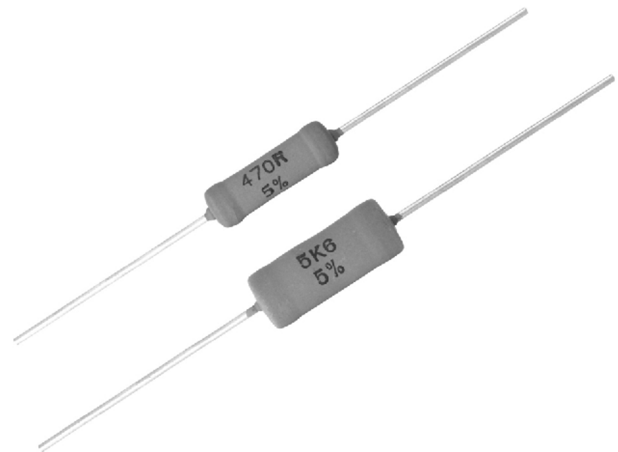
Z300-C Cemented Axial Wirewound Resistor for Surge Control in Energy Meters



Modern electronic circuits and devices are getting smaller in size and offering more features. Due to smaller PCB size and reduced component count, these circuits are more sensitive than ever to transients and this has led to an increased need for transient protection. Designers are faced with great challenge in finding a reliable solution in terms of the level of protection required and the ability of the individual components to withstand transients or pulses. This challenge is even more while designing input circuit of modern electronic energy meters as power supply from the grid can be unreliable and at times produces very high transients.

Wirewound resistors are most commonly used for surge control and in-rush current protection. Vishay's Z300-C axial cemented wirewound resistor series is a preferred resistor to meet this challenge. We work closely with customers to develop customized wirewound resistors to meet their specific surge control requirements.

Customers are requesting typical peak pulse voltage withstanding capability of 8 kV. This requirement is now being increased up to 12 kV level.

Following parameters must be considered while designing a suitable Z300-C wirewound resistor to withstand such a surge:

- Nominal power rating P_{70}
- Ohmic value as the energy handling capacity depends on ohmic value too
- Winding material (resistive wire alloy composition and mass) to withstand the pulse energy
- Ceramic core with necessary alumina contents to dissipate energy in short time
- Body size (length, diameter) of the resistor

In order to relate the pulses experienced in an application to the pulse performance stated on the datasheet, it is necessary to calculate energy for wirewound because wirewound resistors have an energy capacity which depends on the resistance value, due to the related winding parameters. Common exponential pulse shapes must be converted to rectangular pulses of equivalent energy as rectangular pulses are generally used to characterize resistor performance. If pulses are continuous, the average power dissipation must be calculated so as to ensure that the nominal power rating, P_{70}, is not exceeded.

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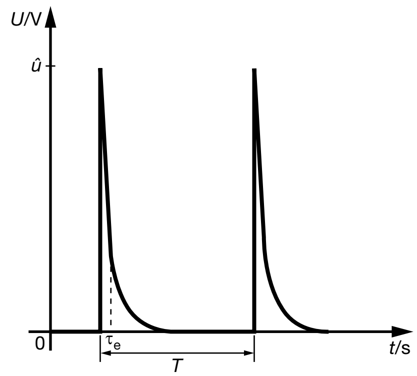
EXPONENTIAL CONTINUOUS PULSES

The average power of the pulse calculates to:

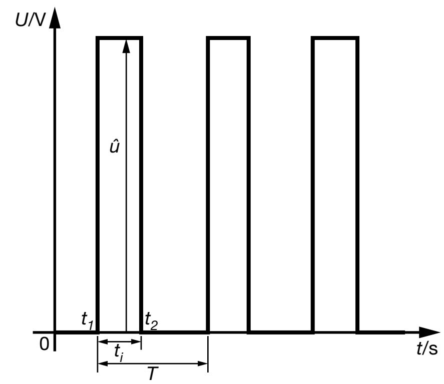


$$P_e = \frac{1}{T} \times \frac{\tau_e}{2} \times \hat{P} = \frac{1}{T} \times \frac{\tau_e}{2} \times \frac{\hat{u}^2}{R}$$

with $\tau_e = R \times C$ or $\tau_e = \frac{L}{R}$

RECTANGULAR CONTINUOUS PULSES

The average power of the pulse calculates to:



$$P_{rec} = \frac{t_i}{T} \times \hat{P} = \frac{t_i}{T} \times \frac{\hat{u}^2}{R}$$

with $t_i = t_2 - t_1$

P_e = Average pulse power for exponential pulse

P_{rec} = Average pulse power for rectangular pulse

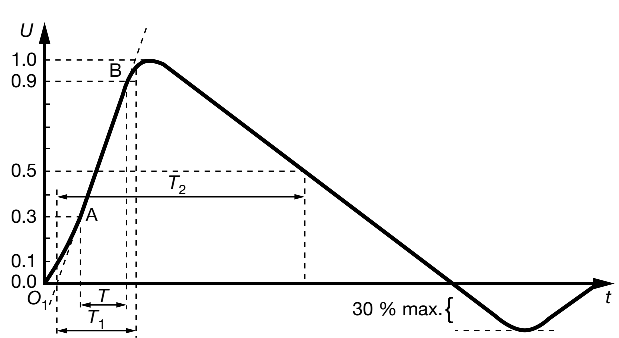
$\hat{P}$ = Peak pulse power

$\hat{U}$ = Peak pulse voltage

τ = Time constant (for a RC or LR circuit)

T = Time period of the pulse

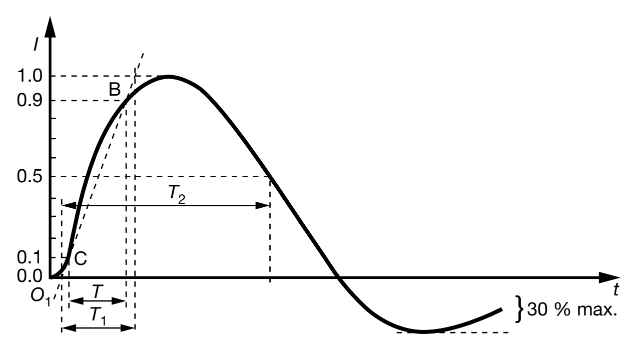
The specially designed Z300-C wirewound "Surge Resistors" are tested for surge handling capability by applying surge voltage of 8 kV/10 kV/12 kV as per the 1.2 µs/50 µs exponential open circuit voltage waveform or 8 µs/20 µs short circuit current waveform as per IEC 61000-4-5 shown below.



Front time: T1 = 1.67 x T = 1.2 µs ± 30 %

Time to half-value: T2 = 50 µs ± 20 %

Waveform of open-circuit voltage (1.2 µs/50 µs) at the output of pulse generator



Front time: T1 = 1.25 x T = 8 µs ± 20 %

Time to half-value: T2 = 20 µs ± 20 %

Waveform of short current (8 µs/20 µs) at the output of pulse generator

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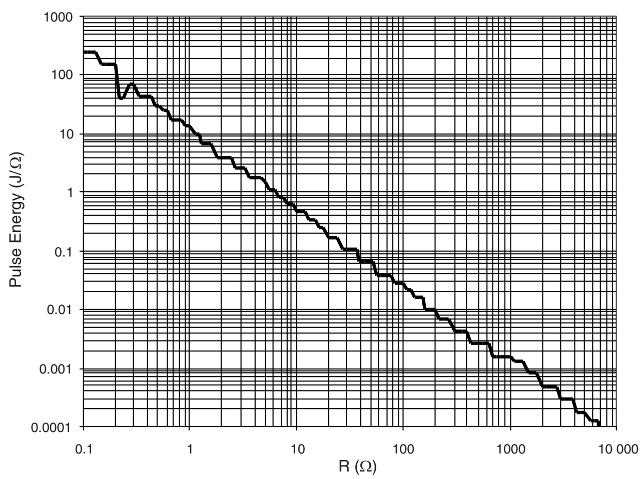
ENERGY CALCULATIONS

Take an example of Z303-C (4 W), 1 kΩ, 5 % resistor designed for handling 8 kV pulse of 1.2 µs/50 µs.
Here as the pulse shape can be approximated to a triangular pulse, then the equivalent rectangular pulse width will be half i.e. 25 µs.

1. R = 1000 Ω
2. Peak pulse voltage, U_{peak} = 8000 V
3. Effective pulse width, τ = 25 µs
4. Energy is as below
   $E = (U_{peak})^2/R \times \tau$ = 1.60 J
5. In case of repetitive pulse train, the average power shall be less than actual wattage of resistor.
   Assuming that repetition time between to pulses is 10 s, the average power
   P_{avg} = $(U^2/R) \times (\tau/T)$
   = (8000 x 8000/1000) x (25 µs/10 s)
   = 0.16 W
   This is far less than nominal rated power P_{40} = 4 W.

Referring to the pulse energy chart below, we can see that maximum energy allowed is 0.0016 J/Ω.
Hence the resistor is suitable for this application.



MINIMUM RESISTANCE VALUE FOR HANDLING SURGE VOLTAGE AS PER IEC 61000-4-5 (1.2/50 µs PULSE)						
RATED DISSIPATION, P_{40}	**TYPE**	**4 kV SURGE**	**6 kV SURGE**	**8 kV SURGE**	**10 kV SURGE**	**12 kV SURGE**
1 W	Z301-C	430 Ω	1.5 kΩ	-	-	-
2 W	ZDA0411-C	180 Ω	510 Ω	1.1 kΩ	2.2 kΩ	3.3 kΩ
3 W	Z302-C	62 Ω	330 Ω	660 Ω	1.8 kΩ	2.2 kΩ
4 W	Z303-C	27 Ω	91 Ω	220 Ω	470 Ω	820 Ω
5 W	Z304-C	15 Ω	43 Ω	82 Ω	100 Ω	330 Ω
6 W	Z305-C	4.7 Ω	18 Ω	27 Ω	68 Ω	130 Ω

Z300-C WIREWOUND RESISTORS

FEATURES

- All welded construction
- Non flammable cement coating
- Ceramic core
- High pulse loading capability, customized designs
- Available with rated dissipation P_{40} of 1 W to 6W with wide resistance range and tolerance

ORDERING INFORMATION

The format of the part number and of the product description is given in the Z300-C datasheet. (www.vishay.com/doc?21027)

For further information, please contact:
ww1resistors@vishay.com