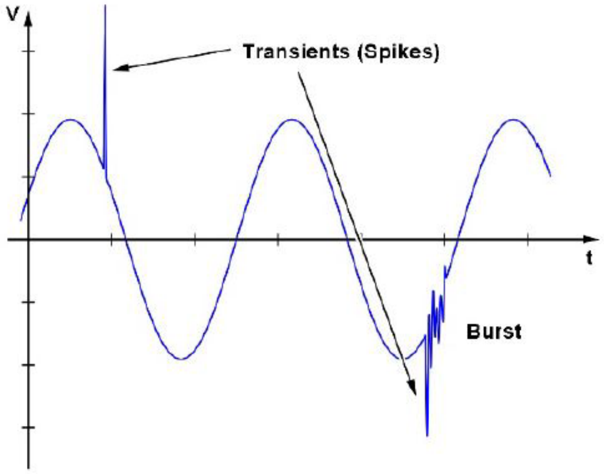
Power Quality Issues - Part 3 - Transients and Interference

Discussed here together because they are both high frequency power quality events, interference and transients, or spikes as they are often referred, can have an effect on the equipment within and operation of an electrical installation ranging from mildly irritating to extremely damaging and costly. In part 3 of this series on power quality issues **Julian Grant - General Manager at Chauvin Arnoux UK**, looks at the causes and effects of interference and transient voltages on the electrical supply of an installation, along with solutions to protecting against, or removing them.

An electrical transient is a very fast, short duration spike in voltage which could be several kV in magnitude. This voltage spike produces a corresponding increase in current in the load, seen as a current spike, and this in turn results in a momentary increase in transferred energy. Depending on the magnitude and duration of the transient, the resulting transferred energy to the load can be of little to no consequence, or it could cause significant damage. Transients may also occur as bursts rather than singular events.



As with most power quality issues transients are often assumed to be generated by outside sources such as lightning strikes, load switching, and fault clearance within the utility supply equipment. However, while lightning induced transients present the greatest risk of equipment failure and damage, due to the voltages they reach and the energy levels they may contain, most transients originate from internal sources within a facility. In fact, studies have indicated that greater than 80% of transients in any particular facility are internally generated.

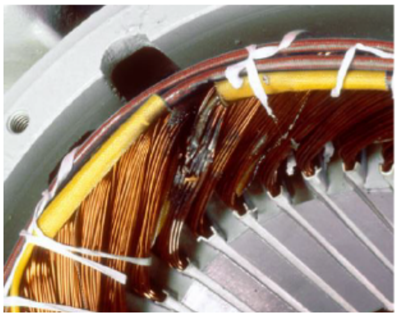
So, accepting they are rare, why are lightning induced transients potentially so damaging? The current within a typical lightning strike rises quickly to its maximum level within 1 to 10 microseconds, before it then decays at a rate of about 50 to 200 microseconds. Because the current within a lightning strike is of a transient nature several phenomena come into play. Short duration current spikes tend to travel on the surface of a conductor due to skin effect, and rapidly changing currents also create electromagnetic pulses (EMPs) that radiate outward from the point of the strike. If the radiated pulses pass over conductive items such as power lines, communication lines, or metallic pipes, they may induce a transient current into those items that then runs along the surface to the point of termination. Even a strike to the ground near to a piece of electrical infrastructure can have such an effect.

Other infrequent external factors like load switching and fault clearance within the utility supply can generate transients, although generally smaller than those generated by lightning. This is due to either the interaction between magnetic and electrostatic energy stored in the inductance and capacitance of the circuit, and a load being connected to it during the closing of the switch contacts, or the interaction between the mechanical energy stored in rotating machines, and the energy stored in the inductance and capacitance of the circuit, when additional generation capacity is switched in and out.

Transients are more often produced from within the installation each time a switching operation occurs, such as bus transfer switching or even a normal circuit breaker or contactor opening or closing. Simply turning a light switch on or off can create a transient, and in all cases the transients generated will be worsened by breakers and switches arcing due to faulty or corroded contacts. Abnormal events such as MCB's tripping during the clearing of faults also cause transients.

Office equipment such as photocopiers and laser printers are notorious for generating transients, as are HVAC systems. In fact, whenever an inductive or capacitive load is either connected to or disconnected from the power source it generates a surge impulse that propagates back through the electrical system.

That shock you get after you walk across a carpeted office and touch the coffee machine, resulting from the static electricity generated through the interaction between your shoes and the flooring material, can also induce a transient into the mains supply.


Winding damage due to voltage transients

With regards to the effect of spikes on an electrical installation and the equipment connected to it, it is generally the case that internally generated transientactivity may weaken equipment over time, but the threat posed by lightning and the switching of large inductive loads can reach levels that can cause insulation breakdown and subsequently deliver vast amounts of energy into equipment resulting in premature failure. When a transient voltage occurs that is higher than the breakdown voltage of the insulation in a piece of equipment a flashover may occur.

During the period of this flashover there is effectively a low impedance path created through the arc, which the lower normal supply voltage will now be able to flow through. With all of the energy of the mains supply behind it the burning effect of the arc will increase and can cause the immediate failure of insulation in rotating machines and other equipment.

Modern electronic equipment is particularly vulnerable to transient voltages due to microcontrollers and other internal components containing millions of active circuits in a package with increasingly smaller dimensions. Basic electrical theory means that the smaller the spaces between conductors the lower the transient voltage required to cause a flashover. Consequently, the voltage element of a transient will stress these components, and repeated exposure to such spikes will result in an otherwise healthy silicone device failing. Based on the utilisation of electronic components in all aspects of the modern facility this could result in process automation disruption, including variable speed drive (VSD) failure, computer, network, or general IT crashes, loss of data, or the need for premature equipment replacement. Electrical spikes may also cause nuisance tripping of RCDs.

Methods for protecting against transients largely depend on what the voltage, duration and power levels of the transients are, and the nature of the equipment connected to the installation. Power equipment, such as rotating machines, should be specified with an adequate level of insulation according to the point on the supply to which they are connected.

In the world of test equipment, we have to develop products such that they are able to withstand specific transient voltages depending on the point on an electrical installation to which they will be connected and used according to BSEN61010-1 (see table).

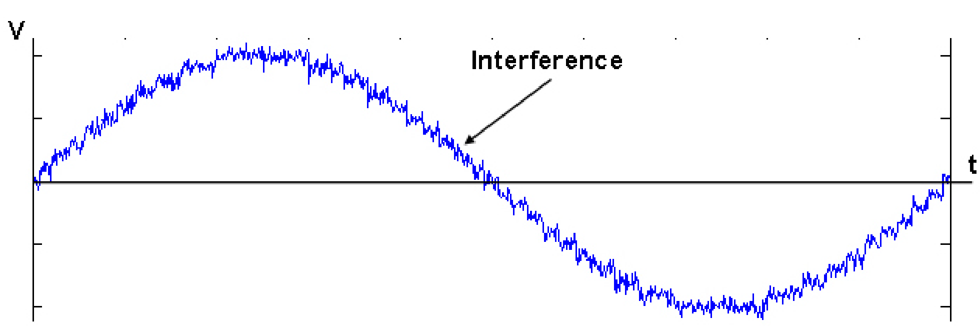
BSEN61010-1 Transient Overvoltage Tests				
Supply Voltage	**Transient Overvoltage**			
	CAT I	**CAT II**	**CAT III**	**CAT IV**
150 V	800 V	1500 V	2500 V	4000 V
300 V	1500 V	2500 V	4000 V	6000 V
600 V	2500 V	4000 V	6000 V	8000 V
1000 V	4000 V	6000 V	8000 V	12000 V

This basically recognises that externally generated transients of a certain magnitude will appear at an installation, with that transient slowly reducing in voltage as it moves through the installation wiring due to the effects of that wiring and the installation equipment. In other words, products connected at the point of the supply need to be able to withstand transient voltages higher than products designed to be connected to the fixed wiring within the supply, which in turn experience higher voltage transients than items plugged into a wall socket, and so on.

CAT I rated products can be used for measurements performed on secondary circuits not directly connected to mains. CAT II for measurements performed on items connected to a standard 230v mains socket. CAT III for measurements performed on the fixed wiring on the building installation, for example distribution boards, circuit-breakers, busbars, junction boxes and industrial equipment. CAT IV for measurements performed on the source of the low voltage installation, like the power input to the installation or the primary overcurrent protection device. Such appreciation of likely transient levels can similarly enable industrial equipment to be selected that is manufactured to applicable standards and with levels of insulation appropriate to its location and use.

Transients may be mitigated by utilising Surge protection devices (SPDs). SPDs are designed to prevent voltage spikes and surges damaging the installation wiring infrastructure and equipment. If an overvoltage event occurs the SPD diverts the resulting excess current flow to earth and clips the voltage. Depending on circumstances, they can be located close to the internal source of the transients, or close to the electronic load equipment, or both. There are three types of SPD currently available. Type 1 for protection against transient overvoltages due to direct lightning strikes. Type 2 for protection against transient overvoltages due to switching and indirect lightning strikes. And type 3 for local protection of sensitive loads. With sensitive electronic components being used in almost every piece of equipment vital for the smooth operation of everyday life, protection against transient overvoltages and the use of SPDs now has its own section in the UK wiring regulations.

Electrical interference is generally much less harmful and is caused by either electromagnetic interference (EMI), or radio-frequency interference (RFI), generated by external sources. It enters the installation by electromagnetic induction, electrostatic coupling, or conduction.



Electrical interference can come from a variety of sources including Radar, TV, radio, mobile phone and microwave transmitters. It can be generated by equipment within the installation, although electrical appliances and equipment should be manufactured to EMC standards that minimise this.

Other less obvious external sources of electrical interference include solar magnetic storms and other cosmic noise, atmospheric noise, and even noise generated by the earth's magnetic field flux. Under normal conditions there is constant radiation from the sun, which varies over time in a solar cycle, and electrical disturbances such as corona discharges and sunspots produce additional noise. Atmospheric noise, also called static noise or white noise, is another natural source of disturbance caused by lightning discharge in thunderstorms and other electrical disturbances occurring in nature.

Electrical interference is generally unlikely to affect power equipment or lighting, although sensitive electronic equipment and devices controlling such items could be vulnerable. It most notably appears as noise, hum or hiss on audio equipment, and white lines or snow appearing on television and radar screens. It can degrade the performance of data networks, or even stop them from functioning completely, with effects ranging from an increase in error rate to total loss of data. Interference can be transmitted between close running cables through crosstalk and care should be taken to segregate power and data or signal cables and use appropriate screening.

Electrical interference is relatively easily removed or blocked from entering equipment by a widely available array of products. EMI suppression filters and AC line filters efficiently suppress noise, ferrite cores and microwave absorbers help suppress it further, and ESD protection devices protect semiconductors from static electricity. These should be used in conjunction with appropriate shielding. Shields effectively shut out electromagnetic fields by enclosing sensitive items within a metal box, or Faraday cage. Screening on data cables is an obvious example of this.

If you suspect you've got issues with transients or electrical interference it's time to get a power quality analyser and set it up to monitor the installation. Interference will be immediately visible superimposed on the mains waveform, although it may be intermittent in nature and therefore only revealed by logging for a period of days or weeks. Thresholds and alarms can be set to alert of the presence of transients and capture them for analysis.

Chauvin Arnoux Ltd
Unit 1 Nelson Ct, Flagship Sq, Shaw Cross Business Park
Dewsbury, West Yorkshire - WF12 7TH
Tel: +44 1924 460 494
Fax: +44 1924 455 328
info@chauvin-arnoux.co.uk