

Using The New "TWIN VERTICAL" PTC as an Over-Current Protection Element in Telecom

INTRODUCTION

Ceramic PTC thermistors are widely used in telecom infrastructure equipment as an over-current protection element for more than 30 years. Their main function is to block too high or faulty line currents. Usually they operate together with overvoltage protection elements to form a resettable overload protection against all kinds of external disturbances.

Ceramic PTCs have been the preferred choice for over-current protection in fixed telecom applications because of their ability to return to the original state after fault conditions and their robust and safe design. These components have a long history of problem-free functionality and a guaranteed lifetime of over 25 years.



As the drive towards miniaturization and added value components in the telecom application field is ongoing, the availability for smaller and easy to use components is crucial. Past designs have been through-hole parts with relatively small print occupation. In the late nineties, Vishay BCcomponents developed a special PTC SMD leadframe version for the telecom market for those applications driven by SMT. The major drawback of these components was their relative big surface occupation when compared to leaded devices.

Vishay BCcomponents has developed an innovative ceramic over-current protection part, combining two PTCs in one single package : The "TWIN" Vertical SMD PTC.

This special design uses two high-performance rectangular PTCs to obtain the best possible volume-surface utility. It saves up to 50 % more space when compared to former "horizontal" SMD PTC designs and occupies up to 10 % less space when compared to dense through-hole designs with a reduced height of maximum 7 mm (11.5 mm for GR-1089 compatible part).

THE DESIGN OF TWIN VERTICAL SMD PTC

The TWIN concept uses two fully metallized high performance PTC ceramics made of high purity doped Barium Titanate. They are spaced by a special T-shaped ceramic spacer for good mechanical and thermal stability. Electrical connections are made by a 4 termination design with so called J-wing leads. These terminations are widely spaced for good mechanical stability and high voltage insulation between the two PTCs. The part is soldered to a specific solderland design with enough copper surface to have a good heat-flow from the ceramic body to the PCB.

Thanks to the rectangular form of the ceramics, the confined volume and PCB space requirements are kept to a minimum. Standard component surface occupation ranges from 55 mm² to 72 mm², depending on ceramic size and spacer dimensions.

Fast Pick and Place equipment call for restricted component height below 7.0 mm or even 6.0 mm maximum. Both requirements can be met with this component. Even for GR-1089 compatible parts the height is restricted to 11.5 mm.

ELECTRICAL SPECIFICATIONS

The electrical requirements for over-current protectors in telecom follow the specific needs of SLIC and overvoltage protectors, together with the defined fault conditions as described in the ITU-T standard recommendations ITU-T K20-21-45. For USA also GR-1089 compatible parts are available.

For the line-card application, the ideal protection is a resettable one with short reaction times to faulty currents and a well defined resistance value which is equal in the Tip and Ring wire. Both requirements can be met with the Twin vertical design. Due to its limited ceramic body volume, reaction times are well within current requirements and the resistance matching between the PTCs is based on pre-selected values which can be as close as 0.2 Ω at 25 °C. Because the PTCs are thermally coupled by a ceramic spacer, the temperature difference between the Tip and Ring PTC will be small and tracking over a wider temperature range from 0 °C to 85 °C can be as close as 2 times the guaranteed matching at 25 °C. See Graph 1 for a more detailed view on the matching ratio at different temperatures with the matching at 25 °C as reference value.

Currently available resistance values cover a wide range of applications in the telecom line protection. Values range from 10 Ω up to 60 Ω . Lower resistance values down to 4 Ω are available for special application with reduced fault voltages. Two different pitch dimensions are available for easy placement and surface optimization. The size is primarily determined by the ohmic value and the maximum current and voltage handling capabilities.



Table 1

ITU-T COMPATIBLE PARTS									
Code Number 2381 673		$R_{25} \pm 20\%$ (Ω)	Matching at 25 °C ⁽¹⁾ (Ω)	$I_{max.}$ at $V_{max.}$ (A)	$I_{non-trip}$ at			I_{trip} at 25 °C (mA)	Max. Trip Time at 1 A _{RMS} (s)
Small Pitch	Large Pitch				25 °C (mA)	70 °C (mA)	85 °C (mA)		
61109	62109	10	0.5	4.0	140	85	55	300	4.0
61209	62209	20	0.5	8.0	90	60	40	200	2.0
61259	62259	25	0.5	4.0	100	60	40	200	2.0
61359	62359	35	1.0	4.0	100	60	40	200	1.5
61509	62509	50	1.0	2.5	90	50	35	190	1.2

Note

⁽¹⁾ Other values on request
www.vishay.com/doc?29088

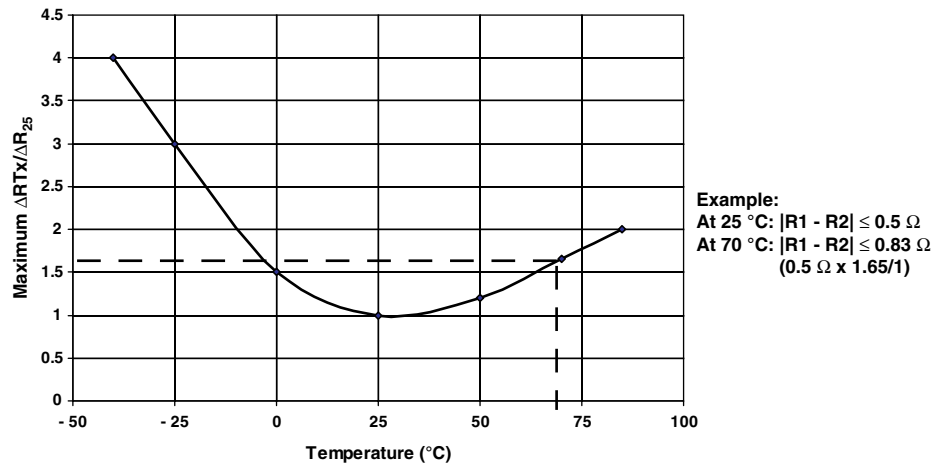
Table 2

ITU-T AND GR1089 COMPATIBLE PART									
Code Number 2381 673	$R_{25} \pm 20\%$ (Ω)	Matching at 25 °C ⁽²⁾ (Ω)	$I_{max.}$ at $V_{max.}$ (A)	I_{nt} at			I_t at 25 °C (mA)	Max. Trip Time at 1 A (s)	
				25 °C (mA)	70 °C (mA)	85 °C (mA)			
97301	60	1.0	5.5	80	45	35	200	1.5	

Note

⁽²⁾ Other values on request
www.vishay.com/doc?29112

MATCHING RATIO



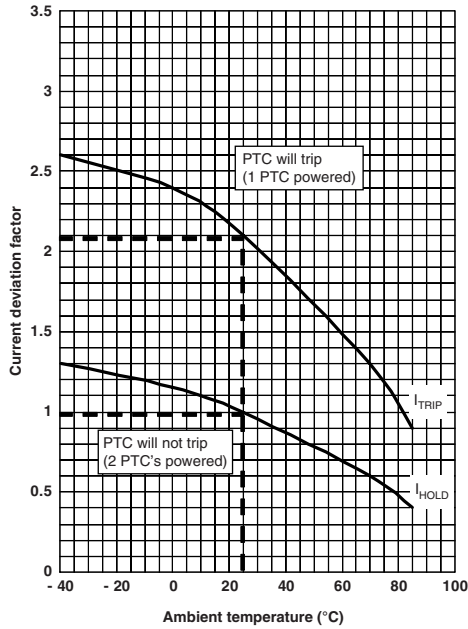
Matching between the two PTC's is controlled at 25 °C reference temperature.

At other temperatures over the complete operating temperature range, the referenced maximum resistance

difference between the two PTC's should be multiplied with the factor as indicated in the graph.

In the normal operating temperature range between 0 °C and 70 °C a max. factor of 1.5 can be guaranteed.

TYPICAL TRIP CURRENT VS. AMBIENT

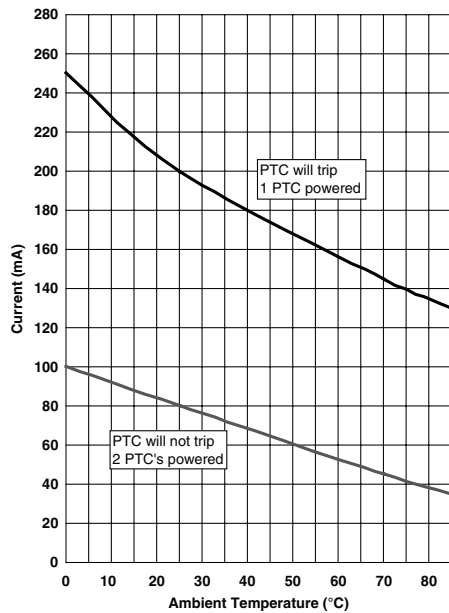


Graph 2

The ratio value between non-tripping and tripping behavior of over-current protectors in telecom line applications is typically around 2. This ratio is mainly determined by the PTC's resistance tolerance values and the reproducible accuracy of the so called switching temperature, together with the mounting conditions. Due to its very reproducible ceramics, values down to 1.4 are possible, giving the application a well determined protection level. See graph 2 and 4 for the standard telecom trip-hold ratios.

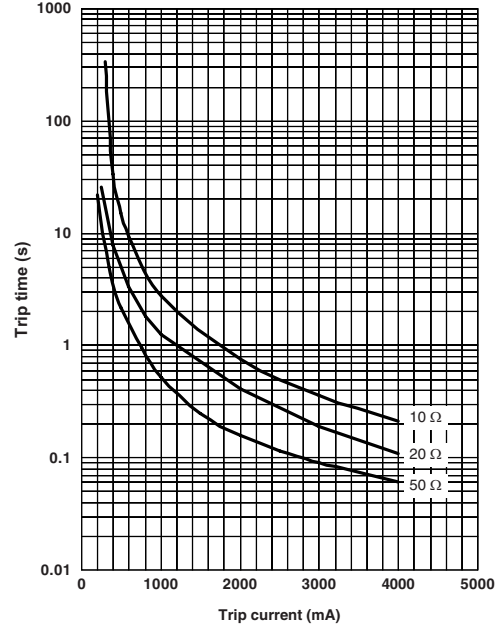
TRIP CURRENT VS. T_{AMB}

R25: 60 Ω
GR-1089 compatible



Graph 4

TYPICAL TRIP TIME VS. TRIP CURRENT AT 25 °C

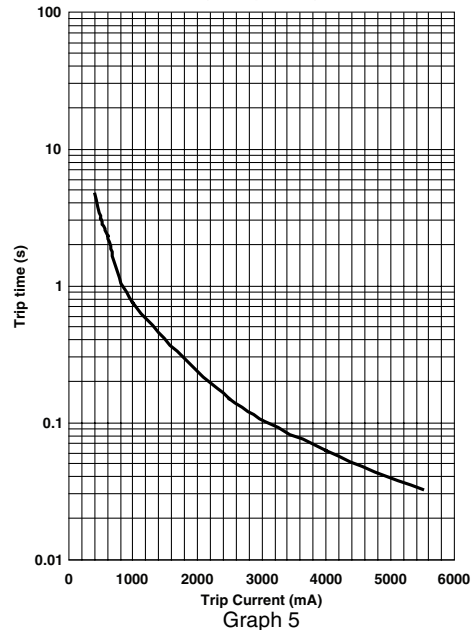


Graph 3

The tripping times of specific types are dependent mainly on the applied over-current and the size and the difference between the switching temperature of the PTC and its ambient body temperature prior to the trip cycle. Current values just above the specified guaranteed tripping current will give relatively long tripping times which will reduce very rapidly with increased current levels. Some typical values are indicated at a temperature of 25 °C in graph 3 and 5.

TRIP TIME VS. TRIP CURRENT

R25: 60 Ω
GR-1089 compatible
(1 PTC powered)



Graph 5



HOW TO USE

Combining two PTCs in one package assures that PTCs are correctly matched on the PCB when changing component reels or bulk containers. The small sized components are packed in a 16 mm blistertape and can contain up to 1200 parts, depending on the component size, which reduces the need for fast reel changing when compared to single SMD or through-hole parts. The overall assembly cost of a linecard can significantly be lowered by using the Twin Vertical SMD PTC.

For soldering this part to a PCB, some considerations have to be taken into account.

Standard reflow process parameters following J-STD-020D can be used for Pb bearing as well as lead (Pb)-free processing. The part is RoHS compliant to cover the requirements on lead (Pb)-free soldering. A specific solderland has been outlined to accommodate the part on the PCB with wide spacings and a big enough copper surface to have a regulated heatflow from ceramic to the PCB.

TELECOM APPLICATION REQUIREMENTS

International resistibility requirements for telecom applications are specified in the international recommendations ITU-T K20-21 and 45. Latest updates can be found on www.itu.int.

In these recommendations, there are three specific telecom applications where there is a need for well defined protection criteria. The K20 describes the tests for equipment installed in a central switching office. The K21 describes equipment installed at the customer premises. The K45 describes the requirements for equipment installed in between the telecom center and the customer premises.

The specific test descriptions are outlined in recommendation ITU-T K44.

An overview of all tests relevant for overcurrent and overvoltage fault conditions is described in table 2.

In the K21, lightning surge tests are more severe due to less strict grounding and bonding assumptions.

There are two levels of equipment performance specified. Basic level testing is valid for equipment installed in low exposure environments. In those cases where equipment is more vulnerable to exposure or where local regulations or telecom operators ask for higher protection levels, enhanced resistibility is required.

There are two acceptance criteria specified for Criteria A: the equipment can withstand all tests without damage and can operate without disturbance after the test. Criteria B accepts possible damage to the equipment, but no fire shall arise and damage should be confined to a small part of the equipment.

For USA market the GR-1089-Core edition 3 standard is applicable. To fulfill these requirements we developed a larger ceramic and a coated part.

OVERVIEW OF OVER-CURRENT AND OVERVOLTAGE FAULT CONDITIONS TESTS				
TEST NO.	TEST DESCRIPTION	PRIMARY PROTECTOR	BASIC LEVEL	ENHANCED LEVEL
2.1.1 a-b-c	Lightning surge 10/700 μ s R = 25 Ω Single port Transverse, port to earth Port to ext. port 2 x 5 pulses alt. polarity	None	K20 1.0 kV K21 1.5 kV K45 1.5 kV Crit. A	K20 1.5 kV K21 1.5 kV Trans K21 6.0 kV P/E–P/eP K45 1.5 kV Crit. A
2.1.2 a-b-c	Lightning surge 10/700 μ s R = 25 Ω Single port Transverse, port to earth Port to ext. port 2 x 5 pulses alt. polarity	Yes Special Test Protector	K20 4.0 kV K21 4.0 kV K45 4.0 kV Crit. A	K20 4.0 kV K21 6.0 kV K45 4.0 kV Crit. A
2.1.3 a-b	Lightning surge 10/700 μ s R = 25 Ω Multiple port 100 % 8 max. Port to earth Port to ext. port 2 x 5 pulses alt. polarity	None	1.5 kV Crit. A	1.5 kV Crit. A
2.1.4 a-b	Lightning surge 10/700 μ s R = 25 Ω Multiple port 100 % 8 max. Port to earth Port to ext. port 2 x 5 pulses alt. polarity	Yes Agreed Protector	4.0 kV Crit. A	6.0 kV Crit. A

OVERVIEW OF OVER-CURRENT AND OVERVOLTAGE FAULT CONDITIONS TESTS				
TEST NO.	TEST DESCRIPTION	PRIMARY PROTECTOR	BASIC LEVEL	ENHANCED LEVEL
4.2 (GR-1089)	Lightning source 10/1000 μ s 1000 V/100 A 25 pulses	None	Crit. A	
4.2 (GR-1089)	Lightning source 2/10 μ s 2500 V/500 A 10 pulses	None	Crit. A	
2.2.1 a-b-c	Power induction Transverse, port to earth Port to ext. port 5 power tests	None	$U_{AC} = 600$ V $R_s = 600$ Ω $t_{on} = 0.2$ s $W_{max.} = 0.2$ A ² s Crit. A	$U_{AC} = 600$ V $R_s = 600$ Ω $t_{on} = 0.2$ s $W_{max.} = 0.2$ A ² s Crit. A
4.6.10 (GR-1089)	First level AC power Fault test 600 V_{RMS} /60 A $t_{on} = 5$ s 60 cycles	None	Crit. A	
2.2.2 a-b-c	Power induction Transverse, port to earth Port to ext. port 5 power Tests (for each critical combination of voltagetime)	Yes Special Test Protector	$U_{AC} = 600$ V $R_s = 600$ Ω $t_{on} = 1.0$ s $W_{max.} = 1.0$ A ² s Crit. A	$U_{AC}=1500$ V $t_{on}=0.18$ s $U_{AC}=448$ V $t_{on}=2.0$ s $R_s = 200$ Ω $W_{max.} = 10.0$ A ² s Crit. A
4.6.10 (GR-1089)	First level AC Power fault test 440 $V_{RMS}/R_s = 200$ Ω $t_{on} = 2$ s 5 cycles	None	Crit. A	
2.3.1 a-b-c	Power contact Transverse, port to earth Port to ext. port 1 power test (for each test resistor)	None	$U_{AC} = 230$ V $t_{on} = 15$ min $R_s = 10, 20, 40, 80, 160, 300, 600, 1000$ Ω Crit. B	$U_{AC} = 230$ V $t_{on} = 15$ min $R_s = 10, 20, 40, 80, 1000$ Ω Crit. B $R_s = 160, 300, 600$ Ω Crit. A
4.6.12 (GR-1089)	Second level AC Power fault test 600 V_{RMS} /60 A $t_{on} = 5$ s 1 power test	None	Crit. B	
4.6.12 (GR-1089)	Second level AC Power fault test 600 V_{RMS} /7 A $t_{on} = 5$ s 1 power test	None	Crit. B	
4.6.12 (GR-1089)	Second level AC Power fault test 600 V_{RMS} /2.2 A $t_{on} = 15$ min 1 power test	None	Crit. B	

When we look into the application diagram (figure 1), we can find different stages in the set-up of telecom equipment protection.

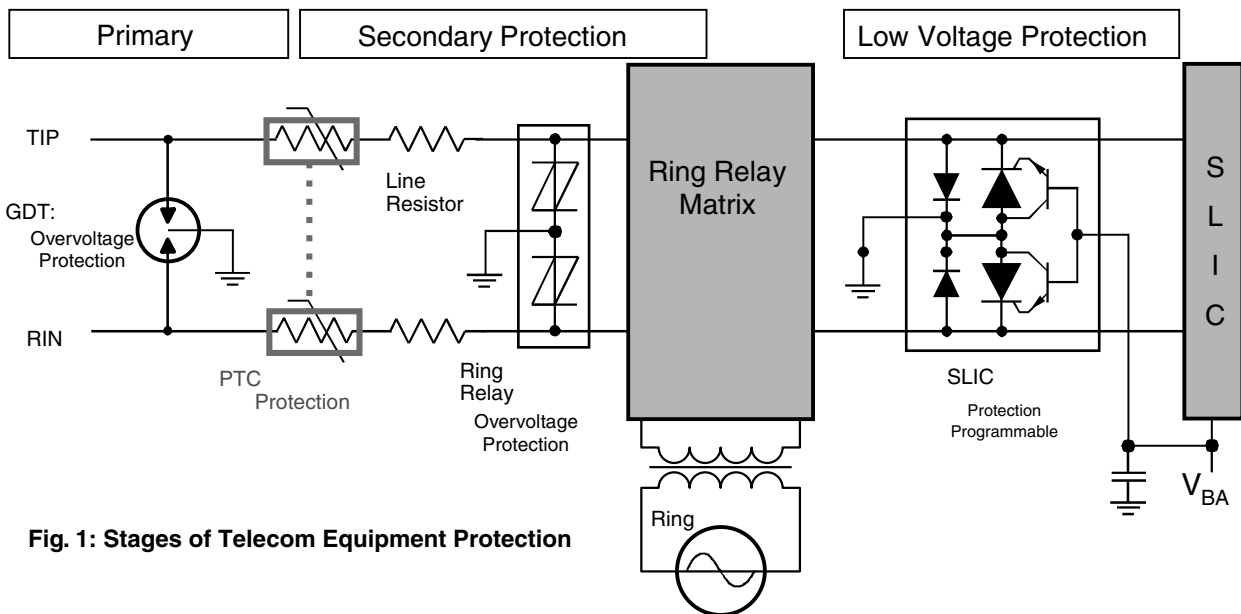


Fig. 1: Stages of Telecom Equipment Protection

PROTECTION AGAINST OVERVOLTAGE DUE TO LIGHTNING SURGE

The primary protection is usually made with a Gas Discharge Tube or GDT. In most cases, it will clamp all voltages above 900 Vp and conduct fault currents to ground. These overvoltage protectors usually have a built-in mechanism to short circuit to ground in case long term power dissipation occurs.

As the secondary overvoltage protector has clamping or breakdown voltage levels below the primary protection levels, a good coordination between primary and secondary protection is needed. For this purpose, the PTCs will act as a series impedance reducing the peak current through the secondary protector to a safe level. As Ceramic PTC's exhibit a voltage dependency effect, care should be taken that resistance values under peak voltage are considered and not the specified cold resistance values at 25 °C.

Depending on the cold resistance value of the PTC, its resistance can easily drop with a factor of 2 to 3 when exposed to a high surge voltage above 1000 Vp. As the ITU-T surge test generator has an output impedance of 15 Ω plus a specified serial resistor of 25 Ω, voltage drop on the PTC will usually be below 500 Vp during a worst case 1500 V lightning surge.

PROTECTION AGAINST OVER-CURRENT AND VOLTAGE DUE TO POWER INDUCTION

Power induction tests as outlined in the ITU-T recommendations simulate worst case induced voltage levels that are caused by nearby electrical power cables or electrical railway systems. The enhanced levels specify

voltages up to 1500 V during limited time and with a maximum specified energy level. During the short time limited current tests, it is very unlikely that the PTC will trip into its high resistance stage. In case the PTC trips during the longer fault times, the agreed primary protector will take over and lead the fault current to ground, thus limiting the voltage on the PTC far below its breakdown voltage.

The rectangular PTCs as used in the Twin Vertical SMD have breakdown voltage ratings above 500 V_{AC} or above 900 V_{AC} for the 600 V type. For longer exposure times and higher currents, a suitable primary protector is needed to block maximum AC voltage on the PTC below these levels.

PROTECTION AGAINST POWER CONTACTS

Power contacts occur only in the rare event that mains power lines interfere with telecom lines due to cable faults, faulty CPE, or any other disturbance. The impedance of the source voltage can range from 10 Ω for in the building faults up to 1000 Ω for remote fault conditions. The TWIN vertical SMD PTC will react to these power contacts in a very fast way, thus limiting the possible danger for other components like BODs or TVS devices. As indicated in the ITU-T requirements, some tests have a Criteria B acceptance because it is not economical to have full protection against very severe power faults. The majority of types of the Vertical TWIN SMD PTCs will be able to sustain all power contact tests ranging from 10 Ω to 1000 Ω without failure, thus passing the tests according to Criteria A