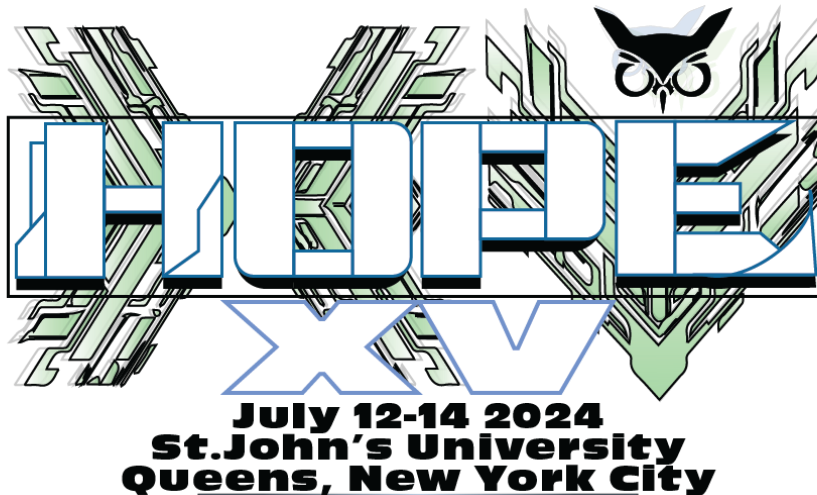


Using Amateur Radio Digital Modes

Joe Cupano, NE2Z

HOPE XV



Disclaimer

To perform any of the exercises within this workshop you either **MUST** have an FCC Technician Class license or greater

OR

perform the exercises under the supervision of someone holding an FCC Technician Class license or greater agreeing to act as control operator.

Disclaimer (2)

- Workshop attendees are required to have the pre-requisite hardware listed in the workshop. Please pair up with those who may not have kit.

Disclaimer (3)

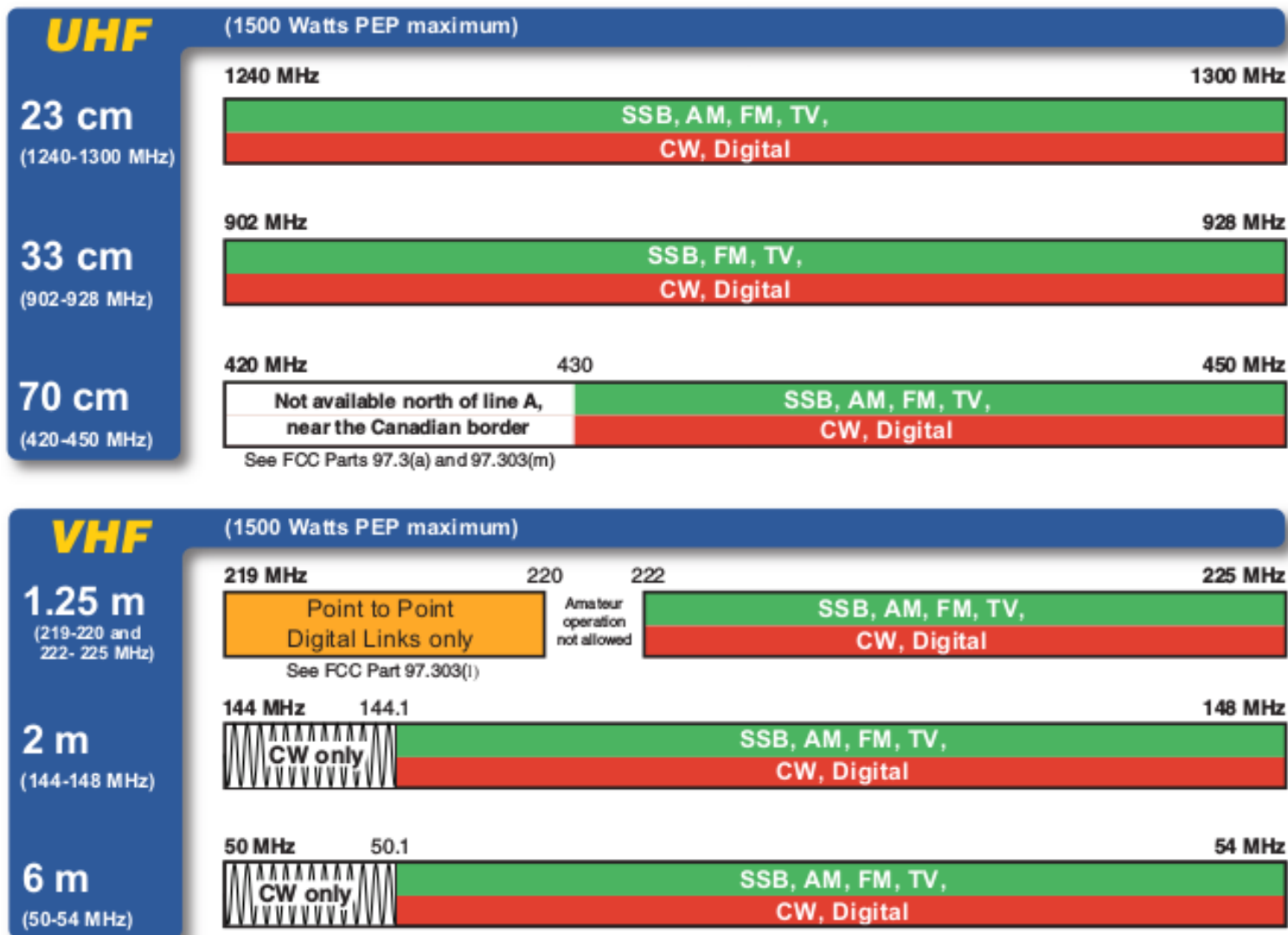
- Material provided does not present itself as an authoritative guide on the topic of Digital Modes and is an introductory only
- In some cases, we take the most expedient route in conveying an idea at the sacrifice of some technical detail to avoid confusion.
- The workshop is structured to provide a path of least resistance to quickly experience Digital Modes and inspire your interest in Amateur Radio.

Onward . . .

Overview of Amateur Radio

- Popular hobby and service that brings people, electronics and communication together
- Uses radio frequencies designated for licensed amateur radio operators for non-commercial exchange of messages, wireless experimentation, self-training, private recreation, contesting, and emergency communications
- Encryption is not generally permitted
- Is the only hobby governed by international treaty

US Technician Class VHF/UHF Privileges



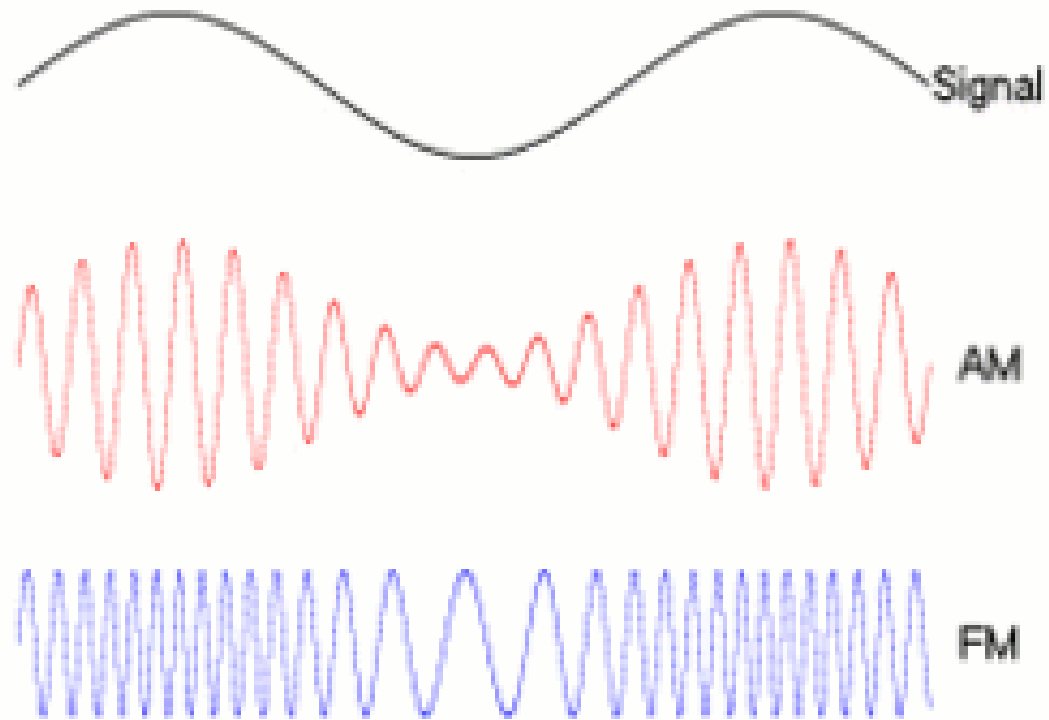
2 Meter Band Plan

2 Meters (144-148 MHz)

144.00-144.05	EME (CW)
144.05-144.10	General CW and weak signals
144.10-144.20	EME and weak-signal SSB
144.200	National calling frequency
144.200-144.275	General SSB operation
144.275-144.300	Propagation beacons
144.30-144.50	New OSCAR subband
144.50-144.60	Linear translator inputs
144.60-144.90	FM repeater inputs
144.90-145.10	Weak signal and FM simplex (145.01,03,05,07,09 are widely used for packet)
145.10-145.20	Linear translator outputs
145.20-145.50	FM repeater outputs
145.50-145.80	Miscellaneous and experimental modes
145.80-146.00	OSCAR subband
146.01-146.37	Repeater inputs
146.40-146.58	Simplex
146.52	National Simplex Calling Frequency
146.61-146.97	Repeater outputs
147.00-147.39	Repeater outputs
147.42-147.57	Simplex
147.60-147.99	Repeater inputs

Notes: The frequency 146.40 MHz is used in some areas as a repeater input. This band plan has been proposed by the ARRL VHF-UHF Advisory Committee.

Modulation

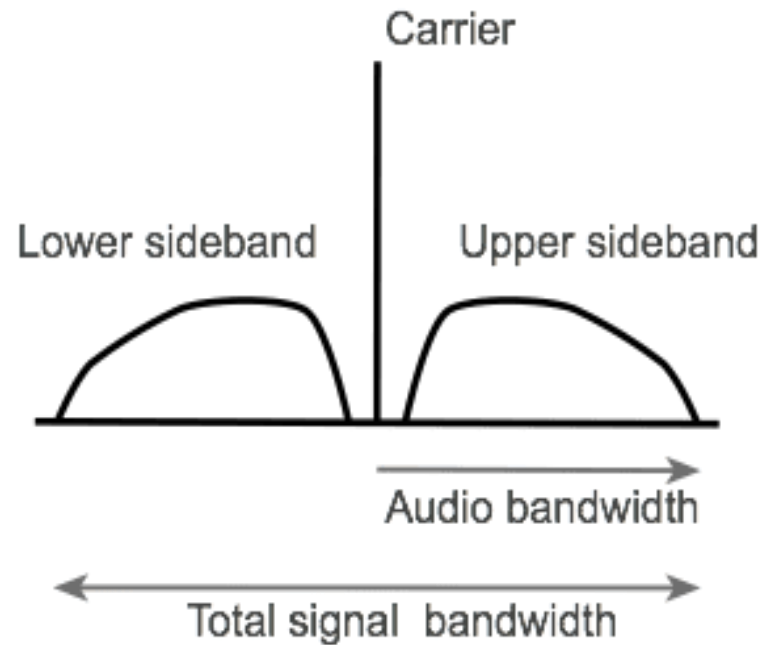


Bandwidth

- AM modulation produces upper and lower sidebands on either side of the carrier signal which can lead to a total bandwidth twice the highest audio signal, around 6 KHz.
- SSB is a refinement of AM that makes efficient use of power and bandwidth by suppressing the carrier signal and one of the sidebands
 - either Lower Sideband (LSB) or Upper Sideband (USB.)
- With radio spectrum a precious limited resource, the bandwidth of a signal limits how many simultaneous communications can occur within a given piece of spectrum.

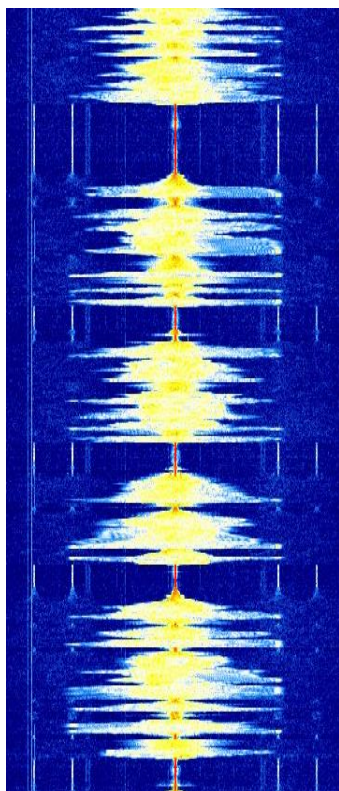
Bandwidth (2)

- FM 15 KHz
- AM 6 KHz
- SSB 3 KHz
- CW 100 Hz

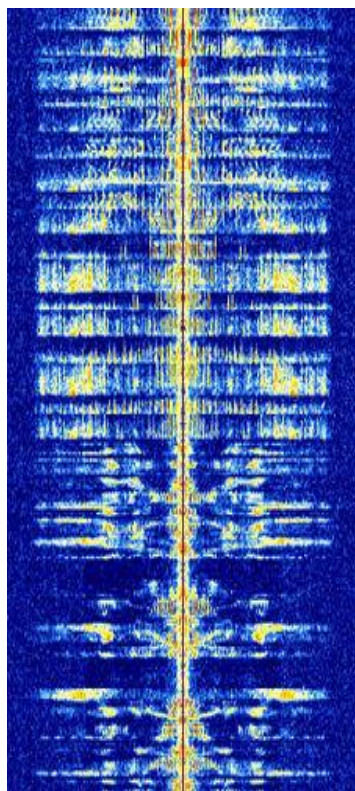


Modulation & Bandwidth Visual

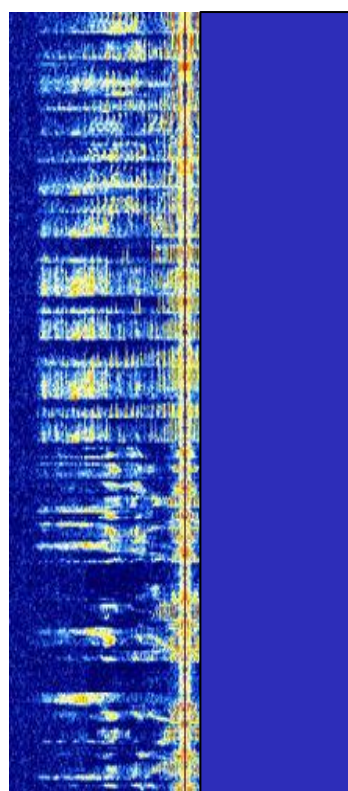
FM



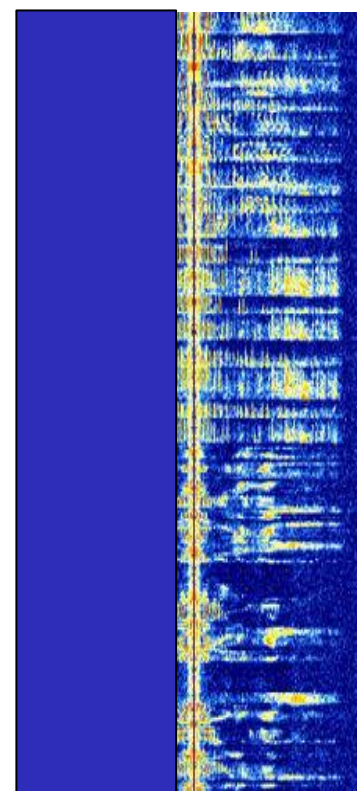
AM



LSB



USB



Performance

- Signals travel across an atmosphere fraught with natural and man-made phenomenon that can impact the integrity of a signal
- When we talk about performance in Amateur Radio communications, we are looking at the best way to communicate intelligence expediently and reliably without loss of integrity across varying atmospheric conditions using minimal power and making efficient use of radio spectrum.
- Performance is where digital modes excel.

Digital Modes

- Rooted in 1's and 0's in some fashion.
- Frequency Shift Keying (FSK)
 - Shifting the frequency of a signal with one frequency represent 0's and another representing 1's
- Audio Frequency Shift Keying (AFSK)
 - Differing audio tones upon a signal with one tone representing 0's and another representing 1's
 - Audio levels are critical to success
 - When audio levels set correctly AFSK presents the same signal as FSK

CW and Modulated CW (MCW)

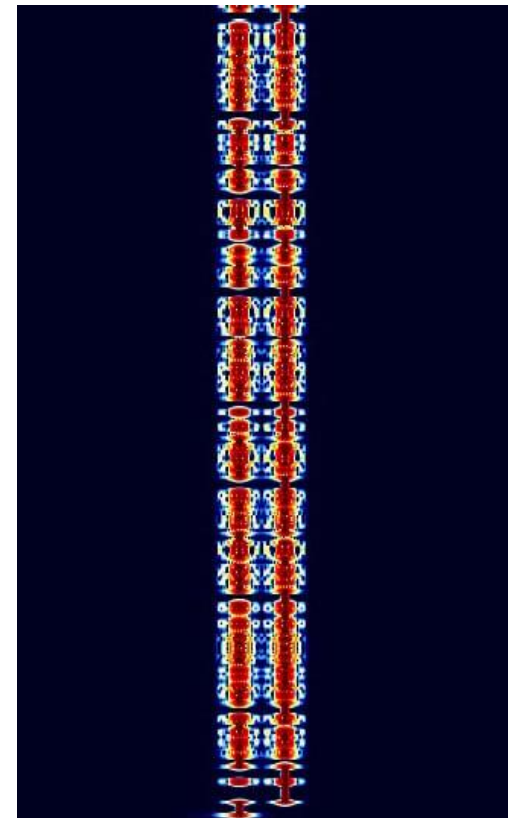
Modulated continuous wave (MCW) is Morse code telegraphy transmitted using an audio tone to modulate a carrier wave.

Continuous wave (CW), by contrast, does not use a subcarrier, so there is no emission at all between Morse code symbols



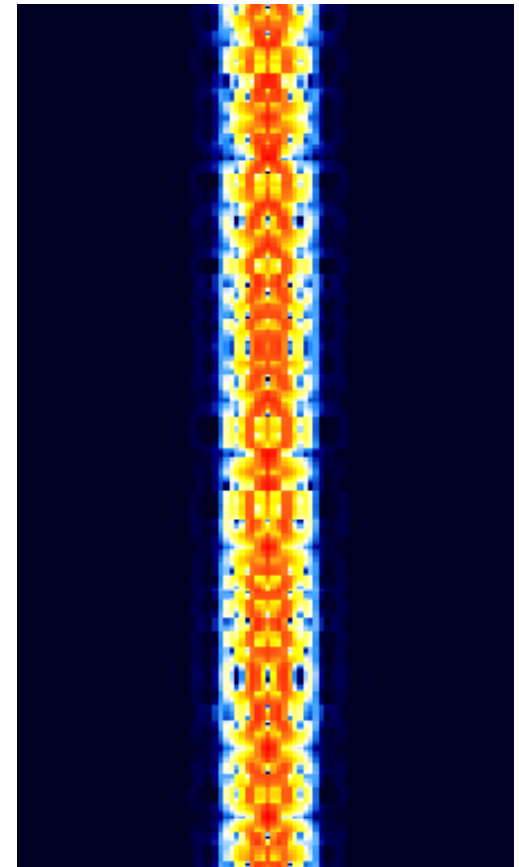
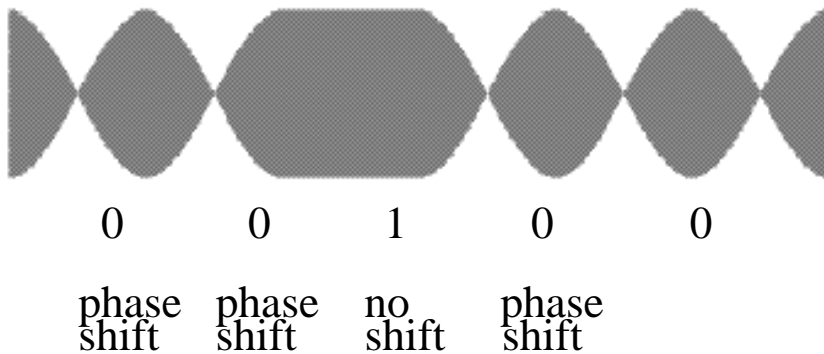
Radioteletype (RTTY)

- FSK signal that shifts 170 Hz.
- 1 is MARK frequency, 0 SPACE frequency.
- Baudot Character set
- Paper Rolls, Punch Tape, and a Bell.



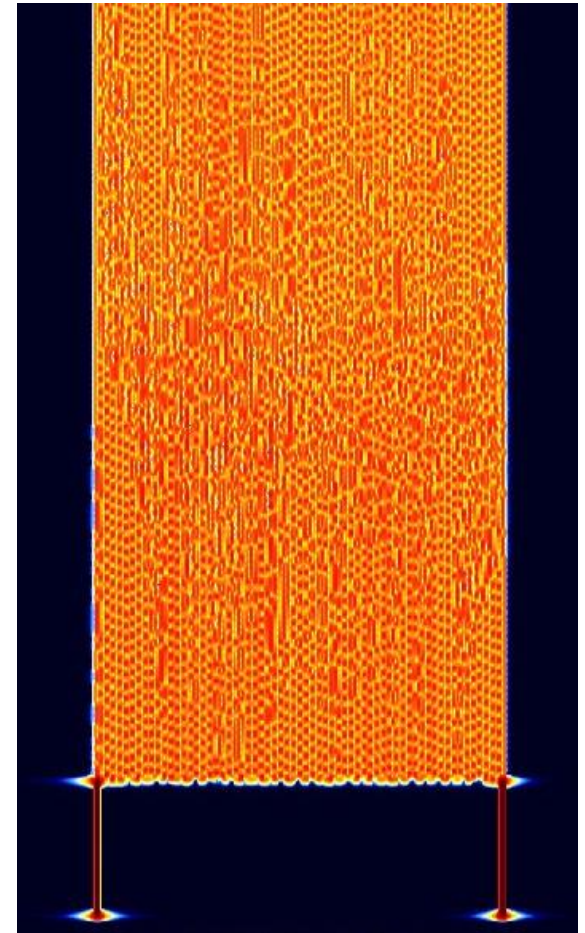
PSK31

- Uses binary phase shift keying (BPSK) and a special code (Varicode) to achieve character rates similar to RTTY (50 wpm) in a much narrower bandwidth
- Better error rate than RTTY on noisy channels
- Lower RF power requirement



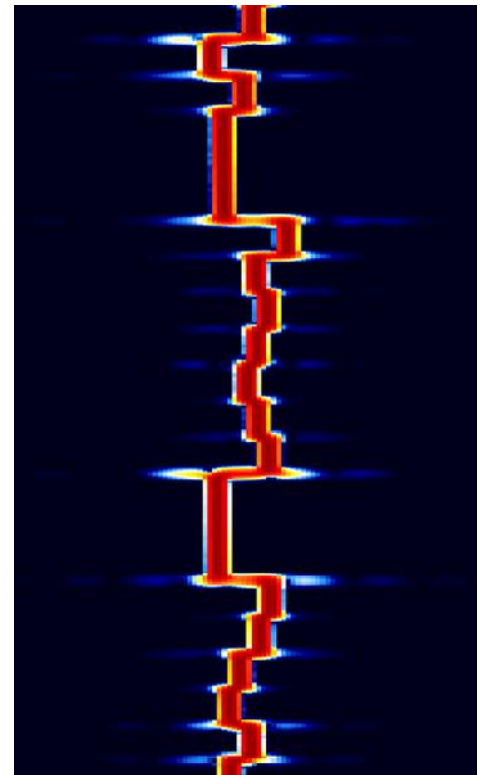
MT63

- Used on VHF/UHF by Amateur Radio Emergency Services organizations for message handling.
- The mode provides Forward Error Correction (FEC) and 2 KHz of bandwidth providing transfer rates of 1 KB/minute.
- I know the transfer rate does not sound like much compared to a WiFi connection but at this rate on VHF/UHF frequencies using an omni-directional antenna depending on terrain, range goes from tens of miles to a hundred miles.



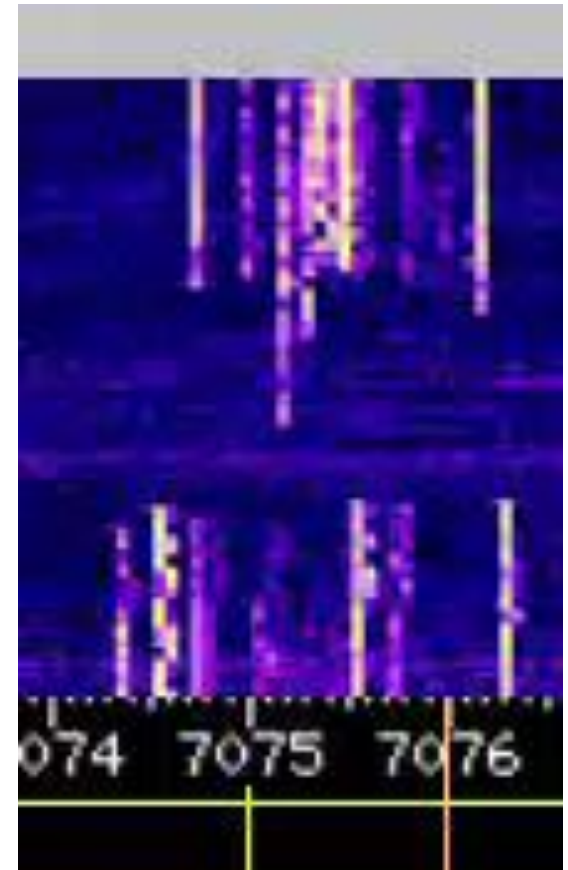
FT8

- Popular for its ability to send signals despite challenging propagation conditions, high noise environments, low power operations (QRP), or even compromised antennas.
- Transmits and receives only the bare essentials needed to make a contact in a semi-automated timed fashion.
- Not a "keyboard-to-keyboard" (real-time chat) mode.



FT8

- 80M on 3.573 MHz
- 40M on 7.071 MHz and 7.074 MHz
- 30M on 10.136 MHz
- 20M on 14.074 MHz
- 17M on 18.1 MHz
- 6M on 50.313 MHz and 50.323 MHz
- 2M on 144.174 MHz,
- 70cm on 432.061 MHz and 432.174 MHz



What about <INSERT MODE HERE>

- Did I say this was an introductory workshop
- Learning digital mode fundamentals is best when referencing established modes and understand the attributes that contribute to their longevity.
- No matter what protocol comes along, you have an understanding of its fundamentals.

Workshop Caveats

- We will be using AFSK for all digital modes so sound levels will be CRITICAL
- Using the VHF/UHF spectrum and low power eliminates band conditions as a variable to be considered in lab exercises.
- Since we will be using FM, we will be subject to a phenomenon known as the capture effect ,which will interfere with our ability to show how multiple signals simultaneously share a frequency as done on HF with SSB.

Labs

1. Setup and functional test of the Baofeng UV-5R radio
2. Setting up the USB Audio
3. Setup Digital modes software
4. Making your First Contact
5. Experimentation

Lab 1: Setting up the Radio

- Setup and functional test of the Baofeng UV-5R radio.

Lab 2: Setting up the USB Audio

- Setup and functional test of external USB sound device.
- Remember for many OS the MASTER level needs to be set as well.

Lab 3: Set up Digital Mode Software

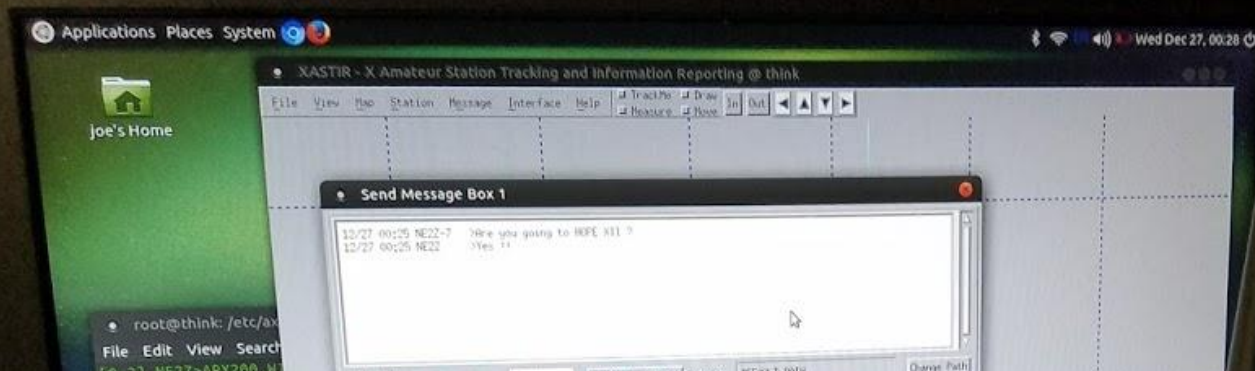
- Installation and setup of the digital mode software.

Lab 4: First Contact

- Keep checking Audio Levels.
- Frequencies we use in class
 - CHAN1
 - CHAN2
 - CHAN3
 - CHAN4

Lab 5: Experimentation

- Get familiar with various digital modes understanding their strengths and weaknesses.



Thank you !

