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# EVEN MORE ON LTE INTERFACE

By RON HRANAC

I've written several articles on Long Term Evolution (LTE) interference, largely from the perspective of cable network signal leakage in the 698 MHz-806 MHz band causing interference to LTE service. But what about the other direction – that is, over-the-air LTE signals interfering with signals inside the cable network?

There are a couple ways that can happen. One is ingress interference to downstream cable signals from an LTE service provider's tower-to-user equipment (UE) transmissions, and the other is interference inside the customer premises caused by a UE's transmitted signal entering the drop wiring as ingress or via direct pickup in the customer premise equipment (CPE).

Let's look at the former scenario first. I'm aware of at least one cable operator in a major metropolitan area that has abandoned cable channels 116 and 117 because of ingress interference from Verizon's LTE downlink (tower-to-UE) signals in the 746 MHz-756 MHz band. I've also heard of some operators that have experienced localized ingress interference in parts of their networks and drops near the towers themselves.

The culprit here isn't the over-the-air LTE signals per se. Remember, our networks are supposed to be shielded, allowing cable operators to take advantage of something called "frequency reuse." The latter means we can carry signals inside of our networks that usually re completely different from the over-the-air signals on the same frequencies. As long as our networks' shielding effectiveness remains intact, the two RF environments can coexist with no problem. Where problems do occur is when something causes the shielding effectiveness of our networks to be degraded. Use of high-quality materials and components, good workmanship in plant construction and drop installation, and a diligent signal-leakage and ingress-management program together help ensure maximum shielding integrity.

In-the-home problems include the previously mentioned ingress and direct pickup. Ingress there usually is related to loose, damaged or improperly installed F connectors; substandard parts installed by our subscribers (splitters and other devices from the local electronics retailer); poor quality coax jumpers that often accompany consumer electronics; poorly shielded cable-ready TVs and other CPE connected directly to the drop; and physical damage to the drop: tree limbs rubbing the cable, pet or rodent chews, etc.

Most of the time, ingress interference will manifest itself as on-channel interference. For example, in homes close to a LTE service provider's tower, cable channels that overlap the tower's downlink frequency band might be susceptible to interference. Likewise, uplink (UE-to-tower) interference could occur on one or more cable channels that overlap the LTE UE uplink frequency range. For instance, when on-channel interference occurs to a single digital video quadrature amplitude modulation (QAM) signal, it usually will affect all of the video/audio streams in that QAM "haystack" and appear to the subscriber as multi-channel interference.

Direct pickup by a cable modem or set-top typically happens when a mobile device (LTE or even a conventional cellphone) is near the affected CPE. The culprit here is insufficient shielding of the CPE itself. Older set-top and modem designs are likely to be more susceptible, given that they were designed to comply with FCC Part 15 and possibly other rules in effect at the time of manufacture. Interference either can be on-channel or fundamental overload, the latter where reception of all channels is affected. The latest CPE designs generally comply with newer and much tougher electromagnetic compatibility (EMC) specs. To illustrate why this is important, let's go through some field-strength math. Grab your scientific calculator and a strong cup of coffee, and follow along.

The maximum LTE UE transmit power is +23 dBm (199.53 mW), with a +/-2 dB tolerance, and the minimum is -40 dBm (0.0001 mW). That's a pretty significant power range that must be supported by a LTE UE. I've seen numbers for UE antenna gain ranging from -1 dBi to -3.5 dBi. With that information, I've done some number-crunching to see what the predicted field strength might be 1 meter away from a LTE handset if that handset were transmitting at the maximum +23 dBm power output (the +/- 2 dB tolerance could mean that some UEs transmit as high as +25 dBm at maximum output, but I'm using the +23 dBm value in this example). The transmit frequency range for a Verizon LTE handset is 777 MHz-787 MHz, so I'll use the middle of that for the calculation (782 MHz).
Free space path loss is calculated with the formula:
LossdB = 20log(fMHz) + 20log(dkm) + 32.45
where
fMHz is the frequency in megahertz
dkm is the path length in kilometers (1 meter = 0.001 km)

The free space path loss over a 1-meter distance at 782 MHz is:
LossdB = 20log(782 MHz) + 20log(0.001 km) + 32.45
LossdB = [20 * log(782 MHz)] + [20 * log(0.001 km)] + 32.45
LossdB = [20 * 2.89] + [20 * -3.00] + 32.45
LossdB = [57.86] + [-60.00] + 32.45
LossdB = 30.31 dB

OK, the path loss over a 1-meter distance at 782 MHz is 30.31 dB. Let's assume a resonant half-wave dipole antenna at the point where field strength 1 meter away from the LTE UE is being measured. The received signal power at the receive dipole's terminals is:
Transmit power (dBm) – transmit feedline loss (dB) + transmit antenna gain (dBi) – free space path loss (dB) + receive antenna gain (dBi)

I'll assume a worst-case scenario of a transmit antenna with -1 dBi gain being connected directly to the transmitter's power amplifier stage — no feedline loss, no filter insertion loss. I'll also assume that there is no additional attenuation to the LTE UE's transmitted signal caused by someone holding the device. Plugging in some numbers gives

23 dBm – 0 dB + (-1 dBi) – 30.31 dB + 2.14 dBi = -6.17 dBm

at the dipole's terminals.
Converting the received power in dBm to dBmV is done by adding 48.75 to the dBm value: -6.17 dBm + 48.75 = +42.58 dBmV. This assumes the receive dipole's impedance is 75 ohms, which is close to a half-wave dipole's free-space impedance value of 73.1 ohms. Next, convert dBmV to field strength in microvolts per meter (μV/m):
μV/m = 21 * (782 MHz) * 10(42.58/20) = 2,210,172 μV/m or ~2.2 V/m

From this, the maximum field strength 1 meter away that could be produced by a LTE handset operating at maximum transmit power is ~2.2 million microvolts per meter or ~2.2 V/m. Doubling the distance to two meters will still result in a calculated field strength of around 1.1 V/m.

Practically speaking, the UE antenna gain is likely to be a little worse than -1 dBi, and some additional attenuation will occur as a result of the UE being handheld or sitting by itself on a table or other surface. Assuming 6 dB of additional attenuation, the 1-meter field strength would be about 1.1 V/m and the 2-meter field strength would be about 0.55 V/m when the UE is transmitting at its maximum power of +23 dBm.

What does all of this tell us? To avoid interference from a LTE UE to a set-top or cable modem requires that the subscriber drop be tight from a leakage and ingress perspective, and that the CPE have sufficient shielding performance. In the outside plant, ingress interference problems can be minimized by an effective leakage and ingress management program, but with one caveat: Monitoring for leakage only in the 108 MHz-137 MHz aeronautical band isn't enough. The poor correlation of signal leakage field strength in the aeronautical band and the spectrum used for LTE means that leakage also should be monitored at higher frequencies.

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