IEC 60255-151

Edition 1.0 2009-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Measuring relays and protection equipment – Part 151: Functional requirements for over/under current protection

Relais de mesure et dispositifs de protection – Partie 151: Exigences fonctionnelles pour les protections à minimum et maximum de courant

IEC 60255-151:2009

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX V

ICS 29.120.70
ISBN 978-2-88910-078-1

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 151: Functional requirements for over/under current protection

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60255-151 has been prepared by IEC technical committee 95: Measuring relays and protection equipment.

This first edition cancels and replaces IEC 60255-3, published in 1989.

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

FDIS	Report on voting
95/255/FDIS	95/258/RVD

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, published under the general title *Measuring relays and protection equipment*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 151: Functional requirements for over/under current protection

1 Scope and object

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

This part of IEC 60255 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 current functions covered by this standard are the following:

	IEEE/ANSI C37.2 Function Numbers	IEC 61850-7-4 Logical nodes
Instantaneous phase overcurrent protection	50	PIOC
Time delayed phase overcurrent protection	51	PTOC
Instantaneous earth fault protection	50N/50G	PIOC
Time delayed earth fault protection	51N/51G	PTOC
Negative sequence overcurrent or current unbalance protection	46	PTOC
Phase undercurrent protection	37	PTUC
Voltage-dependent overcurrent protection	51V	PVOC

This standard excludes thermal electrical relays as specified in IEC 60255-8. 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 60050-447, *International Electrotechnical Vocabulary – Part 447: Measuring relays*

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 definitions 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 versus 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
reference value used for the definition of the theoretical curve of time versus characteristic quantity

3.4
threshold value of the characteristic quantity
G_T
lowest value and highest value for dependent time overcurrent and undercurrent relays, respectively, of the input quantity for which the relay is guaranteed to operate

3.5
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

3.6
operate 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 relay operates

[IEV 447-05-05]

3.7
disengaging time
duration of the time interval between the instant a specified change is made in the value of input energizing quantity which will cause the relay to disengage and instant it disengages

[IEV 447-05-10, modified]

3.8
reset time
duration of the time interval between the instant when the characteristic quantity of the measuring relay in operate condition is changed, under specified conditions, and the instant when the relay resets

[IEV 447-05-06]

3.9
overshoot time
difference between the operate time of the relay at the specified value of the input energizing quantity and the maximum duration of the value of input energizing quantity which, when suddenly reduced (for the overcurrent relay)/increased (for the undercurrent relay) to a specified value below (for the overcurrent relay)/above(for the undercurrent relay) the setting value is insufficient to cause operation

3.10
time multiplier setting
TMS
setting which describes an adjustable factor that may be provided by a relay manufacturer which is applicable to the theoretical curve of time versus characteristic quantity

NOTE Its purpose is to allow adjustment of the relay operating times. This adjustable *TMS* factor is usually expressed in "per unit". The preferred reference setting of *TMS* for declaration of relay characteristic is 1,0.

3.11
threshold of independent time operation
G_D
value of the characteristic quantity at which the relay operate time changes from dependent time operation to independent time operation

3.12
reset ratio
disengaging ratio
ratio between the point where the relay just ceases to start (start signal changes from ON to OFF) and the actual start current of the element

NOTE It is usually defined as a percentage such that for an overcurrent element the reset ratio is less than 100 % and for an undercurrent element the reset ratio is greater than 100 %.

3.13
transient overreach
measure of the effect of the d.c. component of a waveform on the start signal of the functional element. Generally this d.c. component will result in the relay reaching further than the setting should permit, or specifically in the terms of an overcurrent relay, starting at a value of a.c. current below the set threshold

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.

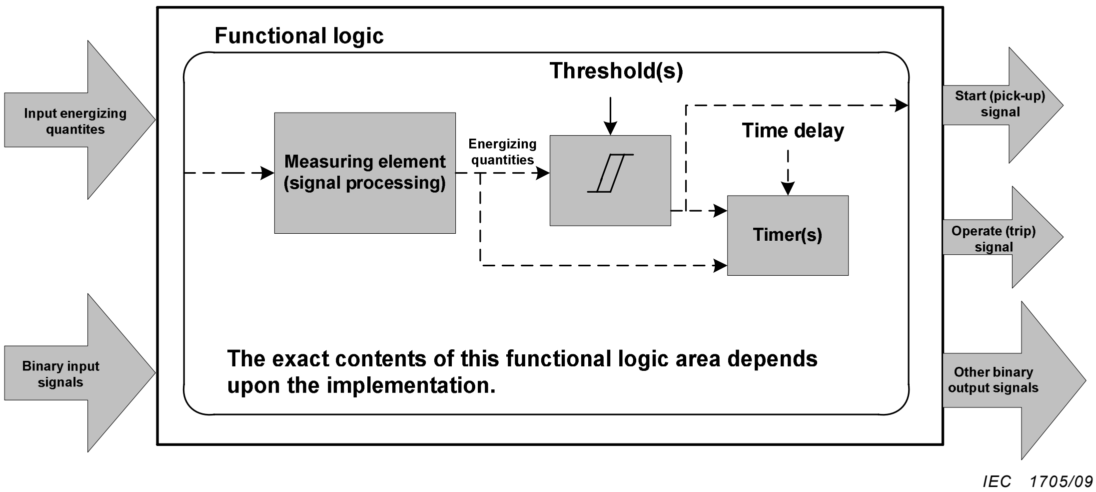

Figure 1 – Simplified protection function block diagram

4.2 Input Energizing quantities / energizing quantities

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

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

- single phase current measurement;
- three phase current measurement;
- neutral current or residual current measurement;
- positive, negative or zero sequence current measurement.

The type of measurement of the energizing 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 energizing 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 overcurrent relays, $t(G) = t_{op}$ when $G > G_S$. The independent time characteristic is presented in Figure 2.

Figure 2 – Overcurrent independent time characteristic

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

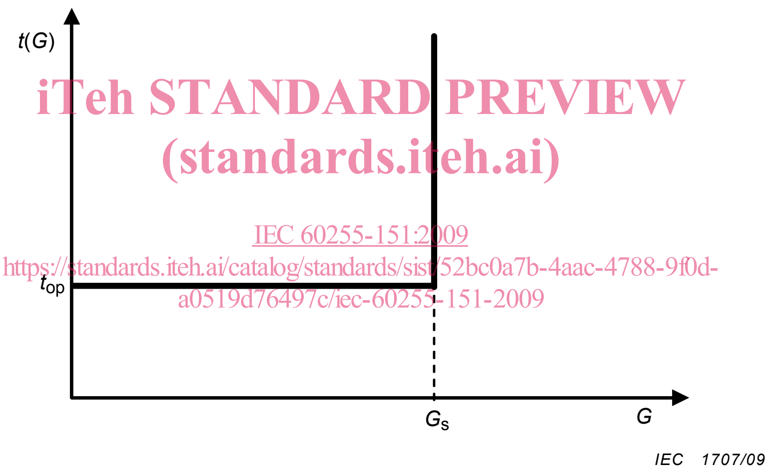

Figure 3 – Undercurrent independent time characteristic

4.4.1.3 Dependent time characteristics

Dependent time characteristics are only defined for overcurrent relays.

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

$$t(G) = TMS\left[\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + c\right] \qquad (1)$$

where

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

k, c, α are the constants characterizing the selected curve;

G is the measured value of the characteristic quantity;

G_S is the setting value (see 3.3);

TMS is the time multiplier setting (see 3.10).

The constants, *k* and *c*, have a unit of seconds, α has no dimension.

The dependent time characteristic is shown in Figure 4.

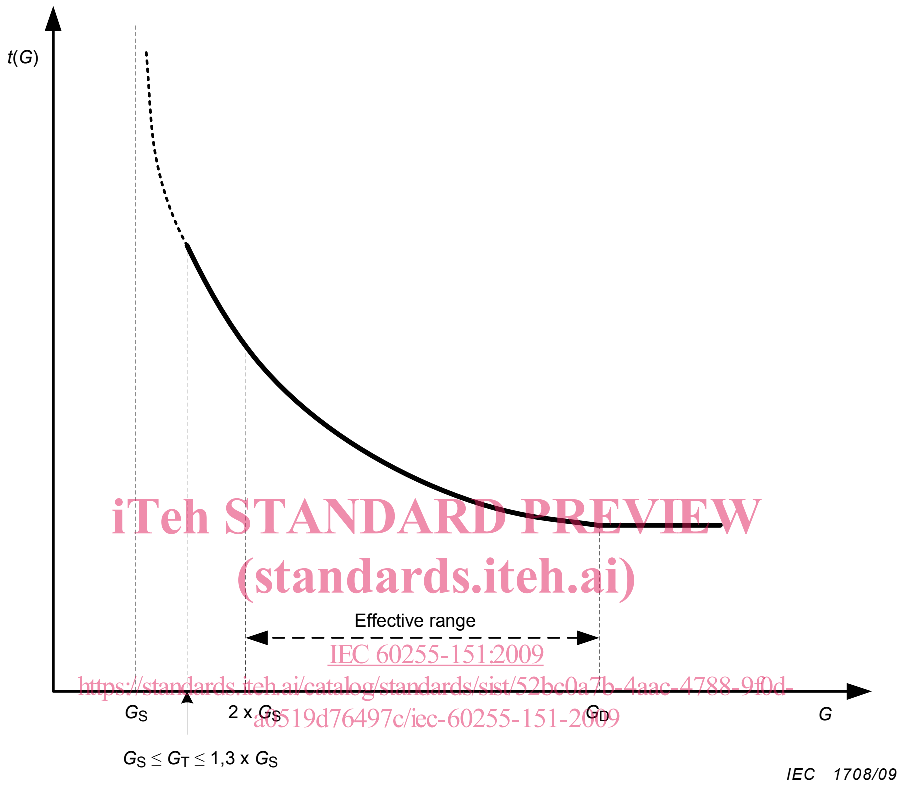

Figure 4 – Dependent time characteristic

The effective range of the characteristic quantity for the dependent time portion of the curve shall lie between 2 × G_S and G_D. The minimum value of G_D is equal to 20 times the setting value G_S. The manufacturer shall declare the setting value range for which this is applicable. For setting values higher than this range, the manufacturer shall declare the value of G_D.

The threshold value G_T is the lowest value of the input energizing quantity for which the relay is guaranteed to operate. G_T lies between G_S and 1,3 × G_S. Its value shall be defined by the manufacturer.

Dependent time relays shall have a definite minimum operate time. This requirement may be defined by assigning a definite time delay for currents above a given energizing quantity level. Alternatively, the manufacturer can make the dependent time relay behaviour to cease for levels of energizing quantity in excess of a specified value (G_D/G_S), as described by the following equation:

For $G > G_D$

$$t(G) = TMS \cdot \left(\frac{k}{\left(\frac{G_D}{G_S} \right)^{\alpha} - 1} + c \right) \qquad (2)$$

where

G_D	is the level of the characteristic quantity at which dependent time operation ceases and independent time operation commences (see 3.11);
$t(G)$	is the theoretical operate time with constant value of G in seconds;
k, c, α	are constants characterizing the selected curve;
G	is the measured value of the characteristic quantity;
G_S	is the setting value (see 3.3);
TMS	is the time multiplier setting (see 3.10).

There are six curves denoted as A, B, C, D, E and F whose coefficients for Equations (1) and (2) shall be from Annex A. The manufacturer shall declare which of these curves are implemented and state the values of G_D and G_T.

Power system fault conditions can produce time varying currents. 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 $G > G_S$

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

where

T_0	is the 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 1.

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 reset characteristics shall be defined by the manufacturer. Different reset characteristics may be used depending upon the settings on the relay and whether the element has completed operation or not. The recommended reset characteristics are defined below.

The manufacturer shall declare if compensation of the internal measurement time (disengaging time) is included in the reset time.

4.4.2.2 No intentional delay on reset

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

4.4.2.3 Definite time resetting

Generally, this reset characteristic is applicable to overcurrent 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 5. 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 6.

This reset option can apply to both dependent and independent time elements. A graphical representation of this reset characteristic is shown in Figures 5 and 6 for partial and complete operation of the element.

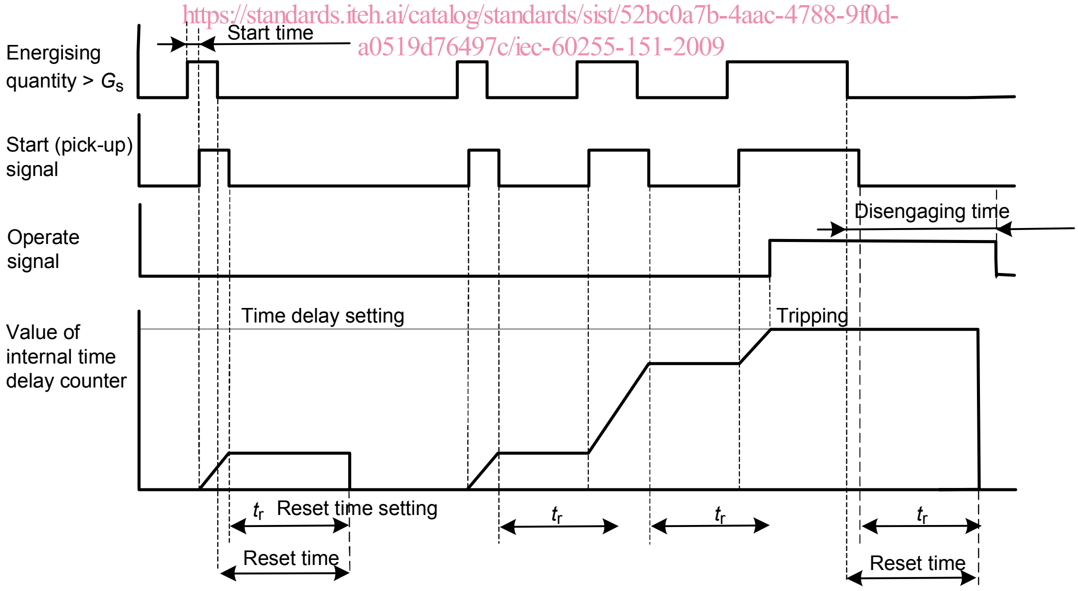

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Figure 5 – Definite time reset characteristic