Surge Protection for EMI Effects in Antennas

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The LPZ concept can be applied to lead the lightning current to ground and to avoid potential differences between the external lightning protection system and the grounded parts of the equipment.

INTRODUCTION

Antennas and components linked via cable networks are susceptible to lightning and overvoltages. The installation of protection devices has shown that the effects of even a direct lightning strike in an antenna can be limited by a lightning current arrester in the internationally-accepted Lightning Protection Zone (LPZ) and by adequate bonding. The purpose behind the LPZ concept is to lead the lightning current of enormous energy in a defined way to the earth potential and to avoid potential differences between the external lightning protection system and the grounded parts of the equipment.

This article describes the phenomenon of lightning and its influences on modern home electronic systems as well as the compatibility of modern measurement control and regulation systems. The LPZ concept offers a method of protection against these influences and the possibilities of using home electronic equipment or computers during thunderstorms. An example will show how and where the surge protection devices are to be installed. An overview of international standards is also discussed.

LIGHTNING STRIKES

Uninterruptible use of any type of modern electronic equipment, including televisions, computers, and multimedia stations can be achieved only when all components and devices work adequately. Disturbances like lightning, surges, or transient voltages can damage or upset either power or data conductors. Damage from the loss of electronic systems is always greater than the cost of protection systems.

There are many different ways for lightning strikes, transient voltages or surges to enter a house or electronic system and damage electronic equipment. Damage of highly sensitive systems can be observed more than two kilometers from the place where the lightning struck. Basic protection can be achieved by using the building steel, typically rebar, as a protection network or a Faraday cage. Modern building techniques allow the integration of metal parts into the external lightning protection to achieve bonding.

While compact buildings are relatively easy to protect against surges using lightning current arresters and overvoltage arresters, distributed electronic systems require a systematic treatment of the entire building in accordance with the LPZ technique. This concept involves a three-dimensional planning and construction method that incorporates principles of electromagnetic compatibility (EMC). It is an easy-to-follow set of rules which represents a practical method for fulfilling international requirements for protection and for identifying the correct device and installation site.

ARRESTER DEVICES

The goal behind all arrester devices is to bring the immensely high lightning current in a defined way to earth and to avoid potential differences between lightning protection and parts of the electronic equipment. However, statistics cited by insurance companies show that in spite of the correct installation of the antenna equipment, there can be damage, especially in overvoltage-sensitive electronic components in the system (Figure 1).

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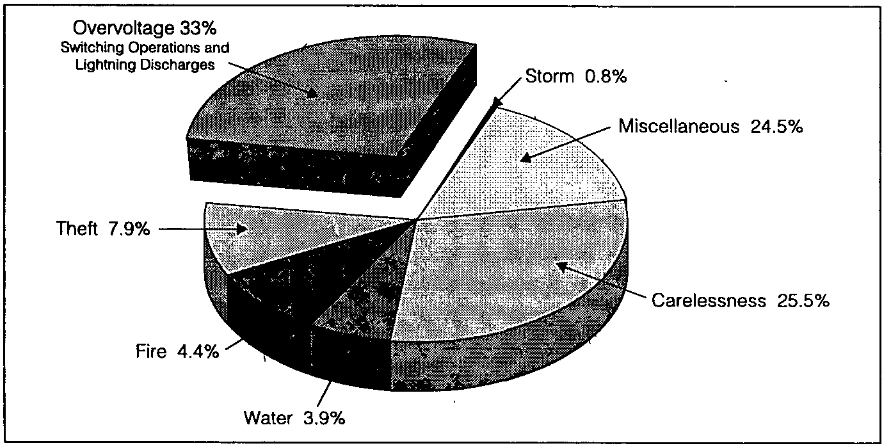

***Figure 1**. Causes of Damage to Antenna Equipment (11,000 Cases, 1995).*

The reason is that the existing antenna system and ground can only offer limited protection against the quickly altering magnetic field of the lightning current, which can induce high overvoltages in all loops. At the end of these loops, e. g., at the antenna ground, antenna line and power supply, overvoltages can be induced which are strong enough to upset, damage or destroy the linked equipment.

The crucial electrical parameters of a lightning strike are found in the international standards IEC 1024 and IEC 1312.

Requirements	Limits for i/t in kA/µs			
	First Stroke		Negative Follow Stroke	
Normal	10	For t = 10 µs	100	For t = 0.25 µs
High	15		150	
Extreme	20		200	

Table 1. *Limits for Steepness i/t.*

Distance to Lightning Channel	Maximum Values for			
	E (kV/m)	E/t (kV/m/µs)	H (A/m)	H/t (kV/m/µs)
s = 1 m	3,000	15,000	8,000	40
s = 100 m	40	300	110	1
s = 1 km	4	30	10	0.1
s = 100 km	0.04	0.4	0.1	0.001

Table 2. *Parameters of the Electromagnetic Field of the Lightning Channel Dependent on the Distance S.*

GALVANIC COUPLING

Typical influences on satellite antennas are galvanic coupling and radiation coupling. In the case of a current flow over the bonding line of the antenna or the external lightning protection cage, a potential difference exists, e.g., for power-feed equipment over the protective earth (PE) between power and antenna. The voltage is produced by:

- The inductance of the antenna ground line
- The steepness di/ dt of the lightning current

Calculation shows that induced voltages of about 1600 kV are possible (Table 1). This potential difference is illustrated in Figure 2A as the difference between power and antenna, and will cause, in addition to the arcing from the antenna cable to ground (equipotential bus bar system), arcing between the safety ground and the signal ground. With a direct lightning strike in the cable network, e. g., the head station of a cable television equipment, the head station will have a different potential. A current will flow over the cable screen which produces a potential difference with respect to the power ground.

Likewise, the coupling mechanism can be found for lightning current at satellite antennas. If the antenna is installed at the building, the effects illustrated by Figure 2A must be taken into account. If the antenna is installed in proximity to the building, the setup given in Figure 2B must be used.

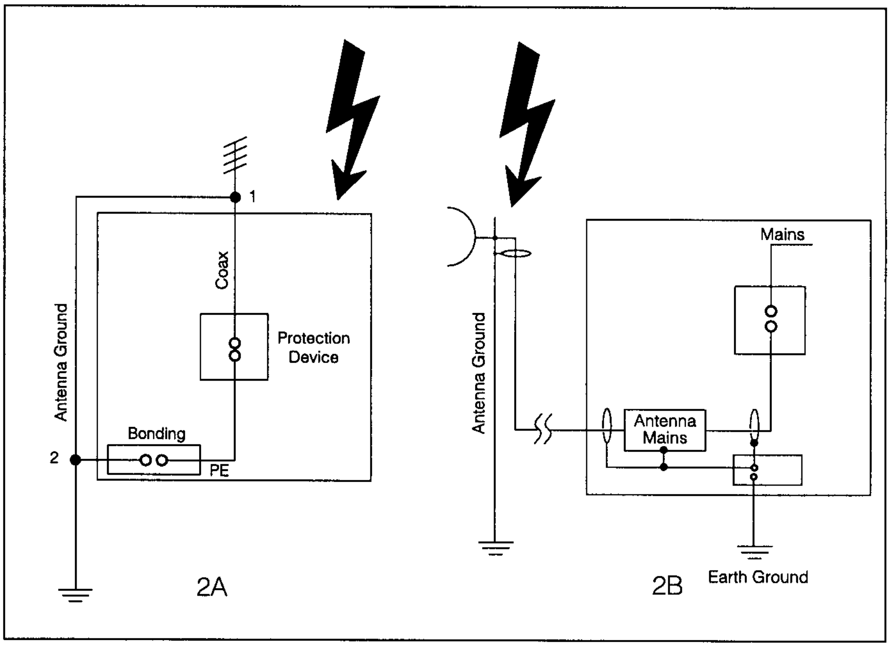

Figure 2. *Potential Difference between Power and Antenna.*

RADIATION COUPLING

Due to the electromagnetic field of the lightning channel, termed lightning electromagnetic pulse (LEMP), the high dI/dt influences, which induce high currents in installation loops, can generate flashovers. Following the basic standards, certain parameters can be expected. Table 2 shows that a voltage of 4 kV, which in the case of a flashover can generate a current of up to 10 A, can be induced in the radius of 1 kilometer from the direct lightning strike in an installation loop of 1 m x 1 m. A flashover or a coupling with the power line can generate an arc and the resultant current which can destroy systems or equipment.

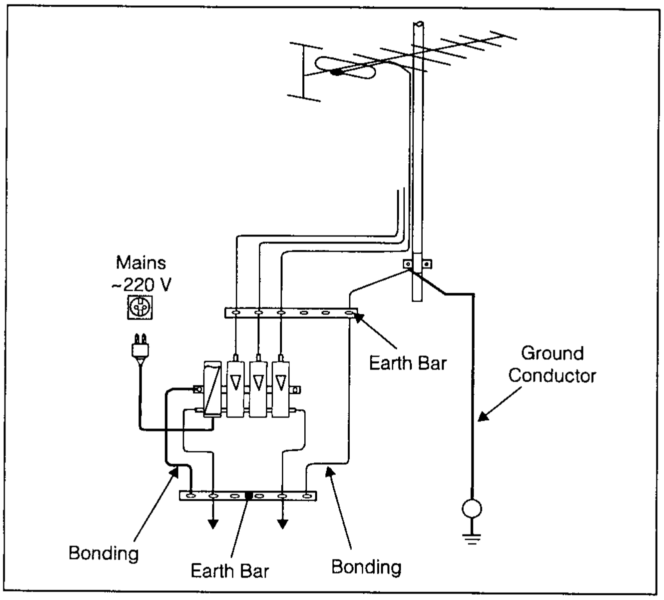

Figure 3. Equipotential Bonding for an Antenna Amplifier.

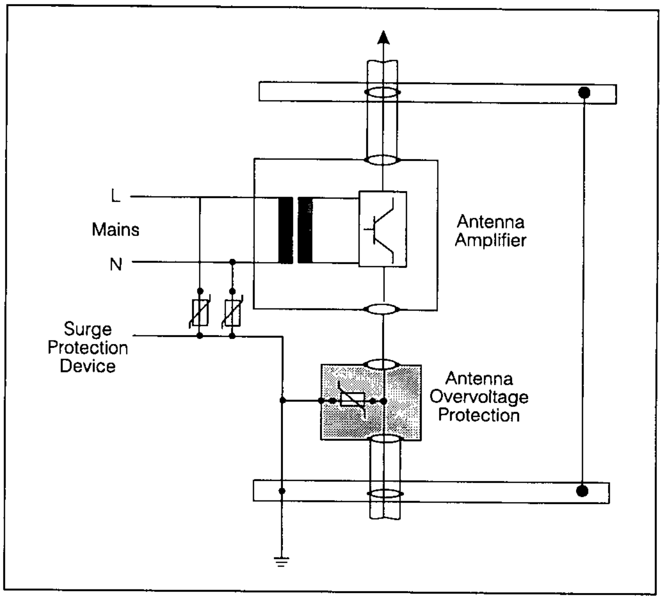

Figure 4. Surge Protection Device and Grounding for an Antenna Amplifier.

System-Component	Imp. Voltage Withstand Cap. (1.2/50)		Damage
	Inner Condition Outer Condition	Antenna/ Mains	
Mains	<4 kV	—	PCB Defect
Amplifier	<1 kV	>10 kV	HF-Transistor Defect
Sockets	<500 kV	—	SMD Defect
Coupler	<500 kV	—	SMD Defect
Distributor	<1,000 kV	—	SMD Defect

Table 3. Maximum Values of Impulse Voltage Withstand Capability of Antenna System Components.

PROTECTION

Grounding an antenna in accordance with local safety codes and international standards is obligatory. Together with the antenna ground and the external protection, devices for internal protection systems (lightning protection systems) can protect against these events. It should be realized that not only the equipment, but also the system components of the antenna system, such as the amplifiers, switches, shunts, etc., can be damaged. Thus, it makes sense that protection measures are employed during the installation to avoid disturbances or to prevent destruction of the equipment. Specific steps are recommended.

- Installation of potential differences (open loops) is avoided by bonding
- Potential differences between lines and coax cables are avoided by using surge protection devices (Figure 3).
- Potential differences to external networks, e. g., power, are avoided by using surge protection devices (Figure 3).

How to accomplish the bonding per EN and IEC requirements is described (Figure 4). The use of surge protection devices means that for the duration of the effects, the surge protection also pulls the equipment being protected to reference (Figure 3). The performance of the overvoltage protection devices is prescribed by the application. The devices which meet the Standardization Committee for Surge Protection (SC37 A) requirement have to be effective under network conditions as well as under lightning current conditions. They are linked between active lines (L, N) and earth (PE).

The surge protection devices for antenna systems must fulfill the following requirements:

- Good high frequency performance, i.e., low flow-attenuation and fast switch attenuation
- Good protection level between inner wire and outer wire during lightning current.

The need for surge protection devices between the inner wire and outer wire is illustrated by the fact that part of the lightning current potential differences due to inductances can cause flashover. The best laboratory results on different system components have shown that at voltage differences of more than 500 V between the inner wire and outer wire, equipment can be damaged. That is why the surge protection devices must have a lower protection level (Table 3). These levels cannot be reached by gas arresters.

Figure 5 shows the difference of a typical limiting voltage of a 230-V gas arrester together with the last antenna protection device. The antenna fine protection device is an overvoltage protection device following DIN and IEC standards, which applies to fine protection in satellite antenna and distribution equipment to protect system components against overvoltages at the antenna side. The protection devices are used at the fixed antenna installation (Figure 6).

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