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ITU-T K.30

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(03/93)

PROTECTION AGAINST INTERFERENCE

POSITIVE TEMPERATURE COEFFICIENT (PTC) THERMISTORS

ITU-T Recommendation K.30

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation K.30 was prepared by the ITU-T Study Group V (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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POSITIVE TEMPERATURE COEFFICIENT (PTC) THERMISTORS

(Helsinki, 1993)

1 Foreword

Current-limiting protective devices have been used worldwide to limit currents conducted by telecommunications wiring during faults from nearby power lines and electric traction systems. These devices are non-resetting, typically heat coils or fuses, placed at the Main Distribution Frame (MDF), at the subscriber network interface or inside communication equipment. A new generation of current-limiting devices, PTC thermistors, which are self-restoring, have been introduced and are now in use in a variety of applications worldwide. These devices are based on resistors with positive temperature coefficient. It is believed that availability of performance requirements on these devices would facilitate their application. This Recommendation presents performance parameters for PTC thermistors.

2 Introduction

The purpose of this Recommendation is to provide performance requirements for PTC thermistors to ensure their satisfactory operation in telecommunication networks.

The PTC thermistor is intended for the same application as heat coils or fuses. However, this device is self-restoring; there is no need for replacement after each operation when the device is used within the range of its self-restoring capability. This allows protection systems to be self-restoring for current limiting as well as voltage limiting.

A PTC thermistor is mainly intended to limit overcurrents of relatively long duration and will normally have too slow a response time for switching transients or surges caused by lightning discharges.

PTC thermistors have some characteristics that may limit the use of the device:

- Due to frequency dependence of some PTC thermistors, the transmission in high frequency (tens of MHz) systems might be influenced.
- As series resistance on the a and b conductors, the devices can effect the balance of the line.
- An activated device might still let a small current flow in the circuit. This small current can be high enough to generate too high heat dissipation in other devices like secondary overvoltage protection components if careful coordination is not achieved.
- An activated PTC thermistor may not self-restore on certain communications circuits, which have continuous current flow.

3 Scope

The Recommendation applies to current-limiting devices that address the principles of protection against overcurrents in accordance with Recommendation K.11. The performance parameters described herein are intended as a guide for general-purpose communications circuits. Specific systems, terminal equipment, or environments may have different needs.

4 Performance parameters

4.1 Environment characteristics

PTC thermistors should operate satisfactorily in temperature and humidity ranges selected for the intended application. The selected temperatures should be a designated range that is within the extreme values of –40 °C and +70 °C. The selected humidity range should be up to 95% r.h.

Tests contained in electrical characteristics, subclause 4.2, shall be performed at room temperature of +25 °C. Further testing may be performed at the selected extreme temperatures. However, the response time, the rated current, and the d.c. series resistant characteristics of the device may differ from those specified at room temperature. Each test contained in 4.2 shall be performed on previously untested devices.

4.2 Electrical characteristics

4.2.1 Operation of PTC thermistors

The PTC thermistor operates to limit the current as an open circuit. The device operates to limit the current by increasing its resistance from a low to a high value.

The PTC thermistor is placed as a series element in the telecommunication loop. The current-limiting device may be provided in the same package with the primary protector unit on the MDF, at the subscriber network interface or on printed circuit boards of the communication equipment.

4.2.2 PTC thermistor operating characteristics

PTC thermistors are available with a variety of operating characteristics to suit the particular needs of each application. The following characteristics are of particular importance:

- Response time, T_R, is the maximum time required for the PTC thermistor to reduce a given fault current to an acceptable value that will not cause a damage or safety hazard to the protected load.

- Transition current, I_t, is the current level required to cause a PTC thermistor to change state at a given temperature and duration.

- Rated current, I_r, is the maximum current that a PTC thermistor is able to carry for a specified period of time. The selected current should be greater than the maximum normal operating current over the operating temperature range.

- Maximum voltage, V_{max}, is the highest voltage that may be applied to the PTC thermistor without altering its performance.

- Impulse and a.c. life are the number of lightning impulse and a.c. currents and voltages that a PTC thermistor withstands without experiencing a failure mode. End-of-life is defined when the d.c. resistance of the device is not within its specified limit values after the end of current applications or fails to meet the rated current and response time characteristics.

- The PTC thermistor should withstand overload surges and a.c. power without causing safety hazard or propagating fire.

Table I.1 shows examples of some PTC thermistor characteristics.

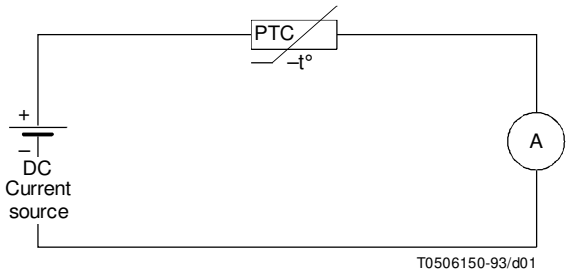
4.2.3 Response time, T_R

The PTC thermistor shall operate within the response time when the specified transition current (see Table I.1) is applied through its terminal. When the device operates, the current shall decrease to an acceptable current value.

The device shall have a resistance within the specified values measured after the source is disconnected. Restoral of the d.c. series resistance to its specified value shall be measured after a time period selected for the intended application.

Test method

Figure 1 depicts an example of a circuit that can be used to perform the test. The current source of Figure 1 shall have the transition current value as specified in the appropriate category when the current-limiting device is placed in the test circuit. Check that the current decreases to an acceptable current value within the appropriate response time. After the source is disconnected and the device has reached the ambient temperature and a specified time has passed, measure the resistance of the PTC thermistor to ensure it is within its specified values. Repeat the above procedure five times for each load current. The repetition rate shall be sufficient to avoid thermal accumulation.



PTC PTC thermistor
A Ammeter

FIGURE 1/K.30

Response time test circuit

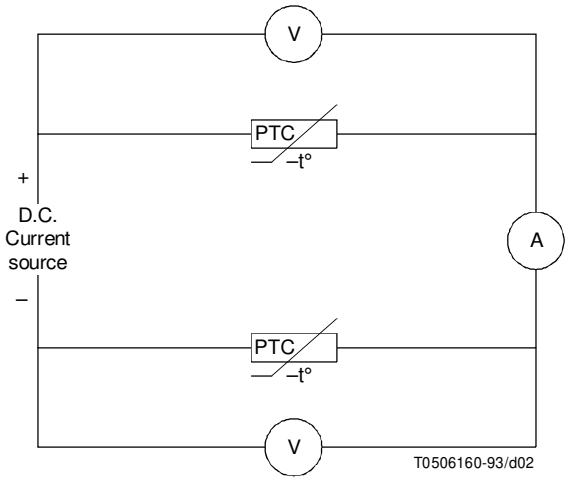
4.2.4 Rated current, I_r

The PTC thermistors shall carry the specified rated current (see Table I.1) applied simultaneously to each current-limiting device as shown in Figure 2 for the appropriate test period.

During the rated current tests, the devices shall have a resistance within the specified values.

Test method

Figure 2 depicts an example of a circuit that can be used to perform the test. In applications where there is no thermal coupling between devices, only one device need be tested, rather than two devices simultaneously. The d.c. constant current source shall have the rated current value as specified in the appropriate category when the PTC thermistor is placed in the test circuit. During the rated current tests, measure the resistance of the device to ensure that it is within the specified values. The d.c. series resistance of the device is the quotient of the voltage measured across the PTC thermistor divided by the current measured by the ammeter.



PTC PTC thermistor
A Ammeter
V Voltmeter

FIGURE 2/K.30

Rated current test circuit

4.2.5 Impulse life

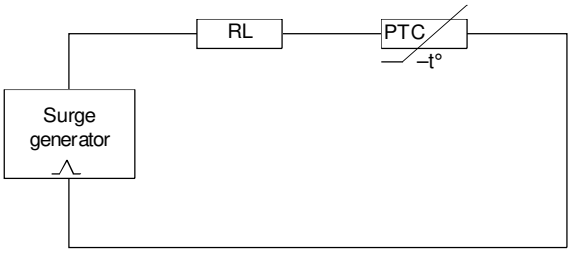
The PTC thermistor shall conduct the number of applications of impulse currents specified in the appropriate impulse life without experiencing a failure. Examples of test pulses are shown in Table I.2.

The end-of-life of the device is determined when:

- its resistance is not within the specified limit values;
- it fails to pass the rated current and response time test at 25 °C.

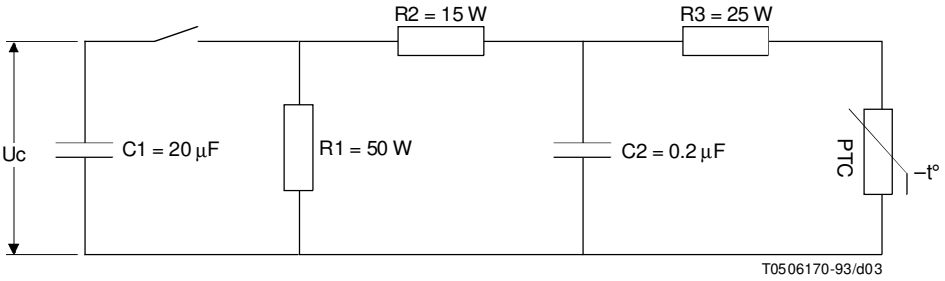
Test method

Figure 3 depicts examples of circuits that can be used to perform the test. The generator may be defined as the waveforms for the open circuit voltage and the short circuit current or as a generator with specified components. After each ten current applications, and when the device has reached the ambient temperature and a specified time has passed, measure the resistance of the devices to ensure that it is within the specified limit values. The impulse repetition rate shall be such as to avoid thermal accumulation.



a) Impulse life test circuit

PTC PTC thermistor
RL Load resistance



b) Impulse life test circuit

PT PTC thermistor
Uc Open circuit test voltage

FIGURE 3/K.30

4.2.6 a.c. life

The self-restoring current-limiting mechanism shall conduct the number of applications of the 48-62 Hz sinusoidal currents specified in the appropriate a.c. life without experiencing a failure. Examples of test values are shown in Table I.3.

The end-of-life of the PTC thermistor is determined when:

- its resistance is not within its specified limit values;
- it fails to pass the rated current and response time test at 25 °C.

Test method

Figure 4 depicts an example of a circuit that can be used to perform the test. In applications where there is no thermal coupling between devices, only one device need be tested rather than two devices simultaneously. The open-circuit voltage and the short-circuit current of the generator shall be specified. After each ten current applications, and when the device has reached the ambient temperature and a specified time has passed, measure the resistance of the devices to ensure that it is within the specified limit values. Perform the rated current and response time test at 25 °C. The a.c. repetition rate shall be such as to avoid thermal accumulation.

4.2.7 Failure mode test

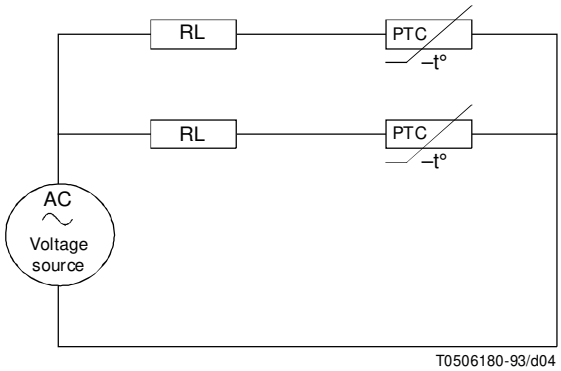
The PTC thermistor shall survive or fail open circuit or high resistance mode when overloaded by a surge or an a.c. voltage.

The PTC thermistor shall withstand an application of a 48-62 Hz sinusoidal power contact current for a 15 minute duration with an open circuit voltage source and source resistance specified to be appropriate for the intended application.

The PTC thermistor shall withstand an application of an impulse current with an open circuit voltage source and source resistance specified to be appropriate for the intended application.

Test method

Figures 3 and 4 depict examples of circuits that can be used to perform the impulse and power contact tests respectively. During the current application, the PTC thermistor shall not cause a safety hazard or propagate a fire. Use cheesecloth wrapped on the housing containing the devices intended for the application as a fire hazard indicator.



PTC PTC thermistor
RL Load resistance

FIGURE 4/K.30

Failure mode test circuit

4.3 Selection of PTC thermistors

The PTC thermistor shall have no effect on circuit operations up to normal load current but should have high resistance at currents larger than the defined overload current and duration within the relevant temperature range.

A selection of the device may follow the steps below:

- define the maximum operating current of the equipment at all relevant ambient temperatures;
- define the minimum overload current and duration at all relevant ambient temperatures;
- define the maximum fault current and voltage to which the device will be exposed;
- choose a component with rated current greater than the maximum operating current at all relevant ambient temperatures using the thermal derating factor f_D defined in manufacturers' data sheet;
- check that the device transition current is less than the minimum overload current at all relevant ambient temperatures using the factor f_D;
- the response time depends on the specific energy i^2t (Ws/Ω) heating the device. The response time as a function of the current is normally given at 25 °C. For different temperatures a derated fault current should be using the factor f_D.

  Response times should be below the time at which the currents can cause unacceptable damage to the protected load.

Appendix I

Examples of characteristics of PTC thermistors

(This appendix does not form an integral part of this Recommendation)

TABLE I.1/K.30

Response time and rated current characteristics

Item	Transition current (A r.m.s.)	Maximum response time (s)	Rated current (A r.m.s.)	Test period	Nominal resistance Ω	Maximum resistance Ω	Minimum resistance Ω[a)]
1	1.875	210	1.2	3 hours	–	0.25	–
2	0.54	210	0.15 0.26	3 hours 30 s	1.5	4	0.8
3	0.5	210	0.135	1 hour	10	12	8
4	0.25 1.0	90 2.5	0.145	30 min	8.5	15	7
5	0.35 1.0 4.0	35 4 0.8	0.11	1 hour	15	18	12
6	0.2 1.0	90 1.0	0.11	30 min	17	30	13

a) Minimum resistance is needed only in these applications where a minimum resistance level is important (e.g. coordination of primary and secondary overvoltage protectors).

TABLE I.2/K.30

Impulse life characteristics

Minimum open-circuit peak voltage (V)	Short-circuit impulse current (A)	Waveform (μs/μs)	Applications
1000	25	10/1000	30
1500	37.5	10/310	10

TABLE I.3/K.30

a.c. life characteristics

Voltage (V r.m.s.)	Current (A r.m.s.)	Duration (s)	Applications
283	1	1	60
250	3	600	1
300	0.5	1	10
650[a)]	1.1	2	10
[a)] Lines without primary protection.			