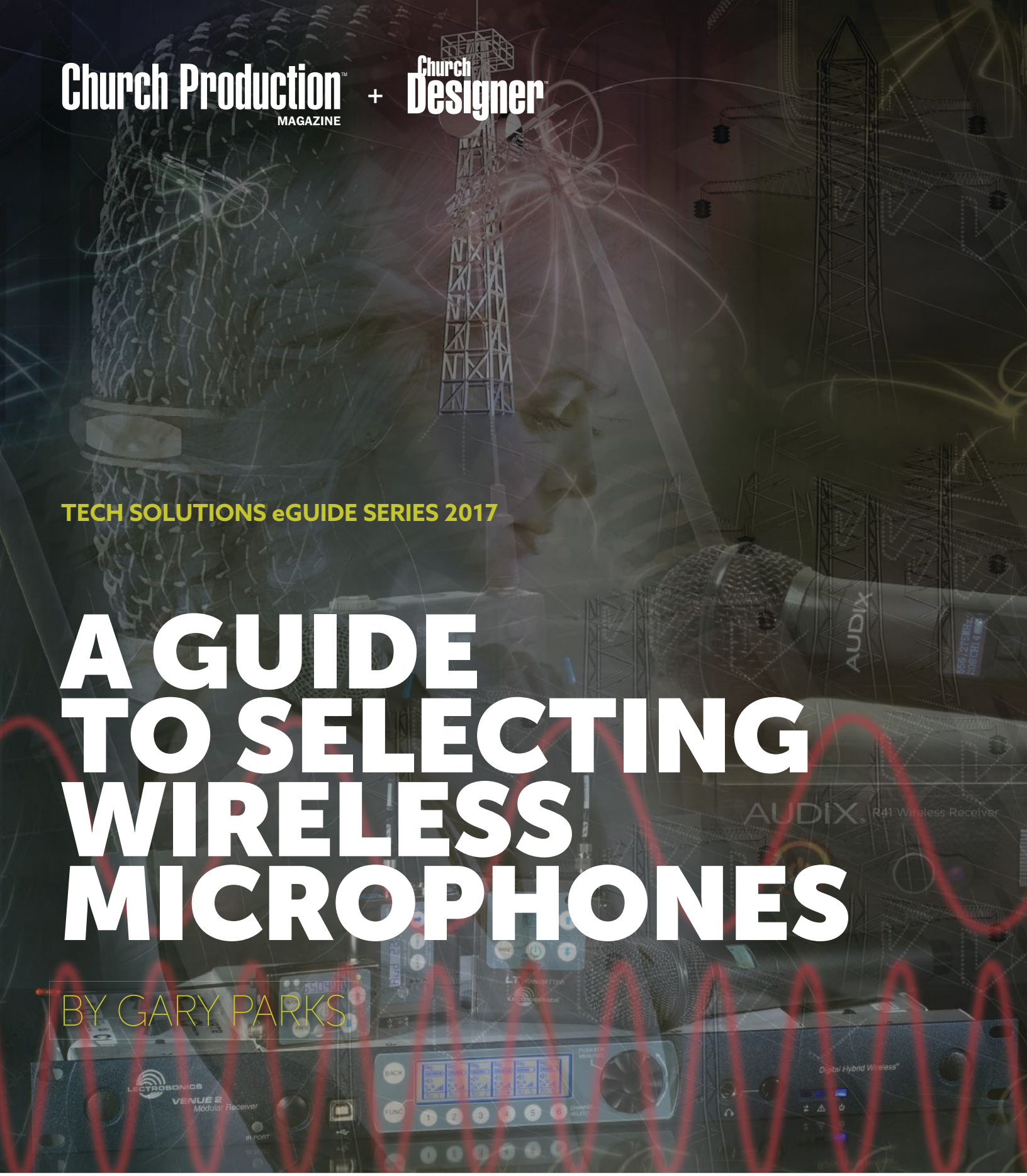
Church Production MAGAZINE + Church Designer

TECH SOLUTIONS eGUIDE SERIES 2017

A GUIDE TO SELECTING WIRELESS MICROPHONES

BY GARY PARKS



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A GUIDE TO SELECTING WIRELESS MICROPHONES

WIRELESS SYSTEMS ARE NOT THE PLACE TO SCRIMP ON YOUR BUDGET. HERE'S HOW TO CHOOSE A WIRELESS SYSTEM THAT SOUNDS GREAT AND HAS THE FEATURES REQUIRED TO OPERATE RELIABLY FOR YEARS TO COME.

For all except the smallest churches, wireless microphones and perhaps other wireless audio and video devices have been fully integrated into the worship service, allowing flexibility and freedom of movement that was not possible with a podium or other wired mics. Along with the many benefits this technology offers, it can also bring technical complications to the process of sound reinforcement. This is especially true when the church is located in a very populated area with many TV stations and other wireless services, and when you are using multiple channels of wireless.

This eGuide offers tips to help navigate the selection and use of wireless mics and related devices, such as:

- **The differences between analog and digital systems, types of wireless systems and their applications.**
- **Quality and price considerations based on whether a church is operating a handful or many channels.**
- **Distinguishing between the wireless systems' audio quality and RF performance.**
- **The ramifications of the 600 MHz spectrum auction and licensed vs. unlicensed operation.**

Remember that you are primarily selecting an audio tool. The capabilities of the microphone are as important as the wireless performance.

WIRELESS FREQUENCY BANDS

Wireless microphones operate in several different bands of radio spectrum, each of which is shared with other devices. These include VHF, UHF, and ISM frequency bands. Use of the VHF and UHF bands is, at least theoretically, for licensed users, although secondary use is permitted without a license if it doesn't interfere with authorized broadcasters.

USE OF THE VHF AND UHF BANDS IS FOR LICENSED USERS, at least theoretically, although secondary use is permitted without a license if it doesn't interfere with authorized broadcasters.

VHF FREQUENCIES propagate well, and can travel a fairly long distance; however, these longer wavelengths require longer antennas on the transmitter and receiver. In this range, the band between 169-172 MHz has eight specific frequencies designated for public use, and often referred to as "traveling frequencies." They can work well, though some are also open to use by hydrologic and other government applications.

The VHF range from 174-216 MHz is occupied by TV channels seven through 13, and wireless mics may be used here on a secondary basis, when they do not interfere with broadcasts—such as in open channels and guard bands between stations. Traditionally, all of the wireless mics operating in this band were analog, although digital technology is beginning to enter the picture. Assistive listening systems sometimes operate in the low VHF spectrum around 72 MHz, and perform credibly, though frequencies in that band are not used by professional wireless mics.

UHF SPECTRUM covers 470-806 MHz, but the 700 MHz band was cleared of television and wireless microphone use in 2010, and the 600 MHz band is in the process of being cleared. Current professional wireless microphones and similar devices are usually placed within this spectrum, in channels not occupied by broadcast television. Propagation characteristics are quite good, and

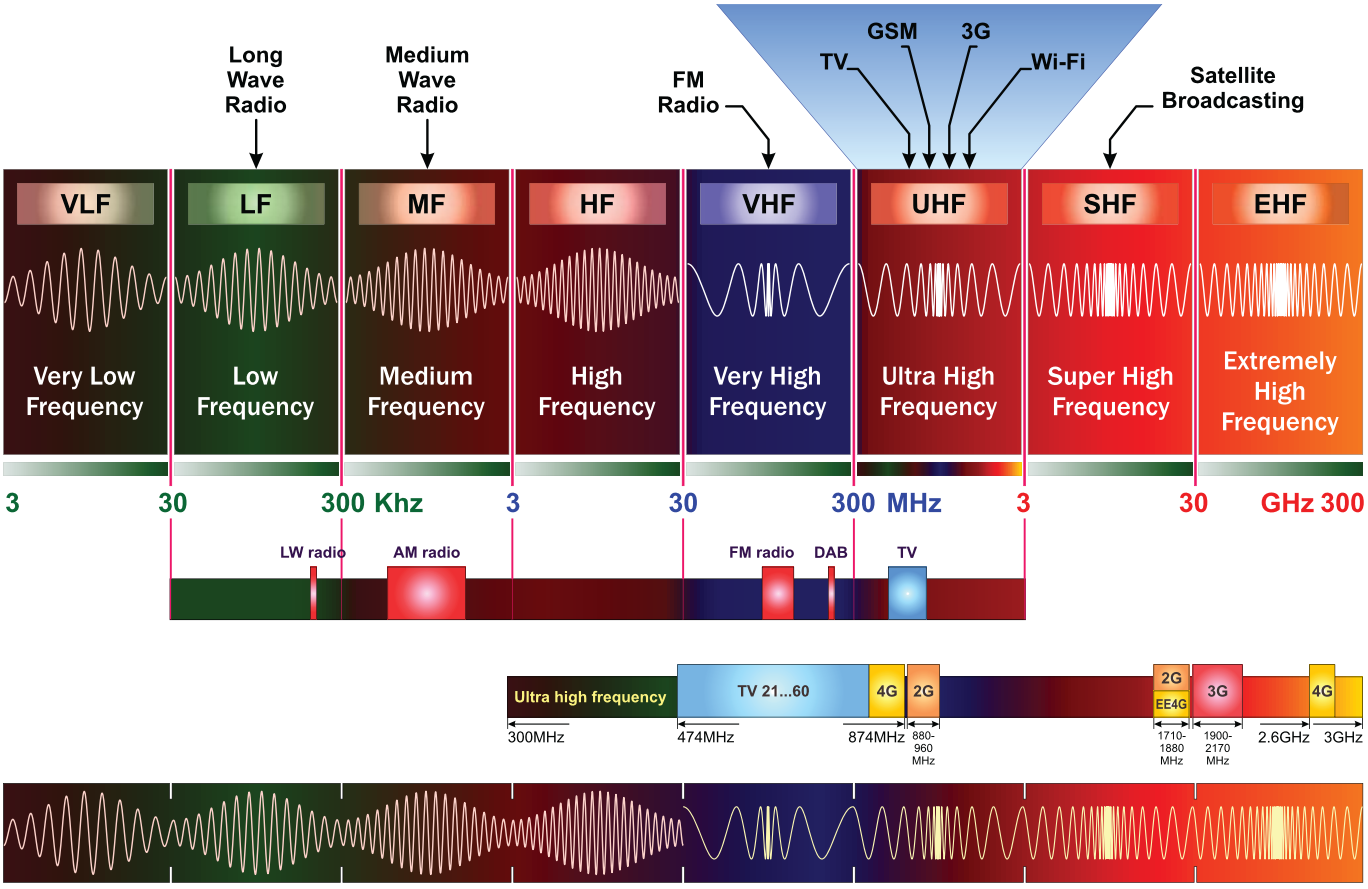
UHF spectrum will remain a key location for wireless mics.

The ISM bands are open for license-free use, putting them in competition with other devices.

antenna lengths can be considerably shorter than with VHF. Until the past few years, high-quality analog systems predominated, but digital and hybrid systems from many manufacturers are commonly used now. UHF spectrum will remain a key location for wireless mics.

THE INDUSTRIAL, SCIENTIFIC AND MEDICAL (ISM) BANDS are open for license-free use, in competition with other devices. They include a small portion of the lower 900 MHz band from 902-928 MHz, the 2.4 GHz WiFi band from 2.400-2.4835 GHz, and the 5.725-5.875 GHz band which is not used much for wireless mics.

In the 900 MHz band, both analog and digital systems are available, offering a handful of compatible frequencies. The 2.4 GHz systems are typically digital, and can offer up to a dozen simultaneous channels, depending on how much competing WiFi is in use (Bluetooth also uses this band). Many of these wireless mic systems are fine for semi-pro and professional use, and they contain technologies to navigate potential interference and consistently deliver a good audio signal.



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Most current wireless microphone systems are "FREQUENCY AGILE," where the user can select among several or many different frequencies.

SOME WIRELESS INTERCOM SYSTEMS USE THE DIGITAL ENHANCED CORDLESS TELECOMMUNICATIONS (DECT) BAND, which is centered around 1.9 GHz. This spectrum is shared with cordless phones using the same basic technology, and works fine for most spoken word applications. DECT technology has greater latency than the digital UHF and 2.4 GHz systems, and not as wide of an audio frequency bandwidth.

SELECTING A WIRELESS MIC

A wireless mic can be purchased for under $100 or may entail an investment of several thousand per channel, ranging from systems with very basic features and passable performance to professional-quality audio and versatile frequency and networking options. Excellent systems for many applications can be found for several hundred dollars per channel. This middle range has greatly improved in the areas of audio quality and features since the 1990s.

What are some key differences?

Most current wireless microphone systems are "frequency agile," where the user can select among several or many different frequencies. This feature can range from a handful of pre-coordinated, compatible "channels" covering a modest range of RF spectrum to full access to any frequency over bandwidths of 75, 150, or more MHz. Especially for professional applications where many microphones are in use within

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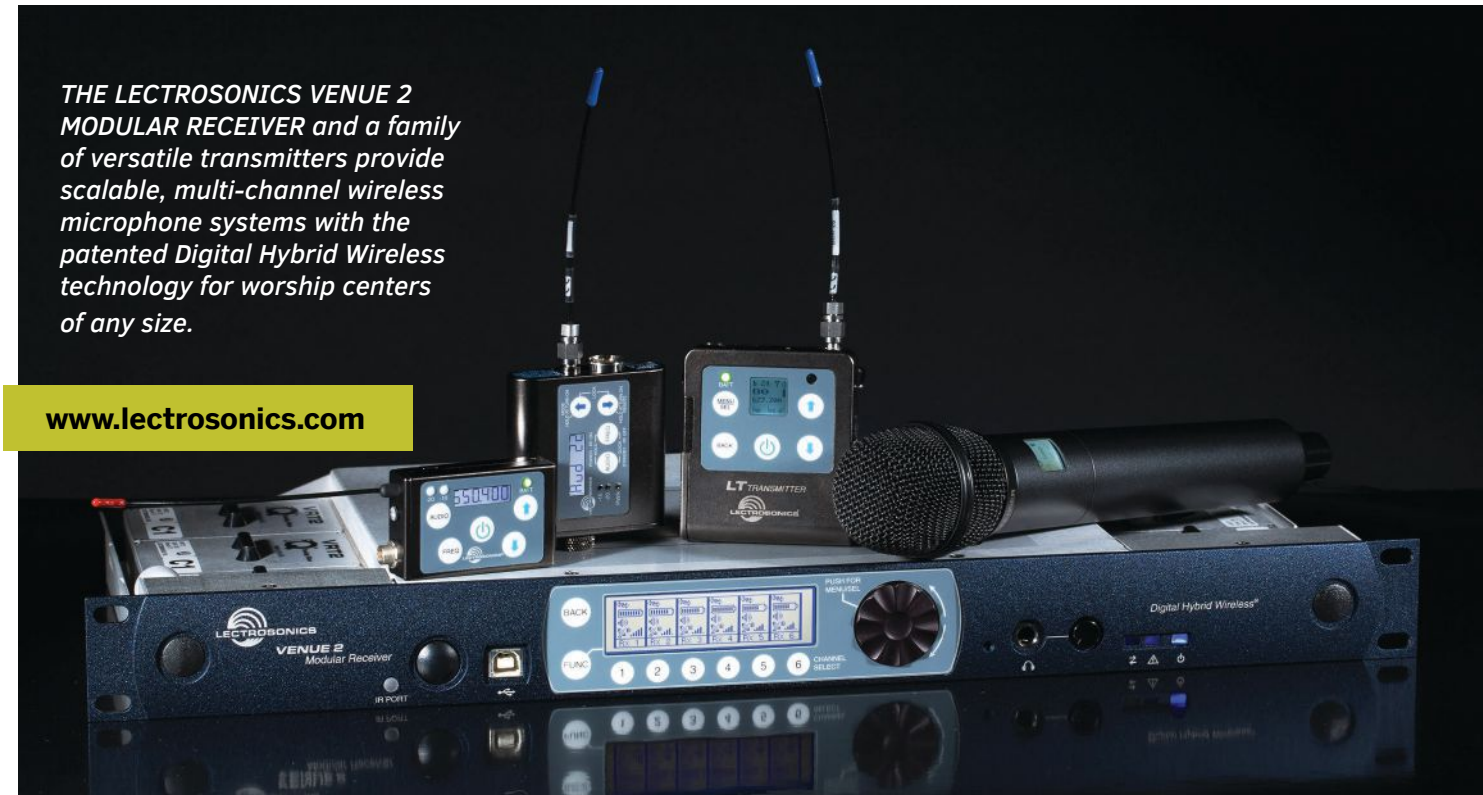
Digital wireless systems typically have a wider audio bandwidth, at both ends of the spectrum, than analog.

an urban area with multiple DTV station and other spectrum users, the ability to set your wireless to a particular clear frequency is paramount. Many mid- and high-level systems also have scanning abilities to detect existing interference and suggest usable frequencies.

The more professional (and higher priced) wireless systems will have better, more linear radio transmitters and better filtering within the receivers, lessening the impact of intermodulation between multiple transmitters and allowing more channels of wireless to operate simultaneously without interference. Many also offer monitoring and control software so that sound techs can detect and deal with potential problems quickly. The receivers can be connected and communicate together, and share antennas via internal or external multicouplers—allowing specialized antennas to be mounted remotely to counteract difficult RF situations. More upscale receivers typically feature balanced XLR and even digital outputs, will often have internal power supplies, and may have multiple receiver modules in 1RU.

DIGITAL AND ANALOG TECHNOLOGIES

Analog wireless microphone systems were the norm until the past decade or so, and can produce excellent audio results. Such systems are still available, although most manufacturers have begun to emphasize digital technology. Analog systems function by slightly modulating a carrier frequency with the audio signal within the transmitter, and recapturing that modulated signal in the receiver—filtering out the audio signal "riding" on the carrier and passing it to the sound



A good analog system may boast a response from 50 Hz to 15 kHz, while the digital ones are close to flat from about 20 Hz to 20 kHz.

system. Typically, to control the dynamic range and its effect on the carrier wave during transmission, the audio signal is compressed at the transmitter and expanded at the receiver, in a process called companding.

Digital wireless systems still use a carrier frequency. However, the incoming audio signal is sampled and converted to numeric data within the transmitter, which is encoded on the carrier essentially as a string of ones and zeroes, and decoded in the receiver back to audio. This newer technology brings substantial benefits, especially in a time of scarcer spectrum resources.

Digital and hybrid wireless systems typically have a wider audio bandwidth, at both ends of the spectrum, than analog. A good analog system may boast a response from 50 Hz to 15 kHz, while the digital ones are close to flat from about 20 Hz to 20 kHz. Digital systems also don't require companding circuitry that has the potential to affect audio quality. From my listening tests using several of these systems with voice and instruments, I've found the audio to be quite accurate and uncolored, even with the entry-level wireless.

Greater resistance to interference is a hallmark of digital wireless systems. Digital transmission requires a lower signal-to-noise ratio to deliver a usable signal to the receiver, compared with analog wireless. In addition, the signal is either on and with undiminished audio quality, or off and silent. The "noising up" and other audio artifacts are rare with these systems. However, we're still talking about radio systems, and an interfering signal falling on a transmission channel can diminish range (since they're all frequency

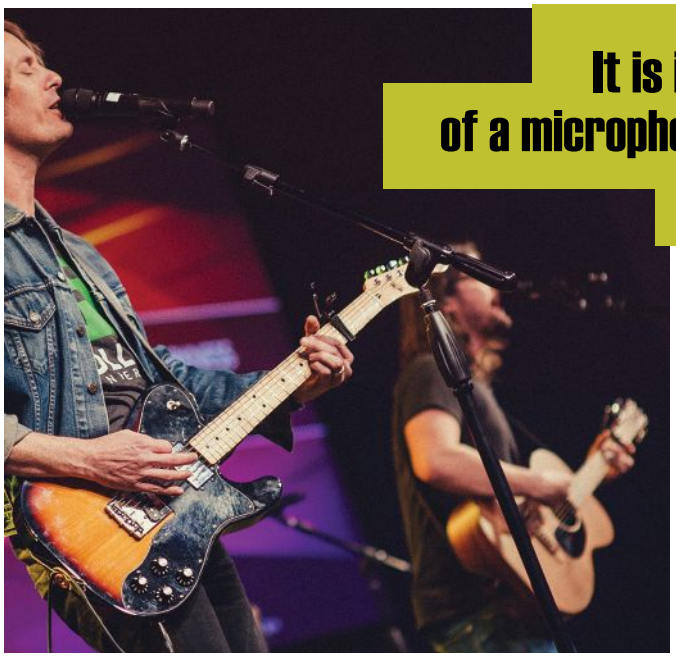


Image courtesy of Valley Creek Church.

It is important to evaluate the performance of a microphone within your sanctuary and with the particular presenters and vocalists who will be using it.

agile, moving to a clear frequency will provide the solution)—but having an interfering signal break in and be reproduced as audio noise is unlikely. This characteristic makes frequency coordination and channel spacing easier.

Typically, a lower transmission power is required from the digital system's transmitter to achieve the range found with a 50 mW analog unit. One of the solutions for packing more channels into less spectrum, used by many of the newer digital wireless systems, is lower power transmitters—often with variable output levels such as 1, 10, or 20 mW. While this approach can somewhat diminish the maximum range of these systems, closer placement of receivers and the application of remote and/or directional antennas can compensate. The diminished overall RF level generated by lower power transmitters can make it easier to increase channel density, decrease intermodulation, and allow frequency reuse by offering less potential interference among systems operating in nearby locations. Longer battery life is an additional benefit.

AUDIO QUALITY AND RF QUALITY

When selecting a wireless microphone, an important consideration is that the "wireless" part is simply the transmission portion of the equation—analogous to a microphone cable carrying the information from the user to the mixing console. The microphone element is the actual transducer that converts your voice or instrument to an audio signal. As with the wireless electronics, the quality and performance of the microphones can also vary widely.

Remember that you are primarily selecting an audio tool, and you want to choose one that has the coverage pattern, gain before feedback, and frequency response that meets the requirements of the user. Other elements to check for include handling noise, wind and breath resistance, and how the mic responds to pops and other plosive sounds from the voice. When using a bodypack with a headset or lavalier microphone, you have considerably more leeway in selecting another brand that better meets your requirements; many manufacturers offer their mics with a variety of connectors to accommodate different transmitters.

For most spoken word applications in a live setting, a wireless headset mic is preferable to a lavalier. The microphone element is placed close to the corner of the mouth rather than on the chest or collar, so the level (and gain before feedback) are much higher and the audio quality is more natural. Headsets are available in both dual- and single-ear formats, and the microphones and


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Image courtesy of DPA Microphones.

Wireless headset mics are available in both dual- and single-ear formats, and the booms are quite unobtrusive.

booms are quite unobtrusive. For TV broadcast, or when nothing can obscure the speaker's face, a lavalier can be substituted.

Handheld wireless transmitters integrate the microphone capsule into the handle, often permanently in low- to mid-priced systems. Therefore, it is important to evaluate the performance of the microphone within your sanctuary and with the particular presenters and vocalists who will be using it. Does it have the frequency response, coverage pattern, gain-before-feedback, and handling characteristics that you need? Several wireless manufacturers offer handheld transmitters that accept a variety of thread-on microphone heads, giving you a broader choice of dynamic and condenser mics and greater flexibility.

Finally, the wireless transmission can also have a significant effect on the final quality of the audio signal that reaches the mixing console. Entry-level or consumer-grade wireless equipment may work alright for less critical applications or when a channel or two are all that are necessary, although they are more likely to combine inexpensive microphone elements with less quality-controlled electronics—potentially resulting in more dropouts, extraneous noises, a more modest or uneven frequency response, and poor reliability. So, it's advisable to select more professional audio equipment for your services, since what the congregation hears begins here.

SELECTION SCENARIOS FOR SMALLER AND LARGER CHURCHES

If you are only operating a few channels of wireless, it will be relatively easy in most locations to run them all within a relatively small swatch of UHF, VHF, or WiFi (2.4 GHz) spectrum. However, if you have dozens of channels to contend with, taking advantage of several different spectrum bands may be wise. For example, wireless intercom could be placed in VHF, 1.9 GHz, or 2.4 GHz rather than in UHF; excellent systems are available in all three bands. If you're adding wireless capability to another location on-site, or for the music team, consider a 900 MHz or 2.4 GHz system for those few extra channels.

Entry-level receivers will typically feature fixed antennas, so make sure to position them so that they are within line of sight of the transmitters, and test for coverage and audio anomalies. Some but not all of these systems will feature an XLR as well as a quarter-inch connector for your mixer. To avoid interference when choosing UHF or VHF systems, make sure you know which TV channels are operating, and note the frequencies of any existing wireless equipment.

Wireless receivers can be connected together and share antennas via internal or external multicouplers.

Image courtesy of www.sweetwater.com.

In general, when purchasing additional channels of wireless, add them in the lower UHF bands (470-608 MHz), and supplement with VHF and the unlicensed 900 MHz and 2.4 GHz bands.

For up to perhaps a dozen channels of wireless (mics, IEMs, intercom) in a more crowded RF environment, consider semi-professional 2.4 GHz or UHF systems operating in the 470-600 MHz spectrum, with scanning features and the ability to select compatible channels. Make sure that they are frequency-agile over several UHF television channels.

When you need many channels of wireless in your service, select professional wireless systems with the linearity to allow multiple, more closely spaced channels to operate together and resist interference, and the flexibility to monitor and easily change the frequency of individual channels if problems are detected. Especially in larger sanctuaries, antenna combiners and remote antennas may be required. Most of these receivers feature between two and eight channels per 1RU unit, and in some cases modular receivers can be added as needed. Consider placing some of your channels into 2.4 GHz, 900 MHz, and VHF.

In general, when purchasing additional channels of wireless, add them in the lower UHF bands, and supplement with VHF and the unlicensed 900 MHz and 2.4 GHz bands. For wireless intercoms, the Radio Active Designs UV-1G operates in the VHF band, Clear-Com's Freespeak II operates at 1.9 and 2.4 GHz, as well as the RTS BTR-240 at 2.4 GHz. Wireless mics and IEMs suitable for semi-professional and professional applications can also be found in these bands.

600 MHZ SPECTRUM CLEARING

The Federal Communications Commission (FCC) mandated Broadcast Incentive Auction of large swaths of the 600-MHz band—repurposing it from television broadcast (and secondarily for

use by wireless microphones) to mobile broadband services—is ongoing as of this writing. In early 2016, broadcasters were invited to provide a price for which they would be willing to give up the spectrum they occupy, and agree to either move to a less desirable band, share spectrum with other broadcasters, or cease broadcasting.

As you may remember from the 700 MHz clearing a few years back, wireless mics operating in the affected bands were prohibited from operating. Once the auction completes (likely by early 2017), users of wireless mics operating in these newly cleared frequencies will have only 39 months before they must retire them. TV broadcasters who relinquished their 600 MHz spectrum will be "repacked" into lower bands.

During the coming transition, it will be important for wireless mic operators to use RF scanning hardware and software to conduct local environmental scans before setting channels in cleared spectrum.

The original and most extreme outcomes—clearing down to the upper portion of the 500 MHz band—have not come to fruition, since the telecom carriers and other Internet-related companies did not bid anywhere near the prices that broadcasters are asking for the spectrum. In October, Shure's Mark Brunner reported that some industry observers expected the end result might be approximately 86 MHz of spectrum becoming cleared and unavailable for use by wireless microphones. Karl Winkler of Lectrosonics concurred, suggesting that "the floor for new services will be the top of TV 37, or 614 MHz." Indeed, this is what has come to pass, with the spectrum between 614-698 MHz being cleared.

New services will be phased into the cleared spectrum. In the coming year or two, "telecom services will be moving into their newly acquired space on a market-by-market basis," according to Brunner. "This is what is challenging for wireless mic operators, in that the 600-MHz band spectrum that is auctioned will not all be declared off-limits at a consistent time; it will also vary market-by-market. The only requirement is that they don't interfere with newly licensed services that come on the air."

During the coming transition, it will be important for wireless mic operators to use RF scanning hardware and software to conduct local environmental scans before setting channels in cleared spectrum. They will also need to consult the nationwide geo-location databases, which will reflect the new services commencing operations in those markets. Complying with cases of interference will continue to be done as it is currently, on a complaint-driven basis. If you haven't yet done so, check your current inventory and determine whether mics operating in that spectrum will need to be replaced over the next three years.

UNLICENSED AND LICENSED OPERATION

Recognizing the widespread and essential use of wireless mics by churches, as well as in event production, the FCC in 2013 broadened the types of users who are able to obtain licenses to encompass sound companies, live theatre, houses of worship, and many other entities—going beyond the original categories of broadcasters and film production. Larger users, who typically employ 50 or more channels of wireless, will be able to obtain a Part 74 license. The licensing will give them

priority to use the RF spectrum at specific times and locations, meaning that unlicensed users of white space devices or other wireless mics in those particular frequency bands will have to turn them off if they are causing interference.

In addition to the many benefits wireless mic technology offers, this technology can complicate the process of sound reinforcement. BUY A SYSTEM YOU'RE COMFORTABLE OPERATING.

However, the typical wireless microphone user is unlicensed, and operates equipment in the frequency "spaces" between television broadcasters and other licensed users—making sure not to interfere with those signals. Your best action is to regularly monitor other users of wireless spectrum in your vicinity, including services that may not be active all the time but might surprise you on Sunday morning, so that you know what frequency bands remain clear and usable. Use the wireless system's scanning abilities plus frequency coordination software to set compatible channels.

Image courtesy of Valley Creek Church, Lewisville, TX. As seen in Church Production Magazine's April 2017 issue.

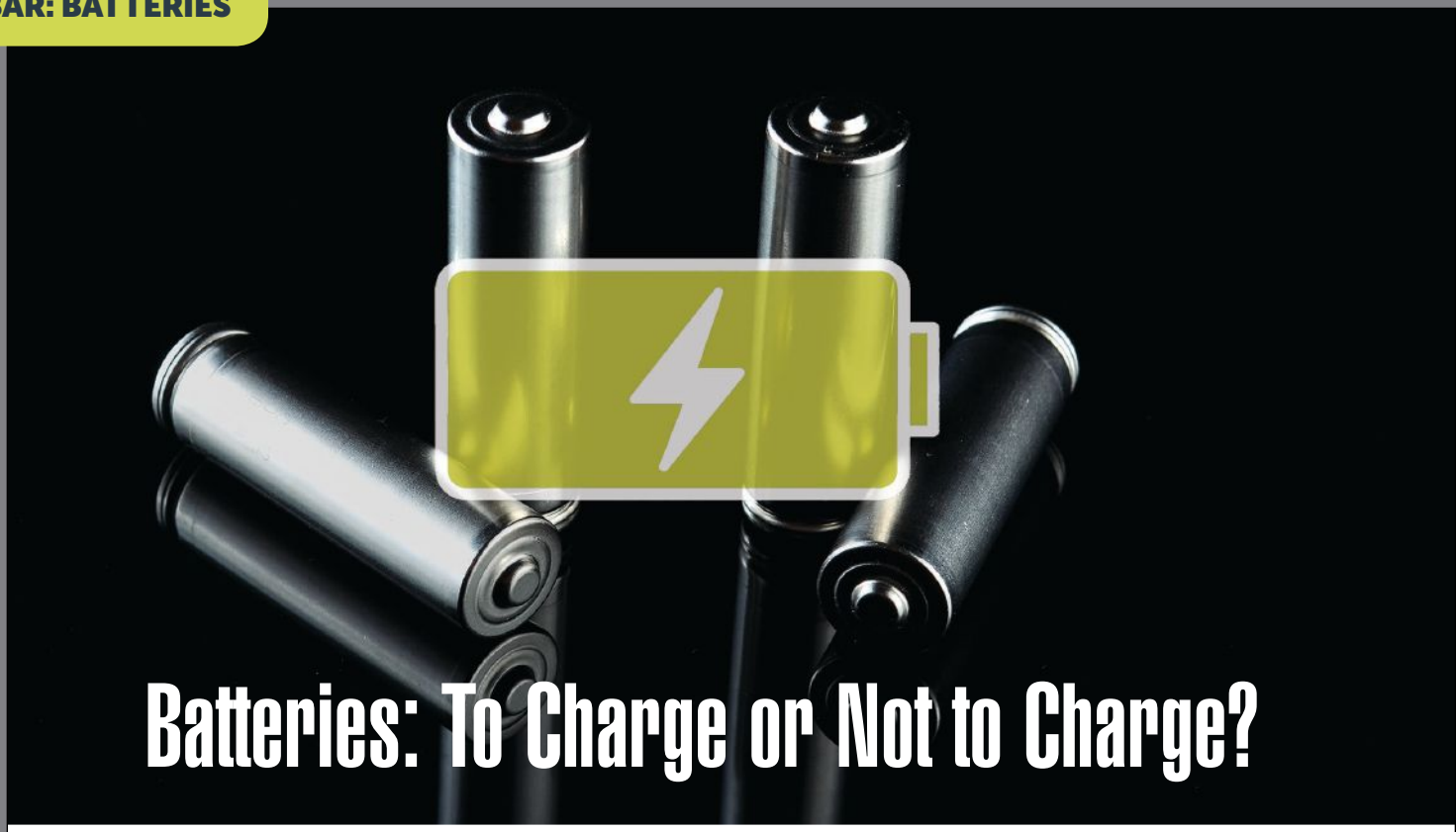
For the largest churches that are using 50 or more channels of wireless (including mics, in-ears, and intercom), it is beneficial to begin the licensing process. Licensing will give your operations priority over any unlicensed user that might create interference, and allow you to use the newly authorized mid-900 MHz and 1.4 GHz bands when compatible equipment becomes available.

SOME BRANDS AND MODELS

There are many manufacturers of wireless systems, including those who also make wired microphones and some who concentrate on the wireless delivery system and use others' mics. Some microphone companies, such as **Shure, Sennheiser, Audio-Technica, AKG, Audix, Mipro, Electro-Voice, and Beyerdynamic** have a variety of wireless systems ranging from modestly priced to professional quality. **Lectrosonics** also offers several models and the ability to use a variety of different microphone brands with them.

Line 6 and **Sony** (as well as **Audio-Technica** and others) have digital wireless systems operating in the 2.4 GHz spectrum that sound good and work well for many applications, with handheld and bodypack transmitters for headsets and instruments. Other brands are also available and worth exploring, especially if needs and budget are modest.

SIDEBAR: BATTERIES



Batteries: To Charge or Not to Charge?

If you use wireless mics then you have struggled with the question of whether or not to use standard Pro Cell-type batteries or rechargeables. It's interesting, because at the end of the day, batteries of all kinds are disposable. This is money literally being thrown away, and if you have enough wireless systems it's not a trivial amount. Now, there isn't much you can do about it; you are going to have to use batteries one way or another, ***so which is better and why?***

To get to the bottom of the issue, *Church Production Magazine* talked to three experts in their fields who have opposing views on the topic: Mike Sessler from Church Tech Arts, a former church tech director and rechargeable battery fan; Andres Rivera, a current church TD and Pro Cell user; and David Schliep, national sales manager at rechargeable battery manufacturer Ansmann USA Corp.

Sessler has several articles on his blog about his reasons for going with rechargeable batteries, and has done numerous testing and studies to support his choice.

"So, if we had stuck with Pro Cells, we would have used roughly $1,000 worth of disposable batteries by now. I've spent less than $500 on everything including chargers in the last two years. And now that the chargers are paid for, I can plan on about $120 in new batteries every two budget years."

Schliep says there are environmental concerns, too, and adds,

"Think about waste and expense—one rechargeable battery can save up to 2,100 alkaline batteries."

The reason most churches will continue to choose rechargeables is budget: the cost savings is there.

But it's not all roses. Rechargeable batteries require some care and feeding to get the most out of them. Sessler suggests rotating them to get even use, and always going directly from charger to mic, then back to charger for best results. Testing to determine approximate run time is also a good idea. "Don't try to push the batteries. If you get to half charge on a mic, swap the battery out for a fully charged one. You're not losing anything," he advises.

In addition, the rechargeables will start becoming a bit unreliable after a great deal of use. As Rivera notes, "Rechargeables start to fail after roughly a year, and you can't really trust the charge it reads. Rather than buy them every year, it's easier just to keep using regular batteries." In Rivera's experience, the cost benefit of the rechargeables was not as drastic as it was in Sessler's case.

This leads to the competitive advantage of the Pro Cell: reliability. According to Rivera, when you put in a new Pro Cell, you can be sure that battery is good. If it's a mission-critical application, there is something to be said for always knowing you have fresh, new batteries. Rivera says reliability is his reason for going with Pro Cells. He admits to throwing away batteries that had some juice left in them, and spending a little more money. However, he chalked up the money as an investment in peace of mind, knowing that the batteries he is using are fresh.

Schliep argues that his company's product is reliable enough to have earned the trust of Cirque du Soleil, saving the organization nearly $50,000 per year.

While monetary concerns will drive most churches, there are valid arguments about the environmental impact of standard batteries, and the stigma of rechargeables being less reliable. The question may come down to: ***Would you rather spend less, and invest a little more time in your batteries? Or would you rather have the assurance that your batteries are fresh—and spend a little more money?***

MAKING CHOICES

One fact about the wireless landscape is inevitable—it will continue to be more congested with a variety of devices, and available space for wireless mics, in-ear monitors, and intercoms may be harder to find. The 600 MHz auction and the repacking of television stations into the lower UHF spectrum will contribute to this situation, especially in more highly populated areas.

THE MIC IS THE CONNECTION TO THE PASTOR'S WORD AND THE SINGER'S HYMN, AND THE SERVICE SHOULD NOT RISK BEING INTERRUPTED BY DROPOUTS OR AUDIO GLITCHES.

Choose to buy quality wireless systems—this is not the place to scrimp on your audio budget. The mic is the connection to the pastor's word and the singer's hymn, and the flow of the service should not be interrupted by dropouts or audio glitches. The systems must be reliable enough to be used from once to several times a week for years. Make a good choice, and you'll enjoy the benefits and freedom of wireless with minimal last-minute panic or discomfort.

LOOK AT CURRENT AND FUTURE REQUIREMENTS FOR WIRELESS MICS, AND TAKE INVENTORY OF WHAT YOU ARE NOW USING AND ASK 5 IMPORTANT QUESTIONS:

1. ***Will any of them need replacing because they operate in the 600 MHz band, or because needs have changed?***
2. ***How many more channels of wireless will you need over the next few years for services or for other church activities?***
3. ***Are you located in a crowded RF area?***
4. ***Is the sanctuary larger or smaller; are receivers located within line of sight or in a control area; and do you need to combine or remotely locate your antennas?***
5. ***Will guest speakers or musicians be bringing in additional wireless channels that require coordination?***

***Gary Parks** has served as marketing manager and wireless product manager for Clear-Com Intercom Systems. He has also worked with loudspeaker and wireless product management at Electro-Voice, performed technical writing at Meyer Sound, and worked in RF planning software sales with EDX Wireless. He is a freelance writer and can be reached at garycparks1@gmail.com.*

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