ProSoundWeb EXPERT SERIES

WIRELESS SYSTEMS: BEST PRACTICES FOR ANTENNA DISTRIBUTION

Chapter 3 of 6: Wireless Systems Expert Series

WIRELESS SYSTEM ANTENNAS

The essentials for achieving optimum reception and avoiding interference.

When moving beyond use of one or two channels of wireless in a building, it's vital to make sure things are designed to work together and are installed properly. While it's true that a bunch of wireless receivers with 1/4- or 1/2-wave antennas can be stacked at a given location (i.e., front of house or monitors) and still work — some of the time — it's usually not the right or best way to go.

The problem is that once you start putting all those antennas next to each other, they start causing interference with each other. Fire up enough channels and there are sure to be issues. The answer is proper *antenna distribution* and *transmitter combining*. Let's clarify these two terms.

Antenna distribution is used with wireless microphone systems. Basically, take a couple of specialized antennas – usually log periodic dipole arrays (LPDA, a.k.a., “paddles”) that are run into an antenna distributor – technically called a multi-coupler – and spread them out so they cover the intended area. Most multi-couplers will output signal to four to eight wireless mic receivers, and can have a cascade out to connect to a second multi-coupler in case it’s needed.

When it comes to wireless in-ear monitoring (IEM), wireless interruptible foldback (IFB) and wireless intercom systems, we’re dealing with transmission antennas, and this means a transmitter combiner is needed. A combiner is similar to a distributor, only in reverse. It takes the outputs of four to eight transmitters and combines them into a single output signal port that goes to the antenna itself.

A word about antennas with built in preamplifiers, also called “active” antennas: although in widespread use, they in fact should not be used except in rare circumstances where exceptionally long coax cable lengths are required. There are several reasons why amplified antennas are to be avoided in general use:

1) As an active non-linear gain stage, mixing will occur and additional IM products are created;
2) Easily overloaded by nearby RF transmitters such as two-way radios, IEM/IFB transmitters and the like, causing the amplifier to go into saturation and thus causing harmonics and other spurious emissions creating self-interference;
3) Adds noise to the RF system, and;
4) Amplifies all RF energy within the unit’s passband, most of which is actually unwanted (active TV stations, two-way radios, IEM/IFB transmitters, etc.).

The purpose of a preamp located at the antenna is to make up for coaxial losses when appropriate. In almost all wireless microphone deployment cases, it’s not appropriate. A typical LPDA antenna has a passive forward gain of 5 to 6 dB, which is more than enough to compensate for about 150 feet of low loss (double shield, braid over foil construction) RG8/U Type coax at UHF frequencies, and over 350 feet at Hi-VHF.

Further, if the antennas are properly deployed right at the desired coverage area, there will be sufficient CNR (carrier to noise ratio, or signal strength) that the system can even withstand a several dB deficit at the receiver. In short, amplified antennas can cause significantly more problems than they solve in everyday applications.

Coaxial Cable Loss

First, be aware that all coaxial cable has signal loss. The amount of loss is related to the operating frequency, the type and size of the coax and the length. The higher the frequency, the greater the loss through the cable.

Table 1 shows the different types of cable and the loss per 100 feet at the 700 MHz operating frequency. Note for U.S. wireless users – 608 MHz will soon be the upper limit of the standard UHF frequencies. Thus, losses for frequencies between 470 – 608 MHz are less than these figures, but the concept still applies.

Antenna	Cable	Amplifier	Result	Comments
Dipole	100 ft. RG-58A/U	None	-11.7 dB at receiver	Too much loss
Dipole	100 ft. RG-58A/U	+12 dB	+0.3 dB at receiver	Ideal
Dipole	100 ft RG-174	+12 dB	-15 dB at receiver	Too much loss
LPDA	400 ft 9913F7	+12 dB	-3.2 dB at receiver	OK
LPDA	400 ft RG-58	+12 dB	-34.8 dB at receiver	Bad News

Table 1

The second to last type shown in the list, Belden #9913F7, is a low-loss, braid-over-foil shield, foam-dielectric cable of the RG8/U Type, and the electrical, and physical equivalent of Times Microwave LMR400-UF. Both cables are .4-inch OD and exhibit a very good compromise between size, performance and cost, with the 9913F7 being a bit less expensive and more flexible. These are a good choice for antenna runs over 25 feet, while a low loss version of RG8X (a.k.a., “mini-RG8”) is excellent for shorter runs and between rack interconnects.

Low Loss, Double Shielded Coax

Most coax sold with wireless microphone systems and sold by the manufacturers is standard RG58 and RG8 with a single braid with only about 95 percent shielding coverage. Not only are these lossier cables, but the porous shielding actually permits outside RF to get into the receive system which can cause an increase in the RF noise floor and desensitize the receiver.

Low-loss coax for wireless microphone applications is generally a braid over foil shield construction providing 100 percent shielding coverage, Time Microwave’s LMR series being one of the most well-known brands. Other types of low-loss coax include a double braid design providing 97 to 98 percent coverage and generally used for higher power multi-carrier transmit applications, and a single corrugated shield, also providing 100 percent coverage, used only in permanent installs where losses and noise factors require this very expensive and one-time use coax.

Directional Antennas

As mentioned above, it may seem that directional antennas are always good. And in many cases, they are the right choice. However, be aware that directional antennas have gain in one direction, and thus will pick up signals coming from that direction, including those that you intend to pick up and those you don't (such as DTV transmissions, etc.).

Thus placement becomes more critical. A dipole antenna can do a better job for short range applications where a lot of movement is required on the part of the talent or a wide area needs coverage but not at a great distance. In short, the antenna coverage pattern should match the desired coverage area from the perspective of the antenna. **Figure 1** shows three antenna/cable scenarios and the results for each.

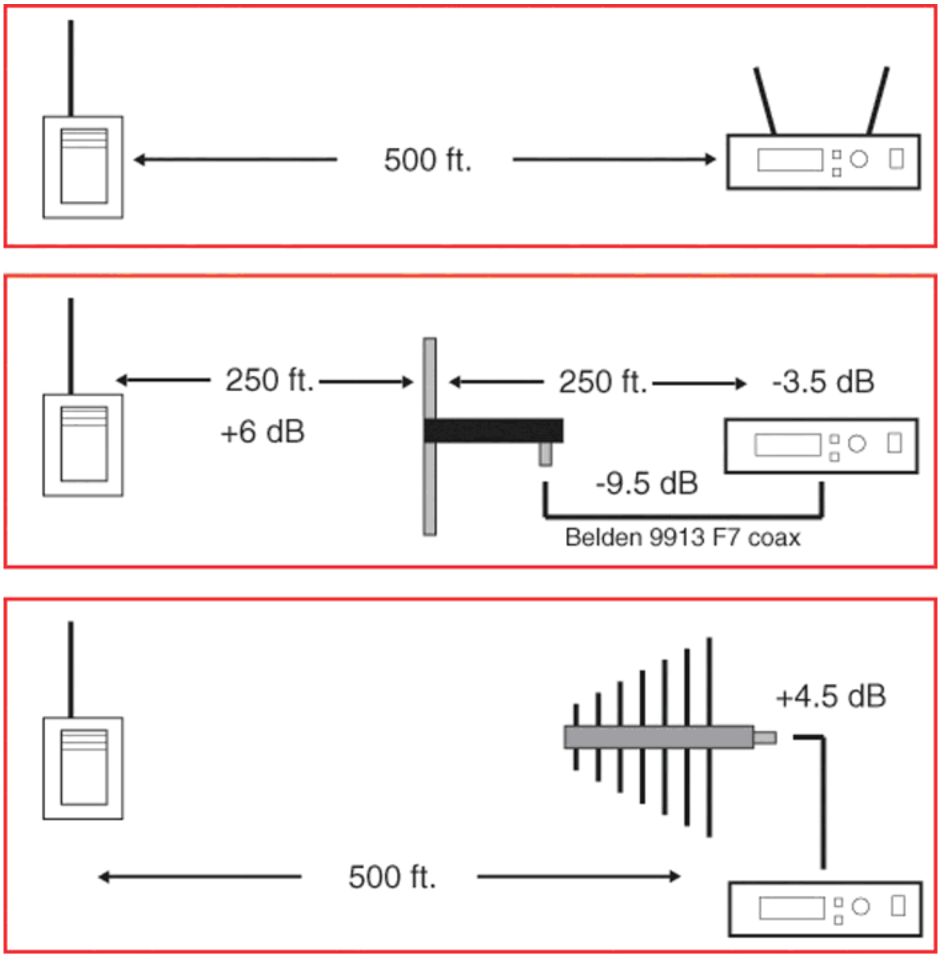

Figure 1

Diversity

You've no doubt heard about "diversity" wireless systems; almost all semi-professional and professional wireless microphone systems sold over the past 20 years are a diversity design. This term simply refers to the fact that the receiver accommodates [two] diverse antennas for reception. (Whether the receiver chassis simply switches between the two antennas based solely on signal strength, or has two complete receiver sections, one for each antenna, and switches based on audio quality, will determine the performance and cost of the wireless system.)

The reason for diversity design is that at times there can be an RF "null" at the receiver, caused by RF phase cancellations due to reflected signals arriving at the antenna out of phase from the direct signal. These reflections can be caused by metal or concrete surfaces.

In order to counter this, a second antenna in a different place will generally be receiving a slightly different version of the transmitter's signal, and it is very unlikely that a null will happen on both antennas at the same time. But the key is that the two antennas are in different positions and this is one reason it is often better to use remote antennas for your receiver rather than just the short whips that came with it.

For VHF wireless systems, this means a yard or two between antennas. For UHF systems, a few feet will usually do. However, more distance between antennas is even better, as long as both antennas cover as much of the performance area as possible. Some users put one on either side of the stage, for instance.

Figure 2 provides an example of overcoming RF nulls by using a diversity antenna arrangement. One easy way to evaluate a potential antenna/cable setup is to remember that the goal should be to have unity gain between

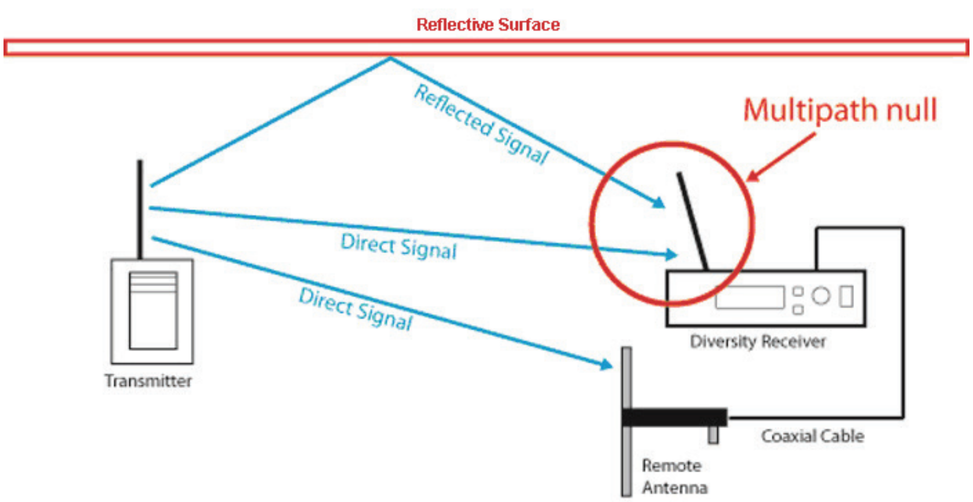

Figure 2

the antenna and the receiver. Thus, the proper combination of antenna type and cable size should be considered before purchasing any one of these components.

Since this information can at times be confusing, I would suggest making use of your equipment manufacturer as a free resource, or if budget permits, some of the excellent RF companies serving the entertainment production industry They're very good in assisting with properly implementing your wireless systems, and most likely they'll have helped someone else through similar challenges before.

The bottom line: Talk to the right people. When building wireless systems, the best place to start is with the manufacturers. They want their equipment to work and all have tech support departments who will help you get the right equipment, offer advice on installation and design.

You can do hundreds of channels in a room (consider the Super Bowl). But it takes a lot of work, expensive and specialized equipment, and people who really know their stuff. Make sure your wireless systems are of good quality, designed well and installed properly.

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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