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Surge protective component application guide – Fuses

Recommendation ITU-T K.140

ITU-T

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Surge protective component application guide – Fuses

Summary

Recommendation ITU-T K.140 describes the types, construction, operation and selection of fuses used in information and communication technology (ICT) and alternating current (AC) powering equipment ports. Series connected fuses and fusible components operate by the fusing of one or more of their elements which opens a connected circuit by breaking the current when it exceeds a given value for a sufficient time. Fuses and fusible components are intended to prevent potential hazards caused by overcurrents. The two main equipment application areas are AC mains ports and ICT ports where AC mains incursion is possible. This Recommendation considers fuse and fusible component types, the electrical stress levels pre- and post-operation and gives circuit examples.

History

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* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/11830-en>.

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Table of Contents

		Page
1	Scope.....	1
2	References.....	1
3	Definitions	1
	3.1 Terms defined elsewhere	1
	3.2 Terms defined in this Recommendation.....	2
4	Abbreviations and acronyms	2
5	Conventions	2
6	Characteristics and ratings.....	2
	6.1 General	2
	6.2 Types and construction.....	2
	6.3 Current-time characteristic	3
	6.4 Operating	4
7	Surge I^2t levels.....	8
	7.1 ICT ports.....	8
	7.2 AC mains ports	9
8	ICT port power fault current levels	11
9	AC mains port continuous current level	11
	Annex A – Fusible resistors	12
	A.1 Fusible resistors	12
	A.2 Pulse absorbing resistors	13
	Appendix I – Resistive component overload performance	15
	I.1 Carbon composition resistors	15
	I.2 Carbon film resistors	16
	Appendix II – Printed Wiring I^2t	18
	II.1 Melting current	18
	Bibliography.....	19

Recommendation ITU-T K.140

Surge protective component application guide - Fuses

1 Scope

This Recommendation covers the types, construction, operation and selection of fuses used in information and communication technology (ICT) and alternating current (AC) powering equipment ports. Particular attention is paid to fuse operation under lightning surge conditions to quantify the I^2t and let-through current to the following electronic circuits.

Information is also provided on the overcurrent performance of fusible resistors, standard resistors and printed circuit board (PCB) traces.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 arc voltage of a fuse [b-IEC 60269-1]: Instantaneous value of the voltage which appears across the terminals of a fuse during the arcing time.

3.1.2 arcing time of a fuse [b-IEC 60269-1]: Interval of time between the instant of the initiation of the arc in a fuse and the instant of final arc extinction in that fuse.

3.1.3 breaking capacity of a fuse [b-IEC 60269-1]: Value of prospective current that a fuse is capable of breaking at a stated voltage under prescribed conditions of use and behaviour.

3.1.4 conventional fusing current [b-IEC 60269-1]: Value of current specified as that which causes operation of the fuse-link within a specified time (conventional time).

3.1.5 conventional non-fusing current [b-IEC 60269-1]: Value of current specified as that which the fuse-link is capable of carrying for a specified time (conventional time) without melting.

3.1.6 current-limiting fuse-link [b-IEC 60269-1]: Fuse-link that during and by its operation in a specified current range, limits the current to a substantially lower value than the peak value of the prospective current.

3.1.7 fuse [b-IEC 60269-1]: Device that by the fusing of one or more of its specially designed and proportioned components opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device.

3.1.8 I^2t ; Joule integral [b-IEC 60269-1]: Integral of the square of the current over a given time interval.

NOTE 1 – The pre-arcing I^2t is the I^2t integral extended over the pre-arcing time of the fuse.

NOTE 2 – The operating I^2t is the I^2t integral extended over the operating time of the fuse.

NOTE 3 – The energy, in joules, released in $1\ \Omega$ of resistance in a circuit protected by a fuse is equal to the value of the operating I^2t expressed in A^2s .

3.1.9 operating time; total clearing time [b-IEC 60269-1]: Sum of the pre-arcing time and the arcing time.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
EMC	Electromagnetic Compatibility
ICT	Information and Communications Technology
PCB	Printed Circuit Board
RMS	Root Mean Square

5 Conventions

None.

6 Characteristics and ratings

6.1 General

There are numerous decisions to be made when selecting a fuse. One of the first is determining what type of current is being interrupted. Special fuses are required for breaking direct current (DC) sources as there isn't any polarity reversal to stop arcing as with AC sources. The electricity supply voltage value is another important factor in fuse selection. Where transients are expected, the fuse characteristic needs to have an I^2t value greater than the expected surge to be resistant to such events. The rated fuse current needs to be greater than the normal system current to avoid nuisance operation. A further item is that the fuse form factor needs to be appropriate for the application. This Recommendation only covers a few of these fuse selection factors. Fuses are a surprisingly complex subject and readers are encouraged to consult reference works, such as [b-Wright] and fuse manufacture resources.

6.2 Types and construction

Fuses are classified into the following three categories: high voltage, low voltage and miniature. The division between high and low voltage occurs at 1000 V AC, and miniature fuses by physical dimensions. Fuses are produced in the following basic forms: cartridge, semi-enclosed, liquid and expulsion. Cartridge fuses form the most common group and may be designed for high voltage, low voltage and miniature applications. Fuses for the protection of electronic equipment are selected from the miniature fuse category, of which there are many types ranging from a few mA to 10 A. Fuses have a tolerance which results in a minimum and maximum fusing current. The minimum fusing current must be greater than the normal system current at all times and the maximum fusing current must be below the following circuit maximum current capability. Miniature fuses are sub-divided into the following categories depending on breaking capacity and speed of operation: FF – super

quick acting; F – quick acting; M – medium time lag; T – time lag and anti-surge; TT – super time lag.

Quick action fuselinks (category F) are constructed with a single wire element of uniform cross-section, which is made from a variety of materials such as silver, copper and its alloys, nickel and nickel-chromium. Low current rated fuselinks are constructed of high resistivity materials, in order to maximise the cross-sectional area. This is an important factor considering that a typical 50-mA fuse, made from nickel- chromium, will have an element diameter of only 0.013 mm. If constructed of silver or copper this diameter would be prohibitively small having very little tensile strength. Low current rated fuses restrict the maximum current due to high resistance, an example of this is a 50-mA fuse which has a typical resistance of 150 Ω .

Super quick-acting fuselinks (category FF) are similar to quick acting fuses but with the addition of a restriction in the element which increases the localised resistance by reducing the cross-sectional area and therefore enhancing the fusing performance by reducing the let-through current to the protected circuit. This type of fuse is used to protect very sensitive electronic components and equipment. However, they are difficult to produce and generally it is more cost effective to use a semiconductor device with a current rating just above the nominal circuit value.

Medium time-lag fuselinks (category M) utilise the "M" effect, which enhances the fusing performance by lowering the minimum fusing level. This is achieved by a silver element with a solder globule deposited centrally on the element. The solder acts on the silver element by diffusing at temperatures above the normal operating level, which reduces the melting point of the silver, by up to 60%, depending on the solder composition. Fuses using the "M" effect are susceptible to ambient temperature affects.

Time-lag fuselinks (category T) are usually constructed with a spirally wound element on an insulated former. The pitch of the turns is maintained within close limits to ensure consistent performance. The wire diameter is larger than the straight wire fuse types to be comparable in resistance due to the longer length. The increase in element mass results in lower temperature rise and consequently slower speed of operation. This type of fuse does not use the "M" effect and therefore is not prone to ambient temperature effects. It can be used in systems up to 70°C without any major degradation to the performance.

Super time-lag fuselinks (category TT) consist of a straight wire element soldered to a coil spring. For use in high ambient conditions the soldered joint must use high melting point solder, to prevent susceptibility to ambient temperatures greater than 50°C. Below 50°C, low melting point solders are used. The operating times depend on the following parameters to control the heat transfer process the specific heats, masses and physical dimensions of the element, spring and solder.

Telecommunication electronic circuit protection fuses are specifically designed and selected from the T and TT categories. They must employ anti-surge properties to withstand the secondary protection surge specifications, as well as being able to clear at low current levels, minimising the let-through current to the equipment.

6.3 Current-time characteristic

A typical set of current time characteristics are shown in Figure 1.