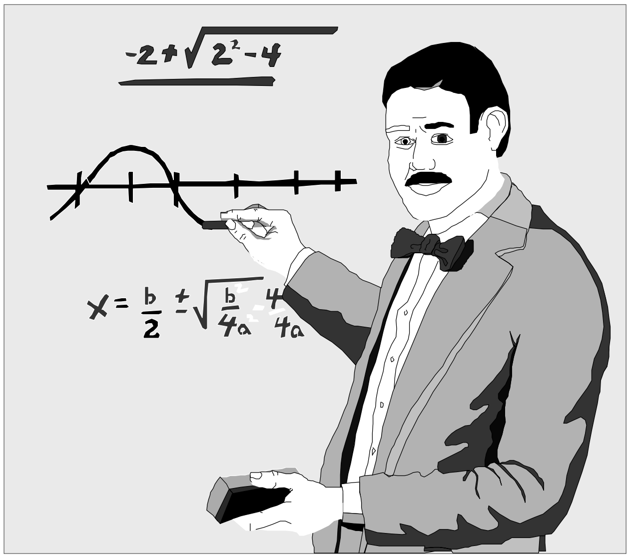
White Paper # 5206



Understanding ANSI/IEEE C62.41
(formerly IEEE 587)

ETA SYSTEMS

Introduction

As the power protection industry has matured, two guidelines have become defacto standards. IEEE C62.41 (formerly IEEE 587) and UL1449 are often used as performance yardsticks by those who sell, select, and specify power protection solutions. What has been forgotten, however, is that neither of these guidelines was ever developed as a performance standard for measurement of a power protection product's effectiveness. What are these standards all about?

Answering this question is the subject of this Whitepaper and its companion, Whitepaper 5207 – Understanding UL1449. These two documents will describe the intent of both guidelines and describe how test data resulting from these guidelines should be interpreted when evaluating appropriate power protection solutions.

Defining the problem

A summer thunderstorm rolls through the midwest United States, and, as a lightning flash races into the wiring of a video studio, tens of thousands of dollars of digital production equipment goes up in smoke. Meanwhile in the Pacific Northwest, on a rare but beautiful sunny day, an audio console in a broadcast station fails without warning. In the failure's wake is only the smell of charred components.

These fictional scenarios are replayed every day in the world of high tech electronics -- ask any field engineer. Modern electronic components are intolerant of voltage transients exceeding their design limitations. To make matters worse, the cause of catastrophic transient voltages isn't always readily identifiable.

Exploring Voltage Transients

Transient voltage impulses (often called surges in our everyday conversation) originate from two major sources: **electrical system switching activities** (i.e. utility operations, capacitor switching, facility load cycling, etc.) and **direct or indirect lightning effects introduced into the electrical distribution system.**

Regardless of the source, and depending on the energy content of the transient, modern microelectronics will either be outrightly destroyed or invisibly degraded and weakened by exposure to such events.

As the electronic age moved from vacuum tube to transistor, manufacturers experienced catastrophic system failure more frequently, and most began to have questions about what transient voltages and currents their electronic system designs needed to tolerate.

The existence of transient surges in electrical systems was recognized and well documented at the time. Such factors as frequency of occurrence, transient waveshapes, surge energy content, source currents and voltage amplitudes were less understood, and electronic manufacturers were seeking guidelines to help them provide system survivability in a worst case transient voltage scenario.

To the Rescue

Working groups of the IEEE and the IEC (International Electrotechnical Commission) began a technical appraisal of the problem. Previously, it was considered appropriate for a manufacturer to attempt to duplicate, in the laboratory, the actual range of environmental conditions a system might encounter. IEEE and IEC representatives suspected, however, that a more appropriate protocol would be to test systems for survivability against one or more ***arbitrary but standardized waveforms*** that could be considered as representative of worst-case conditions. The groups set out on the task of determining what these worst case conditions were and defining disturbance waveforms that could be used to simulate these worst case conditions in a test laboratory.

The standard defined

The working groups discovered, to no ones surprise, that transient impulses were different depending on where in the electrical system they occurred. As a result, ANSI/IEEE C62.41 defines three categories of exposure: <u>Category C</u> *– Outside and service entrance,* <u>Category B</u> *– Distribution panel and short branch circuits, and* <u>Category A</u> *– Long branch circuits or anything more than 30 feet from Category B.* Figure 1 illustrates.

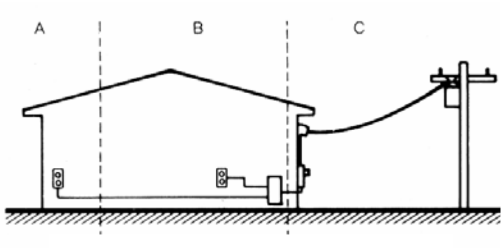


Figure 1 – Category Definitions

In addition, the working groups also discovered that transient voltage waveshapes, source currents, and rise times varied depending on where the disturbance was observed. As a result, the standard recommends five different representative waveforms. Of these five waveforms, two are *basic waveforms* and three are *supplementary waveforms* (i.e. for use in unusual circumstances).

Figure 2 illustrates the waveform found in Category C locations, and, since it may also occur in Category B, it is often shown with a peak voltage representation of 6000 volts. It is important to recognize that Category C locations may be exposed to substantially higher voltages and currents -- often as large as 10 kVolts at 10 kAmps or more.

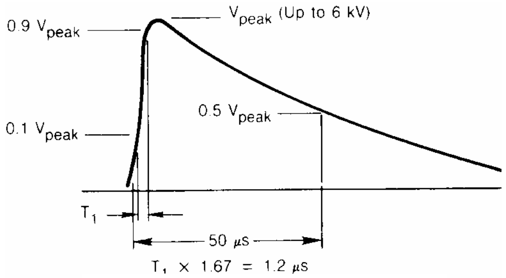


Figure 2 – Unipolar Impulse

System designers find the Category A waveform, often referred to as the "100 KHz ringwave," of greatest importance because its characteristics closely match those seen in locations where systems are installed. The natural reactance of building wiring gives an electrical system an inherent resonant frequency, much like the tuning circuit of a radio receiver. When the high energy impulse of Figure 2, impinges on building wiring, it excites these natural resonant tendencies and is changed into the decaying waveform shown in Figure 3.

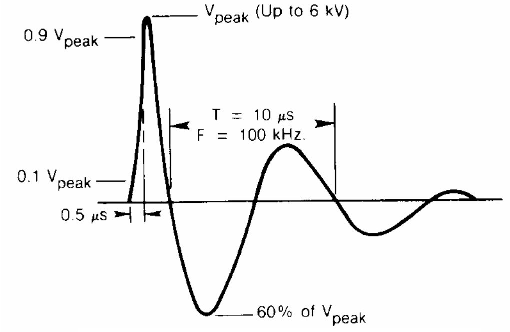


Figure 3 – 100 KHz. Ringwave

The ringwave can have peak voltages of 6000 volts at amperages of 200 amps for Category A and 500 amps for Category B.

Making Sense of the Statistics

It's important to keep in mind that in spite of all the mind numbing technical jargon, the IEEE/IEC working groups had a real goal in mind -- to provide system manufacturers with a good idea of the worst case electrical disturbances that their system designs might encounter in the real world. And they succeeded. Armed with all the preceding data, system manufacturers began testing their system designs to make sure they could survive in the face of *worst case* real world power disturbances. Conducting "withstand testing" on electronic systems to determine if they can withstand Category A and B disturbances is standard practice. It's important to note, however, that system manufacturers don't necessarily conduct these tests to determine if their systems can survive *repetitious* exposure. As a result, surviving the "withstand" test is no guarantee of a system's resiliency in an electrical environment where it may be subject to repeated electrical disturbances of a potentially catastrophic nature. And that's an important point to recognize.

Slightly Off Course

Along the way, part of the power protection industry has misconstrued the original intent of the guideline. It's not uncommon for someone to ask if our products meet ANSI/IEEE C62.41, and it's not difficult to understand why they ask.

Technical specifications for power protection products often state that a product complies with ANSI/IEEE requirements. However, C62.41 isn't a requirement, it's a *recommendation* for product survivability. Incidentally, it is important that power protection products are tested to ANSI/IEEE guidelines since no one wants to buy a power conditioner, surge protector or UPS with less survivability than the system it's protecting.

ANSI/IEEE C62.41 was never intended as a performance measurement for power protection equipment, and it's our industry's use of the guideline that requires an explanation.

In the same way that system manufacturers use the test waveforms to determine their withstand capability, a power protection manufacturer can use the same waveforms to *deduce* something about his product's performance. It's important to note that the energy contained in a power disturbance is what causes system damage. If most of the disturbance energy can be prevented from reaching the system, the power protection device will be highly effective. Therefore, the power protection capabilities of any individual product can be partly assessed by measuring how much of the test waveform's voltage reaches the protected product. This is called the *let-through* measurement of the surge protector, power conditioner, or UPS. It's an important piece of information that is sometimes omitted from product advertising, and it shouldn't be. Where let-through is concerned, least is best.

What the purchaser or specifier must look for, is a power protection product that is tested by injecting ANSI/IEEE defined test waveforms and then measuring the let-through performance in both normal mode and common mode. Low let-through in both modes means system survivability, even when the disturbance isn't catastrophic. That's highly important. Electronic systems are subjected to numerous power disturbances during their installed life. Not all of them are large enough to be immediately destructive. To meet the guidelines of the semiconductor industry, let- through voltage should be <10 volts normal mode and <1/2 volt common mode.