

Causes and Effects of Transient Voltages

What are Transients?	Transient Characteristics	Transient Sources
Transient Generators	Transients & Electronics	Transients & Electrical Systems

- **Transient activity is believed to account for 80% of all electrically-related downtime.**
- **Lightning accounts at least 5% of Insurance claims and costs an average of \$13,000 per occurrence.**
- **Effective transient voltage suppression equipment can double or triple the life of electrical and electronic equipment.**
- **A systems approach to transient voltage surge suppression can result in dramatic performance in terms of return-on investment.**
- **Transient Voltage Surge Suppression is the most immediately apparent, and the most cost-effective means of improving your power quality.**

What are transient voltages?

"Transients", a term we'll use for simplicity here, are actually "Transient Voltages". More familiar terms may be "surges" or "spikes".

Basically, transients are momentary changes in voltage or current that occur over a short period of time. This interval is usually described as approximately 1/16 (one sixteenth) of a voltage cycle (in the US, about 1/60th of a second) or about 1 milliseconds (milli = .001--one thousandths...In laymen's terms, .0166 seconds.....or really darned quick.).

Voltage transients normally last only about 50 microseconds (micro = .000001--one millionth) and current transients last typically 20 microseconds according to the ANSI C62.41-1991 which is the standard for transients in facilities operating under 600 Volts.

Here's the technical definition:

(ANSI std. 1100-1992) A subcycle disturbance in the AC waveform that is evidenced by a sharp brief discontinuity of the waveform. Transients may be of either polarity and may be of additive or subtractive energy to the nominal waveform.

Transients are divided into two categories which are easy to identify: impulsive and

oscillatory. If the mains signal is removed, the remaining waveform is the pure component of the transient. The transient is classified in the impulsive category when 77% of the peak-to-peak voltage of the pure component is of one polarity. Each category of transient is subdivided into three types related to the frequencies contained. Each type of transient can be associated with a group of phenomena occurring on the power system.

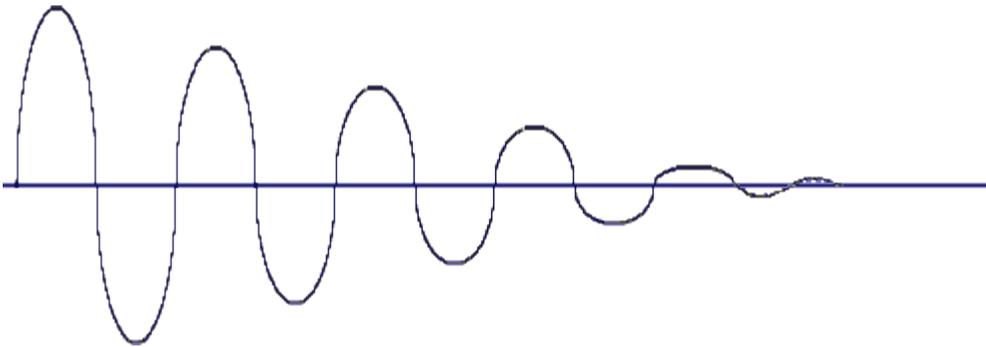
The impulsive low-frequency transient rises in 0.1 ms and lasts more than 1 ms. Its companion, the oscillatory low-frequency transient, contains frequency components up to 5 kHz. These types are the most common transients recorded on a power system. They are not only easily propagated but they can also be amplified by a power-system resonance phenomenon. Measurement of these types of transients should be useful for all classes of application (benchmarking, legal, trouble shooting and laboratory)

The medium-frequency impulsive transient lasting between 50 ns to 1 ms and oscillatory transients between 5 and 500 kHz are less frequent than the low-frequency types but have much higher amplitude. These transients may not propagate as easily as the low-frequency types but may cause arcing faults on the power distribution system which result in voltage sag on many user power systems. It is most appropriate to measure these types of transients for trouble shooting and laboratory classes.

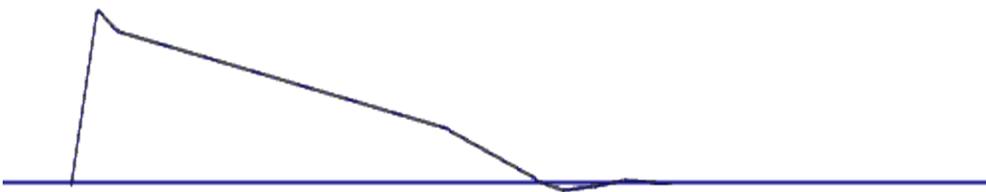
High-frequency types with high amplitude can be observed only near where the phenomenon occurs. The high-frequency impulsive transient has duration below 50 ns and the frequency of the high frequency oscillatory type ranges between 0.5 and 5 MHz. These measurements are useful for laboratory and trouble shooting classes of application.

Characteristics of the Transient Voltage Waveform

The most common transient, is the "oscillatory transient" . It is sometimes described as a "ringing transient". This type of transients is characterized by swings above and below the normal line voltage.



The other type (impulse) transient, is more easily explained as a "one-shot" type of event, and it is characterized by having more than 77% of it being one pulse above the line voltage. A lightning strike can be composed of multiple transients of this type.



Even these transients can be broken up into other categories identified by their frequency.

1. Mid-to-Low Frequency Transients, like lightning and utility capacitor switching propagate (travel) very well on electrical systems. Higher amplitudes tend to be damped by the building's distribution system at voltages above 16,000 volts. There is almost no damping below 10,000 volts.
2. High Frequency transients, however, are usually only seen near the source. This means that surge suppression equipment installed a distance away will never see the effect. It is for this reason that multiple suppressors are recommended within the facility.

Where do Transient voltages come from?

Transients can be generated internally, or they can come into a facility from external sources. The least common of the two are externally generated transients. They've been described as "electronic rust".

External sources:

Lightning is the most well known of the externally generated transients. Most lightning transients are not actually the result of direct lightning strikes....they are most often "induced" onto conductors as lightning strikes near the power line. The large electric fields generated during a discharge can couple into the power system, creating induced transients. A cloud-to-cloud discharge can generate a 70 Volts per meter electric field. On a 1/2-mile length of transmission line this is equal to a 56,000-volt transient--and it didn't even touch the line!

Other externally generated transients may also be imposed on power lines through normal utility operations. Switching of facility loads, opening and closing of disconnects on energized lines, switching of capacitor banks, re-closure operations and tap changing on transformers can all cause transients.

Poor or loose connections in the distribution system can also generate transients. They may be caused by high winds, which can blow one power line into another or blow tree limbs into the lines causing arcing. You'll probably be able to hear a buzzing sound and see sparks when the arc occurs, or you may even be able to smell the burnt insulation around the arc.

Accidents and human error account for some externally generated transients since most power lines are run above-ground. Animals and weather can also produce conditions which generate transients.

Another common source, not commonly known, is neighboring businesses. If you share a transformer with other users, any transient activity generated on his premises will be seen at your electrical main. Remember, you are both physically connected at the secondary side (some people call it the "south side") of the transformer.

Internal Sources:

The vast majority of transients are produced within your own facility. The main culprits are device switching, static discharge, and arcing.

Each time you turn on, turn off, load, or unload an inductive device, you produce a transient. Inductive devices are those devices that use "magnetic mass" to function. Examples of inductive loads are motors and transformers. The inductive "kick" from a 5-horsepower motor turning on can produce a transient in excess of 1,000 volts. A motor with a faulty winding, commutator, or other insulation faults can produce a continuous stream of transients exceeding 600 volts! Even transformers can produce a large transient, particularly when energizing. Interestingly enough, this isn't produced the way many people think (from the sudden load on the system), but is a result of the collapse of the magnetic field upon energizing the transformer.

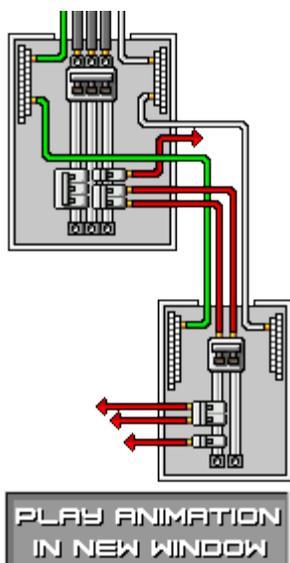
Static electricity (also called "electrostatic discharge") can generate up to 40,000 volts. This type of hazard is very dependent upon environmental conditions and areas with lower humidity have the worst problems.

Arcing can generate transients from a number of sources. Faulty contacts in breakers, switches, and contactors can produce an arc when voltage jumps the gap. When this gap is "jumped" the voltage rises suddenly and the most common effect is an oscillatory-type transient. Faulty connections and grounds can produce arcing.

Common Internal Sources of Transient Activity

Photocopiers	PC Power Supplies	Laser Printers	Electronic Ballasts
Welders	Power Factor Correction Equipment	Power Supplies	Temperature Controllers
Motor Controllers	Pumps	Inverters	Compressors
Generators	Variable Speed Motors	Standard Electric Motors	High-Frequency Lighting Power Supplies

How Do Transients "Travel"?



The common aspect of all these internally generated voltages is your electrical distribution system. Your facility wiring is designed to transmit electricity with the least impedance possible so that maximum efficiency is maintained. This same efficiency works to transfer the transients produced throughout your facility with minimal obstruction.

All of your panels are physically bonded together by multiple means. Transient activity "seen" at one panel is easily transmitted to all other panels within your system, dependent upon transient frequency and magnitude.

You may even have transient activity you are unaware of even after you have "measured" your power quality. This is because high-frequency transient activity must be measured near its source. Many facility managers check power quality at the service entrance panel (because this is where the utility companies tend to do it for free).

What are the effects of transient activity?

Electronic Equipment:

Electronic devices may operate erratically. Equipment could lock up or produced garbled results. These types of disruptions may be difficult to diagnose because improper specification and installation of transient voltage surge suppression equipment can actually INCREASE the incidents of failure as described above.

Electronic devices may operate at decreased efficiencies. Damage is not readily seen and can result in early failure of affected devices. Unusually high frequency of failures in electronic power supplies are the most common symptom.

Integrated circuits (sometimes called "electronic chips") may fail immediately or fail prematurely. Most of the time, the failure is attributed to "age of the equipment". Modern electronic devices provided clean, filtered power should outlast the mechanical devices they control.

Motors:

Motors will run at higher temperatures when transient voltages are present. Transients can interrupt the normal timing of the motor and result in "micro-jogging". This type of disruption produces motor vibration, noise, and excessive heat. Motor winding insulation is degraded and eventually fails. Motors can become degraded by transient activity to the point that they produce transients continually which accelerates the failure of other equipment that is commonly connected in the facility's electrical distribution system. Transients produce hysteresis losses in motors that increase the amount of current necessary to operate the motor. Transients can cause early failures of electronic motor drives and controls.

Lighting:

Transient activity causes early failure of all types of lights. Fluorescent systems suffer early failure of ballasts, reduced operating efficiencies, and early bulb failures. One of the most common indicators of transient activity is the premature appearance of black "rings" at the ends of the tubes. Transients that are of sufficient magnitude will cause a sputtering of the anodes--when these sputters deposit on the insides of the tube, the result is the black "ends" commonly seen. Incandescent lights fail because of premature filament failures. The same hysteresis losses produced in motors are reproduced in transformers. The results of these losses include hotter operating temperatures, and increased current draws. Do you want to see a graphic illustration of the results of transient activity on fluorescent tubes? Look at the ends of your tubes.....see those dark rings? Effective transient suppression will eliminate those rings and make your bulbs last 4 to 6 times longer.

Electrical Distribution Equipment:

The facility's electrical distribution system is also affected by transient activity. Transient degrade the contacting surfaces of switches, disconnects, and circuit breakers. Intense transient activity can produce "nuisance tripping" of breakers by heating the breaker and "fooling" it into reacting to a non-existent current demand. Electrical transformers are forced to operate inefficiently because of the hysteresis losses produced by transients and can run hotter than normal.



