ARRL's Clean Signal Initiative Adopts Metrics for Transmitter Performance

This program, which is currently being developed, is tasked with helping to improve transmitter performance.

ARRL CSI Working Group

Transceiver performance is an essential consideration for efficient amateur communications. The combination of the availability of higher-performance semiconductors and the manufacturer's attention to receiver performance has resulted in significant receive improvements. Compared to 20 years ago, a typical receiver's capability to separate weak stations surrounded by strong QRM has improved dramatically. The receive performance of most radios today is much better than is typically needed for most operating environments. On the other hand, the transmit performance has not improved in parallel with the receive functions; the reception limit in QRM pileups is not from one's own receiver but the transmit bandwidth of nearby signals. This may be due to excessive CW key clicks, SSB splatter, or wideband transmit composite noise.

ARRL has adopted the goal of improving transmitter performance by recommending performance standards in an effort to encourage radio manufacturers to improve their designs. This concept grew into ARRL's Clean Signal Initiative (CSI), which has been in development since 2022. Voting members of the CSI include ARRL Lab staff, representatives from manufacturers, and renowned experts on amateur radio testing. This working group has come up with performance metrics that, if implemented by original equipment manufacturers (OEMs), can reduce QRM over time as transmitters begin to catch up with how well receivers perform. Because most modern transceivers have firmware that can be updated by the operator, improvements can often be applied to existing equipment.

Metrics to Strive For

Currently, CSI has adopted three metrics for OEMs to work toward.

CW bandwidth can be expressed visually with a mask displaying the maximum desirable key click bandwidth. The width of a CW signal in current equipment is often determined in software and can be easily adjusted. If a signal meets the suggested mask, CW key clicks should be down to at least 60 dB with a bandwidth of 675 Hz or less. Figure 1

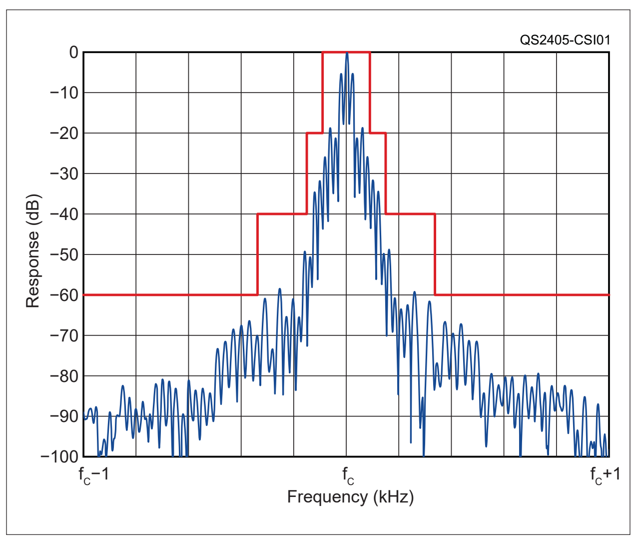

Figure 1 — This graph shows what a clean CW signal would look like (in blue) in relation to the CSI mask (in red). Because no part of the signal exceeds the mask at any point, this transmitter would meet the mask.

shows mask values for a CW signal (key clicks) being equal to or narrower than the following: –20 dBc at 180 Hz, –40 dBc at 300 Hz, and –60 dBc at 675 Hz.

SSB intermodulation splatter is a more difficult problem to solve. However, presently, two OEMs have implemented ways to deal with this issue. To date, this has been addressed in pre-distortion software. Each OEM will likely have a different approach to cleaner (narrower) SSB signals. Transmitter performance is often judged in terms of linearity, meaning the signal coming out of the final amplifier is identical to the input signal but at a higher amplitude. Small, non-linearities in the transmitter cause the generation of artifacts that extend beyond the targeted, or ideal, RF bandwidth. These artifacts result in intermodulation distortion (IMD) that encroaches on adjacent spectrum.

On SSB, the IMD (splatter) mask values in peak envelope power (PEP) are as follows: third order, –42 dB (–36 dBc); fifth order, –48 dB (–42 dBc), and seventh order, –54 dB (–48 dBc). Higher-order products should exhibit an overall 3 dB slope approaching the noise (see Figure 2).

The last metric is transmit composite noise, which isn't mode-specific. Composite noise interference typically exists where the offending signal is very strong and likely line of sight. The stretch goal is a metric for which OEMs should strive to meet with their future designs. Currently, the ARRL Lab reports phase noise — which is one component of composite noise, along with amplitude noise — but will soon be reporting composite noise, as it paints the entire picture of noise that can affect transmissions (see Table 1).

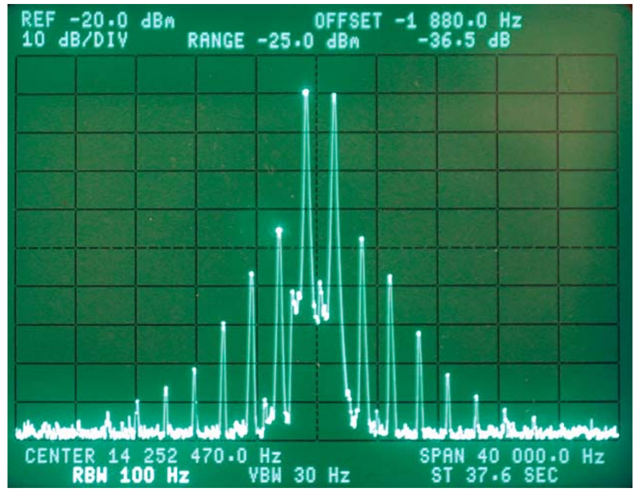

Figure 2 — An example displaying dBc of a transmitter that meets the SSB mask. [ARRL CSI Working Group, photo]

Table 1 — Current CSI Standards

CW Signal Mask		
Attenuation	**Bandwidth**	
–20 dBc	180 Hz	
–40 dBc	300 Hz	
–60 dBc	675 Hz	
IMD Mask*		
Harmonic	**Attenuation**	
Third order	–42 dB PEP (–36 dBc)	
Fifth order	–48 dB PEP (–42 dBc)	
Seventh order	–54 dB PEP (–48 dBc)	
Composite Noise Mask		
Spacing from Carrier	**Working Mask**	**Stretch Goal**
10 kHz	–136 dBc/Hz	–142 dBc/Hz
20 kHz	–139 dBc/Hz	–145 dBc/Hz
100 kHz	–142 dBc/Hz	–148 dBc/Hz

*Higher-order products should exhibit an overall 3 dB slope approaching the noise.

Moving Forward

The CSI ratings will help amateurs compare transceivers and make informed decisions, in addition to the full battery of test results reported by the ARRL Lab. Look for the official rollout of the CSI program to happen soon. More details about the test methods and rating system are forthcoming.

Just as this article was going to press, we learned that our good friend and CSI Working Group voting member Adam Farson, AB4OJ/VA7OJ, had become a Silent Key. Adam grew up in South Africa and was first licensed as ZS1ZG in 1962. He had a long and interesting career as a telecom engineer. After earning his bachelor and master of science degrees in electrical engineering from the University of Cape Town, Adam worked for the Marconi Company in the UK and at the CERN particle collider near Geneva, Switzerland. He was also a Senior Life Member of the Institute of Electrical and Electronics Engineers. Adam spent enormous amounts of time over the years testing amateur transceivers, with a great deal of his work being focused on Icom products. We appreciate his contributions to the CSI, and he will be missed by the amateur radio community. His website, **www.ab4oj.com**, is still currently online and is a great resource for technical information.