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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Measuring relays and protection equipment – Part 127: Functional requirements for over/under voltage protection

Relais de mesure et dispositifs de protection – Partie 127: Exigences fonctionnelles pour les protections à minimum et maximum de tension

IEC 60255-127:2010

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CONTENTS

FOREWORD 4
1 Scope and object 6
2 Normative references 6
3 Terms and definitions 6
4 Specification of the function 8
4.1 General 8
4.2 Input energising quantities/Energising quantities 8
4.3 Binary input signals 9
4.4 Functional logic 9
4.4.1 Operating characteristics 9
4.4.2 Reset characteristics 13
4.5 Binary output signals 14
4.5.1 Start (pick-up) signal 14
4.5.2 Operate (trip) signal 15
4.5.3 Other binary output signals 15
5 Performance specification 15
5.1 Accuracy related to the characteristic quantity 15
5.2 Accuracy related to the operate time 15
5.3 Accuracy related to the reset time 16
5.4 Transient performance 16
5.4.1 Overshoot time 16
5.4.2 Response to time varying value of the characteristic quantity 16
5.5 Voltage transformer requirements 16
6 Functional test methodology 16
6.1 General 16
6.2 Determination of steady state errors related to the characteristic quantity 17
6.2.1 Accuracy of setting (start) value 17
6.2.2 Reset ratio determination 18
6.3 Determination of steady state errors related to the start and operate time 18
6.4 Determination of steady state errors related to the reset time 19
6.5 Determination of transient performance 20
6.5.1 Overshoot time for undervoltage protection 20
6.5.2 Response to time varying value of the characteristic quantity for dependent time relays 20
7 Documentation requirements 21
7.1 Type test report 21
7.2 Other user documentation 22
Annex A (informative) Reset time determination for relays with trip output only 23
Bibliography 24

Figure 1 – Simplified protection function block diagram 8
Figure 2 – Overvoltage independent time characteristic 9
Figure 3 – Undervoltage independent time characteristic 10
Figure 4 – Dependent time characteristic for overvoltage protection 11
Figure 5 – Dependent time characteristic for undervoltage protection 12

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Figure 6 – Definite time reset characteristic 14
Figure 7 – Definite time reset characteristic (alternative solution with instantaneous reset after relay operation) 14
Figure 8 – Test waveform 21
Figure A.1 – Dependent reset time determination 23

Table 1 – Test points for overvoltage elements 19
Table 2 – Test points for undervoltage elements 19
Table 3 – Test points for overvoltage elements 20
Table 4 – Test points for undervoltage elements 20
Table 5 – Recommended values for the test 21

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MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 127: Functional requirements for over/under voltage protection

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International Standard IEC 60255-127 has been prepared by IEC technical committee 95: Measuring relays and protection equipment.

The text of this standard is based on the following documents:

CDV	Report on voting
95/254/CDV	95/261/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60255 series can be found, under the general title *Measuring relays and protection equipment*, on the IEC website.

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MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 127: Functional requirements for over/under voltage protection

1 Scope

This part of IEC 60255 specifies minimum requirements for over/under voltage relays. The standard includes specification of the protection function, measurement characteristics and time delay characteristics.

This standard defines the influencing factors that affect the accuracy under steady state conditions and performance characteristics during dynamic conditions. The test methodologies for verifying performance characteristics and accuracy are also included in this standard.

The over/under voltage functions covered by this standard are as follows:

	IEEE/ANSI C37.2 Function numbers	IEC 61850-7-4 Logical nodes
Phase undervoltage protection	27	PTUV
Positive sequence undervoltage protection	27D	PTUV
Phase overvoltage protection	59	PTOV
Residual/zero-sequence overvoltage protection	59N/59G	PTOV
Negative sequence/ unbalance overvoltage protection	47	PTOV

The general requirements for measuring relays and protection equipment are specified in IEC 60255-1.

2 Normative references

The following referenced documents are indispensable for the application 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 60044 (all parts), *Instrument transformers*

IEC 60255-1, *Measuring relays and protection equipment – Part 1: Common requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definition apply

3.1
theoretical curve of time versus characteristic quantity
curve which represents the relationship between the theoretical specified operate time and the characteristic quantity

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3.2
curves of maximum and minimum limits of the operate time
curves of the limiting errors on either side of the theoretical time vs. characteristic quantity which identify the maximum and minimum operate times corresponding to each value of the characteristic quantity

3.3
setting value (start) of the characteristic quantity
G_S
the reference value used for the definition of the theoretical curve of time vs. characteristic quantity

3.4
start time
duration of the time interval between the instant when the characteristic quantity of the measuring relay in reset condition is changed, under specified conditions, and the instant when the start signal asserts

3.5
operate time
duration of the time interval between the instant when the characteristic quantity of a measuring relay in reset condition is changed, under specified conditions, and the instant when the relay operates

[IEC 60050-447:2010, 447-05-05]

3.6
disengaging time
duration of the time interval between the instant a specified change is made in the value of the input energizing quantity which will cause the relay to disengage and the instant it disengages

[IEC 60050-447:2010, 447-05-10]

3.7
reset time
duration of the time interval between the instant when the characteristic quantity of a measuring relay in operate condition is changed, under specified conditions, and the instant when the relay resets

[IEC 60050-447:2010, 447-05-06]

3.8
overshoot time
the difference between the operate time of the relay at the specified value of the input energising quantity and the maximum duration of the value of input energising quantity which, when suddenly reduced (for the overvoltage relay)/increased(for the undervoltage relay) to a specified value below(for the overvoltage relay)/above(for the undervoltage relay) the setting value, is insufficient to cause operation

3.9
threshold of independent time operation
G_D
the value of the characteristic quantity at which the relay operate time changes from dependent time operation to independent time operation

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3.10
reset ratio
disengaging ratio
ratio between the voltage value at the point where the relay just ceases to start (start signal changes from ON to OFF) and the actual start voltage of the element.

NOTE It is usually defined as a percentage such that for an overvoltage element the resetting ratio shall be less than 100 % and for an undervoltage element the reset ratio shall be greater than 100 %.

4 Specification of the function

4.1 General

The protection function with its inputs, outputs, measuring element, time delay characteristics and functional logic is shown in Figure 1. The manufacturer shall provide the functional block diagram of the specific implementation.

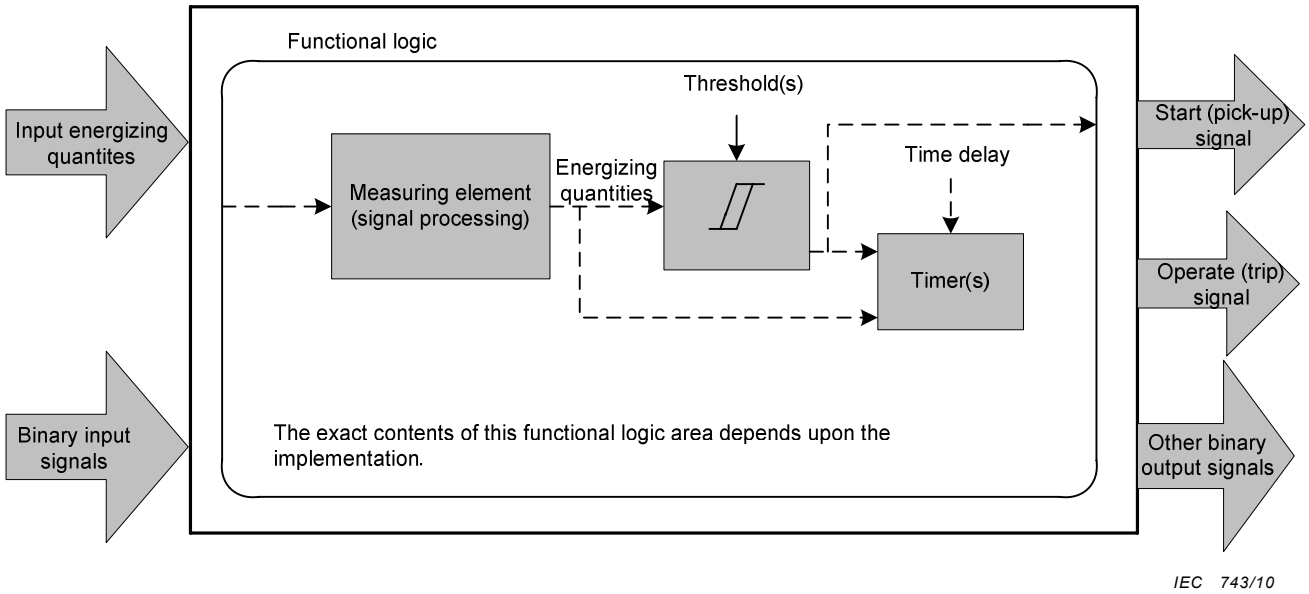

Figure 1 – Simplified protection function block diagram

4.2 Input energising quantities/Energising quantities

The input energising quantities are the measuring signals, e.g. voltages. Their ratings and relevant standards are specified in IEC 60255-1. Input energising quantities can come with wires from voltage transformers or as a data packet over a communication port using an appropriate communication protocol (such as IEC 61850-9-2).

The energising quantities used by the protection function need not be directly the voltage at the secondary side of the voltage transformers. Therefore, the measuring relay documentation shall state the type of energising quantities used by the protection function. Examples are:

- single phase voltage measurement;
- three phase voltage (phase to phase or phase to earth) measurement;
- neutral to earth voltage or residual voltage measurement;
- positive, negative or zero sequence voltage measurement.

The type of measurement of the energising quantity shall be stated. Examples are:

- RMS value of the signal;

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- RMS value of the fundamental component of the signal;
- RMS value of a specific harmonic component of the signal;
- peak values of the signal;
- instantaneous value of the signal.

4.3 Binary input signals

If any binary input signals (externally or internally driven) are used, their influence on the protection function shall be clearly described on the functional logic diagram. Additional textual description may also be provided if this can further clarify the functionality of the input signals and their intended usage.

4.4 Functional logic

4.4.1 Operating characteristics

4.4.1.1 General

The relationship between operate time and characteristic quantity can be expressed by means of a characteristic curve. The shape of this curve shall be declared by the manufacturer by an equation (preferred) or by graphical means.

This standard specifies two types of characteristics:

- independent time characteristic (i.e. definite time delay);
- dependent time characteristic (i.e. inverse time delay).

The time characteristic defines the operate time which is the duration between the instant when the input energising quantity crosses the setting value (G_S) and the instant when the relay operates.

4.4.1.2 Independent time characteristic

Independent time characteristic is defined in terms of the setting value of the characteristic quantity G_S and the operate time t_{op}. When no intentional time delay is used then the independent time relay is denoted as an instantaneous relay.

For overvoltage relays, $t_{(G)} = t_{op}$ when $G > G_S$. The independent time characteristic is presented in Figure 2.

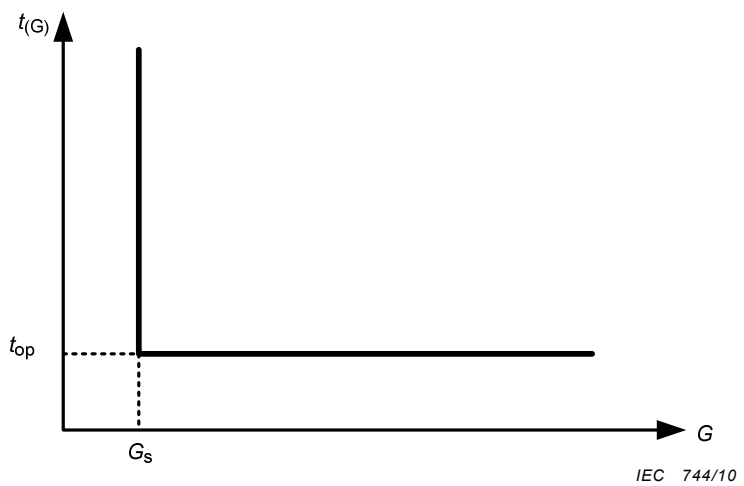

Figure 2 – Overvoltage independent time characteristic

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For undervoltage relays, $t_{(G)} = t_{op}$ when $G < G_S$. The independent time characteristic is presented in Figure 3.

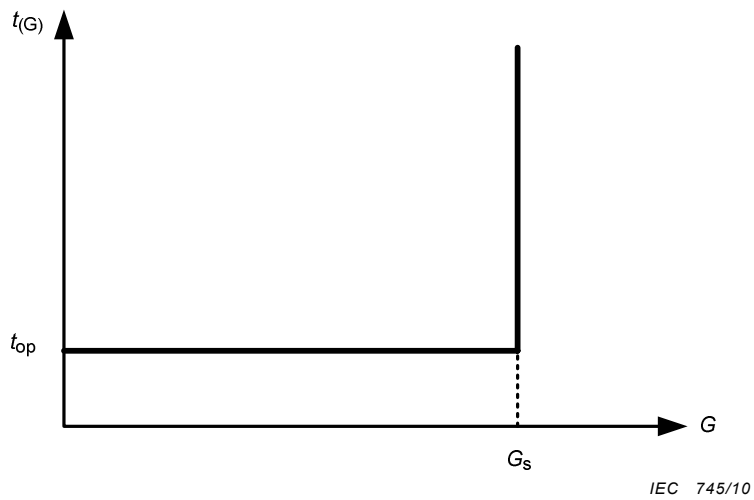

Figure 3 – Undervoltage independent time characteristic

4.4.1.3 Standard dependent time characteristics

For overvoltage protection, the characteristic curves of dependent time relays shall follow a law of the form:

$$t_{(G)} = \frac{T}{\left(\frac{G}{G_S}\right) - 1} \qquad (1)$$

where:

$t_{(G)}$ is the theoretical operate time with constant value of G in seconds;

T is the time setting (theoretical operate time for $G = 2 \times G_S$);

G is the measured value of the characteristic quantity;

G_S is the setting value (see 3.3).

This dependent time characteristic is shown in Figure 4.

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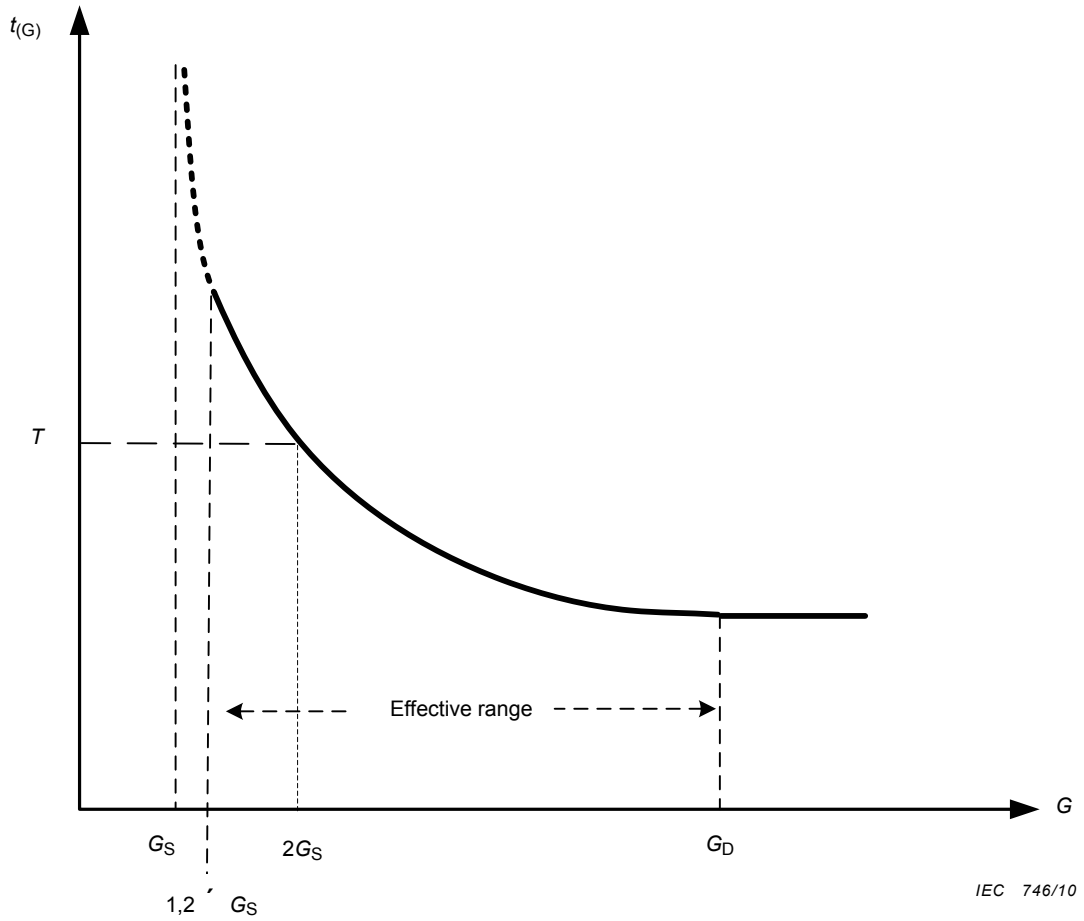

Figure 4 – Dependent time characteristic for overvoltage protection

The effective range of the characteristic quantity for the dependent time portion of the curve shall lie between $1{,}2 \times G_S$ and G_D. The value of G_D shall be stated by the manufacturer for the upper limit of the setting range.

For undervoltage protection, the characteristic curves of dependent time relays shall follow a law of the form:

$$t_{(G)} = \frac{T}{1 - \left(\frac{G}{G_S}\right)} \qquad (2)$$

where:

$t_{(G)}$ is the theoretical operate time in seconds with constant value of G;

T is the time setting (theoretical operate time for $G = 0$);

G is the measured value of the characteristic quantity;

G_S is the setting value (see 3.3).

This dependent time characteristic is shown in Figure 5.

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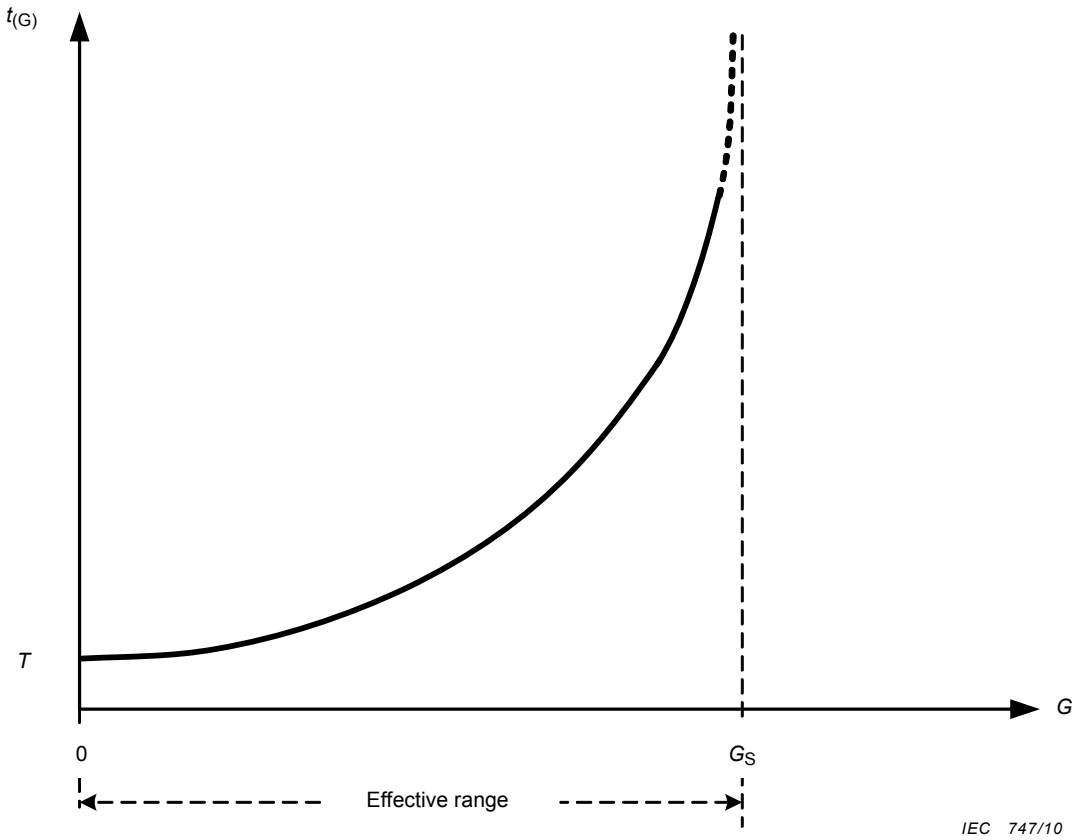

Figure 5 – Dependent time characteristic for undervoltage protection

The effective range of the dependent time portion of the characteristic quantity shall lie between 0 and G_S.

Power system fault conditions can produce time varying voltages. To ensure proper coordination between dependent time relays under such conditions, relay behaviour shall be of the form described by the integration given by Equation 3.

For $G > G_S$ (overvoltage protection) or $G < G_S$ (undervoltage protection):

$$\int_0^{T_0} \frac{1}{t(G)} dt = 1 \qquad (3)$$

where:

T_0 is the theoretical operate time where G varies with time;

t(G) is the theoretical operate time with constant value of G in seconds;

G is the measured value of the characteristic quantity.

Operate time is defined as the time instant when the integral in Equation 3 becomes equal to or greater than one.

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4.4.2 Reset characteristics

4.4.2.1 General

To allow users to determine the behaviour of the relay in the event of repetitive intermittent faults or for faults which may occur in rapid succession, relay resetting characteristics shall be defined by the manufacturer. The recommended reset characteristics are defined below.

4.4.2.2 No intentional delay on reset

For undervoltage relays, for G > (reset ratio) × G_S, the relay shall return to its reset state with no intentional delay. This reset option can apply to both dependent and independent time relays.

For overvoltage relays, for G < (reset ratio) × G_S, the relay shall return to its reset state with no intentional delay. This reset option can apply to both dependent and independent time relays.

4.4.2.3 Definite time resetting

This reset characteristic is applicable to overvoltage and undervoltage protection. Here the definite time reset is described for an overvoltage protection. The principle is the same for an undervoltage protection.

For G < (reset ratio) × G_S, the relay shall return to its reset state after a user-defined reset time delay, t_r. During the reset time, the element shall retain its state value as defined by $\int_0^{t_P} \frac{1}{t(G)} dt$ with t_P being the transient period during which $G > G_S$. If during the reset time period, the characteristic quantity exceeds G_S, the reset timer t_r, is immediately reset to zero and the element continues normal operation starting from the retained value.

Following $G > G_S$ for a cumulative period causing relay operation, the relay shall maintain its operated state for the reset time period after the operating quantity falls below G_S as shown in Figure 6. Alternatively, the relay may return to its reset state with no intentional delay as soon as the operating quantity falls below G_S after tripping as shown in Figure 7.

This reset option can apply to both dependent and independent time elements. A graphical representation of this reset characteristic is shown in Figures 6 and 7, for partial and complete operation of the element.

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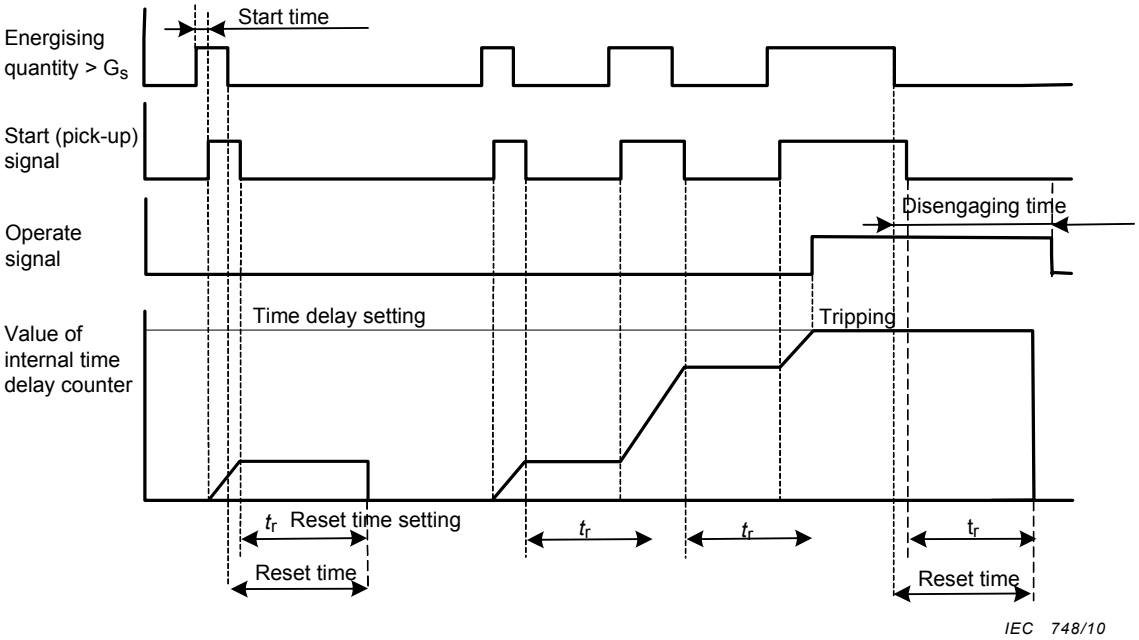

Figure 6 – Definite time reset characteristic

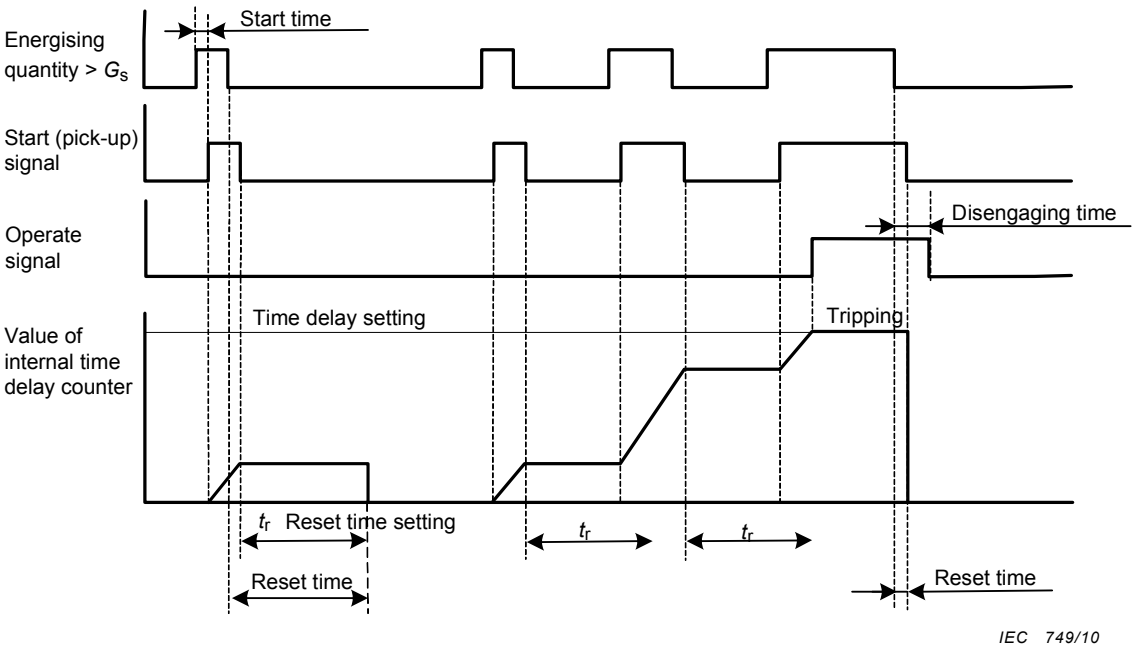

Figure 7 – Definite time reset characteristic
(alternative solution with instantaneous reset after relay operation)

4.5 Binary output signals

4.5.1 Start (pick-up) signal

The start signal is the output of measuring and threshold elements, without any intentional time delay. If start signal is not provided, the manufacturer shall give information on how to conduct testing related to start signal as defined in Clause 6.

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4.5.2 Operate (trip) signal

The operate signal is the output of measuring and threshold elements, after completion of any intentional operating time delay. In the case of instantaneous elements, this signal may occur at the same time as the start signal (if provided).

4.5.3 Other binary output signals

If any other binary output signals are available for use, their method of operation shall be clearly shown on the functional logic diagram. Additional textual description may also be provided if this can further clarify the functionality of the output signal and its intended usage.

5 Performance specification

5.1 Accuracy related to the characteristic quantity

For both independent and dependent time relays, the accuracy and the reset ratio related to the characteristic quantity shall be declared by the manufacturer.

For both dependent and independent time relays, the manufacturer shall declare the accuracy related to the characteristic quantity along with a setting value range over which it is applicable.

5.2 Accuracy related to the operate time

For independent time relays, the maximum permissible error of the specified operate time shall be expressed as either:

- a percentage of the time setting value, or;
- a percentage of the time setting value, together with a fixed maximum time error (where this may exceed the percentage value), whichever is greater. For example, ±5 % or ±20 ms whichever is greater, or;
- a fixed maximum time error

For dependent time relays, the reference limiting error is identified by an assigned error declared by the manufacturer. For relays with a decreasing time function, the value of the assigned error shall be declared at the maximum limit of the effective range of the dependent time portion of the characteristic (G_D) as a percentage of the theoretical time. The reference limiting error shall be declared either as:

- a theoretical curve of time plotted against multiples of the setting value of the characteristic quantity bounded by two curves representing the maximum and minimum limits of the limiting error over the effective range of the dependent time portion of the characteristic or,
- an assigned error claimed for the effective range of the dependent time portion of the characteristic of the characteristic quantity.

For both dependent and independent time relays, the manufacturer shall declare the maximum limiting error related to the operate time along with a setting range of time delay over which it is applicable.

The manufacturer shall declare if the internal measurement time of the characteristic quantity and the output contact operation time is included in the time delay setting or it is in addition to the time delay setting.

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