example auxiliary power supply, earth connection, inputs, outputs, communication ports.

A.6.8.3.2 Markings to be used

All TRD2 shall comply with requirements provided in Annex E.

A.6.8.3.3 Indication of relative polarities

For TRD2 monitoring current, all the terminals marked P1, S1 and C1 shall have the same polarity at the same instant.

For TRD2 monitoring voltage, terminals having corresponding capital and lower-case markings shall have the same polarity at the same instant.

A.6.8.3.4 Method of marking

The terminals shall be marked clearly and indelibly, either on their surface or marked (or provided by others means) in their immediate vicinity.

The marking shall consist of letters (in block capitals) followed by numbers, (or preceded where necessary, e.g. for 2 output circuits), or with an arrow pointing from the P1 toward P2.

If possible, the output terminals shall be identified clearly and indelibly, either on the surface of the transducer or, in case of an 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.

A.6.9 Documentation requirements

A.6.9.1 General

The manufacturer shall make available to the purchaser the technical documentation, which is necessary for the installation, use and maintenance of the TRD2.

The following information shall either be marked on the transducer or specified in the documentation:

- mass in kg (if > 25kg);
- all measuring characteristics and all markings.

The following information shall be specified in the documentation:

- safety instructions (see 5.4 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 and see A.6.2);
- identification of connections and colour code in case of flying leads connection;
- instructions for transportation and storage;
- instructions for assembly, installation, connection and maintenance;
- instructions for dismantling and disposal;
- noise spectral information for specific transducers;
- ratings defined in A.5.1:
 - input ratings;
 - output ratings;
 - general ratings.
- EMC emission class A or class B ;
- safety class: class F or class D;
- limits of environment use and mitigation measures:
 - indoor or outdoor use;
 - installation inside cabinets (or panels or cubical) with or without locking means;
 - kind of bushings or other means for additional insulation.

A.6.9.2 Information for selection of TRD2

In order to facilitate the selection of transducers compatible with the instrument interface, an interface code, as specified in Annex B, shall be documented by manufacturers.

A.7 Tests for TRD2

A.7.1 Type tests

A.7.1.1 General

A.7.1.1.1 Selection of test specimens

All the type tests shall be carried out on a set of identical specimens.

A type test may also be considered valid if it is made on a TRD2 that has minor constructional deviations from the TRD2 under consideration.

All the type tests shall be carried out at ambient temperature between 10 °C and 30 °C.

A.7.1.1.2 Sequence of tests

No specific sequence of test is requested.

A.7.1.2 Safety tests

All relevant clauses related to test in IEC 61010:2010 and IEC 61010-1:2010/AMD1:2016 apply.

A.7.1.3 Electromagnetic compatibility tests

A.7.1.3.1 General

Test shall be conducted according to IEC 61326-1:2020.

The measurements shall be made in the operating mode in accordance with the EMC test plan (arrangements, including cabling, representative of normal installation conditions, etc.).

A.7.1.3.2 Immunity tests

Tests shall be conducted according to requirements specified in A.6.3.2 with the following additions.

- The output equipment, and the auxiliary power supply if any, shall not be subjected to the test stress.
- During the immunity tests, the length of cable connections between the EUT and the output equipment used as auxiliary test equipment shall be the maximum allowed according to the manufacturer's specifications.
- The TRD2 shall be subjected, during the test, to the nominal input signal for which it is rated. However, for ease of testing, in case of TRD2 monitoring current, it is allowed to reduce the input current value, with a minimum of 10 % of the rated value or 10 A, whichever is greater.

A.7.1.3.3 Emission tests

Tests shall be conducted according to requirements specified in A.6.3.3 with the following additions: TRD2 needs not to be loaded.

A.7.1.4 Climatic tests

Tests shall be conducted according to requirements specified in A.6.4.

A.7.1.5 Mechanical tests

Tests shall be conducted according to requirements specified in A.6.5.

A.7.1.6 Accuracy tests

A.7.1.6.1 General

Tests shall be conducted according to requirements specified in A.6.7.

The limits of error shall be tested at ambient temperature and at the rated frequency(ies).

A.7.1.6.2 Accuracy tests for TRD2 measuring AC currents

Accuracy measurements shall be made at each value of current given in the tables of A.6.7 for the declared accuracy class and the rated frequency relevant to the type of transducer. Measurements shall be made at the highest and at the lowest value of the specified burden range.

If a security factor FS is declared, the following test applies in addition.

With the input circuit open-circuited, the output circuit is energized at rated frequency by a substantially sinusoidal voltage. The voltage shall be increased until the exciting current I_e reaches $I_{sr} \times FS \times 0,1$.

The RMS value of the obtained terminal voltage shall be less than the output limiting EMF E_{FS} .

The exciting voltage shall be measured with a transducer which has a response proportional to the average of the rectified signal, but calibrated in RMS. The exciting current shall be measured using an RMS measuring transducer having a minimum crest factor of 3.

A.7.1.6.3 Accuracy tests for TRD2 measuring DC currents

Tests shall be made at each value of current given in the tables of A.6.7 for the declared accuracy class relevant to the type of transducer, at rated burden, and at ambient temperature, unless otherwise specified.

The test shall be made up to the rated input current (I_{pr}).

For input current equal to zero, the measured absolute error shall not exceed the value of the absolute error allowed at $0,05 \times I_{pr}$.

For the test at accuracy limit input current, the DC current source might not be available. The accuracy of the whole system may be tested using an alternating DC signal input method. The manufacturer shall supply all necessary information for the calculation of the accuracy at the specified input level.

For some technologies, instead of applying the input current on the input terminals, an auxiliary test circuit may be used to supply a corresponding test current.

A.7.1.6.4 Accuracy tests for TRD2 measuring AC voltages

Tests shall be made at each value of the input signal given in A.6.7.7 at the rated frequency and at ambient temperature, unless otherwise specified.

The tests shall be made with each burden listed in Table A.12.

Table A.12 – 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.

Then the voltage is set to the rated input voltage U_{pr} and maintained up to the thermal stabilization and then the accuracy is measured again. In case of a defined range of input 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.

NOTE 1 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 2 This test can be performed in combination with the temperature-rise test, or can be combined with the temperature cycle accuracy test.

A.7.1.6.5 Accuracy tests for TRD2 measuring DC voltages

Tests shall be made at each value of voltage given in the tables of A.6.7 for the declared accuracy class relevant to the type of transducer, at rated burden, and at ambient temperature, unless otherwise specified.

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.

Then the voltage is reduced to U_{pr} and maintained up to the thermal stabilization. The accuracy is measured and the accuracy variation at U_{pr} is determined.

From this result, the accuracy variation at intermediate voltages and maximum voltage is estimated according to the thermal characteristics of the resistors.

The errors shall be within the limits of the relevant accuracy class, both at the time the test voltage is applied and after the correction of the accuracy variation.

The stability is considered after a period of 3 times the time constant, which shall be defined by the supplier.

For input voltage equal to zero, the measured absolute error shall not exceed the value of the absolute error allowed at $0,05 \times U_{pr}$.

NOTE This test can be performed together with the temperature-rise test.

A.7.1.6.6 Tests of the step response time (T_{sr}) for TRD2 measuring DC current or voltage

A.7.1.6.6.1 Test setup for TRD2 measuring DC currents

The determination of the step response time requires a current generator and instruments to measure the input signal and the output signal. The rise time of the generated signal shall be less than $0,2 \times T_{sr}$ (see Figure A.3).

The input current step-up may be replaced by a current step-down. The rise time is then replaced by the fall time. The positive current polarity generates a negative step-down and vice versa.

The step response time of the signal measurement systems shall be lower than $0,05 \times T_{sr}$.

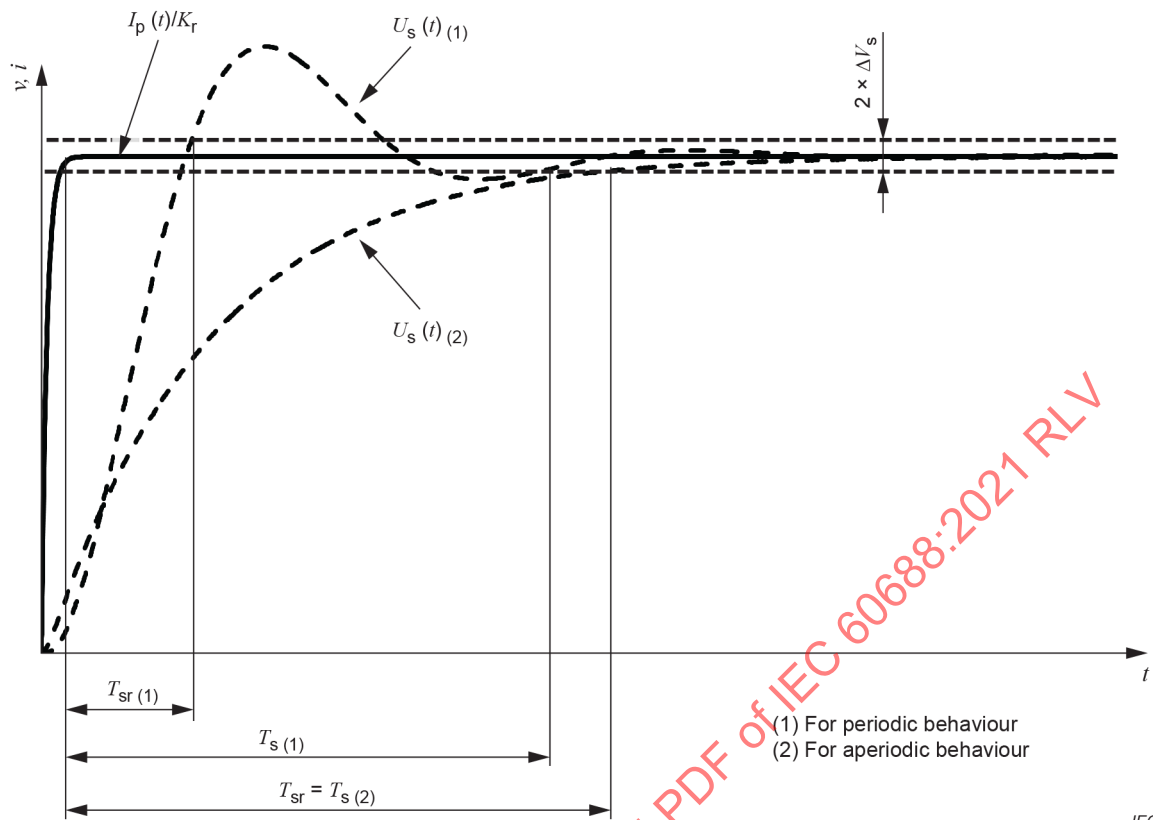
The test shall be performed with input current of positive and negative polarity. A test current value equal to the rated current shall be used.

A step current will be applied and both input current and output signal will be recorded simultaneously.

The tolerance limit ΔV_S is defined as 5 % of the steady-state value of the output signal V_∞ .

NOTE A reduced tolerance limit can be defined by agreement between the purchaser and the manufacturer.

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$I_{p(1)}$	input current for periodic behaviour
$I_{p(2)}$	input current for aperiodic behaviour
$U_{s(1)}$	output signal of test object for periodic behaviour
$U_{s(2)}$	output signal of test object for aperiodic behaviour
$T_{sr(1)}$	measured step response time for periodic behaviour
$T_{sr(2)}$	measured step response time for aperiodic behaviour
$T_s(1)$	settling time for periodic behaviour
$T_s(2)$	settling time for aperiodic behaviour

Figure A.3 – Measurement of the step response time

In case of difficulties to generate the input signal with the specified rise time, the test procedure may be adapted as follows.

- Inject an equivalent sensor signal on the input of the input converter. The supplier shall supply necessary information for the calculation of the step response time at the input level.
- For some technologies, instead of applying the input current on the input terminals, an auxiliary test circuit may be used to supply a corresponding test current. The supplier shall supply information for the calculation of the step response time at the input level.

Test results: see A.7.1.6.6.3.

A.7.1.6.6.2 Test setup for TRD2 measuring DC voltages

The input test voltage should be the rated input voltage and represents an impulse voltage characteristic with an accuracy of $\pm 3\%$. The step voltage can be generated by an impulse voltage generator. In case of difficulties in generating the input signal with the specified rise time, the test procedure may be adapted, using a reduced input voltage signal, provided that the linearity of the system is proven, and the output signal level permits an accurate measurement (see Figure A.3).

The front time corresponds to the definitions of lightning impulse definition with a front time of $1,2\ \mu\text{s}$, with a relative tolerance of $\pm 30\%$.

The time to half value corresponds to the definitions of switching impulse definition with a time to half value of $2\ 500\ \mu\text{s}$, with a relative tolerance of $\pm 60\%$.

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

The input voltage is measured with a reference divider. The output of the reference divider and the output voltage of the transducer is measured with a transient recorder (see Figure A.3).

The tolerance limit ΔV_S is defined as 5% of the steady-state value of the output signal V_∞ .

NOTE A reduced tolerance limit can be defined by agreement between the purchaser and the manufacturer.

Test results: see A.7.1.6.6.3.

A.7.1.6.6.3 Test results

The TRD2 is considered to have passed the test if

- the measured step response time T_{sr} is lower than the rated value, and
- the settling time is less than $10 \times T_{sr}$.

A.7.1.6.7 Temperature cycle accuracy test

This test is intended to show compliance with the accuracy requirements under rated conditions the rated temperature categories is given in Table A.3.

If it can be proven with general engineering practices that the transducer under its normal conditions according to Clause A.4 and for its declared ratings will remain within its accuracy limits over its complete temperature range, this test may not to be performed.

The temperature rise test of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016, 10.4, shall be performed prior to this test. From the temperature rise test, the thermal time constant (τ) and the temperature rise (ΔT) shall be determined at the rated continuous thermal current for TRD2 measuring currents or, for TRD2 measuring voltages, at the rated voltage factor multiplied by the rated input voltage. Temperature rises may be negligible for some technologies. Thus, temperature rise tests may not be conducted for those transducers.

The temperature cycle accuracy test shall be performed under the following conditions:

- at rated frequency;
- at rated burden (external burdens may be kept outside the chamber);
- active electronic components and the transmitting system may be exposed in the same chamber or, to their specified minimum and maximum operating ambient temperature if different from the temperatures of the transducer. Other components such as auxiliary power supply may be kept at room temperature.

TRD2 are subjected to a temperature cycle in accordance with Figure A.4.

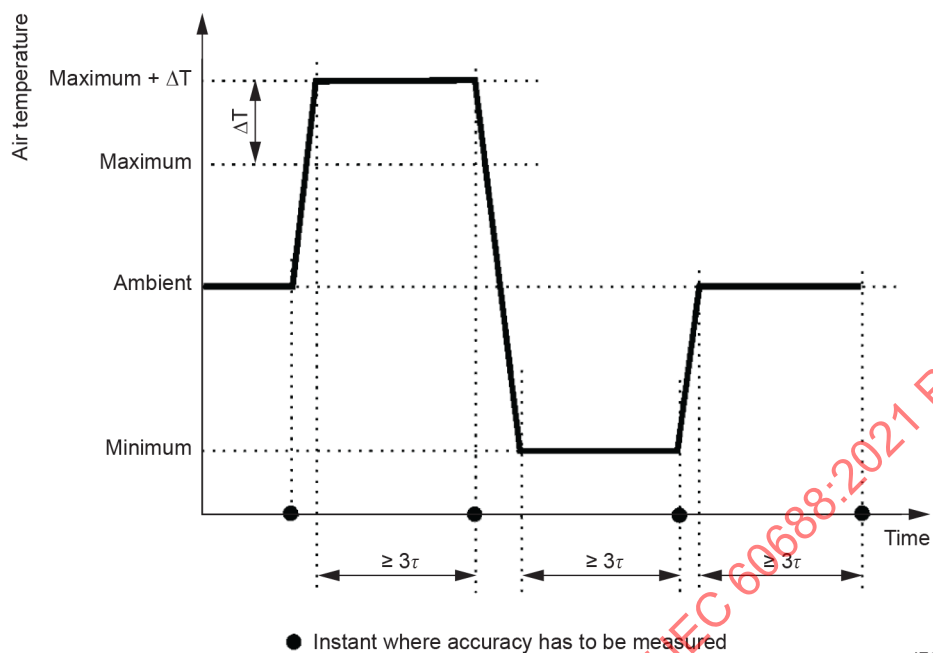


Figure A.4 – Temperature cycle accuracy test

The ambient air temperature at the start and at the end of the test shall be between 10 °C and 30 °C.

The minimum and maximum air temperatures correspond to the specified minimum and maximum operating ambient temperatures.

The acclimatization before the accuracy test for maximum ambient temperature shall be performed with the air temperature equal to the maximum operating ambient temperature increased by the established temperature rise ΔT .

The test is performed without input signal. When a input signal is required for powering the transducer or its associated equipment, the input may be energized.

The temperature variation part of the test is when the air temperature in the climate chamber is changed; this can be either a positive or a negative change. The minimum temperature variation rate is 20 K/h. Condensation shall be avoided. The temperature variation rate shall preferably be noted in the report.

After each temperature variation, the transducer shall enter a stabilizing period with a duration of at least three times the thermal time constant τ .

At the end of each stabilizing period, the accuracy of the transducer shall be measured. After the stabilizing period, measures shall be taken to avoid cooling or heating other than caused by the accuracy measurement itself.

Measured values at every point of the test shall be within the limits of the specified accuracy class. The accuracy measurement at the start of the temperature cycle may be omitted if the accuracy at ambient temperature is known from previous tests.

For TRD2 with multiple rated frequencies, accuracy class measurements may be done at one rated frequency only.

A.7.1.7 Verification of markings and documentation

Conformity of markings and documentation is checked by inspection. Legibility of markings is checked by the tests defined in IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016.

A.7.1.8 Short-time currents tests

A.7.1.8.1 General

The following tests apply as far as possible depending on the kind of device under test and its technology. Thus, if the tests described in this clause cannot be applied, manufacturers should reference in their documentation the product standard used for the tests.

However, short time current tests may not apply to some specific technologies.

A.7.1.8.2 For TRD2 measuring AC currents

The thermal test shall be made at a current I' for a time t' , so that:

$$I'^2 \times t' \geq I_{th}^2 \times t$$

where

t is the specified duration of the short-time thermal current;

t' shall have a value between 0,5 s and 5 s.

The dynamic test shall be made with an input current the peak value of which is not less than the rated dynamic current (I_{dyn}) for at least one peak.

The dynamic test may be combined with the thermal test above, provided the first major peak current of that test is not less than the rated dynamic current (I_{dyn}).

For TRD2 with mA output, the tests shall be made with the output circuit(s) short-circuited.

For TRD2 with mV output, the output terminals shall be left open or connected to the rated burden.

A.7.1.8.3 For TRD2 measuring DC currents

Tests should be applied as stated in A.7.1.8.2 but with a single test at a value of test current as declared by the manufacturer. The value of the test current should be at least equal to either

- ten times the rated current, or
- five times the rated current multiplied by K_{epcr} .

If there is no limitation of use of transducer, then above limit of time applies. If the use is limited to specific applications, then the time limit can be reduced according to manufacturer specification.

A.7.1.8.4 Test results

The device is deemed to have passed these tests if, after cooling to ambient temperature, it satisfies the following requirements:

- it is not visibly damaged;
- its errors after demagnetization do not differ from those recorded before the tests by more than half the limits of error appropriate to its accuracy class;

- it withstands the dielectric tests specified in IEC 61010-1:2010 but with test voltages reduced to 90 % of those given;
- examination of the insulation next to the surfaces of the conductors does not show significant deterioration (e.g. carbonization).

The examination is not required if the current density in the input and output circuits, corresponding to the rated short-time thermal current (I_{th}), does not exceed

- 180 A/mm² where the circuit is of copper of conductivity not less than 97 % of the value given in IEC 60028, or
- 120 A/mm² where the circuit is of aluminium of conductivity not less than 97 % of the value given in IEC 60121.

A.7.1.9 Inter-turn overvoltage tests

Tests shall be performed at the full circuit in accordance with one of the following procedures A or B.

NOTE 1 Due to the test procedure, the wave shape can be highly distorted.

NOTE 2 Tests can result in voltage values lower than specified in A.6.7.

- **Procedure A**

With the output circuit open-circuited (or connected to a high impedance device which reads peak voltage), a substantially sinusoidal current at some suitable test frequency between rated frequency and 400 Hz and of RMS value equal to the rated input current (or rated extended input current if specified) shall be applied for 60 s to the input circuit.

Test results:

- The applied current shall be limited if the test voltage for inter-turn insulation is obtained before reaching the rated input current (or rated extended input current).
- If the test voltage for inter-turn insulation is not reached at maximum input current, the obtained voltage shall be regarded as the test voltage.

- **Procedure B**

With the input circuit open-circuited, the test voltage for inter-turn insulation (at some suitable test frequency) shall be applied for 60 s to the terminals of each output circuit.

Test results:

- The RMS value of the output current shall not exceed the rated output current (or the appropriate extended value if specified).
- If the test voltage for inter-turn insulation is not reached at maximum output current and maximum test frequency, the obtained voltage shall be regarded as the test voltage.

The inter-turn overvoltage test is not a test carried out to verify the suitability of a transducer to operate with the output circuit open-circuited. Transducers should not be operated with the output circuit open-circuited because of the potentially dangerous overvoltage and overheating which can occur.

A.7.1.10 Anti-aliasing tests

This test addresses anti-aliasing requirements defined in Annex C, when applicable.

The attenuation is calculated, and above limits are checked. Where agreed to by the user and manufacturer, injection may be into the output converter.

The magnitude of the input signal shall be at least 1 % of the rated input signal.

NOTE Due to the fact that aliasing occurs, the input signal and the output signal do not have the same frequencies. Therefore, test arrangements using bridge configurations cannot be used. The easiest way to do the test is to calculate or measure the RMS values for input and output separately using a digital system or a simple multi-meter for analogue systems.

Test results: see Annex C.

A.7.1.11 Test with harmonics and at low frequencies

This test addresses requirements for the measurement of harmonics and low frequencies defined in Annex D when applicable.

In an ideal case, tests on harmonics should be made with the rated input signal at the rated frequency plus a percentage of the rated input signal at each considered harmonic frequency. Such an input signal should provide a realistic image of the dynamic requirements on the transducer and will yield a good image of some non-linear phenomena which can happen in the transducer (intermodulation, for example).

However, it can be difficult to achieve a test circuit which generates such a input input signal. For practical considerations, it is accepted that the accuracy tests be made with only one single harmonic frequency applied at the input side for each measurement.

Frequency response requirements defined in Table E.1 are very important for achieving device interoperability. Verification of these requirements may, however, be quite difficult and requires intimate knowledge of physical properties and limitations of the tested device's technology. Frequency response testing shall fulfil the harmonics requirement described in Table E.1.

The use of a suitable test setup is required.

Transducers susceptible to saturation cannot in general be tested at low frequencies using full voltage/current levels. For these devices, measurements at frequencies below the nominal system frequency should be performed with test signal magnitude reduced in inverse proportion with the frequency:

$$I_{\text{test}} = I_{\text{pr}} \times \frac{f_{\text{test}}}{f_r}$$

To avoid measurement circuit clipping, testing of transducers with output signals increasing with frequency should be performed with test signal magnitude reduced in proportion with the frequency

$$I_{\text{test}} = I_{\text{pr}} \times \frac{f_r}{f_{\text{test}}}$$

In case of difficulties or limitations of the laboratory capabilities, it is also accepted to reduce the input test current of TRD2 measuring current to a value not lower than 10 % of the rated value or 10 A, whichever is greater.

Test results: see Annex D.

A.7.2 Routine tests

A.7.2.1 General

Routine tests shall be conducted on 100 % of manufactured TRD2.

Except otherwise specified, TRD2 may be in any position for routine tests as long it does not influence the test results.

Except otherwise specified, accessories and other optional parts may be omitted for routine tests as long it does not influence the test results.

A.7.2.2 Accuracy tests

Accuracy of TRD2 shall be verified in order to verify that the TRD2 complies with its assigned accuracy class. Conformity is checked by any relevant means, under the responsibility of the manufacturer.

Routine test is performed at room temperature at routine test location and at rated frequency only.

A.7.2.3 Verification of markings

It shall be verified that the markings are clearly readable. Conformity is checked by inspection.

A.7.2.4 Safety tests

TRD2 class F shall comply with Annex F of IEC 61010-1:2010.

A.7.2.5 Inter-turn overvoltage tests

No requirements.

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Annex B (normative)

Interface coding

B.1 General

Annex B provides a way to specify an interface coding, aiming at facilitating the selection of transducers compatible with the equipment interface.

This interface coding includes

- the characteristics of connection between the output of transducers and the instrument,
- the rated output value at the output of the transducer,
- the rated power supply at the output of the transducer, in case an auxiliary power supply is supplied from a standardized connector, and
- the rated transfer curve.

This interface coding shall be described in the manufacturer technical literature, in order to ease the selection of the relevant transducer by the customer before ordering.

This interface code is not supposed to be marked on the transducer name plate, because this name plate is visible by the customer once the transducer has been delivered, that is too late.

B.2 Characteristics of interface connection

Table B.1 provides options for connections, either through wires or through a standardised connector.

Table B.1 – Coding of interface connection

Connector specification	Code letter
RJ45 with pinout as specified in A.6.6.2	R
Wires	W
Terminal for wires	T
Special connectors	S
NOTE 1 Soldered terminals on PCB is an example of special connector.	
NOTE 2 Screw/screwless terminals or spring terminals are examples of wired terminal for wires.	

B.3 Coding of rated output values for transducers

Table B.2, Table B.3, Table B.4, Table B.5, Table B.6, Table B.7 and Table B.8 provide lists of rated values to be used for TRD2, and that may be used for TRD1 if relevant.

Table B.2 – Rated AC RMS voltage output

Kind of output	Rated output value	Code letter ^a	Applicable for	
			TRD1	TRD2
AC voltage output	22,5 mV AC RMS	U1		X
	100 mV AC RMS	U2		X
	150 mV AC RMS	U3		X
	225 mV AC RMS	U4		X
	333 mV AC RMS	U5		X
	1V AC RMS	U6		X
	112,5mV AC RMS	U7		X
	Special value	Ux		X
^a In case the output depends on other items (e.g. configuration, position of transducer, frequency or phase of AC input signal) than the input level, then the curve shall be noted "dU" instead of "U" or "dx" instead of "x"				

Table B.3 – Rated DC voltage output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
DC voltage output	1,66 V DC	U8		X
	3 V DC	U9		X
	4 V DC	U10		X
	5 V DC	U11		X
	Special value	Ux		X

Table B.4 – Rated range of DC voltage output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
Range of DC voltage output	0 V to 1 V DC	U21	X	
	0 V to 10 V DC	U22	X	
	–1 V to 1 V DC	U23	X	
	–10 V to 10 V DC	U24	X	
	Special value	Ux		

Table B.5 – Rated AC RMS current output less than 1A

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
AC current output (less than 1 A)	20 mA AC RMS	I1		X
	50 mA AC RMS	I2		X
	100 mA AC RMS	I3		X
	Special value	Ix		X

Table B.6 – Rated range of DC current output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
Range of DC current output	4 mA to 20 mA DC	I21	X	
	0 mA to 20 mA DC	I22	X	
	0 mA to 1 mA DC	I23	X	
	0 mA to 10 mA DC	I24	X	
	–1 mA to 1 mA DC	I25	X	
	–5 mA to 5 mA DC	I26	X	
	–10 mA to 10 mA DC	I27	X	
	–20 mA to 20 mA DC	I28	X	X
	–50 mA to 50 mA DC	I29		X
	–100 mA to 100 mA DC	I30		X
	–200 mA to 200 mA DC	I31		X
	–500 mA to 500 mA DC	I32		X
	Special value	Ix		X

Table B.7 – Rated frequency output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
Range of frequency output proportional to the input quantity	0 to 20 kHz	F1		X
	Special value	Fx		X

Table B.8 – Rated pulse density output

Kind of output	Rated output value	Code letter	Applicable for	
			TRD1	TRD2
Pulse density output proportional to the input quantity	10 MHz	P1		X
	20 MHz	P2		X
	Special value	Px		X

B.4 Coding of auxiliary power supply for transducers

Table B.9 provides possible options for power supplies for transducers supplied from measuring instrument via the connector.

Table B.10 provides possible options for external power supplies for transducers.

Table B.9 – Coding of power supply for transducers supplied from measuring instrument via the connector

Power supply characteristics	Voltage	Code letter
Power supply when provided by the measuring equipment connected to the transducer output via the connector	No need	(blank)
	3,3 V DC	PS1
	5 V DC	PS2
	12 V DC	PS3
	24 V DC	PS4
	48 V DC	PS5
	Special voltage or range of voltage	PSx

Table B.10 – Coding of external power supply for transducers

External power supply characteristics	Voltage	Code letter
Power supplied by external power supply	3,3 V DC	EPS1
	5 V DC	EPS2
	12 V DC	EPS3
	24 V DC	EPS4
	48 V DC	EPS5
	±15V DC	EPS6
	±24V DC	EPS7
	110V AC	EPS8
	230 V AC	EPS9
	Special voltage or range of voltage	EPSx

B.5 Coding of transfer function curves for transducers

Table B.11 provides coding for transfer function curves, if applicable.

Table B.11 – Coding of transfer function curves for transducers

Transfer function curve	Code letter
Transfer function curve A, as defined in Figure 2	A
Transfer function curve B, as defined in Figure 3	B
Transfer function curve C, as defined in Figure 4	C
Transfer function curve D, as defined in Figure 5	D
Transfer function curve E, as defined in Figure 6	E
Transfer function curve F, as defined in 5.8	F

B.6 Interface full coding for output of transducers**B.6.1 General**

Table B.12 provides the full coding of the output of transducers.

Table B.12 – Interface full coding for output of transducers

Coding of connectors for the output of transducers	Coding of rated output values	Blank	Coding of auxiliary power supply	Blank	Coding of transfer function curve
Code according to Table B.1	Code according to Table B.2 to Table B.8		Code according to Table B.9 or to Table B.10, if relevant		Optional code according to Table B.11, if relevant

B.6.2 Examples of interface codes and most common interface codes

Table B.13 provides a list of examples, and the most common interface codes for transducers.

Table B.13 – Examples of interface codes and most common interface codes

Kind of transducers	Interface code	Meaning of the interface code	Most common
Transducers delivering an AC RMS voltage output	WU2	Transducer with wires connection, 100 mV AC rated voltage output	
	WU3	Transducer with wires connection, 150 mV AC rated voltage output	
	TU3	Transducer with terminal block connection, 150 mV AC rated voltage output	
	WU5	Transducer with wires connection, 333 mV AC rated voltage output	x
	TU5	Transducer with terminal block, 333 mV AC rated voltage output	x
	WU6	Transducer with wires connection, 1 V AC rated voltage output	
	RU1	Transducer with RJ45 standardised connector, 22,5 mV AC rated voltage output	
	RU7	Transducer with RJ45 standardised connector, 112,5 mV AC rated voltage output	x
	RU5	Transducer with RJ45 standardised connector, 333 mV AC rated voltage output	x
	RdU3	Transducer with RJ45 standardised connector, 150 mV AC rated voltage output depending on other items than the input level	x
	RU4	Transducer with RJ45 standardised connector, 225 mV AC rated voltage output	x
	SU2	Transducer with special connector, 100 mV AC rated voltage output	
	SdU2	Transducer with special connector, 100 mV AC rated voltage output depending on other items than the input level	
	SU5	Transducer with special connector, 333 mV AC rated voltage output	
	Sx	Transducer with special connector, special analog output	
	Sdx	Transducer with special connector, special analog output depending on other items than the input level	
Transducers delivering a DC voltage output	WU8	Transducer with wires connection, 1,66 V rated voltage output	
	WU9	Transducer with wires connection, 3 V DC rated voltage output	
	WU10	Transducer with wires connection, 4 V DC rated voltage output	
	WU11	Transducer with wires connection, 5 V DC rated voltage output	
	RU11	Transducer with RJ45 connection, 5 V DC rated voltage output	x
	SU10	Transducer with special connector, 4V DC analog output	
	Sx	Transducer with special connector, special analog output	

Kind of transducers	Interface code	Meaning of the interface code	Most common
Transducers delivering a DC range of voltage output	WU21	Transducer with wires connection, 0 V DC to 1 V DC rated voltage output	
	WU22	Transducer with wires connection, 0 V DC to 10 V DC rated voltage output	
	WU23	Transducer with wires connection, –1 V DC to 1 V DC rated voltage output	
	WU24	Transducer with wires connection, –10 V DC to 10 V DC rated voltage output	
	Sx	Transducer with special connector, special analog output	
Transducers delivering an AC current output	WI1	Transducer with wires, 20 mA DC rated current output	
	WI2	Transducer with wires, 50 mA DC rated current output	
	WI3	Transducer with wires, 100 mA DC rated current output	x
	Sx	Transducer with special connector, special analog output	
Transducers delivering an AC range of current output	WI21	Transducer with wires, 4 mA DC to 20 mA DC rated current output	x
	WI22	Transducer with wires, 0 mA DC to 20 mA DC rated current output	
	WI23	Transducer with wires, 0 mA DC to 1 mA DC rated current output	
	WI24	Transducer with wires, 0 to 10 mA DC rated current output	
	WI25	Transducer with wires, –1 mA DC to 1 mA DC rated current output	
	WI26	Transducer with wires, –10 mA DC to 10 mA DC rated current output	
	WI27	Transducer with wires, –20 mA DC to 20 mA DC rated current output	
	WI28	Transducer with wires, –50 mA DC to 50 mA DC rated current output	
	WI29	Transducer with wires, –100 mA DC to 100 mA DC rated current output	
	WI30	Transducer with wires, –200 mA DC to 200 mA DC rated current output	
	WI21	Transducer with wires, –500 mA DC to 500 mA DC rated current output	
Range of frequency output	WF1	Transducer with wires, 0 kHz to 20 kHz rated range of frequency	
Pulse density output	WP1	Transducer with wires, 10 MHz pulse output	
	WP2	Transducer with wires, 20 MHz pulse output	

Annex C (Informative)

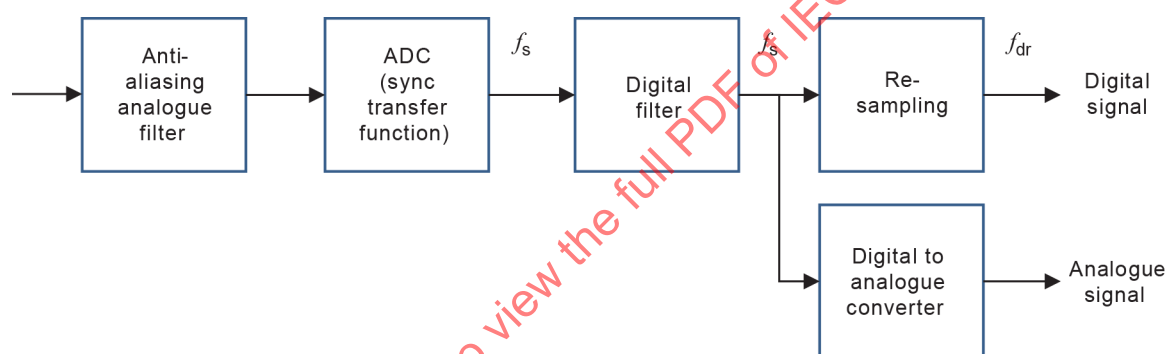
Anti-aliasing requirements

The requirements in Annex C are applicable to transducers with embedded digital data processing or transmission.

Digital and discrete time data processing limits the bandwidth to half the digital sampling rate f_s . If different sampling rates along the signal processing path are used, the lowest rate is the limiting factor. For transducers with digital output, the lowest rate is usually the output sampling rate. Frequencies above $f_s / 2$ are mirrored to frequencies below $f_s / 2$. From the point of view of accuracy, the most critical frequencies are those mapped on to the power system frequency f_r . The first frequency which is mapped on f_r is

$$f_s - f_r$$

Figure C.1 shows an example of a digital data acquisition system.



IEC

Key

f_s ADC sampling rate

f_{dr} digital signal data rate rate

Figure C.1 – Digital data acquisition system example

If f_s is greater than f_{dr} , the maximum signal bandwidth is equal to $f_{dr} / 2$; otherwise, the maximum signal bandwidth is equal to $f_s / 2$.

Hence, a so-called anti-aliasing filter shall be used. Minimum anti-aliasing filter attenuation requirements are specified, as a function of the transducer accuracy class, in Table C.1.

Table C.1 – Anti-aliasing filter

Accuracy class	Anti-aliasing filter attenuation ($f \geq f_s - f_r$)
0,1	≥ 34 dB
0,2	≥ 28 dB
0,5	≥ 20 dB
1	≥ 20 dB
Other classes	≥ 20 dB

Attenuation, expressed in decibels (dB), is calculated according to the following formula (for voltage transducer, replace current I by voltage U):

$$\alpha = 20 \log_{10} \frac{I_p \times Y_{sr}}{Y_s \times I_{pr}} \text{ (dB)}$$

where

α is the attenuation

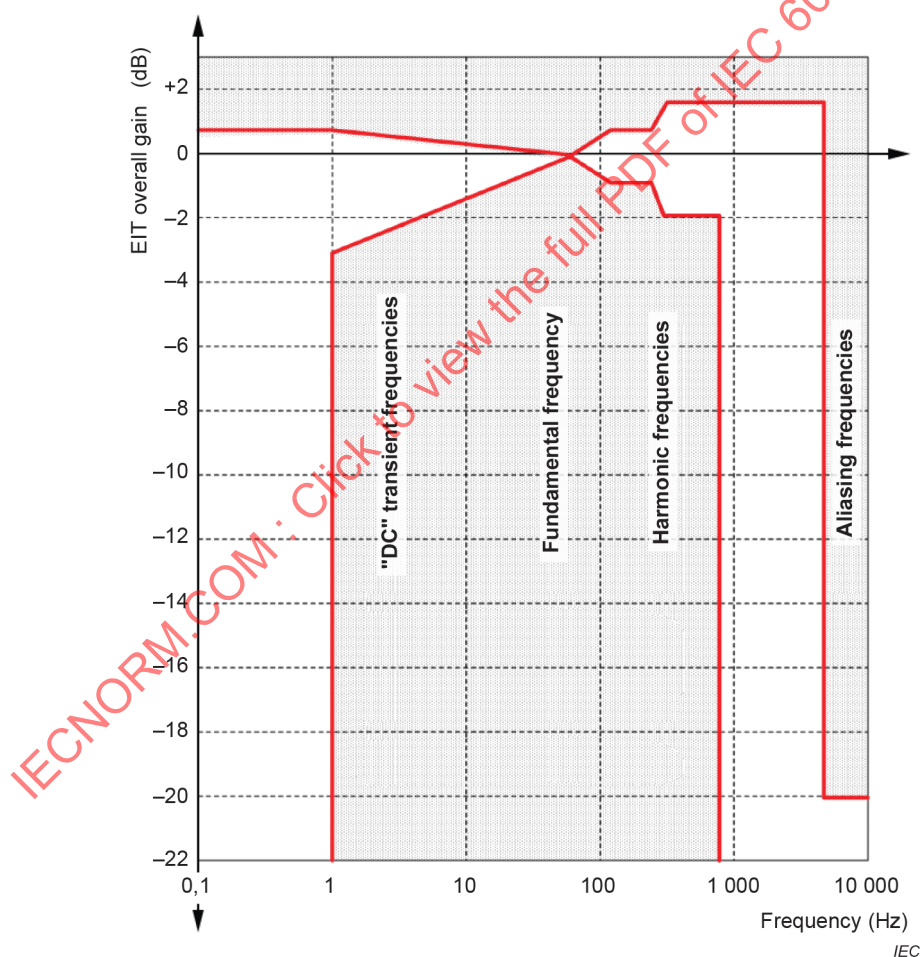
I_p is the RMS value of the input current at frequency f , with $f \geq f_s - f_r$;

Y_s is the RMS value of the output signal at the mirrored frequency, that is, at $f_s - f_r$;

I_{pr} is the rated input current;

Y_{sr} is the rated output signal.

Figure C.2 illustrates an example of harmonic and anti-aliasing frequency response magnitude requirements for metering accuracy class 1, where $f_r = 60$ Hz and $f_s = 4\,800$ Hz.



Key

 Prohibited region for response

Figure C.2 – Frequency response mask for metering accuracy class 1
($f_r = 60$ Hz, $f_s = 4\,800$ Hz)

Annex D (informative)

Requirements for the measurement of harmonics and low frequencies

D.1 General

Annex D may become normative in a future edition.

Due to the use of specific devices (non-linear loads, railway) harmonics can be generated on the network. The amount of harmonics depends on the network and the voltage level.

Harmonics are of interest for monitoring applications, because they may have an impact on all the electrical quantities. Such applications include basic energy management, power metering and monitoring, and power quality monitoring, which require the performance on harmonic measurement to be quantified. Specific accuracy requirements for each class are given in Clause D.2 and Clause D.3.

If harmonics measurement and low frequencies performance is declared by the manufacturer, the requirements for accuracy with harmonics in the next subclauses are applicable as needed.

D.2 Measuring accuracy classes with harmonics

Table D.1 gives the limit of errors on the magnitude and phase (as applicable) for the measuring classes.

Table D.1 – Limits of error for harmonics – Accuracy classes

Accuracy class (at f_r)	Error limit at low frequency		Error limit at harmonics of f_r					Phase error limit at low frequency	Phase error limit at harmonics of f_r			
	%		%					Degrees	Degrees			
	DC ^a	1 Hz	2 nd to 4 th	5 th and 6 th	7 th to 9 th	10 th to 13 th	Above 13 th	1 Hz	2 nd to 4 th	5 th and 6 th	7 th to 9 th	10 th to 13 th
0,1	+1 –100	+1 –30	±1	±2	±4	±8	+8 –100	±45	±1	±2	±4	±8
0,2 and 0,2 S	+2 –100	+2 –30	±2	±4	±8	±16	+16 –100	±45	±2	±4	±8	±16
0,5 and 0,5 S	+5 –100	+5 –30	±5	±10	±20	±20	+20 –100	±45	±5	±10	±20	±20
1	+10 –100	+10 –30	±10	±20	±20	±20	+20 –100	±45	±10	±20	±20	±20
3 and 5	–	–	–	–	–	–	–	–	–	–	–	–

^a –100 % means DC coupling is possible but not required.

The transition between points defined in the above table shall be a straight line when shown in log/log scale.

D.3 Accuracy class extensions of transducers for high bandwidth applications

According to EN 50160 and IEC 61000-4-7, for such purposes, harmonics up to the 40th order (in some cases even to the 50th order) are measured. IEC 61000-4-7 specifies that the relative error (related to the measured value) shall not exceed 5 %.

These extensions can be applied to all accuracy classes to indicate better performances at high frequencies. This performance is indicated by a wide bandwidth (WB) accuracy class extension.

The limits of accuracy for high bandwidth applications are given in Table D.2.

Table D.2 – Limits of error for harmonics – Accuracy class extensions WB1 and WB2

Accuracy classes	Error limits at frequencies shown below			Phase error limits at frequencies shown below		
	±%			± Degrees		
WB1	$0,1 \leq f < 1 \text{ kHz}$	$1 \leq f < 1,5 \text{ kHz}$	$1,5 \leq f < 3 \text{ kHz}$	$0,1 \leq f < 1 \text{ kHz}$	$1 \leq f < 1,5 \text{ kHz}$	$1,5 \leq f < 3 \text{ kHz}$
WB2	$0,1 \leq f < 5 \text{ kHz}$	$5 \leq f < 10 \text{ kHz}$	$10 \leq f < 20 \text{ kHz}$	$0,1 \leq f < 5 \text{ kHz}$	$5 \leq f < 10 \text{ kHz}$	$10 \leq f < 20 \text{ kHz}$
0,1	1	2	5	1	2	5
0,2 and 0,2S	2	4	5	2	4	5
0,5 and 0,5S	5	10	10	5	10	20
1	10	20	20	10	20	20
For DC applications, the phase errors are not applicable.						

The above limits of Table D.2 apply equally to both TRD2 measuring current and TRD2 measuring voltage.

The accuracy classes 0,2S and 0,5S apply only to TRD2 measuring current.

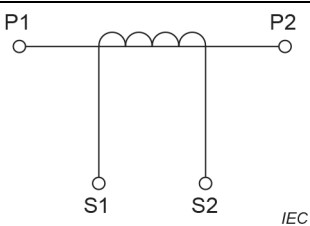
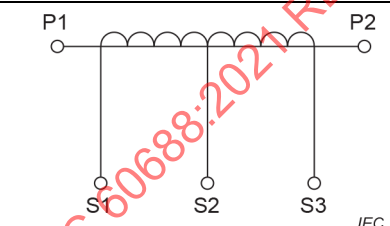
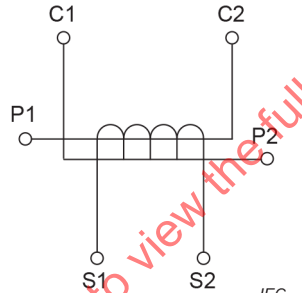
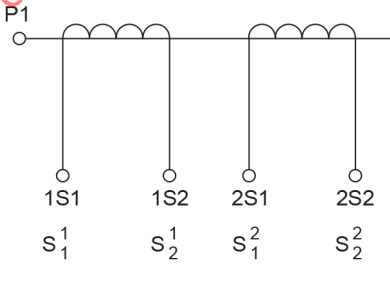
Annex E (normative)

Markings terminals of TRD2

E.1 Marking of terminals for TRD2 monitoring AC current

The markings of TRD2 monitoring AC current shall follow the principles illustrated in the examples in Table E.1.

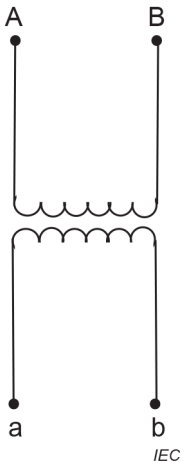
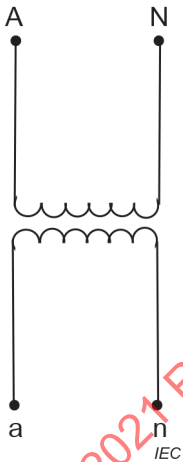
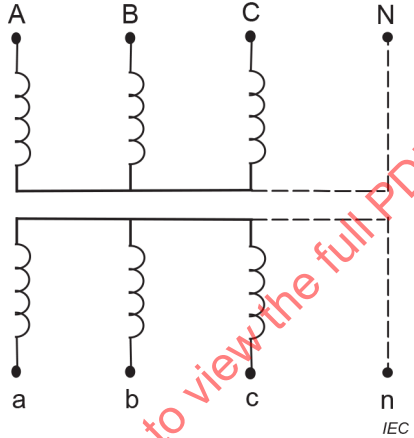
Table E.1 – Marking of terminals for TRD2 monitoring current

Input terminals		
Output terminals	Single-ratio TRD2	TRD2 with an intermediate tapping on output circuit
Input terminals		
Output terminals	TRD2 with input circuit in 2 sections intended for connections either in series or in parallel	TRD2 with 2 output circuits; each with its own magnetic core (two alternative markings for the output terminals)
NOTE For TRD2 using curve F _p , S can be replaced by T.		

E.2 Marking of terminals for TRD2 monitoring voltage

The markings of TRD2 monitoring AC voltage shall follow the principles illustrated in the examples in Table E.2.

Table E.2 – Marking of terminals for TRD2 monitoring voltage

Input terminals	 Single-phase TRD2 with a single output LL	 Single-phase TRD2 with a single output LN
Input terminals	 Three-phase assembly TRD2 with a single output 3L-N	
Output terminals		

Annex F (informative)

Guidance related to cables, busbars and bare conductors within an installation

F.1 Insulation of cables

Cables used in cabinets, panels and cubicles are supposed to provide a basic insulation at the working voltage specified for this cable.

A bushing can provide a supplementary insulation, provided this bushing is specified for at least the same working voltage as for the cable or the same working voltage of the system.

Under some conditions (see installation rules), a cable may be considered to provide a reinforced insulation.

Busbars and bare conductors do not provide any insulation. A bushing can provide a "basic insulation" provided this bushing is specified for at least the same working voltage as for the busbar or the same working voltage of the system.

Under some conditions (see installation rules), a bushing may be considered to provide a reinforced insulation.

Means to avoid contact with cable, busbars or bare conductor (e.g. integral means to avoid contact with cable or busbar) are not supposed to provide any additional insulation to the one provided by bushing, the insulation of cable and insulation of TRD2.

F.2 Temperature of cables and busbars

F.2.1 Cables

According to Table 6 of IEC 61439-1:2020, the maximum temperature-rise limits on terminals for external insulated conductors, for a daily average ambient air temperature up to 35 °C under service conditions, is 70 K.

Therefore, maximum permissible total daily average temperature of cable terminals is 105 °C (35 °C + 70 K).

Considering the usual decrease of cable temperature from terminal, 90 °C can be considered as a common value. This covers copper and aluminium cables.

F.2.2 Busbars

According to Table 6 of IEC 61439-1:2020, the maximum temperature-rise limits on copper busbar, for a daily average ambient air temperature up to 35 °C under service conditions, is 105 K.

Therefore, maximum permissible total daily average temperature of busbar terminals is 140 °C (35 °C + 105 K).

Considering the usual decrease of busbar temperature from terminal, 105 °C can be considered as a common value. This covers copper busbar and also aluminium busbar having lower permissible temperature.

Annex G (informative)

Guidance related to overvoltage categories and measurement categories

G.1 Concept of overvoltage category

The concept of overvoltage categories is defined in 4.3.2 of IEC 60664-1:2020, or IEC 60364-4-44 or IEC 61010-1:2010.

G.2 Approach of IEC 60664-1 for primary circuits of TRD2

G.2.1 General

IEC 60664-1 uses the concept of overvoltage categories (OVC).

G.2.2 Examples with IEC 60664-1:2020, for primary measuring circuits, OVC III, PD 2, altitude under 2 000 m, inhomogeneous field

Two examples are considered below:

- example 1 = 230/400 V network, material group II;
- example 2 = 400/690 V network, material group I.

Table G.1 and Table G.2 show clearances and creepage distances, respectively, according to IEC 60664-4.

Table G.1 – Clearances according to IEC 60664-1:2020

Distribution system (LN/LL) V AC	Reference voltage for clearances V	Basic insulation		Reinforced insulation	
		U_{imp}^a kV	Clearance ^b mm	U_{imp}^c kV	Clearance ^b mm
230/400	300	4	3	6	5,5
400/690	600	6	5,5	8	8
NOTE Clearances according to Table F.2 of IEC 60664-1:2020 can be reduced under some circumstances, see IEC 60664-1:2020. However, values of impulse tests cannot be reduced. ^a According to Table F.1 of IEC 60664-1:2020. ^b According to Table F.2 of IEC 60664-1:2020. ^c For reinforced insulation, values are defined one step higher in the preferred list of values in 4.2.2.1 of IEC 60664-1:2020 (see 5.2.3.1 of IEC 60664-1:2020).					

Table G.2 – Creepage distances according to IEC 60664-1:2020

Distribution system (LN/LL) V AC	Voltage rationalized for insulation line to line ^a V	Material Group	Basic insulation	Reinforced insulation
			Creepage distance ^b mm	Creepage distance ^c mm
230/400	400	II	2,8	5,6
400/690	630	I	3,2	6,4

NOTE See 5.3.2.5 of IEC 60664-1:2020 for the relationship of creepage distance to clearance.

^a According to Table F.4 (rationalized voltages) of IEC 60664-1:2020.

^b According to Table F.5 of IEC 60664-1:2020.

^c For reinforced insulation, creepage distance are twice the creepage distance for basic insulation, see 5.3.5 of IEC 60664-1:2020.

G.3 Approach of IEC 61010 for primary circuits of TRD2

G.3.1 General

IEC 61010-1 is the generic standard for safety requirements for electrical equipment for measurement, control, and laboratory use that refers to IEC 61010-2-030 for circuits dedicated to testing or measuring purposes.

IEC 61010-2-030 has introduced a concept of measurement categories (MC, named as CAT II, CAT III, and CAT IV) that replaces the concept of overvoltage categories.

IEC 61010-2-030 applies to testing and measuring circuits.

G.3.2 Example with IEC 61010-2-030:2017, for primary measuring circuits, OVC III, PD 2, altitude under 2 000 m, inhomogeneous field

Two examples are considered below:

- Example 1 = 230/400 V network, material group II,
- Example 2 = 400/690 V network, material group I.

Table G.3 and Table G.4 show clearances and creepage distances, respectively, according to IEC 61010-2-030:2017.

Table G.3 – Clearances according to IEC 61010-2-030:2017

Distribution system (LN/LL) V AC	Reference voltage for clearances V	Basic insulation		Reinforced insulation	
		U_{imp}^a kV	Clearance ^b mm	U_{test}^c kV	Clearance ^b mm
230/400	300	4	3	6,40	5,9
400/690	600	6	5,5	9,50	10,5

NOTE Clearances according to K.101 of IEC 61010-2-030:2017 can be reduced under some circumstances, see IEC 61010 series.

^a According to Table K.16 of IEC 61010-1:2010

^b According to Table K.101 of IEC 61010-2-030:2017.

^c According Table K.16 of IEC 61010-1:2010.

Table G.4 – Creepage distances according to IEC 61010-2-030:2017

Distribution system (LN/LL) V AC	Voltage rationalized for insulation <u>line to line</u> V	Material Group	Basic insulation	Reinforced insulation
			Creepage distance ^a mm	Creepage distance ^b mm
230/400	400	II	2,8	5,6
400/690	690	I	3,5	7,0

^a According to Table K.13 of IEC 61010-1:2010.

^b For reinforced insulation, creepage distance are twice the creepage distance for basic insulation, see IEC 61010-1:2010.

G.4 Approach for secondary circuits of TRD2

Propagation of overvoltage is linked to the "coupling power capability" between primary circuit and secondary circuit. This coupling capability is usually limited for TRD2.

For TRD2 having a current measurement input, the coupling power capability is deemed to be low. Therefore, very low values of transient overvoltages can be expected on the secondary circuit. In case of doubt, a verification by measurement should be performed.

For TRD2 having a voltage measurement input, the coupling power capability is deemed to be limited. Values for clearances can be found in Table K.11 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016 or a verification by measurement should be performed in order to determine the remaining value of transient overvoltages on the secondary and to calculate according K.3.2 of IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016.

Even if transient should not be considered on the secondary (low values for clearance), other safety-related requirements should apply (e.g. creepage distances).

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¹ This document has been withdrawn.

² This document has been withdrawn.

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

**TRANSDUCTEURS ÉLECTRIQUES DE MESURE CONVERTISSANT
LES GRANDEURS ÉLECTRIQUES ALTERNATIVES OU CONTINUES
EN SIGNAUX ANALOGIQUES OU NUMÉRIQUES**

AVANT-PROPOS

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L'IEC 60688 a été établie par le comité d'études 85 de l'IEC: Équipement de mesure des grandeurs électriques et électromagnétiques. Il s'agit d'une Norme internationale.

Cette quatrième édition annule et remplace la troisième édition parue en 2012. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) mise à jour des références normatives;
- b) exigences supplémentaires pour les transducteurs spécifiques utilisés pour les applications de surveillance de la BT (basse tension)
- c) création d'un codage d'interface pour faciliter la sélection par l'utilisateur final.

Le texte de cette Norme internationale est issu des documents suivants:

CDV	Rapport de vote
85/748/CDV	85/781/RVC

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

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- NOTES: petits caractères romains;
- *conformité*: caractères italiques.

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INTRODUCTION

Les nouveaux transducteurs peuvent maintenant être équipés de microprocesseurs utilisant des signaux numériques, des méthodes de communication, des capteurs auxiliaires. Ceci les rend plus complexes que des transducteurs de mesure analogique conventionnels et leur donne une valeur ajoutée considérable.

Le système de classification par indice de classe utilisé dans le présent document est fondé sur la série IEC 60051. Dans ce système, les variations admises du signal de sortie dues aux variations des grandeurs d'influence – température ambiante, tension, fréquence, etc. – sont prises en compte dans la classification.

Il est nécessaire d'attirer l'attention sur les particularités de ce système par indice de classe. Si, par exemple, un transducteur est de Classe 1, cela ne veut pas dire que, dans les conditions pratiques d'utilisation, l'erreur sera à ± 1 % du signal de sortie, ou à ± 1 % de la pleine échelle. Cela signifie qu'il convient que l'erreur ne dépasse pas ± 1 % de la valeur conventionnelle pour des conditions strictement spécifiées. Lorsque les grandeurs d'influence varient entre les limites spécifiées du domaine nominal d'utilisation, il peut se produire une variation de la valeur comparable à la valeur de l'indice de classe, et cela pour chaque grandeur d'influence.

L'erreur admissible d'un transducteur dans les conditions de fonctionnement est la somme de l'erreur intrinsèque admissible et des variations admissibles dues à chacune des grandeurs d'influence. Cependant, l'erreur réelle est probablement beaucoup plus faible, car il est peu probable que les grandeurs d'influence prennent simultanément leurs valeurs les plus défavorables, certaines des variations pouvant s'annuler l'une l'autre. Il est donc important de prendre ces faits en considération dans la spécification d'un transducteur pour une application particulière.

D'autre part, certains des termes utilisés dans le présent document sont différents de ceux utilisés dans la série IEC 60051 en raison des différences fondamentales qui existent entre les appareils indicateurs et les transducteurs de mesure.

Toutes les déclarations relatives aux performances sont rapportées à la grandeur de sortie, laquelle est régie par deux éléments fondamentaux:

- "la valeur nominale", qui peut être, selon le cas, positive, négative ou bien positive et négative;
- "l'intervalle de sortie", qui est la plage des valeurs du signal de sortie, depuis la valeur maximale positive jusqu'à la valeur maximale négative, le cas échéant.

TRANSDUCTEURS ÉLECTRIQUES DE MESURE CONVERTISSANT LES GRANDEURS ÉLECTRIQUES ALTERNATIVES OU CONTINUES EN SIGNAUX ANALOGIQUES OU NUMÉRIQUES

1 Domaine d'application

Le présent document s'applique aux transducteurs à grandeurs d'entrées et de sorties électriques destinés à mesurer des grandeurs électriques alternatives ou continues. Le signal de sortie peut être sous la forme d'un courant continu analogique ou d'une tension continue analogique ou d'un signal numérique.

Le présent document s'applique aux transducteurs de mesure destinés à convertir des grandeurs électriques, telles que:

- le courant,
- la tension,
- la puissance active,
- la puissance réactive,
- le facteur de puissance,
- l'angle de phase,
- la fréquence,
- les harmoniques ou la distorsion harmonique totale, et
- la puissance apparente

en signal de sortie.

Le présent document ne s'applique pas:

- aux transformateurs de mesure conformes à la série IEC 61869,
- aux transmetteurs utilisés dans le processus industriel conformes à la série IEC 60770, et
- aux dispositifs de mesure et de surveillance des performances (PMD – *performance measuring and monitoring device*) conformes à l'IEC 61557-12:2018.

Dans l'étendue de mesure, le signal de sortie varie en fonction du mesurande. Une alimentation auxiliaire peut être nécessaire.

Le présent document s'applique:

- a) si la fréquence nominale de la ou des grandeurs d'entrée est comprise entre 0 Hz et 1 500 Hz;
- b) à un transducteur de mesure électrique appartenant à une chaîne de mesure d'une grandeur non électrique, et si, par ailleurs, celui-ci relève du domaine d'application du présent document, et
- c) aux transducteurs destinés à une utilisation générale, par exemple à la télémessure, à la commande de processus et dans un des nombreux environnements spécifiés.

Le présent document a pour objet:

- de spécifier la terminologie et les définitions relatives aux transducteurs dont l'application principale relève du domaine de l'industrie,
- d'unifier les méthodes d'essai utilisées pour évaluer les performances des transducteurs, et

- de spécifier les limites de précision et les valeurs de sortie des transducteurs.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068-2-6, *Essais d'environnement - Partie 2-6: Essais - Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-27, *Essais d'environnement - Partie 2: Essais - Essai Ea et guide: Chocs*

IEC 60255-151, *Relais de mesure et dispositifs de protection - Partie 151: Exigences fonctionnelles pour les protections à minimum et maximum de courant*

IEC 61010 (toutes les parties), *Règles de sécurité pour appareils électriques de mesure, de régulation et de laboratoire*

IEC 61010-1:2010, *Règles de sécurité pour appareils électriques de mesure, de régulation et de laboratoire - Partie 1: Exigences générales*

IEC 61010-1:2010/AMD1:2016

IEC 61010-2-030:2017, *Exigences de sécurité pour appareils électriques de mesure, de régulation et de laboratoire - Partie 2-030: Exigences particulières pour les appareils équipés de circuits d'essai ou de mesure*

IEC 61326-1:2020, *Matériel électrique de mesure, de commande et de laboratoire - Exigences relatives à la CEM - Partie 1: Exigences générales*

IEC 61557-12:2018, *Sécurité électrique dans les réseaux de distribution basse tension jusqu'à 1 000 V c.a. et 1 500 V c.c. - Dispositifs de contrôle, de mesure ou de surveillance de mesures de protection - Partie 12: Dispositifs de comptage et de surveillance du réseau électrique (PMD)*

IEC 61558-1:2017, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et des combinaisons de ces éléments - Partie 1: Exigences générales et essais*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

3.1 Termes généraux

3.1.1

transducteur (de mesure électrique)

transducteur

TRD

dispositif destiné à convertir, à des fins de mesure, un mesurande électrique alternatif ou continu en courant continu ou alternatif, en tension continue ou alternative ou en signal numérique

3.1.2

transducteur (de mesure électrique) de type 1

transducteur de type 1

TRD1

transducteur conventionnel

Note 1 à l'article: Les transducteurs de type 1 utilisent des sorties d'interface conventionnelles et sont généralement des dispositifs à fonction unique

3.1.3

transducteur (de mesure électrique) de type 2

transducteur de type 2

TRD2

transducteur à fonction unique utilisé dans les applications de surveillance en basse tension (BT)

Note 1 à l'article: Les transducteurs de type 2 utilisent des sorties d'interface spécifiques et sont généralement plus précis que ceux de type 1

3.1.4

dispositif à fonction unique

dispositif effectuant le mesurage d'une seule grandeur électrique (par exemple, courant, facteur de puissance, distorsion harmonique totale ...) sous une seule forme (par exemple, valeur efficace, crête ou moyenne ...) mais pas deux

3.1.5

transducteur de mesure analogique

dispositif destiné à convertir, à des fins de mesurage, un mesurande électrique alternatif ou continu en courant continu ou alternatif, ou en tension continue ou alternative

3.1.6

transducteur de mesure numérique

dispositif destiné à convertir, à des fins de mesurage, un mesurande électrique alternatif ou continu en signal numérique

3.1.7

alimentation auxiliaire

alimentation en courant alternatif ou continu, autre que le mesurande, nécessaire pour assurer le fonctionnement correct du transducteur

3.1.8

circuit auxiliaire

circuit généralement alimenté par l'alimentation auxiliaire

Note 1 à l'article: Le circuit auxiliaire est parfois alimenté à partir d'une des grandeurs d'entrées.

3.1.9

transducteur à zéro supprimé

transducteur dont le signal de sortie est égal à zéro, pour un mesurande supérieur à zéro

3.1.10

charge de sortie

<pour les signaux analogiques> résistance totale des circuits et des appareils connectés extérieurement aux bornes de sortie du transducteur

3.1.11

ondulation

<d'un signal de sortie analogique> dans des conditions d'entrée en régime permanent, quotient, exprimé en pourcentage, de la valeur crête à crête de la composante alternative du signal de sortie analogique, par la valeur conventionnelle

3.1.12**signal de sortie**

représentation analogique ou numérique du mesurande

3.1.13**puissance de sortie**

puissance disponible aux bornes de sortie du transducteur

3.1.14**courant de sortie**

<pour les signaux analogiques> courant produit par le transducteur ayant une représentation analogique du mesurande

3.1.15**tension de sortie**

<pour les signaux analogiques> tension produite par le transducteur ayant une représentation analogique du mesurande

3.1.16**élément de mesure**

<d'un transducteur> composant ou sous-ensemble d'un transducteur convertissant le mesurande, ou une partie du mesurande, en un signal correspondant

3.1.17**transducteur à éléments de mesure multiples**

transducteur ayant au moins deux éléments de mesure

Note 1 à l'article: Les signaux des éléments individuels sont combinés pour donner un signal de sortie qui correspond au mesurande

3.1.18**temps de réponse**

temps qui s'écoule entre l'instant d'application d'un changement spécifié du mesurande et l'instant à partir duquel le signal de sortie atteint et reste à sa valeur finale permanente ou à l'intérieur d'un intervalle spécifié centré sur cette valeur

3.1.19**tension disponible**

tension de sortie maximale permettant de garantir la précision

<pour les transducteurs à charge de sortie variable dont la grandeur de sortie est un courant> valeur de la tension aux bornes de sortie jusqu'à laquelle le transducteur satisfait aux exigences du présent document

3.1.20**stabilité**

aptitude d'un transducteur à maintenir ses performances sans modification pendant une durée déterminée, lorsque les grandeurs d'influence restent à l'intérieur de leurs plages spécifiées

3.1.21**groupe d'utilisation**

groupe de transducteurs capable de fonctionner dans des conditions d'environnement spécifiées

3.1.22**sortie à densité d'impulsion**

représentation numérique du mesurande, dans laquelle la densité relative des impulsions de sortie correspond à l'amplitude du signal analogique

3.2 Termes désignant les transducteurs selon le mesurande

3.2.1

transducteur de tension

transducteur destiné au mesurage d'une tension alternative ou continue

3.2.2

transducteur de courant

transducteur destiné au mesurage d'un courant alternatif ou continu

3.2.3

transducteur de puissance apparente

transducteur destiné au mesurage d'une puissance électrique apparente

3.2.4

transducteur de puissance active

transducteur destiné au mesurage d'une puissance électrique active

3.2.5

transducteur de puissance réactive

transducteur destiné au mesurage d'une puissance électrique réactive

3.2.6

transducteur de fréquence

transducteur destiné au mesurage de la fréquence d'une grandeur électrique alternative

3.2.7

transducteur d'angle de phase

transducteur destiné au mesurage du déphasage existant entre deux grandeurs électriques alternatives de même fréquence

3.2.8

transducteur de facteur de puissance

transducteur destiné au mesurage du facteur de puissance d'un circuit à courant alternatif

3.2.9

transducteur d'harmoniques

transducteur destiné au mesurage des harmoniques ou à la distorsion harmonique totale d'un circuit alternatif

3.2.10

TRD2-PFA

transducteur de facteur de puissance (méthode arithmétique) pour les applications de surveillance de la BT

3.2.11

TRD2-PFV

transducteur de facteur de puissance (méthode vectorielle) pour les applications de surveillance de la BT

3.2.12

TRD2-THDU

transducteur de tension THD (distorsion harmonique totale) pour les applications de surveillance de la BT

3.2.13

TRD2-THDI

transducteur de courant THD pour les applications de surveillance de la BT

3.2.14**TRD2-UAC**

transducteur de tension pour les applications de surveillance de la BT qui est utilisé pour le mesurage de la tension alternative

3.2.15**TRD2-UDC**

transducteur de tension pour les applications de surveillance de la BT qui est utilisé pour le mesurage de la tension continue

3.2.16**TRD2-IAC**

transducteur de courant pour les applications de surveillance de la BT, utilisé pour le mesurage du courant alternatif

3.2.17**TRD2-IDC**

transducteur de courant pour les applications de surveillance de la BT qui est utilisé pour le mesurage du courant continu

3.3 Termes désignant des transducteurs selon leur charge de sortie**3.3.1****transducteur à charge de sortie fixe**

transducteur qui ne satisfait aux exigences du présent document que lorsque sa charge de sortie a sa valeur nominale, dans les tolérances spécifiées

3.3.2**transducteur à charge de sortie variable**

transducteur qui satisfait aux exigences du présent document pour toute valeur de la charge de sortie comprise dans une certaine plage

3.4 Valeurs nominales**3.4.1****valeur nominale**

valeur, ou une des valeurs, indiquant l'utilisation prévue d'un transducteur

Note 1 à l'article: Les valeurs nominales inférieures et supérieures du mesurande sont celles qui correspondent aux valeurs nominales inférieures et supérieures du signal de sortie.

3.4.2**intervalle****intervalle de sortie**

différence algébrique entre la valeur nominale supérieure et la valeur nominale inférieure du signal de sortie

3.4.3**valeur conventionnelle**

valeur à laquelle il est fait référence pour spécifier la précision d'un transducteur

Note 1 à l'article: La valeur conventionnelle est l'intervalle de sortie, sauf pour les transducteurs ayant un signal de sortie réversible et symétrique: dans ce cas la valeur conventionnelle peut être la moitié de l'intervalle de sortie, suivant la spécification du fabricant

3.4.4**facteur de puissance nominal**

facteur par lequel il faut multiplier le produit de la tension nominale par le courant nominal pour obtenir la puissance nominale

Note 1 à l'article: Quand le courant et la tension sont des grandeurs sinusoïdales, le facteur de puissance nominal est $\cos \varphi$ où φ est le déphasage entre le courant et la tension. Pour les transducteurs de puissance réactive, le facteur de puissance nominal est $\sin \varphi$

3.4.5

valeur limite du signal de sortie

<courant ou tension> valeur supérieure du signal de sortie qui, par conception, ne peut pas être dépassée, quelles que soient les conditions d'utilisation

3.4.6

étendue de mesure

plage définie par deux valeurs du mesurande à l'intérieur de laquelle les performances satisfont aux exigences du présent document

Note 1 à l'article: Voir 3.4.3 de l'IEC 60051-1:2016.

3.4.7

valeur nominale de la tension mesurée

valeur nominale de la tension du circuit extérieur (par exemple, l'enroulement secondaire d'un transformateur de tension) auquel le circuit d'entrée de tension du transducteur doit être connecté

3.4.8

valeur nominale du courant mesuré

valeur nominale du courant du circuit extérieur (par exemple l'enroulement secondaire d'un transformateur de courant) auquel le circuit d'entrée de courant du transducteur doit être connecté

3.5 Termes désignant les transducteurs offrant la possibilité de réglage par les utilisateurs

3.5.1

valeur d'étalonnage

valeur d'une grandeur à laquelle est amenée la valeur nominale par réglage accessible à l'utilisateur pour une application particulière

3.5.2

plage d'ajustage

plage possible de valeurs d'ajustage du courant ou de la tension mesurée

3.6 Grandeurs d'influence et conditions de référence

3.6.1

grandeur d'influence

grandeur (autre que le mesurande) qui peut affecter la performance d'un transducteur

3.6.2

conditions de référence

conditions spécifiées pour lesquelles le transducteur satisfait aux exigences relatives aux erreurs intrinsèques

Note 1 à l'article: Ces conditions peuvent être définies par une valeur ou une plage de référence.

3.6.2.1

valeur de référence

valeur spécifiée unique d'une grandeur d'influence pour laquelle le transducteur satisfait aux exigences relatives aux erreurs intrinsèques

3.6.2.2**plage de référence**

plage spécifiée des valeurs d'une grandeur d'influence pour laquelle le transducteur satisfait aux exigences relatives aux erreurs intrinsèques

3.6.3**domaine nominal d'utilisation**

plage spécifiée des valeurs qu'il est prévu qu'une grandeur d'influence puisse prendre sans que le signal de sortie du transducteur sorte des limites spécifiées

3.7 Erreurs et variations**3.7.1****erreur**

valeur réelle du signal de sortie moins la valeur attendue de ce signal de sortie, en prenant leurs expressions algébriques

3.7.2**erreur intrinsèque**

erreur déterminée lorsque le transducteur est dans les conditions de référence

3.7.3**variation due à une grandeur d'influence**

différence entre les deux valeurs du signal de sortie, pour une même valeur du mesurande, lorsqu'une grandeur d'influence prend successivement deux valeurs spécifiées différentes

3.7.4**variation due à une grandeur d'influence**

<exprimée en pourcentage de la valeur conventionnelle> cent fois le quotient de la variation due à une grandeur d'influence par la valeur conventionnelle

3.8 Précision, classe de précision et indice de classe**3.8.1****précision**

précision d'un transducteur définie par les limites de l'erreur intrinsèque et les limites des variations

3.8.2**classe de précision**

ensemble des transducteurs dont la précision est caractérisée par le même nombre si ces transducteurs satisfont à toutes les exigences du présent document

3.8.3**indice de classe**

nombre qui désigne la classe de précision

Note 1 à l'article: L'indice de classe est utilisé pour l'erreur intrinsèque aussi bien que pour les variations.

Note 2 à l'article: Dans tout le présent document, l'expression "x % de l'indice de classe" signifie: "x % des limites de l'erreur correspondant à l'indice de classe".

4 Généralités**4.1 Architecture générale d'un transducteur**

Organisation de la chaîne de mesure: la grandeur électrique à mesurer peut être directement accessible, ce qui est généralement le cas dans les réseaux basse tension, ou accessible par

l'intermédiaire d'un capteur de mesure comme un capteur de tension (VS – *voltage sensor*) ou un capteur de courant (CS – *current sensor*).

La Figure 1 représente l'architecture standard d'un transducteur (TRD).

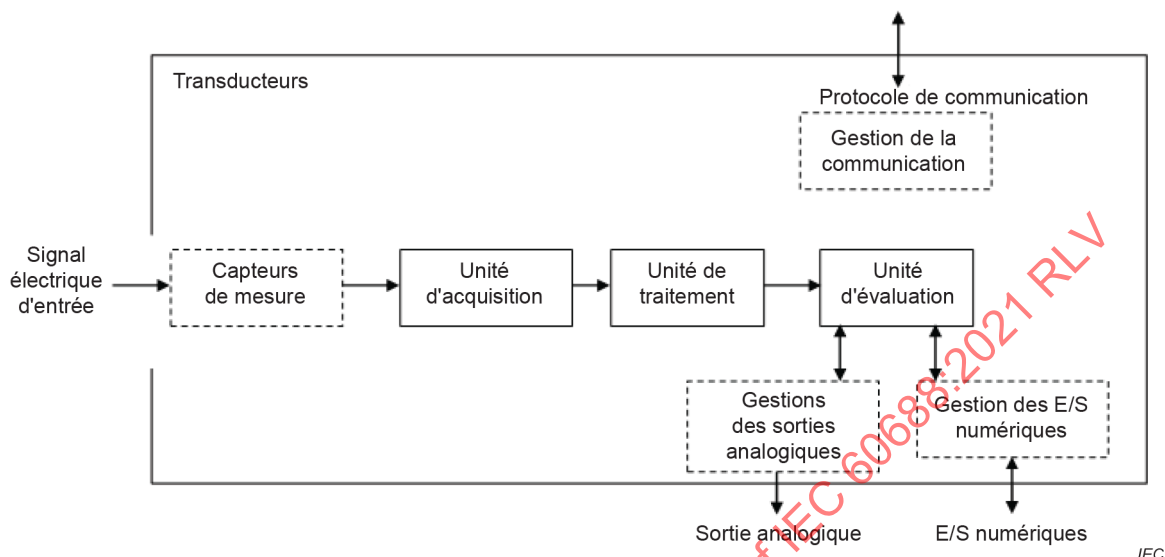


Figure 1 – Architecture d'un transducteur (TRD)

4.2 Classification des transducteurs (TRD)

Les transducteurs sont classés selon les applications, comme cela est défini dans le Tableau 1.

Tableau 1 – Classification fonctionnelle des transducteurs ayant des fonctions exigées minimales

Exigences	Type de transducteur	
	TRD1 (transducteur de type 1)	TRD2 (transducteur de type 2)
Voir l'Article 5	■	
Voir l'Annexe A		■
NOTE Voir également l'Annexe B pour de plus amples informations sur les différences entre le TRD1 et le TRD2.		

5 Exigences pour le TRD1

5.1 Exigences de sécurité: distances d'isolement et lignes de fuite

Les transducteurs doivent être conformes aux exigences de sécurité de la série IEC 61010 ainsi qu'aux exigences suivantes.

Les distances d'isolement et les lignes de fuite doivent être choisies au moins conformément aux éléments suivants:

- degré de pollution 2,
- catégorie de mesure III pour les circuits d'entrée de mesure, et
- catégorie de surtension III pour les circuits d'alimentation sur le réseau.

NOTE 1 La catégorie de mesure est définie dans l'IEC 61010-2-030.

5.2 Exigences relatives à la CEM

5.2.1 Immunité

Pour l'essai de perturbation à haute fréquence, voir la série IEC 61326.

Si, par accord, d'autres essais sont exigés, alors le TRD1 avec des composants électroniques actifs peut être conforme à l'Article 6 de l'IEC 61326-1:2020.

NOTE Ces exigences sont cohérentes avec celles de 6.21 et de 6.23.

5.2.2 Émission

Si, par accord, d'autres essais sont exigés, alors le TRD1 avec des composants électroniques actifs peut respecter les limites de la classe A ou de la classe B telles que définies à l'Article 7 de l'IEC 61326-1:2020.

NOTE Cette exigence est cohérente avec celle de 6.23.

5.3 Exigences relatives à l'indice de classe

5.3.1 Indice de classe

L'indice de classe pour un transducteur doit être choisi parmi les valeurs données dans le Tableau 2.

Cette définition de l'indice de classe s'applique seulement aux sorties analogiques des transducteurs.

Tableau 2 – Relation entre les limites de l'erreur intrinsèque, exprimée en pourcentage de la valeur conventionnelle, et l'indice de classe

Indice de classe	0,2	0,5	1	2	2,5	3	5	10	20
Limites de l'erreur	±0,2 %	±0,5 %	±1 %	±2 %	±2,5 %	±3 %	±5 %	±10 %	±20 %
Les indices de classes de 0,3 et 1,5, bien que non préférentiels, peuvent être utilisés.									

5.3.2 Indice de classe pour un transducteur utilisé avec des capteurs

Si des transducteurs sont utilisés avec des capteurs, le fabricant doit spécifier la classe de précision de l'ensemble transducteur et capteurs.

Dans certains cas, quand un transducteur n'inclut pas de capteurs, les incertitudes associées ne sont pas prises en considération. Quand un transducteur inclut des capteurs, les incertitudes associées sont prises en considération.

5.3.3 Erreur intrinsèque

Le transducteur étant placé dans les conditions de référence, l'erreur en un point quelconque entre les valeurs inférieures et supérieures nominales du signal de sortie ne doit pas dépasser les limites de l'erreur intrinsèque, exprimées en pourcentage de la valeur conventionnelle, indiquées dans le Tableau 2.

Les corrections éventuellement indiquées dans un tableau accompagnant le transducteur ne doivent pas être prises en compte pour la détermination des erreurs.

5.4 Conditions à respecter pour la détermination de l'erreur intrinsèque

Avant le préconditionnement et avant la détermination de l'erreur intrinsèque, le transducteur doit être réglé conformément aux instructions du fabricant. Le transducteur doit être à la température de référence.

Le transducteur doit être alimenté dans les conditions indiquées dans le Tableau 3.

Tableau 3 – Préconditionnement

Conditions	Valeurs
Tension (y compris toute alimentation auxiliaire)	Valeur nominale
Courant	Valeur nominale
Fréquence	Valeur de référence
Facteur de puissance	Valeur de référence
Durée entre la mise en circuit et le début de la détermination des erreurs	30 min

Après le préconditionnement spécifié, les transducteurs équipés de dispositifs de réglage accessibles à l'utilisateur doivent être réglés conformément aux instructions du fabricant.

Les conditions de référence relatives à chaque grandeur d'influence sont indiquées dans le Tableau 4. Les conditions de référence relatives au mesurande sont indiquées dans le Tableau 5.

Tableau 4 – Conditions de référence relatives aux grandeurs d'influence et tolérances admises pour les essais

Grandeur d'influence	Conditions de référence en l'absence d'indication	Tolérances admises pour les essais dans le cas où une valeur de référence est spécifiée ^a
Température ambiante	À indiquer dans le rapport d'essai de type	±1 °C
Groupe d'utilisation (voir 6.1.2)		
I	K55	–
II	K70	–
III	Kx ^b	–
Fréquence de la grandeur d'entrée		
Non sensible à la fréquence	Valeur nominale	±2 %
Sensible à la fréquence	À indiquer dans le rapport d'essai de type	±0,1 %
Forme d'onde de la grandeur d'entrée	Sinusoïdale, sauf pour les transducteurs d'harmoniques	Le facteur de distorsion × 100 ne doit pas excéder l'indice de classe sauf indication contraire du fabricant
Charge de sortie		
Transducteurs à charge de sortie fixe	Valeur nominale	±1 %
Transducteurs à charge de sortie variable	Valeur moyenne du domaine nominal	±1 %
Alimentation auxiliaire		
Tension alternative	Valeur nominale	±2 %
Tension continue	Valeur nominale	±1 %
Fréquence	Valeur nominale	±1 %

Grandeur d'influence	Conditions de référence en l'absence d'indication	Tolérances admises pour les essais dans le cas où une valeur de référence est spécifiée ^a
Facteur de distorsion	0,05 maximum	–
Champ magnétique d'origine extérieure	Nul	40 A/m à une fréquence quelconque du courant continu à 65 Hz et dans une direction quelconque ^c
^a Lorsqu'une plage de référence est indiquée, aucune tolérance n'est admise. ^b Kx représente les conditions étendues. ^c 40 A/m est à peu près la valeur la plus élevée du champ magnétique terrestre.		

Tableau 5 – Conditions de référence relatives au mesurande

Mesurande	Conditions de référence		
	Tension	Courant	Facteur de puissance, active ou réactive
Puissance apparente	Tension nominale $\pm 2\%$	Courant quelconque entre zéro et le courant nominal	$ \cos \varphi $ ou $ \sin \varphi = 1,0$ à $0,8$ inductif ou capacitif
Puissance active	Tension nominale $\pm 2\%$	Courant quelconque entre zéro et le courant nominal	$ \cos \varphi = 1,0$ à $0,8$ inductif ou capacitif
Puissance réactive	Tension nominale $\pm 2\%$	Courant quelconque entre zéro et le courant nominal	$ \sin \varphi = 1,0$ à $0,8$ inductif ou capacitif ^a
Angle de phase ou facteur de puissance	Tension nominale $\pm 2\%$	40 % à 100 % du courant nominal	–
Fréquence	Tension nominale $\pm 2\%$		–
Grandeurs polyphasées	Tensions symétriques ^b	Courants symétriques ^b	–
^a Les transducteurs de puissance active, réactive et apparente sont normalement utilisés ensemble et sont connectés aux mêmes transformateurs de courant et de tension. Il faut noter que $\sin \varphi = 1,0$ à $0,8$ est utilisé ici seulement pour la simplification des essais. ^b La différence entre n'importe laquelle des deux tensions simples et deux tensions composées ne doit pas excéder 1 % de leur moyenne (tensions simple et composée, respectivement). Aucun des courants dans les conducteurs de phases ne doit différer de plus de 1 % de la moyenne des courants. Les déphasages présentés par chacun des courants avec la tension simple (étoilée) correspondante ne doivent pas différer entre eux de plus de 2° . Lorsque les interactions entre les différents éléments de mesure d'un transducteur à éléments de mesure multiples sont bien caractérisées, l'essai du transducteur avec une source monophasée est acceptable.			

5.5 Alimentation auxiliaire

5.5.1 Généralités

Quelques-uns des transducteurs traités dans le présent document peuvent nécessiter une alimentation auxiliaire. Celle-ci est spécifiée en deux grandes familles, alimentations en courant continu et alimentations en courant alternatif.

5.5.2 Alimentation en courant continu

- La valeur de la tension de l'alimentation en courant continu doit être une de celles spécifiées en 5.6.3.
- L'alimentation par batterie peut être référencée par rapport à la masse ou rester flottante. Des moyens appropriés doivent être prévus dans le transducteur pour assurer une séparation galvanique entre l'alimentation et les circuits d'entrée/sortie du transducteur (pour les détails des essais de tension, voir 6.19).

- c) Le transducteur doit supporter une ondulation de tension, jusqu'à un maximum de 10 % crête à crête ajouté à l'alimentation en courant continu.
- d) Le bruit réinjecté dans la batterie par le transducteur doit être limité à 100 mV crête à crête, lorsqu'il est mesuré avec une résistance de source spécifiée, à toutes les fréquences jusqu'à 100 MHz.

De plus, lorsque la batterie alimentant le transducteur est également utilisée pour le téléphone, le bruit ne doit pas excéder 2 mV psophométriques.

NOTE Les caractéristiques de pondération psophométrique sont données dans la Recommandation O.41 de l'UIT-T.

5.5.3 Alimentation en courant alternatif

Pour la valeur nominale de la tension de l'alimentation en courant alternatif, voir 5.6. Cette tension peut être fournie par une alimentation séparée ou peut être dérivée de la tension ou du courant mesuré.

5.6 Valeurs d'entrée

5.6.1 Généralités

Les valeurs nominales de la tension, du courant, de la fréquence et de l'alimentation auxiliaire doivent être spécifiées par le fabricant.

5.6.2 Plages d'ajustage

Plage d'ajustage pour les transducteurs équipés d'un dispositif de réglage accessible à l'utilisateur:

- a) pour la tension d'entrée: 80 % à 120 % de la valeur nominale;
- b) pour le courant d'entrée: 60 % à 130 % de la valeur nominale.

Cela signifie que la valeur nominale du signal de sortie peut être obtenue pour une valeur d'ajustage quelconque du mesurande dans les plages indiquées ci-dessus.

5.6.3 Valeurs nominales préférentielles

La valeur nominale préférentielle des alimentations auxiliaires en courant continu doit être de 24 V, 48 V ou 110 V.

5.7 Valeurs des signaux de sortie analogiques

5.7.1 Généralités

Les valeurs nominales inférieures et supérieures du signal de sortie et de la tension disponible doivent être choisies parmi celles mentionnées en 5.7.2 et 5.7.3 ou 5.7.6.

5.7.2 Courant de sortie

Le signal 4 mA à 20 mA est la valeur préférentielle.

NOTE La condition "0 mA" a une signification spéciale (IEC 60381-1).

Les autres valeurs admissibles sont:

- 0 mA à 20 mA,
- 0 mA à 1 mA,
- 0 mA à 10 mA,
- -1 mA à 1 mA,

- -5 mA à 5 mA,
- -10 mA à 10 mA, et
- -20 mA à 20 mA

5.7.3 Tension disponible

- 10 V;
- 15 V

5.7.4 Tension de sortie maximale

Le fabricant doit donner la valeur maximale de la tension de sortie lorsque la charge de sortie et l'entrée prennent des valeurs quelconques. Cette tension ne doit pas dépasser la limite de la très basse tension de sécurité.

5.7.5 Risque d'interférence sur courant de sortie

L'attention est attirée sur les problèmes d'interférence qui peuvent se poser si le courant de sortie est faible.

5.7.6 Tension de sortie

- 0 V à 1 V
- 0 V à 10 V
- -1 V à 1 V
- -10 V à 10 V

NOTE Les transducteurs ayant une sortie en tension ne sont pas préférentiels.

5.8 Fonction de transfert de sortie

Pour les transducteurs de mesure analogique, la fonction de transfert utilisée doit être l'une des courbes suivantes.

Pour les transducteurs de mesure analogique, les variables x , y peuvent être réglables.

La courbe A est décrite à la Figure 2.

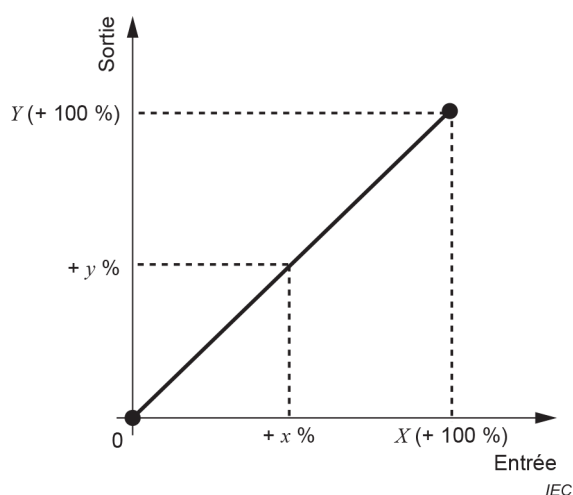


Figure 2 – Courbe de la fonction de transfert A

La courbe B est décrite à la Figure 3.

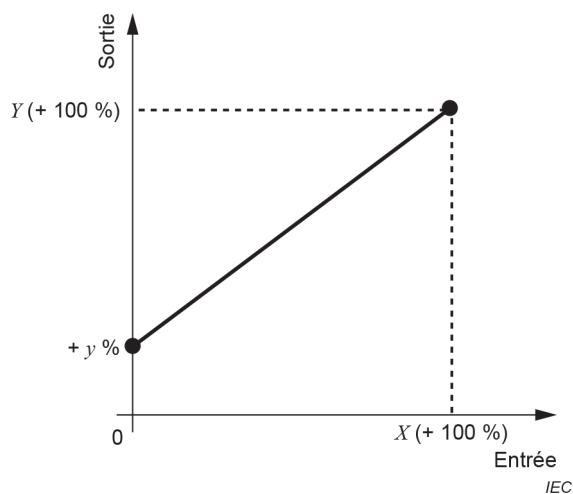


Figure 3 – Courbe de la fonction de transfert B

La courbe C est décrite à la Figure 4.

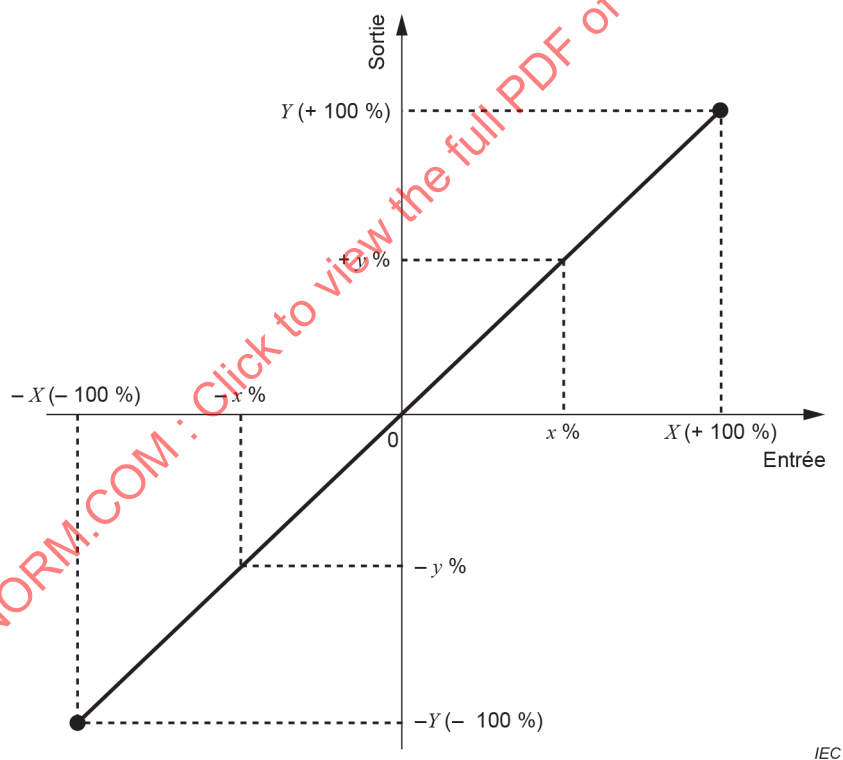


Figure 4 – Courbe de la fonction de transfert C

La courbe D est décrite à la Figure 5.

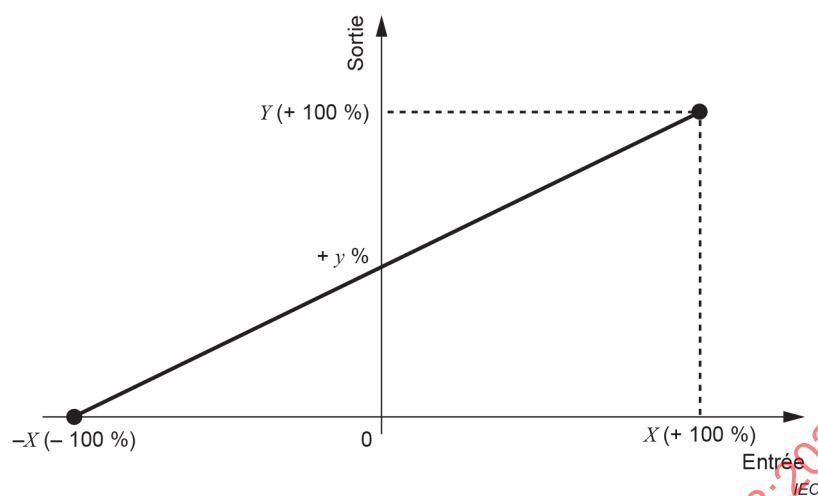


Figure 5 – Courbe de la fonction de transfert D

La courbe E est décrite à la Figure 6.

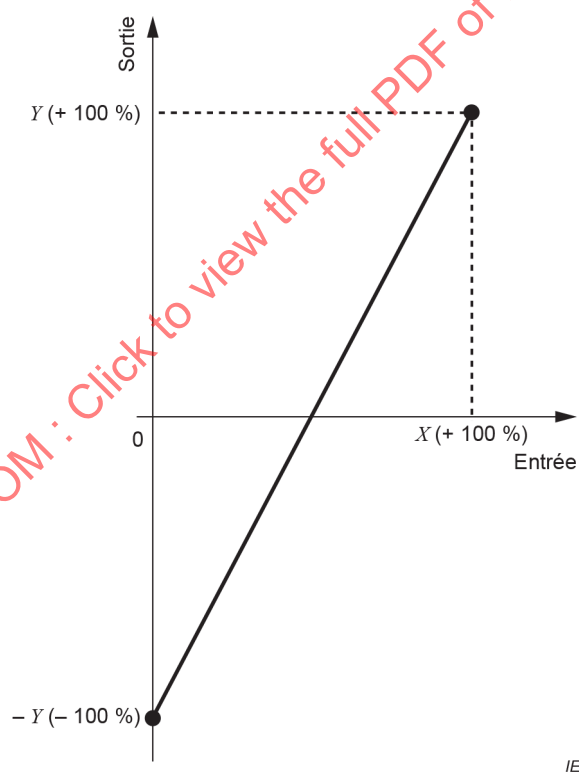


Figure 6 – Courbe de la fonction de transfert E

Courbe F (tous les autres types de courbes):

La classe de précision doit être vérifiée en chaque point de la fonction de transfert selon la formule:

$$\frac{Y - R}{R} \times 100$$

où

R est la valeur du signal de sortie dans les conditions de référence;

Y est la valeur du signal de sortie mesurée à une limite de la grandeur d'influence;

NOTE Pour les courbes F , remplacer F par R dans les paragraphes 6.1 à 6.23.

5.9 Signaux de sortie numériques

Les signaux de sortie numériques choisis doivent correspondre aux exigences pour les transducteurs concernant la précision et le temps de réponse ainsi qu'aux exigences du système de communication.

Pour une sortie numérique, l'indice de classe doit être conforme aux classes de performance décrites dans l'IEC 61557-12:2018.

Si des relais de sortie sont fournis, ils doivent être conformes à l'IEC 60255-151.

5.10 Ondulation (pour les sorties analogiques)

L'ondulation maximale de la grandeur du signal de sortie ne doit pas excéder deux fois l'indice de classe.

5.11 Temps de réponse

5.11.1 Avant la détermination du temps de réponse, le transducteur doit être dans les conditions de référence et le circuit auxiliaire doit être alimenté au moins pendant la durée de préconditionnement, à moins qu'il ne soit alimenté par une des grandeurs d'entrée et qu'il ne soit pas indépendant.

5.11.2 Le temps de réponse doit être indiqué par le fabricant et doit être déterminé pour une entrée en échelon qui fait varier le signal de sortie de 0 % à 90 % de la valeur conventionnelle.

5.11.3 Si un essai dans lequel est fait décroître la grandeur d'entrée est exigé, il convient que l'échelon de la grandeur d'entrée fasse varier le signal de sortie de 100 % à 10 % de la valeur conventionnelle.

5.11.4 L'intervalle (voir 3.1.24) doit correspondre à ± 1 % de la valeur nominale supérieure du signal de sortie.

5.11.5 Les méthodes d'essai pour les transducteurs de fréquence et les transducteurs à zéro supprimé doivent être définies par le fabricant.

5.12 Variation due à un surplus du mesurande

Si, par accord, un transducteur doit fonctionner avec une entrée qui va jusqu'à 150 % de la valeur nominale, la différence entre l'erreur intrinsèque à 100 % et l'erreur à 150 % de la valeur nominale de l'entrée (dans les conditions de référence) ne doit pas excéder 50 % de l'indice de classe.

Pour les transducteurs de puissance active et réactive, 150 % de la valeur nominale sont obtenus en augmentant le courant pendant que la tension est maintenue à sa valeur nominale.

5.13 Valeur limite du signal de sortie

La valeur du signal de sortie doit être limitée à un maximum de deux fois la valeur nominale supérieure.

Lorsque le mesurande n'est pas compris entre ses valeurs nominales inférieures et supérieures, le transducteur ne doit, en aucun cas, par exemple pour un courant excessif ou une tension trop faible, produire une sortie ayant une valeur comprise entre ses valeurs nominales inférieures et supérieures.

5.14 Conditions limites de fonctionnement

Les limites du domaine nominal d'utilisation données à l'Article 6 sont celles dans lesquelles le transducteur satisfait aux exigences du présent document. Il est possible de faire fonctionner les transducteurs au-delà de ces limites mais il convient que l'utilisateur sache que:

- la précision ne peut être maintenue et/ou
- la durée de vie opérationnelle peut être réduite.

Par exemple, un grand nombre de transducteurs fonctionnent à une température ambiante très basse comme -25 °C et très élevée comme $+70\text{ °C}$ mais il convient de consulter le fabricant au sujet de la dégradation prévue de la précision et de la durée de vie opérationnelle.

5.15 Limites de l'étendue de mesure

Lorsque les limites de l'étendue de mesure ne coïncident pas avec les valeurs nominales inférieures et supérieures de la sortie, les limites de l'étendue de mesure doivent être indiquées – (voir 7.1 i).

5.16 Conditions limites de stockage et de transport

Sauf indication contraire du fabricant, les transducteurs doivent être capables de subir, sans dommage, une exposition à des températures comprises entre -40 °C et $+70\text{ °C}$.

Après retour aux conditions de référence, ils doivent satisfaire aux exigences du présent document.

Le fabricant doit spécifier toute autre condition limite exigée pour assurer l'intégrité du transducteur.

5.17 Plombage

Lorsque le transducteur est scellé pour empêcher des réglages non autorisés, l'accès aux circuits internes et aux composants situés dans le boîtier ne doit pas être possible sans que le scellé soit détruit.

5.18 Stabilité

Les transducteurs doivent respecter les limites appropriées d'erreur intrinsèque spécifiées pour leurs classes de précision respectives pendant une durée spécifiée par le fabricant, à condition que les conditions d'utilisation, de transport et de stockage spécifiées par le fabricant soient remplies.

NOTE En règle générale, la période est inférieure à une année.

6 Essais pour le TRD1

6.1 Généralités

6.1.1 Détermination des variations

Les variations doivent être déterminées pour chacune des grandeurs d'influence. Pendant les essais, toutes les autres grandeurs d'influence doivent être maintenues dans leurs conditions de référence.

Toutes les grandeurs d'influence sont données de 6.1 à 6.23, ainsi que les procédures d'essai et les calculs appropriés et les variations admissibles pour chaque groupe d'utilisation exprimées en pourcentage de l'indice de classe. Aucune des variations déterminées ne doit excéder les valeurs admissibles.

Les variations doivent être déterminées à la valeur nominale supérieure de la sortie et à, au moins, un autre point. Pour les transducteurs de puissance apparente, active et réactive, ces valeurs doivent être obtenues en maintenant la tension et le facteur de puissance dans leurs conditions de référence et en faisant varier l'intensité du courant.

Lorsqu'une plage de référence est spécifiée, la grandeur d'influence doit varier entre chacune des limites de la plage de référence et une valeur quelconque de la partie du domaine nominal qui est adjacente à la limite du domaine de référence choisi.

6.1.2 Conditions d'environnement

Les conditions de température et d'humidité sont classées d'après la sévérité dictée par le groupe d'utilisation conformément au Tableau 6.

Tableau 6 – Groupes d'utilisation

	Classe de température K55 des transducteurs	Classe de température K70 des transducteurs	Classe de température Kx ^b des transducteurs
Groupe d'utilisation	I	II	III
Plage de fonctionnement assignée (avec incertitude spécifiée)	-5 °C à +55 °C	-25 °C à +70 °C	Supérieure à +70 °C et/ou inférieure à -25 °C ^a
Plage limite de fonctionnement (pas de défaillance matérielle)	-5 °C à +55 °C	-25 °C à +70 °C	Supérieure à +70 °C et/ou inférieure à -25 °C ^a
Plage limite pour le stockage et le transport	-25 °C à +70 °C	-40 °C à +85 °C	Selon la spécification du fabricant ^a
^a Les limites doivent être définies par le fabricant, selon l'application.			
^b Kx représente les conditions étendues.			

Pour les besoins du présent document, la température ambiante doit être la température mesurée en un seul point représentatif, le transducteur fonctionnant normalement. Ce point de mesure doit être tout proche du transducteur, ventilé librement et ne doit pas être affecté par la chaleur dégagée par le transducteur ou exposé directement aux rayons solaires ou autres sources de chaleur.

L'humidité n'est pas considérée comme une grandeur d'influence si les conditions d'environnement sont dans les limites spécifiées.

6.1.3 Calculs

Dans les paragraphes 6.2 à 6.22, un calcul est exigé en rapport avec une formule. Les termes des formules suivent un principe général:

- R est la valeur du signal de sortie dans les conditions de référence;
- X (ou Y) est la valeur du signal de sortie mesuré à une limite de la grandeur d'influence;
- F est la valeur conventionnelle.

NOTE Pour les courbes de type F (voir 5.8), remplacer dans toutes les formules suivantes F par R .

6.2 Variations dues à la tension de l'alimentation auxiliaire

6.2.1 Application

Tous les transducteurs qui sont alimentés par une alimentation auxiliaire en courant continu ou alternatif, sauf lorsque cette alimentation est prélevée sur le circuit de tension ou le courant d'entrée et que les connexions ne peuvent pas être séparées pour les essais.

6.2.2 Procédure

Appliquer la valeur nominale de la tension de l'alimentation auxiliaire et enregistrer la valeur de signal de sortie (R).

Pour une valeur constante du mesurande, réduire la tension de l'alimentation auxiliaire jusqu'à la limite inférieure donnée en 6.2.4 et enregistrer la valeur du signal de sortie (X). Augmenter la tension de l'alimentation auxiliaire jusqu'à la limite supérieure donnée en 6.2.4 et enregistrer la valeur du signal de sortie (Y).

6.2.3 Calcul

Les variations sont: $\frac{X-R}{F} \times 100$

et: $\frac{Y-R}{F} \times 100$

6.2.4 Variations admissibles

Pour les alimentations auxiliaires en courant alternatif, le Tableau 7 s'applique.

Tableau 7 – Variations admissibles dues à l'alimentation auxiliaire en courant alternatif

Groupe d'utilisation	Domaine nominal d'utilisation (%)	Variation % d'indice de classe
I	90 à 110	50
II	80 à 120	50
III	80 à 120	50

Pour les alimentations auxiliaires en courant continu, le Tableau 8 s'applique.

Tableau 8 – Variations admissibles dues à l'alimentation auxiliaire en courant continu

Groupe d'utilisation	Domaine nominal d'utilisation (%)	Variation % d'indice de classe
I	85 à 125	50
II	85 à 125	50
III	85 à 125	50

6.3 Variations dues à la fréquence de l'alimentation auxiliaire

6.3.1 Application

Tous les transducteurs qui sont alimentés par une alimentation auxiliaire alternative, sauf lorsque cette alimentation est prélevée sur le circuit de la tension ou du courant d'entrée et que les connexions ne peuvent pas être séparées pour les essais.

6.3.2 Procédure

Appliquer la valeur nominale de la fréquence de l'alimentation auxiliaire et enregistrer la valeur du signal de sortie (R). Pour une valeur constante du mesurande, réduire la fréquence de l'alimentation auxiliaire jusqu'à la limite inférieure donnée en 6.3.4 et enregistrer la valeur du signal de sortie (X).

Augmenter la fréquence de l'alimentation auxiliaire jusqu'à la limite supérieure donnée en 6.3.4 et enregistrer la valeur du signal de sortie (Y).

6.3.3 Calcul

Les variations sont: $\frac{X - R}{F} \times 100$

et: $\frac{Y - R}{F} \times 100$

6.3.4 Variations admissibles

Le Tableau 9 s'applique.

Tableau 9 – Variations dues à la fréquence de l'alimentation auxiliaire

Groupe d'utilisation	Domaine nominal d'utilisation (%)	Variation % d'indice de classe
I	90 à 110	50
II	90 à 110	50
III	90 à 110	50

6.4 Variations dues à la température ambiante

6.4.1 Application

Tous les transducteurs.

6.4.2 Procédure

Pour une valeur constante du mesurande et à la température de référence, enregistrer la valeur du signal de sortie (R).

Augmenter la température ambiante jusqu'à la limite supérieure donnée en 6.4.4 et maintenir pendant un temps suffisant pour obtenir les conditions de stabilisation (30 min est un temps habituel satisfaisant). Enregistrer la valeur du signal de sortie (X).

Abaisser la température ambiante jusqu'à la limite inférieure donnée en 6.4.4 et maintenir pendant le même temps pour obtenir les conditions de stabilisation. Enregistrer le temps de stabilisation et la valeur du signal de sortie (Y).

6.4.3 Calcul

Les variations sont: $\frac{X-R}{F} \times 100$

et: $\frac{Y-R}{F} \times 100$

6.4.4 Variations admissibles

Le Tableau 10 s'applique.

Tableau 10 – Variations admissibles dues à la température ambiante

Groupe d'utilisation	Domaine nominal d'utilisation °C	Variation % d'indice de classe
I	10 à 35	100
II	0 à 45	100
III	-10 à 55	100

6.5 Variations dues à la fréquence de la ou des grandeurs d'entrée

6.5.1 Application

Tous les transducteurs sauf les transducteurs de fréquence. Les transducteurs qui sont sensibles à la fréquence (par exemple, ceux qui utilisent des variateurs de phase) sont des exceptions et le domaine nominal d'utilisation doit être toujours marqué.

6.5.2 Procédure

Appliquer la valeur nominale de la fréquence d'entrée et enregistrer la valeur du signal de sortie (R).

Pour une valeur constante du mesurande, réduire la fréquence jusqu'à la limite inférieure donnée en 6.5.4 et enregistrer la valeur du signal de sortie (X).

Augmenter la fréquence jusqu'à la limite supérieure donnée en 6.5.4 et enregistrer la valeur du signal de sortie (Y).

6.5.3 Calcul

Les variations sont: $\frac{X-R}{F} \times 100$

et: $\frac{Y-R}{F} \times 100$

6.5.4 Variations admissibles

Le Tableau 11 s'applique.

Tableau 11 – Variations admissibles dues à la fréquence de la grandeur d'entrée

Groupe d'utilisation	Domaine nominal d'utilisation (%)	Variation % d'indice de classe
I	90 à 110	100
II	90 à 110	100
III	90 à 110	100
Sensible à la fréquence	Comme marqué	100

6.6 Variations dues à la tension d'entrée

6.6.1 Application

Tous les transducteurs sauf les transducteurs de courant et de tension.

6.6.2 Procédure

Appliquer la valeur nominale de la tension d'entrée et enregistrer la valeur du signal de sortie (R).

Pour une valeur constante du mesurande, réduire la tension d'entrée jusqu'à la limite inférieure donnée en 6.6.4 et enregistrer la valeur du signal de sortie (X).

Augmenter la tension d'entrée jusqu'à la limite supérieure donnée en 6.6.4 et enregistrer la valeur du signal de sortie (Y).

6.6.3 Calcul

Les variations sont: $\frac{X-R}{F} \times 100$

et: $\frac{Y-R}{F} \times 100$

6.6.4 Variations admissibles

Le Tableau 12 s'applique.

Tableau 12 – Variations admissibles dues à la tension d'entrée

Groupe d'utilisation	Domaine nominal d'utilisation (%)	Variation % d'indice de classe
I	90 à 110	50
II	80 à 120	50
III	80 à 120	50

6.7 Variations dues au courant d'entrée

6.7.1 Application

Transducteurs d'angle de phase et de facteur de puissance.

6.7.2 Procédure

Appliquer la valeur nominale du courant d'entrée et enregistrer la valeur du signal de sortie (R).

Pour une valeur constante du mesurande, réduire le courant d'entrée jusqu'à la limite inférieure donnée en 6.7.4 et enregistrer la valeur du signal de sortie (X).

Augmenter le courant d'entrée jusqu'à la limite supérieure donnée en 6.7.4 et enregistrer la valeur du signal de sortie (Y).

6.7.3 Calcul

Les variations sont: $\frac{X-R}{F} \times 100$

et: $\frac{Y-R}{F} \times 100$

6.7.4 Variations admissibles

Le Tableau 13 s'applique.

Tableau 13 – Variations admissibles dues au courant d'entrée

Groupe d'utilisation	Domaine nominal d'utilisation (%)	Variation % d'indice de classe
I	20 à 120	100
II	20 à 120	100
III	20 à 120	100

6.8 Variations dues au facteur de puissance

6.8.1 Application

Transducteurs de puissance apparente, active, et réactive.

6.8.2 Procédure

Appliquer respectivement 50 % (5 %) de la valeur nominale au courant d'entrée à un facteur de puissance de 1,0 et enregistrer les deux valeurs du signal de sortie (R). Pour une valeur constante du mesurande, augmenter le courant d'entrée à 100 % (10 %) de la valeur nominale, et réduire le facteur de puissance respectivement jusqu'à 0,5 inductif/capacitif. Enregistrer les deux valeurs du signal de sortie (X).

Pour faciliter l'essai des transducteurs de puissance réactive, les valeurs de $\sin \varphi$ équivalentes sont généralement appliquées.

Les transducteurs de puissance active doivent aussi être soumis à l'essai pour l'erreur à un facteur de puissance égal à zéro, et les transducteurs de puissance réactive à $\sin \varphi = 0$.

6.8.3 Calcul

Les variations sont: $\frac{X-R}{F} \times 100$

et:
$$\frac{Y-R}{F} \times 100$$

6.8.4 Variations admissibles

Le Tableau 14 s'applique.

Tableau 14 – Variations admissibles dues au facteur de puissance

Groupe d'utilisation	Domaine nominal d'utilisation	Variation % d'indice de classe
I	Cos (sin) $\varphi = 0,5 \dots 1 \dots 0,5$	50
II	Cos (sin) $\varphi = 0,5 \dots 1 \dots 0,5$	50
III	Cos (sin) $\varphi = 0,5 \dots 1 \dots 0,5$	50

Pour tous les transducteurs, l'erreur à un facteur de puissance de zéro (ou $\sin \varphi = 0$) ne doit pas excéder 100 % de l'indice de classe.

6.9 Variations dues à la charge de sortie

6.9.1 Application

Tous les transducteurs à charge de sortie variable.

6.9.2 Procédure

Appliquer à la charge de sortie une valeur égale à la moitié du domaine nominal et enregistrer la valeur du signal de sortie (R).

Pour une valeur constante du mesurande, réduire la résistance de la charge de sortie jusqu'à la limite inférieure donnée en 6.9.4 et enregistrer la valeur du signal de sortie (X).

Augmenter la résistance de la charge de sortie jusqu'à la limite supérieure donnée en 6.9.4 et enregistrer la valeur du signal de sortie (Y).

6.9.3 Calcul

Les variations sont:
$$\frac{X-R}{F} \times 100$$

et:
$$\frac{Y-R}{F} \times 100$$

6.9.4 Variations admissibles

Le Tableau 15 s'applique.

Tableau 15 – Variations admissibles dues à la charge de sortie

Groupe d'utilisation	Domaine nominal d'utilisation (%)	Variation % d'indice de classe
I	10 à 100	50

II	10 à 100	50
III	10 à 100	50

6.10 Variations dues à la distorsion de la ou des grandeurs d'entrée

6.10.1 Application

Tous les transducteurs caractérisés par le fabricant pour être utilisés sur les systèmes ayant des formes d'ondes déformées, sauf les transducteurs d'harmoniques.

6.10.2 Procédure

Appliquer la valeur choisie de la grandeur d'entrée, sans distorsion et enregistrer la valeur du signal de sortie (R). Introduire une distorsion de troisième harmonique au niveau donné en 6.10.4, les valeurs efficaces étant maintenues constantes, et enregistrer la valeur du signal de sortie (X). Il convient de modifier l'angle de phase entre l'harmonique et le fondamental de façon à obtenir les conditions les plus défavorables.

Pour les transducteurs de puissance apparente, active et réactive, l'essai est réalisé avec la forme d'onde déformée du courant et puis répété avec la forme d'onde déformée de la tension.

Pour les transducteurs de puissance apparente, active et réactive qui n'utilisent pas de variateurs de phase, les variations admissibles sont données en 6.10.4.

Pour les transducteurs de puissance réactive utilisant des variateurs de phase, les variations admissibles doivent être spécifiées par le fabricant.

6.10.3 Calcul

La variation est: $\frac{X - R}{F} \times 100$

6.10.4 Variations admissibles

Le Tableau 16 s'applique.

Tableau 16 – Variations admissibles dues à la distorsion de la ou des grandeurs d'entrée

Groupe d'utilisation	Domaine nominal d'utilisation	Variation
		% d'indice de classe
I	Facteur de distorsion 0,2	200
II	Facteur de distorsion 0,2	200
III	Facteur de distorsion 0,2	200

6.11 Variations dues à un champ magnétique d'origine extérieure

6.11.1 Application

Tous les transducteurs.

6.11.2 Procédure

Le transducteur est placé au centre d'une bobine de 1 m de diamètre moyen, de section carrée et d'épaisseur radiale faible par rapport à son diamètre. Il est également admissible d'utiliser un autre appareil capable de produire un champ magnétique homogène convenable en l'absence du transducteur en essai. 400 ampères-tours de cette bobine produisent, au centre de la bobine, en l'absence du transducteur en essai, une intensité du champ de 0,4 kA/m. Le champ magnétique doit être produit par un courant de même nature et de même fréquence que celui qui alimente le circuit de mesure, et doit être tel que la combinaison de phase et d'orientation soit la plus défavorable. Les valeurs indiquées pour les champs alternatifs sont des valeurs efficaces.

Tout transducteur ayant une dimension extérieure supérieure à 250 mm doit être soumis à l'essai dans une bobine de diamètre moyen au moins égal à quatre fois la plus grande dimension du transducteur. L'intensité du champ magnétique étant la même que celle donnée ci-dessus.

En l'absence du champ extérieur, enregistrer la valeur du signal de sortie (R).

Pour une valeur constante du mesurande, appliquer le champ extérieur et enregistrer la valeur du signal de sortie (X).

6.11.3 Calcul

La variation est:
$$\frac{X - R}{F} \times 100$$

6.11.4 Variations admissibles

Le Tableau 17 s'applique.

Tableau 17 – Variations admissibles dues à un champ magnétique d'origine extérieure

Groupe d'utilisation	Variation % d'indice de classe
I	100
II	100
III	100

6.12 Variations dues au déséquilibre des courants

6.12.1 Application

Transducteurs de puissance apparente, active et réactive ayant des éléments de mesure multiples.

6.12.2 Procédure

Les courants doivent être équilibrés et ajustés de façon à ce que le signal de sortie soit approximativement au milieu de l'intervalle de sortie ou, si le zéro du signal de sortie est à l'intérieur de l'intervalle de sortie, la moitié entre zéro et la valeur nominale supérieure du signal de sortie. Enregistrer la valeur du signal de sortie (R).

Couper l'un des courants, en maintenant les tensions équilibrées et symétriques, et ajuster les autres courants, en les maintenant égaux, de façon à restaurer la valeur initiale du mesurande.

Enregistrer la valeur du signal de sortie (X).

6.12.3 Calcul

La variation est: $\frac{X-R}{F} \times 100$

6.12.4 Variations admissibles

Le Tableau 18 s'applique.

Tableau 18 – Variations admissibles dues au déséquilibre des courants

Groupe d'utilisation	Variation % d'indice de classe
I	100
II	100
III	100

6.13 Variations dues à l'interaction entre les éléments de mesure

6.13.1 Application

Tous les transducteurs de puissance apparente, active et réactive à éléments de mesure multiples, sauf ceux ayant deux éléments de mesure pour mesurer des puissances triphasées non équilibrées sur quatre fils avec trois circuits de courant (parfois appelés transducteurs à "deux ponts et demi") et les transducteurs de puissance réactive utilisant des méthodes de connexions traversables.

6.13.2 Procédure

Le circuit de tension d'un seul circuit de mesure doit être alimenté à sa tension nominale. Les circuits de courant de tous les autres circuits de mesure doivent être alimentés successivement avec leurs courants nominaux. Le plus grand écart du signal de sortie (X) par rapport à la valeur correspondant au zéro du mesurande doit être noté, tout en faisant varier le déphasage entre la tension et les courants dans toute la plage de 0° à 360° .

Si l'alimentation auxiliaire est commune à l'un des circuits d'entrée de tension, c'est ce circuit qui doit être alimenté.

6.13.3 Calcul

La variation est: $\frac{X}{F} \times 100$

6.13.4 Variations admissibles

Le Tableau 19 s'applique.

Tableau 19 – Variations admissibles dues aux interactions entre les éléments de mesure

Groupe d'utilisation	Variation % d'indice de classe
I	50