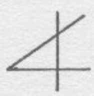
Signal Training Bulletin

COMMITTEE G: Education & Training
Communication & Signal Division, AAR

A-18 Surge Protection

Definition: Equipment used to protect electrical or electronic components from surge voltage or current.

Symbol:



Description: Included under the category of surge protective devices are: various filters and chokes, fuses and circuit breakers, silicon controlled rectifiers (SCR's), zener and other diodes, spark gaps, gas tubes, transformers, non-linear resistors, as well as many hybrid designs combining several of these concepts.

It is readily seen that there is a wide variety of protection devices. A detailed description of the characteristics of each of these is beyond the scope of this document.

However, the characteristic shared by all these devices is that each device causes the transient to see a different circuit than that seen by the normal signal. A circuit breaker opens the circuit, while a spark gap or diode shorts two wires together for certain transient voltage levels. Similarly, a filter has different impedances to different signals. Thus the devices differ primarily in the manner in which they change the response of the circuit to a transient.

Purpose and Application: Devices used in electrical circuits of all types to protect the components from damage by surges in voltage and resulting current.

General Information: Modern technology has radically changed the character and duties of the signal departments of today's railroads. It has also changed the equipment with which they work.

The equipment used in the not too distant past, prior to 1960, consisted basically of relays and motors. To protect this apparatus, an arrester was designed with a breakdown voltage of 1000 volts or below. Since the equipment was designed to meet 3000-volt breakdown ratings, it was protected by the arrester. Also, the equipment was relatively large in size, had large inductances and could absorb the surges until they were dissipated by the arresters.

The advent of vacuum tubes followed by transistors and most recently, integrated circuits, has reduced the signal levels in some railroad signaling equipment from the neighborhood of a hundred volts to as little as a few millivolts, and the response of the circuitry from seconds to microseconds and even less. Whereas formerly an intermittent surge level of 2000 volts and a continuous noise level of up to 10 volts were acceptable, modern complex solid-state electronic equipment and computers can tolerate surge levels of only a few volts and continuous noise levels of a few millivolts. This reduction has necessitated a second look at the techniques which were developed in the 1940s and 1950s for protection of electromagnetic equipment such as relays, against the surges created by lightning.

As a result, a full line of solid-state protectors has been developed which will provide proper protection for the solid-state equipment.

The arresters and lightning protection techniques that have been satisfactory in the past, are still quite useful but today the surge levels they allow must be reduced by a second and in some cases even a third device to the surge levels solid-state equipment can tolerate. In general, the arresters we have been familiar with and have used in the past are sufficiently rugged to withstand the greatest part of the surge. The equipment with which we must now become familiar is that which will shield the solid-state device from that remaining part of the surge which the arrester allowed to pass. Part of this new equipment is a different way of wiring; and a more thorough way of grounding the equipment housings.

To understand the reasons for these new techniques, it is first necessary to know where surges come from, what they are and how they are transmitted. When this is known, some general statements which can be made about lightning and surge protection will become clear and the reasons behind a set of rules for wiring cases, bungalows and equipment towers can be justified.

How Surges and Transients are Generated: Surges and their less powerful brothers, transients, are generated when a steady flow of current (AC or DC) is initiated or interrupted. Lightning is a great generator of surges. The very sudden application and immediate interruption of very heavy DC currents associated with lightning provide the greatest source of surges encountered in railroad work. There are other sources, however, such as the energization

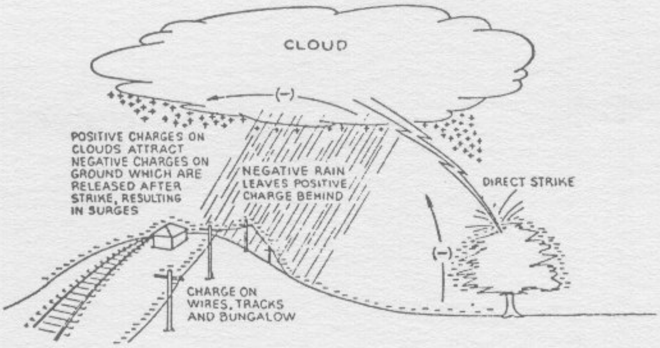


Figure 1: Source of most surges.

of AC power transformers which draw currents briefly, that cause surges. Even the normal operation of relays generates surges. These are of lesser magnitude and are generally known as transients.

Some equipment, such as flashers and other repetitively operating devices, general surges continuously and can be very bothersome to sensitive equipment.

How Surges are Induced into Railroad Circuits: When a highly charged cloud capable of producing lightning strikes is blown by the storm over railroad property, electrical charges are attracted from the ground with opposite polarity but with equal quantity to a spot on the surface of the earth directly beneath the charged cloud. These charges may accumulate in the rails, line wires, apparatus housings, or on any exposed surface. Figure 1 illustrates the fact that if the cloud is discharged to earth at some distant point, even miles away, these charges which have accumulated slowly are instantaneously released. This release creates surges in conductors such as rails and line wires which can cause heavy damage.

The Prime Ground Terminal Equalizes Surge Potentials: The factor that causes breakdown of insulation in equipment or the overloading of solid-state circuitry is not the absolute potential to which it is raised during a surge but the difference in potentials between various components of the circuit at that time. If all points of the circuit rise in potential at the same rate to the same level, no difference in potential can exist and, therefore, nothing can be damaged. It is like two men riding up in an elevator together. They can shake hands or converse at will, but this is not so if one of them remains behind on the ground floor.

The problem of lightning protection, therefore, becomes one of getting all components of a circuit to rise in potential together during a surge. This is where the prime ground terminal comes in. The prime ground terminal is a single terminal to which all components of a location should be connected. To this terminal should be connected the ground leads to the buried ground contact, the heavy conductors from the lightning arresters on the incoming wires, the chassis of the equipment in the housing, the housing itself and the arresters from the rails. The terminal serves as a sort of interchange point and, regardless of which component a surge arrives on, it can leave the location through the path of least resistance. For instance, if the ground contact at the particular location is not good, the surge will take the path of least resistance back to earth ground to break down the gap of the rail arresters and use the rails as the means of reaching the true ground. In any event, the terminal assumes some elevated potential and, because of the interconnections, all the apparatus assumes the same potential and no harm is done.

This is, therefore, the function of the prime ground terminal: It functions as though it were grounded even though it may rise in potential during a surge discharge to many thousands of volts.

The Flow of Surge Current: Figure 2 is an arrangement showing the connection of apparatus and arresters to the prime ground terminal in an equipment housing. For purposes of illustration, the connections are kept very simple with only one line wire and one track lead.

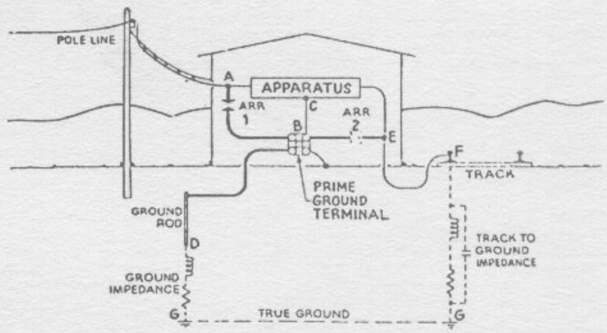


Figure 2: Simplified arrangement showing connection of apparatus and arresters to prime ground terminal in equipment housing.

In reference to Figure 2, it should be remembered that grounding is applied only to lightning arresters. They act as normally open switches activated by excess voltages which cause the circuit to be grounded and dissipate the surge. Equalizers, on the other hand, are high resistance devices connected across two separate conductors and are not grounded. They equalize the voltage surge between two conductors.

When it is necessary to replace lightning arresters or equalizers, it is important that they be replaced with ones of equal voltage rating. If the voltage breakdown is too great, it will not protect the equipment it is intended to. If the voltage breakdown is too low, it will interfere with the operation of the device that it is protecting.

A detailed description of the various types of lightning and surge protection and their application may be obtained from the various manufacturers of this type of equipment.

Note: This Bulletin is for general information only. For specific applications consult the rules, standards and instructions published by your railroad.