Sandia BOS Testing

BRIEF #7, Jun 1999

Evaluating Static Inverter Voltage Sags & Surges

Published by Sandia National Laboratories PV Design Assistance Center
This work funded by the DOE Photovoltaic Division

Background

Because transient under and over voltage conditions may cause problems with equipment operation, electrical equipment is designed to be supplied by a voltage that is within a tolerance window. Electronic equipment usually stores a small amount of energy in the equipment's power supply and can generally, ride-through very short voltage drop-outs. In addition, very short duration over voltages do not have enough energy to cause damage to equipment.

Voltage Tolerance Envelope

The Institute of Electrical and Electronic Engineers (IEEE), US Navy, National Institute of Standards and Technology (NIST), and the Information Technology Industry Council (ITIC), have all worked on developing standards for such voltage tolerances. One such standard is a **voltage tolerance envelope** that includes over and under voltage limits for transient, short-term, and steady-state voltages.

ITIC has developed a voltage tolerance envelope commonly called the ITIC (formally CBEMA) Curve (figure 1). The curve was developed as a **recommended** design goal for electronic equipment manufacturers. Equipment is typically designed to operate satisfactorily while the voltage is maintained within the tolerance envelope. Note that the ITIC steady-state over-voltage limit of 110% is higher than the 106% specified by ANSI C84.1.

The ITIC limits allow the voltage to drop to zero for up to 20 milliseconds, 70% (84V for a 120V system) for up to 0.5 seconds, 80% (96V) for up to 10 seconds and 90% (108V) continuously. The voltage is allowed to be as high as 500% (600V) for up to 10 milliseconds, 120% (144V) for up to 0.5 seconds, and 110% (132V) continuously.

Objective

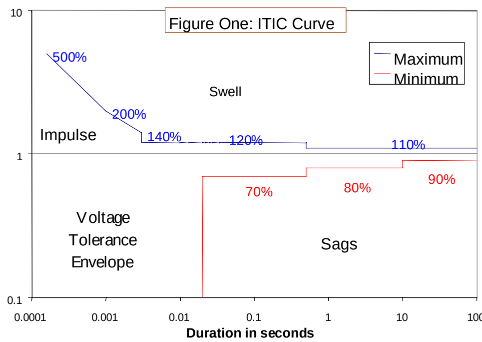
The SNL PV inverter test laboratory has adopted the ITIC curve to provide an indicator of inverter surge/sag tolerence. Various tests are performed on the inverters and the resulting transients are plotted on the curve as an indication of how likely it is that the load will operate through the transient.

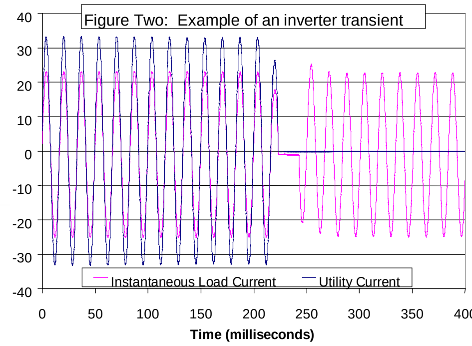
The voltage tolerance envelope is **not** a pass-fail test, but a general indication that equipment designed to operate within the ITIC curve will continue to operate correctly when the voltage waveform is within the limits stated. Data points between the maximum and minimum curve imply that this class of equipment will probably continue to operate during the types of disturbances represented. Data points outside the curve are more likely to cause problems.

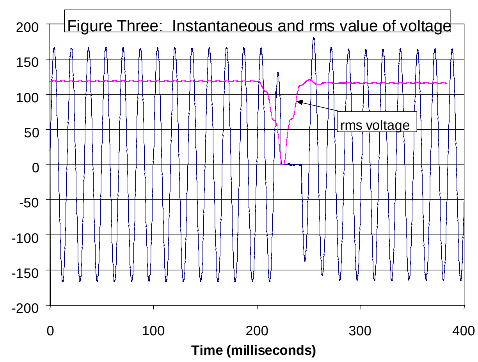
One of the inverter tests performed for a grid connected inverter monitors the load voltage during a simulated utility outage. During the period when the inverter transfers the critical load from the utility grid to the batteries, there may be a momentary dropout of the load voltage. A typical transfer event is shown in figures 2 through 5.

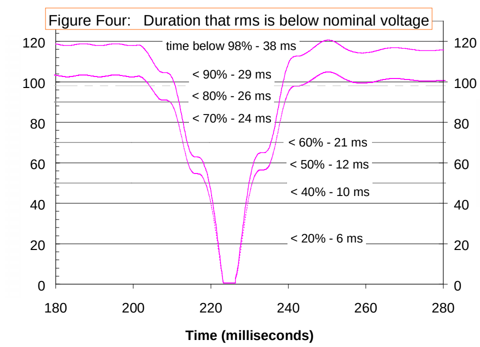
The plot in figure 2 shows the instantaneous voltage waveforms for the utility grid and the load. Electrical equipment is more sensitive to the average voltage than to the instantaneous voltage, and because the average of a sinusoidal waveform is zero, a root-mean-square (rms) value is used. Figure 3 shows the instantaneous and rms value for the load voltage. The rms values are calculated over a one-cycle period. The duration that the rms value of the load voltage is below the 20%, 40%, 50%, etc. of the nominal voltage is shown in figure 4.

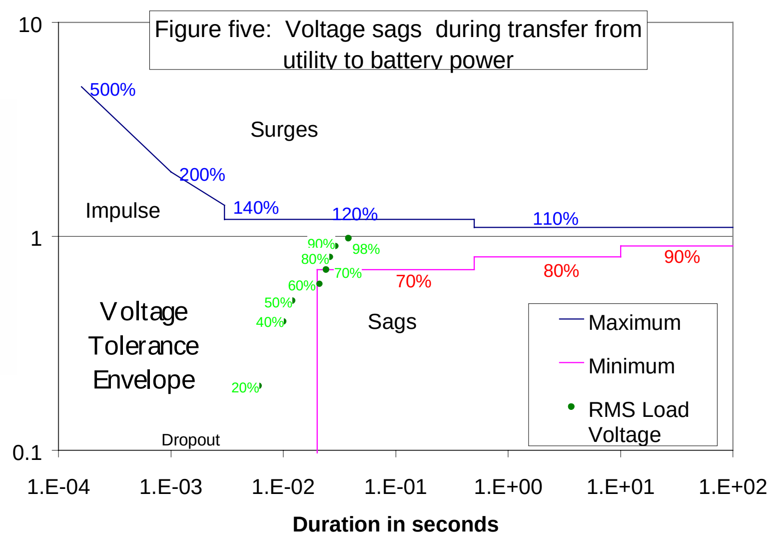
The period when the voltage is below the nominal for the various ranges is plotted on the ITIC Curve in figure 5. The data points are all within or on the line of the tolerance waveform. During the disturbance shown, well designed equipment should continue to operate without interruption. This type of plot provides a means of quantitatively comparing various voltage disturbances.











References

ANSI/NEMA C84.1-1995, Electrical Power Systems and Equipment–Voltage Ratings (60 Hz)

ANSI/IEEE 446-1995, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.

IEEE 1159-1995, Recommended Practice for Monitoring Electric Power Quality.

Federal Information Processing Standard Publication 94 – withdrawn.

Information Technology Industry Council, http://www.itic.org

For More Information Contact:

Mark Ralph, 505-845-3343, meralph@sandia.gov
Russell Bonn, 505-844-6710, rhbonn@sandia.gov
Sandia National Laboratories, PO Box 5800
Albuquerque, NM, 87185-0753