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BSI Standards Publication

Measuring relays and protection equipment

Part 127: Functional requirements for over/under voltage protection

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National foreword

This British Standard is the UK implementation of EN 60255-127:2014. It is identical to IEC 60255-127:2010. Together with BS EN 60255-151:2009 it supersedes BS EN 60255-3:1998, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/95, Measuring relays and protection systems.

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(IEC 60255-127:2010)

Relais de mesure et dispositifs de protection - Partie 127: Exigences fonctionnelles pour les protections à minimum et maximum de tension (CEI 60255-127:2010)

Messrelais und Schutzeinrichtungen - Teil 127: Funktionsnorm für Über- /Unterspannungsschutz (IEC 60255-127:2010)

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Foreword

The text of document 95/254/CDV, future edition 1 of IEC 60255-127, prepared by IEC/TC 95 "Measuring relays and protection equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60255-127:2014.

The following dates are fixed:

– latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-07-10
– latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-09-19

This document supersedes EN 60255-3:1998.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60255-127:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61850	NOTE	Harmonized in EN 61850 series.
IEC 61850-7-4	NOTE	Harmonized as EN 61850-7-4.
IEC 61850-9-2	NOTE	Harmonized as EN 61850-9-2.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60044	series	Instrument transformers	EN 60044	series
IEC 60255-1	-	Measuring relays and protection equipment Part 1: Common requirements	EN 60255-1	-

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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

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

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.

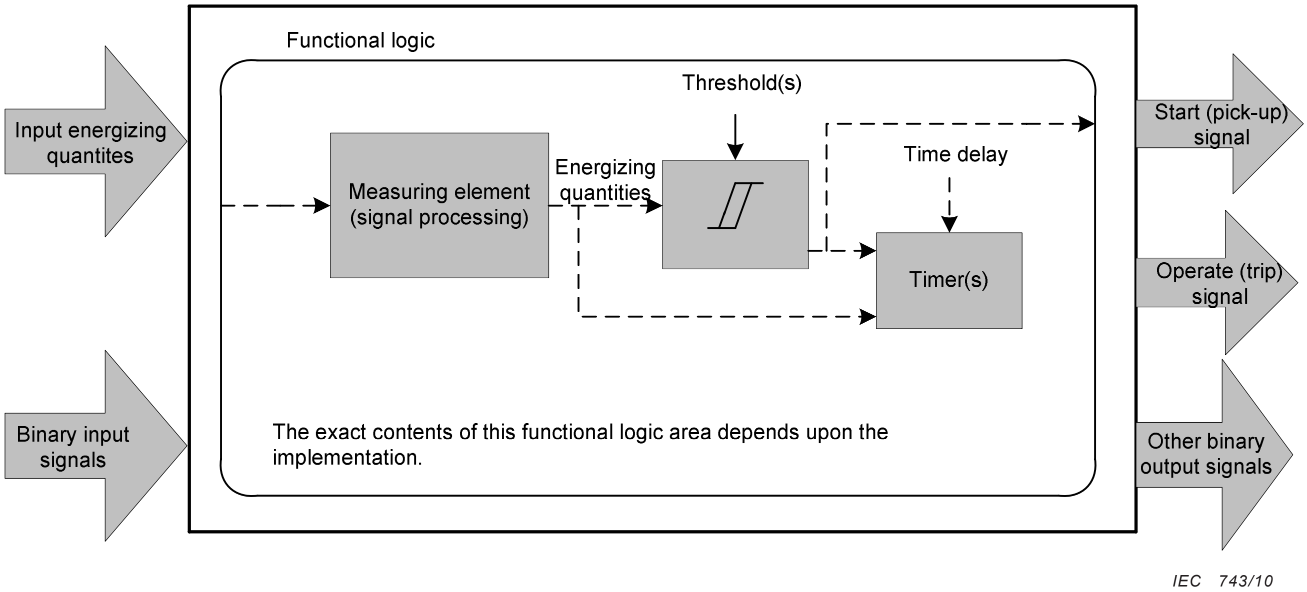

Figure 1 – Simplified protection function block diagram

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;

- 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.

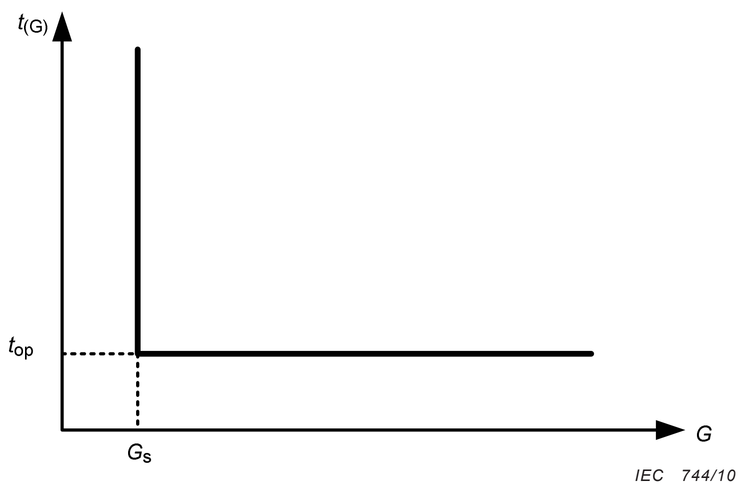

Figure 2 – Overvoltage independent time characteristic

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

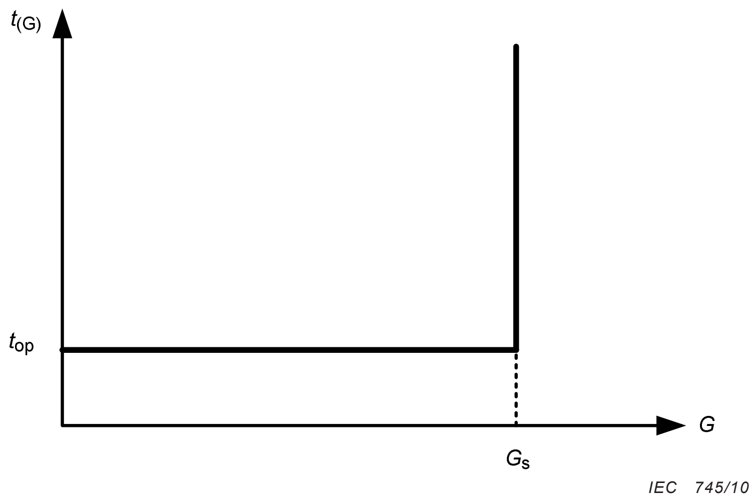

Figure 3 – Undervoltage independent time characteristic

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:

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

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.

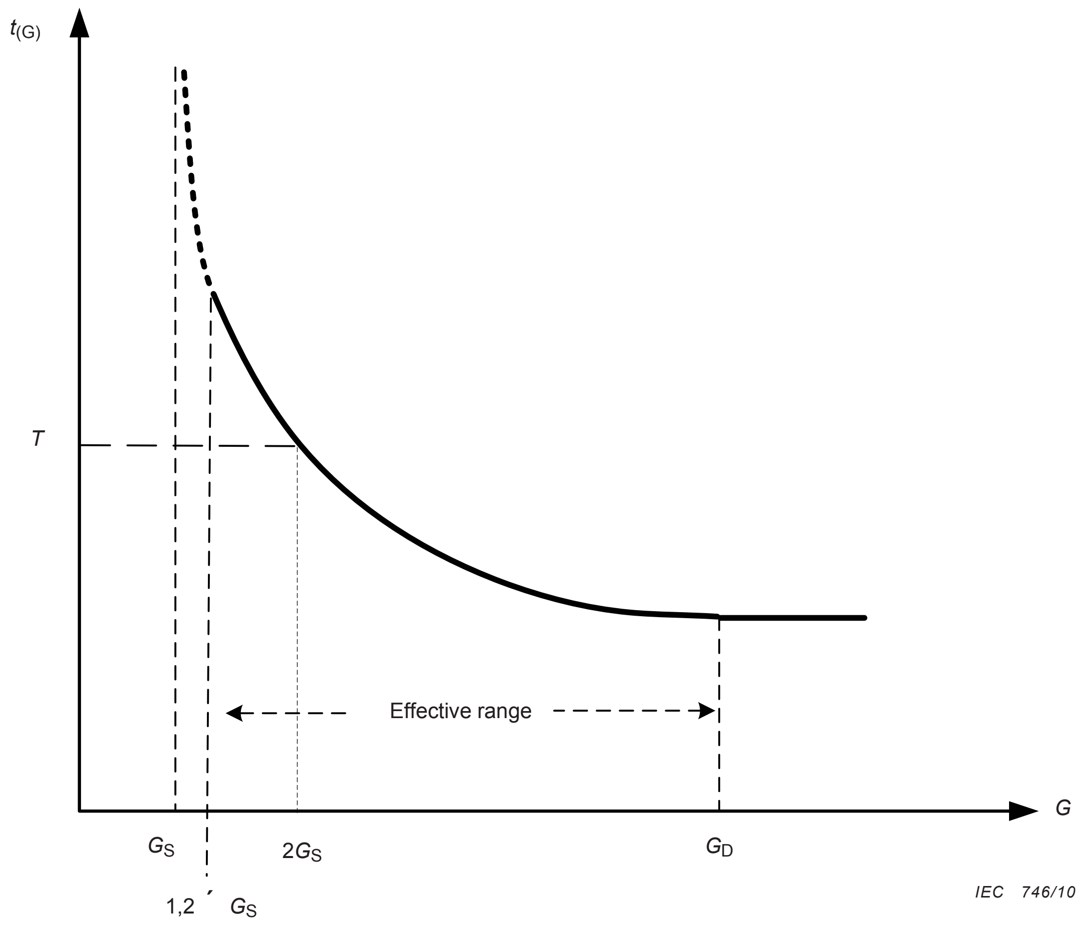

Figure 4 – Dependent time characteristic for overvoltage protection

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:

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

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.

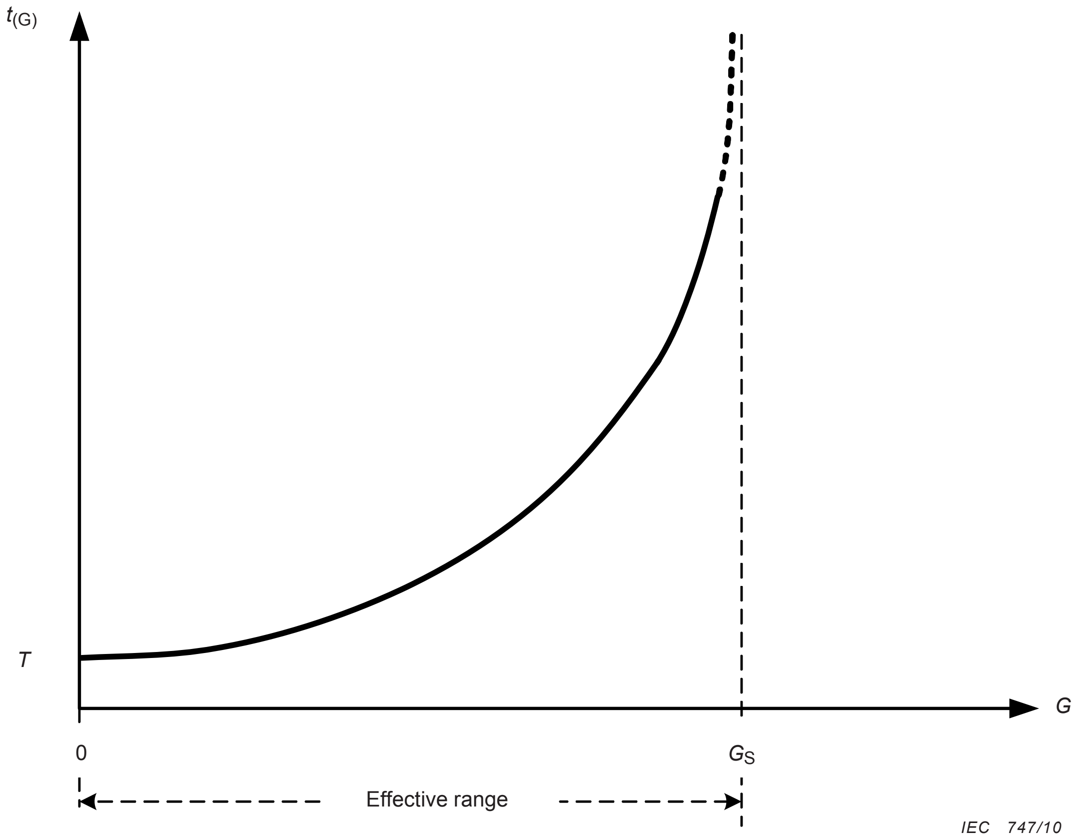

Figure 5 – Dependent time characteristic for undervoltage protection

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.

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) $\times G_S$, 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) $\times G_S$, 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) $\times G_S$, 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.

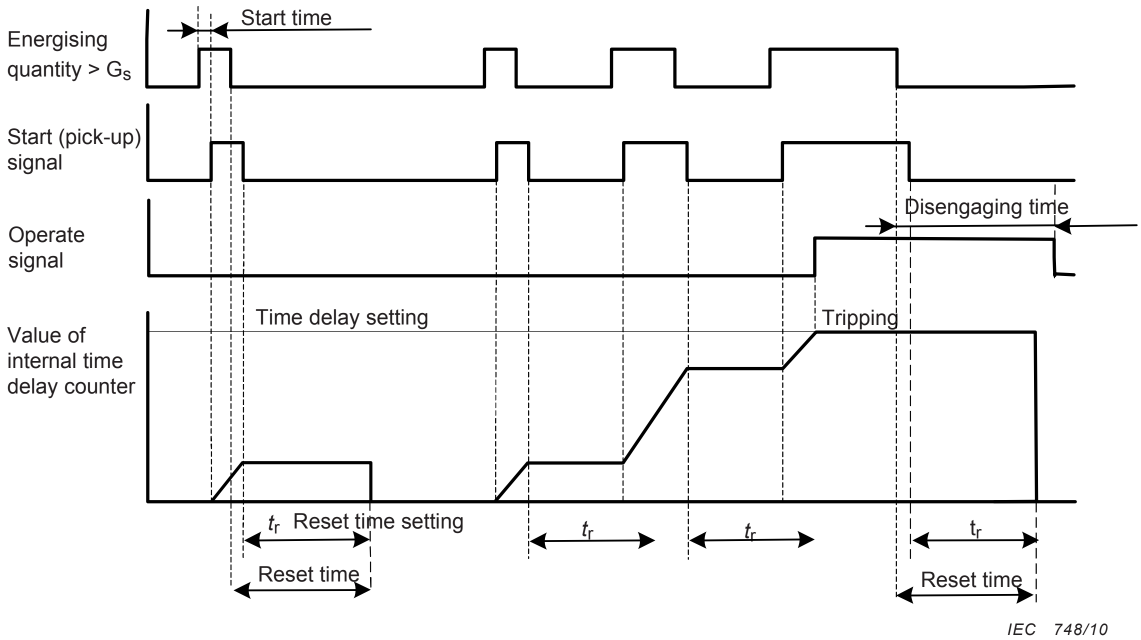

Figure 6 – Definite time reset characteristic

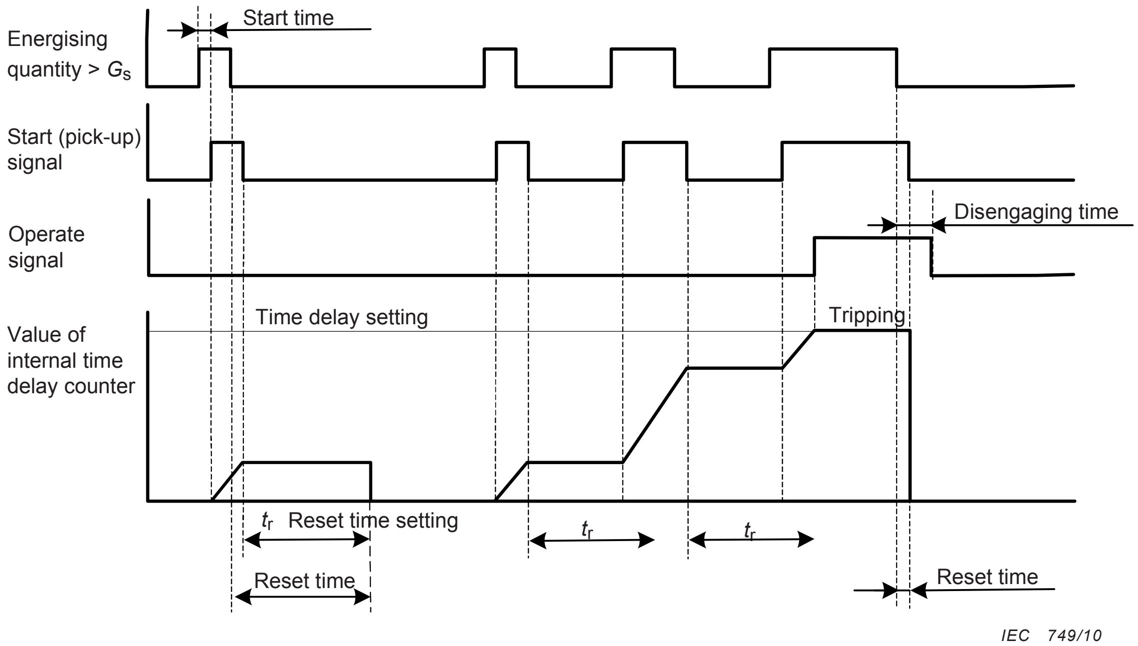

Figure 7 – Definite time reset characteristic (alternative solution with instantaneous reset after relay operation)

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.

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.

5.3 Accuracy related to the reset time

For relays with no intentional reset delay, the manufacturer shall declare the reset time of the element.

For relays with a definite time delay on reset, the maximum permissible error of the specified reset time shall be expressed as either:

- a percentage of the reset time setting value, or;
- a percentage of the reset 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.

The manufacturer shall declare the maximum limiting error related to the reset time along with a setting range of time delay over which it is applicable.

The manufacturer shall declare if the internal measurement time (disengaging time) is included in the reset time setting or it is in addition to the reset time setting.

5.4 Transient performance

5.4.1 Overshoot time

The manufacturer shall declare the overshoot time.

5.4.2 Response to time varying value of the characteristic quantity

To ensure proper coordination with dependent time relays, the relay performance under time varying fault conditions (characteristic quantity varies with time) shall be tested. The manufacturer shall declare any additional errors, but in all cases, the additional error shall be less than 15 %.

5.5 Voltage transformer requirements

The manufacturer shall declare the types of the voltage transformers required to maintain the claimed performance levels (refer to IEC 60044 series standards).

6 Functional test methodology

6.1 General

Tests described in this clause are for type tests. These tests shall be designed in such a way to exercise all aspects of the hardware and firmware (if applicable) of the over/under voltage protection relay. This means that injection of voltage shall be at the interface to the relay, either directly into the conventional voltage transformer input terminals, or an equivalent signal at the appropriate interface. Similarly, operation shall be taken from output contacts wherever possible or equivalent signals at an appropriate interface.

If for any reason it is not possible to measure the results from signal input to output, the point of application of the characteristic quantity and the signal interface used for measurement shall be declared by the manufacturer. For relays where the settings are in primary values one voltage transformer ratio can be selected for performing the tests.

In order to determine the accuracy of the relay in steady state conditions, the injected characteristic quantity shall be a sinusoid of rated frequency and its magnitude should be varied according to the test requirements.

Some of the tests described in the following subclauses can be merged to optimize the test process. Depending upon the technology of the relay being tested, it may be possible to reduce the number of test points in line with the limited range and step-size of available settings. However, the test points listed should be used or the nearest available setting if the exact value can not be achieved.

In the following subclauses, the test settings to be used are expressed in a percentage of the available range with 0 % representing the minimum available setting and 100 % representing the maximum available setting. Similarly 50 % would represent the mid-point of the available setting range. The actual setting to be used can be calculated using the following formula:

$$S_{AV} = (S_{MAX} - S_{MIN}) \cdot X + S_{MIN}$$

where

S_{AV} is the actual setting value to be used in test;

S_{MAX} is the maximum available setting value;

S_{MIN} is the minimum available setting value;

X is the test point percentage value expressed in test methodology (see Tables 1, 2, 3, and 4).

For example, for the operating voltage setting in Table 1, assuming the available setting range is 60 V to 180 V, the actual operating voltage settings to be used would be: 60 V; 120 V; 180 V.

6.2 Determination of steady state errors related to the characteristic quantity

6.2.1 Accuracy of setting (start) value

In order to determine the accuracy of the setting value (G_S) the characteristic quantity (magnitude) should be varied slowly and the start output of the element monitored for operation.

For overvoltage protection, the characteristic quantity shall be increased according to the criteria below:

- the initial value of the characteristic quantity shall be below the setting value by at least two times the specified accuracy of the element;
- the ramping steps shall be at least ten times smaller than the accuracy specified for the element;
- the step time shall be at least two times the specified start time and not more than five times the specified start time.

For example:

If the setting value is 100 V, accuracy ±10 % and start time 20 ms, the initial ramp start value is 80 V, ramp step size of 1 V with a step time of (40 – 100) ms.

For undervoltage protection, the characteristic quantity shall be decreased from an initial value which is above the start value by at least two times the specified accuracy of the element. The ramping process is similar to the overvoltage protection.

Sufficient test points should be used to assess the performance over the entire setting range of the element, but as a minimum ten settings shall be used, with a concentration towards lower start settings where errors are relatively more significant. Preferred values are: minimum setting (or 0 % of the range); 0,5 %; 1 %; 2 %; 3 %; 5 %; 10 %; 30 %; 60 %; maximum setting (or 100 % of the range).

For overvoltage and undervoltage relays, each test point shall be repeated at least 5 times to ensure repeatability of results, with the maximum and average error values of all the tests being used for the accuracy claim.

6.2.2 Reset ratio determination

In order to determine the reset ratio, the element shall be forced to operate and then the characteristic quantity should be varied slowly while monitoring the output of the element with no intentional delay on reset. For overvoltage protection, the characteristic quantity shall be decreased according to the criteria below:

- the initial value of the characteristic quantity shall be above the start value by at least two times the specified accuracy of the element;
- the ramping steps shall be at least ten times smaller than the accuracy specified for the element;
- the step time shall be at least two times the specified disengaging time and not more than five times the specified disengaging time.

If reset does not occur within the time interval, the element is considered to have not reset and, the next lower value of voltage shall be used.

For example

If the setting value is 100 V, accuracy ±10 % and disengaging time 20 ms, the initial ramp start value is 120 V, ramp step size of 1 V with a step time of (40 to 100) ms.

For undervoltage protection, the characteristic quantity shall be increased from an initial value which is below the start value by at least two times the specified accuracy of the element. The ramping process is similar to the overvoltage protection.

The reset ratio shall be calculated as follows:

$$\textit{Reset ratio}\ (\%) = (V_{\mathrm{reset}}/V_{\mathrm{start}}) \times 100$$

Sufficient test points should be used to assess the performance over the entire setting range of the element, but as a minimum ten settings shall be used, with a concentration towards lower start settings where errors are relatively more significant. Preferred values are: minimum setting (or 0 % of the range); 0,5 %; 1 %; 2 %; 3 %; 5 %; 10 %; 30 %; 60 %; maximum setting (or 100 % of the range).

For overvoltage relay, each test point shall be repeated at least 5 times to ensure repeatability of results, with the minimum and average values of all the tests being used for the accuracy claim.

For undervoltage relay, each test point shall be repeated at least 5 times to ensure repeatability of results, with the maximum and average values of all the tests being used for the accuracy claim.

6.3 Determination of steady state errors related to the start and operate time

In order to determine the steady state errors of the operate time, voltage shall be applied to the relay with no intentional delay and the start and operate output contacts of the element monitored. The switching point of the voltage from initial test value to end test value shall be at the zero crossing of the waveform. Tests shall be conducted on an individual phase basis. Sufficient test points should be used to assess the performance over the entire time delay setting range, at various operating voltage values and throughout the effective range of the dependent time portion of the characteristic. Each test point shall be repeated at least 5 times to ensure the repeatability of results, with the maximum and average value of the 5 attempts being used for the analysis. The times recorded for the operate output contact will provide a measure of the operating time accuracy, whilst the times recorded for the start output contact provides a measure of element start time. The following test points, Table 1 for overvoltage and Table 2 for undervoltage elements, are suggested:

Table 1 – Test points for overvoltage elements

Time setting	Operating voltage setting	Initial test voltage value	End test voltage value [a]
Minimum (0 %)	Minimum (0 %)	Zero	1,2 × G_S
50 %	50 %	Zero	1,6 × G_S
Maximum (100 %)	Maximum (100 %)	Zero	2 × G_S

[a] The end test voltage value shall be limited to the maximum withstand voltage.

Table 2 – Test points for undervoltage elements

Time setting	Operating voltage setting	Initial test voltage value [b]	End test voltage value
Minimum (0 %)	Minimum (0 %) [a]	2 × G_S	0,8 × G_S
50 %	50 %	2 × G_S	0,4 × G_S
Maximum (100 %)	Maximum (100 %)	2 × G_S	Zero

[a] Some relays may block operation of the undervoltage element when injected voltage is equal to zero, or below threshold. In this case, the zero test cases shall be replaced with a test at the minimum voltage threshold.

[b] The initial test voltage value shall be limited to the maximum withstand voltage.

6.4 Determination of steady state errors related to the reset time

In order to determine the steady state errors of the reset time, voltage shall be applied to the relay to cause element operation. With operation complete, the voltage applied to the relay shall be stepped to the initial test voltage value for one second, and then stepped to the end test voltage value with no intentional delay and a suitable output contact of the element monitored. If an output contact is not available, then the procedure described in Annex A can be applied to determine the reset time of the relay.

Sufficient test points should be used to assess the performance over the entire reset time setting range, at various operating voltage values and throughout the effective range of the dependent time portion of the characteristic. Each test point shall be repeated at least 5 times to ensure the repeatability of results, with the maximum and average value of the 5 attempts being used for the analysis. The times recorded by monitoring the start contact will provide a measure of the disengaging time of the element, while other suitable signals shall be used to give a measure of the reset time accuracy. The following test points, Table 3 for overvoltage elements and Table 4 for undervoltage elements, are suggested:

Table 3 – Test points for overvoltage elements

Reset time setting [b]	Operating voltage setting	Initial test voltage value [a]	End test voltage value
Minimum (0 %)	Minimum (0 %)	$2 \times G_S$	$0,8 \times G_S$
50 %	50 %	$2 \times G_S$	$0,4 \times G_S$
Maximum (100 %)	Maximum (100 %)	$2 \times G_S$	Zero

[a] The initial test voltage value shall be limited to the maximum withstand voltage.

[b] The first column is not applicable to relays with no intentional delay on reset.

Table 4 – Test points for undervoltage elements

Reset time setting [b]	Operating voltage setting	Initial test voltage value	End test voltage value [a]
Minimum (0 %)	Minimum (0 %) [c]	Zero	$1,2 \times G_S$
50 %	50 %	Zero	$1,6 \times G_S$
Maximum (100 %)	Maximum (100 %)	Zero	$2 \times G_S$

[a] The end test voltage value shall be limited to the maximum withstand voltage.

[b] The first column is not applicable to relays with no intentional delay on reset.

[c] Some relays may block operation of the undervoltage element when injected voltage is equal to zero, or below threshold. In this case, the zero test cases shall be replaced with a test at the minimum voltage threshold.

6.5 Determination of transient performance

6.5.1 Overshoot time for undervoltage protection

This subclause describes the test for overshoot time for undervoltage protection function. The overshoot time is generally not relevant for overvoltage function.

With the relay setting at reference conditions (nominal voltage), voltage shall be switched from $1,2 \times G_S$ to $0,8 \times G_S$, and the relay operate time shall be measured as a maximum value out of 5 attempts. With this known operating time value, the voltage shall be switched from $1,2 \times G_S$ to $0,8 \times G_S$ for a period of time 5 ms less than the maximum operate time and then increased to $1,2 \times G_S$ with no intentional delay. If relay operation occurs, the period of time for which the voltage is removed shall be reduced by a further 5 ms, and the test shall be performed again. The time of voltage removal shall be decreased further until 5 successive removal of voltage do not cause the relay to operate.

The difference in time between the voltage removal period and the measured relay operate time is the relay overshoot time.

6.5.2 Response to time varying value of the characteristic quantity for dependent time relays

The test waveform of the characteristic quantity is shown in Figure 8, which represents a 50 Hz or 60 Hz waveform modulated by a square wave so that the changes in magnitude of the sine-wave occur at zero crossings.

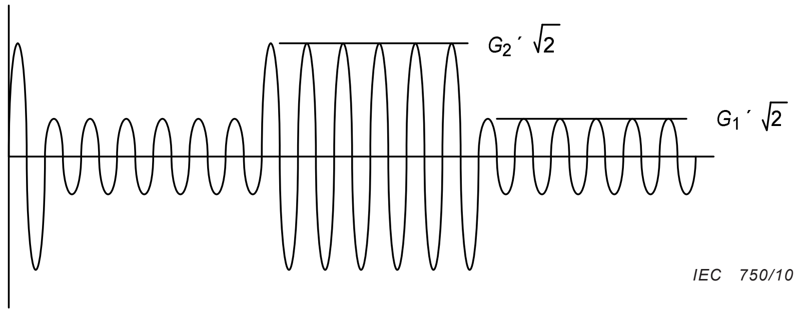

Figure 8 – Test waveform

The frequency of the modulating square-wave shall not be higher than 1/10 of the main frequency, so that the transient behaviour of the relay does not affect the operate time.

The magnitudes G_1 and G_2 of the characteristic quantity are both above G_S, the setting value of the characteristic quantity. The magnitudes are selected so that the operate time of the relay is high with respect to the period of the modulating square wave.

With the above conditions, the theoretical operate time T_0 is:

$$T_0 = \frac{2 \cdot T_1 \cdot T_2}{T_1 + T_2} \qquad (4)$$

where

T_1 is the operate time for characteristic quantity equal to G_1;

T_2 is the operate time for characteristic quantity equal to G_2.

Recommended values for the time varying characteristic quantity are given in Table 5, where the frequency of the modulating square-wave is 1/10 of the main frequency. With values of Table 5, the measured operate time shall not differ from T_0 by more than 15 %.

Table 5 – Recommended values for the test

Curve	T s	G_1	G_2	T_1 s	T_2 s	T_0 s
Overvoltage	10	1,2 × G_S	1,5 × G_S	50	20	28,57
Undervoltage	10	0,5 × G_S	0,2 × G_S	20	12,5	15,39
NOTE T is the time delay setting (see Equations (1) and (2)).						

7 Documentation requirements

7.1 Type test report

The type test report for the functional elements described in this standard shall be in accordance with IEC 60255-1. As a minimum the following aspects shall be recorded:

- equipment under test: this includes details of the equipment / function under test as well as specific details such as model number, firmware version shall be recorded as applicable;
- test equipment: equipment name, model number, calibration information;

- functional block diagram showing the conceptual operation of the element including interaction of all binary input and output signals with the function;
- details of the input energising quantity and the type of measurement being used by the function;
- details of the available characteristic curves/operation for both operating and reset states that have been implemented in the function, preferably by means of an equation;
- details of the behaviour of the function for voltages in excess of G_D, and its value;
- details of any specific algorithms that are implemented to improve the applicability of this function to a real power system, and their performance claims. In the case of generic algorithms that are used by more than one function, for example voltage transformer supervision, it is sufficient to describe the operation of the algorithm once within the user documentation but its effect on the operation of all functions that use it shall be described;
- test method and settings: these include details of the test procedure being used as well as the settings that are applied to the equipment under test to facilitate the testing. This may include settings other than those for the function being tested. This permits repeat testing to be performed with confidence that the same test conditions are being used;
- test results: for every test case outlined in the test method and settings, the complete sets of results are recorded as well as a reference to the particular test case. From these results, accuracy claims are established;
- test conclusions: based upon the recorded test results, all claims required by Clause 5 of this standard shall be clearly stated. Where appropriate, these claims are compared with the performance specifications contained in this standard to allow individual pass / fail decisions to be given, as well as an overall pass / fail decision for the entire function.

7.2 Other user documentation

Not all users insist on viewing the complete type test documentation, but require a subset of the information that it contains. For this purpose, as a minimum the following aspects shall be recorded in generally available user documentation, although this may not be required in a single document:

- functional block diagram showing the conceptual operation of the element including interaction of all binary input and output signals with the function;
- details of the input energising quantity and the type of measurement being used by the function;
- details of the available characteristic curves/operation for both operating and reset states that have been implemented in the function, preferably by means of an equation;
- details of the behaviour of the function for voltages in excess of G_D, and its value;
- details of any specific algorithms that are implemented to improve the applicability of this function to a real power system, and their performance claims. In the case of generic algorithms that are used by more than one function, for example voltage transformer supervision, it is sufficient to describe the operation of the algorithm once within the user documentation but its effect on the operation of all functions that use it shall be described;
- all claims required by Clause 5 of this standard shall be clearly stated.

Annex A
(informative)

Reset time determination for relays with trip output only

A.1 General

Measuring relays and protection equipment have different output configurations. For equipment that has only a trip output the determination of a dependent reset time can be achieved by many different methods. The following article describes an example of such a test method.

A.2 Test method

The determination of the reset time for relays without an appropriate contact can be achieved using the following method to determine a basic accuracy of the reset time. A voltage of twice setting (or the maximum allowed if twice the voltage is more than the maximum allowed) is applied to the relay for a pre-determined length of time such that the unit does not operate but has reached 90 % of its trip value. The voltage is then reduced instantaneously to a pre-determined value below setting for a fixed time. After this time has elapsed, the voltage is instantaneously increased to twice setting value until the element trips. The trip time is determined based on the value of the internal integrator. This is shown graphically in Figure A.1. The test method is repeated with the applied voltage being reduced to a different value on each occasion. This generates a range of trip times from which the reset times can be extrapolated and with sufficient points a reset curve can be created.

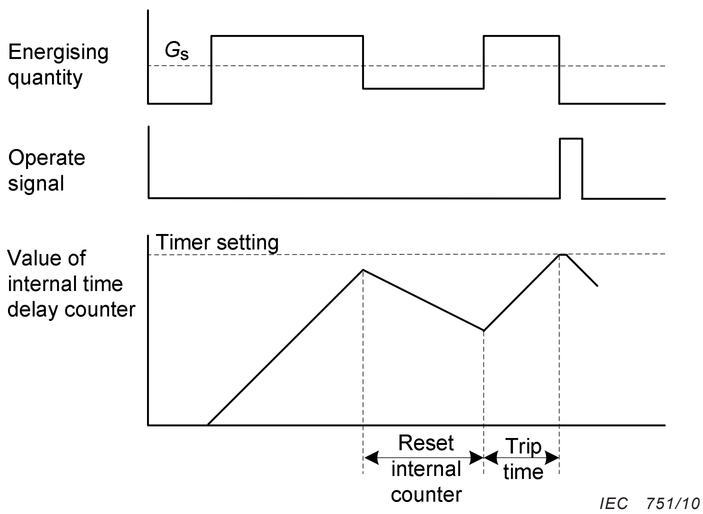

Figure A.1 – Dependent reset time determination

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