Innovating Direct Conversion Technology: A White Paper on the Zaxcom VRX1 VHF IFB Receiver

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Abstract

In February 2024, Zaxcom released a new VHF IFB audio receiver called VRX1, designed to monitor audio and cue talent in the film, television, and broadcast industries. The portable, belt-worn VHF IFB receiver can tune and decode up to ten analog broadcast channels in the VHF frequency range, specifically 192-217 MHz. It also has an adaptive squelch algorithm that intelligently minimizes noise when a transmitter signal is absent, among other advanced features like voice prompts, audio delay, and voting that automatically connects VRX1 to the strongest transmitter signal in the area when more than one transmitter is operating.

VRX1 has been developed using technology known as direct conversion. This technology is rarely used in the film and television industry due to its difficulty to implement and the high cost of chips typically used to materialize the process.

At Zaxcom, we have found a way to innovate direct conversion technology, eliminating radio frequency (RF) interference and extending battery life at a competitive cost to the consumer.

What is Direct Conversion?

Direct conversion works by generating the exact frequency in the receiver it attempts to receive. When this local frequency is mixed with the received signal, the result is a very high-resolution audio signal with much lower noise and distortion, which is typical of receivers that use intermediate frequency (IF) to recover the transmitted audio.

Direct Conversion Obstacles

The key to direct conversion is to stop the internally generated frequency from leaking out of the receiver and interfering with the receiving frequency at the antenna.

The more significant challenge is doing it at a power consumption level that makes battery-powered receivers possible and surpasses the performance of even the best rack-mounted power systems. Lastly, keeping the cost of the product competitive when compared to other manufactured products is vital.

Direct Conversation Technology Explained

Direct conversion eliminates, to a great degree, the need for a front-end filter. This is because the primary job of the front-end filter is to prevent reception of what are known as image frequencies.

What are Image Frequencies?

An image frequency is an unintended frequency of reception that can interfere with the intended frequency you're trying to receive. When frequencies mix, they produce sums and differences of the two frequencies being combined. While the sum may be advantageous, the difference is interference.

Image frequencies can be received due to the need for down conversion to an intermediate frequency (IF) in traditional superheterodyne receivers. The image frequency adds interference and noise from RF that you do not want to receive.

For example, if you intend to receive a signal at 500 MHz and you have an IF frequency of 70MHz, in this case, you might receive interference from a frequency of 640MHz. This is because 640MHz can mix with the receiver's local oscillator frequency of 570MHz to generate an unintended interference at the 70MHz IF and interfere with the intended receiver frequency of 500MHz.

Direct Conversion Eliminates IF Filtering

Since direct conversion eliminates the IF frequency, there is no image frequency to filter out. This increases the receiver's reliability by eliminating noise and interference that might exist in the image frequency. Since airwaves are crowded, it is not unusual for the image frequencies to have high-power interfering signals from cell phones, walkies, and television stations that easily pass through front-end filters that do not have enough rejection for high-power interfering signals. This degrades the receiver's sensitivity to the point where operating distance can be and is reduced.

By eliminating the IF frequency, the conversion from the intended frequency of reception to a baseband signal is more easily filtered by hardware components, saving power. It also has a lower distortion signal than RF that has been converted to one or more intermediate frequencies before being sampled by an A to D converter.

Direct Conversion Advantages over Intermediate Frequency (IF)

Direct conversion is advantageous over receivers using intermediate frequency (IF) sampling. Suppose sampling converts an entire block of spectrum to a wide band A to D converter. Direct conversion offers a hardware filter for each channel that eliminates the possibility of A to D overload from a wide block of frequencies you have no desire to receive.

The benefit of direct conversion is that only the frequencies you intend to receive arrive at the receiver's A-to-D converter. This makes receiver overload much less likely than IF sampling type receivers where one off-channel high-level signal can degrade multiple channels being received with a single A to D, wide band block converter.

Since there are no IF frequencies, the direct conversion receiver cannot be interfered with at any frequency other than the intended reception frequency. It is common for non-direct VHF IFB receivers that don't use direct conversion to pick up interference from different types of

wireless communications due to the susceptibility of the IF stages in the receivers being overloaded by strong RF signals on any frequency.

As an added benefit, direct conversion receiver technology also eliminates IF crosstalk between channels in multichannel receivers. Many traditional receivers that contain multiple channels in the same box suffer from IF crosstalk. This happens when strong signals generate strong IF signals. When one channel has a strong signal, and another channel has a weak signal, the IF signal can leak into the other receivers in the box, raising the noise level of the receivers with weak signals and limiting the distance that the already weak signal can go. The direct conversion design eliminates this problem by eliminating the IF stage in the receiver, so there is no issue with crosstalk between receivers in the same box.

Summary

Zaxcom is pleased to deploy our new VRX1 VHF IFB audio receiver using innovative direct conversion technology. The RF performance alone will show its value, eliminating RF interference commonly found on production sets and locations. Additional features such as delay, voting, adaptive squelch, headphone equalization, and voice prompts will positively change the IFB experience in production environments, making VRX1 a refreshing change to the typical high-distortion audio commonly found in VHF FM IFB receivers.

For more information, visit zaxcom.com