UNDERSTANDING PULSE & OVER LOAD CAPABILITY OF WIRE WOUND RESISTORS

Due to existing needs, modern Electronic Circuits & Devices are very sensitive to transients.

This in turn has led to the need to "**design in**" transient protection.

Designers often face the dilemma of the level of protection required and the ability of the individual component to withstand given transients or pulses.

It is also a fact that whilst there is a plethora of information available on this subject for active devices like semi-conductors, passive devices such as resistors are often neglected and their role in withstanding pulses / transients is not fully grasped by the designer.

In actuality resistors are often located in areas likely to experience transients, for eg. Power Supplies & Lighting Circuits and therefore the full understanding of the ability / capability of the resistor to handle transients / pulse stresses is indeed a critical issue.

The most common and cost effective type of resistor that can be used for transient protection are wire wound resistors and this fact is often neglected by the designer as they do not have ready access to the pulse handling / over load characteristics of wire wound resistors.

In order to over come this obstacle **HTR** has worked closely with designers to produce custom built resistors for specific protection applications and the data obtained is now given below in the form of tables and data which has been gleaned through years of research & study :-

OVERLOADING OF THE WIRE WOUND RESISTORS

As excessive heat both environmental & self produced are the single most common factor contributing to the failure of a resistor, wire wound resistors have maximum continuous power ratings to limit their temperature rise.

In practical terms this is in the form of limiting element voltage(L.E.V.).

The limiting element voltage is the maximum continuous voltage that can be applied to a resistor.

For lower values the power rating is exceeded before L.E.V. is reached. However, in the case of higher resistance values the L.E.V. imposes limitations on the applied power.

Though L.E.V. cannot be exceeded for continuous working, wire wound resistors are the only resistors which are capable of withstanding 3 times their L.E.V. for pulse applications.

In addition to the above, wire wound resistors also have a well defined overload rating and this is referred to as short time over load (STOL) on published datasheets.

The short time overload rating of HTR's wire wound resistors are calculated as given below:-

For resistors upto 3 watts, the STOL voltage is calculated as :-

STOL Voltage = $\sqrt{\text{5 Times x Power Rating x Resistance value}}$ for period of 5 sec.

For resistors above 3 watts, the STOL voltage is calculated as :-

STOL Voltage = $\sqrt{\text{10Times x Power Rating x Resistance value}}$ for period of 5 sec.

For eg. HTR's HTA series H2B Type 4K0 $\pm$ 5% resistor has a STOL Voltage / rating which is calculated as :-

STOL Voltage = $\sqrt{\ \text{x} \quad \text{x 4000}}$ = 223.6 volts

Similarly, HTR's HTA series H9 Type 27K777 $\pm$5% resistor has a STOL Voltage / rating which is calculated as :-

STOL Voltage = $\sqrt{10 \text{ x } 9 \text{ x } 27777}$ = 1581.12 volts

It can be seen that in the above case the H2B type which is rated as 2.5W is capable of dissipating 12.5W for 5 sec.
In terms of energy, this corresponds to 62.5 Joules.

The danger over here is that it might be thought that this device is capable of handling 62.5 Joules **irrespective** of the pulse width.

At this point it must be remembered that it takes a finite time for the heat produced to be properly distributed throughout the resistor body and therefore it is necessary to impose limits on the applied pulse energy so as to prevent excessive stresses due to thermal shock damaging the component.

Now suppose the same 2.5W 4K0 $\pm$5% resistor is subjected to 10000 volts for 1.5 milli sec., the energy is 37.5 Joules as per the formula given below :-

$E = V^2/R \times t$ = 10000 x 10000/4000 x 0.0015 sec. = 37.5 Joules

Now, 37.5 Joules is within the 62.5 Joules shown above but it must be remembered that it would take longer than 1.5 Milli Sec. for the heat produced in the wire to flow into the surrounding materials and therefore the temperature of the wire would rise far beyond what it was intended to handle and if the wire is subjected to temperatures which are beyond its operating limits the resistance value of the resistor will change excessively, the coating can be damaged and in extreme cases the resistance wire itself can melt which will render the component useless.

Therefore since resistors can be subjected to different types of pulses, it is very necessary to take into consideration the pulse width duration and the applied pulse voltage / power.

A general point to be noted is that the average power of the pulse applied should not exceed the rated power of the resistor.

Also the term pulse implies a single pulse applied to a resistor, which is not already dissipating power and is in an ambient temperature of 70°C or less.

HTR has collected data for 3 different pulse ratings for their most popular standard wire wound resistors which should be referred to as given below for the safe operation of the resistors.

1. For very short pulses which are < 1Milli Sec. (1.2/50Micro Sec. as defined by IEC 61000-4-5 & ANSI C62.41), please refer to Table-1.
2. For longer pulses from > 1Milli Sec. to 100Milli Sec., please refer to Table-2.
3. For pulses > 100Milli Sec. upto 5 Sec., the short time over load capability (STOL) calculation as shown above should be referred to.

PULSE HANDLING CAPABILITY DATA

- Table - 1 is for very short pulses which are < 1 Milli sec. (1.2/50Micro Sec. As defined by IEC 61000-4-5 & ANSI C62.41)
- Table - 2 is for longer pulses from > 1Milli Sec. to 100Milli secretary.

HIA SERIES

Sr. No.	Type	Table–1	Table-2
1.	H1	1200 V	750 V
2.	H2	1800 V	1200 V
3.	H3A	2000 V	1300 V
4.	H3	3500 V	2250 V
5.	H4	4000 V	2500 V
6.	H5A	5000 V	3250 V
7.	H5	6500 V	4250 V
8.	H7A	8500 V	6250 V
9.	H7	10500 V	7000 V
10.	H10 / H10A	12000 V	9500 V
11.	H15	15000 V	12250 V

HTA SERIES

Sr. No.	Type	Table–1	Table-2
1.	H1B	600 V	525 V
2.	H2B	1500 V	1000 V
3.	H6	3000 V	2000 V
4.	H9	7500 V	5000 V
5.	H12	11250 V	7500 V

HFA SERIES

Sr. No.	Type	Table–1	Table-2
1.	F1	1200 V	750 V
2.	F2	1800 V	1200 V
3.	F3	2500 V	1750 V
4.	F5	4250 V	3000 V
5.	F7	6250 V	4000 V
6.	F9	7750 V	5250 V
7.	F10	8500 V	5750 V

HIP SERIES

Sr. No.	Type	Table–1	Table-2
1.	H3P	2000 V	1300 V
2.	H5P	6500 V	4000 V
3.	H7P	10500 V	7000 V
4.	H10 P	12000 V	8500 V

HFP SERIES

Sr. No.	Type	Table–1	Table-2
1.	F2P 0/1	1800 V	1250 V
2.	F4P 0/1	3250 V	2000 V
3.	F5P 0/1	4750 V	3250 V
4.	F7P 0/1	6750 V	4500 V
5.	F8P 0/1	8750 V	6000 V

HSR SERIES

Sr. No.	Type	Table–1	Table-2
1.	SR8	10000 V	6750 V
2.	SR11	13000 V	8750 V

HEA SERIES

Sr. No.	Type	Table–1	Table-2
1.	C2A	1500 V	1000 V
2.	C4	2750 V	2000 V
3.	C5B	3500 V	2500 V
4.	C6	4500 V	3000 V
5.	C7B	4800 V	3250 V
6.	C7A	5750 V	3750 V
7.	C9/C10A	6500 V	4500 V
8.	C11	9000 V	6000 V
9.	C17	13250 V	8750 V

HSV / HSVA / HSVAU SERIES

Sr. No.	Type	Table–1	Table-2
1.	SV4 / SV4A / SV4AU	2750 V	2000 V
2.	SV5 / SV5A / SV5AU	3500 V	2500 V
3.	SV7 / SV7A / SV7AU	4800 V	3250 V
4.	SV7B / SV7BA / SV7BAU	5750 V	3750 V
5.	SV9 / SV9A / SV9AU	6500 V	4500 V
6.	SV11 / SV11A / SV11AU	9000 V	6000 V
7.	SV17 / SV17A / SV17AU	13250 V	8750 V

HCP SERIES

Sr. No.	Type	Table–1	Table-2
1.	CP3A	3000 V	2000 V
2.	CP5 / CP5A / CP5Z	4250 V	3000 V
3.	CP7 / CP7A / CP7Z	6250 V	4000 V
4.	CP10 / CP10A / CP10Z	9000 V	6000 V
5.	CP15 / CP15A / CP15B / CP15C / CP15Z	10500 V	7000 V
6.	CP20 / CP20A / CP20B / CP20C / CP20Z	14500 V	9500 V

HCL SERIES

Sr. No.	Type	Table–1	Table-2
1.	CL10	9000 V	6000 V
2.	CL20	14500 V	7000 V
3.	CL40	22000 V	14750 V

The voltages given have been determined at 0.02mm dia wire resistance values.