Environmental Potentials

Power Quality For The Digital Age

EP UNIT DURABILITY TEST

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Abstract

ANSI/IEEE C62.41 is a typical 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 normal mains waveform (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 sufficient to cause equipment damage or operational upset. While surge protective devices (SPDs) acting primarily on the amplitude of the voltage or current are often applied to divert the damaging surges, the upsetting surges might require other remedies.

B3 combination wave from IEEE C62.41 is a typical industrial standard surge that a facility can expect. This report demonstrates the EP durability for this surge.

Equipment Used

Velonex 587E Voltage and Current Surge Generator, Tektronix THS720P scope, EP 2000 as EUT (equipment under test), Fluke 40,000V Voltage probe 80k-40, necessary cables and cords

Theory and Procedure

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.

The following graphs demonstrate the characteristics of the above said waveform.

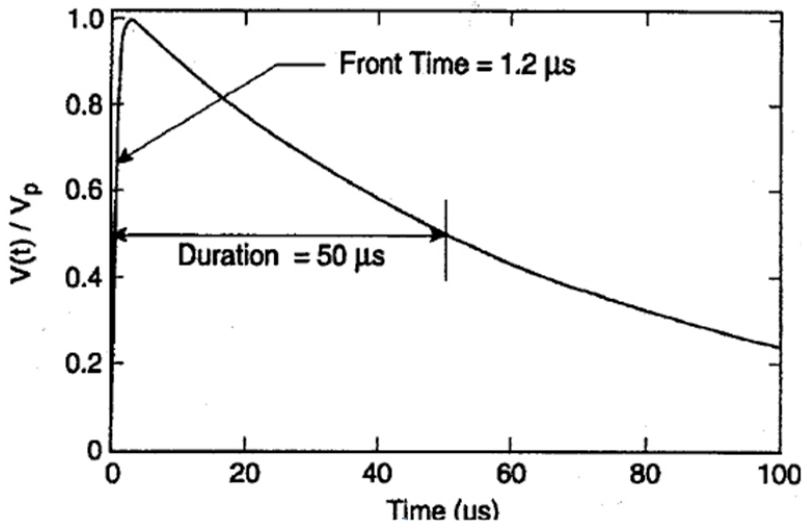

Figure 1: Combination wave under open circuit voltage

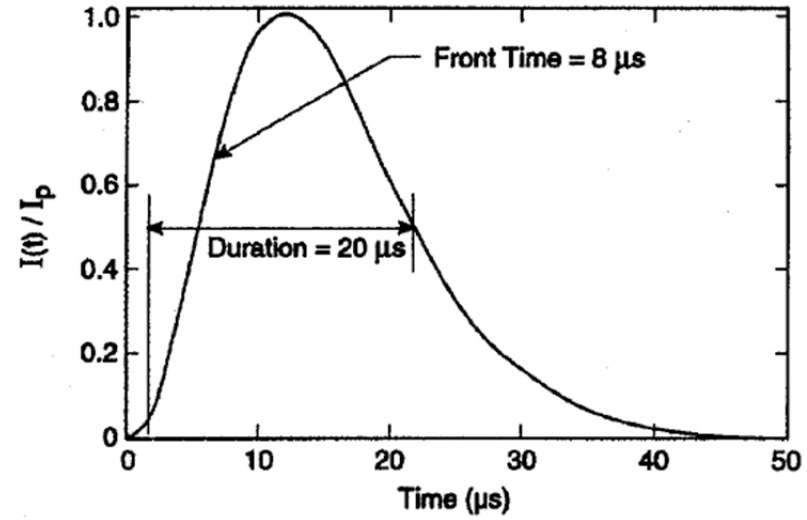

Figure 2: Combination wave under short circuit current

The Combination Wave involves two waveforms, an open-circuit voltage and a short-circuit current, shown in Figure 1 and Figure 2, respectively. The Combination Wave is delivered by a surge generator that applies a 1.2/50 µs voltage wave across an open circuit and an 8/20 µs current wave into a short circuit. The magnitudes of voltage and current are 6000v and 3000A under open circuit and short circuit 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) High voltage probe is connected to the surge generator to monitor the output on Tektronix THS 720P scope.
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 3)
5) EUT (EP2000) is connected to the surge generator
6) Combination wave surge is given to the EUT
7) Output of EUT is monitored in the scope and the values were noted down. (Figure 4)
8) 1989 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 on a graph (Figure 7)

Results:

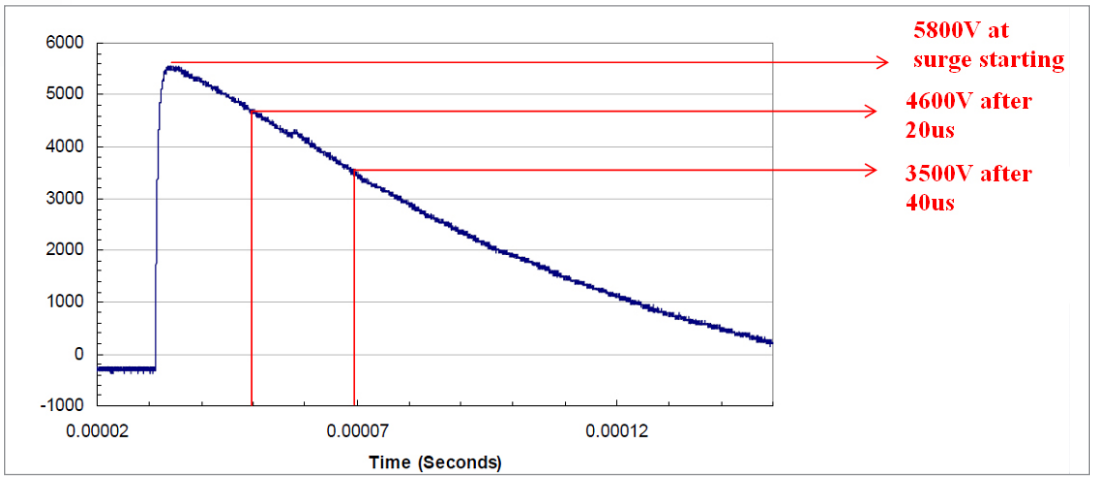

Figure 3: An Ideal B3 combination waveform when no load is connected.

The graph above shows the typical B3 combination waveform, when no load is connected to the surge generator.

Following graph is the output combination waveform that is attenuated after passing through the EUT (EP2000 unit)

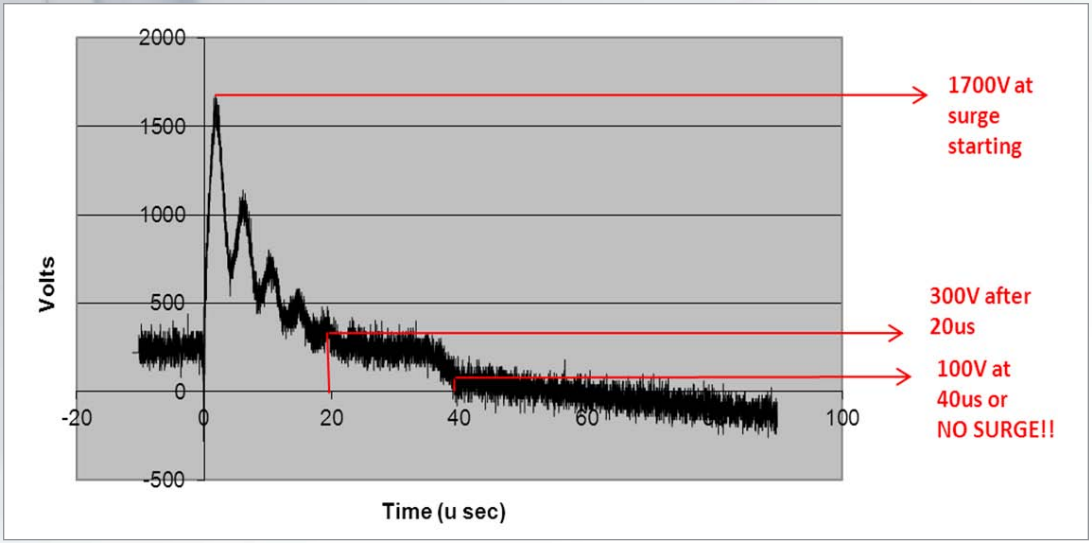

Figure 4: Response of EP2000 for B3 Combination waveform

Figure 4 shows the B3 combination waveform after passing through the EP unit. Comparing to Figure3, it is clearly shown here that the width and height of the surge is significantly decreased. Prior to adding EP, the peak value was at 5800V while the waveform has a magnitude of 4600V after 20us (figure 3). After adding the EP unit to the surge generator the output waveform has a peak voltage of 1700V while the magnitude of voltage after 20us was 300V. This means the EP unit reduced the peak from 5800V to 1700V, and reduced the surge event to a very low value 300v down from 4600v.

It is also measured that the surge magnitude of the output waveform after adding the EP unit was 100V after 40us. It was initially 3500V after 40us. This means that the EP unit completely absorbed the surge after 40us (attenuation from 3500v to 100V/zero). For a filter which doesn't shunt any energy to the ground, this is a tremendous amount of energy to absorb.

dv/dt Analysis

B3 combination waveform dv/dt is measured with following values

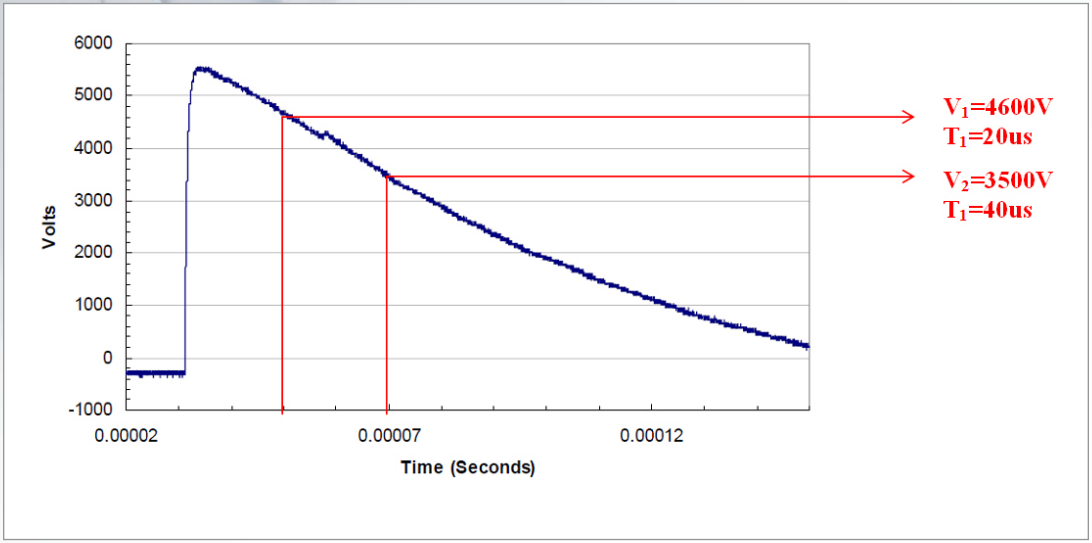

Figure 5: dv/dt values for the ideal combination wave

At initial conditions: V_1=4600V and T_1=20x10^{-6}S

At Final conditions: V_2=3500V and T_2=40x10^{-6}S

dv/dt formula says, it is the ratio of change in voltage

to the corresponding change in the time.

Based on this data, dv/dt of the combination wave is calculated as

$$\frac{dV}{dT} = \frac{V_1 - V_2}{T_2 - T_1} = \frac{4600 - 3500}{40 * 10^{-6} - 20 * 10^{-6}} = 55 * 10^6 V / Sec$$

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.

dv/dt Analysis

B3 combination waveform dv/dt is measured with following values

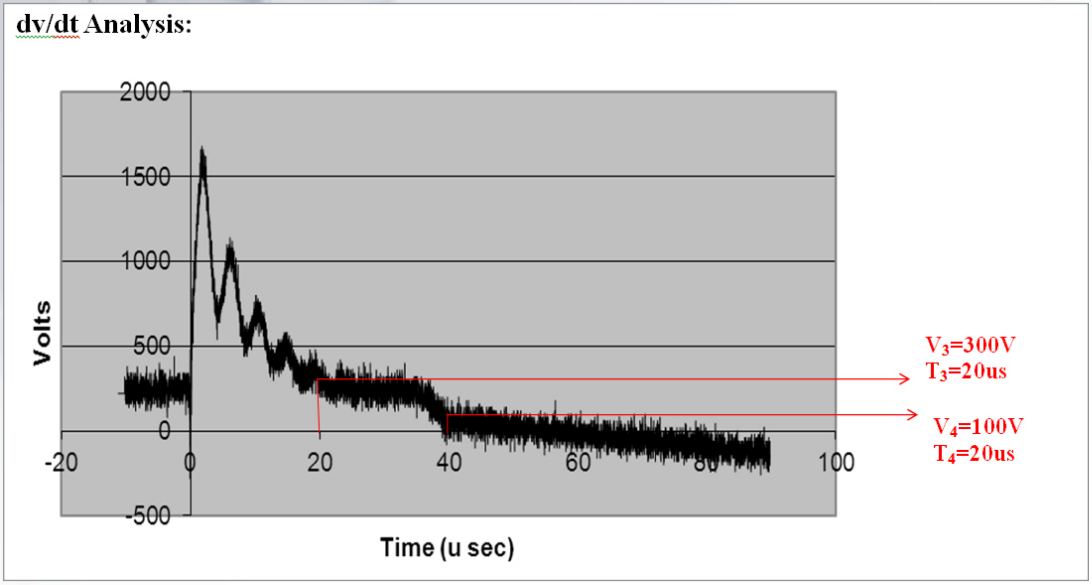

Figure 6: dv/dt values for the combination wave after passing through EUT(EP2000)

At initial conditions: V_1=300V and T_1=20x10^{-6}S

At Final conditions: V_2=100V and T_2=40x10^{-6}S

dv/dt is calculated as:

$$\frac{dV}{dT} = \frac{V_1 - V_2}{T_2 - T_1} = \frac{300 - 100}{40 * 10^{-6} - 20 * 10^{-6}} = 10 * 10^6 V / Sec$$

From the above calculations, dv/dt for an ideal combination wave is 55MV/Sec (read as Mega Volts per Second), while after adding the EP2000 it is reduced to 10MV/Sec.

This indicates that the dv/dt of the waveform is decreased by

$$\% \text{ decrease in dv/dt} = \frac{55\text{-}10}{55} = 81.81$$

EP2000 decreased the dv/dt of the waveform by ***81.81%***

What does this mean

A decrease in the dv/dt means that the slope of the waveform (in this case a surge) is decreasing. EP waveform correction technology is decreasing intensity of the surge by spreading it thefore, it can be easilty dissipated by the built in dissipation circuit.

Durability Test

To check the durability of the test, continuous surges were imposed on the EP unit. Each hit was a B3 combination wave and the duration between each surge was 25 seconds. Output of the EP unit was plotted in the following graph.

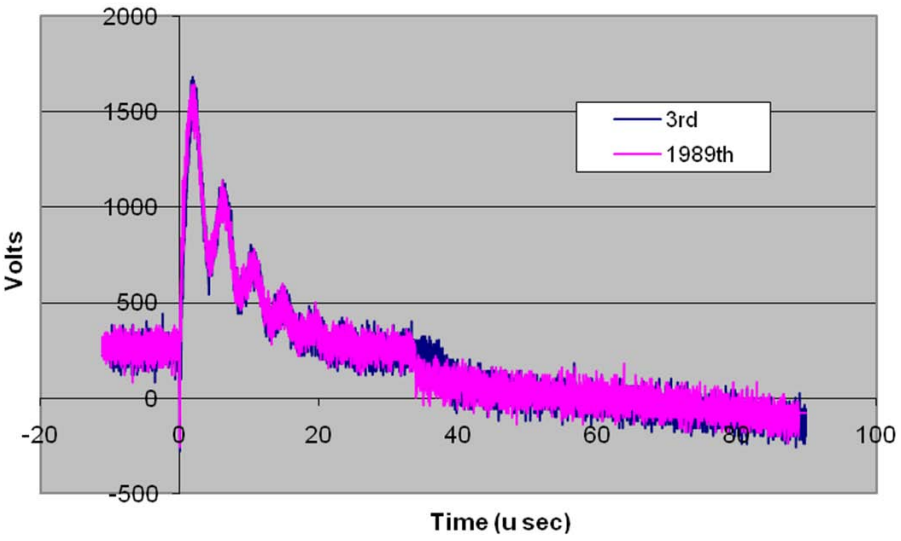

Figure 7: Comparison of EP unit after 1,989th surge

Above figure shows the EP unit output after 1,989 surges. The blue line shows the EP behavior for the B3 combination waveform when it was hit by 3rd surge. The orange line shows the EP behavior for the same B3 combination waveform when it was hit by 1,989th surge. Based on the above data, it is shown that both blue line and orange line are equal in magnitude. This means that EP unit is working with same effectiveness at 1,989th surge as it did at 3rd surge. This clearly indicates that, any of the components that are used in the EP unit are neither deteriorated nor degraded for all the 1,987 (1,989th surge – 3rd surges = 1,987 hits) hits. Both the lines maintain the same attenuation levels, meaning that the EP effectiveness is same.

Conclusion

An IEEE C62.41 combination wave is imposed on an EP-2000 unit and the output was plotted. The dv/dt was calculated for the combination wave and the EP-2000 output waveform. It was measured that the dv/dt of the surge is decreased by 81.81% after adding an EP-2000 unit. Then the EP unit was hit by the same combination wave 1,987 times and results were plotted. The performance of the EP-2000 on the 3rd surge and 1,989th surge were equal with same powerful filtration and attenuation. Therefore, it is concluded that the EP unit performs to its maximum capability even after 1,987 surges.

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