AN579
Application note

Protection concepts in telecommunications equipment

Introduction

The goal of a telecommunication network (see *Figure 1*) is to permit data exchange (speech or digital) between two or more subscribers. The network is made up of different parts which are subject to various disturbances. The most susceptible elements are the lines, due to their length and their geographical location.

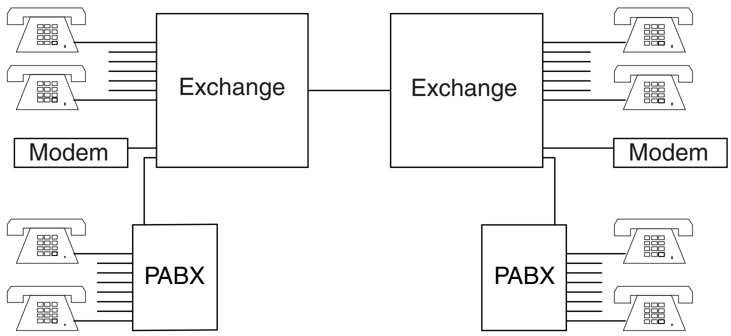
Disturbances strike the lines and are then propagated to the extremities of the lines at which lie telephone sets and the subscriber line interface cards (SLIC).

So the lines receive two kinds of overvoltages:

- Surges of short duration with high peak voltage value (a few thousand volts for a few hundred micro seconds). These are generated by atmospheric phenomena.
- Surges of long duration with medium voltage value (a few hundred volts rms for greater than one second). These are due to the mains AC power networks.

The purpose of this application note is to analyse these two kinds of overvoltages.

Figure 1. Classic telecommunication network topology



1 Overvoltages across telecommunication lines

1.1 Atmospheric effects

Lightning phenomena are the most common surge causes. They are mainly due to a voltage difference between the ground and the clouds (a few 100 kV). Two kinds of strikes may occur:

- Negative discharge with a peak current of 50 kA, rise time of 10 µs to 15 µs and 100 µs duration
- Positive discharge with a peak value of 150 kA, rise time between 20 µs and 50 µs and a duration between 100 ms and 200 ms

The lightning effect appears on the lines in two ways.

- Direct shock
- Induced shock

Figure 2. Lightning phenomenon

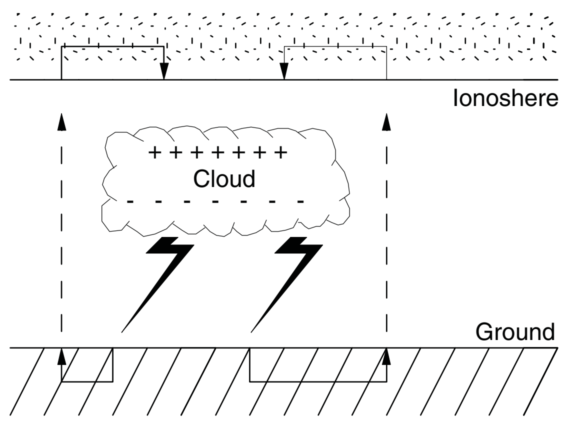


Figure 3. Direct lightning strike

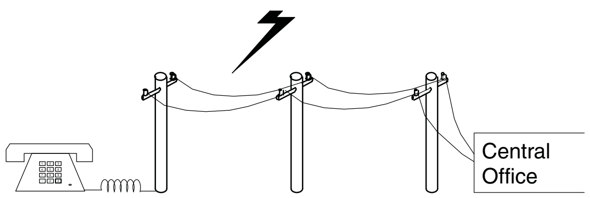
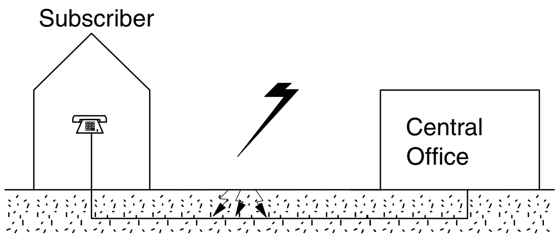


Figure 3 shows the first case which is produced mainly on overhead lines.

Induced shock is more frequent than a direct shock. Lightning strikes the ground and a current flows in the cable shield. This current produces a voltage gradient which in some places is above the insulation capability of the cable material (see *Figure 4*).

Figure 4. Direct lightning strike



1.2 Proximity and crossing with AC mains lines

For these kinds of surges two cases may be seen:

- AC mains cable fallen on a telephone line
- Proximity of a subcriber line with an AC mains line or equipment (mainly capacitive coupling)

Typically these events create disturbances with an rms value of a few amperes for a duration of between 1 s and 15 min.

2 Primary and secondary protection

Figure 2, *Figure 3* and *Figure 4* give us an idea of the energy which may appear on the lines. In the field these surge values are lower due to the losses of ground resistance, the capacitive coupling and so on, but are signifiant nevertheless.

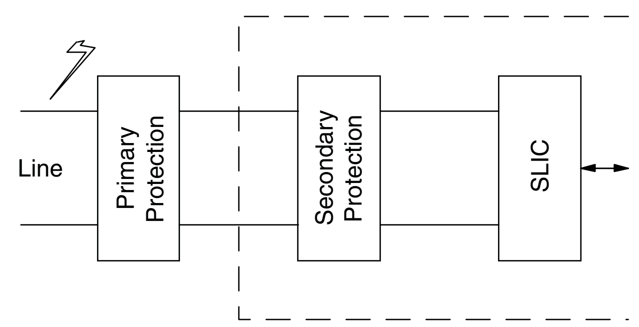
We have to divide these disturbances into two families:

- High peak value and short duration (lightning)
- Reduced peak value and long duration (crossing with AC power)

For both cases the present state of the art of silicon protection devices does not permit the suppression of these levels of energy.

A second parameter to keep in mind is the very low clamping factor needed by the IC's used to realize the line interface. The clamping factor is the ratio of the normal operating voltage over the maximum clamping voltage. This forces the designer to use a protection solution with silicon (fast response time/low clamping factor).

Figure 5. Primary/secondary protection topology



High energy values and low clamping factor impose two protection levels.

The first level called primary protection (see *Figure 5*), located on the connecting terminal of the exchange, suppresses the major part of the disturbance. The second level called secondary protection reduces the remaining overvoltage.

Figure 6. Primary/secondary protection topology resukts

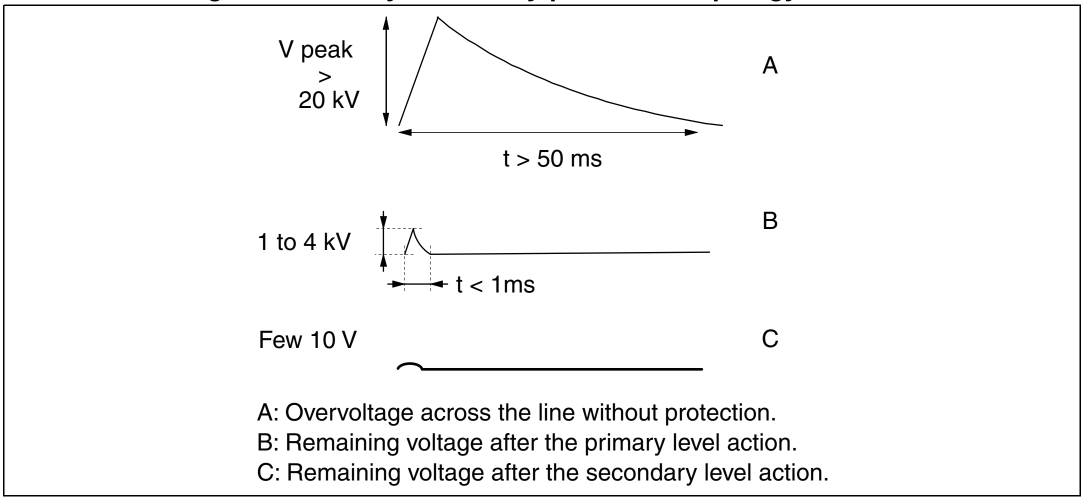


Figure 6 shows the goal of both protection levels.

In this example the surge across the line without protection will be several 10s of kV peak value for several 10 ms duration (*Figure 6*A).

After the primary protection the major part of the energy is eliminated (*Figure 6*B). The remaining overvoltage may be a few kV (depending on the dv/dt of the surge and the surge arrestor technology used).

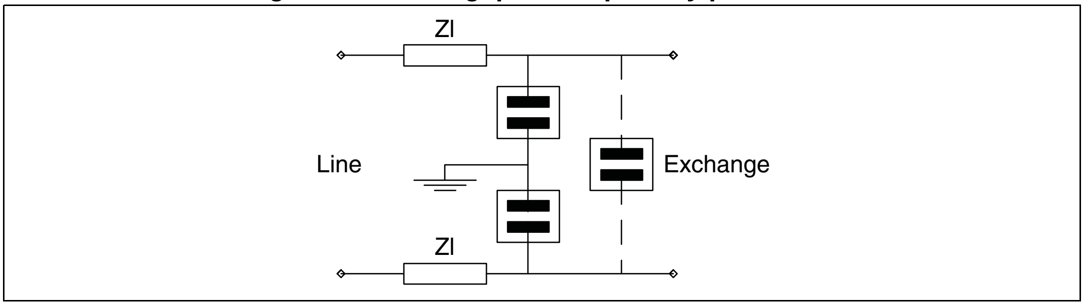
Across the second level protection the voltage does not exceed a few 10s of volts.

2.1 Primary protection

Two kinds of primary protection are used:

- Carbon gaps
- Gas tubes

Figure 7. Carbon gap based primary protection

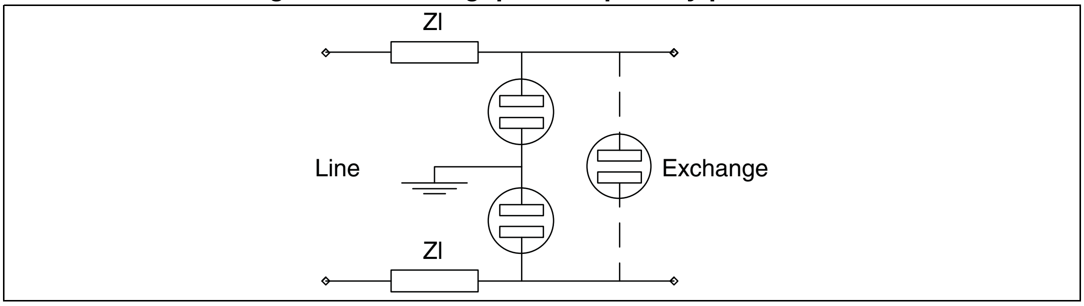


2.1.1 Carbon gaps

These components are made by two carbon electrodes. The carbon gap is a low cost primary protection but it has two major disadvantages:

- short life duration
- variable spark threshold

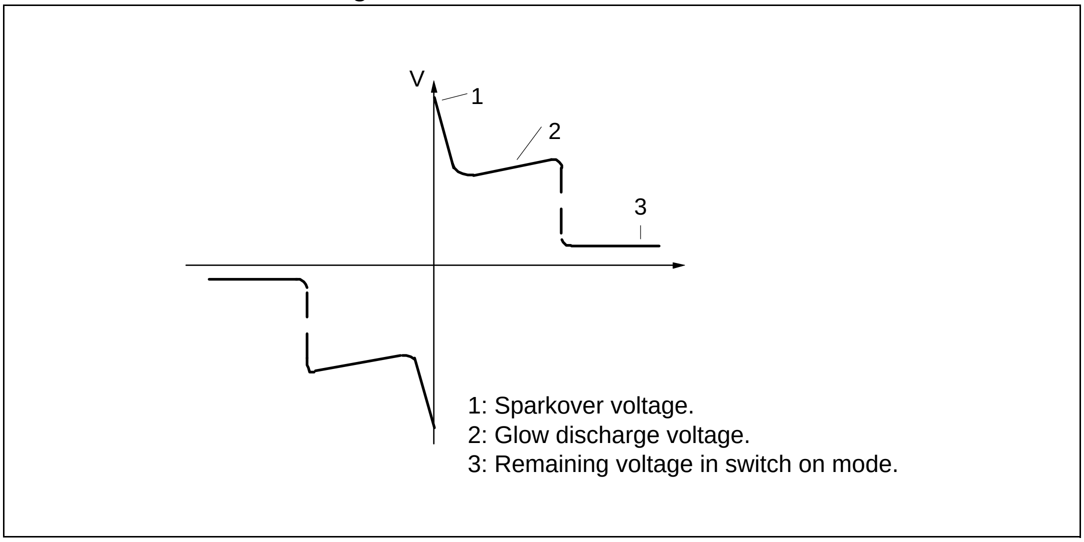
Figure 8. Carbon gap based primary protection



2.1.2 Gas tubes

These components are made of two metallic electrodes in a sealed case. Generally the sealed tub contains a low pressure gas.

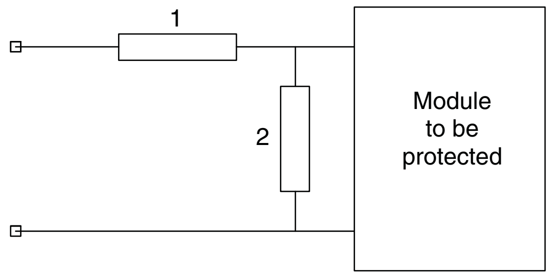
Figure 9. Gas tube characteristics



The major disadvantage of this kind of device is its response time, in fact the maximum voltage across the gas tube depends on the dv/dt of the surge.

2.2 Secondary protection

Figure 10. Series and parallel protection



1: Series protection.
2: Parallel protection.

The secondary protection level is generally achieved with two types of devices:

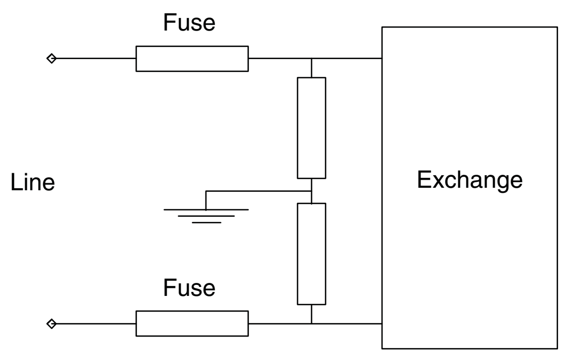
- The series protection ensures protection against the proximity of or the crossing with AC power lines.
- The parallel protection operates to suppress the overvoltages due to the lightning effects.

2.2.1 Series devices

Series devices operate either by:

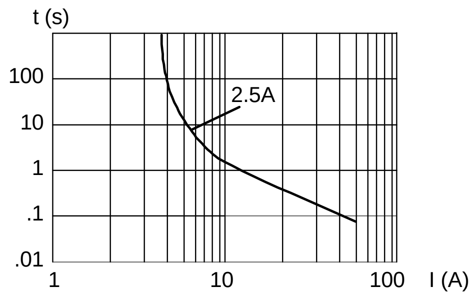
- opening the circuit (fuse)
- an increment of the resistance (PTC)

Figure 11. Fuse protection



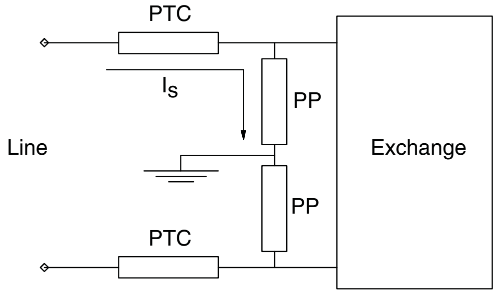
The fuse is a classical case of protection by opening the circuit. *Figure 11* shows an exchange protected by fuses and *Figure 12* represents an example of the limit curve of the fusing action.

Figure 12. Fuse blowing results



These components provide an absolute security after action, but their major disadvantage is the need for maintenance.

Figure 13. PTC based protection

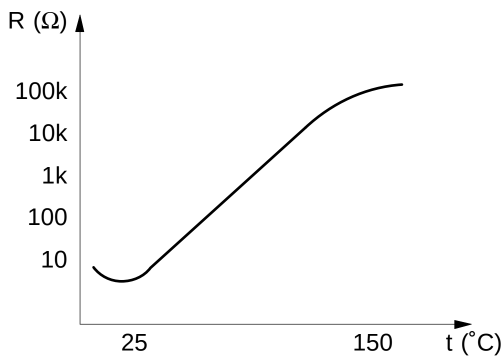


The PTC thermistor is a device which operates through a very rapid resistance increase as a function of the temperature.

When the surge occurs across the line, the parallel protection PP is activated.

The surge current I_S, generated by PP action, flows through the PTC device and increases its internal temperature. As shown in *Figure 14* the resistance value of the PTC device rises quickly with the temperature.

Figure 14. PTC based protection results



The major disadvantage of the fuse does not exist with the PTC device. Unfortunately this kind of component has a large tolerance, a long time to return to its stand off point and a drift of its value.

Another series device is the simple resistance which limits the current through the parallel protection device.

2.2.2 Parallel devices

The parallel protection function may be assumed by different devices based on different technologies.

In fact it is clear that the future in term of SLIC topology is based on the use of ICs. So the consequent requirement for good response times and high clamping factor necessitates the use of silicon protection.

Parallel silicon protection functions in two different modes:

- The clamping mode with the Transil™
- The crowbar mode with the Trisil™

3 Conclusion

Due to atmospheric effects and disturbances on mains networks, telecommunication lines have to be protected. Due to the improvement in telecommunication system technology, a need for fast and precise protection solutions results.

The choice of the protection technique will be made considering local standards and the technology of the devices to be protected.

This protection will be assumed to be dual level:

- Primary level to suppress high energy
- Secondary level to optimize the remaining overvoltage

TM: Transil and Trisil are trademarks of STMicroelectronics

4 Revision history

Table 1. Document revision history

Date	Revision	Changes
March-1993	1	First Issue
19-Apr-2004	2	Stylesheet update. No content change.
28-Jul-2014	3	Updated trademark statements.