Amateur Digital Modes

Something for Everyone

Utah Digital Communications Conference

February 15, 2020

John Mitton (KK7L)

Agenda

What we <mark>will</mark> cover:

- "Newbie" background on essentials of modulation
- Review of the wide variety of modes commonly used
- Choosing modes which match your interests in the hobby

What we <mark>won't</mark> cover:

- Deep-dive into the WSJT modes
- Detailed software setup
- Topics covered in later sessions

FT8

Photo: Forbes – annotated ☺

Wide-Wide-World of Amateur Radio

Public Service
Emergency & Disaster Relief
Event Communications
Humanitarian Outreach
Education & Mentoring

Designing & Building
Antennas
Radios – Traditional & Software Defined
Programming & Interface Design
Remote Control Systems

HF
DXing
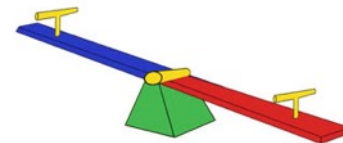Contesting
"Ragchewing" & Nets
QRP

VHF/UHF
Repeaters
Satellites
EME Moonbounce
Tropospheric Communications

Categories – Popular Published* Modes

WSJTX & Derivatives	Binary Transfer	Digital Audio	Text Transfer & Keyboard Chat	Image Transfer
FT8	PACTOR	D-STAR (voice)	CW	SSTV
FT4	Packet / APRS	DMR	PSK (31, 63)	ATV
WSPR	D-STAR (data)	System Fusion	RTTY	Feld-Hell
JS8Call	Vara (Winlink)	Radio Mondiale	AMTOR	
JT9 / JT65	Ardop (Winlink)		Olivia	
MSK144	Winmor (Winlink)		MT63	
ISCAT	Clover			

* Ref. § 97.309

Basics: Bandwidth

Trade-off between required bandwidth, throughput, S/N ratio

Minimum SNR, dB in 2500 Hz BW (SSB Filter)

- SSB: 6
- CW (casual): -5
- RTTY/PSK31: -9
- CW (DX): -15
- FT8: -20
- JT65: -24
- JT9: -27
- WSPR: -32
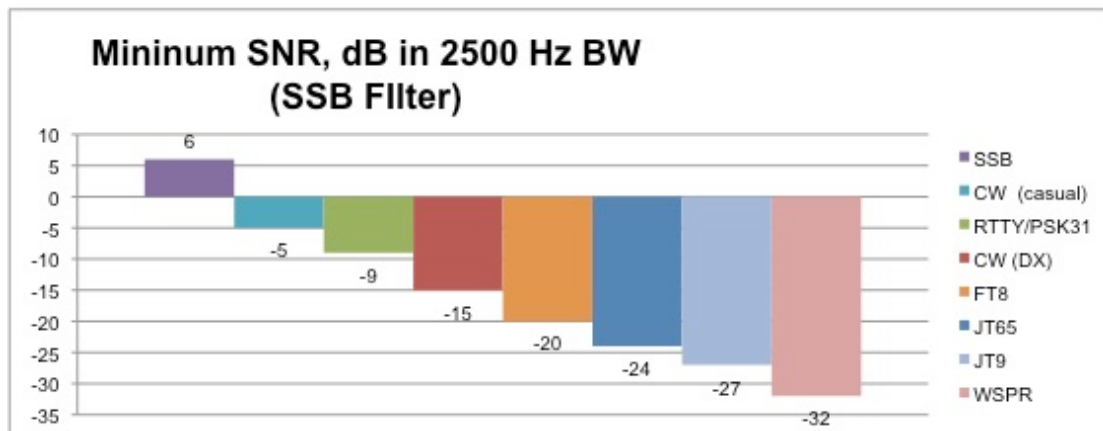
Upper Sideband For HF modes

SSB Signal (Upper Sideband)

USB

Carrier Frequency (Hz, untransmitted)

FM for most VHF/UHF modes

- CW: 150 Hz
- SSB: 3000 Hz
- AM: 6000 Hz
- FM: 5,000 - 15,000 Hz
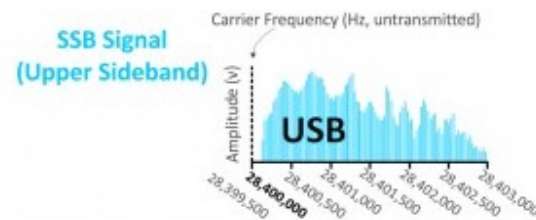
Bandwidth (Hz)

| Mode	Bandwidth	Throughput
WSPR	6 Hz	1.5 baud
FT8	50 Hz	23 baud
RTTY	270 Hz	45 baud
PACTOR	2400 Hz	5500 bps
FM PACKET	12000 Hz	2400/9600 bps

Graphics: HamRadioSchool.com

Basics: Modulation

Modulation is a process by which some characteristics of a carrier wave is varied in accordance with a modulating (message) signal.
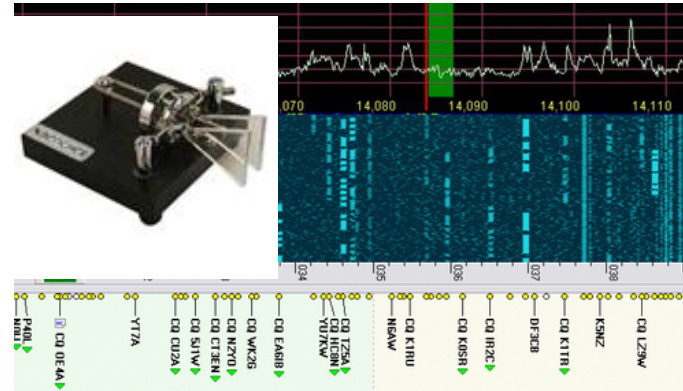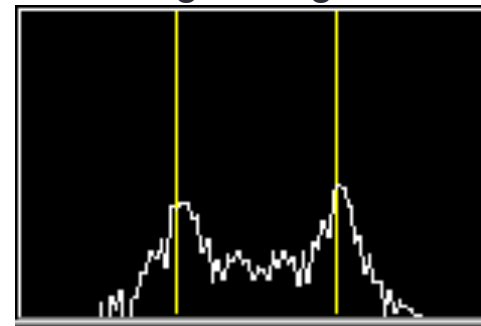

Graphic: NN4ZZ

AM: "Amplitude Modulation" The original analog mode!
CW: "Continuous Wave" The original digital mode!
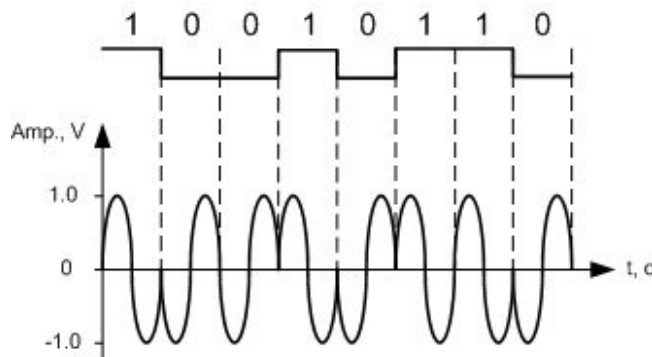
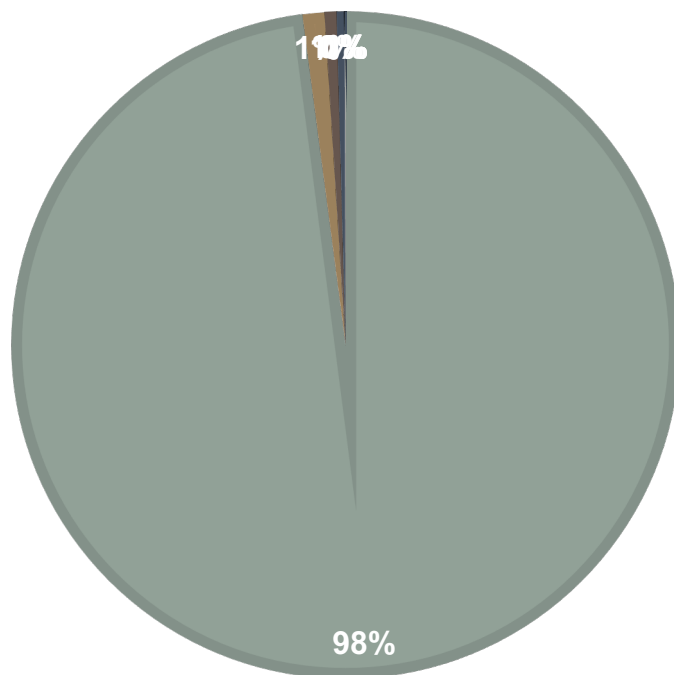PSK (31, 63): "Phase Shift Keying"
Phase inverts with binary change

FSK: "Frequency Shift Keying"
RTTY: Modulates between two frequencies

FT8 Dominates for Chasing HF Awards
But other modes are really useful !

Mode	Count
FT8	1212068
FT4	13400
JS8	7253
CW	4194
OPERA	178
PSK31	139
RTTY	40
JT65	36
JT9	21
PI4	9
T10	8
ROS	6
OLIVIA 4	5
MSK144	4
OLIVIA	4
OLIVIA-4	4
SSB	1
OLIVIA 8	1

PSKREPORTER.INFO
2/11/20

Public Service – Winlink® Modes

PACTOR
Dedicated modem 2500 Hz bandwidth
Optimizes throughput in all conditions
Expensive but worth it to get data through

VARA
PC soundcard mode 2500 Hz bandwidth
Small software fee to EA5HVK
Similar to PACTOR auto-BPSK leveling
Impressive throughput & adaptability

ARDOP
PC soundcard mode built-in to Winlink
Replacing veteran WINMOR mode
Narrower bandwidth (200, 500, 1000 Hz)
Slower throughput

VARA FM 1200					
Level	Symbol Rate (sps)	Carriers	Mod.	Net Data Rate (bps)	User Data Rate (bps)
1	42	55	4PSK	2267	2006
2	42	55	8PSK	3400	3009
3	42	55	8PSK	4534	4013
4	42	55	16QAM	5689	5035
5	42	55	32QAM	7111	6293
6	42	55	32QAM	8532	7551

VARA FM 9600					
Level	Symbol Rate (sps)	Carriers	Mod.	Net Data Rate (bps)	User Data Rate (bps)
1	42	116	BPSK	2383	2109
2	42	116	4PSK	4768	4220
3	42	116	8PSK	7155	6332
4	42	116	8PSK	9540	8443
5	42	116	16QAM	11972	10595
6	42	116	32QAM	14996	13271
7	42	116	32QAM	17957	15892

Humanitarian Outreach:
Remote Tuvalu Islands Winlink® Project
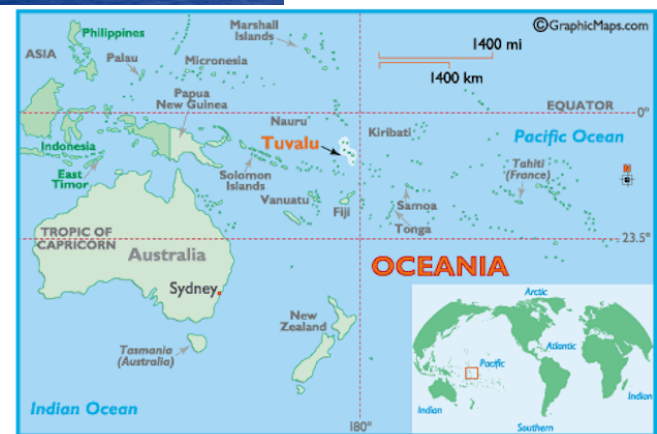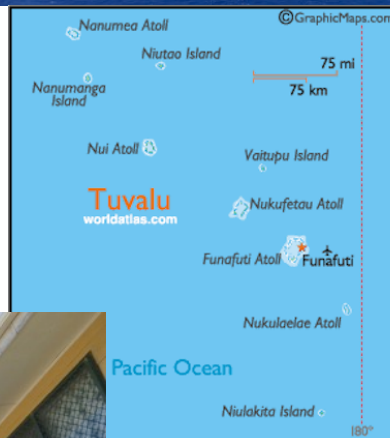
Nine remote islands: only one with an air strip
One of the least-connected countries in the world
Satellite-based comms are expensive & unreliable

Radio amateurs established a Winlink® e-mail system
over HF Pactor on all islands

Public Service – Other Modes

Slow Scan Television (SSTV)
Nepal Earthquake 2015: Nepali radio amateurs provided first photos of affected areas via SSTV

Olivia
Robust, forward error correction
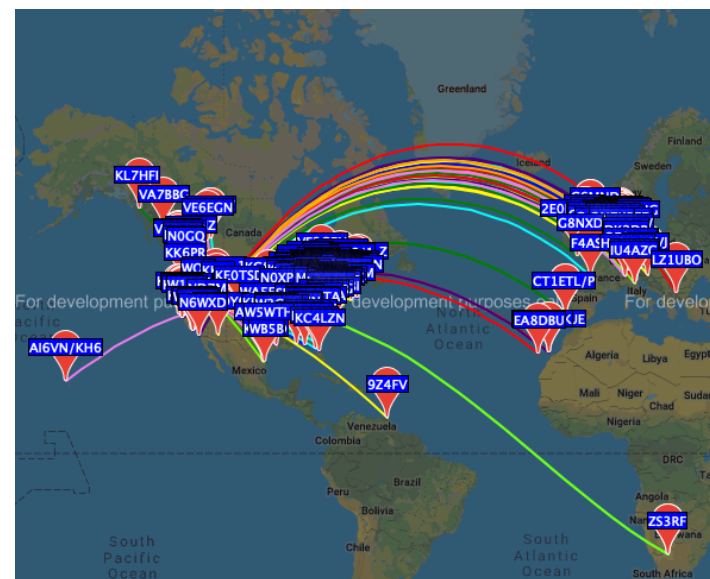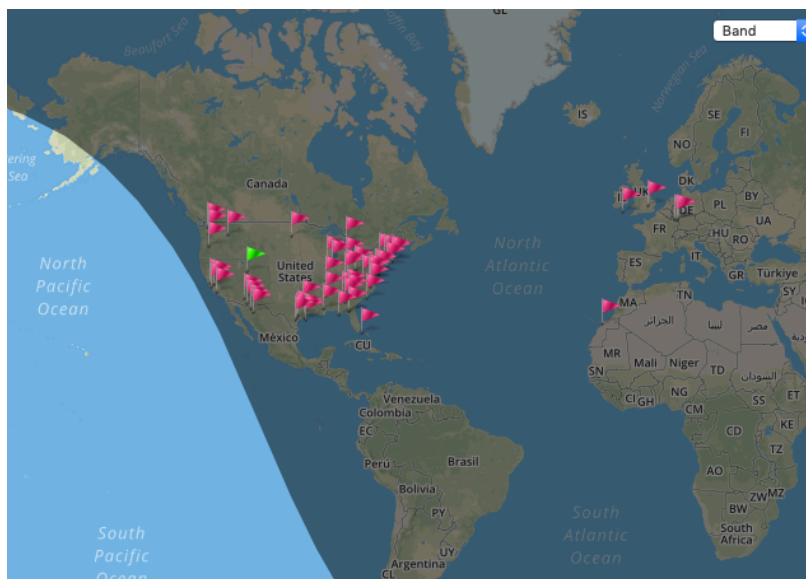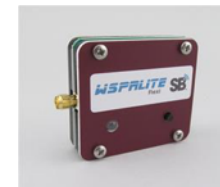Still popular among ARES networks

April 27 Tesa Radhakrishna Temple 9N1

TNC2400

PACKET / APRS
Digipeater data relay commonly utilized in event coordination (parades, races, etc.), location tracking

Amateur TV
UHF Fast Scan TV for audio-visual links at events

Experiment with Antennas & Propagation WSPR & JS8CALL Modes

5 Watt WSPR Beacon Test:
Comparing the flagpole vertical with an end-fed halfwave long wire:

| Timestamp	Call	MHz	SNR	Reporter	RGrid	km	az
2019-12-29 01:56	KK7L	3.570128	-17	KD2LZI	FN22vt	3119	72
2019-12-29 02:02	KK7L	3.570128	-14	KD2LZI	FN22vt	3119	72
2019-12-29 01:56	KK7L	3.570084	-20	W2GNN	FN20qh	3134	78
2019-12-29 02:02	KK7L	3.570084	-13	W2GNN	FN20qh	3134	78
2019-12-29 01:56	KK7L	3.570082	-4	WO7I	DN10cw	503	279
2019-12-29 02:02	KK7L	3.570082	+6	WO7I	DN10cw	503	279

Programming & Interface Design

Example: N7SMI High Altitude Balloon Projects

- Homebrew 10 mW (1/100th of a watt!) solar transmitter
- GPS board provides altitude, latitude, longitude
- Quarter wavelength 20 meter ham band antenna
- WSPR beacon transmissions during daylight hours
- Signal reports from as far away as Australia!

hab.smithplanet.com

Programming & Interface Design

PiGate Emergency E-mail Gateway
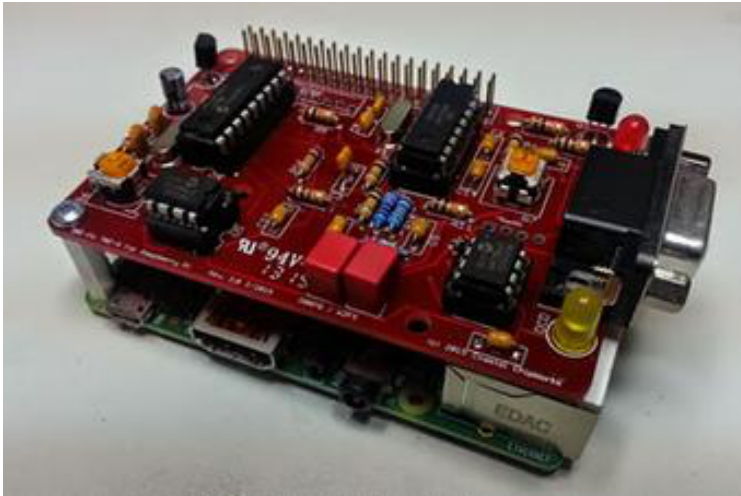
Arduino APRS Tracker
DXZone.com

DX & Digital Modes

- CW: the original weak signal digital mode!
  - Occupies only 150 Hz
  - Very fast QSOs = more stations work the DX
  - Remains a mainstay DX & contesting mode
- RTTY: the original keyboard digital mode
  - DXpeditions continue to offer this mode
  - Fast QSO rates, sometimes inaccurate decoding
- FT-8 (DXing) FT4 (Contesting)
  - By far the most popular HF digital modes today
  - Slow QSO rates: up to 60 seconds each
    - New Fox/Hound DXpedition mode speeds this up
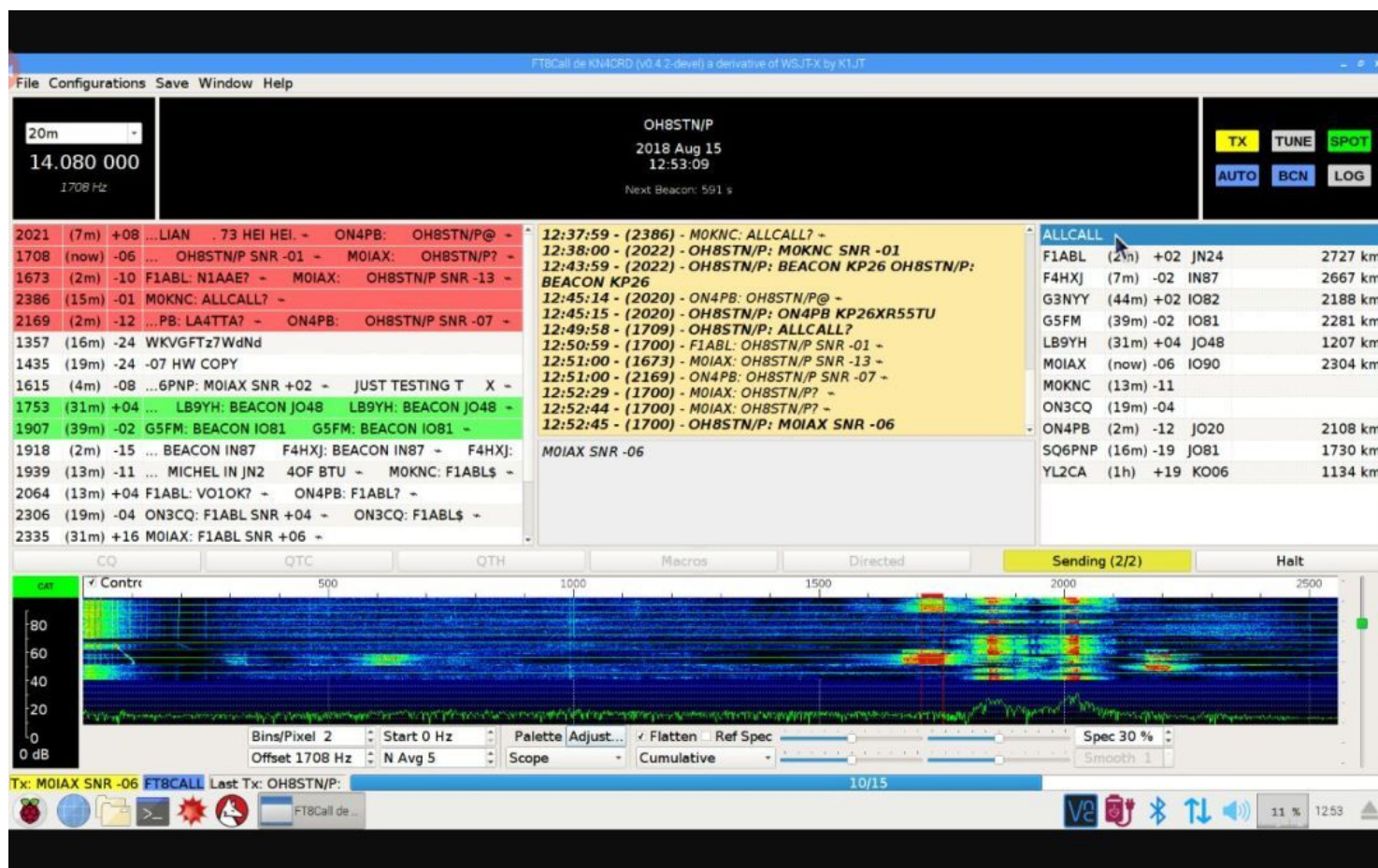- EME (moon bounce) modes, satellites on VHF
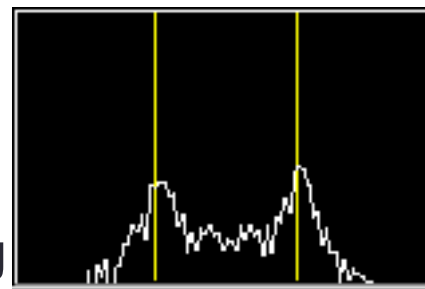
PSK31
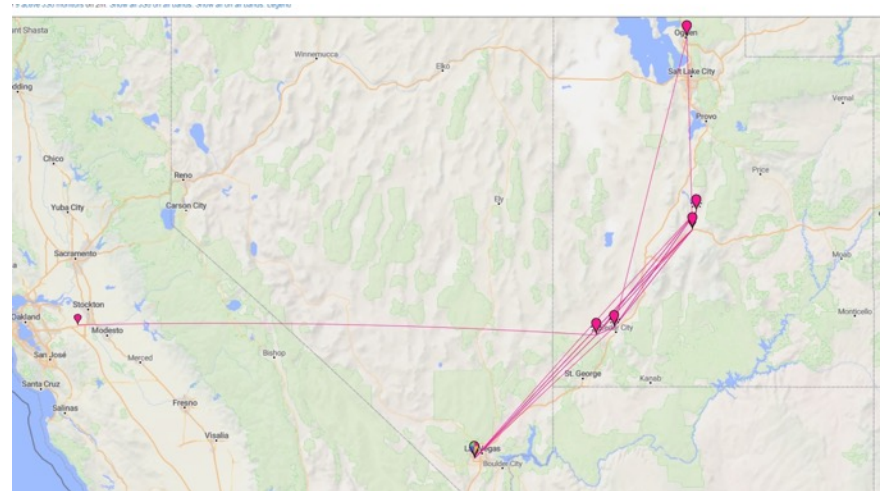# Still a solid performer for chat & DX
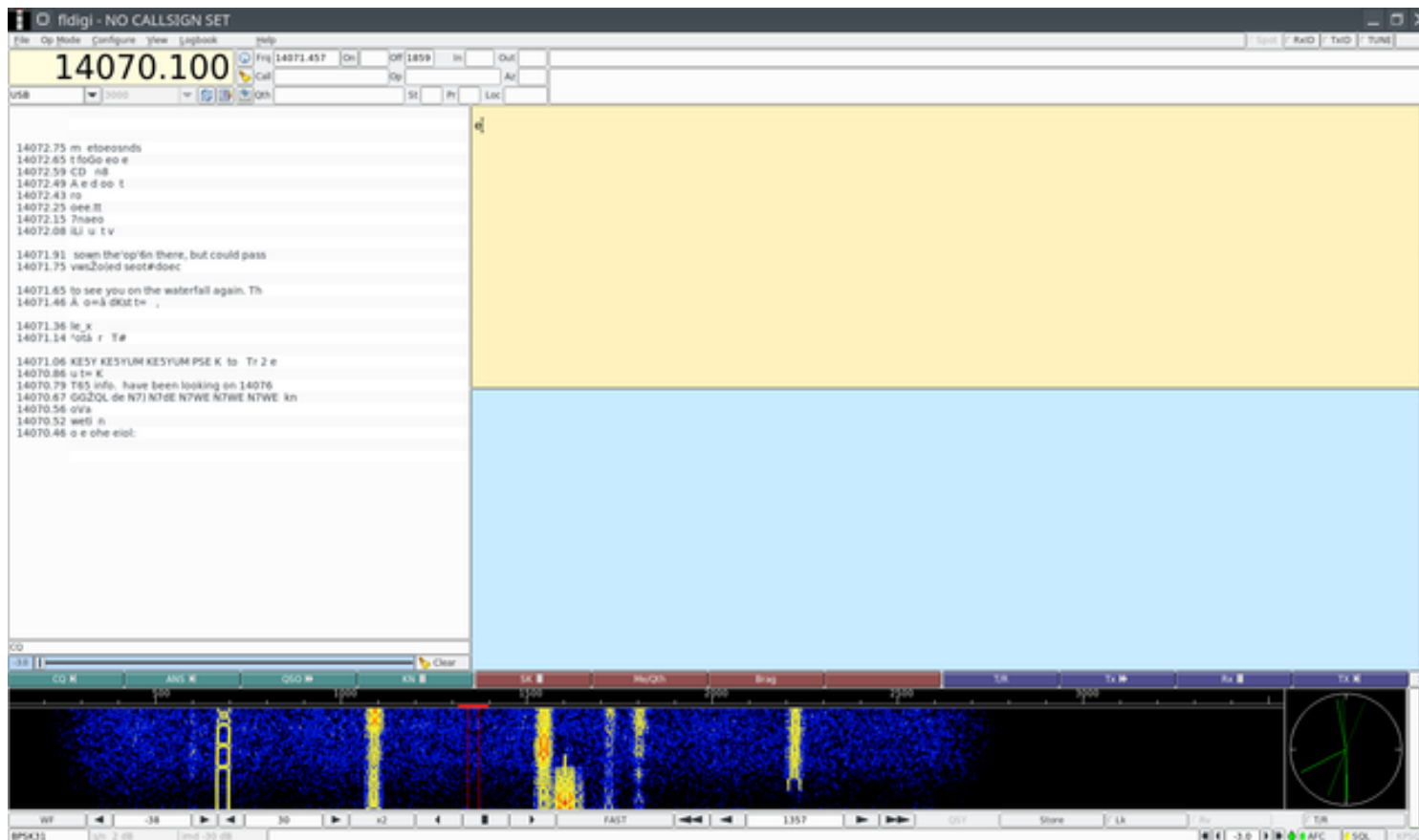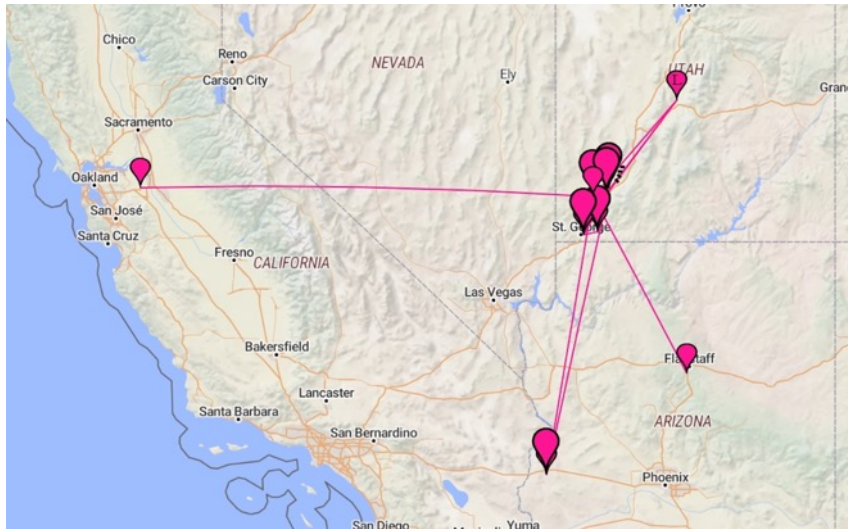
JS8Call
FT8 meets keyboard chat with auto response & forwarding

Sourthern Utah VHF JS8Call Network
(Courtesy of George Gallis AL7BX)

- Extension of weak signal SSB net Sunday nights: 144.178 mHz

- JSCall "HeartBeat" every 10 minutes
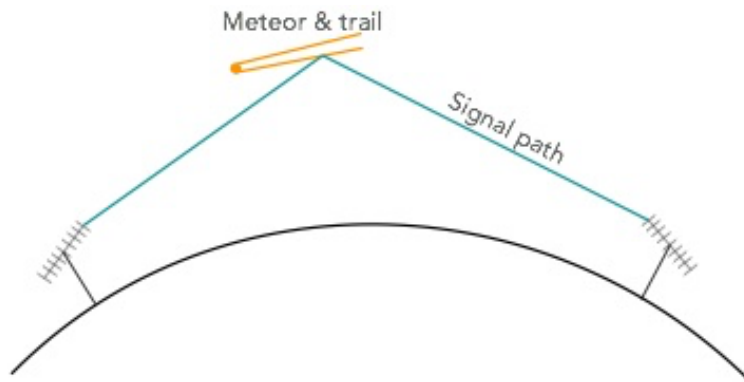
- Auto signal report reply

Near daily 300 mi QSOs possible

PSK Reporter mapping

VHF/UHF Propagation

FSK441 (a WSJT mode) for Meteor Scatter
Four tones at 441 baud
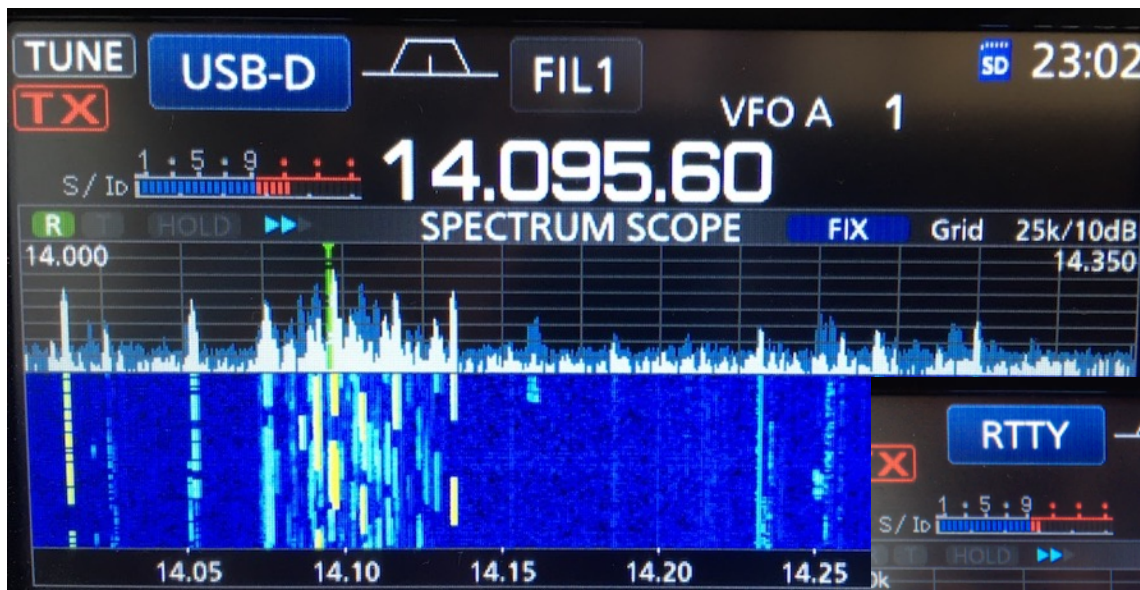Very short pings for very short openings!

JT65 (a WSJT mode)
Earth-Moon-Earth (EME) aka "moonbounce"
Deep decoding for extremely weak signals
1 minute TX cycles

Randy WI7P ready to light up the moon!

Multiple Mode Co-existence?

Last weekend: CQ Worldwide WPX RTTY Contest
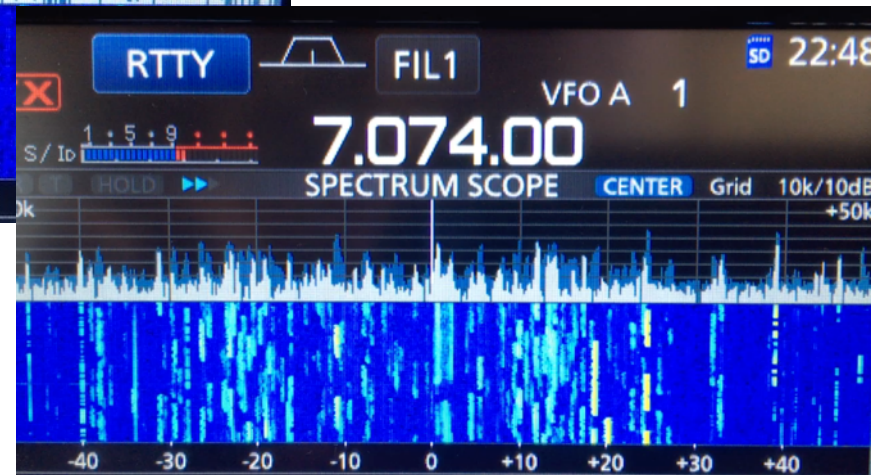HF digital segments were wall-to-wall RTTY

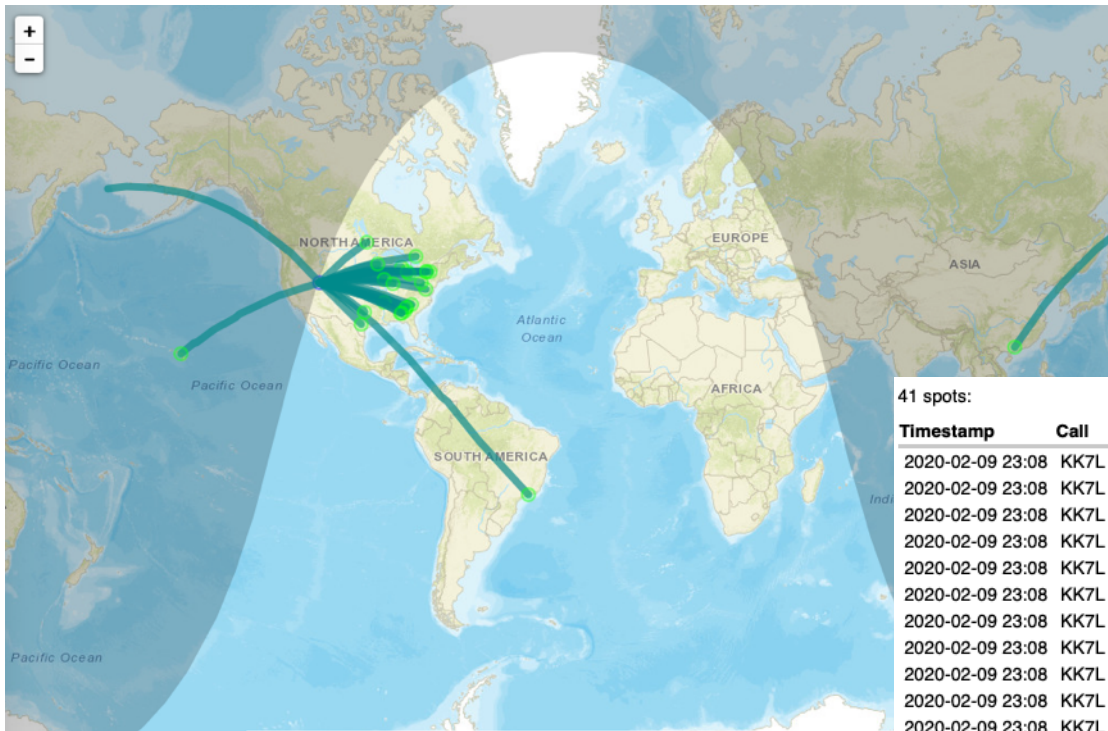
Contesters tend to avoid:
- PSK frequencies
- FT8 frequencies

But the WSPR frequencies…
- 20dB over 9 signals pounding
- *Would anyone hear a 10 watt transmission through this*?

WSPR 10w Amidst RTTY Contest

YES!

Maui -12 report
Brazil -16 report
China -26 report

41 spots:

Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	RGrid	km	az
2020-02-09 23:08	KK7L	14.097075	-24	0	DN40bi	10	KA3JIJ	EM84cj	2557	96
2020-02-09 23:08	KK7L	14.097079	-6	0	DN40bi	10	W4HOD	EM72eo	2489	102
2020-02-09 23:08	KK7L	14.097078	-21	0	DN40bi	10	KD4YDD	EM84ab	2557	97
2020-02-09 23:08	KK7L	14.097071	-9	0	DN40bi	10	KX4AZ/W	EN73hx	2211	71
2020-02-09 23:08	KK7L	14.097080	-25	0	DN40bi	10	KG5UWB	EM12jv	1546	118
2020-02-09 23:08	KK7L	14.097079	-2	0	DN40bi	10	KN4USN	EM45	1901	100
2020-02-09 23:08	KK7L	14.097087	-12	0	DN40bi	10	VE4BJZ	EN19pm	1565	44
2020-02-09 23:08	KK7L	14.097096	-4	-1	DN40bi	10	W4DJW	EM84ux	2658	93
2020-02-09 23:08	KK7L	14.097088	-18	0	DN40bi	10	K4IQJ	EM72gn	2505	102
2020-02-09 23:08	KK7L	14.097082	+2	0	DN40bi	10	KA4PKB/0	EN41kf	1745	80
2020-02-09 23:08	KK7L	14.097078	-9	0	DN40bi	10	K9AN	EN50wc	2010	83
2020-02-09 23:08	KK7L	14.097073	-14	0	DN40bi	10	N2HQI	FN13sa	2934	72
2020-02-09 23:08	KK7L	14.097074	-26	0	DN40bi	10	BA7JA	OL52xx	11639	319
2020-02-09 23:08	KK7L	14.097078	-16	0	DN40bi	10	PY1EME	GG76qt	9906	122
2020-02-09 23:08	KK7L	14.097078	-22	0	DN40bi	10	K1RA	FM18cr	2910	82
2020-02-09 23:08	KK7L	14.097064	-27	0	DN40bi	10	K8NVH/X	EN82lm	2404	75
2020-02-09 23:08	KK7L	14.097070	-22	-1	DN40bi	10	K3KQV	FN00	2763	79
2020-02-09 23:08	KK7L	14.097078	-23	0	DN40bi	10	WA2ZKD	FN13ed	2838	72
2020-02-09 23:08	KK7L	14.097080	-21	0	DN40bi	10	KD2OM	FN12gx	2854	73
2020-02-09 23:08	KK7L	14.097089	-12	0	DN40bi	10	AI6VN/KH6	BL10rx	4720	257

ARRL Draft Band Plan

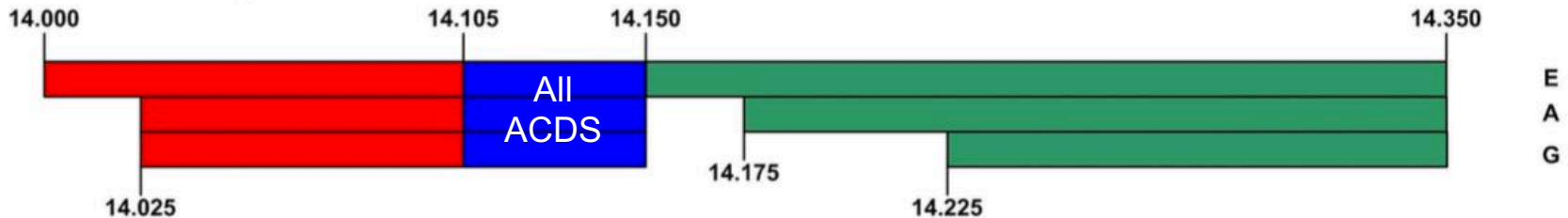Extends ACDS (Automatically Controlled Digital Station) Segments
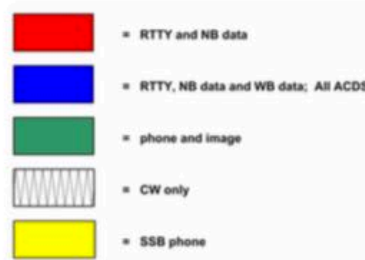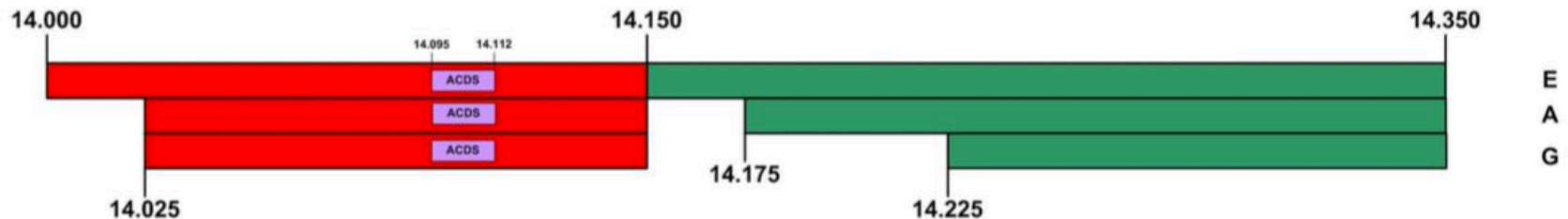
Speaking of ARRL…

- If you're not yet a member then JOIN!
- The league:
  - Defends our spectrum from those who lust after it
  - Is our voice with the FCC and government*
  - Publishes great books & magazines on all aspects of the hobby
  - Organizes fun on-air activities
  - Offers numerous services for all members

THE AMERICAN RADIO RELAY LEAGUE, INC.
Utah Section: State Government Liaison
Jay Brummett – W7WJB , Utah Section State Government Liaison,
548 E. Julep Cir, Murray, UT 84107, 801.725.9771, w7wjb@arrl.net

Position Statement: Utah H.B. 101 DISTRACTED DRIVER AMENDMENTS

Slicing the Data Sub-bands
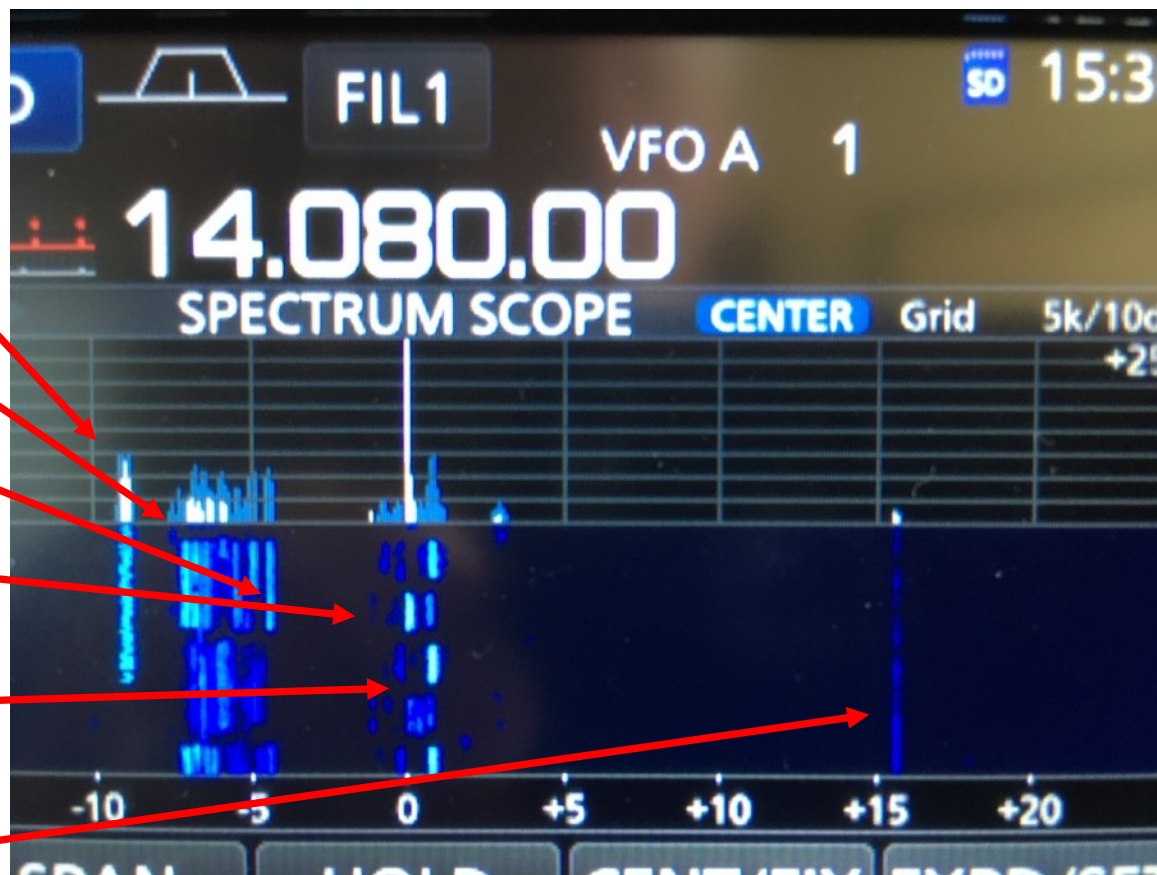## Can you identify the modes?

14.070 is PSK

14.074 is FT8

14.076 is JT65

14.078 is JS8Call / JT9

14.080 is FT4

14.097 is WSPR

Transceivers & Digital Devices

- Any HF rig with "data" or "ACC" socket will do
- PC soundcard interface:
  - Keys rig (PTT)
  - Modulates TX & RX
  - Sets delay (if needed)
  - Sets TX & RX levels

- Rigs with internal sound cards are ideal:
  - Most all newer rigs have this
  - USB cable all that is needed

| ACC(1)	PIN	PIN NAME	DESCRIPTION	SPECIFICATIONS
	1	CWK	CW and FSK keying input.	Input level: Less than 0.6 V for transmit.
	2	GND	Connects to ground.	Connected in parallel with ACC(2) pin 2.
	3	SEND	Input/output pin. Goes to ground when transmitting. When grounded, transmits.	Ground level: −0.5 to 0.8 V Input current: Less than 20 mA Connected in parallel with ACC(2) pin 3.
	4	MOD	Modulator input. Usable when pin 3 is grounded.	Input impedance: 10 kΩ Input level: Approx. 100 mV rms
	5	AF	AF detector output. Fixed, regardless of the [AF] position.	Output impedance: 4.7 kΩ Output level: 100–300 mV rms
Rear panel view	6	SCAN	Starts scan when grounded.	Scan operation: Less than 0.6 V
	7	13.6 V	13.6 V output when power is ON.	Output current: Max. 1 A Connected in parallel with ACC(2) pin 7.
	8	ALC	ALC voltage input.	Control voltage: −3 to 0 V Input impedance: More than 10 kΩ Connected in parallel with ACC(2) pin 5.

Software

- WSJT-X (free)
  - Foundational: K1JT's team develops this open source code set
  - Provides in addition to popular FT-8 mode:
    - WSPR – weak signal propagation reporting
    - Modes for EME (moonbounce), meteor scatter
- JT-Alert (free, donations accepted)
  - Alerts you to missing DXCC, states, grids when stations are on air
- JTDX (free)
  - Derivative of WSJT-X. Intuitive and very popular with DXers!
- Ham Radio Deluxe ($100)
  - Integrated software for logging, rig control, digital modes, satellites
- JS8Call (free)
  - FT8 derivative: keyboard chat for personalized QSO experience
- Fldigi (free)
  - Multi-mode program for RTTY, PSK and other traditional modes

Common Setup Mistakes

- PC's "speaker" & "mic" confusion with rig's TX & RX ports
- Windows / Mac system sounds going out on TX
- Inaccurate computer clock (check time.is & use Meinberg NTP app)
- Over-modulation
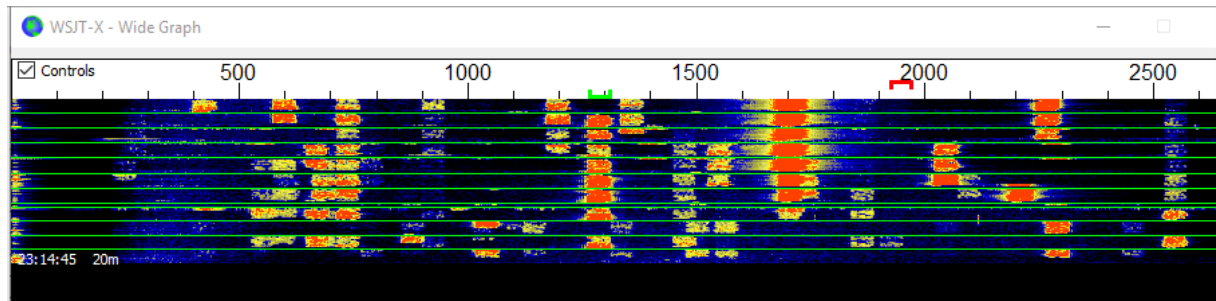
- Failure to check the "Hold TX Freq" box
  (best not to TX on your contact's same freq.)
- RF in the shack: shield & ferrite everything!

Resources

- Your local ARRL-affiliate Radio Club http://www.arrl.org/clubs

- Utah Valley Hamfest May 9th 2020

- ARRL: Get on the Air with HF Digital

- FT8 Operating Guide by ZL2IFB http://www.g4ifb.com/FT8_Hinson_tips_for_HF_DXers.pdf

- Utah DX Association's "*WSJT Deep-Dive Breakfast*"
  Hosted at the KK7L shack in Saratoga Springs
  February 29th 2020 (leap day!) from 8:00 am to 10:00 am
  Up to 30 guests: please sign up at the www.UDXA.org Calendar