COMMSCOPE®

White paper

The impact of cellular deployment on MSO networks at lower frequency bands

Contents

Abstract

This white paper examines the expansion of cellular networks, the increasing bandwidth usage by cable TV (CATV) networks, and signal interference issues. It also explores known causes of CATV network signal egress and ingress, and reviews possible solutions.

In the beginning of the 21st century, the U.S. government began re-appropriating the frequency spectrum to accommodate more cellular transmissions. This re-appropriation included band frequencies (e.g., 700 MHz band) that were traditionally reserved for television network broadcasts and successfully used by multiple systems operators (MSOs). So, when MSOs began experiencing new signal interference, many logically concluded that cellular network signals may have been the cause.

But, prior to the growth of the long-term evolution (LTE) wireless networks, signal egress and ingress had always been an obstacle. Challenges that ranged from aging infrastructure to improper cable installations have long been the nemesis of strong cable signals since the start of CATV networks. So even though LTE wireless networks were now operating on the same frequencies as CATV networks, poorly grounded distribution boxes and loose connectors could easily cause more signal degradation than cell network transmissions.

This is not to say that growing cellular networks shouldn't share some of the responsibility for signal interference (and vice versa). In many of these cases, shielded set-top boxes (STBs) and tri-shielded cables can combat signal interference. In fact, upgrading a standard RG6 60 percent braided drop cable to a 77 percent tri-shield XpressPrep® cable can give MSOs more dB interference resistance per dollar and can even be deployed in a shorter installation time.

The rise of the cellular networks

In the beginning, cellular phones were simple devices that translated the same analog voice signal as landlines but used radio signals with simple frequency modulation to communicate between the base stations and mobile devices. This was known as the first generation (1G) of cellular phones. And, as adoption grew, cellular networks soon replaced 1G with a more robust and spectrally efficient, digital second-generation (2G) technology—which allowed users to also send messages and pictures.

With the emergence of the smartphone, consumers were regularly using their mobile devices to access the Internet as well as stream videos and music by the time cellular networks launched the third generation (3G). Today, LTE cellular networks are transitioning from 3G to the fourth generation (4G) technology, which provides users with access to multimedia content, HD voice over LTE, cloud computing, high-definition video and other robust broadband services at superfast data transfer speeds.

As these cellular networks grew, the U.S. government began revisiting the allocation of public airwaves and how they should be assigned to satisfy the increased appetite for more broadband use on LTE networks. By the early 2000s, the Federal Communications Commission (FCC) determined that the traditional television broadcast bands were ideal for the wireless networks since signals at these lower frequencies traveled farther and penetrated buildings more easily than the higher microwave frequencies. In March 2008, the FCC held Auction 73 and sold off licenses for four out the five available blocks of the lower 700 MHz bands for nearly $19 billion.

Following Auction 73, cellular networks immediately started expanding into the new frequencies. But, as different companies gravitated towards different network protocols, confusion ensued. The license holder for Block A (698-704 MHz and 728-734 MHz) wanted to use signaling protocols known as Band Class 17 to avoid future interference. But other companies who had rights to use Block A frequencies balked since their equipment operated solely on Band Class 12. Six years later, these telecommunication companies, along with the FCC, came to an agreement to deploy a universal signaling protocol (Band Class 12) that would resolve the interoperability issues and support all carriers starting in September 2015.

With the majority of the 700 MHz band now vacated by television broadcasters for the exclusive use of cellular network transmissions, cell phone users were now free to operate their mobile devices nationwide without any outside interference. Or were they?

The evolution of cable TV networks

In the 1940s, only a handful of television broadcast networks existed and offered limited programming on the very high frequency (VHF) spectrum. These TV broadcasts were confined to what's now known as channels 1-13 (44-216 MHz). Broadcasting on these lower frequencies permitted television networks to reach a widely dispersed audience with low-power antennas. But, even as the number of TV stations and transmission points grew, geography still prevented some communities from receiving these broadcast signals.

In an effort to provide broadcast TV to remote areas, CATV companies emerged as a middleman—picking up broadcast programming signals and distributing them via coaxial cable.

As television broadcasters and programming grew, CATV operators also flourished. During these times, CATV operators shared the VHF and ultra-high-frequency (UHF) bands with licensed TV broadcasters with few problems. Since cable operators deployed signals that were different from over-the-air signals on the same frequencies, the overlap didn't create much interference. In addition, broadcasters' signals weren't very robust and cables shielded most CATV signals. So the two RF environments coexisted peacefully.

Then, CATV operators discovered the advantages of digital compression. By using more compact and efficient signals, CATV operators could deliver more programming and services over their existing infrastructure. This digital revolution not only allowed cable companies to deliver more content, but also provided a means in which they could engage in two-way communications with their customers. This enabled CATV operators to expand their services by offering highspeed Internet, video on demand, and even VoIP telephone service. And, as cable operators increased the amount of data they deployed, they also began extending their RF plant beyond the traditional broadcast frequencies into the 1 GHz range.

By the 2000s, the landscape for broadcast TV had also changed. The FCC mandated that public broadcasters transmit their programming in a more compact and efficient digital format instead of the traditional analog signals. And, at the same time, the traditional TV broadcast spectrum was repurposed for cellular network usage. These newly vacated frequencies were the answer to how LTE networks could increase their coverage and improve their capacity.

By 2010, network broadcasters had fully vacated the 700 MHz band while CATV operators were still fully utilizing this band inside their cables for additional programming and services.

The inevitability of frequency overlap

With cellular networks gradually moving down the frequency spectrum and CATV operators firmly set on deploying signals at higher and higher frequencies, it was just a matter of time before these signals converged. Not long after Auction 73, dozens of cases were documented in which cellular network signals interfered with CATV channels operating in the same frequency bands.

Oftentimes, poorly shielded set-top boxes (STBs) were the cause. But in others, damaged RF components or loose connectors could permit signal ingress into the CATV network. Since not all signal degradation would be traced back to the LTE network, MSOs needed to re-examine their CATV network to understand where signal interference was originating.

Where does signal interference come from?

From the day the first coaxial cable was laid, CATV operators have been battling signal interference in their networks. During simpler times, locating the signal egress or ingress was easier to manage because there were fewer potential culprits. And, in some cases, the CATV networks tolerated the ingress because the interference was minimal.

Today, signal interference is much more sophisticated and destructive because the CATV networks are more complex. The following are some known causes of signal interference in the CATV networks.

Aging infrastructure: Although most cable and RF components were designed and built to last, given enough time they will degrade. Constant flexure of aerial cable or repeated exposure to warm and freezing temperatures will cause fatigue in most components.

Environmental conditions: Regardless of a CATV operator's best-laid plans, environmental elements continue to plague cable networks beyond a company's control. Harsh weather—such as intense heat or cold, high winds, or constant humidity—can negatively affect any component along the network. In addition, native wildlife such as rodents, birds or even neighborhood pets can also wreak havoc on cables and connectors due to chewing or nesting behavior.

Installation/design flaws: A network's signal integrity is only as strong as its weakest link. For example, if an aerial cable was installed without a messenger wire, if a connector wasn't firmly fitted, if a distribution box wasn't properly grounded or if a live cable wasn't properly terminated, the signal may not be as robust as it should be. The last hundred feet to the subscriber's residence is critical only if the rest of the network leading up to the pole was properly deployed.

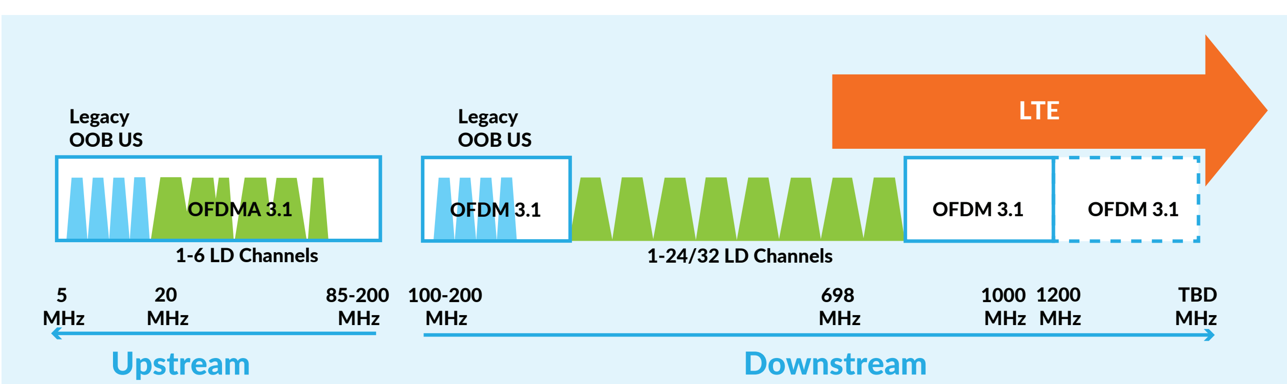

Figure 1. CATV and LTE Frequency Overlap

Customer-premise equipment (CPE): Often-overlooked components in the network are CPE, which include set-top boxes (STBs) and modems. Depending on their age, the amount of usage and the environment in which they're housed, they can be the root cause to signal interference. In fact, something as simple and common as a poorly shielded STB or a faulty modem or router can potentially add digital noise that gets transmitted throughout the network.

Electromagnetic interference (EMI): With the proliferation of household gadgets and appliances, everyday electronic devices can also introduce noise into the network. Most electronics with motors—such as microwave ovens, vacuum cleaners, exercise equipment and air conditioners—have the potential to degrade a subscriber's signal. This also applies to commercial sites such as hospitals, where specialized machinery can create unique interference. In addition, seemingly benign home products like garage door openers, walkie talkies, security alarm systems and video gaming devices are also capable of producing radio frequency interference (RFI), which could also impair a CATV network.

LTE transmissions: As the use of smartphones skyrockets across the nation, LTE service providers' base-station-to-user equipment (UE) transmissions can have a substantial impact on a cable network's signal as well as the UE's transmissions back to the base station. Since more cellular networks are now operating on the same frequencies as CATV operators, there are more potential opportunities for transmissions to interfere with each other's signals. In addition, cell towers located near the headend or plant may theoretically affect the cable signals when the headend or plant had improper or poor connectors.

Shannon's Law

Although a limited amount of interference can be tolerated, it can eventually lead to bigger problems if not addressed. The Shannon-Hartley theorem explains how there is a finite amount of bandwidth available in a channel. This means that the power level of the noise and interference in a channel relative to the desired signal level (called SNR) determines the data throughput. As SNR increases, so does the data throughput through the channel. Said differently, for a given signal level, an increase in interference will reduce the data throughput. So, for every bit of noise that lives in a channel, the less room there is for the actual content that is being transmitted. Even when multilevel encoding techniques are employed, the maximum throughput for a channel is a strong function of SNR.

Properly locating signal interference

Prior to the rapid growth of cellular networks, uncovering signal egress was simpler. A signal was injected into the VHF aeronautical band (typically 108-139 MHz) and analog detectors were used to locate the leak along the network. But today, just using a VHF aeronautical signal isn't enough.

To properly resolve egress, cable TV networks need to also check for leakage in the 700 MHz band. By using higher frequencies, MSOs can more accurately pinpoint the causes of egress in the network, which may also be the source of ingress. Unfortunately, a major challenge to using the 700 MHz band to find network signal interference is that most leakage detectors are not able to detect digital (QAM) cable signals. So MSOs must find an alternate means—such as directional antennas and near-field probes—to locate the leak.

Reducing interference with new cable

As mentioned earlier, loose connectors, faulty CPE, and improper field installations are the cause of the majority of egress and ingress in CATV networks. But there are times when updating the network's drop cable can address current issues while preparing the network for the future.

For most CATV networks, the RG6 size, 60 percent braided drop cable was the standard. Developed prior to the cellular network revolution, it provided protection against environmental hazards and reasonable defense against signal ingress. But, over time, better cables were designed that deliver better performance at a reasonable cost.

A cable's performance is tied to its construction. One key element of the cable is the laminated aluminum, polymeric, aluminum shielding tape (LST). These thin layers of aluminum deliver the necessary electrical properties needed to allow the signal to flow while reducing signal egress and ingress.

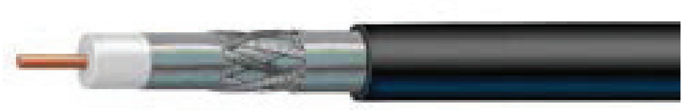

Figure 2. Tri Shield Drop Cable

In addition to LST, premium cables feature braided wire that delivers enhanced tensile strength to the cable in addition to low-frequency signal shielding. The braid also provides a solid mechanical base that connectors can grip, thus improving connector retention and interface longevity.

A cable's performance varies by the amount of LST and braid used. The more layers of tape, the better the signal integrity. The higher the braid density, the stronger the cable. Of course, there is a trade-off as additional tape layers and braid thickness will eventually limit the practical usefulness of the cable by increasing stiffness and cost.

To understand a cable's performance, it's not only important to see how it performs after it's been manufactured, but it's also crucial to see how effective it remains after it has been installed. To simulate the stresses of handling and installing cable, CommScope and the SCTE initiated a rotaryflex fatigue test that simulates long term cable life by placing the cable through 10,000 rotations

From the chart overleaf, after exposure to 10000 rotations, the 77 percent tri-shield (TS) XpressPrep (XP) solution provides excellent shielding performance for the dollar. While the F660 is a strong,

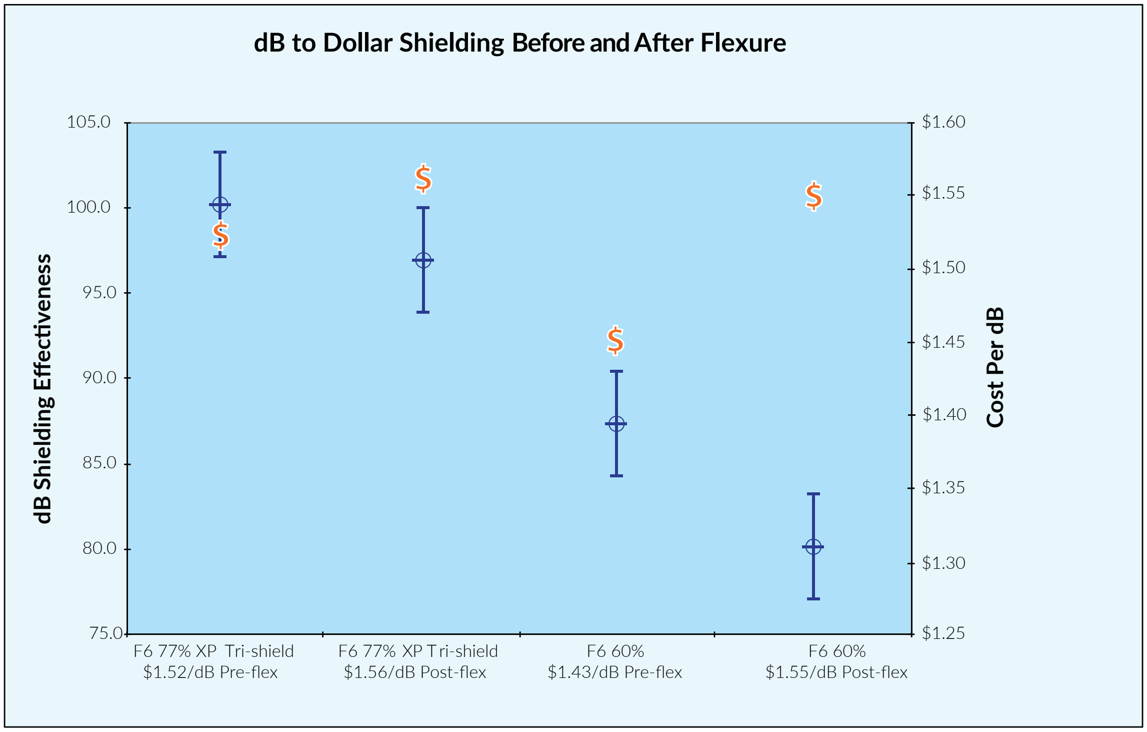

Figure 3. dB to Dollar Shielding Before and After Flexure

reliable cable for general applications, in environments where additional shielding is warranted, the 77 percent TS XP cable offers superior performance at a great value.

In addition to providing more shielding, the 77 percent TS XP also features a unique prep property that allows the installer to deploy the cable in half the time it takes to install typical tri-shield cables. This XpressPrep cable has an outer tape layer that's bonded to the jacket—making the extra step of removing the tape unnecessary and installing connectors properly easier, which makes it significantly more reliable than even a quad-shield cable.

Summary

While it is possible for signal interference to come from the growing cellular networks, the more likely causes stem from installation errors such as poor grounding and loose connectors.

Ensuring proper connectorization, maintaining the plant and making sure CATV networks are well shielded are keys to preventing such potential sources of signal interference. In addition, as wireless networks expand into the 700 MHz band (and soon into the 600 MHz band), updating a CATV network with a 77 percent tri-shield drop cable can virtually eliminate any current ingress at a reasonable price-to-performance ratio and prepare the CATV network for the future.

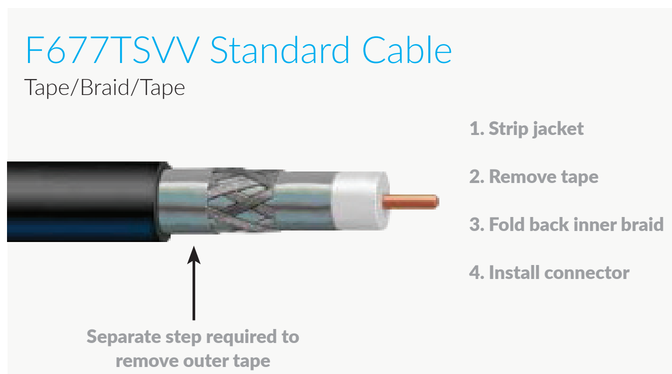

Figure 4. XpressPrep Preparation Advantages

Everyone communicates. It's the essence of the human experience. *How* we communicate is evolving. Technology is reshaping the way we live, learn and thrive. The epicenter of this transformation is the network—our passion. Our experts are rethinking the purpose, role and usage of networks to help our customers increase bandwidth, expand capacity, enhance efficiency, speed deployment and simplify migration. From remote cell sites to massive sports arenas, from busy airports to state-of-the-art data centers—we provide the essential expertise and vital infrastructure your business needs to succeed. The world's most advanced networks rely on CommScope connectivity.

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