

Understanding FM squelch systems

CARES General Meeting: 2025-10-09 (short form)

Agenda

- We'll be considering FM systems only
- Noise
- What is squelch and what does it do?
- Noise squelch
- ~~CTCSS~~
 - ~~Aside - CTCSS tones - for accessing repeaters~~
- CTCSS tone squelch and how it relates to our operations
- Questions

Not covering: carrier squelch, DCS or other squelch functions

Noise - what is it?

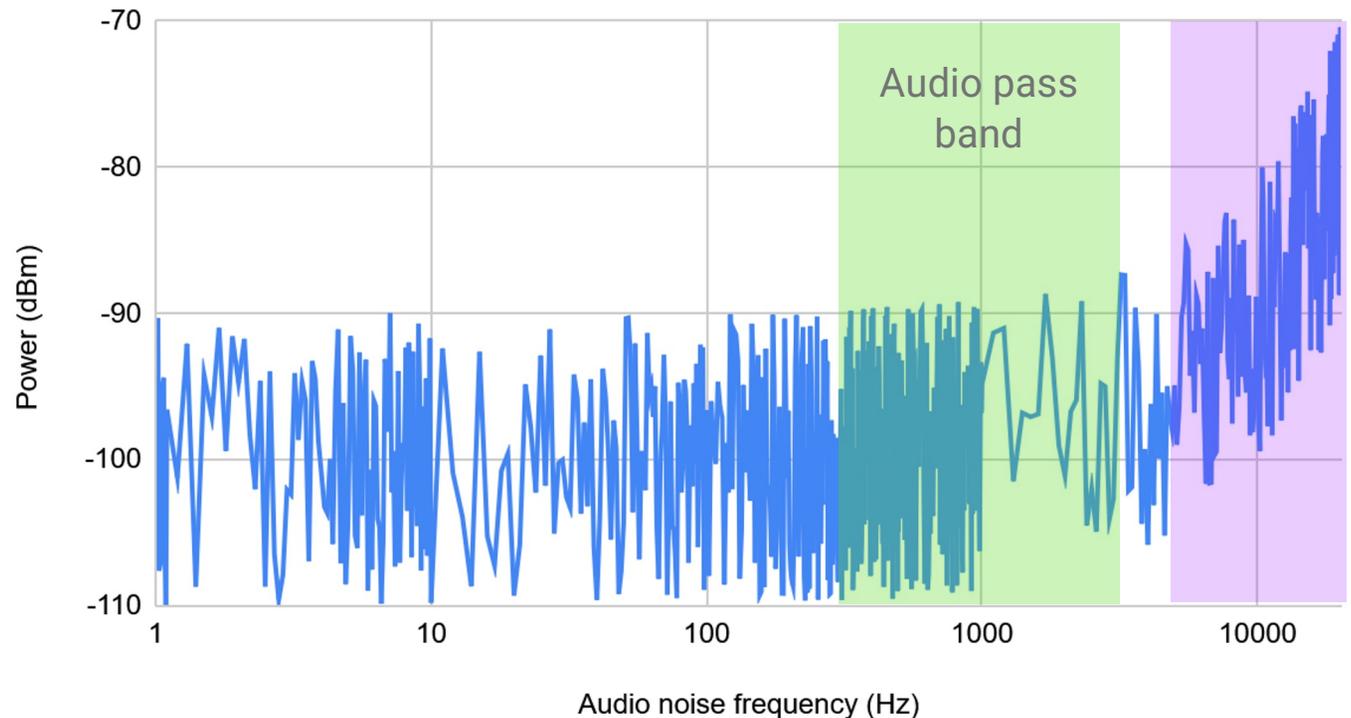
Unfiltered audio noise over an FM channel

Unfiltered audio noise spectrum over a whole 20 kHz FM channel

Noise at higher frequencies generally has higher power

Modulated RF with **greater power** at receiver can **quiet** this noise

Unfiltered audio noise spectrum over an FM channel



What causes noise?

Everything.

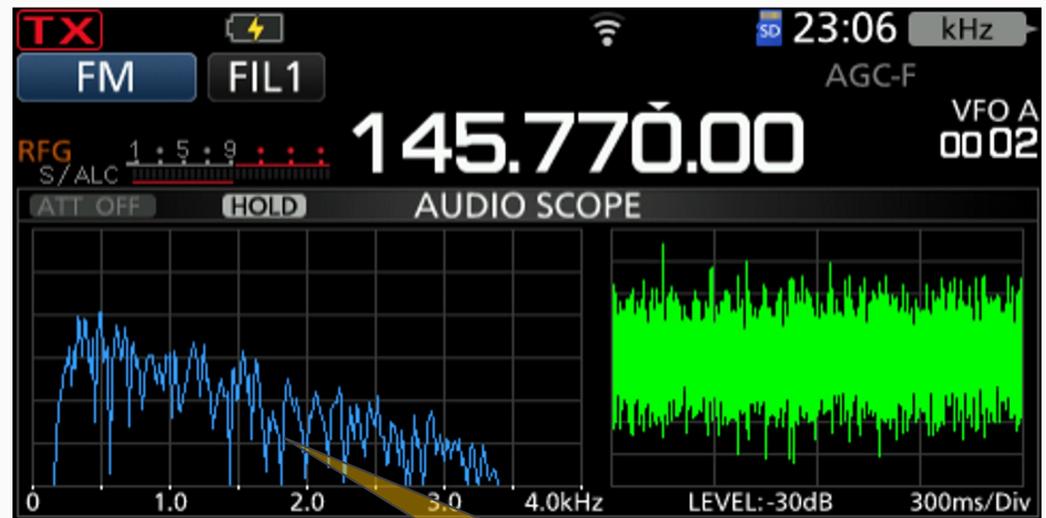
Pretty much, but what are some examples?

Uniform. But it looks like this on my radio's spectrum!

Decodes to uniformly distributed random audio frequencies in **pass band**

- aka: white noise

Unlike a transmitted signal, noise in the pass band is not pre-emphasised



Audio noise spectrum - uniform, really???

Squelch - what is it?

FM radio comms: what is squelch?

A **receiver** function set to **mute audio output** when there is:

- an absence of an **adequately strong** modulated signal
- or, the absence of an adequately strong, **specifically-encoded** signal

The receiver's operator usually controls the squelch function

Noise squelch - what is it?

Noise squelch

Fact: Desired RF signals are usually much more powerful than the RF noise signal (SNR > 20 dB)

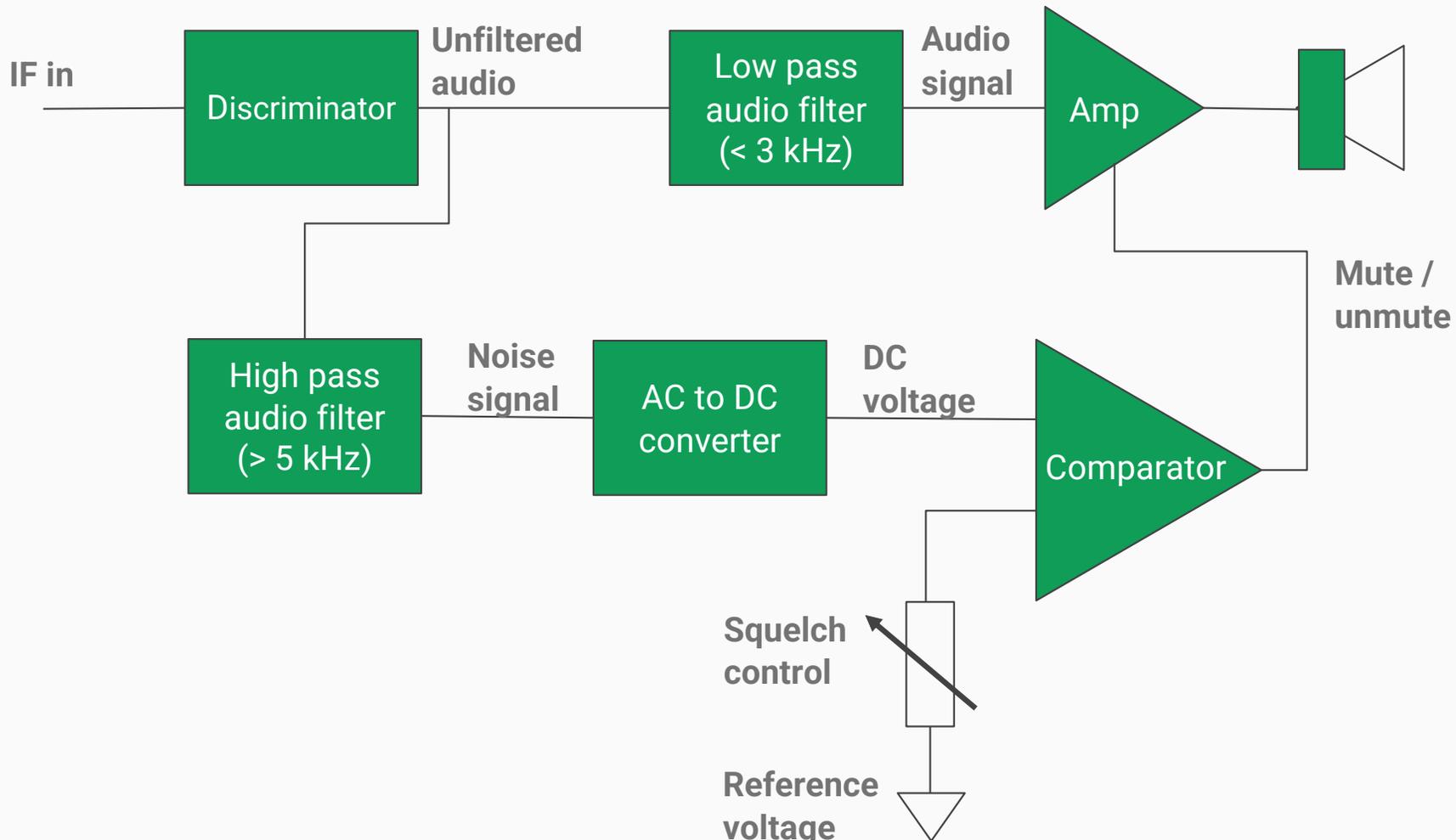
Mutes audio output depending on **noise audio signal strength**

- We usually mute audio noise by adjusting noise squelch level
- Many radios, many ways to set noise squelch level:
 - up/down buttons
 - Ring on volume knob
 - Menu settings
 - Old radios - presets
 - Tone-burst repeaters - level fixed by the operator prior to deployment

Noise squelch - how does it work?

- **Key idea 1:** Noise is distributed across the full audio frequency spectrum (20 Hz to 20 kHz)
- **Key idea 2:** Desired, in-range signal power is (usually) much, much greater than background noise power
 - FM quieting
- FM discriminator's limiting amplifier boosts demodulated audio signal's power to maximum **before** filtering.
- **Key idea 3:** Demodulated audio above 5 kHz > threshold?
Mute receiver output audio

Noise squelch block diagram



Noise squelch - a couple of questions for you:

When is it desirable to use noise squelch?

When is it not desirable?

CTCSS - wtf is it?

So, what is tone squelch?

Tone squelch

If tone squelch is **enabled** in a receiver:

The audio output (speaker) is always muted unless received audio signal is accompanied by a specific CTCSS tone

Corollary: Transmitting station must mix correct CTCSS tone into signal to unmute a tone-squelched receiver's audio

Note 1: you don't hear the tone - your receiver filters it out.

Note 2: with many modern radios, the receiver's noise squelch filtering is bypassed when using tone squelch

What is tone squelch used for?

Can be used for simplex networks:

- A functional group **sharing** an analogue channel with other groups
 - Each group gets a different tone
 - Groups **can interfere** with each other - you just can't hear it
 - e.g. Wildland fires: useful for different functions within a division
- To mask other interference
 - Doesn't stop the interference
 - Effective communications relies on the FM capture effect

What is tone squelch used for?

Many repeaters actually transmit tone encoded signals:

- May be used when there is a **chance of hearing** nearby repeaters on the **same channel**
- Example: 444.300 MHz
 - Lake Oswego repeater - output tone: 82.5 Hz
 - Cathlamet (Longview) repeater - output tone: 118.8 Hz
- Listeners between the repeaters
 - Select one repeater by enabling tone squelch
 - Otherwise, they listen to both or a combination of both!

To use tone squelch

The transmitting station **must set a transmit tone**

Receiving station **should** set the **same receive tone**

Usually the
same



As a receiving station:

- **Rx tone + Tx tone**: you'll hear only the signal you want
- **No Rx tone**: hear the all signals on a frequency
- **Wrong Rx tone**: won't hear the signal you expect to hear

For example L02:

- 146.500 MHz
- 82.5 Rx and Tx tone

To use tone squelch

Most amateur radios have a tone squelch mode:

- (Almost always) Sets Rx == Tx tone
- Annunciator often:
 - **TSQL** for Alinco, Icom and Yaesu
 - **CT** for Kenwood
 - **C** for Baofeng

Baofeng, etc. allow Rx and Tx tones to be set **independently**

- Classic Baofeng menu options: R-CTCS and T-CTCS
- This also allows the operator to just set an Rx tone

Green plan channels with tone squelch

```
26, EVENT1, +, TSQL, 103.5
27, EVENT2, +, TSQL, 103.5
28, EVENT3, +, TSQL, 103.5
29, LO 1, +, TSQL, 82.5
30, LO 2, , TSQL, 82.5
43, MOLA 1, +, TSQL, 77.0
47, WEST 2, -, TSQL, 100.0
50, WILS 2, +, TSQL, 100.0
```

Many tone-accessed repeaters actually transmit tone-encoded signals too

Tone squelch with split tones

Rx tone \neq Tx tone

- **Don't see this often in amateur radio**
- **Quite a few GMRS repeaters run this way**
- Deters unauthorised repeater use
 - Repeater Rx access tone unpublished
 - Tone scanning only picks up the repeater Tx tone
- Many big 3 manufacturers DO NOT support split tones
 - Older Yaesu do have this feature (e.g. FT-7900)

Questions?

Appendix - Carson's rule for FM channel bandwidth

FM bandwidth is roughly twice the sum of max deviation and max modulating frequency

Example: 3.5 kHz deviation and max audio frequency of 2800 Hz

Estimated bandwidth = $2(3.5 + 2.8) = 2(6.3) = 12.6$ kHz.