Alternatives in lightning protection devices

Lightning protection devices are available which insure that high-voltage pulses are not introduced into the primary communication equipment.

David Hall
AMP Harlow Facility, UK
David Meaney
M/A-COM, Lowell, MA

Some surge protection devices incorporate gas discharge tube (GDT) technology. A GDT is a hermetically-sealed tube containing an inert gas. The tube is inserted into the RF transmission line through an easily accessible weather-sealed port. During normal operation the tube is inactive. When an installation is struck by lightning, a high voltage impulse will appear on the coaxial line. As the impulse amplitude rises, a level is reached where the impulse surpasses the dynamic voltage threshold, causing the inert gas to go into a conductive state, discharging the energy to ground. Prior to activation of the tube, there is a short period of time during which energy is present on the line. This energy level is equal to the dynamic voltage threshold of the tube. The maximum impulse voltage a tube can handle without discharging is referred to as the impulse sparkover voltage. The characteristics of the GDT are given in Table 1.

As indicated, the voltage rises at one kilovolt per microsecond and the tube fires after 800 nanoseconds. During activation a small percentage of voltage (called arc voltage) will still pass through the unit. This potential is approximately 20 volts. When the pulse subsides, the tube again becomes inactive, leaving a small residual voltage present on the RF transmission line.

The capability of a device to protect a system is defined as the impulse discharge current rating, and is less than or equal to a 20-kA level. This is defined as the peak current of an impulse which the device can withstand ten times (five at each polarity at fixed intervals) without affecting the device. Maximum impulse discharge current is the peak current the device can withstand per strike. This is rated at less than or equal to a 50-kA level. Surge protectors are often used in applications requiring a bias for active antenna applications. The maximum applied voltage of a surge protector, prior to surpassing the static voltage threshold, is defined as DC sparkover voltage. This limit is quoted in Table 2.

In these applications it is important to select a device that will assure the tube can return to an inactive state after the

Characteristic	Symbol	Definition	Impulse	Typical Value
Impulse Sparkover Voltage	U_{zdyn}	Dynamic Voltage Threshold	1 kV/µs	800 V

Table 1. Characteristics of a gas discharge tube.

Characteristic	Symbol	Definition	Impulse	Typical Value
DC Sparkover Voltage	U_{zstat}	Static Voltage Threshold	N/A	230 V

Table 2. DC sparkover voltage.

strike has occurred. This characteristic is known as the holdover voltage. If the device continues to conduct, the protected line will be short-circuited and the tube will heat up, in which case it is said to be in "glow mode." If left in this state, the tube can overheat and destruct. GDTs have a finite life span which is inversely proportional to the energy dissipated. At extremes, it is possible to reach a level where the tube is unable to discharge all the energy and is destroyed. It is therefore necessary to schedule routine maintenance checks and periodically replace the tube (Figure 1).

λ/4 WAVE STUB TUNERS

The λ/4 wave stub tuners are three-port coaxial connectorized devices. The port extending from the main through-path is terminated in a short circuit at a predetermined length calculated to be exactly one-quarter wavelength of the operating frequency.

Unlike surge protectors, this design eliminates concerns about residual pulse, sparkover voltage and residual voltage. Stub tuners absorb lightning strikes without the need for replacing components. These devices yield very low VSWR and feature high attenuation. They have a bandwidth of 150 MHz (+/- 75 MHz) of the operating frequency. This is a relatively narrow frequency band which makes them application-specific. Stub tuners also pass energy in bands that are harmonically related to the fundamental center frequency. Figure 2 shows a typical test impulse and the response of a stub tuner.

Stub tuners are maintenance-free since they incorporate no active components. However, it is recommended that a check of the stub tuner be made following severe thunderstorm activity at or near an installation (Figure 3).

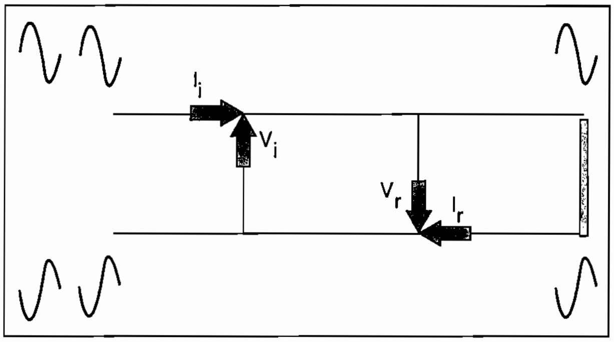

Figure 2. Typical test impulse and response of stub tuner.

SELECTION OF A LIGHTNING PROTECTION DEVICE

Table 3 shows the basic advantages and limitations for both types of protection to be considered during the selection process. Worth consideration are the following questions:

If lightning rods are installed in an antenna site, is additional protection required?

Yes. Lightning is highly unpredictable and can strike locations other than the lightning rod. When lightning does strike a rod, there are still secondary pulses from which installations should be protected in key areas.

Where should lightning protection be positioned within the cellular infrastructure?

Lightning protection needs to be tailored to the particular infrastructure. The type of devices used and locations depend on the sensitivity of the electronics and their location within the infrastructure (i.e., mast-top electronics vs. standard base station location). Normally, protection is installed at the junctions where the transmission line joins the antenna and where the cable joins the base station electronics.

What is the shelf-life of a replacement GDT?

The typical shelf life of a replacement GDT is five years. This enables the maintenance provider to inventory GDTs for routine maintenance and insures a speedy return to service in case of severe lightning strikes.

When should a GDT be replaced within the surge protector?

GDTs are capable of withstanding multiple strikes of varying intensity depending on the specification of the device. However, there are no outward signs of how many strikes a GDT has absorbed. Routine replacement should be scheduled based on the frequency and magnitude of storms in the area of the site.

Will lightning protectors contribute to intermodulation?

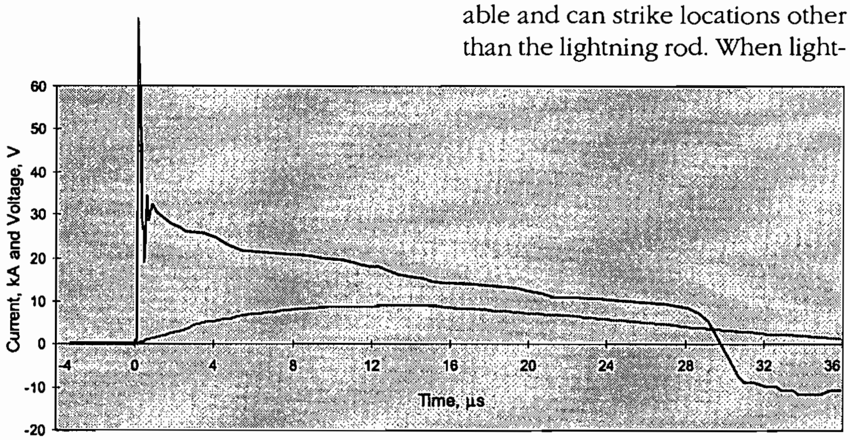

Figure 1. Typical characteristics of a surge arrestor.

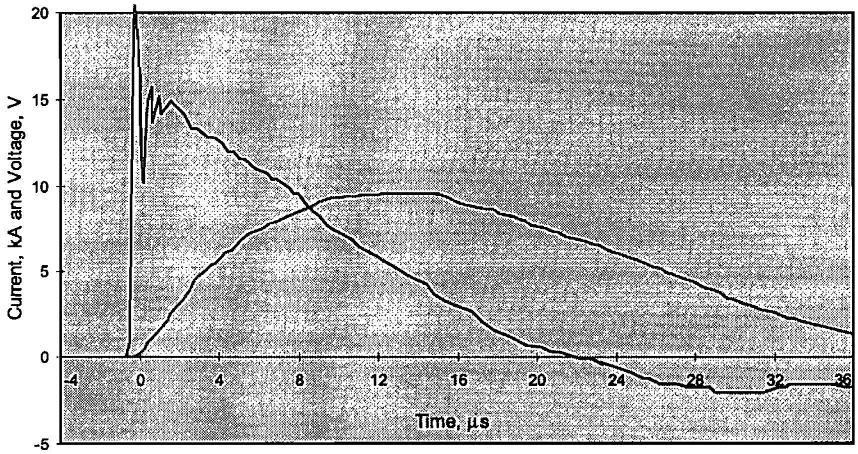

Figure 3. Typical characteristics of a $\lambda/4$ wave stub tuner.

There is always potential for intermodulation when a device is placed in an RF transmission line between the antenna and the filter. When manufacturing these devices, non-ferrous materials and a superior plating finish should be used to minimize this condition.

Can existing antenna sites be retrofitted with lightning protection?

These products can be easily retrofitted into existing systems. The above information gives the basic guidelines for determining which protection system is correct for your application.

CONCLUSION

A defining feature of a surge protection device is its impulse discharge current rating. Stub tuners eliminate several shortcomings associated with standard surge protectors, but have other limitations. Careful comparison is necessary to select the optimum device.

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Surge Protectors	$\lambda/4$ Stub Tuners
ADVANTAGES	**ADVANTAGES**
Broadband	Minimal maintenance
Allows DC bias on the transmission line	Pass-through voltage eliminated
No harmonic bandpass	No sparkover or residual voltage
Easy installation	Easy installation
GDT easily accessible for replacement	
LIMITATIONS	**LIMITATIONS**
Routine maintenance recommended	Narrowband
2.5 GHz maximum frequency	Harmonic bandpass
Initial pass-through voltage	Does not allow DC bias on a transmission line
Low VSWR in bandpass	

Table 3. Comparison of protection devices.

Glossary of Terms

Arc Voltage – Voltage that continues to pass through a surge protector during activation of GDT (approx. 20 volts)

DC Sparkover Voltage – Maximum voltage across a device before it discharges the energy to ground when subjected to a slowly rising voltage ramp. A rate of rise of 100 V/s is usually chosen for testing purposes.

Gas Discharge Tube (GDT) – Hermetically sealed device containing an inert gas.

Glow Mode – Condition in which the GDT continues to conduct after an impulse passed. Characterized by a visible glow in the device caused by overheating.

Hold-over Voltage – Maximum line voltage at which recovery of the GDT to its inactive state will take place within a specified period of time (normally 150 ms) after an induced lightning pulse (normally 10/1000 ms) has been applied.

Impulse Sparkover Voltage – Maximum level of voltage across a device before it discharges the energy to ground when subjected to a voltage impulse.

Impulse Discharge Current – Peak current of an impulse which the device can withstand ten times (5 of each polarity at fixed time intervals) without substantially affecting device performance.

Maximum Discharge Current – Peak current of an impulse which the device can withstand once without substantially affecting device performance.

Residual Impulse – Voltage that will pass through the device prior to activation of the GDT.

Residual Voltage – The small amount of voltage left on the line after an impulse passes.

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__DAVID HALL__ has over 17 years experience in microwave component design, including waveguide and dielectric resonator filters, optoelectronic transmitters and receivers, and coaxial connectors. He received his MA in Electrical Sciences in 1981 from Cambridge University, and worked initially for GEC in the UK, moving to M/A-COM/AMP Incorporated in 1996. He is a specialist in lightning protection, low-intermodulation RF connectors and cable assemblies, and electromagnetic modelling of microwave components. David is a Member of the UK's Institution of Electrical Engineers. (44) 1344-869-595.

__DAVID MEANEY__ has over 14 years experience in the electronics industry. His areas of expertise include wireless transmissions, including voice and data, collision avoidance RADAR, SONAR, differential GPS, LORAN and satellite communications. Mr. Meaney received his BSEE from the University of Massachusetts in 1994. He has held his current position as Applications Engineer with the M/A-COM/AMP Incorporated since 1997. Prior to joining M/A-COM, Mr. Meaney worked in product support and as a product development engineer with Raytheon Electronics, and as an electronics technician with the United States Coast Guard. (978) 442-5000.

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become standardized and accepted internationally among these groups. This means that a set of minimum error items needs to be included in the uncertainty analysis and the method for measuring the error must also be included. Unless measurement uncertainty analysis requirements become standardized, comparisons of measurement uncertainties between different organizations will have no meaning. This problem also applies to measurement uncertainties used for radiated and conducted emission measurements.

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__MIKE HOWARD__ is a NARTE-certified EMC engineer and president of Liberty Labs, Inc., a NVLAP-accredited calibration facility for antennas. (712) 773-2199. mhoward@Liberty-labs.com.