Lightning

Idaho Falls Bishops' Storehouse
On-Air Training
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Situation Awareness

Good evening. We often begin many of our trainings talking about situation awareness and tonight is no different. There was a wide-spread power outage in the area this morning affecting Lewisville, Rigby and Rexburg. The outage lasted about 90 minutes in some areas. I know there were a few of you on the radio sharing information. I hope many more of you were listening. It should become second nature for all of us to grab a radio when events such as this happen.

Introduction

There have been a lot of summer thunder storms in the area lately. And with thunder there is always lightning. Tonight's training centers on how we can protect our shacks from these devastating bolts of energy.

The bulk of this training comes from a three part article in QST magazine, June, July, and August 2002, by Ron Block KB2UYT entitled *Lightning Protection for the Amateur Radio Station*.

I do not intend to make each of you lightning experts, nor do we have sufficient time to cover this topic in excruciating detail. However, I hope that the points we touch tonight will at least make you more aware of some of the risks and prompt you to do further research on your own.

What is lightning?

Usually, there will be lots of moist air rising from ground level to a few thousand feet. There is cooler air above with little or no wind. There also needs to be plenty of sun to heat the air mass near the ground. As the warm, moist air is heated, it rises quickly to heights where the temperature is below freezing. Within the thundercloud, the constant collisions among ice particles driven by the rising air causes a static charge to build up. Eventually the static charge becomes sufficiently large to cause the electrical breakdown of the air and LIGHTNING STRIKES!

The average thunderstorm is approximately six miles wide and travels about 25 mph. The anvil shape of the cloud is due to a combination of the thermal layer (tropopause) and upper high velocity winds that cause the top of the cloud to mushroom and be pushed forward. The area of imminent danger is the area up to 10 miles in front of the leading edge of the cloud. You don't have to be directly beneath or even in the storm to be susceptible to a lightning strike.

When a lightning strike does occur, the return stroke rapidly deposits several large pulses of energy along the leader channel. That channel is heated by the energy to above 50,000ºF in only a microsecond and hence has no time to expand while it is being heated, creating extremely high pressure. The high pressure channel rapidly expands into the surrounding air and compresses it. This disturbance of the air propagates outward in all directions. For the first 10 yards or so it propagates as a shock wave (faster than the speed of sound) and after that as an ordinary sound wave—which produces the thunder we hear.

During a lightning strike your equipment is subjected to several huge impulses of energy. The majority of the energy is pulsed DC with a substantial amount of RF energy created by the fast rise time of the pulses.

If someone can give us a simple definition of “rise time”, please come now with your call sign?
[The time required for a signal to change from a specified low value to a specified high value, often the change from 10% to 90% of the steady value.]

A typical lightning strike rise time is 1.8 µS. That translates into a radiated RF signal at 139 kHz. Rise times can vary from a very fast 0.25 µS to a very slow 12 µS, yielding an RF range from 1 MHz down to 20 kHz. However, the attachment point for a direct lightning strike has a time as fast as 10 nS.
In addition to the strike pulses, the antennas and feed lines form tuned circuits that will ring when the pulses hit. This is much like striking a tuning fork in that ringing is created from the lightning’s pulsed energy.

Average peak current for the first strike is approximately 18kA (98% of the strikes fall between 3 kA to 140 kA). For the second and subsequent impulses, the current will be about half the initial peak. Yes, there is usually more than one impulse. The reason that we perceive a lightning strike to flicker is that it is composed of an average 3 to 4 impulses per lightning strike. The typical interval between impulses is approximately 50 mS.

What is the risk?

The probability of having your tower struck by lightning is governed primarily by where you are located and the height of the tower. In 1952, The Weather Bureau compiled a contour map of the United States showing the mean number of thunderstorm-days that occur in a year. The counting criterion is relatively simple—a thunderstorm-day is one in which one or more claps of thunder are heard.

In southeast Idaho, according to the map, we average between 20 and 30 days of thunderstorms. As you move further west, that number decreases to as few as 5 days per year. As you move toward the southern states, that number increases to 60 or 70, peaking as high as 90 days a year in parts of Florida.

The other significant factor that affects the probability of being struck is the height of the tower above the average ground level. As you might suspect, the higher your tower, the higher the probability of being struck. In our area, if your tower is 200 feet tall, you could average between 2 and 3 direct strikes each year. 125 foot towers average about 1 strike per year. 50 foot towers barely get above 0 on the graph.

Develop a Plan

So what can you do to protect your shack? The QST article recommends a comprehensive plan. Begin by making a list of all of the equipment in your shack and prioritize it based on importance. For most of us, the transceiver is going to be the most important and probably the most expensive. Protecting it will be paramount. For others, maybe you are using a $150 dollar mobile in your shack and the $1200 laptop is more important. Everyone’s list will be different. Everyone will think differently about the equipment in their shack.

Now create a block diagram of your shack. Create a box for each piece of equipment. Now draw lines between each of the boxes that have a connection to each other: the transceiver to the amplifier; from the amplifier to the tuner; from the transceiver to the microphone; from the transceiver to the Morse code key, etc.. Don't forget about the power connections from the power supply to the wall. You'll also need to label any coax that goes to radio antennas or from satellite dishes or from television providers or from Internet ISPs.

Everyplace there is a line that leaves your shack, such as the antenna coax, power cable, etc., is a point that needs to be protected from lightning. The best way to do it is with an in-line device, one that actually severs the connection with the outside world when tripped.

Feed Line Protection

Select coaxial protection for your antenna feed lines that do not induce additional SWR or signal loss. It should cover a broad range of frequencies—at least those used by that antenna—and support the maximum power level you might transmit with.

Power Line Protection

When protecting your power connections, avoid protection systems that have plastic housings, printed circuit boards, or rely solely on a safety ground wire. Make sure the protection you select supports the voltage and current levels drawn by your equipment.

Telephone Protection

For your telephone lines, if you still have them, select an in-line protection device. Avoid systems that use the simple modular plugs or flammable plastic housings.

Control Circuit Protection

Your tower may have devices such as a rotator, remote tuner or a remote antenna switch. Any wire that runs from these devices into your shack also needs protection. In-line is the best, but a shunt type system is usually sufficient in these cases.

Grounding in the Shack

All system grounds inside the shack must be connected to a single ground point in the shack. This is usually accomplished by mounting a copper plate or copper bus to a wall or side panel of the desk. Device grounds should be run as directly and as short as possible to this plate. Do not daisy chain device grounds. For example: do not connect the transceiver ground to the amplifier ground, then the amplifier ground to the tuner ground and then the tuner ground to the ground plate. If you have a VHF antenna coax connected directly to your transceiver and the antenna gets struck by lightning, the surge will travel into and through your transceiver, through the amp, and through the tuner and then out to the ground plate damaging everything along the way.

That ground bus or plate needs to be grounded to the earth also. Use flat copper strap as direct and short as possible to connect the ground plate in the shack to the earth ground system outside the shack. (More on this in a minute.)

The recommendation is that the width of that strap needs to be equal to or greater than the total circumference of coax entering your shack. For example, the circumference of 7/8" hardline is about 2.75 inches. If you have three of those entering your shack, you would need at least a 9" ground strap leaving your shack. 12 inches would be better.

Grounding the tower

The purpose of the outside ground is to disperse as much of the lightning energy as possible. You need more than a single ground rod—ground systems are a better description.

Your tower should have a system of interconnected rebar embedded in the concrete the tower is mounted on. This rebar should then be bonded to the tower. Multiple ground radials should extend out from the tower. Ground radials are basically copper wire buried in the ground. 8' ground rods should be mechanically driven in to the ground every 16' and attached to the radials. Anything metal within 4' of a radial should also be connected to the radial. This included chain-link fences and swing sets.

This radial system should also be connected to a perimeter ground that circles the shack or house. The utility ground from the house should also be connected to this perimeter ground.

You can use shorter ground rods, but the rule of thumb is that you space the ground rods along the radials at twice the length of the rods. 8' rods are located every 16'. 5' rods every 10'. 4' rods every 8'. The longer rods are better because they provide more ground area in which the lightning energy can be dispersed.

A final note about safety

One last note about safety. There is no connection that is better than "no connection". Many hams will disconnect their rigs from outside connections when not in use.

Also, if you are in the shack, holding a microphone for example, when lightning strikes your system, it will find you. You represent less resistance than the copper strap exiting the shack to earth ground. If lightning is in the forecast, it is better if you are not in the shack. Some elaborate setups will have an alarm system that monitors that amount of electrical energy in the air. When it gets to a certain threshold, the alarm will sound, signaling any occupants to exit the shack.

Conclusion

I've condensed about 15 pages of QST articles into 15 minutes. Many of the sections I highlighted tonight are simply that—highlights. I would encourage you to look up the articles and read them in their entirety. They are very enlightening. … That's a poor pun. Sorry.

You can find the articles by going to arrl.org/lightning-protection or by going to the arrl.org website and searching for lightning in the search field.

That is all for tonight. Thank you all for listening in. This is N7TMS, back to net control.