WIRELESS MICROPHONE THEORY

Quote: "There is nothing in the world worse than a cheap wireless system," Hosch says. "It's scary when your future is hanging on a $ 1.98 battery. Anytime you can, you should get someone to use a wired mic over a wireless system." Scheirman adds, "and just remember that even the best wireless microphone system, a $10,000 system, is almost as good as a mic cable." (From TCI, May 1993, page 25).

A wireless microphone system is a small-scale version of a typical commercial FM broadcasting system. In a commercial broadcasting system, a radio announcer speaks into a microphone that is connected to a high-power transmitter in a fixed location. The transmitted voice is picked up by a FM receiver and heard through a speaker or headset.

In a wireless microphone system, the components are miniaturized but the same principles apply. The transmitter is small enough to fit into the microphone handle or into a small pocket-sized case. Since the microphone and transmitter are battery powered, the user is free to move around while speaking or singing into the mic. The transmitted voice is picked up by a receiver that is wired to a speaker.

Two types of microphones are available with wireless mic systems: the handheld mic, with a transmitter in its handle; and the lavalier mic, which is small enough to be concealed as a lapel pin or mounted on a headset. Lavalier mics are wired to miniature body-pack transmitters, which fit into a pocket or clip onto a belt. There are also some transmitter which accepts any three-pin XLR input and acts as a wireless mic-then you can use any mic you want with the transmitter.

Wireless microphones are widely used today in the DJ industry. They eliminate the need for cables around the dancefloor. Wireless mics make it possible to obtain usable audio from any place on the dancefloor or table area.
Handheld mics are used by DJs where they provide the freedom needed to move around the dancefloor and gesture spontaneously. They are used by speakers and entertainers who need to pass the mic from one person to another. In concerts, hand-held wireless mics permit vocalists to walk and dance around the stage and even into the audience without restriction and with no chance of shock in the event of rain.

Lavalier and headset mics are used in game shows, soap operas and dance routines. They eliminate the need for handheld mics and help to alleviate visual clutter. Lavalier mics are used by MCs, panelists, lecturers, clergy, stage actors, and dancers because they can be concealed easily and provide hands-free mobility. Some lavalier transmitter models have high impedance line inputs that accept cords to create wireless electric guitars.

Technology in the early 1970s introduced the integrated circuit component which was incorporated into wireless mics to reduce noise. At about the same time, the FCC authorized the use of frequencies in TV channels 7-13 for wireless mics. Thus the wireless microphone's most serious problem, radio interference from other services, was virtually eliminated. Later, the application of diversity reception minimized the problem of dropouts (transmission losses due to cancellation of radio waves), greatly improving system reliability.

Today's wireless mics perform almost as well as conventional wired mics. In the 1980s, wireless mics were manufactured with an improved dynamic range and smaller transmitters, a result of better component integrated circuitry and advanced circuit design techniques. A variety of standard microphones with different sound characteristics is available.

There are no international standards for wireless mic radio frequency allocations. Performance is not controlled for transmitter power limits, frequency stability, or RF bandwidth occupancy. Wireless mics could therefore, theoretically, operate at any frequency. Certain frequency bands are more commonly used. In the United States, the FCC regulates the operation of wireless mics at specified frequency bands.

WIRELESS PROBLEMS - Transmission Loss

There is a calculated transmission loss between transmitter and receiver through use of an isotropic antenna. Less transmitter power is required for an equivalent signal strength at the receiver as frequency is lowered. One problem with wireless microphones is the difficulty in designing antennas that are small but efficient in the VHF low-band area. However, for the VHF high-band, small and efficient antennas are practical.

Interference from other radio services is the major problem at both VHF and UHF. The only clear channels available are the unused TV channels in a given location and the "B" channels. For touring groups the TV channels become a problem, as a clear TV channel in one city may not be clear in another. Therefore, the "B" channels are recommended for this purpose. [The "B" channels are specific frequency bands designated by the FCC for wireless mics.]

Dropout

Loss of reception at the receiver of a wireless mic due to radio wave cancellation called multipath reflection is usually referred to as dropout. This problem has several possible sources. Dropout characteristics are different between VHF and UHF frequency bands. The dropout zones are much shorter at UHF where rapid flutter is often heard.

Loss of reception may also be caused by a transmitter being too far away from the receiver. This may be corrected by relocating either the transmitter and receiver antennas closer to each other. The power of a signal received by an antenna is a critical factor in causing dropout. When examining practical solutions and limitations in alleviating dropout, it is important to consider that not all of the power transmitted will reach the receiver. A wireless mic transmitter radiates power in many directions simultaneously, depending on the specific mechanical configuration of the antenna system. This makes the transmission vulnerable to many types of interference.

System performance is degraded by path losses due to interfering objects between the transmitter and receiver, such as other equipment or people, as well as by the position of the transmitter antenna and interfering signals due to multipath reflections.

Several paths can occur when the environment in which the wireless microphone is operating contains objects such as music equipment, lighting equipment, or stage props made of metal or other materials that reflect radio signals. Due to phase differential of the arriving signal, the resultant signal can be enhanced or totally cancelled, causing multipath dropouts. These path losses affect the total power received at the antenna. Multipath cancellation is the most common cause of dropout.

Solutions
*Use a high gain receiving antenna at the mix position: High gain antennas can improve the signal-to-noise ratio, and may thus reduce fades and dropouts if they are due to weak. Signal cancellations will not be aided. High gain receiving antennas are generally also a bad idea because: (a) the transmitter is constantly moving around with the performer so the antenna would have to be continuously re-aimed, and (b) much of the received radio signal is actually caught on the bounce from walls, props, etc., so even if one stood offstage and aimed a beam antenna at the performer, it could be aiming at the wrong target.

*Place the receiving antenna(s) and receivers near the mic(s) and run audio signals back to the mix position: With wireless mics, an alternative is to place the receiving antenna(s) on or above the stage, run a moderate length of antenna cable to a nearby wireless mic receiver, and then run a standard audio cable between the receiver's audio output and the mixer's input. Most receivers provide line level outputs that are ideal in this situation. This keeps the mic transmitting antenna(s) and the receiving antenna(s) reasonably close, which optimizes the RF S/N ratio.
*Diversity reception: In some wireless microphone installations, it may be impossible to locate a single antenna to eliminate multipath dropout or signal fading. The technique that has been adapted for wireless microphones to minimize multipath dropouts is called diversity reception. This is the application of two or more receiving antennas to receive signals that have been diverted into more than one path (multipath). The idea, in general, is that if the signal is weak at one antenna, it will probably be stronger at the other, at any given instant. Diversity reception enhances the performance of a wireless mic system. It is usually effective, although nothing will guarantee a total absence of dead spots. There are a number of different ways to accomplish diversity reception, and each manufacturer of wireless microphones tends to favor one approach or another. The conditions required to achieve this reception are:

*a single transmitter source
*uncorrelated, statistically independent signals
*multiple receiving antenna systems.

This success of any diversity reception system depends on the degree to which the independently received signals are uncorrelated. If a diversity reception system cannot produce uncorrelated, statistically independent signals, then diversity reception does not exist.

Implementation of a diversity reception system can be accomplished in several ways, but all system implementations have the need to combine the received, independent signals in some method. The major drawback with any multiple reception diversity system is cost. Combining techniques are chosen based on cost and the degree of improvement required. The less predictable or less closely related the signals, the more significant the benefits of the diversity system.

There are various techniques of diversity reception based on the exact method for processing and extracting the transmitted signals. Space diversity is the technique most commonly used for wireless mics. Space diversity can be implemented in many different ways, but the three basic requirements of diversity reception mentioned earlier must be satisfied. Two or more receiving antennas are required and must be at least one half wavelength apart (typically three feet). The amount of separation determines the degree of the uncorrelated signals. Polarization diversity is a method of space diversity in which the antennas on the receiving system are placed at angles to each other in order to capture the uncorrelated, independent signal. Each antenna provides an independent path that is selected or combined to produce the desired signal improvement. These selecting and combining methods of processing the independent signals are shown below:

In space diversity the incoming signal with the best signal-to-noise ratio is selected from the two or more antennas used. The signal selection can be accomplished either prior to or after audio detection.
Another method of signal improvement is that of combining the incoming independent signals. The two methods of doing this are called maximal ratio combining and equal gain combining. In maximal ratio combining, independent signals are combined in order to derive the maximum signal voltage/noise power ratios from each of them. A modification of this approach is equal gain combining in which all incoming signals are set to an average constant value.

Clearly, the maximal ratio combining method offers the best possibility for improvement over a non-diversity system, although it is the most difficult to implement. Wireless mics typically use selection or equal gain combining diversity. The choice is based on greatest reduction of the probability of dropouts. Any of the selection/combining techniques can be implemented in the pre-detection or post-detection stage of the receiver.

MULTIPLE WIRELESS SYSTEMS
A wireless microphone requires system design and analysis consistent with the channels and particular design being used. When using multiple wireless mics, the following interference sources must be considered:

*transmitter spurious emissions,
*transmitter and receiver inter-modulation, and
*splatter

Spurious signals are generated within the transmitter due to mixing products created in multiplying the crystal oscillator to the carrier frequency. These mixing products, if the fall within the bandwidth of the receiver, will be heard as squeals or chirping sounds. The spurious outputs of the transmitter are discrete spectral signals (splatter), and typically cannot be removed easily once a transmitter is designed.
Transmitter intermodulation (IM) occurs when a carrier frequency from another source is coupled into the output stage of a transmitter and becomes a second signal source. The transmitter IM products will overwhelm the receiver and will be recognized as acceptable signals, thus creating the chirping and squeals and overall sensitivity degradation.

WIRELESS MOUNTING
In the case of concealed mics, either suspended round the neck or clipped to clothing, three things are vital:

1] The material must not generate static electricity-this tends to rule out silk garments. Clothes with metal supports can also cause problems.

2] The antenna lead must be straight and firm-not allowed to bend and break, it is best taped to the skin.

3] The mic itself should be as near the mouth as possible-unless specified otherwise most neck mics and Omni-directional and will generate feedback if the gain is really turned up-which it might need to be if the mic is buried at chest level. Small cardioid pickup capsules are available but they can lose some frequency response which might need some correcting at the mixer. Since these mics are tiny they can also be concealed in wigs, and in all locations need frequent cleaning to remove perspiration and make-up.

CLOTHING NOISE & WIND NOISE

One of the ever-present difficulties in hiding lavalieres under wardrobe is clothing noise. In actuality, there are two different causes of "clothing noise": contact noise and acoustic noise.

Contact noise is the result of garments rubbing directly against either the mic capsule itself or the leading few inches of cable (equally sensitive to friction). Contact noise can usually be controlled-if not completely eliminated-by careful positioning and taping down of the mic and cable.

Begin by securing the clothing on both sides of the mic capsule. This can be done by sandwiching the mic between two sticky triangles of cloth camera or gaffers tape. Form these triangles by folding a few inches of 1" wide tape corner over corner, similar to folding a flag.

By immobilizing the mic between both layers of clothing, you have eliminated the possibility of either layer of clothing rubbing against or flapping onto the microphone. If the lavalier must be positioned between skin and clothing, or attached directly to skin, then a professional medical/surgical tape should be used against the skin.
Once the mic capsule has been secured, the next step is to form a strain relief for the thin cable. Make a small loop just under the mic capsule. In the case of very sensitive mics, such as the ECM-77 and MKE 2, make the loop go around twice. Tie a small thread of camera tape (sticky side out) to preserve the loop. Tie the loop loose enough so that it can "breathe" (change diameter to absorb tugs).

Apply a few inches of tape along the cable below the loop. Any tension on the cable will be absorbed by the garment, rather than by the microphone (which is somewhat isolated by the floating loop).

When using an external "tie clip," it is still important to think it terms of creating a strain relief. Loop the thin cable up and under the tie clip, forming a semi-circle, and passing through the wide hinge of the clip. Continue the loop behind the garment, and bring the cable around downward, thus completing the circle. As the cable loops downward, it should be inserted between the jaws of the tie clip and the back of the garment. Hide the balanced of the cable behind the wardrobe.

Not only is this arrangement more pleasing to the eye than a dangling cable, but the floating loop of cable isolates the mic while the grip of the tie clip serves as a strain relief.

Acoustic clothing noise is the sound generated by the clothing itself as garments or layers rub against each other when the actor moves. Noise is much more prevalent from synthetic fabrics than from natural cottons or wool's. There is no simple remedy, only prevention, so it is wise to consult early with the wardrobe department.
However, here are a couple of tricks that may help. Anti-static sprays, such as Static Guard ™, will

reduce static electric discharge, clinging, andreduce friction. Dry silicon spray lubricants sometimes help, but be careful of staining. Stiff or starched clothing can be softened with water or alcohol (make sure the colors don't bleed). Saddle soap, silicon, or light oil can take the bite out of hard leather.

Another noise problem common to lavalieres is that of wind noise.
Manufacturers usually supply small foam or metal mesh windscreens with their lavalieres, but these are usually more effective against breath pops than against outdoor gusts of wind. Lavalieres used under clothing have the advantage of being partially shielded from the wind, but may still require added protection.

Clothing rubbing against windscreens can be extremely noisy, so that great care must be taken when using hidden lavalieres out of doors. Surrounding the windscreen with sticky tape and securing it to both layers of clothing, as you would a bare mic, will reduce the friction noise. However, the tape may destroy a foam windscreen when it is removed! Inexpensive, expendable foam windscreens can be made by wrapping the mic in acoustafoam; or by pulling the foam booties off of video cleaning swabs.

Cheesecloth over a mic works very well against wind. Another Hollywood variation is to snip the finger tips off of children's woolen gloves, and pull the wool tips over a lavalier wrapped in foam or cheesecloth.

WIRELESS BODYPACK APPLICATION

Body pack transmitters can be hidden almost anywhere. The most common sites include the small of the back, rear hip, inside thigh, ankle, pants pocket, and inside chest pocket of a jacket, or in the heroine's purse. When talent is wearing a scant bathing suit, for example, radio mics can sometimes be hidden under straw hats, or even on the back of the neck under long tresses of hair. Leg warmers provide a convenient place to hide radios when dealing with exercise attire.

There are a number of ways transmitters may be secured. Belt clips work fine under a jacket or loose top. Special pouches or pockets can be pinned (or permanently sewn) into wardrobe. Sometimes it is possible to merely hang the unit with a safety pin that has been taped onto the transmitter casing. Specially constructed elastic belts can be worn around the waist, thigh, calf, or ankle. Transmitters can also be held in place by elastic bandages.
Avoid placing the transmitter directly against the skin, since perspiration does not get along well with fragile electronics. Many mixers have found that unlubricated condoms provide excellent protection from excess perspiration, rain, or water spray. Normal-size condoms work fine, just stretch them out a bit before rolling them onto the body-pack.

Care should be taken in securing the flexible transmitter antenna cable. To prevent the antenna from being torn from its connector the first time the DJ moves or bends over, use a rubber band to provide elastic strain relief. Attach one of the rubber band to the tip of the antenna. The free end of the rubber band can be safety-pinned to the clothing or taped in place (use medical tape on skin). Thus, the antenna can be maintained reasonably straight (a little bit of slack is okay) yet protected against tearing. Avoid running the antenna directly against the skin, since body moisture tends to interfere with (absorb) the outgoing signal.

The transmitter antenna can be run vertically up or down from the body pack. However, if the antenna trails downward, then the transmitter should be mounted in an inverted position to avoid making a loop in the line. The transmitter antenna can also be run horizontally, such as partially around the waist. However, in these instances, the receiver antenna may need to be tilted sideways (matching the angle) to improve reception.

Under no circumstances should the mic line and antenna wire ever cross. Run the microphone cable out from the body pack in the opposite direction of the antenna. When the transmitter is mounted on the body upside-down (the antenna running downward), it is okay for the mic line to loop upward, as long as it doesn't cross the antenna.
Install a fresh battery in the transmitter every time you use it. It sounds like a detail that should be obvious, but all too often radio mic problems boil down to a weak battery in the transmitter. Change the battery frequently-every four to six hours with most brands.

WIRELESS RECEIVER PLACEMENT
Strive to maintain minimum distance between the transmitter and receiver. Move the receiver/antenna from shot to shot in order to achieve close and clean line-of-sight placement. Given the option, it is better to run long lengths of audio cable (from receiver to recorder) than to have long lengths of antenna cable (from antenna to receiver).
Virtually anything can interfere with good radio transmission and cause bursts of static. Check for metallic objects of any kind, such as jewelry, zippers, coins, snaps, and keys. If you cannot eliminate the metal, then at least reposition the antenna on the actor. Carefully eyeball the path of the transmission between the DJ and the receiver. Pay attention to lighting or speaker stands that may be in the way.

Examine the location itself. Check for additional electrical lines, especially coiled feeds, which can generate magnetic fields. Dimmers and special effects equipment (especially neon's) are always a problem. Motors can produce interference; be aware of golf carts, forklifts, camera cranes, automobiles, and kitchen appliances.

WIRELESS OPERATION
Mics with switches should never be purchased-Control should always be with the operator-but in radio mics sometimes a switch is an asset since offstage and private conversation will be picked up by a neck mic which the DJ cannot easily unplug and which the operator may have forgotten to fade out, of course he has to remember to switch it on again! Wherever radio mics are used it is vital that the mixing operator is fitted with a pre-fade listen push so that the operator can listen in to the channel before the performer goes on stage and check that all is well.
If mics with switches are used, be sure to tape over the switches so that the actor/performer does not voluntarily or involuntarily switch the mic on or off. Control should lie solely with the mixing engineer or members of the sound crew.

WIRELESS REPAIR and TROUBLESHOOTING
If you work with wireless mics for an extended period of time (i.e. not just one day), you are bound to come across problems.

Dead mics? Replace batteries. If the belt-pack is clearly on, check the physical connection point between the mic and the belt-pack. If the system is detachable, test the belt-pack connection with a mic that you know works.
Sometimes the mics will "thunk" on and off. The problem, other than being out of range, is usually

that the battery is too lose in its chamber and is contacting on and off. Either add padding at the bottom of the battery case or adjust the battery contacts inside the body-pack.

Other problems? Check the location of the body pack on the performer. Sometimes metal objects will interfere with transmission. Check the location of the receiver. It may be too close to metal objects or sources of interference. Change the position of the antenna(s) or even the whole receiver. Other than that? Get a new wireless system. Or a new auditorium. Whichever is faster.