

Application Note AN-113

# Surge Protection of Main Distribution Frame



Transient voltages induced in the telecommunication cable network can cause considerable damage to main distribution frame and telecommunication equipment. Effective surge protection can avoid expensive repair work and improve product reliability.

This article describes the possible transient sources which can occur on the telecommunication network and how to take preventive protective measures on the main distribution frame, based on tests and practical experience.

**INTRODUCTION**

Modern telephone systems are fast, efficient, and complex. Many developments have been made in control office equipment which involve solid state circuitry.

Unfortunately, solid state devices are much more susceptible to malfunction or failure due to transient voltages. In addition, the increased usage of telephone lines for data transmission has produced a further intolerance for transient voltages.

Telephone networks, having a wide cable distribution, are highly exposed to voltage transients and therefore require protection components with maximum power capability, long life and high reliability.

For these reasons gas discharge tube (GDT) surge arrestors find an increasing use as the primary protector in telephone systems, replacing older types of protectors (air gaps, carbon blocs) and being designed into nearly all new and future equipment systems.

**CAUSES AND EFFECTS OF TRANSIENTS ON TELEPHONE EQUIPMENT**

**Direct Lightning Strike**

The earth's surface continuously experiences electrical disturbance activities. The extent of this activity is significant as it is estimated that 100 lightning flashes strike the earth every second. It is therefore not surprising that lightning is the most common source of overvoltage surges in communication systems.

The effects of a direct lightning strike are devastating. It has been estimated that the energy dissipation per unit length of channel in a single lightning stroke is 100 KJ/m. The average length of a lightning stroke is 3 km. The average duration of a stroke is 30µs with 4 strokes per lightning. Therefore, the peak power per stroke is  $1 \times 10^{13} \text{W}$ .

The destructive power of lightning arises from high pressure generated in the lightning channel. In open air, energy deposited by a single stroke is equivalent to approximately 22g of TNT per meter, or 1/10 ton of TNT for the average channel. Most of this energy, however, is converted along the lightning channel leaving only a fraction of it at the end of the channel.

Four lightning parameters have to be considered when studying the effects of direct lightning strikes:

- Current amplitude (I): responsible for ohmic voltage drop in earth ground resistance.
- Steepness of the lightning current rise (di/dt): determines inductive voltage drops.
- Electric charge (∫idt): is a measure of the energy transmitted by the lightning arc to metallic surfaces, causing melting effects.
- Current square impulse (∫i<sup>2</sup>dt): is at the base of every mechanical effect and electrical impulse heating of ohmic resistors.

*Table 1. Lightning Parameters*

Percent of strokes	90%	50%	10%
Crest current i	2-8kA	10-25kA	40-300kA
Rate of current rise di/dt	2kA/µs	8kA/µs	20-300kA/µs
Duration of single pulse	100-600µs	0.5-3ms	20-400ms
Total stroke duration	10-100ms	100-300ms	0.5-1.5s
Number of pulses per stroke	1-2	2-4	5-34

Reference: Ezell, T.F., survey of lightning characteristics SC-TM-67-630 (August 1976).

### Indirect lightning:

The most noticeable and frequent interference in telephone systems is due to the inductive effect of lightning strikes. Although the induced effect of lightning is more common on overhead lines, buried lines are still susceptible through resistive coupling.

Overvoltages, mostly induced by cloud-to-cloud discharges, can be as high as several kilovolts with kiloamperes short circuit current. The surge voltage that appears at the end of the cable depends on the distance to the source, the type of cable, the shield material, and its thickness and insulation, along with the amplitude and waveshape of the lightning current in the shield.

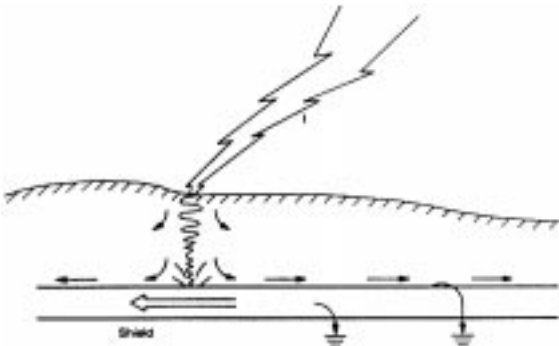


Figure 1. Indirect Lightning in Buried Cables

### Power System Induced Transients:

Overhead telephone lines often share a utility pole and ground wire with the commercial AC power system. Buried telephone and power cables often share the same trench. Because of this, three types of overvoltage transients induced into the telephone lines can occur in conjunction with power system faults:

- Power contact or power cross: power lines make direct contact with telephone cables.
- Power induction: electromagnetic coupling of a heavy fault in the power system (this can be solved with proper shielding).
- Ground potential rise: heavy ground currents of power system faults flow in the common ground connections and cause substantial differences in potential.

Protection engineers have defined the power cross situation as the most severe condition. Therefore, the many requirements call for the suppression device to withstand 10A rms for a duration ranging from 10 to 60 cycles of the power system frequency.

### PROTECTION OF MAIN DISTRIBUTION FRAME

The telephone system is made up of a central switching network which interconnects the different subscribers through repeaters, multiplexers, and concentrators. The cable network which links the subscribers makes the system vulnerable to damaging transients. The cables consist of conductors in shielded cables, which are suspended on poles or buried in earth.

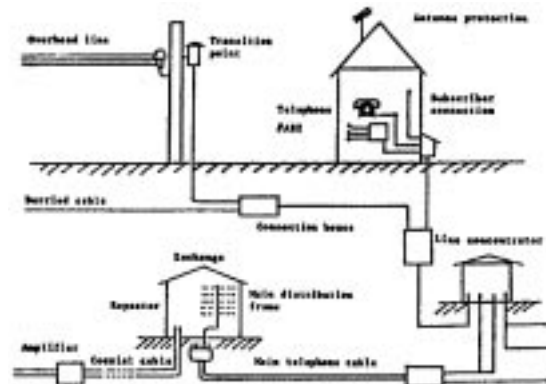


Figure 2. Telecommunications Network

Along with the cable network, antennas on wireless equipment connected to the telephone are also a potential source of transients to the network. Additionally, the power used by a telecom system is usually obtained from commercial power lines which are subjected to the same possible overvoltage surges as the telephone lines.

As one can see, the complexity and exposure of the telephone system makes it highly susceptible to all types of overvoltage transients. From a practical standpoint, however, the cost of installing and maintaining a 100% protection system would not be cost effective. Therefore, network planners usually develop a location's network protection level plan based upon the implementation cost, stroke factor, ground resistance, type of facilities, desired reliability of service, and the exposure to lightning.

The main distribution frame (MDF) (see figure 3) is the link between the cables coming from anywhere in a local telephone network and the cable coming from the exchange switching equipment. The MDF rack consists of tubular and angular rails for the various MDF devices to be attached. On the line side (mostly accommodated on vertically rails), local cables are terminated. On the exchange side, horizontal arranged terminal blocs are connected to the exchange switches. An overvoltage protection magazine installed on the line side protects the exchange switching equipment against harmful overvoltage transients when connected to the external cable network.

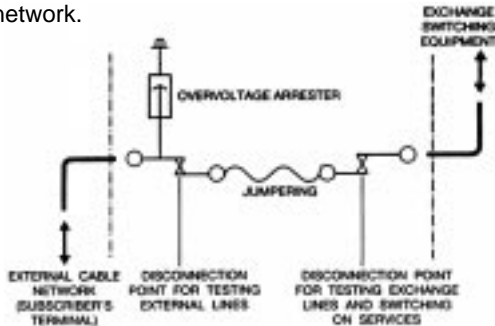


Figure 3. Main Distribution Frame

### Protecting the MDF with GDTs:

Of the devices available for transient protection, the gas discharge tube (GDT) protector reliably offers the highest surge current dissipation that is required to protect against lightning. GDT devices are unique in their ability to handle transient currents many times beyond the capability of solid state devices.

In the presence of a fast rising voltage surge, the GDT crowbars (switches) from its normally high impedance state to short circuit the transient safely to ground. Once in their fired state, GDT surge arrestors act like low voltage clamping devices (10-20V) whose clamping voltage is essentially independent of the transient's current magnitude. In the non-operating mode, the GDT surge arrestors are essentially transparent to the network's performance since they offer extremely high isolation resistance and very low line capacitance.

For these reasons the GDT arrester can be considered the best solution to provide the telephone network the primary protection against direct or induced high voltage transients.

Typical performance requirements of the GDT protector are:

- Environmental:
  - Temperature: -40 to +90°C
  - Relative Humidity: up to 95%
- Electrical:
  - DC Breakdown: 250V nominal
  - Impulse Breakdown at 100 V/μs: 900V max.
  - Insulation Resistance: > 1000 MΩ
  - Capacitance: ≤5pF
- Life Tests:
  - Impulse 8/20, 10 shots, 10 kA peak
  - Impulse 10/1000, 300 shots, 100A peak
  - AC, 15-62 Hz for 1 sec., 5 shots, 10A rms

In many situations, a fail safe system is specified on GDT devices so the line is permanently grounded after excessive heating of the surge arrester by an extensive power cross. If this situation occurs, the GDT device and fail safe mechanism must be replaced.

### Two Electrode Configuration:

SRC Devices' GDT's are used in many telecommunication networks around the world for main distribution frame protection. The Comgaps are constructed of two metal electrodes hermetically sealed in a gas filled, rugged ceramic cylinder. Through ongoing research and engineering improvements, SRC Devices has developed a variety of surge arrester families that offer impressive characteristics for MDF protection.

The two electrode CG2 series can best be used where microsecond transient rise times are expected. They provide fast response time, high holdover voltage and high follow-on current capacity.



Figure 4. SRC Devices Bipolar GDT

**CG2230L Performance:**

Nominal DC Breakdown Voltage: 230 Vdc  
 Impulse Breakdown at 100V/ms: 600V max.  
 Insulation Resistance: 1000 M Ohm min.  
 Maximum Capacitance: 1pF max.  
 Surge Life:  
     Impulse 8/20, 10kA, 10 shots  
     Impulse 10/1000, 500A, 1000 shots  
     AC, 15-62Hz for 1 sec., 10 shots, 20A rms.

SRC Devices is ISO9000 certified and our automated production techniques are tightly controlled to assure a consistent, highly uniform product. Electrical testing is conducted on 100% of our products prior to shipping them to our customers.

**Three Electrode Configuration**

In a telephone cable, signals are conducted through pairs of copper wires. Therefore, transient voltages induced into the conductors will be common to both signal wires (typically called “tip” and “ring”). This is shown in Figure 5A.

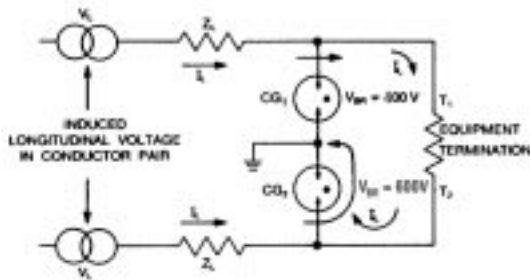


Figure 5a. Unbalanced Line Protection

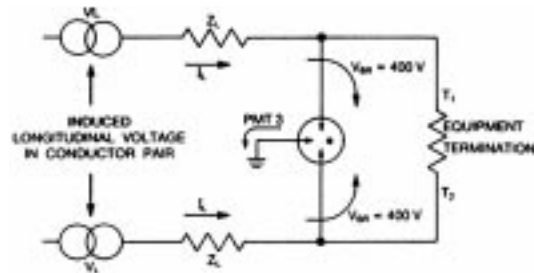


Figure 5b. Balanced Line Protection

If protector CG<sub>1</sub> should breakdown ( $V_{BR}$ ) at 400V while CG<sub>2</sub> requires 600V to breakdown, the difference would cause a transient current to flow through the load. To eliminate the problem of unbalanced line breakdown, dual gap or three electrode tubes like the PMT3 and PMT8 have been developed. See Figure 5B.

The PMT3(310) series from SRC are three electrode, medium duty surge arrestors designed to protect electronic equipment from damage due to excessive voltages and current. The PMT3(310) products have extremely fast response times characterized by the impulse breakdown voltage, which describes their dynamic behavior. For ease of mounting on PC boards, the devices are available in many different lead configurations.



Figure 6. SRC's Tripolar GDT

**PTM3(310)230-04 Performance**

Nominal DC Breakdown Voltage: 230 Vdc  
 Impulse Breakdown at 100V/ms: 600V  
 Insulation Resistance: 1000 Mohm min.  
 Maximum Capacitance: 1 pF max.  
 Surge Life:  
     Impulse 8/20, 10kA per side, 20kA total  
     Impulse 10/1000, 500A, 400 shots  
     AC, 15-62Hz for 11 cycles, 65A

The voltage rating of the surge arrester is determined by the voltage applied between the tip and ring signal wires. Most telecommunication systems have 48 Vdc with a super imposed ring voltage of 100V rms (154V peak) maximum which results in a minimum breakdown voltage of 202V. Therefore, the PMT3(310)230 or PMT8-230 would be appropriate three electrode selections for this application.

### Protection Verification

In actual field operation, surge arrester devices are subjected to transients which, by their nature, are unpredictable in magnitude and duration. In order to best simulate transients such as lightning, international committees have developed standard lightning wave shape tests which can be conducted to evaluate protection components. Figure 7 illustrates the standard characteristics of these wave slopes. SRC utilizes these recommendations and standards when specifying, qualifying, and testing our GDT devices.

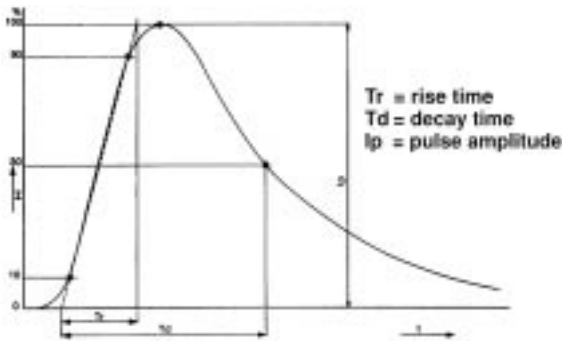


Figure 7. Description of Surge Current

### Maintenance of Protection Devices

Most components utilized in lightning protection systems degenerate gradually due to the effects of repetitive surge damage and weather exposure. Component deterioration can cause a loss of protection resulting in unexpected system damage as well as performance degradation in the power and signal circuits. Periodic maintenance will help insure that the protection system remains at its original design and installation performance capability. Unlike semiconductor devices, the deterioration of GDT protectors can easily be measured. A GDT's performance can gradually degenerate due to erosion of its metallic electrodes. The degeneration, which is a function of lightning stroke frequency and magnitude, may easily be detected by measuring a lowering of the insulation resistance value across the electrodes of the device.

## SRC Devices LOCATIONS

Corporate Headquarters:  
SRC Devices Incorporated  
5151 Murphy Canyon Rd.  
Suite 100  
San Diego, CA 92123  
1-866 SRC 8668

St. Louis Facility:  
4315 N. Earth City Expressway  
Earth City, MO 63045  
Tel: 1-314-770-1832  
Fax: 1-314-770-1812

Guadalajara Facility:  
SRC Devices  
Blvd. Gral M. Garcia  
Barragan 1610  
Guadalajara, Jalisco Mexico 44870

## SALES OFFICES

### AMERICAS

SRC Devices Incorporated  
5151 Murphy Canyon Rd.  
Suite 100  
San Diego, CA 92123  
1-866 SRC 8668

### EUROPE

SRC Devices NV  
Paniswijerstraat 94  
3600 Genk  
Belgium  
Tel: 32 89 328850  
Fax: 32 89 328869

### ASIA PACIFIC

SRC Devices Asia  
12F-2, No. 77, Shin Tai Wu Rd.,  
Sec.1, Shijr City,  
Taipei 221, Taiwan, R.O.C.  
Tel: 886-2-2698-8422  
Fax: 886-2-2698-8421

## WORLDWIDE TECHNICAL SUPPORT

Reed switches: [switchhelp@srcdevices.com](mailto:switchhelp@srcdevices.com)  
Surge Arrestors: [surgehelp@srcdevices.com](mailto:surgehelp@srcdevices.com)  
Reed Relays: [relayhelp@srcdevices.com](mailto:relayhelp@srcdevices.com)  
**or**  
Toll Free 1 866 SRC 8668

[www.srcdevices.com](http://www.srcdevices.com)

---

SRC Devices cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in this SRC Devices product. Neither circuit patent licenses nor indemnity are expressed or implied. SRC Devices reserves the right to change the specification and circuitry, without notice at any time. The products described in this document are not intended for use in medical implantation or other direct life support applications where malfunction may result in direct physical harm, injury or death to a person.

---