2024-09-24 Hamlet Net - Why is FT8 Good for Weak Signals?

Announcements:

- Test Session Info
    - Next VE session is this Saturday, September 28th in the Clover Building at the Boulder County Fairgrounds, and starts at 9 am. t is a PVET session, so there is no fee to test. For more info, and to pre-register, see the Licensing/Testing page on the club web site, https://w0eno.org/, under the Education menu.
- Also on the 28th, Chuck is running a fox hunt from noon to 2pm. This one is different from normal in that you will have to find the operating frequency of the Fox by monitoring its APRS position reports for the fox, which will be operating at W0ENO-9 (which will be sent out approx. once every 15 minutes). The fox will also move approximately every 7-10 minutes to keep things interesting. Once you have the fox's frequency and general location, you can hunt it using RF as you normally would. For more information, see the club website at: https://w0eno.org/another-larc-fox-hunt-2/

  I did try using APRSDroid on my cell phone to decode APRS signals from my mobile radio using just the phone's speaker. It was able to successfully decode APRS packets, so you don't even need a radio with built-in APRS functions - just tune to 144.39 MHz! I don't know if there is a similar program available for Apple devices.
- Three new officers were elected at the last General Meeting. Bob Mathias, WA0JJC, is the new club Treasurer. Ed Mohrman, WA6EM, is our new secretary, and Steve Robbiano, N0FT, filled the new Member at Large Board position. We'll miss Pat and Don, but I'm sure the new guys will do a great job.
- We are still looking for volunteers for Santa on the Air - we can use elves who act as net control, as well as Santas. We've got a script for the elf, and a list of questions for Santa to keep the net going when Santa doesn't have anyone to talk to. No experience is necessary. You can even participate over Echolink as well.
- We have some volunteer opportunities available where you can help out LARC:
    - Photographer / videographer - record team activities and upload to web site / YouTube
    - Newsletter Editor - put together the monthly Splatter newsletter
    - Event Coordinator
- Chuck testing a Broadcastify instance at his house for the LARC repeater network: https://www.broadcastify.com/listen/feed/43650

- You can start earning your 2024 membership or future renewal by acting as NCS for at least 5 nets this year. You can run either this Tuesday night net or the Thursday night net (or both). We have scripts available for both, so all you need is a good connection into the repeater, and somewhere to keep track of names and call signs as people check in. If you're going to be on the net anyway, why not save some dough at the same time! There are four free memberships available for 2023, so don't wait to get started!

- Chuck has set a goal for the Club of running at least one activity a month. This can be a hands-on construction activity, an operating activity like Field Day, a fox hunt, or a special event station. The goal is to get people together to have fun with amateur radio! We have multiple locations at our disposal, as well as lots of Club equipment, so if you have an idea for something you think others hams would like to do, please let us know, and if you're willing to run it, even better!

- The Club is also looking for presentation topics for 2024. If you have any ideas, or better yet, would like to present, please let Chuck know and we'll get you on the schedule!

- All club activities are open to anyone - members and non-members. If you have questions, ask them on a net or **send email to elmer@w0eno.org**

Presenter: Bryan, AF0W

Topic: Why is FT8 Good for Weak Signals?

- Many hams have heard of the HF digital mode called FT8, as well as similar modes like FT4 and JS8Call, although they may or may not be aware of the capabilities they have for weak-signal communications

- Two of the main features of FT8 are its very narrow bandwidth and fast transmission time, but what makes it good for weak signal work?

Weak Signal or Low Power

- First of all,what does "weak signal" mean?

    a. Does it mean QRP or low-power operation?

    b. Not necessarily, although QRP operation can be weak signal

- What it really means is how the signal is received during a communication

- This can be impacted by many things, including:

    a. Transmitter power and antenna gain

    b. Propagation path

    c. Tropospheric and ionospheric conditions

    d. Local noise floor or noise level

    e. Receiving stations' antenna gain, pre-amplification, and radio filtering characteristics

- I found a reference to a distance record of one micro-watt over a distance of 1650 miles on 10 meters from Alaska to Oregon in 1970

    a. This is the equivalent of 1.6 billion miles per watt

    b. That was probably a very weak signal!

- Another area of weak signal work is called EME, which stands for Earth-Moon-Earth where amateurs reflect signals off the Moon

    a. Also referred to as "moonbounce," it is typically conducted on VHF and above

    b. The round-trip path loss is over 250 dB, so you better believe the signal received on Earth is weak indeed!

- One point of contention among hams is how much transmitter power should be used with FT8

    a. Note that it is a "weak signal mode" and not a "low power mode"

- Part 97 states that amateurs should use the minimum power needed to make a QSO

- Depending on propagation conditions, you might be able to make a contact using just 1 watt, or you may have to jump up to 100 watts to get through

    a. A recommendation is to try 10 to 30 watts and see how that works before increasing power

- The local noise floor at the receiving site has a very large effect on weak signals

    a. If you are experiencing significant noise at your location, it will tend to drown out weaker signals

    b. If you're able to take your station (or borrow the Club's GoBox) and take it up into the mountains away from the cities, you'll likely get much better results!

Error Detection

- One generic way of dealing with a lossy transmission medium (such as atmospheric propagation) is to use some sort of protocol that allows the receiving station to verify

whether it received the message that was sent, and control what it should do if it does not

- Many amateur radio digital protocols implement some form of error detection and correction
- Error detection allows the receiving station to determine whether the message was received correctly
    a. The receiver is not able to do anything to correct the message - it only knows that there is something wrong with it
    b. One simple example is called parity
        - An example would be if I had to communicate a single digit to you
        - Instead of just sending the digit, I could also indicate whether it was even or odd
        - If you thought you heard me say "5 even," then you'd know you misunderstood something
        - Parity is used by FT8 when exchanging messages
        - There is more than one hole in this method, for example, if I say "5 odd" and you hear "7 odd," you will think things are fine
    c. A somewhat more complicated method is called a "cyclic redundancy check" or "CRC" - in this case, a mathematical calculation is performed using the message data, the result of which is transmitted along with the data for comparison at the receiving side - this method is also used by FT8
- Error detection can also occur over voice - if your check in transmission gets garbled, and Net Control can only make out "AW," they know this is not a valid amateur call sign
- There are a number of different methods that attempt to address these issues, but the bottom line is that, at best, error detection will only tell you if something is wrong

Error Correction

- Error Correction is when the receiver notices an error and fixes it
- The simplest way this is handled with amateur radio protocols is for the receiver to transmit back either an acknowledgement, indicating the the data was received correctly, or a negative acknowledgement indicating it was not

    a. When the transmitter receives an acknowledgement, it sends the next message block

    b. When it receives a negative acknowledgement, it retransmits the last message

    c. This system is commonly called "automatic repeat request," or "ARQ"

    d. Some amateur digital protocols that use ARQ are packet radio and PACTOR

    e. Amatures also use this method on voice contacts - going back to the previous example during a net check in, when Net Control is expecting a call sign and heard "AW," they'll say something like "I heard a station with Alpha Whiskey - please come again" - this is a "retransmission request"

- Another way of dealing with errors is to include information in the message that not only allows the receiver to detect the error, but also to correct it

    a. This is called "forward error correction," or "FEC"

    b. The net check in procedure is an example of this - if there was static when you stated your call sign initially, Net Control could pick it up when you repeated it phonetically

    c. Amateur digital protocols such as VARA, PSK31 with QPSK modulation, and FT8 use FEC

- Forward error correction allows FT8 to handle both corrupted and weak signals

    a. It uses something called a low-density parity check code, or LDPC, consisting of 77 information bits, which is the message being transmitted, a 14-bit cyclic redundancy check, or CRC, and 83 parity bits, resulting in a 174-bit codeword

        - This is a lot of redundant information: 174 bits to send a 77-bit message

- FT8 also uses a synchronization signal to effectively fine tune the time and frequency between the transmitting station and the decoder which greatly improves the sensitivity of the receiver

- FT8 signals are reliably decodable with a signal-to-noise ratio as low as -20 dB

    a. The signal-to-noise ratio is the ratio between the desired signal and the background noise - the higher the ratio, the clearer the reception

    b. The noise portion is comprised of atmospheric noise and local man-made noise and RFI, or radio frequency interference, and frequently sounds like hash or a frying noise

    c. Keep in mind that for most humans, SSB voice requires about a +10 dB level, and that the audible threshold for digital signals (and for CW Morse code) occurs at a ratio of around -15 dB, meaning FT8 can decode signals that you cannot even hear

- While this is good, there are other WSJT-X modes that can decode even lower - down to -31 dB for WSPR

    a. The tradeoff is that the WSPR transmission duration is almost 2 minutes, compared to a 15 second FT8 transmission

- FT8 was designed specifically for propagation conditions where signals are weak and fading, openings are short, and quick confirmation of reliable, confirmable contacts is particularly desirable

Multiple Signals

- If you've used FT8, you've probably noticed that it does not just decode a single transmission, but rather all FT8 transmissions in the passband, or received bandwidth of your radio

    a. It can actually decode weak signals lying within 1 or 2 Hz of much stronger ones

- When a signal with strong forward error correction is decoded, WSJT-X can calculate its transmitted waveform exactly

- A version of that waveform can be subtracted from the received data and the decoder re-executed on the remainder of the signal allowing weak signals which were previously hidden by the stronger signals to be decoded

- Keep in mind that all of this signal processing has to occur within less than 2.5 seconds, as that is when your station needs to transmit a response

- You can also use your radio's built-in filtering capability to help with weak signals

    a. Narrow your radio's filters to focus on a particular digital signal - change to 500 Hz rather than the usual 3 kHz for SSB

    b. IF shift will allow you to shift the IF passband without changing the center frequency

    c. Lower the RF gain - this will filter out weaker signals

    d. Focuses filter / radio to look at one spot on the waterfall - can help you work weak stations

e. Watched a video from Jason, KM4ACK on Youtube where he made these changes and increased the incoming signal as indicated by JS8Call from -12 dB to +17 dB. Search Youtube for "KM4ACK improve weak signals"

Summary

- This is just scratching the surface of this topic. I've had to trim this presentation down multiple times because there is just so much that can be covered.
- I've included some links for more info in the notes for the presentation, which are available on the Club web site at: https://w0eno.org/ under the "Hamlet Net Topics" link under the "Tuesday Hamlet Net" menu item

Questions:

1. **The question for the week is:** Do you use FT8, FT4, or JS8Call, and if so, what is the furthest contact you've made with it?
2. **In my case,** I've actually not done a lot of FT8. Back when I got into HF digital, the big mode was JT65. Compared to FT8's 15 second transmission time, JT65's 1 minute transmission time gave you plenty of opportunity to look at the decoded signals and determine who you wanted to respond to.

   I do plan to get on the air and try some more FT8, but just haven't gotten around to it.

   I upgraded the computer in my shack, and while I copied the log files over, I haven't got them imported into any logging software yet. I took a look at my QSOs on Logbook of the World, and it looks like my longest logged contact was to a station in Australia on 40 meters using JT65, for a distance of 8005 miles.

   I did not log the power used - I imagine I had my 100 watt transceiver cranked up pretty high into my too-low wire dipole in my backyard. In those days, I would just keep increasing power while attempting to get through to the remote stations!

More Info:

- Does QRP really work? (North American QRP CW Club): http://naqcc.info/qrpworks.html
- Improve Weak Digital Signals (KM4ACK): https://www.youtube.com/watch?v=M7FEqS8QXIA
- Weak Signal (ARRL): http://www.arrl.org/weak-signal-vhf-dx-meteor-scatter-eme-moonbounce

- Earth-Moon-Earth Communication (Wikipedia): https://en.wikipedia.org/wiki/Earth%E2%80%93Moon%E2%80%93Earth_communication
- Weak Signal modes (ARRL): http://www.arrl.org/weak-signal-modes
- Cyclic Redundancy Check (CRC) (Wikipedia): https://en.wikipedia.org/wiki/Cyclic_redundancy_check
- Signal to Noise Ratio: http://www.k0bg.com/signal.html
- FT8 (sigidwiki): https://www.sigidwiki.com/wiki/FT8
- FT8 Operating Guide: https://www.g4ifb.com/FT8_Hinson_tips_for_HF_DXers.pdf
- FT8 (Wikipedia): https://en.wikipedia.org/wiki/FT8
- WSJT-X (FT8 software): https://wsjt.sourceforge.io/wsjtx.html
- Work the World with WSJT-X, Part 2: Codes, Modes, and Cooperative Software Development (Nov 2017 QST): https://wsjt.sourceforge.io/Work_the_World_part2.pdf
- The FT4 and FT8 Communication Protocols (July/August 2020 QEX): https://wsjt.sourceforge.io/FT4_FT8_QEX.pdf
- Packet (sigidwiki): https://www.sigidwiki.com/wiki/PACKET
- QRP (Low-Power Operating): http://www.arrl.org/qrp-low-power-operating
- QRP Operation (Wikipedia): https://en.wikipedia.org/wiki/QRP_operation
- JTSync (Windows time synchronization for WSJT-X): http://www.dxshell.com/jtsync.html
- JS8Call: http://js8call.com/
- JS8Call Time Sync: https://oh8stn.org/blog/2023/01/24/off-grid-js8call-time-sync-no-gps-or-ntp-needed
- Maidenhead Locator System (Wikipedia): https://en.wikipedia.org/wiki/Maidenhead_Locator_System
- Maidenhead Grid Locator Mapping: https://www.karhukoti.com/Maidenhead-Grid-Square-Locator/
- Synchronization in FT8: https://files.tapr.org/meetings/DCC_2019/2019-4-WB2FKO.pdf and http://www.sportscliche.com/wb2fko/TechFest_2019_WB2FKO_revised.pdf
- Costas Array (Wikipedia): https://en.wikipedia.org/wiki/Costas_array

Notes:

- If you have ideas for net topics or general meeting topics / presenters, please let us know! Tell us on a net, or send email to k0itp@w0eno.org

Email to elmer@w0eno.org

1. K0ITP - Chuck - Firestone
2. W7PGF - Philip - Frederick
3. AE0DO - John - N of Longmont
4. AF0W - Bryan - Longmont
5. KF0QMP - Aki - Longmont

End: 8:00pm