INTERPRETING WIRELESS MIC SPECIFICATIONS

Specifications for any product always fall subject to whatever parameters are typically used in the markets where the products are sold. The "spec game" is played by every manufacturer. The allowable tolerances are not strictly controlled and there are few standards, so you generally have to qualify or translate a particular set of specifications before you can make valid comparisons. It is difficult enough to decipher and compare specifications on conventional audio equipment, but it gets to be very nebulous with wireless microphone systems. Add to this the fact that some manufacturers have actually published specifications that are wrong, which is an unforgivable marketing crime.

The performance of a wireless microphone system will vary dramatically from the test bench to the actual application in the field. The results of connecting test equipment directly to a receiver and measuring various performance specs will be very different than when the input signal to the receiver is generated by a weak radio signal coming from a transmitter several hundred feet away. It is safe to assume that the published specs for a wireless mic system are based on ideal RF conditions and a minimal transmitter to receiver distance.

You should always be skeptical of a spec that does not include the basis for measurement, or of a spec that is missing altogether. Anytime a particular spec is hard to interpret or is missing, it is a safe bet that the manufacturer might be trying to disguise the poor performance. In a few cases, it could also be that the manufacturer simply overlooked including the spec in the published literature. We at Lectrosonics would like to say that we never forget anything as important as a spec, but let's face it, we're human too. So, if you don't see something on the published literature, please call us. We'd be glad to tell you more than you ever wanted to know about what's missing.

SENSITIVITY

Good: 1uV for 20 dB SINAD
Excellent: 0.5 uV for 20 dB SINAD

This spec refers to the RF input level at the receiver required to produce a certain signal to noise ratio. Signal to noise performance in a receiver can be measured or rated several ways, but the most common methods are "SINAD" and "S/N RATIO."

Here are six examples of sensitivity specifications as they would appear in various manufacturers literature. Curiously enough, all of these measurements were made on the same receiver.

0.34uV input for 12dB SINAD

0.30uV input for 12dB quieting

0.27uV input for 12dB S/N

0.45uV input for 20dB SINAD

0.47uV input for 30dB S/N

1.20uV input for 50dB S/N

All of these measurements can be called "sensitivity," yet they actually measure different aspects of the receiver's performance. Obviously it is necessary to compare "apples to apples" when making sensitivity comparisons. The above list shows how the sensitivity seems to vary depending on how the measurement is made. The above measurements were all made with an "A" weighting filter to approximate the ear's response to the noise. Most manufacturers will use this filter since it improves the measurements by 3dB to 6dB.

SINAD is a measurement that approximates the audible background noise heard along with a continuous signal at weak RF levels. SINAD is measured by running the system at full deviation with a weak RF signal and measuring the level at the receiver output which consists of signal + noise + distortion. Then a second measurement is made after electronically subtracting the audio signal (while the system is still running) and measuring the remaining noise and distortion. The first and second measurements are then expressed as a ratio. SINAD is probably the most consistent sensitivity measurement at low levels of RF, since it effectively removes the compandor from the circuit. Since the SINAD measurement is made with the system in actual operation at full deviation, it is more realistic than a simple signal to noise ratio measurement.

$$\text{SINAD} = \frac{\text{Signal + Noise + Distortion}}{\text{Noise + Distortion}}$$

S/N RATIO is a measurement that approximates the background noise heard during pauses in speech when the system is operating at a given RF level. It is another valid comparison of sensitivity. It is listed as the amount of RF signal required to produce a certain S/N figure, often 50dB. The 50dB S/N ratio is representative of a minimum usable sensitivity and corresponds to what a non-critical listener would accept. S/N RATIO is determined by measuring the system at a given RF signal level at full modulation, with maximum receiver output, then turning off the audio modulation and measuring the remaining noise. This will produce the RF signal level required for a given signal to noise ratio. This is the sensitivity rating of the receiver based upon signal to noise ratio.

The problem with this method of measurement is that the compandor will make the number twice as good as it really is. SINAD is really the better method to rate a receiver, but it does not produce numbers that look as good as S/N RATIO.

AUDIO DISTORTION

Good: Less than 1% at 1KHz
Excellent: Less than 0.5% at 1KHz

Generally these numbers are straightforward and can be compared directly. The distortion figures are usually taken at 1kHz. This is kind of a "best case" frequency since the compandors add distortion at lower frequencies, and narrow-band IF filters can add distortion at higher frequencies. Distortion at 100Hz can be 2.5% in a system that claims 0.4% at 1KHz.

DYNAMIC RANGE

Good: 90dB
Excellent: 105dB

This number should be a straightforward measurement but some manufacturers include the limiter dynamic range and/or the gain control range also. Sometimes this is done because it is cheaper to print better numbers than it is to design a superior product, but this can also be self-defense against someone else's "better" numbers. Remember that the dynamic range measurement is based on a minimal transmitter to receiver distance in a wireless mic system. When the same measurement is made with the transmitter 50 feet or more away from the receiver, this number will be significantly lower.

AM REJECTION

Good: 50dB at an unspecified RF level
Excellent: 60dB over a range such as 20uV to 50mV

This measurement shows how well the receiver rejects amplitude modulation (AM) of the RF signal caused by such things as fluorescent lamps, bridge rectifiers in other electronic equipment, SCR light dimmers and similar power circuits. This measurement, if given at all, is usually made at one RF level (the level that produces the best numbers of course) but should be made over a wide range since the real world is rarely so kind as to present an optimum RF level to the receiver.

IMAGE REJECTION

Good: 80dB
Excellent: Greater than 100dB

In the mixer stage of all wireless receivers there are two frequencies that will produce the IF frequency, and as far as the mixer is concerned, either frequency is equivalent. These two frequencies are equally spaced on either side of the oscillator frequency. For instance, if the IF frequency in the receiver is 10.7 MHz and the transmitter frequency (the carrier) is 179 MHz then the local oscillator frequency in the receiver will have to be 168.3 MHz (179.0 – 168.3 = 10.7 MHz). This receiver will have an image frequency at 157.6 MHz, because the difference between 157.6 and the local oscillator at 168.3 is also 10.7 MHz (168.3 - 157.6 = 10.7). If it weren't for the RF filters in the front end of the receiver, the receiver would be just as sensitive to the image frequency at 157.6 MHz as the "correct" frequency of 179 MHz.

Since the image frequency of 157.6 MHz is in the taxicab service band and taxicabs are allowed 75 Watts of power (wireless microphones typically only 0.05 to 0.10 Watts), the receiver in this example must do an outstanding job of rejecting the image frequency. Image rejection is a function of the front-end selectivity of a receiver and the IF frequency in the receiver. The image frequency is always twice the IF frequency below the carrier for low side oscillator injection and twice above for high side injection. The higher the IF frequency then the farther the image frequency is from the carrier and the easier it is to reject it in the front end RF filters. Better UHF receiver designs are using IF frequencies of 71 MHz up to 250 MHz and perhaps even higher in the future.

SPURIOUS REJECTION

Good: 80dB
Excellent: Greater than 100dB

This is very similar to image rejection, but measures how well the receiver rejects the entire range of frequencies that can be applied to the receiver by any outside source. Ideally the manufacturer will have tested the receiver from audio frequencies to microwave frequencies. This number measures how well the first RF section, the IF filters and other sections reject interfering signals.

THIRD ORDER INTERCEPT

Good: -15dBm
Excellent: +1dBm or higher

A high third order intercept spec is a desirable receiver specification since it measures how well the receiver resists interference caused by multiple interfering frequencies. Interfering frequencies may be other wireless microphones that are being used in the same location, or combinations of outside transmitters. This specification gives a single, excellent measure of how well the receiver resists many kinds of overload.

Consider transmitters on frequencies A and B, and a receiver on frequency C. If the three frequencies are equally spaced, the second harmonic of one of the transmitters will mix with the fundamental of the other transmitter, producing a signal exactly on the frequency of the receiver.

If: $(A \times 2) - B = C$ or $(B \times 2) - A = C$

Then: the receiver will likely respond to this third order IM.

As an example, consider transmitters on 181 MHz and 182 MHz. These will produce third order interference for receivers on either 183 MHz or 180 MHz.

$$(181 \times 2) - 182 = 180$$

or

$$(182 \times 2) - 181 = 183$$

Notice that the transmitter frequencies we chose are very close to the receiver frequency. This means that the selectivity of the receiver is largely useless. However the better the design of the RF stage and mixer, the less of this intermodulation interference will be produced. You can of course pick transmitter frequencies that will not produce interference with a specific receiver, but this gets to be very difficult in large, multi-channel systems. Additionally, in some urban areas there can be hundreds of high powered transmitters around you, over which you have no control. The receiver must have a high 3rd order intercept specification.

LIMITER RANGE

Good: 15dB
Excellent: 30 dB or more

This indicates the amount of audio overload the transmitter can handle before audibly distorting the signal. A good limiter allows the gain of the transmitter to be set higher, since not as much headroom has to be allowed to prevent audio overload. This important feature is found on only a few wireless systems, and provides an audible improvement in signal to noise ratio.

BATTERY LIFE

Good: 8 hours (5 hours with UHF models) alkaline 9 Volt
Excellent: 12 hours (8 hours with UHF models) alkaline 9 Volt

In some applications, a transmitter must operate for extended periods of 6 hours or more. If the transmitter quits before the session is complete, obviously someone is going to have a problem. In some cases, the cost of re-doing the session or performance could be significant. It is also very important that some means of evaluating the battery status be available. A "warning time" of an hour or more is generally useful.

In other applications, the cost of batteries can be an important consideration. If the transmitter is used for twelve hours a week and has a battery life of 6 hours, it can amount to $250 a year, which is not a negligible sum for some budgets. (using a price of about $2.49 per battery at 12 hours per week)

SPURIOUS EMISSIONS

Good: 50 dB below the carrier
Excellent: 60 dB below the carrier

Some wireless transmitters produce frequencies other than the desired carrier. All crystal controlled transmitters start with a low frequency crystal and multiply up to the carrier output frequency. For example, starting with a 15 MHz crystal controlled oscillator, the next stage would be a tripler to 45 MHz, then a doubler stage to 90 MHz, then a doubling output stage to produce the final frequency of 180 MHz. Many low level spurious frequencies are produced in this process, but the frequencies most likely to cause problems are at the carrier frequency plus and minus the internal crystal fundamental. In the example given they would be 180 MHz plus or minus 15 MHz. Spurs would be produced by this example at 165 MHz and 195 MHz. If there were another receiver at 195 MHz in the same location, it probably would pick up the spurious frequency.

TRANSMITTER OUTPUT POWER

Good: 30 mW for VHF and UHF models
Excellent: 50 mW for VHF; 100mW for UHF models

If there is any single specification that is most abused, it is this one. 50 mW (0.05 Watts) is the maximum output power allowed by the FCC for use in VHF wireless microphones. UHF transmitters are allowed up to 250 mW, but at this power level, battery consumption becomes a factor to consider.

The more power the transmitter radiates, the smaller the chances are for interference and the greater the operating range. There is a suitable "trade off," however, between output power and battery life. Some well known UHF transmitters really put out as little as 10 mW, so it is wise to look at both power output and battery life (or power consumption) when you compare specs from different manufacturers.

A listing in the published specs of a particular transmitter that states that the power is less than the FCC maximum, or one that simply states the FCC allowance itself, is meaningless. All legal transmitters meet the FCC requirement, but the best performance will come from those that put out a true 50 mW in the VHF spectrum, and 100 mW (or more) in the UHF spectrum, and offer battery life long enough for the particular application.