Environmental Potentials

Power Quality For The Digital Age

EP-2800B Module Durability Test

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Executive Summary

Environmental Potentials is committed to providing superior power quality products that will last for many years in harsh environments. EP's research and development team constantly performs stress tests to ensure its products are the most robust in the market. EP's engineering team recently subjected one EP-2800B module to 10,000 surges. Each surge was spaced hit at 25 second intervals. The waveform is a B3 Combination and has 1.2 uS rise time and 50 uS decay time voltage wave with a 6 kV peak voltage under open circuit, and an 8 uS rise time with 20 uS decay time current wave at 3000 A peak under short circuit. The EP-2800B module decreases the dv/dt of the surge is by approximately 81.81%. The EP-2800B maintained the same powerful filtration and attenuation from the 1st surge to the 10,602nd surge.

Abstract

ANSI/IEEE C62.41 is an industrial standard which describes surge testing requirements in low voltage AC power circuits. The scope of this recommended practice is to characterize the surge environment at locations on AC power circuits described in IEEE Std C62.41.1 2002 by means of standardized waveforms and other stress parameters. The surges considered in this recommended practice do not exceed one half-cycle of the fundamental frequency in duration. They can be periodic or random events and can appear in any combination of line, neutral, or grounding conductors. They include surges with amplitudes, durations, or rates of change in voltage sufficient to cause equipment damage or operational upset. Surge protective devices (SPDs) acting primarily on the amplitude of the voltage or current are often applied to divert the damaging surges, however a real solution requires a technology that is able to reduce the duration and the rate of change in voltage.

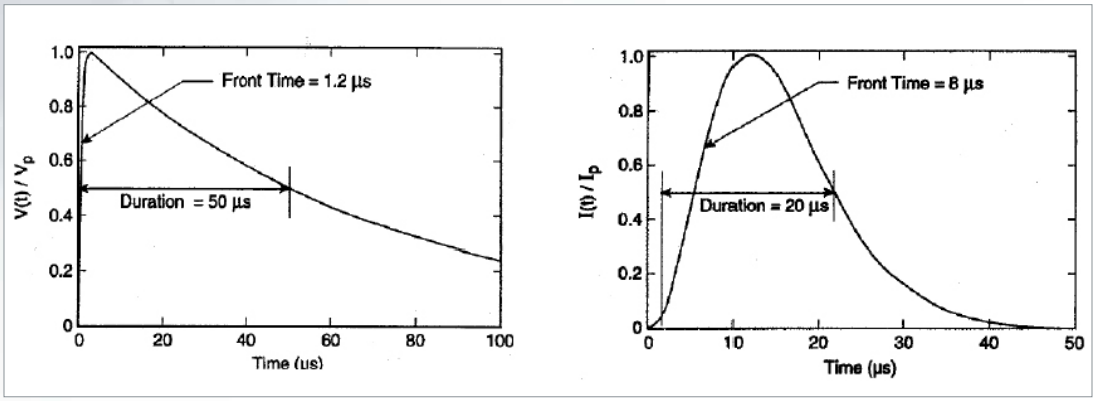
A B3 combination wave from IEEE C62.41 is a typical industrial standard surge every facility can expect multiple times each day. This report demonstrates the EP durability for this surge.

Equipment Used

Velonex 587E Voltage and Current Surge Generator, Tektronix TDS2024C scope, EP-2800B module as EUT (equipment under test), necessary cables and cords.

Theory and Procedure

A B3 combination waveform is generated based on the requirements mentioned in the IEEE C62.41 2002 standard. This waveform has 1.2 uS rise time and 50 uS decay time voltage wave with a 6 kV peak voltage under open circuit, and an 8 uS rise time with 20 uS decay time current wave at 3000 A peak under short circuit. Figures 1 shows the characteristics of the combination waveform.



a) b)

Figure 1: Combination wave under (a) open circuit voltage (b) short circuit current

The Combination Wave involves two waveforms, an open-circuit voltage and a short-circuit current, shown in Figure 1 (a) and (b) respectively.

Testing protocol

1) Surge output on the Velonex 587E surge generator is set to B3 Combination wave parameters 6000v 1.2/50us, 3000A 8/20us
2) 1000:1 BNC cable is connected from generator to the scope to monitor and record the surges.
3) Velonex 587E is turned-on to generate the combination wave surge.
4) Generated surge is monitored on the scope and made sure that the surge generator is generating the required output (Figure 2)
5) EUT (EP-2800B module) is connected to the surge generator
6) Combination wave surge is imposed on the EUT
7) Output of EUT is monitored in the scope and the values were noted down (Figure 3)

8) More than 10,000 surges were generated continuously with this surge generator at an interval of 25 seconds and imposed on EUT.

9) Results were monitored for all the surges and were plotted (Figure 6,7 and 8)

Results

The surge generator is turned on and the surges are recorded in scope. Figure 2 shows the B3 combination waveform before adding the EUT to the circuit.

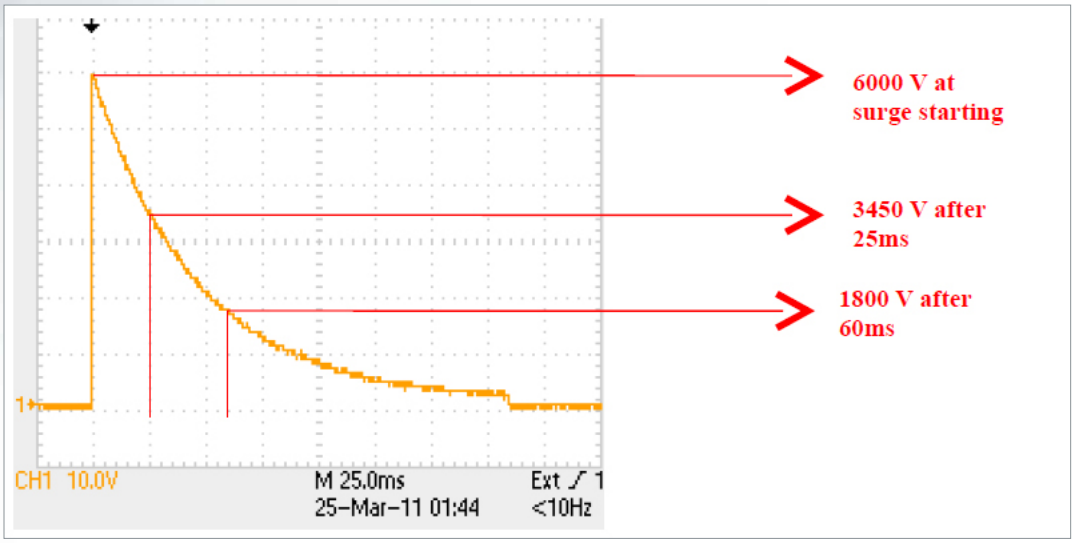


Figure 2: An ideal B3 combination waveform when no load/EUT is connected.

From Figure 2, it is observed that the surge generator is generating B3 combination waveformaccording to its required specifications. Figure 3 is obtained at the scope after the EUT is connected to the circuit.

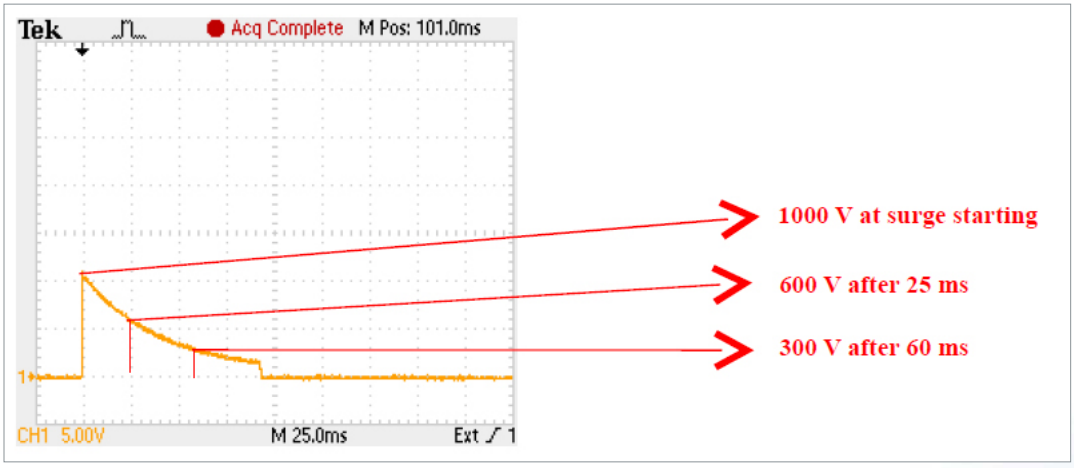


Figure 3: Response of EP-2800B for B3 Combination waveform

Figure 3 shows the combination waveform after passing through the EUT. Figure 3 shows significant reduction in the surge amplitude compared to Figure 2. Comparing to Figure 2, it is clearly shown that the width and height of the surge is significantly reduced. Prior to adding EUT (EP-2800B), the peak amplitude is at 6000 V while the waveform has amplitude of 3450 V after 25ms (Figure 2). After adding the EP unit to the surge generator the output waveform has a peak voltage of 1000 V while the amplitude of voltage after 25ms is 600 V. It is also observed that the EP unit reduced the surge from 1800 V to 300 V after 60 ms.

This means the EP unit reduced the peak amplitude from 6000 V to 1000 V, and a complete removal of surge after 60 ms. This shows that the EP unit absorbs the B3 combination surge. For a filter which doesn't shunt any energy to the ground, this is a tremendous amount of energy to absorb.

dv/dt Analysis

The B3 combination waveform dv/dt is calculated with the following values. Figure 4 is the combination waveform before adding EUT.

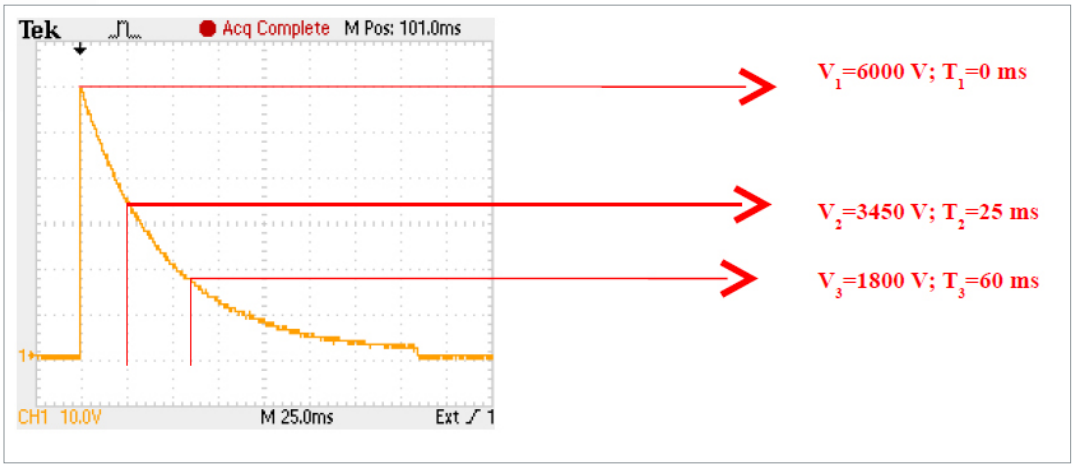


Figure 4: Votlage values at the different timings on B3 combination wavefore before adding EUT to the circuit.

From Figure 4, the voltages and times are observed as,

At T_1=0; V_1=6000 V

At T_2=25 ms; V_2=3450 V and

At T_3= 60 ms; V_3=1800 V

dv/dt is the ratio of change in voltage to the corresponding change in the time. Based on the observed values dv/dt of the combination wave is calculated as,

From T1 to T2

$$\frac{dV}{dT} = \frac{V_1 - V_2}{T_2 - T_1} = \frac{6000 - 3450}{25*10^{-3} - 0} = 102*10^3 V/Sec \quad 1)$$

From T_2 to T_3

$$\frac{dV}{dT} = \frac{V_2 - V_3}{T_3 - T_2} = \frac{3450 - 1800}{60*10^{-3} - 25*10^{-3}} = 47.14*10^3 V/Sec \quad 2)$$

At the same time and under the same timing intervals, after installing an EP unit the dv/dt of the output combination waveform is measured. Figure 5 shows the different values of voltages at different timings after adding EUT to the circuit.

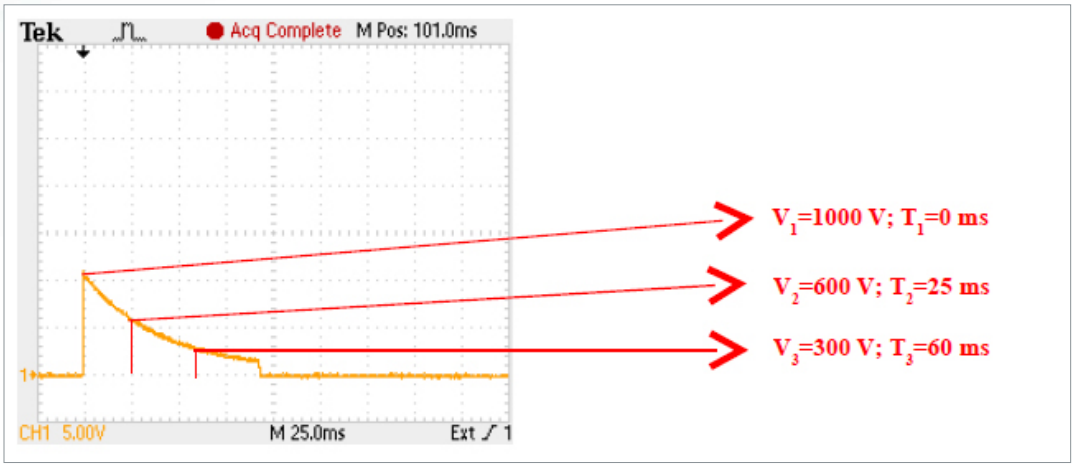


Figure 5: Votlage values at the different timings on B3 combination wavefore after adding EUT to the circuit.

From Figure 5, the voltages and times are observed as,

At T_1=0; V_1=1000 V

At T_2=25 ms; V_2=600 V and

At T_3= 60 ms; V_3=300 V

dv/dt is the ratio of change in voltage to the corresponding change in the time. Based on the observedvalues dv/dt of the combination wave is calculated as,

From T1 to T2

$$\frac{dV}{dT} = \frac{V_1 - V_2}{T_2 - T_1} = \frac{1000 - 600}{25*10^{-3} - 0} = 16*10^3 V/Sec \quad 3)$$

From T_2 to T_3

$$\frac{dV}{dT} = \frac{V_2 - V_3}{T_3 - T_2} = \frac{600 - 300}{60*10^{-3} - 25*10^{-3}} = 8.5714*10^3 V/Sec \quad 4)$$

From Equations (1), (2), (3) and (4) the percentage reduction in dv/dt is calculated as

From T1 to T2 (from Equations (1) and (3)),

$$\% \text{ reduction in dv/dt} = \frac{102 - 16}{102} = 0.8431$$

This indicates that the EP-2800B unit decreased the dv/dt of the waveform from T1 to T2 by 84.31%

From T2 to T3 (from Equations (2) and (4)),

$$\% \text{ reduction in dv/dt} = \frac{47.14 - 8.5714}{47.14} = 0.8181$$

This indicates that the EP-2800B unit decreased the dv/dt of the waveform from T2 to T3 by 81.81%

What does a reduction of dv/dt mean?

High dv/dt causes potential threat to sensitive electronic equipment. A surge with a high dv/dt can puncture the walls of the capacitor in the load and this can cause load failure. Therefore, it is very important to decease the dv/dt of the wavevform to protect the loads in the facility.

Decrease in the dv/dt decreases the slope of the waveform (in this case the surge).

The EP-2800B module reduced the dv/dt of the surge by 84.31% and 81.81% depending on where the timing points are taken. EP waveform correction technology decreases the intensity of the surge by spreading it over a period of time thefore, it can be easilty dissipated by the dissipation circuit.

Durability Test

To check the durability of the test, continuous surges were imposed on the EP unit. Each hit is a B3 combination wave and the duration between each surge is 25s. Surge suppressed after passing through the EP unit is monitored and plotted at frequent intervals.

Figure 3 shows EP's performance for the first surge, while Figure 6, shows EP's performance for the 2238th, 5118th and 10602nd surges.

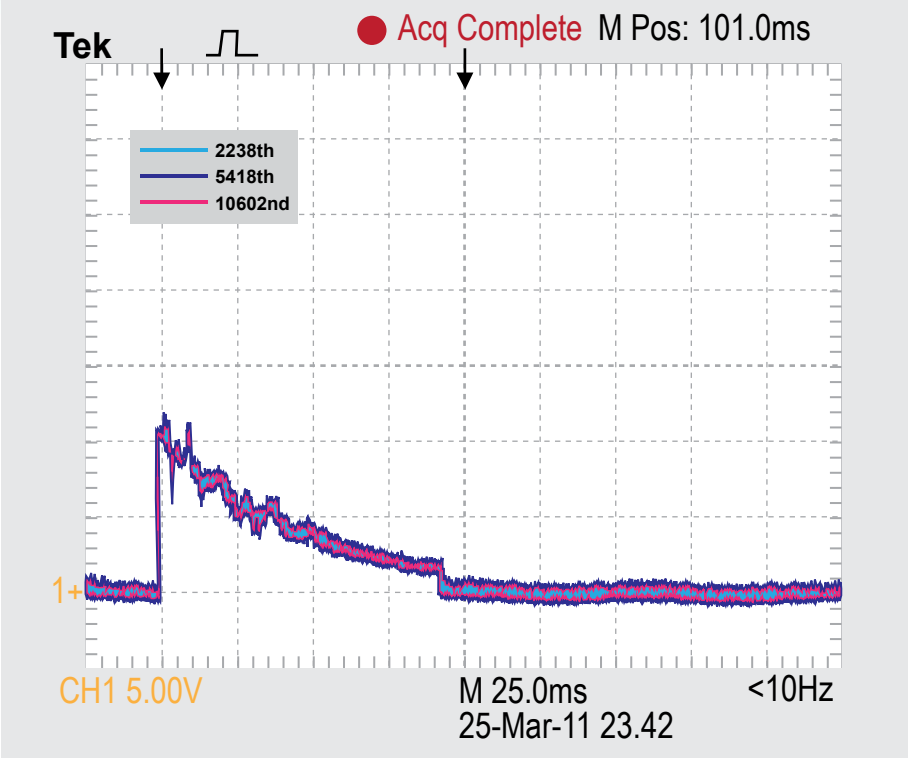


Figure 6: EP2800B Performance for the 2238th, 5118th, and the 10602nd surge.

It is observed from these figures that the EP filter's surge suppression capability remains same for all these surges. This means that EP unit is working with same effectiveness at 10,602th surge as it did at 1st surge. This clearly indicates that, any of the components that are used in the EP unit are neither deteriorated nor degraded for all the 10,601 (10,602nd surge – 1st surge = 10,601 hits) hits.

Conclusion

An IEEE C62.41 combination wave is imposed on an EP-2800B module and the output is plotted. The dv/dt is calculated for the combination wave and the EP-2800B output waveform. It is measured that the dv/dt of the surge is decreased by approximately 81.81% after adding an EP-2800B unit. Then the EP unit is hit by the same combination wave 10,601 times and results are plotted. The EP-2800B maintained the same powerful filtration and attenuation from the 1st surge to the 10,602nd surge. Therefore, it is concluded that the EP unit performs to its maximum capability even after absorbing 10,601 surges.

Environmental Potentials' patented waveform correction technology is able to reduce amplitude, the duration and the rate of change in voltage. This is the only solution to protecting equipment from internal and external surges.

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