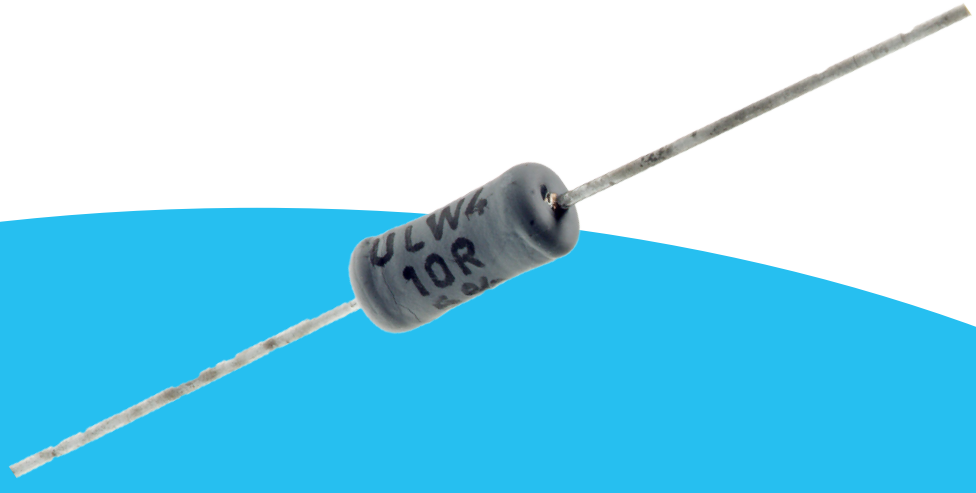
TT Electronics

Circuit Protection Application Note

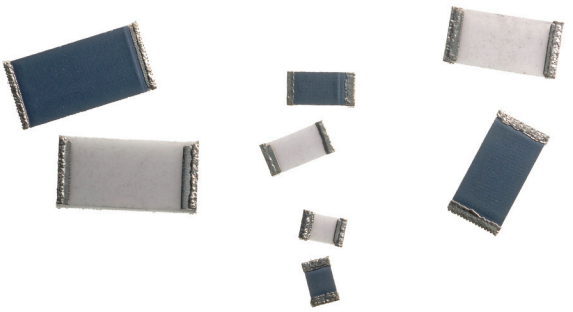
Resistors

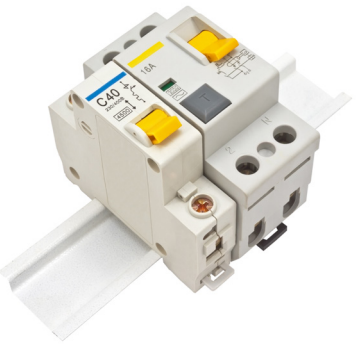
BI Technologies IRC Welwyn



Resistors

Application Note





Today's electronic circuits need reliable protection to operate amidst the potential hazards of inrush currents, high voltage surges and other overload conditions. TT Electronics resistors have kept circuits safe for more than 80 years, and TT Electronics continues to offer the industry's most comprehensive range of circuit protection resistors.

In addition to offering standard components, TT Electronics has worked closely with designers to custom build resistors that are capable of handling high energy pulses. These components may also be designed to fuse, if required, in a controlled and safe manner under fault conditions.

This unique performance is made possible by:

- Selecting the optimum resistor technology necessary to match the performance requirements.
- Utilising a specially designed coating system formulated to aid fusing under fault conditions.
- Utilising a flameproof protection system to eliminate flame during fusing.

Whether you're designing circuit protection for telecommunications, computers, consumer electronics or office equipment, TT Electronics has the right resistor for your application.

Resistor selected /designed to customer specifications

Available technologies

- Metal Film
- Metal Oxide
- Wirewound
- Surface Mount

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Application Note

1. RCD Test Resistors

One specialist application for protection resistors is in RCD (Residual Current Device) or GFD (Ground Fault Detector) protection circuits, where these resistors form part of the test circuit as shown in Figure 1.

In normal operation, if the RCD detects a current imbalance it will trip a relay causing an open circuit. The purpose of the test circuit is to create this imbalance and cause the relay to operate.

The resistor performs two functions in the test circuit; firstly it creates the load to produce the current imbalance. Secondly the resistor must withstand the initial current, to allow the relay to operate, but then if the relay fails to open the circuit after a given time the resistor must fuse safely.

Typically the relay will operate in 30 to 40 milliseconds. If it fails to do so the resistor will fuse safely in 450ms to 2 seconds. The value of this resistor will depend upon the required characteristics of the circuit. Pulse withstanding capability is typically 4000 volts with a 1.2/50-microsecond waveshape and the resistor can absorb up to 50 joules depending upon the value.

The resistor will fuse safely with 330 watts applied. The WMO-S series of metal oxide resistors has proved very effective in this application, due to their energy handling capabilities and overload withstand ability.

Special versions of the WMO-S series have also been produced, as detailed in the example above, which incorporate fusing capabilities to provide fail safe protection.

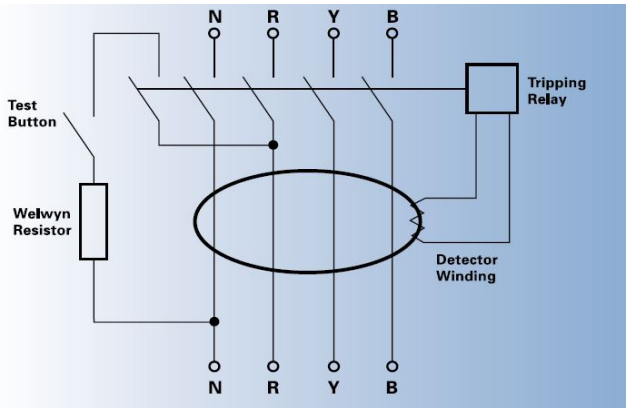


Figure 1

Power Metal Oxide Film Resistors

WMO-S Series

- Small size for power rating
- Can replace carbon composition in many pulse handling applications
- Flameproof protection

Electrical Data

		WMO$^1/_2$S	WMO1S	WMO2S	WMO3S	WMO5S	WMO7S
Power Rating @70%	watts	$^1/_2$	1	2	3	5	7
Resistance Range	ohms	10R-100K	10R-120K	10R-150K		10R-180K	20R-150K
Limiting element voltage	volts	250	300	350		500	750
TCR (25 to 70 °C)	ppm/ °C	350					
Isolation Voltage	volts	250	350			500	750
Resistance tolerance	%	5					
Standard Values		E24					
Thermal Impedance	°C/watt	125	105	75	63	42	36
Ambient temperature range	°C	-55 to +155					

http://www.ttelectronics.com/sites/default/files/resistors-datasheets/WMO-S.pdf

2. Inrush Current

Despite technological advances one problem that has never been fully resolved is that of 'inrush' current. This phenomenon, caused by initial capacitor charging surges and/or transformer magnetising currents can subject the input circuitry of equipment to currents many times higher than under normal operating conditions albeit for only a short duration. This can result in damage to the components through which this current surge flows and in some cases can result in premature failure. Fuses, traditionally used to protect circuits from such overloads, now have to be specially selected to fail only under specific conditions of current and duration. Some of the solutions designers have used to limit these transients and minimise the problems vary from positive temperature co-efficient resistors right through the spectrum of technology to 'soft-start' techniques to gradually ramp up the supplies. Few of these ever meet the all important criteria of reliability and low cost. Figure 2 shows one such application; a battery charger. In this application the customer required the resistor to withstand an inrush surge, and also a lightning strike.

The lightning strike is usually simulated by either a 1.2/50 microsecond or 10/700 microsecond pulse shape, the number of pulses and pulse interval are specified by the customer depending upon the application.

An additional feature which is required for this type of circuit is the ability of the resistor to fuse safely should a short circuit occur (for example if the bridge rectifier were to fail short circuit). Typical parts used are ULW Series (UL recognised wirewound) and WP-S Series (wirewound power - small) resistors often with special features to meet specific application requirements. Both of these parts have defined energy handling capabilities. Special versions can be produced to withstand customer defined pulses and/or to fuse during defined conditions of overload.

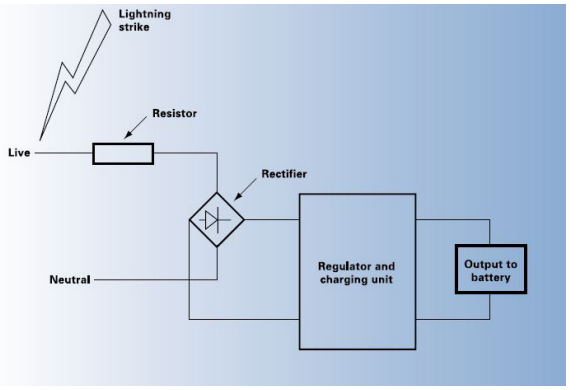


Figure 2

UL Recognised Wirewound Fusible Resistors

ULW Series

- UL1412 recognised fusible resistors
- Pule withstanding wirewound technology
- UL94-V0 flameproof fusing

Electrical Data

		ULW2	ULW3	ULW4	ULW5
Power Rating @25°C	watts	2	3	4	5
5 second overload rating at 25 °C	watts	10	15	20	25
Resistance Range	ohms	1 to 100			
TCR	ppm/ °C	±200			
Isolation Voltage	volts	250	350	500	
Resistance tolerence	%	5			
Thermal Impedance	°C/watt	110	82	62	54
Ambient temp range	°C	-55 to +155			

http://www.ttelectronics.com/sites/default/files/resistors-datasheets/ULW.pdf

Application Note

Flameproof Cement Wirewound Resistors

WP-S Series

- Robust wirewound technology
- UL94-V0 flameproof fusing
- Pulse withstanding version WHS series available

		WP1S	WP2S	WP25S	WP3S	WP4S	WP5S
Power Rating @25°C	watts	1	2	2.5	3	4	5
Overload Rating (5s)	watts	5	10	12.5	15	20	25
Short pulse performance		Available on request					
Resistance Range	ohms	R068 to 430R	R05 to 900R	R05 to 900R	R01 to 2K2	R01 to 10K	R015 to 6K8
Limiting element voltage	volts	50	50	75	100	100	150
TCR	ppm/ °C	<1R:350 = 1R: 200					
Isolation Voltage	volts	250			350	500	
Resistance tolerence	%	<20R: 5 ≥20R: 1, 2, 5				<R10:5 ≥1r10: 1,2, 5	<20R 5 ≥20R: 1, 2, 5
Standard values		E24 preferred					
Thermal Impedance	°C/watt	140	110	90	82	62	54
Ambient temp range	°C	-55 to +155					

http://www.ttelectronics.com/sites/default/files/resistors-datasheets/WP-S.pdf

Pulse Withstanding Fusible Flameproof Metal Film Resistors

EMC Series

- UL1412 recognised*
- Failsafe 240V mains fusing
- Good pulse handling capability
- Small size for power rating
- UL94-V0 flameproof protection

*Values 22R and above. UL file number E234469

Electrical Data

		EMC2
Power rating at 70 °C	watts	2
Resistance range	ohms	4R7 - 68R
TCR	ppm/ °C	100
Isolation Voltage	Volts	500
Resistance tolerance	%	10, 20
Standard values		E12
Thermal impedance	°C/watt	82
Ambient temperature range	°C	-55 to +155

http://www.ttelectronics.com/sites/default/files/resistors-datasheets/EMC.pdf

3. Short Circuit or Overload Protection

Many power supplies incorporate some form of short circuit or overload protection (sometimes called over current protection) in their output stage. Protection in older circuits was often achieved using a simple bimetallic switch in series with the output. However these proved to be inaccurate, slow to react and unreliable in operation. Modern circuits now use an electronic method to monitor the power supply output current and to control the output should a fault occur. A typical example is shown in Figure 3 in the form of a series voltage regulator with constant current limiting (the current limiting section of the circuit is high lighted). The load current (IL) passes through the sense resistor RSENSE and creates a voltage between the base and emitter of transistor T2. When IL reaches a preset maximum value, the voltage drop across RSENSE is sufficient to forward bias the base-emitter junction of T2 causing it to conduct. This diverts the base current from T1 into the collector of T2 so that IL is limited to its maximum value.

The resistor needs to be carefully selected, firstly to give the correct voltage drop for the intended maximum output current and secondly because the full load current will pass though it. Obviously power ratings will vary with the specific power supply and value selected. TT Electronics can offer a wide range of current sense products. One of the most compact and versatile is the LR series of low value chip resistors. For other options, see our Application Note "Current Sense Resistors" http://www.ttelectronics.com/sites/default/files/download-files/Current-Sense_AN.pdf

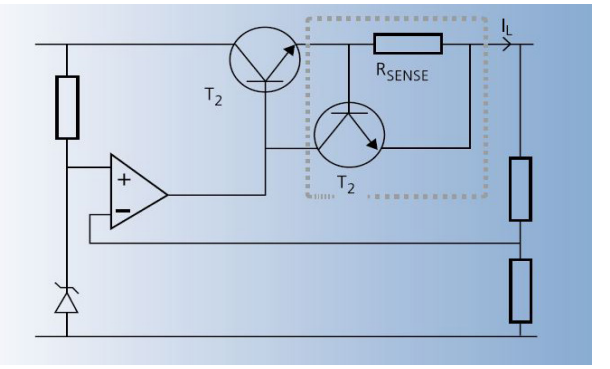


Figure 3

Low Value Flat Chip Resistors

LR Series

- Resistance values down to 0.003 ohms
- Leach resistant solder plated copper wrap around termination
- Low inductance - less than 0.2nH

Electrical Data

		LR1206	LR2010	LR2512	LRF3W
Power Rating @70°C	watts	0.5	1.0	2.0	4
Resistance Range	ohms	0R003 - - 1R0			0R003 - 0R1
Tolerance	%	<0R01: 5 % ≥0R01: 1, 2, 5 %			<0R004: 5 % ≥0R004: 1, 2, 5 %
Number of terminals		2	2	2	2
Dielectric withstand	volts	200	200	200	200
TCR	ppm/ °C	≥0R05 : 100	≥0R05 : 100	≥0R05 : 100	≥0R004 : 100
Temperature rise at rated power	°C	40	80	90	100
Total pad & trace area for rated power at 70 °C	mm2	30	100	300	500
Nominal dimensions L x W		3.20 x 1.63	5.23 x 2.64	6.50 x 3.25	3.25 x 6.50
Termination style	mm	≤0R025 Flip-chip, >0R025 Normal			Flip-chip

http://www.ttelectronics.com/sites/default/files/resistors-datasheets/LR.pdf

4. Telecommunications

Telephone lines can be subjected to a large range of voltage disturbances, many of which can damage switching equipment. This has led to the need for circuit protection against both high voltage transients, usually of short duration due to lightning strikes and overloads of longer duration caused by accidental direct connection to mains power lines.

These two faults are separated into primary and secondary protection. Primary protection handles the high voltage transients, and is usually located within the exchange. Secondary protection is usually built into the equipment to be protected, and deals with both current and voltage limiting. Voltage limiting prevents damage to the equipment and shock hazards, and current limiting prevents damage to wiring and voltage limiters.

A typical application circuit is shown in Figure 4 where the resistors are designed for ring signal sending through a solid state relay. The resistors are protected from lightning surge by Over-voltage Protection in the system and the resistors are required to withstand pulse of 15 Watts for 1 second and 75 Watts for 0.1 second, repeated 60 times.

For this application, TT Electronics has developed the Pulse Withstanding Chip (PWC series) described below.

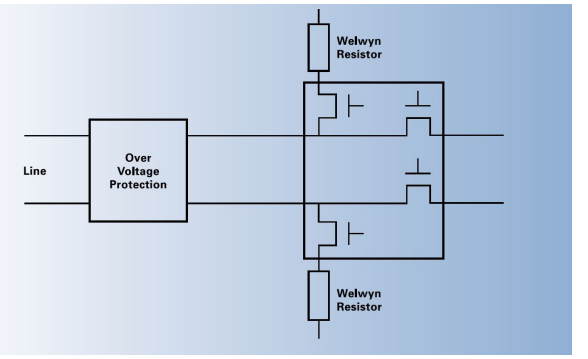


Figure 4

Pulse Withstanding Chip Resistors

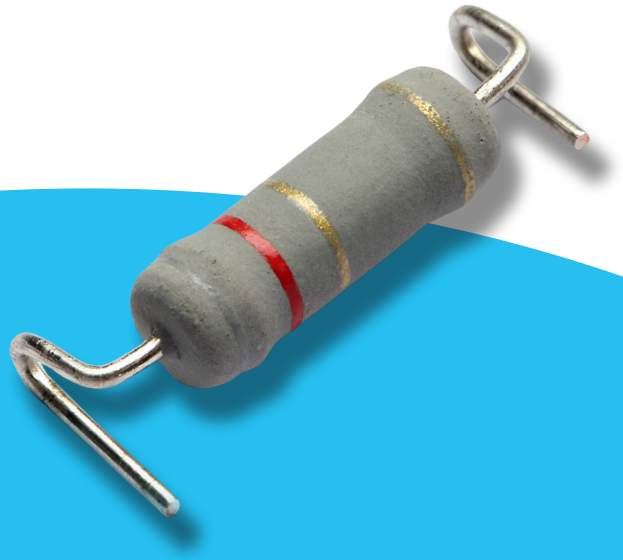
PWC Series

- Excellent pulse handling performance
- Thick film technology provides wide resistance and temperature ranges (1 ohm to 10 meg ohm; -55 to +155 °C)
- Double-sided (DSC) and untrimmed (HPWC) versions

Size	0603	0805	1206	2010	2515
Power @70 °C	0.125W	0.25W	0.5W	1W	2W
Resistance range	1R0 to 10M				
Tolerance	0.5, 1, 2, 5 %				
LEV	75V	150V	200V	400V	500V
TCR	<10R:200ppm/ °C ≥10R:100ppm/ °C				
Operating temperature	-55 to +155 °C				
Values	E96 preferred other values to special order				

http://www.ttelectronics.com/sites/default/files/resistors-datasheets/PWC.pdf

LIT-AN-PROTECTION



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