SIEMENS

Transient
Protection
System

The Effect of Conductor Length on SPD Performance

Overview

This paper investigates the effects of connecting lead length on a SPD System. Measurements show that standard wiring adds approximately 165 Volts per foot to the clamp voltage at 3kA and 500 Volts per foot at 10kA! When specifying Surge Suppression, consideration should be given to **Integral SPD**, installed at the factory by the **Gear Manufacturer**; all major Gear Manufacturers offer high quality units. When utilizing the Gear Companies Products, standardized manufacturing procedures minimize installation costs, insure consistent performance, and provide the lowest possible clamp voltage with optimized lead lengths.

Connecting SPD to Panels

SPD or Surge Protective Device, (suppressor) installations should be planned and connected to the panel or switchboard with the shortest possible conductor length. Wire diameter is also important but not nearly as critical as conductor length.

When determining the shortest possible length it is necessary for the user and installer to understand that the conductor inductive reactance has the major effect on performance. The inductive reactance increases per foot of cable used. The reactance also increases with frequency. Since a transient is composed of many high frequency components, the length of cable connecting a suppressor will have a significant affect on the ability of the suppressor to absorb the transient energy.

We have tested the typical means of connecting suppressors to a panel. The typical installation practice when installing a suppressor is to use straight conductors enclosed in conduit or routed through a panel. The voltage drop across this cable is then added to the suppressor rating and now becomes the system suppression performance level at the transient current under consideration. As the transient current increases the system suppression level will also increase. This increase in system suppression level will reduce the protection for the electrical system.

To illustrate the importance of short conductors refer to the following table:

Suppressor Rating vs Cable vs Surge Current

	Surge Current 3kA			**Surge Current 10kA**		
Suppressor Rating Voltage (Volts)	500	500	500	650	650	650
10ft of Open Conductor Voltage	1650	---	---	5010	---	---
5ft Twisted, 10ft Total Conductor Voltage	---	500	---	---	1500	---
1ft Twisted, 2ft Total Conductor Voltage	---	---	200	---	---	600
Increased System Voltage Level (Rating + Increase due to Lead Length)	2170	1000	700	5660	2150	1250

From the table it is apparent that it is very important to keep the conductors very short and to also use methods of construction that will minimize the effects of the cable used to connect the suppressor. We are concerned that the suppressors we manufacturer are installed to provide the very best in electrical system protection. If care is exercised in the installation the system protection can be optimized.

LEAD LENGTH EFFECTS

To find the effect of lead length to the let-through voltage, Kirchoff's needs to be computed in order to find the voltage drop found across the installed leads required by UL 1449 second edition. The total let — through voltage can be computed by the following equation:

$$v(t) = i(t)R_c + L_c \frac{\partial i(t)}{\partial t} + V_p(t)$$

$v(t)$ = Total let — through voltage

$i(t)R_c$ = Voltage drop across the resistive portion of the installation lead.

$L_c \frac{\partial i(t)}{\partial t}$ = Voltage drop across the inductive portion of the installation lead.

$i(t)$ = Surge current

R_c = Total resistance of connecting cables

L_c = Total inductance of connecting cables

$V_p(t)$ = Voltage across surge protector

For #8 AWG: R_c is approximately 6.57 x 10^{-4} Ω/ft
(decreases with larger conductor size)

L_c is approximately 3.34 x 10^{-7} Henries/ft
(nearly independent of conductor size)

For a 3kA 8/20 Category C1/B3 combination waveform described in the ANSI/IEEE 62.41 standard. Using 1 ft of #8 AWG. Calculate the resistive drop and inductive voltage drop.

Rise Time: $$\frac{\partial i}{\partial t} = \frac{3 \text{ x } 10^3 \text{ Amps}}{8 \text{ x } 10^{-6} \text{ Seconds}} = 3.75 \text{ x } 10^8 \; Amps / Second$$

Resistive drop: $$i_{peak} \text{ x } \frac{R_c}{\text{ft}} \text{ x } 1 foot = (3 \text{ x } 10^3) \text{ x } 0.000657 \text{ x } 1 = 1.971V$$

Inductive drop: $$\frac{L_c}{ft} \text{ x } 1 \; foot \text{ x } \frac{\partial i}{\partial t} = (3.34 \text{ x } 10^{-7}) \text{ x } 1 \text{ x } (3.75 \text{ x } 10^8) = 125.25V$$

Total voltage drop for the installation leads: $125.25 + 1.971 = 127.221V$