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EXPERT SERIES

THE ESSENTIALS OF WIRELESS SYSTEMS

Chapter 1 of 6: Wireless Systems Expert Series

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THE ESSENTIALS OF WIRELESS SYSTEMS

How they operate, changes in the frequency spectrum, basic issues that can plague performance, and solutions that do the trick.

Overview

Anyone who has used wireless microphone, in-ear monitoring and/or intercom systems for even a short time doesn't need to be sold on their advantages. "Going wireless" allows concentration on the message rather than on the mechanics of delivering the message. (No more pesky cables!)

Yet wireless systems can be slightly mysterious, prompting suspicion among some users – particularly if they've experienced problems for unclear reasons. The easiest way to understand wireless systems is to think of them as small-scale radio broadcast stations – a transmitter sends out a signal that is picked up by a receiver. For a number of reasons, including size, weight, battery life and government regulations, wireless systems operate at quite low power and thus have limited range.

The handheld wireless microphone is the transmitter, complete with a mic capsule, some audio circuitry, and an antenna (usually built into the case). The same is true of a bodypack transmitter, which is linked to a microphone element or an instrument. Regardless, it sends radio signals to its companion wireless receiver, which also has an antenna and some circuitry to select and process the signal, which is then sent via a cable to the sound system.

It's pretty much the reverse situation with a wireless in-ear monitor (IEM) system. The bodypack (connected to the actual ear monitors) is the receiver, which is fed a radio signal by its companion transmitter. Wireless intercoms facilitate 2-way communication, with at least one base station unit working with several bodypacks that both transmit and receive.

The transmitter and receiver of each wireless system must share the same frequency. Any other wireless systems in use in the same area must have their own frequencies as well. Ugly noise is produced if two wireless systems are using the same frequency in the same area. The same goes for other transmitters, especially those of TV stations. And because those transmitters send out very powerful signals, they are a common potential cause of interference for wireless systems.

Even though a wireless system needs a clear frequency for the area where it's going to be used, every frequency is used again and again across the U.S. (and any other country, for that matter). Again, this is because the power of the output signal of wireless systems is very low.

Keep in mind, however, that there is no absolute guarantee that a clear frequency in one area will be clear elsewhere, even just across town. This is an aspect about wireless systems that sometimes puzzles users; the government takes care of the problem for the high-power signals such as commercial broadcasting and two-way radio, but wireless system users are responsible for avoiding this problem on their own.

Fortunately, most modern wireless systems (developed in the past 20 years or so) offer at least a minor degree of frequency agility. This means that the user is able to select an operating frequency from a number of possible choices, ranging from as few as four frequencies to 1,400 or more, depending upon the model.

The more frequencies offered by a wireless system, the better the chance of finding a clear frequency that is not being used by someone else in the area. Further, in larger cities where there are more frequencies occupied by numerous users, the ability to choose from a larger number of frequencies is especially important.

Additional Frequency Considerations

Having plenty of open frequencies also helps wireless system users get around another potential problem: intermodulation (or intermod for short). This can occur where the frequencies of two or more transmitters (of any

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type) mix together ("combine") in a wireless system receiver or other amplified stage in the RF path, resulting in noise and interference.

By law in the U.S., wireless systems are supposed to operate only on TV channels not in local use. If a wireless system happens to cause interference to TV viewers in the area of its use (and though rare, can happen even with their lower output level), the interference could be reported, resulting in the user drawing unwanted attention from FCC.

Thus it's vital for the wireless system user to keep handy a list of local TV frequencies in use (available online at several websites, including antennaweb.org, rabbitears.info and the FCC's own Media Bureau TV Query database) and to avoid those frequencies (channels). Although many wireless systems can "automatically" select frequencies or scan to see local RF activity, it's still possible to select the frequency of a local TV channel and get the user into trouble.

Graphic depiction of intermod, where two (or more) transmitters combine and interfere with each other.

Change In The Air

Wireless systems are currently available for VHF and UHF frequency ranges (also called bands), corresponding to TV channels 7 though 13, 174-216 MHz (for VHF) and TV channels 14 through 51, 470-698 MHz (for UHF). The question as to which range is “best” depends on the users needs and application, but for the time being, the greatest selection of equipment remains in the UHF band.

However, things have changed. In the U.S., the Federal Communications Commission (FCC) recently concluded a spectrum auction of a good chunk of the UHF band, and it’s a frequency group where wireless systems have long operated – specifically, the portion from 617-698 MHz. About a half dozen different carriers acquired the available spectrum, with T-Mobile being the largest.

While wireless system users were informed that they would have 39 months from the date of the conclusion of the auction (April 13, 2017) to replace systems operating above 614 MHz, there’s an important caveat: once the winning bidders begin to test equipment in a particular block or blocks of the 600 MHz band, wireless microphone, IEM and intercom system users must cease operations in those blocks immediately.

Further, operating a wireless system in the spectrum owned by the winning bidders once they commence operations becomes illegal. Chances are that T-Mobile, in particular, will energize in your region within the year, if not sooner, so plan accordingly.

Another factor in play is that the “repack” of television stations that broadcast above 614 MHz (above channel 37) will be moving down below 608 MHz in a 10-phase schedule to be completed by 2020.

An estimated 1 million-plus wireless microphone, IEM and intercom systems operating above 600 MHz are currently in service in the U.S. That’s a lot of gear that will need to be replaced or updated in the next year or two. As a result, all wireless users should review their inventories in order to be prepared to replace anything above 608 MHz within the tighter timeframe outlined here.

On a positive note, many wireless manufacturers are offering rebates on equipment that operates in the 600 MHz range, and some are also providing a re-banding service, making it a somewhat less expensive transition for those directly impacted by the auction results. There’s also now a host of equipment offerings in alternate RF bands, with three primary areas of the frequency spectrum to use right now:

1. 72-88 MHz and 179-216 MHz. This is within the VHF space, which actually starts at 54 MHz and includes usage for television stations.
2. 470-609, 614-616, 653-663 MHz. This is within the UHF space, which runs from 300 MHz to 3,000 MHz
3. 2.4 and 5 GHz. The issue with this range is it’s also used for Wi-Fi, which means that any device used as a mobile hotspot or a venue that has

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installed. Wi-Fi presents the risk of interfering with wireless systems operating in the range. That said, thousands of wireless systems are in use in this range, presumably most/all of them with some measure of success. It's up to you (and a good RF scanner) to see if it's usable/suitable for your situation.

4. 6.5 GHz. This is primarily ultra-wideband equipment with relatively small operating range.

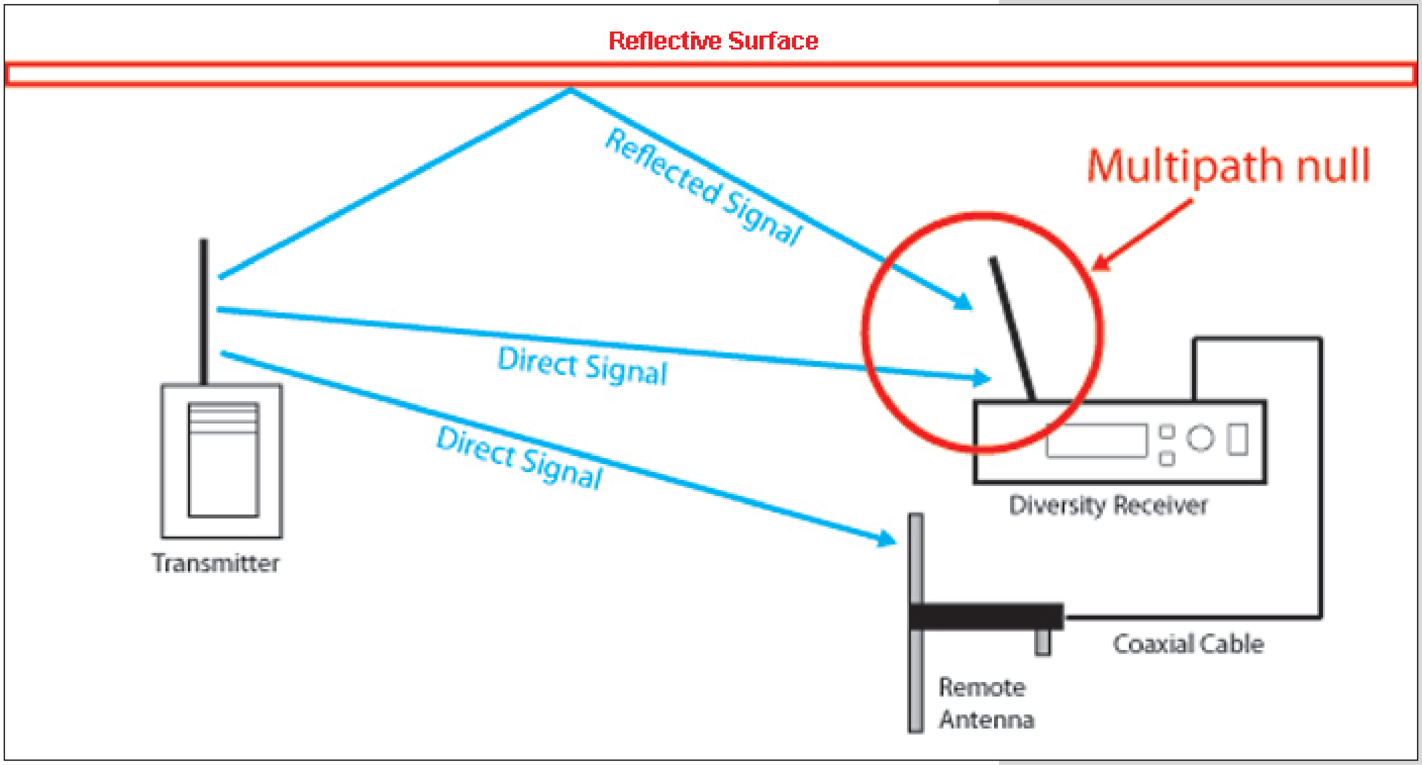
One other note: The FCC also has expanded eligibility for professional sound companies and venues to make use of the 944-952 MHz STL band, with expansion to the the full 941-960 MHz once some technical and coordination issues are resolved.

Following Key Principles

With all of these competing signals in the air throughout the VHF and UHF bands, even high-quality wireless systems can run into problems when operating at relatively close distances between the transmitters and receivers. Range problems usually appear as "fizzing" or "swishing" noises, perhaps followed by the complete loss of the audio signal. (This is called dropout.)

In addition to the low transmitter power, two other problems can limit the range of wireless systems. The first is signal obstruction due to set pieces, building construction, internal equipment, or shielding by metallic objects

A depiction of a multipath problem.



such as electrical wiring, air conditioning ducts, storage cabinets and the like between the transmitter and the receiver.

The term "unobstructed line of sight" is often used to express the idea that the signal path from the transmitter to the receiver should be open and clear of obstructions. This simply means that if the wireless user can physically observe the receiver antenna, RF signal obstruction is likely to be low.

The second problem is called multipath. It's a phenomenon that results in smaller areas where multiple paths of the same wireless signal are present, albeit out of phase, and reach the receiver antenna. Because these out of phase signals could cause a complete signal cancelation, the user can experience loss of signal (dropout) even though the transmitter is relatively close to the receive antenna with little to no obstruction.

To overcome the problem, a majority of modern wireless receivers now use a technique called diversity. With diversity, two spatially separated receiver antennas are used, making it very unlikely that both will simultaneously be in one of the low signal (multipath) areas. The receiver automatically selects the antenna with the strongest signal, not only solving multipath, but also increasing the reliable range of the system.

A final note: After three decades, the FCC finally opened up wireless microphone operations to non-licensed users, under Part 15 rules in 2009, along with expanding Part 74(H) license eligibility to professional non-broadcast/film/TV users such as professional sound and AV companies, large venues and performance organizations.

Next time we'll address common issues with wireless systems and how to solve them.

About Radio Active Designs:

Radio Active Designs, formed by a group of top wireless audio specialists, designs and manufactures spectrally efficient (wireless intercom systems) to ensure that all live events, performing arts, and broadcast media may continue to flourish with minimal negative impact from the fallout of the FCC (600 MHz) auction and TV channel repack.

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