Tones: The Keys that Unlock Repeaters

If you're using an analog FM handheld transceiver, or an FM mobile or base radio to reach repeaters, chances are your radio is transmitting a special tone along with your voice. It's a pure musical note, but no one will hear it, because it isn't intended for human ears.

Don't worry — your radio hasn't gone renegade. On the contrary, you will have programmed your transceiver to send this tone each time you press the push-to-talk button.

Why would you do this? The answer is simple: If you don't program your radio to send this tone, called a CTCSS tone, the repeater you're trying to reach won't repeat your signal. In fact, it will ignore your signal entirely.

CTCSS stands for the *Continuous Tone Coded Squelch System*, which is quite a mouthful for something that is surprisingly straightforward.

CTCSS was created to reduce interference between stations operating on the same frequency, or in areas where several repeaters may have overlapping coverage. CTCSS uses a set of tones at low audio frequencies. The highest tone in common use is at 250.3 Hz; the lowest is at 67 Hz. All the available tones are listed in Table 1.

The receiver of a repeater that uses CTCSS is constantly "listening" for the designated tone. If a transmission isn't accompanied by the proper tone, the repeater won't respond.

Figure 1 shows an example of a mobile operator cruising through an area covered by two FM repeaters using the same input frequency (the frequency you transmit on). When she drives through the coverage overlap zone, both machines will hear her signal, and both will respond, activating their transmitters and relaying her signal. As a result, the conversation our driver intended for Repeater B will be heard by listeners of Repeater A as well, whether they like it or not!

Thanks to CTCSS, our mobile ham can set her FM radio to transmit a 100 Hz tone that only Repeater B will recognize. Repeater A, which is set up to respond to a 77 Hz tone, won't re-transmit her signal and will therefore remain silent. Everyone is happy.

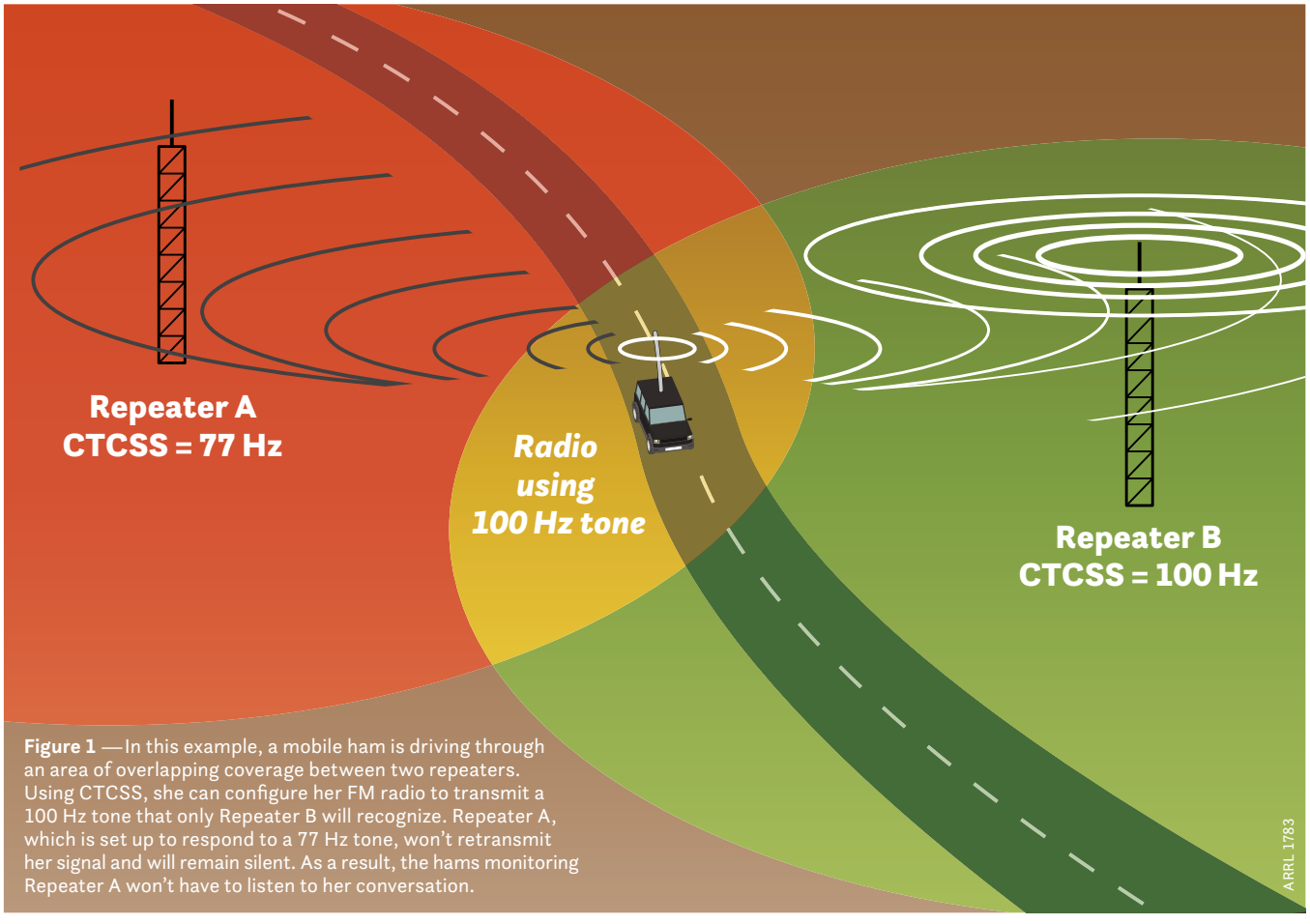


Figure 1 — In this example, a mobile ham is driving through an area of overlapping coverage between two repeaters. Using CTCSS, she can configure her FM radio to transmit a 100 Hz tone that only Repeater B will recognize. Repeater A, which is set up to respond to a 77 Hz tone, won't retransmit her signal and will remain silent. As a result, the hams monitoring Repeater A won't have to listen to her conversation.

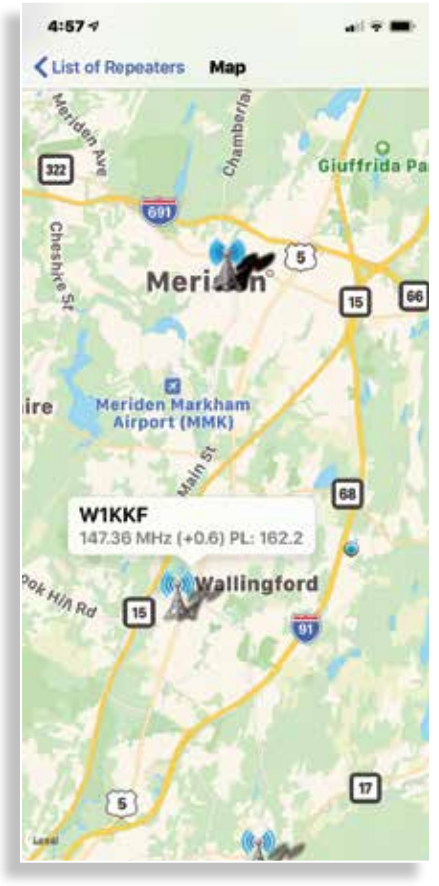


Figure 2 — A repeater map screen from the RFinder smartphone app. Notice that the W1KKF repeater is using a 162.2 Hz CTCSS tone, although here the tone frequency is labeled "PL."

Tone Squelch

In addition to listening for CTCSS, repeaters often transmit CTCSS tones of their own to solve interference issues. Let's say you live in an area where you can occasionally hear a distant repeater on the same frequency as your local repeater. If the local repeater is transmitting a CTCSS tone and your transceiver has a CTCSS *tone squelch* feature — most do these days — you can set the squelch to "open," or let transmissions through, only when it receives the CTCSS tone from the local repeater. That way, you'll never hear sporadic bursts of conversation from the distant machine.

And you'll never hear the CTCSS tones sent by the repeater, either. Just like the repeater's receiver, the receiver in your FM radio is designed to decode CTCSS tones and discard the low-frequency audio before it reaches your speaker.

You can program your radio to send CTCSS tones automatically. Many transceivers can also be programmed to activate a CTCSS tone squelch. When the tone squelch is on, the radio will remain silent until it receives a signal that includes the proper tone.

The ARRL Repeater Directory and the RFinder app (available for iOS and Android) list tone frequencies for every repeater system that uses CTCSS (see Figure 2 for a sample RFinder screen). If a repeater is using different CTCSS tones on both its input and output, the frequencies are shown with a slash between them. The CTCSS input frequency is on the left and the output frequency is on the right. For example, "77/123."

Programming Your Radio for CTCSS

Every transceiver has its own way of dealing with CTCSS, but there are commonalities. In most cases, you'll program your radio's memory channels for the repeaters in your area and include the correct CTCSS tone for each one. Let's say you want your radio to receive transmissions from a repeater that operates on 147.360 MHz. The process might look like this:

- Find the repeater's listing in *The ARRL Repeater Directory* or the RFinder app. In this case, you'll see a + sign, which means that the repeater is listening 600 kHz *above* 147.360 MHz, or 147.960 MHz (147.360 + .600 = 147.960 MHz). A – sign would mean the repeater's receiving frequency is *below* its transmitting frequency. So, for this example, 147.960 MHz is the frequency your radio needs to transmit at.

This difference between a repeater's transmitting and receiving frequencies is called its *offset*. Without going too far off the topic, suffice it to say that each frequency band has a set of common repeater offsets, although these can vary quite a bit. That's why it pays to check the *Repeater Directory* or the RFinder app. On the 2-meter band, the common offset is 600 kHz.

PL From Back in the Day

The CTCSS system was developed decades ago by the Motorola Corporation, and was originally called *Private Line*, or *PL*. You'll still hear veteran hams refer to CTCSS as "PL."

Table 1
Commonly Used CTCSS Frequencies (in Hz)

67.0	69.3	71.9	74.4	77.0	79.7	82.5	85.4	88.5	91.5
94.8	97.4	100.0	103.5	107.2	110.9	114.8	118.8	123.0	127.3
131.8	136.5	141.3	146.2	151.4	156.7	159.8	162.2	165.5	167.9
171.3	173.8	177.3	179.9	183.5	186.2	189.9	192.8	196.6	199.5
203.5	206.5	210.7	218.1	225.7	229.1	233.6	241.8	250.3	254.1

■ Program the repeater's transmitting frequency (147.360 MHz in this example) into an available memory channel. You won't need to program the offset frequency — the frequency your radio will be transmitting on — because your radio will set that for you automatically. Before you are finished, however, you must select the CTCSS tone frequency according to what is listed for your repeater. Let's say it is 100 Hz.

■ Activate your radio's Tone function, select the CTCSS tone frequency from the preprogrammed list, then save the memory channel. That's it! Each time you transmit using that memory channel, your radio will not only send and receive on the proper frequencies, it will send the 100 Hz tone. The repeater will hear the tone and relay your signal.

Of course, these steps are only meant to be general guidelines. Check your transceiver's user manual for instructions on how to program a memory channel.

Silence is Golden

If a repeater transmits its own CTCSS tone, you can use that tone to keep your radio silent unless the repeater is active. This is handy if you live in an area with lots of unwanted signals. Using our memory programming example, you can activate your transceiver's tone squelch so you will only hear audio when the proper tone is received.

For example, let's say your local repeater transmits a tone at 77 Hz. You can program a memory channel to include a tone squelch at 77 Hz. (Once again, check your user manual for instructions about how to do this.) Your radio will remain silent until it detects a signal carrying the 77 Hz tone. When it does, the radio will suddenly come to life and you'll hear the signal.

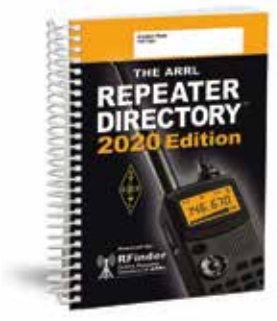
CTCSS tone squelch isn't just for repeaters. You could use it on a direct station-to-station *simplex* frequency. Maybe you have a friend across town that you talk to occasionally. You could program a tone squelch for say, 123 Hz, on the frequency you use for your chats. At the same time, your friend could program her radio to transmit that tone each time she presses the push-to-talk button.

Your radio will be silent until it receives that 123 Hz tone from your friend. All other signals on the frequency will be ignored.

Why Can't I Hear It?

We don't hear CTCSS tones coming over the repeaters with every transmission because repeaters sharply reduce (or *roll off*) low-frequency audio after they process the CTCSS tones.

Find your local repeaters in *The ARRL Repeater Directory* (arrl.org/shop) or the Rfinder app.



HAMSPEAK

CTCSS Continuous Tone-Coded Squelch System
Also referred to as Private Line, a Motorola trade name.

Offset
The difference between a transmit and receive frequency. On the 2-meter frequency band, for example, the common transmit/receive offset for repeater operating is 600 kHz. For example, a repeater that is transmitting on 146.64 MHz is listening 600 kHz below that frequency, or 146.04 MHz.

Simplex
Direct communication between stations on the same frequency.

Squelch
A circuit that suppresses the output of a radio receiver if the signal strength of the transmitting station falls below a certain level.

Tone Squelch
A circuit in a repeater or transceiver that responds to the presence of a specific tone by allowing the signal accompanying the tone to be retransmitted (in the case of a repeater) or heard in a speaker.