Reciprocal Mixing Testing: What Is It?

— Bob Allison, WB1GCM, ARRL Laboratory Engineer

You may notice two new color bars in the "Key Measurements Summary" at the top of transceiver reviews. These are for *reciprocal mixing dynamic range* (RMDR), with measurements at 20 and 2 kHz spacing. We've reported reciprocal mixing since December 2007, but it's easy to overlook these figures in the table. From this review forward, we will include RMDR in the Key Measurements Summary.

We report three dynamic range measurements that determine a transceiver's overall performance. Along with *blocking gain compression dynamic range* and *two tone third order dynamic range,* we must consider RMDR while evaluating how well a receiver hears. Which of these measurements is the most important factor in comparing receivers depends a lot on how you plan to *use* that receiver. For hearing weak signals at or near the receiver's noise floor, receiver noise typically is the limiting factor. For the reception of stronger signals under crowded band conditions, two tone third order DR is the most important number. To assess a receiver's ability to perform well in the presence of a single, strong off-channel signal (common within geographical ham radio "clusters" or with another ham on the same block), blocking gain compression DR is usually the dominant factor.

Reciprocal mixing is noise generated in a superheterodyne receiver when noise from the local oscillator (LO) mixes with strong, adjacent signals. All LOs generate some noise on each sideband, and some LOs produce more noise than others. This sideband noise mixes with the strong, adjacent off-channel signal, and this generates noise at the output of the mixer. This noise can degrade a receiver's sensitivity and is most notable when a strong signal is just outside the IF passband. RMDR at 2 kHz spacing is almost always the worst of the dynamic range measurements at 2 kHz spacing that we report in the "Product Review" data table.

We perform the reciprocal mixing test at 14.025 MHz, using a very low noise Wenzel test oscillator with a measured output of +14 dBm. The test oscillator's sideband noise is considerably below the reciprocal mixing we're measuring. We feed the oscillator's output into a step attenuator, which we adjust until an audio meter on the receiver's output indicates a 3 dB increase in background noise. The RMDR is the output level at which we note this 3 dB increase.

Here's an example: Suppose the receiver's noise floor (minimum discernable signal, MDS) is –133 dBm, and a strong station 2 kHz away causes a 3 dB increase in noise at a level of –53 dBm into the receiver's antenna jack. The reciprocal mixing figure is MDS minus the 3 dB increase level: –133 dBm – (–53 dBm) = –80 dBm. We previously would have reported this as –80 *dBc*. Since we now consider this as a dynamic range number, we report it simply as 80 dB.

In our real-world example, if your receiver's MDS is –133 dBm, a signal 2 kHz away at 20 dB over S-9 will cause the noise in the audio output to increase by 3 dB. This reduces your receiver's MDS by that amount, resulting in an MDS of –130 dBm. A stronger signal will create more noise, but our benchmark for testing is a 3 dB increase in noise.

Source: QST, April 2012, page 55

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The upper end of the RMDR bar on the key measurements summary charts has been set just above the highest RMDR seen in the ARRL Lab to date. SDR and analog type receivers have different performance characteristics and design tradeoffs. For instance, some I/Q SDRs have been observed to have rather mediocre third order IMD dynamic range when tested in a laboratory environment with just two signals, but if hooked to an antenna with multiple signals simulating real band conditions, have considerably higher third order IMD dynamic range. RMDR, on the other hand, can be lower under the same conditions than what is observed in the Lab. If choosing a receiver for real world use, it’s important to consider all three dynamic range parameters.

Note how reciprocal mixing relates to the two-tone third order DR figures, especially at 5 and 2 kHz spacing. A *single*, strong adjacent signal 5 or 2 kHz from the desired signal with resulting reciprocal mixing has a greater impact on a your ability to hear a desired weak signal than do *two* strong signals 5 and 10 kHz away (5 kHz spacing) or 2 and 4 kHz away (2 kHz spacing) with a resulting intermodulation distortion (IMD) product that covers up the desired signal. In many cases, reciprocal mixing dynamic range is the primary limiting factor of a receiver’s performance.

Source: QST, April 2012, page 55