Transient Voltage Suppression Selection Guide

Eng. Eyal Ronen EMI/RFI Group Leader

Introduction

The modern combat fields have varied threats on sensitive electrical equipments. In addition to Radio Frequency Interferences (RFI) and Electro-Magnetic Interferences (EMI), electrical transients caused by lightning, power lines or Electro-Static Discharge (ESD), may harm and cause permanent damages to sensitive electronic and electrical equipments. The growth in modifying and integrating commercials and industries components into military equipments increases their sensitivity and therefore the chances of unfixable malfunction to these equipments. The understanding of the possible transients at specified environment is vital for designing and defining the proper protection which will guaranty safe system operation.

What is a "Transient"?

In this chapter, wherever we use the term transients, we refer to "Transient Voltages", “Surges” or “Spikes”. Usually, Transients are unwanted momentary changes in voltage or current caused by lightning, switching of inductive elements such as relays or motors and electrostatic discharge. Coupled on power or signal lines, transients increase the line nominal voltage. As a consequence, devices that connected to these lines and cannot withstand the transients' peak value may fail and cause permanent damage to the equipment. The transients' voltage/current amplitude level can reach up to few ten thousands depending on there source, the "victim" impedance and the environmental conditions as described in the specified standard. Basically, the transients classified into two main categories: impulsive or exponential transients and oscillatory or sine/cosine transients.

Definitions

According to MIL-STD-1275D (Characteristics of 28 Volt DC Electrical Systems in Military Vehicles):

Transients: Transients are the changing conditions of a characteristic. These usually go beyond the steady-state limits,

return to and remain within the steady-state limits within a specified time. The transient may take the form of either a surge or a spike.

Surge: A surge is a variation from the controlled steady-state level of a characteristic, resulting from the inherent regulation of the electric power supply system and remedial action by the regulator, except for battery only operation. Surges may also occur due to the application of loads in the battery only condition. Surges are transients with duration greater than 1ms and have a recovery time limitation.

Spike: A spike is a high frequency oscillatory variation from the controlled steady-state level of a characteristic. It results from very high frequency currents of complex waveforms produced when reactive loads are switched. An individual spike generally has an interval lasting less than 50 microseconds (μs) but may take up to one millisecond (ms) to decay to the steady-state level.

According to DoDI 3150.09 (Department of Defense Instruction):

EMP: The electromagnetic radiation from a nuclear explosion caused by Compton-recoil electrons and photoelectrons from photons scattered in the materials of the nuclear device or in a surrounding medium. The resulting electric and magnetic fields may couple with electrical/electronic systems to produce damaging current and voltage surges.

The RTCA/DO-160E Standard (Section 22) Environmental Conditions and Test Procedures for Airborne Equipment

This standard defines the Lightning Induced Transient Susceptibility of Airborne Equipment by defining the waveforms, voltage and current levels and tests set-ups "to verify the capability of equipment to withstand effects of lightning induced electrical transients".

The RTCA/DO-160E defines two groups of test, the pin injection tests and the cable bundle tests. Our final products are filtered connectors and in most cases are being supplied without additional harness. Therefore, we will regard only to the pin

injection tests. As we will calculate the energy level of each waveform and TVS (Transient Voltage Suppressor), we will take in account the worst case scenarios.

The required tests can be described by category designation which consists of five characters:

A, B or Z (Pin Injection Test Waveform Set)	1 to 5 or Z (Pin Injection Test Level)	Z or X (Cable Bundle Test Waveform set)	Z or X (Cable Bundle Single and Multiple Stroke Test Level)	Z or X (Cable Bundle Multiple Burst Test Level)

Z indicates that the waveform set, the test configuration or the levels applied are different from the designated and the tests are conducted at voltage and/or current levels other than specified in the RTCA/DO-160E. In such case, the specific test conditions and levels shall be described.

The next table shows the **Pin Injection Test Requirements** according to the RTCA/DO-160E:

Waveform Set	Test Type	Test Levels	Waveform Nos.	Notes
A	Pin Injection	1 to 5	3, 4	Waveform 3 is applied at 1.0MHz (±20%)
B	Pin Injection	1 to 5	3, 5A	Waveform 3 is applied at 1.0MHz (±20%)

The next table shows the **Test Levels for Pin Injection** according to the RTCA/DO-160E:

Level	Waveforms					
	3		4		5A	
	V_{OC}	I_{SC}	V_{OC}	I_{SC}	V_{OC}	I_{SC}
1	100	4	50	10	50	50
2	250	10	125	25	125	125
3	600	24	300	60	300	300
4	1500	60	750	150	750	750
5	3200	128	1600	320	1600	1600

Where V_{OC} is the *Peak Open Circuit Voltage (Volts)* and I_{SC} is the *Peak Short Circuit Current (Amps)*.

Waveform 3
Waveform 3 is defined as 1MHz decaying sine or cosine/damped oscillatory wave as shown in the next figure:

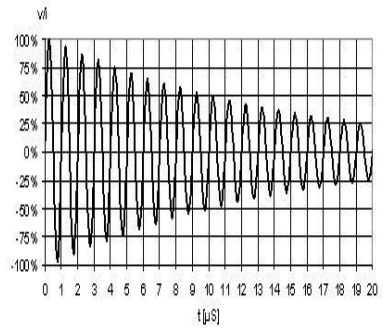

Figure 1: Voltage/Current Waveform 3 worst case, 75% @ 5th peak

As shown, the worst case scenario leads to pulse peak power decaying down to 50% after not long than 5µS.

Waveform 4
Waveform 4 is defined as decaying exponential pulse as described below:

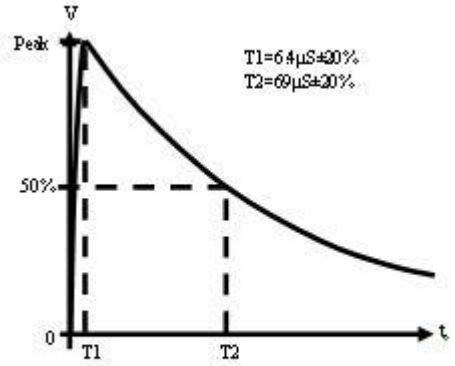

Figure 2: Voltage Waveform 4

In worst case scenario, the pulse peak power decaying down to 50% after not long than 82.8µS.

Waveform 5
Waveform 5 is defined as decaying exponential pulse as described below:

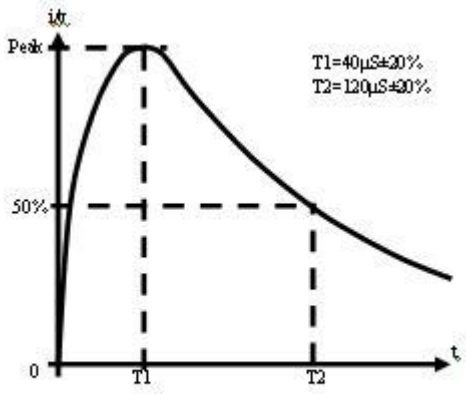

Figure 3: Current/Voltage Waveform 5

In worst case scenario, the pulse peak power decaying down to 50% after not long than 144μS.