

## Seeking The “Holy Grail”

Inside the Shure SLX wireless system

By Gino Sigismondi

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**C**urrent wireless microphone systems for professional audio applications are a far cry from the 49 MHz behemoths of the early days. Advances in companding circuitry allow for sound quality approaching that of wired microphones. The ability

to select from many hundreds of possible frequencies provides users with multiple clear channels.

Wireless frequency selection and coordination are concepts many average users find either daunting or boring, or both. The “holy grail” of pro audio wireless would be one that works like a cellular phone; i.e. turn it on, it finds a clear channel, and it works. (But hopefully with far fewer dropouts than a cell phone!)

It was this type of wishful thinking that guided the design and development of the Shure SLX wireless microphone system.

The system consists of the SLX4 diversity receiver, along with either the SLX1 bodypack or SLX2 handheld transmitter. The tuning range of the system is 24 MHz, selectable in 25 kHz steps, providing the user with 960 possible operating frequencies.

For U.S. operation, there are three different tuning bands available. Up to 12 systems may be operated within a single band, or up to 20 maximum systems across all three bands. To insure maximum compatibility (and take the burden of frequency coordination off the user), each system is pre-programmed with six groups of 12 compatible frequencies.

Three SLX frequency bands were chosen by examining UHF TV channel allocations in the top 50 U.S. television markets. Because UHF wireless



The new SLX wireless system from Shure, with bodypack and handheld transmitter options.

microphone systems share the same range of frequencies allocated for TV channels 14-69 (in the U.S.), it was important to place the frequency bands where there are the largest number of unoccupied TV channels.

A criteria that was established early in the frequency planning process was the requirement that at least 12 compatible frequencies should be possible in any given location. Most manufacturers (Shure included) typically state the maximum number of compatible frequencies, for example, "up to 12 compatible channels per band." This statement usually assumes no interfering TV channels.

In practice, this number tends to be somewhat smaller, and occasionally, quite a bit smaller. By utilizing all three frequency bands, at least 12 channels of SLX wireless can be operated in nearly every city in the country (including everyone's favorite RF nightmare, Los Angeles!)

In order to maximize the number of systems that can be operated simultaneously within a given band, the frequency allocations of Group 3 through Group 6 are "weighted" towards a particular TV channel, with five of the 12 frequencies allocated within one TV channel. (A TV channel in the U.S. occupies 6 MHz of the spectrum – see **Figure 1**.)

This scheme allows for at least five compatible systems within a given



Figure 2: A couple of button pushes and the system is programmed.

band, even if only one open TV channel is available. Using the J3 frequency band as an example (which occupies TV channels 31 to 34), Channels 1-5 of Group 3 are all within the range of TV channel 31 (572-578 MHz).

Therefore, if TV 31 was the only unoccupied channel in your area, choosing Group 3 would allow you to get at least five wireless systems on the air. Similarly, choosing Group 4

accommodates 5 systems within TV 32, and so on and so on. Groups 1 and 2 are an even distribution across all four TV channels, three frequencies per channel.

The advent of DTV (digital television) has significantly reduced the amount of open spectrum left in the UHF band. *Successful wireless system operation is still possible, though, provided use of a "tunable" wireless sys-*

**J3: 572.000–596.000 MHz**

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1	572.400	573.250	572.200	573.775	573.100	572.425
2	575.500	574.500	573.675	576.500	575.225	574.400
3	577.575	576.225	574.800	578.200	576.550	577.425
4	579.050	578.725	576.450	579.600	578.575	579.475
5	581.425	580.350	577.750	580.700	580.900	581.775
6	583.200	581.550	580.200	582.250	584.500	585.675
7	586.450	584.800	582.325	583.500	585.750	587.800
8	587.650	586.575	586.225	587.100	587.300	589.250
9	589.275	588.950	588.525	588.425	588.400	591.550
10	591.775	590.425	590.575	591.450	589.800	593.200
11	593.500	592.500	593.600	592.775	591.500	594.325
12	594.750	595.600	595.575	594.900	594.225	595.600
	Full Range - even distribution for each TV-CH	Full Range - even distribution for each TV-CH	Full Range - max # of frequencies for CH- 31	Full Range - max # of frequencies for CH- 32	Full Range - max # of frequencies for CH- 33	Full Range - max # of frequencies for CH- 34

Figure 1: TV channel 31 occupies 572 MHz to 578 MHz. Group 3 has the most frequencies in this range.

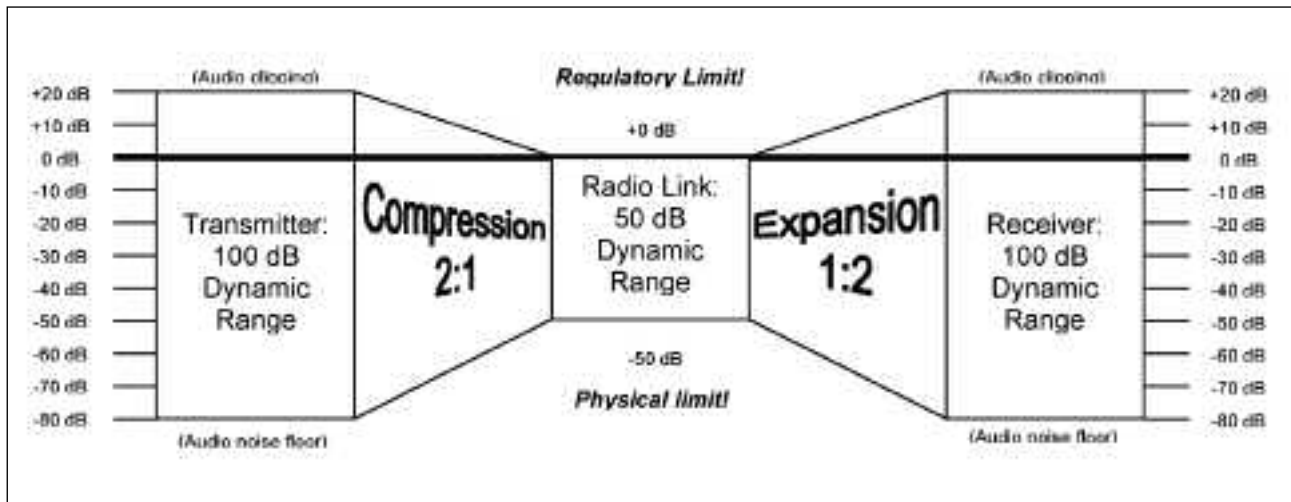


Figure 3: A look at how fixed-ratio companding works.

tem – one that allows the user to select the operating frequency.

The best way to deal with DTV is to get out of the way. Choosing a clear frequency requires knowledge of

potential interference sources on the part of the user, something to which the majority of the population typically doesn't pay much attention (particularly in the age of cable and satellite TV).

As a result, the SLX wireless system incorporates an automatic frequency selection function that allows the receiver to find a clear frequency. This function requires the pushing of two buttons to acquire a useable channel.

Depressing the "Menu" button activates the "Auto Channel Select" mode. Then, by depressing the "Select" button, the receiver finds the clearest channel within the group and sets itself to that frequency.

Finally, the transmitter needs to be programmed to the same frequency as the receiver. The SLX system has been outfitted with infrared ports on the receiver and the transmitter. Holding the transmitter near the receiver and pushing the "Sync" button automatically programs the proper frequency into the transmitter (Figure 2, previous page). The "Ready" light on the receiver illuminates to indicate the transmitter has been successfully programmed.

### AUDIBLE EQUIVALENT

While the sound quality of wireless microphones has improved dramatically over the years, the exact audible equivalent of a wired microphone has yet to be attained. Professional audio applications typically require a dynamic range of more than 100 dB to achieve acceptable performance, yet

even the best analog wireless link, on its own, can achieve no more than about 70 dB.

In order to compensate for this limitation, analog wireless systems employ a process known as companding, required to hide the dynamic range limitations of analog FM demodulation.

Although helpful in improving dynamic range, companding creates distortions ("artifacts") that are more-or-less audible, depending on the way it is implemented. These artifacts have compromised audio purity, and led to our development of a patented technology called Audio Reference Companding found in the SLX system.

Audio Reference Companding is a level-dependent companding scheme that helps eliminate artifacts. To better explain the technology, let's examine the function of the compander circuit in typical wireless mic systems.

The term compander is a contraction of the words compressor and expander, which describe contrary (and in a wireless sense, complementary) dynamics processors. A compressor is employed to reduce the dynamic range of a signal, while an expander increases the dynamic range. In a wireless microphone system, compression takes place in the transmitter, while expansion occurs in the receiver.

Both the compression and expansion are performed by a voltage-controlled-amplifier (VCA). Most wireless

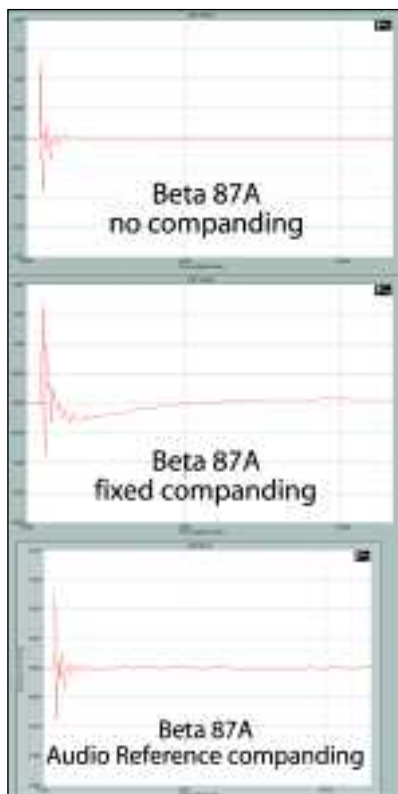


Figure 4: Transient response of wired and wireless microphones. From top: a wired microphone, a wireless system with fixed-ratio companding, and a wireless system that uses Shure Audio Reference Companding.

microphone systems use a fixed 2:1 compression ratio in the transmitter. A 2 dB increase in the compressor input level, for example, gives a 1 dB increase in the compressor output level. An equal but opposite expansion (1:2) occurs in the receiver, restoring the original dynamic range of the system input signal (**Figure 3**, previous page).

Fixed-ratio compressors apply continuous signal processing, regardless of signal level. When companding is applied to low signal levels, the noise floor of the radio signal becomes dynamic and audible. Most wireless users will recognize these low-level artifacts as “breathing” or “pumping.”

This breathing sound results from the suddenly increased level of the noise floor and tends to be masked at higher signal levels. With good design, these artifacts can be minimized, but not eliminated.

### ABSOLUTELY NECESSARY

Our Audio Reference Companding scheme is a level-dependent com-

panding scheme based on the principle that “no companding is the best companding.” At low signal levels, no companding is applied, which means no artifacts.

Audio Reference Companding utilizes a “soft-knee” type of compression, where the onset of compression occurs gradually, allowing the wireless system to avoid companding until it is absolutely necessary. The net result is not only elimination of low level artifacts, but a reduction in system distortion, improved transient response, and a more natural and faithful reproduction overall.

Level-dependent companding relies on a high-quality VCA and precise tracking between the audio sections of the transmitters and receivers. Properly implemented, level-dependent companding results in fewer artifacts (breathing), lower distortion, lower noise floor, and increased headroom. Sound quality, in general, should be improved at any signal level.

The impulse response graphs in **Figure 4** (previous page) illustrate the

differences in transient response between a wired microphone, a wireless system with fixed-ratio companding, and a wireless system that uses Audio Reference Companding. The action of the compander overall is less noticeable, which may be of particular interest to guitarists who have shied away from wireless systems because of the constant action of fixed-ratio compressors.

The lower noise floor of Audio Reference Companding is also intended to provide a less fatiguing listening experience for users of personal (in-ear) monitor systems, where artifacts are even more noticeable due to the closed listening environment.

For performers and presenters who have remained tethered to a wire because they just can't accept the artifacts common to wireless, Audio Reference Companding provides a viable alternative. ■

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