DXpeditions to São Tomé (p. 25) and "Love Island" (p. 32)

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# CQ Amateur Radio

COMMUNICATIONS & TECHNOLOGY
FEBRUARY 2022

## QRP Special

**On the Cover: Robert Williams, N0QLR, operates a Summits on the Air (SOTA) station atop Mt. Herman, Colorado with "mountain goat" Steve Galchutt, WG0AT. Story on page 16, details on page 30.**

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Getting high on QRP! Robert Williams, NØQLR, activates a Summits on the Air (SOTA) operation from the peak of Mt. Herman, Colorado, along with Steve Galchutt, WGØAT. Their story is on page 16; more about SOTA is on page 30. (Cover photo by Steve Galchutt, WGØAT)



QRP SPECIAL ISSUE: Special things happen when you turn the power down less than 5 watts. Find out what happens on pages 8, 10, 16, 19, and 22. Plus ... love is in the air on pages 32 and 38.

## FEATURES



## COLUMNS



## DEPARTMENTS

*W5GW and K5PA conclude their two-part article on helping you sound your best on single sideband, focusing this time on proper settings and add-on features to help tailor your transmitted audio.*

# Microphones and Audio Speech Processing for SSB

## *Part 2 – Optimizing Audio for Band-Limited SSB*

**BY GARY WHITE,* W5GW AND GENE HINKLE,# K5PA**

Part 1 of this article[1] examined SSB and microphone usage and illustrated that band-limiting of SSB reduces intelligibility and clarity. Recommendations on selecting a mic for amateur SSB use were provided.

Part 2 examines the basic adjustments necessary to properly mate your mic to the audio stages of a modern SSB transmitter. The advanced topics of equalization, noise gates, and compression are also covered. As stated previously but worth restating, SSB audio characteristics are very subjective and vary from mic to mic and individual to individual.

*Figure 11. A vision of SSB utopia (Credit: Verlenne Monroe, XYL of Gary White)*

### Basic Adjustments and Practices

Gain – Proper adjustment of microphone gain is the most important adjustment you can make. Get it wrong and everything else will make little difference in improving your signal. An improper mic gain can result in low power and loss of intelligibility and clarity at the receiving end. Surprisingly, this can result from either not enough mic gain or too much mic gain.

Most modern amateur transceivers have some type of automatic level control (ALC) that is used to adjust the mic gain. The ALC circuitry is designed to keep the audio and RF stages from being driven into non-linear operation. Unfortunately, all ALC circuits and their metering are not created equal. For preliminary mic gain adjustments, follow the manual.

For example, the Icom 7300 manual states: "... select the ALC meter and adjust until the meter reading swings between 30 to 50% of the ALC scale." Speak a long "ahhhhh" while adjusting for a quarter to mid-range reading on the ALC meter. Then, when speaking normally, confirm the ALC peaks in the 30-50% range. This adjustment is critical to mating your voice amplitude to the microphone sensitivity and the transmitter's audio and RF amplification levels. Don't be tempted to think that if 30-50% is good, then 60-100% is better.

Experiments have found the peak to average power ratio of saying a long "ahhhhh" is about 10:1 and represents a normal speaking voice. Do not whistle as it is not representative of an average voice. If you are monitoring an average-reading power meter, the long "ahhhhh" will show a power that is about 10% of the peak envelope power (PEP).

We usually follow-up this preliminary adjustment by reading a line or two from a book while monitoring the ALC meter and adjusting the mic gain even more. For our voices, we've noticed the factory default setting of 50 for mic gain needs to be reduced to about 30 when using the Icom-supplied mic to keep the voice peaks below 50% of the ALC scale.

If you have a peak-reading wattmeter, you can make further refinements of the mic gain setting by watching the peak power while speaking. Reduce the mic gain until the power starts reducing from its maximum peak and then increase it back slowly to return to a maximum peak power output while speaking.

If the mic gain is too high, it will overdrive the audio and RF stages and lead to non-linear operation, clipping, distor-

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tion, and splatter outside of the passband. This results in lower power in your SSB passband, loss of clarity, and interference to other stations above or below your passband. If the mic gain is set too low, the RF stages will not be driven to their desired power levels and the received signal strength will be reduced.

Keep Your Speech Volume at a Constant Level – The volume of your voice is not constant. While transmitting, ensure your volume is constant by monitoring the ALC meter. Keeping your voice level constant and speaking normally mates the range of vocal sound pressures to the dynamic range of the mic, and, in turn, the audio and RF amplification stages.

Sometimes we get excited and talk too loudly; other times we tend to speak more softly than normal. Being conscious of our spoken voice is easier said than done. Those of us who wear hearing aids tend to talk louder when wearing them than when they are out.

A hoarse or irritated throat can affect the volume of your articulation. Hams with even minor hearing problems can also have difficulty assessing the loudness of their voice. The ALC meter or indicator is the best way to ensure we keep our voice at a constant level.

Adjust Bandwidth of Your Transmitted Signal to Match Operating Conditions – This assumes you can adjust the bandwidth of your transmitted signal. As an example, the Icom 7300 comes from the factory with three adjustable presets of transmit bandwidth (TBW) settings. They are:

SSB TBW (WIDE): 100-2900 Hz
SSB TBW (MID): 300-2700 Hz
SSB TBW (NAR): 500-2500 Hz

We find removing 200 or 400 Hz from the upper treble ranges impacts intelligibility, and we prefer the following settings:

SSB TBW (WIDE): 100-2900 Hz
SSB TBW (MID): 300-2900 Hz
SSB TBW (NAR): 500-2800 Hz

These settings are subjective, dependent on your voice, microphone, and particular transmitter. While subjective, they are based on language and speech research in how the intelligibility of the English voice is communicated. They are intended as a starting point for your own experimentation and use in different types of operating conditions.

For high SNR (signal-to-noise ratio) QSOs, we like to use the wide setting. For all other QSOs and conditions (DX, low SNR, nets, roundtables, QRM or QRN, etc.), we'll select the middle or narrow setting that is most appropriate.

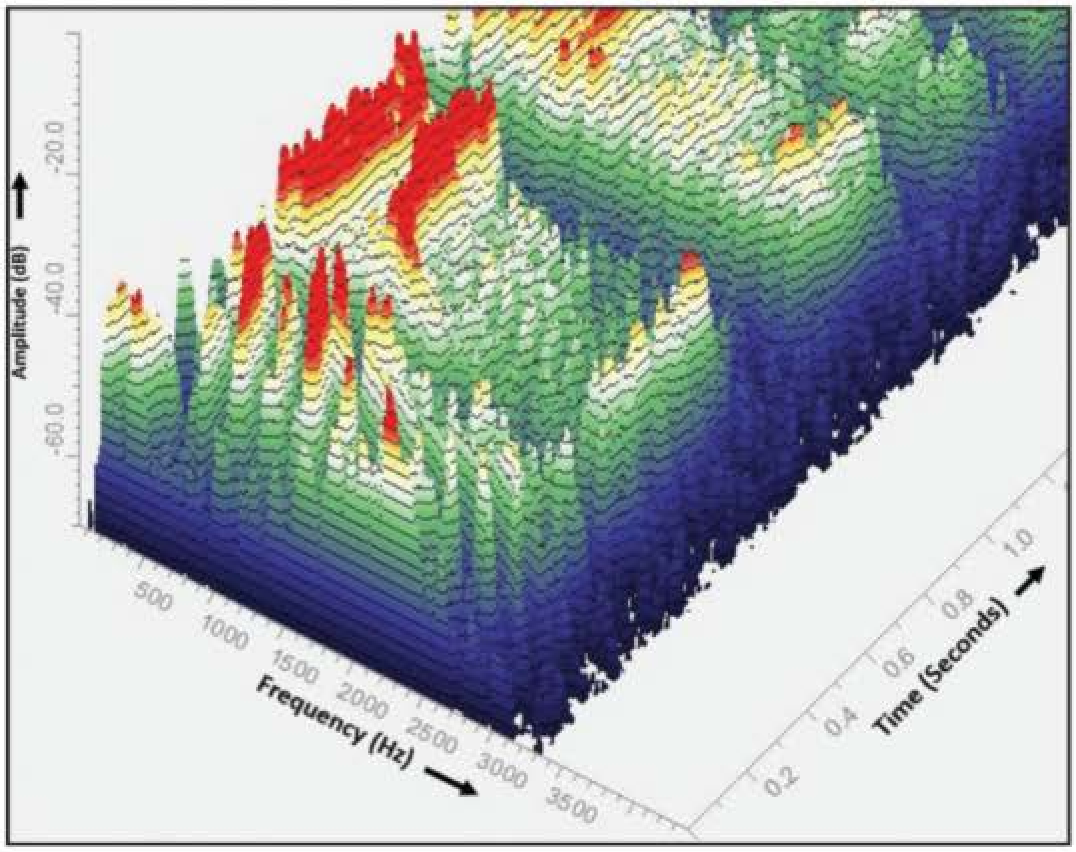


*Figure 12. 3-D spectrum of SSB audio (Credit: Gene Hinkle)*

## Advanced Adjustments and Practices

The aforementioned basic adjustments and practices will improve your SSB signal significantly. Most of us can stop there and be satisfied with the results. In this section, we present advanced signal-processing functions of equalization, compression, and noise gate application. Some of these capabilities are included in modern transceivers. But in many older radios, an external unit is necessary to achieve these signal-processing functions.

Before we get into advanced signal-processing topics, let us visit the human voice in a bit more detail. A 3-dimensional (3-D) spectrum of SSB audio is shown in *Figure 12*. By 3-D, we mean that the voice frequency and amplitude are plotted on the X-Y axis, and then successive plots are stitched together across time, the Z-axis. Thus, the variations in the voice frequencies and amplitudes are plotted across time.

Note that the amplitude of the lower frequencies is generally stronger. Also, there is a wide range of amplitudes in frequency for any given time slice. If this audio signal is amplified equally in a SSB transmitter, a large portion of available power will be allocated to the lower frequencies. We learned in Part 1 that much of the intelligence is carried in the mid-to-higher spectrum of the available SSB bandwidth (1-3 kHz). From *Figure 12*, we see that equal power allocation is not conducive to maximizing intelligibility. This 3-D spectrum was created from a rag-chew net operating on 40 meters. The program that was used for *Figure 12* is called Spectrum Lab by DL4YHF.[2] It can be used to help evaluate settings of band limiting, equalization, and compression.

By redistributing power from the areas of frequency that carry little or no intelligence to bands that provide intelligence, we can improve the intelligibility of our transmitted signal. This process is called *equalization*.

The difference between the lowest discernable signal and the loudest is called *dynamic range*. Because the loudest signal sets the limit of our transmitter's peak power, we look for a method to raise the weaker signals. This process is called *compression*. Most audio or RF compression descriptions state that compression increases our average power while the peak power remains at its upper limit. This is true. But it is also true that compression reduces the dynamic range, and hence fidelity, of the signal.

We want to re-emphasize a point raised in Part 1. Both equalization and compression can increase overall intelligibility, but they do so only by changing the fidelity of the transmitted signal. And carried too far, even the intelligibility of the signal will suffer.

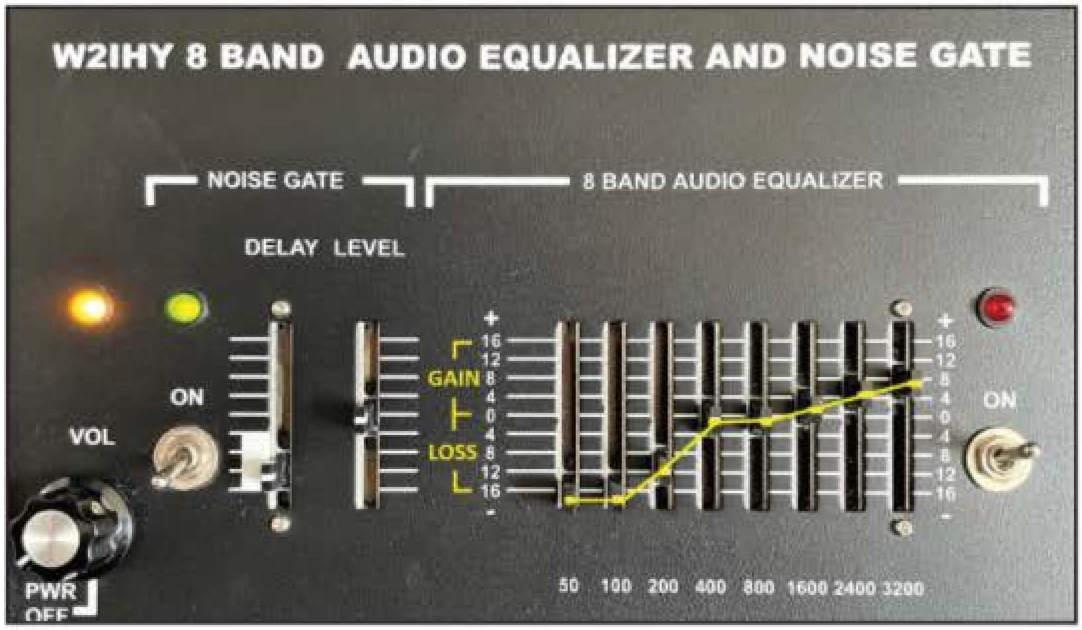


*Photo B. Rag-chew equalization (Credit: Gene Hinkle)*

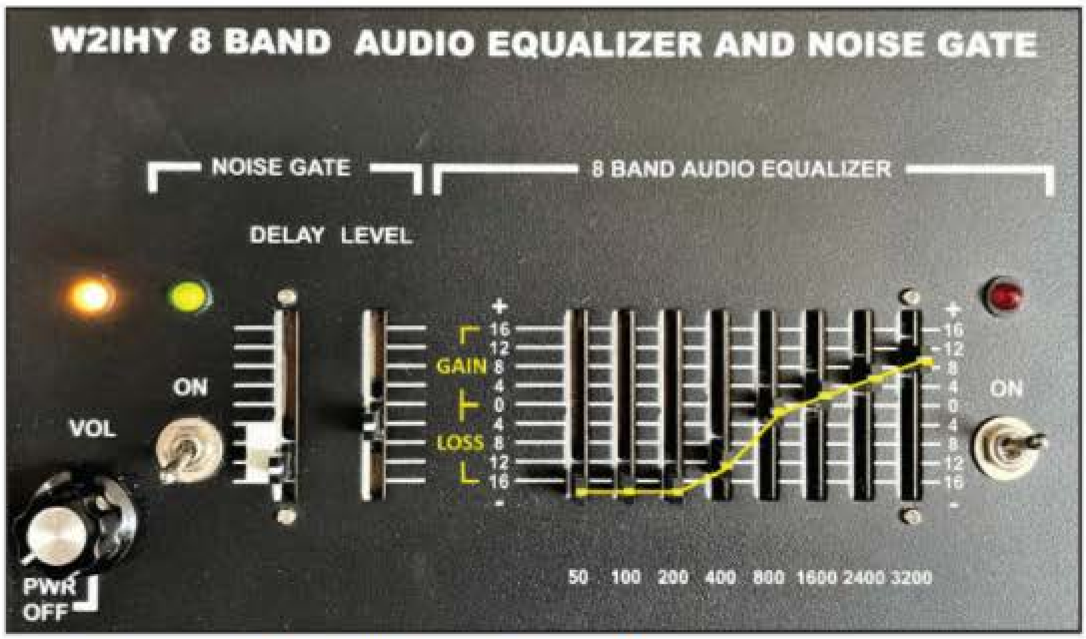


*Photo C. Heavier Equalization (Credit: Gene Hinkle)*

Equalization and compression, while based on scientific principles and facts, have many variables. It's very easy to over-equalize and / or over-compress a signal. The result is loss of clarity, lack of intelligibility, and unpleasant sounding audio. Think "less is more" when it comes to applying equalization and compression techniques.

Both equalization and compression can be used together to improve your success in establishing a communications link. However, it is customary to apply equalization first and then compression while evaluating the results.

## Equalization

We provided an example in Part 1 in which the lower and upper frequencies could be attenuated and emphasized in the settings in an Icom 7300.

The equalizer built into the 7300 is called a two-band equalizer. It has a bass band and a treble band. Unfortunately, the specifications for these two bands and the change in attenuation or emphasis are not provided, so experimentation is required to find the best setting for you. For more control in equalization, you might want to use an external equalizer that has more bands and are better specified, and its gain calibrated in dB. Experimentation is necessary when applying equalization, but we can always follow the general guideline of attenuate first, then emphasize.

We've already learned that consonants are the primary driving force of intelligibility. These higher-pitched, but generally weaker and shorter-duration, sounds are predominately in the range of 500 to 4,000 Hz.

The stronger vowel sounds are in the range of 500 Hz to 2 kHz. Vowel sounds or resonance, for a given individual, are a basic characteristic of that speaker's anatomy (vocal tract) and learned speech patterns (i.e., regional accents). The vowels that a speaker articulates are longer-lasting than the short-duration consonants and help integrate the consonants into syllables and words. Vowels provide resonant substance and make the language pleasant to our ears.

While vowel sounds are a lesser contributor to intelligibility than consonants, it doesn't mean that the 14 vowel sounds we have in the English language are unimportant to intelligibility. For example, consider the single-syllable words *boot* and *boat*. The different vowel sounds of *oo* and *oa* provide the bridge between the two consonants to provide a much different sounding word and meaning. Because vowels are of longer duration than consonants, our ears are better equipped to detect and differentiate their sounds.

Keeping these thoughts about consonants and vowels in mind, here are some guidelines for initial settings of an external equalizer:

For high SNR QSOs (*Photo B*):
Cut or attenuate strongly (> 10 dB) below 200 Hz, and
Emphasize lightly (up to 2-6 dB) in a monotonic manner between 750 to 3 kHz

For all other QSOs (*Photo C*):
Cut or attenuate strongly (> 10 dB) below 300-500 Hz, and
Emphasize moderately (up to 5-10 dB) in a monotonic manner between 750 to 3 kHz

While these settings work well with our stations, microphones, and voices, you may require different adjustments. Don't be afraid to experiment. When applying equalization, be sure to readjust your mic gain as the attenuation and emphasis affect the overall level of the signal.

Finally, when applying an external equalizer and your transmitter has an internal equalizer, set the internal equalizer to the flat or neutral settings. That is, don't use both. Your objective in applying equalization is to create a clear and easily understood audio signal, but be aware, the fidelity of your equalized audio will be different than before equalization was applied.

## Compression

The action of ALC combined with equalization has already resulted in compression or reduction of the dynamic range of our signal. The objective of additional compression is to achieve increased loudness at the receiver by increasing the average-to-peak signal power level. We are willing to give up some degree of fidelity for this increase in received SNR.

The Fletcher-Munson loudness study in 1933 resulted in the famous set of curves shown in *Figure 13*, which has been refined over the years and codified in 1956 to the ISO 226 standard.[3] This curve shows that our hearing sensitivity is best in the regions where vowels and consonants reside. Yet when applying compression, we are increasing the loudness of all frequencies. Hence, for this reason, its best to apply equalization before applying compression.

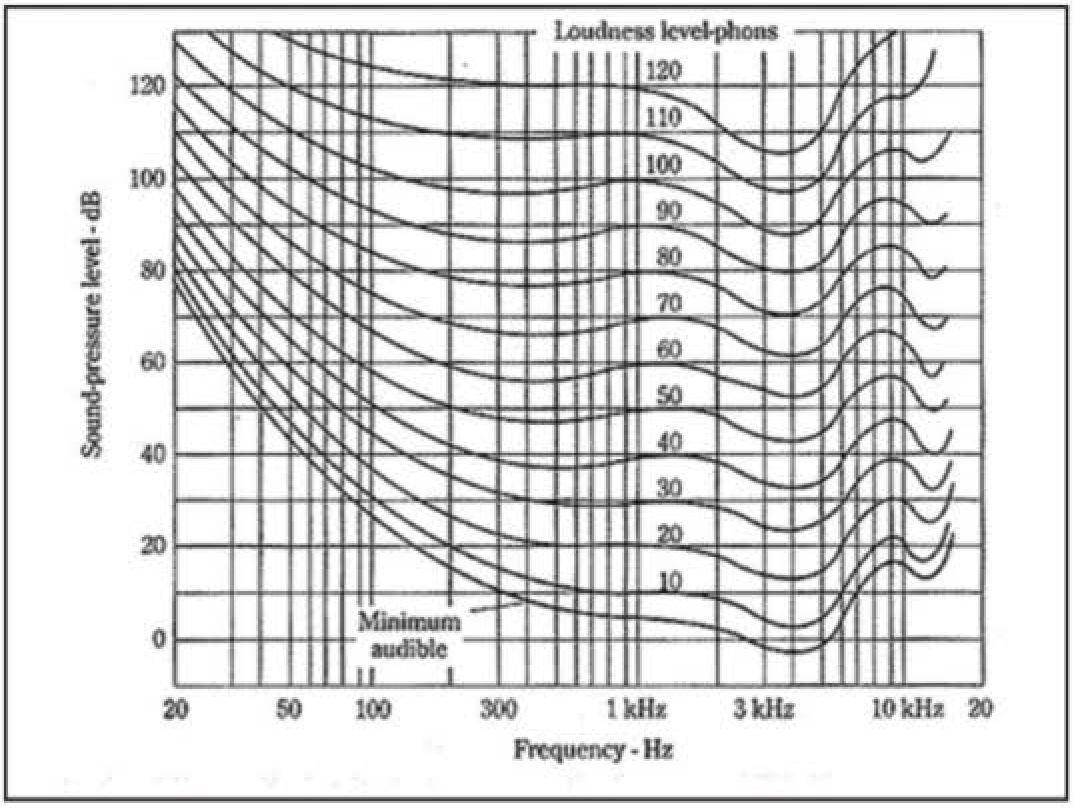


*Figure 13. Fletcher-Munson loudness curves (Credit: Wikipedia)*

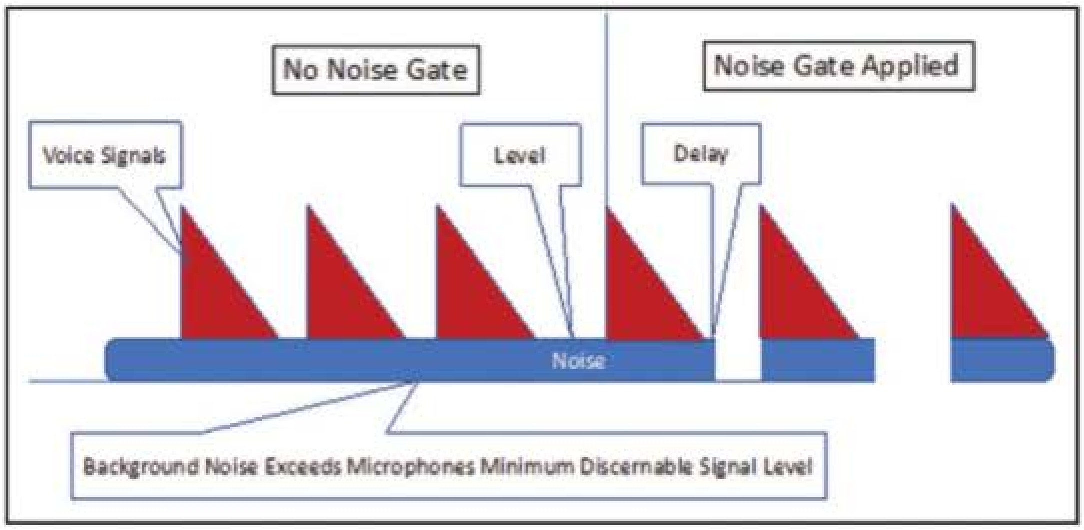


*Figure 14. Noise gate operation (Credit: Gary White)*

Compression can be applied in either the audio or RF stages of a transmitter. Theoretically, either achieves an increase in loudness. If you have a choice, try each (not at the same time of course!) and do some over-the-air tests to see which method you prefer. Our favorite over-the-air test is to transmit a test signal while recording it from an SDR receiver on <websdr.net>.

Many compressors employ limiting or clipping circuitry that can lead to distortion and even signal splatter outside of the desired passband if too much compression is applied. It's impossible to characterize all situations since your transmitting system (voice, microphone, transmitter, and speech processer) may vary. A moderate application of 8-14 dB of compression seems to work best for most radio-microphone-processing systems with typical voices.

Applying too much compression can also reduce intelligibility even if it doesn't create splatter. The received audio sounds muffled and, while louder, words and syllables will be misunderstood. If you don't apply enough compression, the difference in loudness or change in received SNR may not be apparent. As in the case of equalization, after applying compression, go back and check / adjust your microphone gain as necessary.

## Noise Gate

The term *noise gate* is a misnomer. It should really be thought of as a *noise block*. A noise gate neither increases intelligibility nor changes the characteristics of your voice, but blocks background noise from being transmitted when you are not speaking.

A noise gate has two settings, usually called *Level* and *Delay*. When a noise gate processor is applied and you speak, your spoken voice exceeds a specified threshold level and is passed to the transmitter. When you stop speaking, a delay threshold holds the gate open for a small period and then begins to block the background noise (*Figure 14*).

Think of a noise gate as a squelch control, but on the transmit side rather than the receive side. A noise gate only eliminates annoying noises during lulls in the spoken voice. Please note, when you speak, the background noises are still present in your transmitted signal and may still be objectionable. Common solutions are to either reduce the background noise or use a less sensitive microphone while talking closer.

A solution to excessive background noise is to use two microphone elements placed back-to-back and operated 180° out of phase. Most aviation headsets use this approach to achieve a noise-cancelling microphone. They can be obtained in both electret and dynamic microphone implementations. When using an aviation headset mic with a noise-cancelling element, you must speak very close (about 1/8 to ½ inches) to the microphone.

## Additional Instrumentation and Monitoring

There are many methods to monitor a transmitted or received SSB signal. Many modern transceivers have incorporated time (oscilloscope) and frequency domain (waterfall and spectral) displays. The introduction of software-defined radios (SDRs) has made such displays common in even modestly priced transceivers (*Figure 15*). A word of caution, though. Many such built-in displays are at the audio or baseband level and not at the radio frequency (RF) level. It is still possible to overdrive your transmitter or linear amplifier when these displays indicate a clean signal. External sampling of the RF energy before the antenna and measuring with either an oscilloscope or a spectrum analyzer provides the complete picture of the transmitted signal. Used in conjunction with the ALC meter or indicator, valuable insight can be obtained about the quality of your SSB signal.

## Conclusion

Application of audio signal processing is best summed up as a mix of subjective adjustments and techniques based on the science of the spoken and heard human voice. That is, getting a good SSB signal is a mix of art and science. Don't be afraid to mix art with amateur radio. From our own experiences, we've found that a little bit can go a long way, especially when it comes to compression. But most of all, don't be afraid to experiment and try new ideas in your quest for SSB utopia. After all, that is a big part of what makes amateur radio enjoyable.


*Figure 15. Icom 7610 SDR audio scope display of waveform and spectrum (Credit: Gary White)*

Notes:

1. "Microphones and Audio Speech Processing for SSB, Part 1 – Microphone Types, Use, and Selection," White and Hinkle, *CQ*, January 2022, p. 56
2. Spectrum Lab Website <https://tinyurl.com/54kk7fes>
3. "Factors Governing the Intelligibility of Speech Sounds," N. R. French and J. C. Steinberg, Bell Telephone Laboratories, New York, New York (Nov 22, 1946)

## Down

3. Quintessential name for an Italian cafe overlooking the Bay of Fundy
4. After poking a hive in Mauritania, the fennec fox's nose was covered with _______
6. The ______ on an object is equal to its mass times its acceleration in France
7. A humble home in Minnesota
8. Overactive Ego or custom callsign in Nova Scotia
9. Initials of the second-best grade of cognac in Namibia
12. Metal tossed in a fountain in Havana
13. Can cause "rusty" metals in Kalaallit Nunaat
15. The Greek LCD projector had inputs for VGA, HDMI and ________
16. Where the Siberian hockey club played all of its matches
20. The _______ oil passed through the Bosporus Strait
21. After robbing a bank in Wisconsin
23. In bad shape after heavy drinking in a Texas bar
24. Previous CCCP or USSR depending on the language of abbrev.
28. Reunion Island Ami
31. The yacht left Tripoli and _______ east to Alexandria
32. Burning strongly and brightly in Paris
34. When the wind blew through the graveyard, he thought he heard in Newfoundland
35. Eight in a cup and sixteen in a pound in Copenhagen
37. His old war ________ caused him to limp around his Kansas farm
41. Not harder in Barcelona
44. His midwestern friends said he was __ ___ to be around (2 words)
45. Bother in the Netherlands
46. Dostoevsky in French Guiana

*(Answer Key on page 58)*

## Looking Ahead In CQ

Here are some of the articles we're working on for upcoming issues of *CQ*:

- Results: 2021 CQ WW RTTY DX Contest
- HF Activities for Techs
- Profile: Southwest Ohio DX Association

*Plus …*

- The NinoTNC and Old-School Packet
- Updates on 630 / 2200 Meters and Crossing the Pond
- Using Vitamin K (as in Kirchhoff)

*Upcoming Special Issues*

June: Take it to the Field
October: Emergency Comm.
December: Technology

Do you have a hobby radio story to tell? Something for one of our specials? *CQ* covers the entire radio hobby. See our writers' guidelines on the CQ website at <http://bit.ly/2qBFOdU>.

# BEHIND THE BYLINES...

### *… a little bit about some of this month's authors*

James Green, WB9HDH ("Five Watts and a Dipole," p. 8), returned to active hamming last year after a 40-year absence from the bands, as he explains in his article. A retired technical writer, James operates exclusively QRP CW. He lives in Wauwatosa, Wisconsin.

Gene Hinkle, K5PA ("QRP FT8 to the Field," p. 10 and co-author of "Microphones and Audio Speech Processing for SSB," p. 45), is a regular contributor to *CQ*, often teaming up with other authors to share their joint projects. His many ham radio interests can be found on his webpage, <https://www.k5pa.com>.

Steve Galchutt, WGØAT ("QRP Quickies: A Great Introduction," p. 16), has been a ham since the 1950s and is well-known in the QRP and SOTA (Summits on the Air) communities for his goat-assisted hikes to operate from various mountain peaks in Colorado.

Paul Keon, AB4PP ("QRP Quickies: '35,000 Miles Per Watt' and 'Did I Mention it Was Raining?'" p. 17) is an active member and official storyteller ("scribemeister") of the North Carolina-based Knightlites QRP Society. He is a retired state trooper and enthusiastic quilter as well as QRPer.

Zvi Segal, 4Z1ZV ("Love Island DXpedition – 4X100AI," p. 32), enjoys off-roading, photography, and 3D printing in addition to ham radio. Since 2019, he has been active on the geostationary QO-100 amateur satellite, which was a significant part of the expedition he writes about in this issue. He lives in Raanana, Israel.

Gary White, W5GW (co-author "Microphones and Audio Speech Processing for SSB," p. 45), is a retired Professional Engineer. His interests beyond ham radio include photography, astronomy, and fiction-writing. He has published a novel and won awards for his short stories. His webpage is <https://w5gw.com>.