Maximize Your Uptime:
Reducing Risk of Power Supply Failure

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INSPIRING INNOVATIONS

Maximize Your Uptime: Reducing the Risk of Power Supply Failure

Low-power electrical transients generated within a facility are the primary cause of failure to AC/DC power supplies. These transients reduce the life of power supplies and create unplanned downtime. This document will explain why these transients cause failure and outline how placing high-power transient voltage surge suppression (TVSS) devices in front of the power supplies will increase the life and uptime of the power supplies.

The simple act of turning on or shutting off a piece of equipment can generate an impulse of several hundred volts for a very short duration. The overall power is very small, but will have a cumulative effect.   One analogy used is “Death by a Thousand Cuts.” These small surges will keep weakening the power supply until it fails.

Identifying an Existing Problem

When AC/DC power supplies experience frequent failures, there is a very high probability that the cause of failure is internally generated transients. Most industrial environments are at risk for premature failure of a power supply. Internally generated transients will shorten the life of a power supply. These transients are created by common equipment used in everyday operation of a facility. Some examples of this equipment are:

- electric motors
- drives/inverters
- compressors
- welders

A well-designed system has to transmit power with the lowest impedance possible. Having a highly efficient distribution system will transfer the surges produced throughout the facility with minimal loss. Surges at one panel are easily transmitted to all other panels within the system. Because distance traveled depends on the surges’ frequency and magnitude, they can be difficult to detect.

Figure 1 illustrates the results when 3-phase power is applied to a device. As power is applied in the very beginning, the power oscillates then becomes steady. The power slightly exceeds the nominal voltage in the first millisecond of operation. These values are within the normal operating range of a 3-phase power supply.

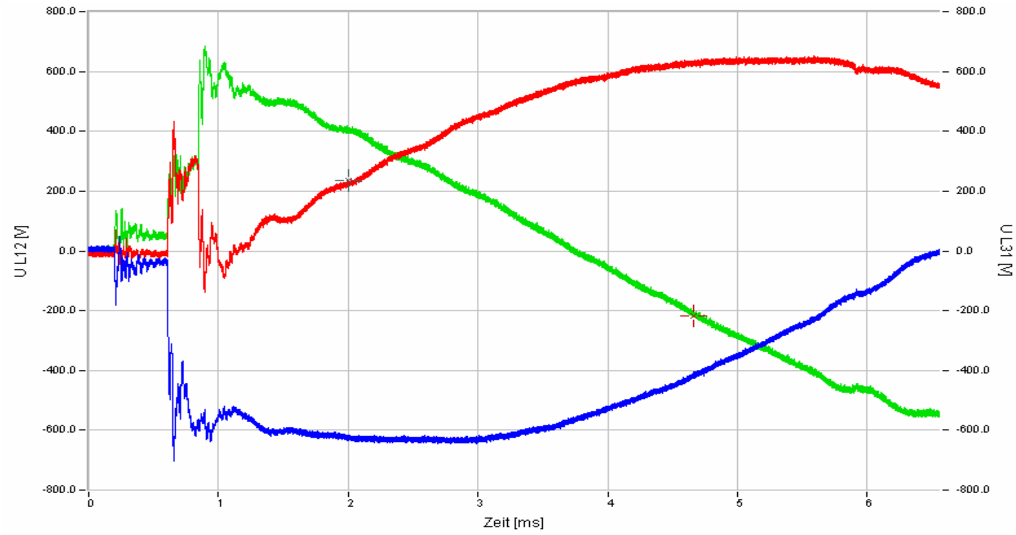


Figure 1: Impulses generated during application of power

Most customers track power supply failures as part of a quality control program. They might experience a higher failure in one area of the facility or across the entire site. For those looking to be proactive, if a site has any of the equipment listed above, there is a very high probability that it has internally generated transients.

Understanding Power Supply Design

It's important to understand how a typical power supply is designed. This will demonstrate why they are susceptible to internally generated transients. Figure 2 is the Information Technology Industry Council power supply design curve. Detailed information on this curve is at the end of this White Paper. Figure 2 is used as a minimum standard for the design of a single-phase power supply. Similar standards are used for 3-phase power supplies. The darker black lines form a border to the "No Interruption in Function Region." A voltage abnormality in this region meeting the voltage and time ratings will not cause a power supply to stop producing DC power to the load.

If a complete power failure occurs, a power supply should be able to supply power for up to 20ms (see Figure 2). This value is located on the X axis about halfway on the line. Capacitors would be used for this "ride-through." Another point of reference is the power supply should be able to run indefinitely at 90% of its rated voltage. This can be seen by moving up and to the right.

The upper section of this chart shows the standards for when the voltage is greater than 100% of nominal voltage. It has a value of 500% of nominal voltage for 0.01 cycles (1 cycle in 60 Hz equals 16.6 ms) or 0.166 ms. Placing a metal oxide varistor (MOV) within the power supply is a very inexpensive way to meet this standard. The MOV will limit the voltage to less than the 500% maximum value and protect downstream components inside the power supply. Most power supplies will include a small MOV on each incoming line.

Product life is dependent on site variables. The more stress placed on any device, the more its operating life is reduced. A designer can exceed the thresholds in Figure 2, but at additional cost.

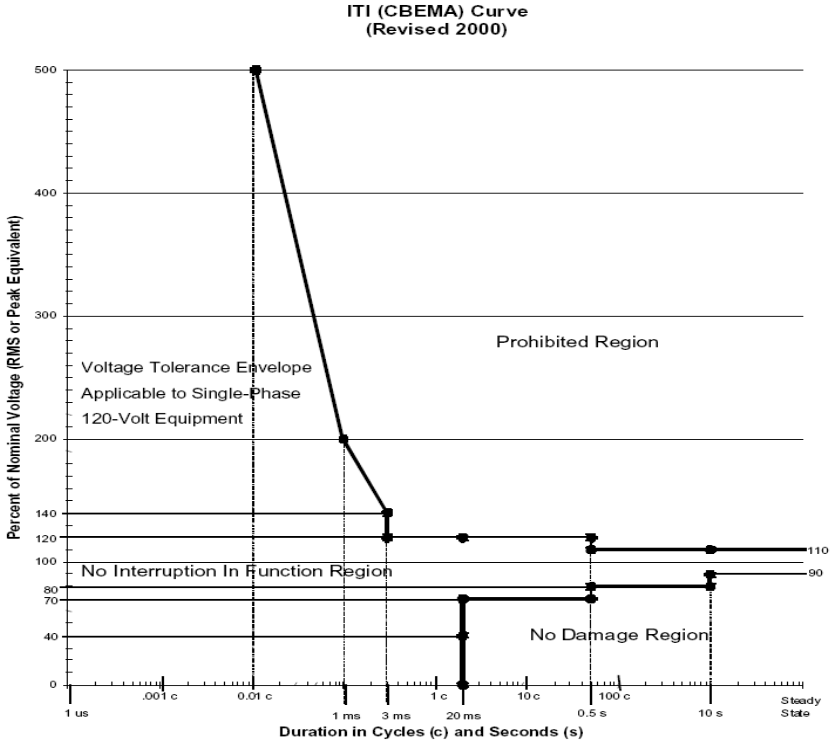


Figure 2: Typical power supply design standards

Source: Information Technology Industry Council (ITI) http://www.itic.org; Used with permission.

MOV Lifetime Expectations

A MOV is a nonlinear device. It acts like a voltage switch; it is "off" until a specific voltage is reached, and then turns "on" and begins conducting. With each surge it experiences, the MOV conducts at a lower voltage. Eventually it conducts at nominal voltage. This creates a short circuit and blows the fuse inside the power supply. A quick visual inspection of the power supply will show a blown fuse, or in some cases, the MOV will be damaged. If the MOV failed, there should be visible damage, carbon burn marks or a pungent odor.

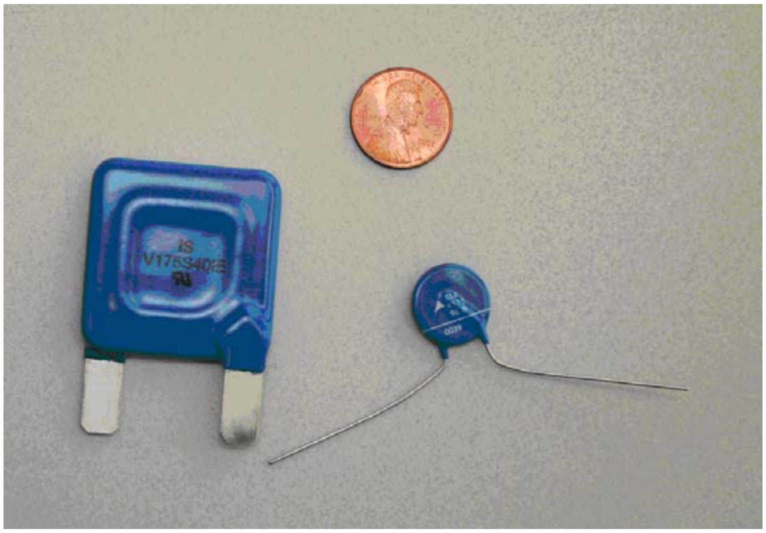


Figure 3: Comparison of MOV size

Figure 3 is a picture of two MOVs, with a penny used to help provide perspective. The MOV on the right is 14 mm in diameter. The larger MOV on the left has a diameter of 34 mm. Both have the same voltage specification and can be used in the same application. The main difference is the maximum amount of current that can pass through each. The rating for the 14 mm MOV is 4,500 amps, and the rating for the 34 mm is 40,000 amps.

MOV manufacturers provide designers with a peak pulse and derating curve. A sample chart is shown in Figure 4. Read the chart using the sloping black lines. In this example, the MOV can withstand one impulse of its maximum rating for 20 microseconds (see the top line). For 100 microseconds, the MOV can only withstand 20% of its maximum current. Figure 5 shows a table of the data in the sample chart using the specifications for a 14 mm MOV for a 20 microsecond pulse.

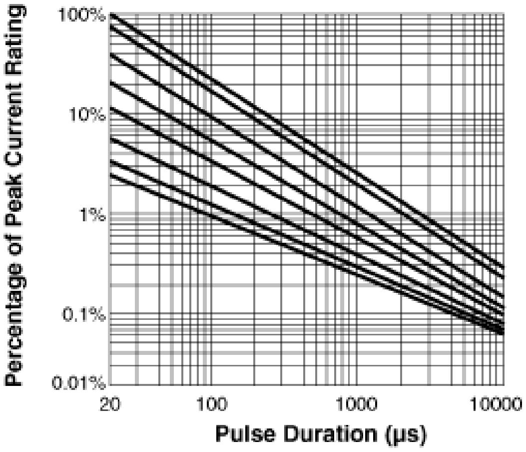


Figure 4: Peak pulse and derating curve

14 mm MOV	Current	# of Impulses
100%	4500	1
80%	3600	2
40%	1800	10
20%	900	100
10%	450	1,000
5%	225	10,000
3%	135	100,000
2.5%	112.5	1,000,000

Figure 5: 14 mm derating data

If one short surge (impulse) occurred once per minute, that equals 525,600 impulses per year (60 minutes x 24 hours x 365 days). From this you can see that in two years, for the smallest impulse, the failure threshold for the 14 mm MOV will be exceeded. If an MOV smaller than 14 mm is used, the life expectancy will be shorter.

Impulses		
Current (amps)	14 mm	34 mm
4500	1	1000
3600	2	2000
1800	10	10000
900	100	100000
450	1000	1000000
225	10000	10000000
135	100000	100000000*
112.5	1000000	1000000000*

Figure 6: Impulse comparison between 14 mm and 34 mm MOVs
*Theoretical values

The 34 mm MOV is typically used in TVSS products. These devices are designed to handle large energy surges. A 40kA surge impulse would be a very large surge, usually associated with a lightning strike. Using the de-rating curve in Figure 4, the quantity of low-power impulses it can withstand are placed in the right column in Figure 6. Compared to the 14 mm MOV's two years, the 34 mm MOV will last more than 10 years. Theoretical values are used because the small current was too low to view the exact data from the derating curve.

Conclusion:

The protection inside a power supply is designed to meet minimum standards and ensure life until the warranty period ends. The MOV inside offers protection, but does become a point of failure within the power supply. Adding a high-power TVSS device in front of a power supply will increase its lifetime and reduce the unplanned downtime resulting from a failure.

ITI (CBEMA) CURVE APPLICATION NOTE

The ITI (CBEMA) Curve, included within this White Paper, is published by Technical Committee 3 (TC3) of the Information Technology Industry Council (ITI, formerly known as the Computer & Business Equipment Manufacturers Association). It is available at http://itic.org/archives/iticurv.pdf.

1) SCOPE

The ITI (CBEMA) Curve and this Application Note describe an AC input voltage envelope which typically can be tolerated (no interruption in function) by most Information Technology Equipment (ITE). The Curve and this Application Note comprise a single document and are not to be considered separately from each other. They are not intended to serve as a design specification for products or AC distribution systems. The Curve and this Application Note describe both steady-state and transitory conditions.

2) APPLICABILITY

The Curve and this Application Note are applicable to 120V nominal voltages obtained from 120V, 208Y/120V, and 120/240V 60Hz systems. Other nominal voltages and frequencies are not specifically considered and it is the responsibility of the user to determine the applicability of these documents for such conditions.

3) DISCUSSION

This section provides a brief description of the individual conditions which are considered in the Curve. For all conditions, the term "nominal voltage" implies an ideal condition of 120V RMS, 60Hz. Seven types of events are described in this composite envelope. Each event is briefly described in the following sections, with two similar line voltage sags being described under a single heading. Two regions outside the envelope are also noted. All conditions are assumed to be mutually exclusive at any point in time, and with the exception of steady-state tolerances, are assumed to commence from the nominal voltage. The timing between transients is assumed to be such that the ITE returns to equilibrium (electrical, mechanical, and thermal) prior to commencement of the next transient.

3.1) Steady-State Tolerances

The steady-state range describes an RMS voltage which is either very slowly varying or is constant. The subject range is +/- 10% from the nominal voltage. Any voltages in this range may be present for an indefinite period, and are a function of normal loadings and losses in the distribution system.

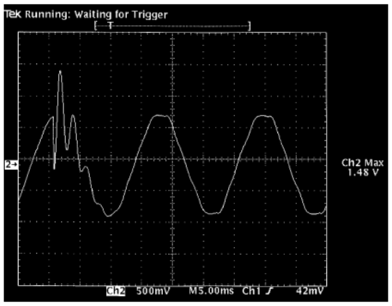
3.2) Line Voltage Swell

This region describes a voltage swell having an RMS amplitude of up to 120% of the RMS nominal voltage, with a duration of up to 0.5 seconds. This transient may occur when large loads are removed from the system or when voltage is supplied from sources other than the electric utility.

3.3) Low-Frequency Decaying Ringwave

This region describes a decaying ringwave transient which typically results from the connection of powerfactor-correction capacitors to an AC distribution system. The frequency of this transient may range from 200Hz to 5KHz, depending upon the resonant frequency of the AC distribution system. The magnitude of the transient is expressed as a percentage of the peak 60Hz nominal voltage (not the RMS value). The transient is assumed to be completely decayed by the end of the half-cycle in which it occurs. The transient is assumed to occur near the peak of the nominal voltage waveform. The amplitude of the transient varies from 140% for 200Hz ringwaves to 200% for 5KHz ringwaves, with a linear increase in amplitude with increasing frequency. Refer to Figure 1 for an example of a typical waveform.

FIGURE 1



TYPICAL LOW FREQUENCY DECAYING RINGWAVE

3.4) High-Frequency Impulse and Ringwave

FIGURE 1: TYPICAL LOW FREQUENCY DECAYING RINGWAVE

3.4) High-Frequency Impulse and Ringwave

This region describes the transients which typically occur as a result of lightning strikes. Wave shapes applicable to this transient and general test conditions are described in ANSI/IEEE C62.41-1991. This region of the curve deals with both amplitude and duration (energy), rather than RMS amplitude. The intent is to provide an 80 Joule minimum transient immunity.

3.5) Voltage Sags

Two different RMS voltage sags are described. Generally, these transients result from application of heavy loads, as well as fault conditions, at various points in the AC distribution system. Sags to 80% of nominal (maximum deviation of 20%) are assumed to have a typical duration of up to 10 seconds, and sags to 70% of nominal (maximum deviation of 30%) are assumed to have a duration of up to 0.5 seconds.

3.6) Dropout

A voltage dropout includes both severe RMS voltage sags and complete interruptions of the applied voltage, followed by immediate re-application of the nominal voltage. The interruption may last up to 20 milliseconds. This transient typically results from the occurrence and subsequent clearing of faults in the AC distribution system.

3.7) No Damage Region

Events in this region include sags and dropouts which are more severe than those specified in the preceding paragraphs, and continuously applied voltages which are less than the lower limit of the steady-state tolerance range. The normal functional state of the ITE is not typically expected during these conditions, but no damage to the ITE should result.

3.8) Prohibited Region

This region includes any surge or swell which exceeds the upper limit of the envelope. If ITE is subjected to such conditions, damage to the ITE may result.