SCTE TECHNICAL COLUMNS

Official archives of articles and columns written by Ron Hranac for Communications Technology and some of its sister publications, published by Access Intelligence, LLC. Reprinted with permission of the author.

By **Ron Hranac**, former ***Senior Technology Editor,*** **Access Intelligence** and ***Communications Technology*** **Magazine**

Originally appeared in the **June 2011** issue of *Communications Technology*.

JUST HOW STRONG IS THAT INGRESS?

By RON HRANAC

From time to time, I correspond with cable system technical staff who are dealing with upstream ingress from a Citizens Band (CB) radio signal in the vicinity of 27 MHz. In some cases, the ingress is quite strong, leading outside plant personnel to believe the CBer must be using an illegal linear amplifier to boost transmitted power to a level in excess of what's allowed by Federal Communications Commission (FCC) rules. Occasionally, the first reaction is to turn the CBer in to the FCC; that will get his signal off the air and eliminate the ingress. Um, not so fast.

§95.410 of the FCC rules states that CB station transmitter output must not exceed 4 watts carrier power for amplitude modulated signals, and 12 watts peak envelope power for single sideband signals. §95.411 prohibits the use of the previously mentioned linear, or power, amplifiers. This brings to mind a couple points: First, 4 watts is a lot of RF power, especially when compared to typical signal levels in a cable network. Second, whether a CBer is operating with 4 watts or 100 watts isn't our concern.

Last point first. Our cable networks are supposed to be fully shielded, allowing us to take advantage of something known as "frequency reuse." The latter means we can use frequencies inside of our networks that are more often than not used for something entirely different in the over-the-air environment. As long as the shielding integrity of the cable plant remains intact, over-the-air signals shouldn't leak in and interfere with our services, and our signals shouldn't leak out and interfere with over-the-sir services. Back to the CB example: It doesn't matter if the CBer is transmitting with the legal 4 watts or a not-so-legal 100 watts. If the cable network is tight, there shouldn't be any ingress.

What about the first point? At first glance, 4 watts doesn't sound like all that much power, but consider the RF power of each downstream signal in the subscriber drop. A typical value at the input to a set-top or cable modem is around 0 dBmV, or 0.00000001333 watt (13.33 nanowatts). That's 13.33 billionths of a watt! The difference between 4 watts and 13.33 nW is 84.77 dB. If we compare a 4-watt CB signal to a cable modem's upstream quadrature amplitude modulation (QAM) signal whose power is, say, +40 dBmV (133.33 microwatts), the difference still is 44.77 dB.

To further emphasize what I'm trying to get across, consider that a 20-microvolts-per-meter (μV/m) field strength caused by signal leakage on cable channel 14 produces a received power of –42.1 dBmV at the terminals of a resonant half-wave dipole antenna. What do you suppose the field strength would be if you were to measure a 4-watt CB radio signal 50 feet from the transmit antenna, using a resonant 27 MHz half-wave dipole antenna? What about a 100-watt CB signal at the same distance? Let's crunch some numbers.

The starting assumption in this exercise is free-space path loss between the CB antenna and a resonant half-wave dipole 50 feet away. In reality, any obstructions in the path, and reflections from nearby objects and the ground, would affect the actual field strength. To calculate the free-space power at our receive dipole antenna's terminals, the following formula is used:

PR = PT – LF + GT – LP + GR

where

PR is the power at the receive antenna terminals, in dBm

PT is the power at the transmitter output, in dBm

LF is the transmit feedline loss, in dB

GT is the transmit antenna gain, in dBi

LP is the free-space path loss between the transmit and receive antennas, in dB

GR is the receive antenna gain, in dBi

Free-space path loss is calculated with the formula:

LP = 36.6 + 20log10(F) + 20log10(D)

where

LP is the free-space path loss in decibels

F is the frequency in megahertz

D is the path length in statute miles

The free-space path loss over 50 feet (50 feet/5,280 feet = 0.00947 mile) at 27 MHz works out to 36.6 + 20log10(27 MHz) + 20log10(0.00947 mile) = 24.75 dB. The next thing we have to do is convert 4 watts (4,000 milliwatts) to dBm: 10log10(4,000 mW/1 mW) = +36.02 dBm. Finally, let's assume 1 dB of transmit feedline loss and 2.14 dBi each for the transmit antenna gain and the receive half-wave dipole-antenna gain. Now, plug everything into the first formula:

PR= PT – LF + GT – LP + GR

PR = +36.02 dBm – 1 dB +2.14 dBi – 24.75 dB + 2.14 dBi

PR = +14.55 dBm

We convert the power in dBm at the receive antenna terminals to dBmV by adding 48.75 to +14.55 dBm, which gives us +63.3 dBmV. Already, it's easy to see the field strength probably is going to be a tad higher than 20 μVm. Field strength E in μV/m is calculated with the formula:

E = 21 * FMHz * 10(dBzmV/20)

E = 21 * 27 MHz * 10(+63.3/20)

E = 829,054 μV/m

Yikes! A 4-watt CB signal can produce a field strength in excess of 800,000 μV/m 50 feet from the transmit antenna. If our cable network has a loose connector or a cracked shield at or near that point, the ingress is going to be on the nasty side — easily strong enough for one to incorrectly assume that the CBer might be operating above the legal power limit. If he were transmitting 100 watts instead of 4 watts, the field strength would be 13.98 dB higher than that produced by a 4-watt signal, or 4,145,559 μV/m.

"There's no way to keep that 100-watt signal out of the system," you say. Actually, there is; it just requires a tight plant. Don't believe me? Take a gander at my May 2004 column, Tackling Serious Ingress (www.cable360.net/ct/operations/bestpractices/15016.html). There, the culprit was a perfectly legal 1,500-watt ham-radio signal hammering the return path, and the cable operator was able to fix the problem. It can be done.

Most of the time when ingress of this sort happens, the interfering signal enters the plant via several low-level ingress points rather than one high-level point. Think loose tap and line passive faceplates, loose housing-to-housing connectors, loose or damaged F connectors, a few bad drops and so forth. More than likely, most or all of the low-level ingress points also are the source of leakage, but probably very low-level leaks — each one way below the FCC's 20 μV/m limit. This makes troubleshooting more challenging, but it also makes for a much cleaner return path when the ingress has been fixed.

Ron Hranac is technical leader, HFC Network Architectures, for Cisco Systems, and former senior technology editor for *Communications Technology*. Reach him at rhranac@aol.com.