

**PROTECTION PRODUCTS**
**Calculating Transient Energy**

This application note explains how to calculate the transient energy which is **absorbed** by a suppression element. An approximation technique is employed for transient current impulse waveforms, assuming the clamping voltage is almost constant during the surge impulse.

In the case of transients which are internal to the circuit, such as those created by inductive switching, the energy of the transient waveform may be readily calculated. Transients which are external to the circuit are more difficult to quantify. In this case an approximation technique may then be used to estimate the energy which is absorbed by the suppression element. The energy which is absorbed by the suppression device is given by:

$$E = \int_0^{t_p} V_c I_p dt = K V_c I_p t_p$$

Where

E = Energy (Joules)

V<sub>c</sub> = Clamping Voltage (Volts)

I<sub>p</sub> = Peak Pulse Surge Current (Amps)

t<sub>p</sub> = Impulse Duration

K = Constant

K values for the most common surge current waveforms are given in Figure 1. For complex waveforms such as a double exponential impulse, the waveform may be divided into two parts to calculate the total energy.

**Example Calculation**

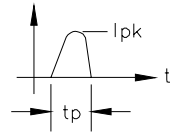
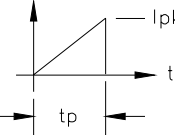
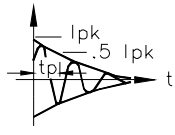
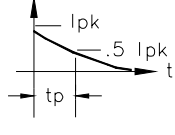
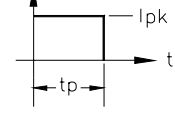
A typical waveform representative of lightning induced transients is shown in Figure 2. It is a 10/1000µs double exponential impulse as defined by Bellcore 1089. To calculate the energy absorbed by an LC01-6 first divide the waveform into two parts with part 1 being the section of the waveform from 0 to 10µs and part two the section from the peak to 1000µs (the 50% decay point). From the LC01-6 data sheet, the maximum clamping voltage at 100A is 15V.

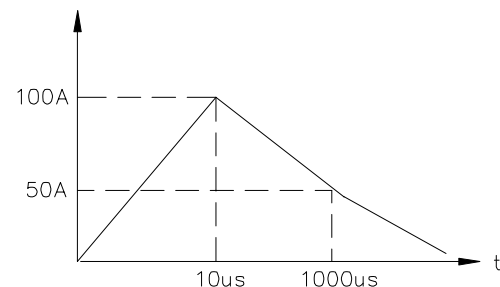
Therefore:

$$\text{Part 1 : } E_1 = K V_c I_p t_p = 0.5 * 15 * 100 * 10 * 10^{-6} = 7.5 \text{mJ}$$

$$\text{Part 2 : } E_2 = K V_c I_p t_p = 1.4 * 15 * 100 * 1 * 10^{-3} = 2.1 \text{J}$$

$$E = E_1 + E_2 = .0075 + 2.1 = 2.11 \text{J}$$

WAVESHAPE	EQUATION	K*
	$I_{pk} \sin\left(\frac{\pi}{t_p} t\right)$	0.637
	$I_{pk} \left(\frac{t}{t_p}\right)$	0.5
	$I_{pk} \sin(\pi t) e^{-t/t_p}$	0.86
	$I_{pk} e^{-t/1.44 t_p}$	1.4
	$I_{pk}$	1.0

**Figure 1 - Energy Waveforms/Form Factor Constants**

**Figure 2 - Double Exponential Impulse Waveform**