Sound Card Digital Modes

K3EUI Barry

Overall Plan

Part I Modulation

Part II - AM, CW, SSB, FM

Part III - Sound Cards

Part IV - EMCOMM

Winlink vs. NBEMS

Sound Card Modulation Methods

What do AM and CW have in common?

What do Olivia, Thor, MFSK, and FT8 have in common?

What do PSK, VARA, 8PSK, and MT63 have in common?

AM and CW are

amplitude shifts

RTTY, Olivia, Thor, MFSK, FT8

frequency shifts

(constant amplitude)

PSK, VARA, 8PSK, and MT63

phase shifts

(not constant amplitude)

Types of QSO

Chat modes and image modes

PSK31, CW, RTTY, MMSSTV, Easy Pal

DX modes – pull out the weak signals from noise

JT65, FT8, FT4, CW, PSK31

Contest modes - log them as fast as you can

RTTY, CW, PSK31, FT4/FT8

EMCOMM - accuracy and speed for traffic

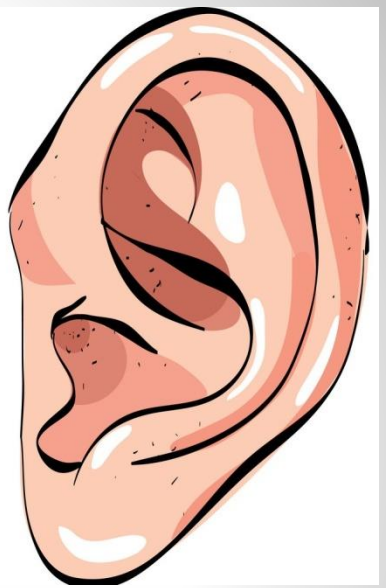
Pactor, VARA, Packet, THOR, MFSK

Guess that mode

Can you identify the "mode" by its sound?

Let's try this out…..

I will send



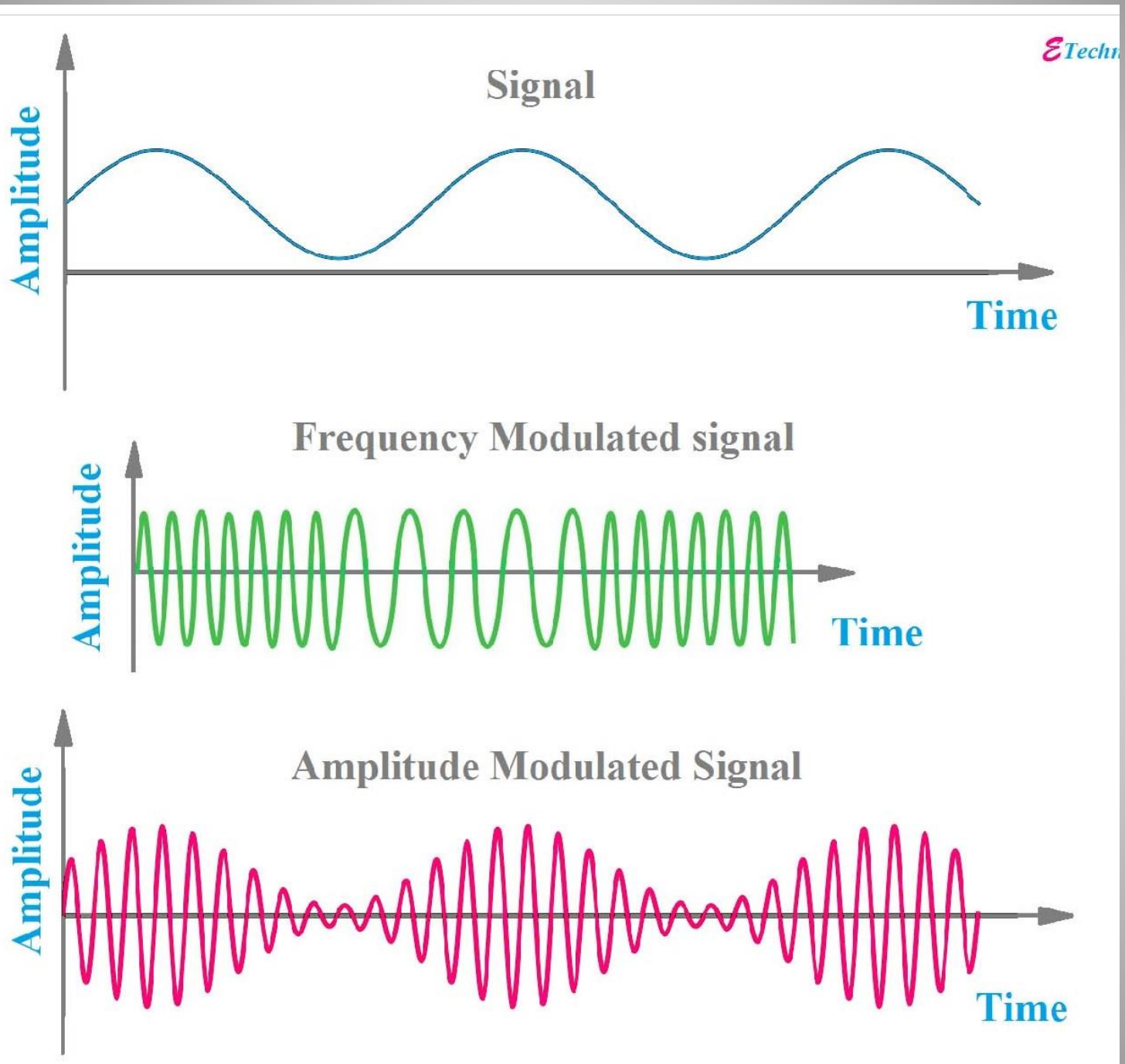
CQ CQ de K3EUI K3EUI k

Modulation - adds information or content to a radio frequency (RF) electromagnetic wave by altering the

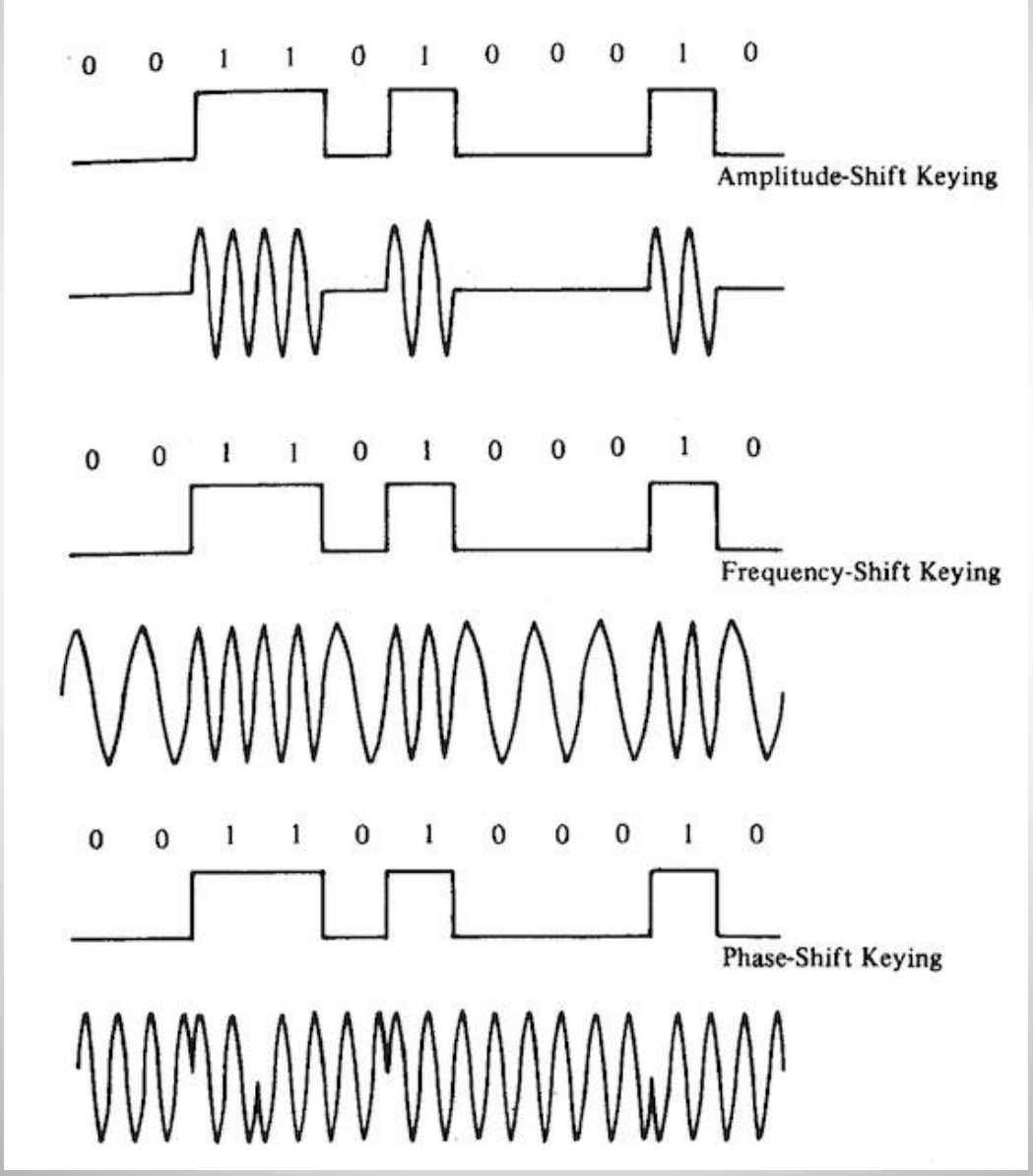
amplitude

frequency

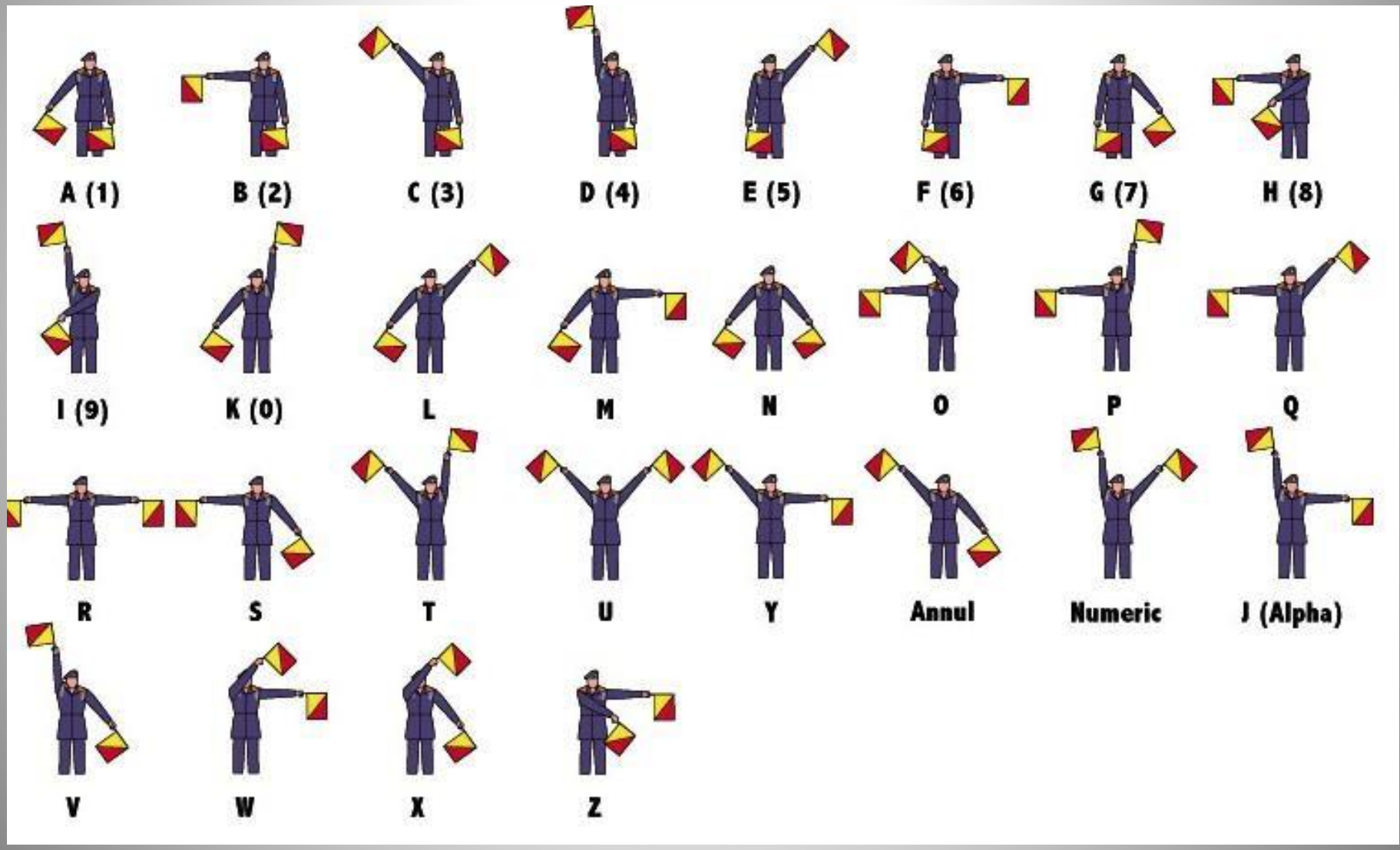
phase


Signal
Amplitude
Time
Frequency Modulated signal
Amplitude
Time
Amplitude Modulated Signal
Amplitude
Time

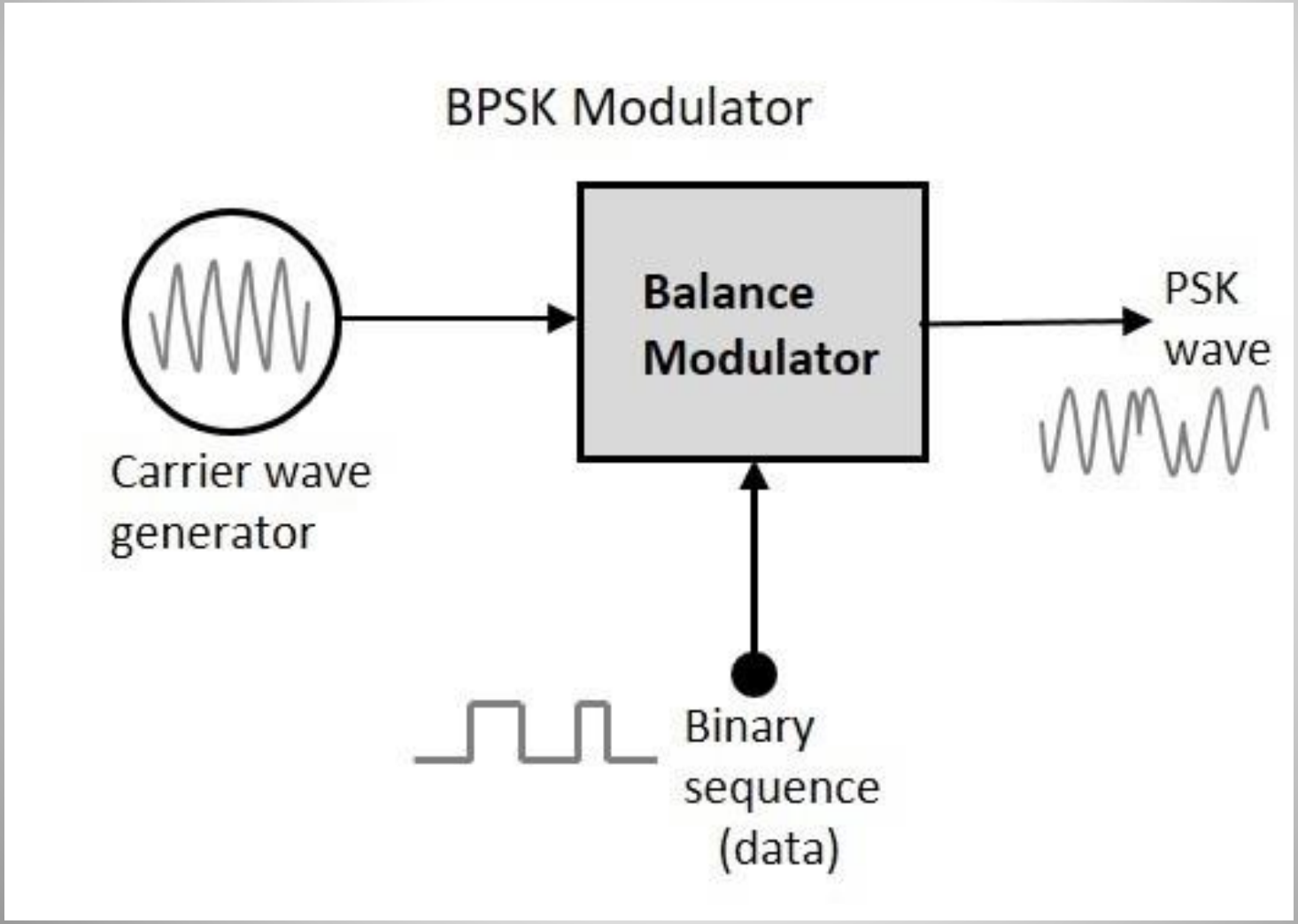
sending DATA by AM,FM,PM



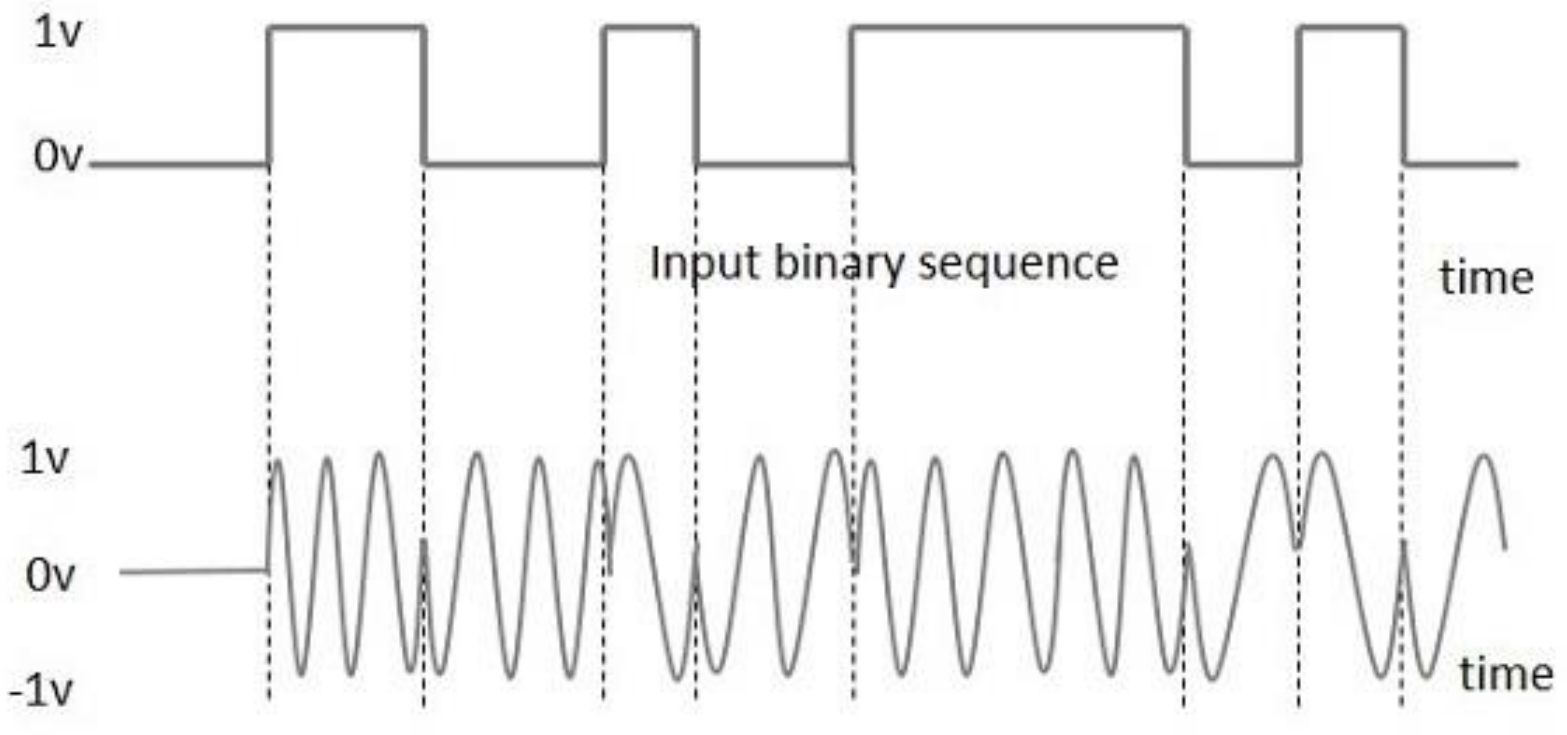
Only two flags can send a lot of information by altering position (**phase**) of flags



PSK modulator - PHASE shifts



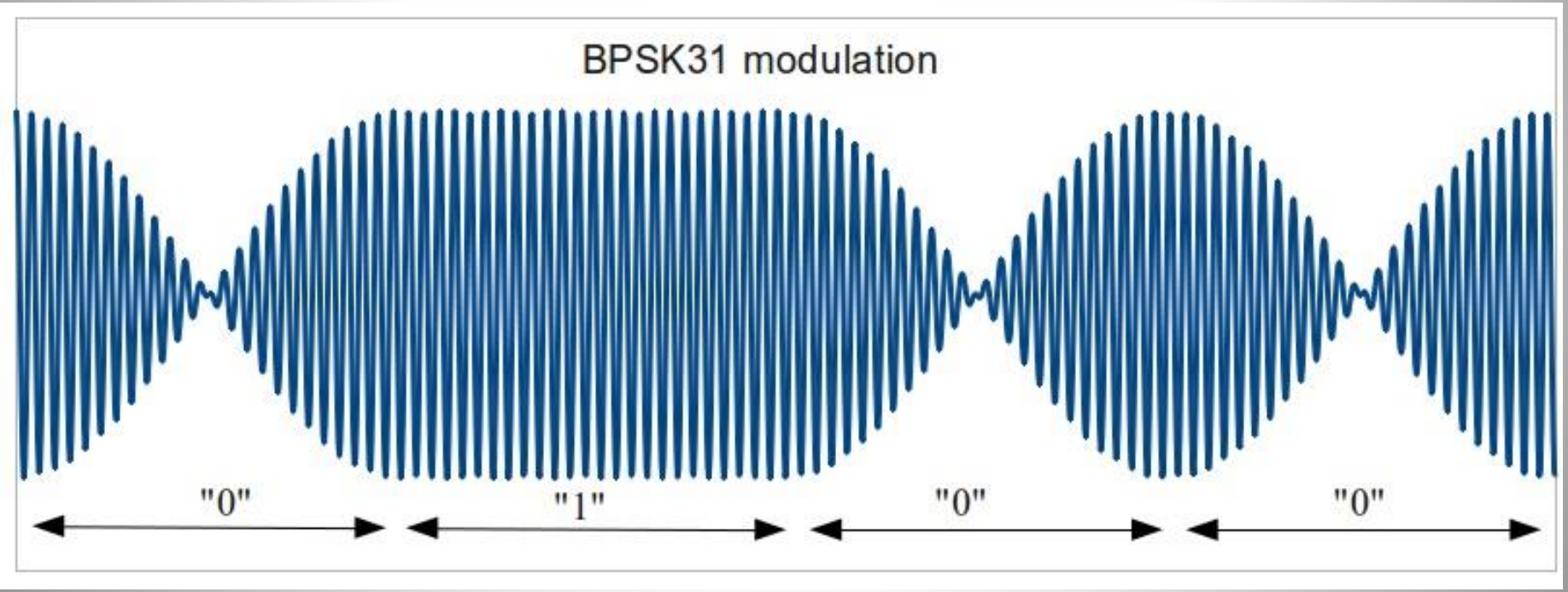
PSK (Phase Shift Keying)



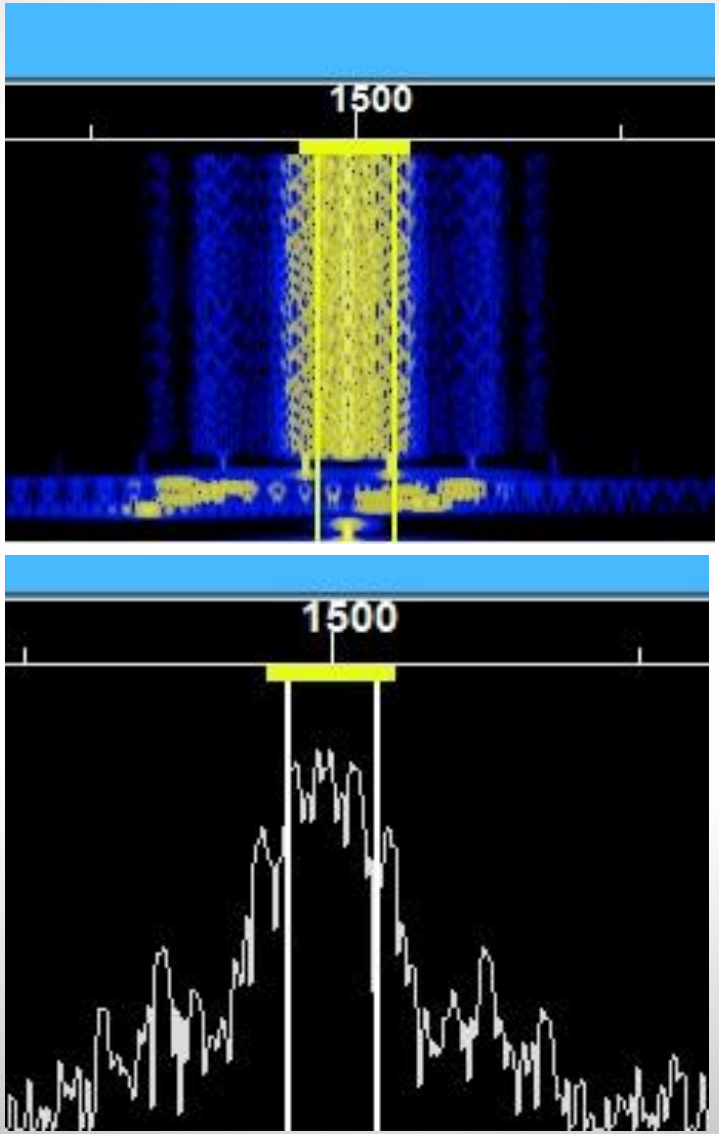
BPSK Modulated output wave

PSK31

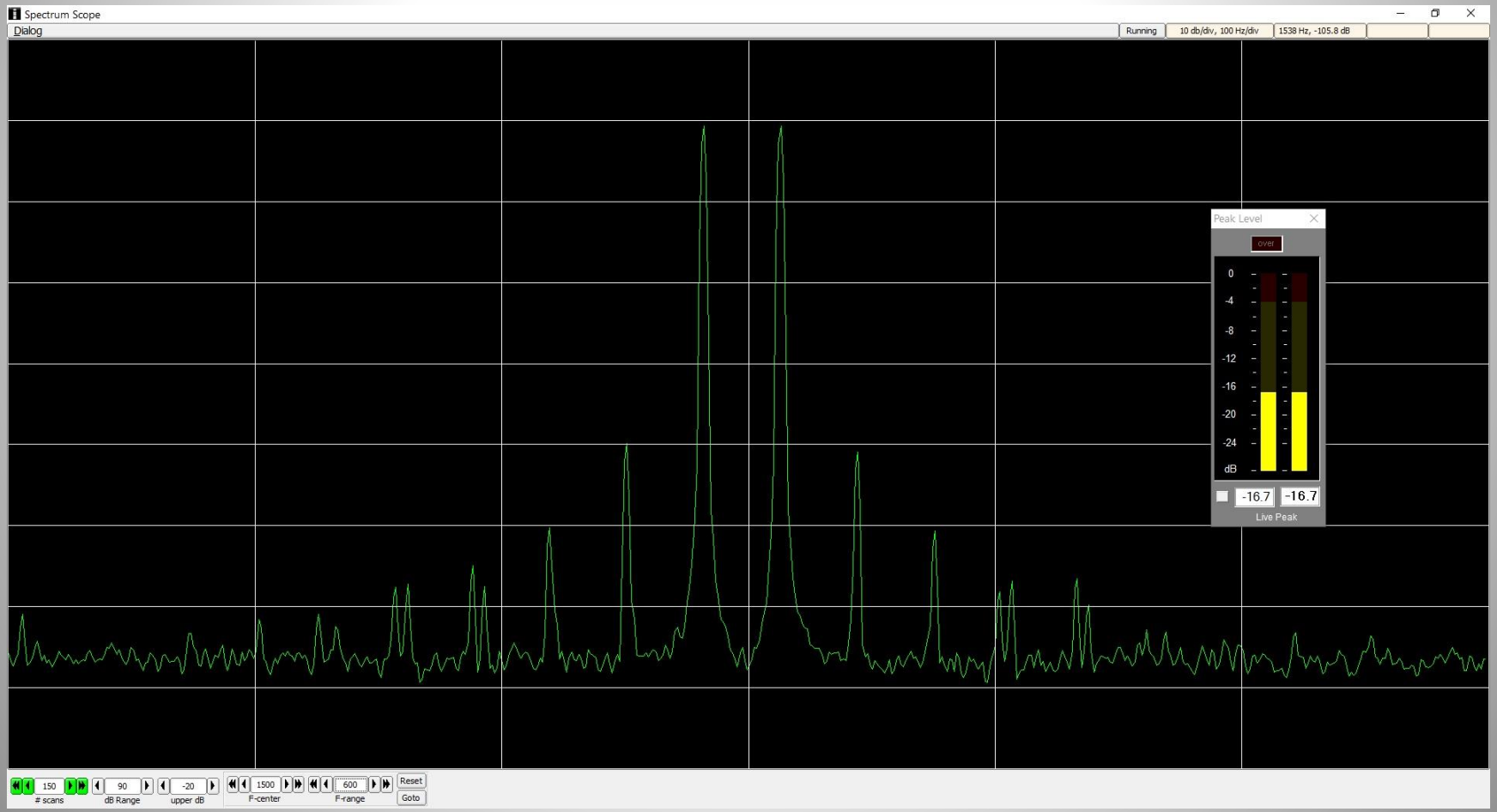
Amplitude changes accompany phase changes to minimize the bandwidth



PSK31 on the waterfall 50 Hz BW



Clean PSK31 Spectrum 100 Hz vertical bars harmonics down -40 dB



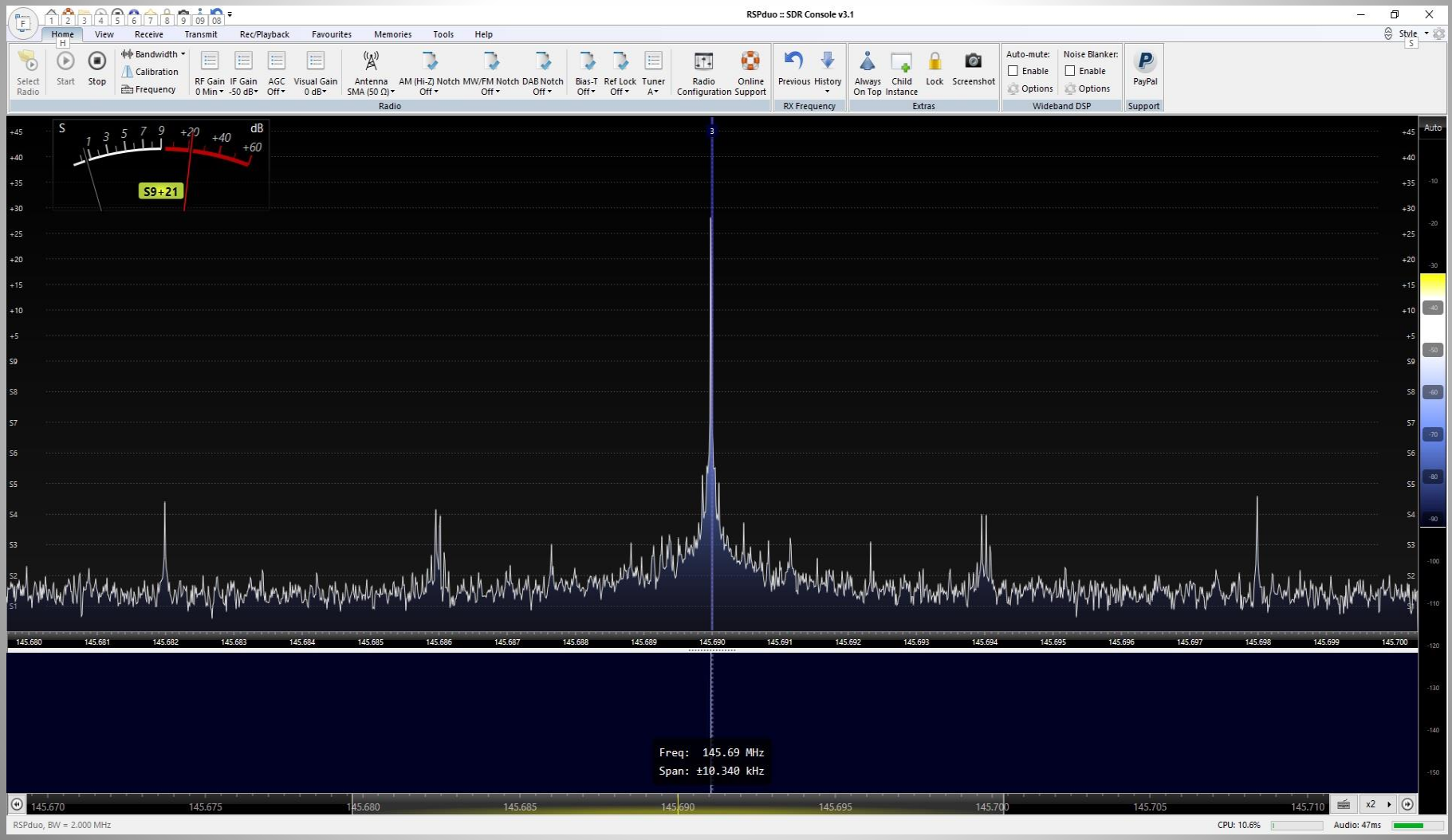
Watering Holes for PSK31

Typical HF frequencies

80 meters: 3.580 MHz
40 meters: 7.070 MHz
20 meters: 14.070 MHz
15 meters: 21.070 MHz
10 meters: 28.120 MHz

What does the RF spectrum look like for a carrier with **NO modulation**?

RF carrier at 145.690 MHz (no modulation)



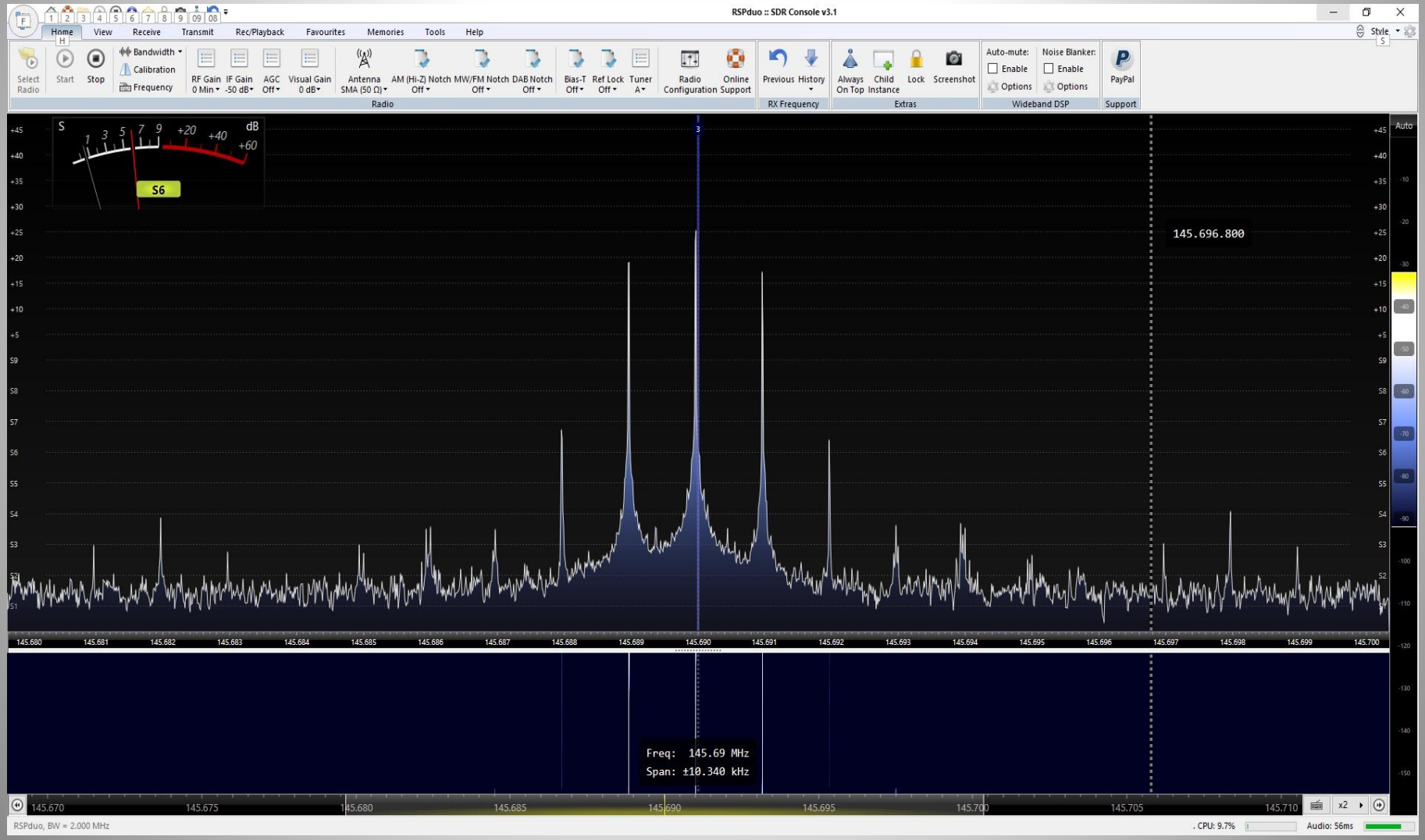
These slides were produced by sending with an
Icom 706MIIG transmitter
on 145.690 MHz

and

receiving with a SDRplay
and SDR Console 3 software

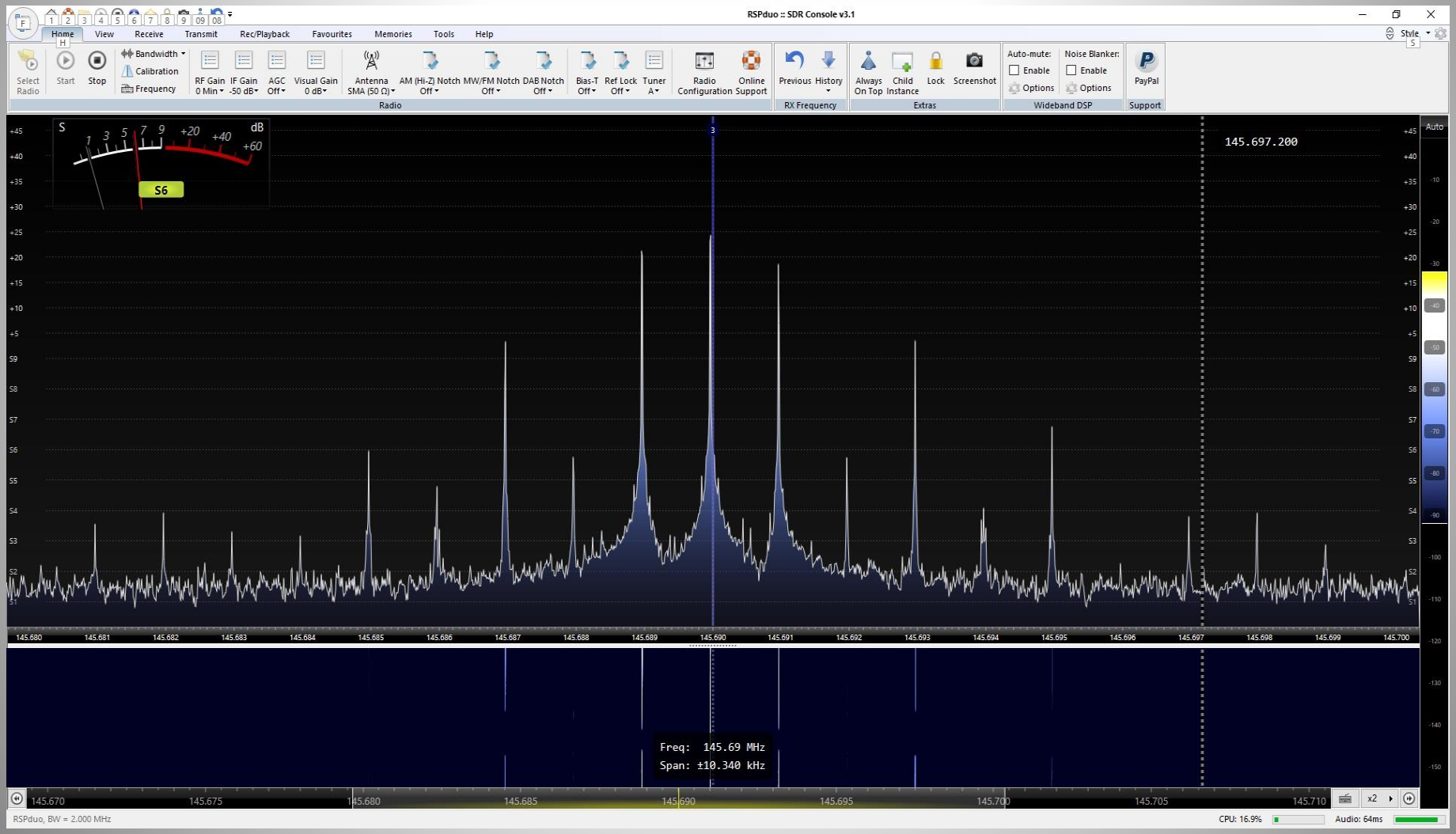
What does the RF spectrum look like for an **AM** signal modulated by a **1 kHz** audio TONE?

AM modulation by a 1 kHz sine wave
note: original "carrier" plus USB and LSB bandwidth about 2 kHz @ -35 dB



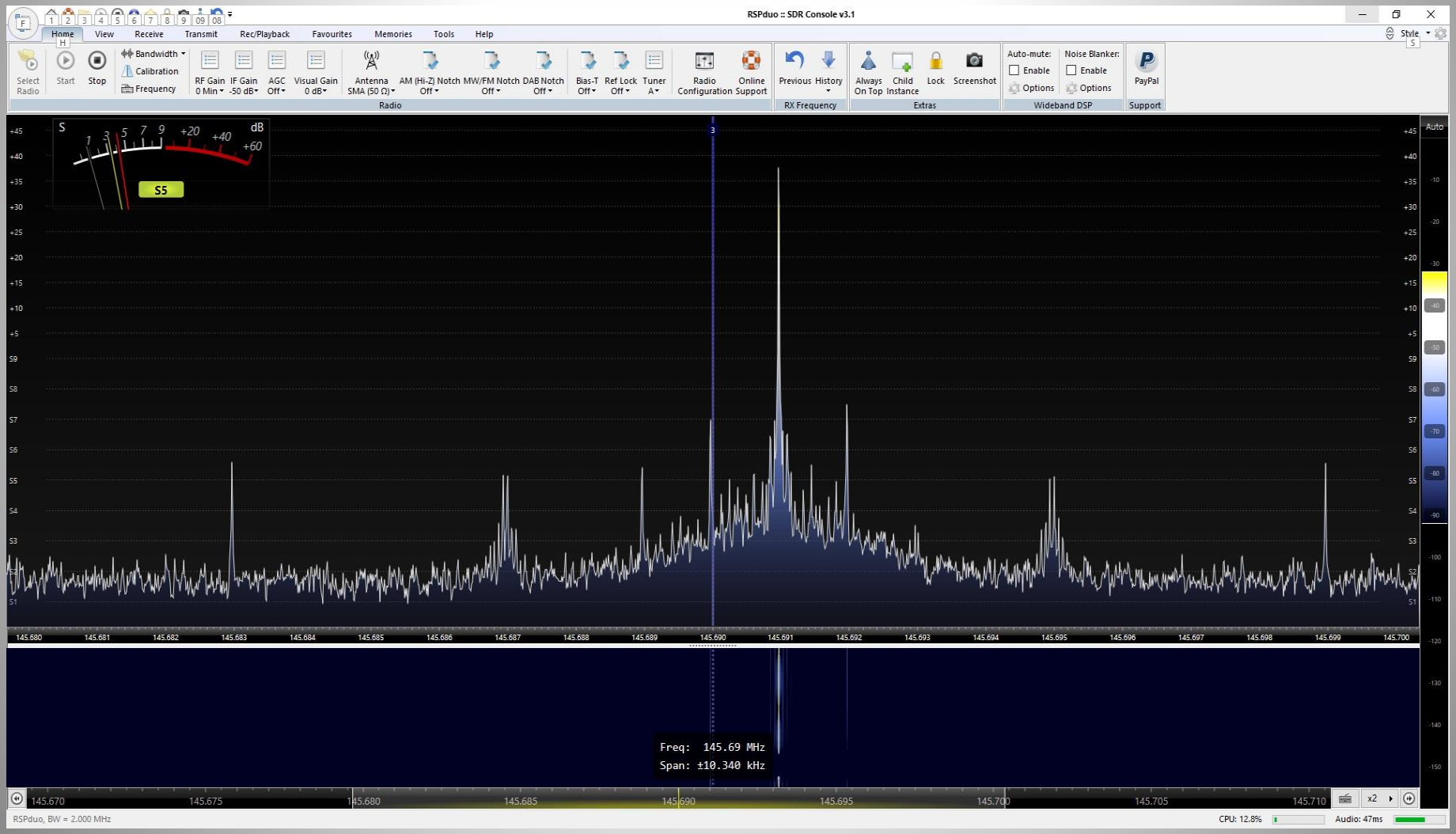
AM overmodulated with a 1 kHz TUNE

note: multiple harmonics (splatter)
and wider bandwidth about 6 kHz



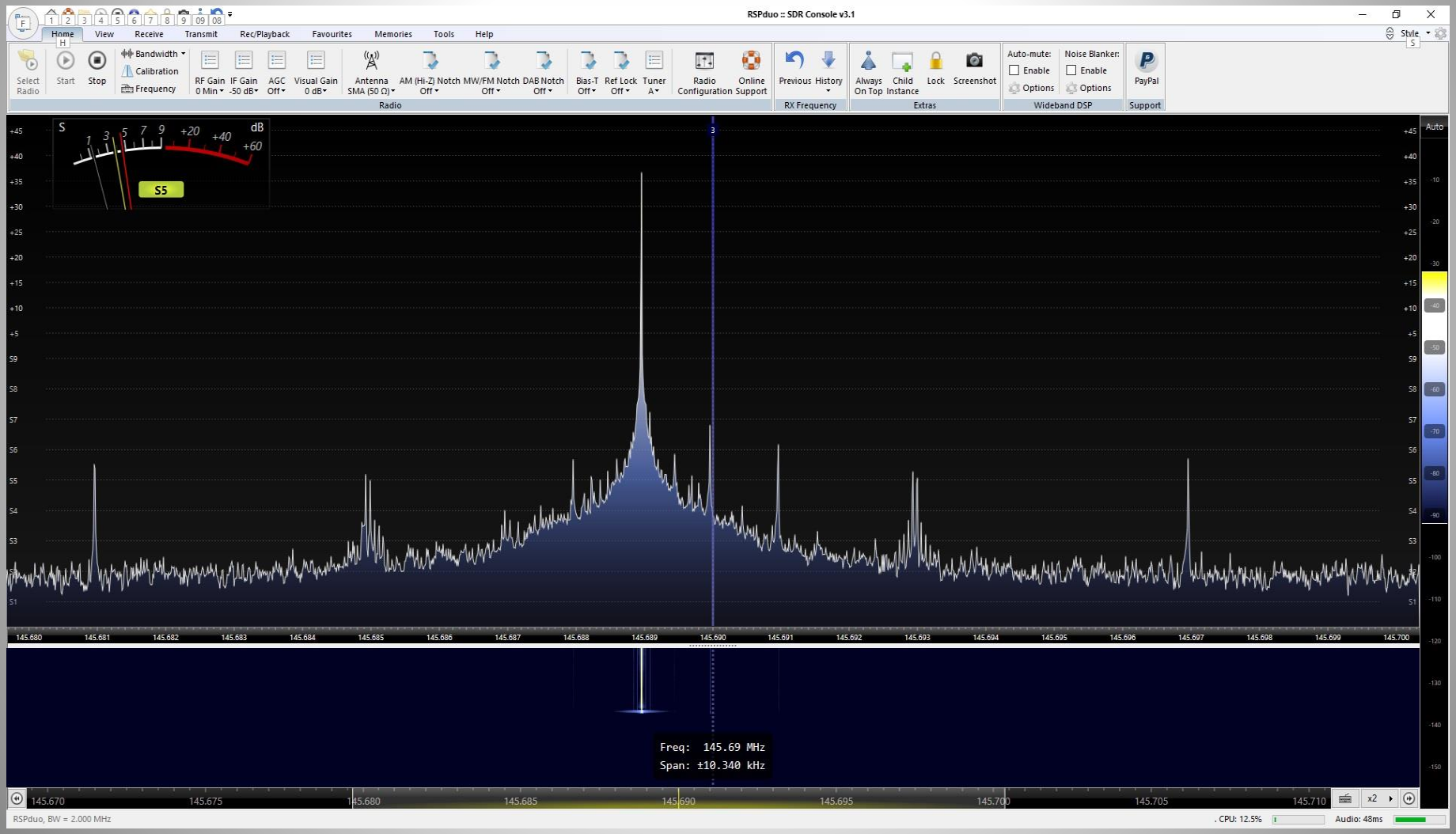
What does the RF spectrum look like for an **UPPER SIDEBAND** signal with a **1 kHz** audio tone?

USB signal with 1 kHz audio
note: carrier and LSB suppressed 40 dB

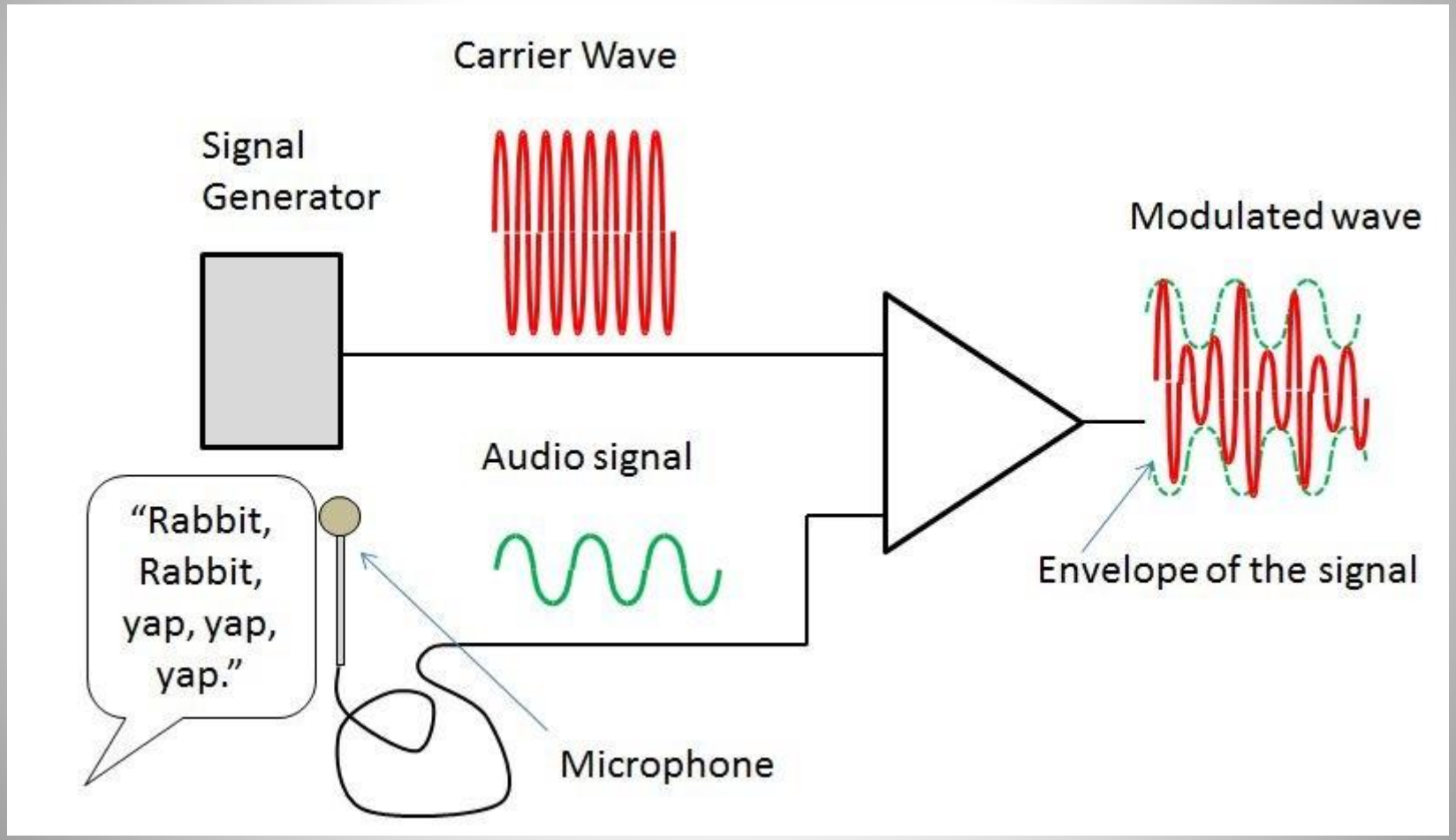


What does the RF spectrum look like for an **LOWER SIDEBAND** signal with a **1 kHz** TUNE audio?

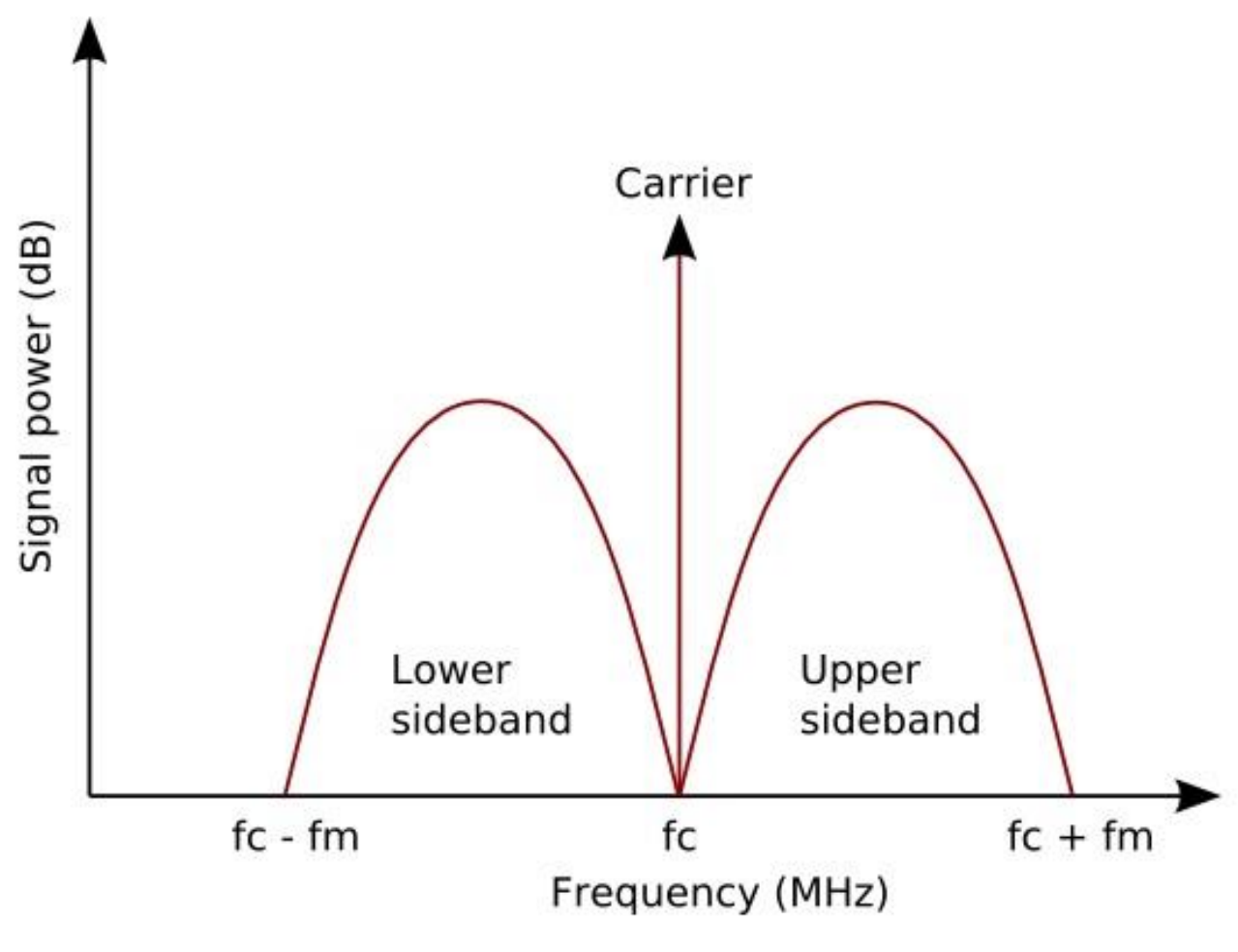
LSB signal with 1 kHz audio
note: carrier and USB suppressed 35 dB



Voice Amplitude Modulation Double Sideband with Carrier



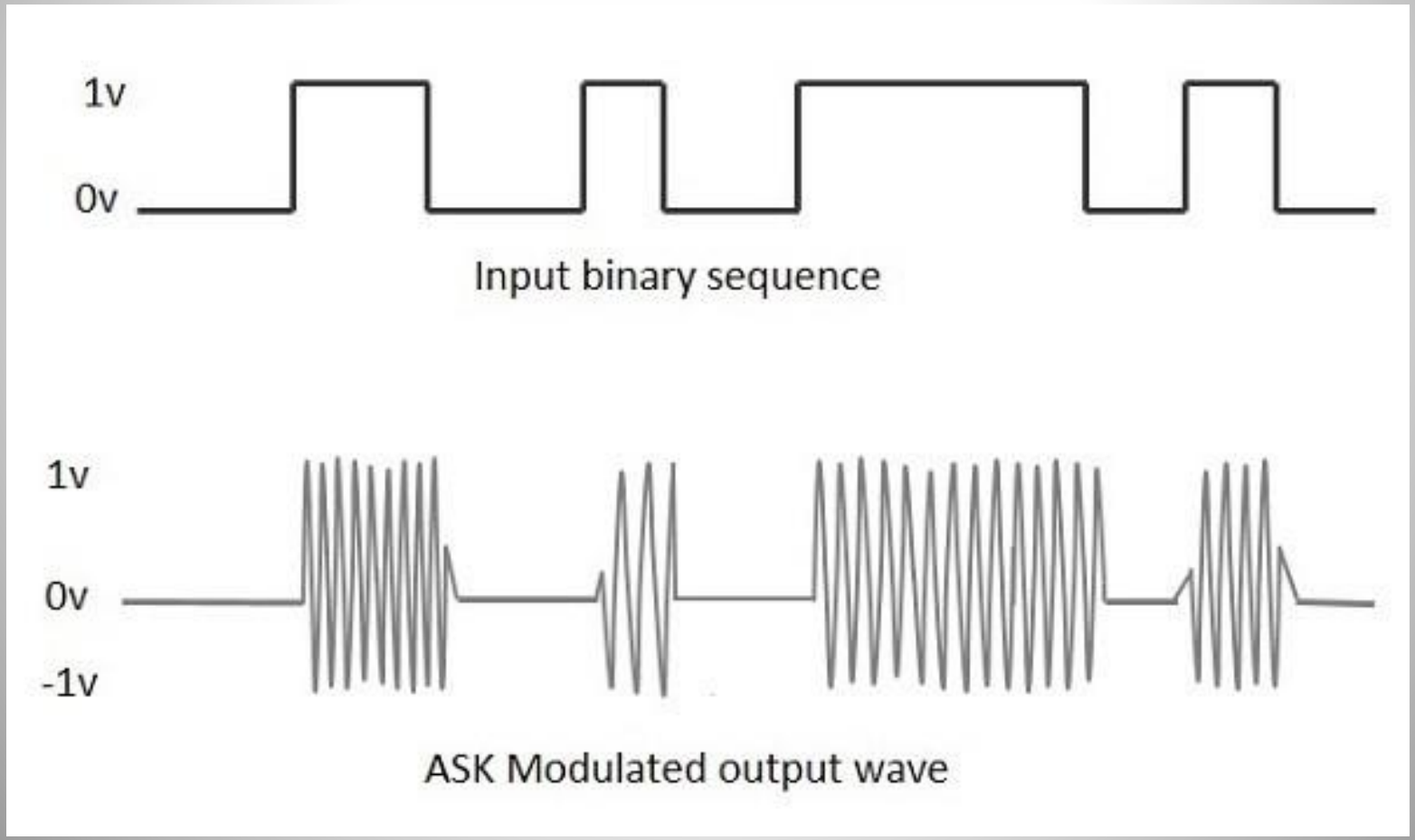
This results in both a CARRIER and a LOWER and an UPPER (redundant) sideband



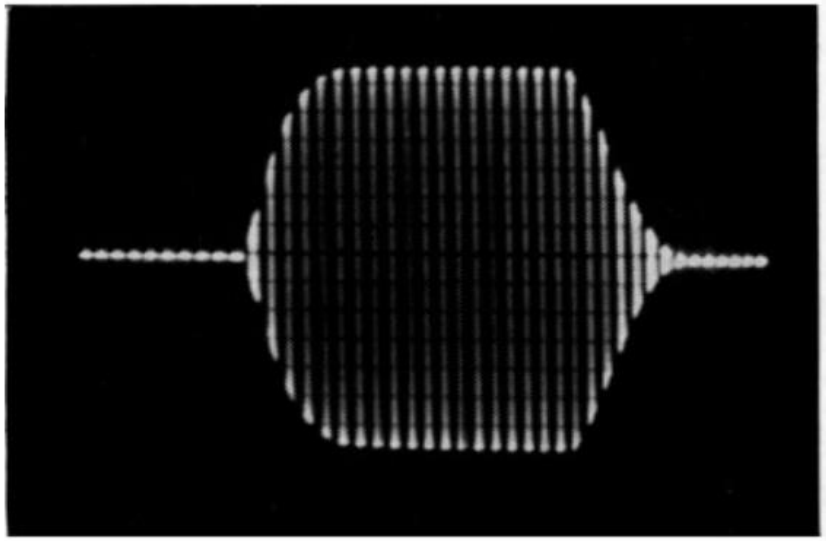
Is the mode CW
a form of
Amplitude Modulation?

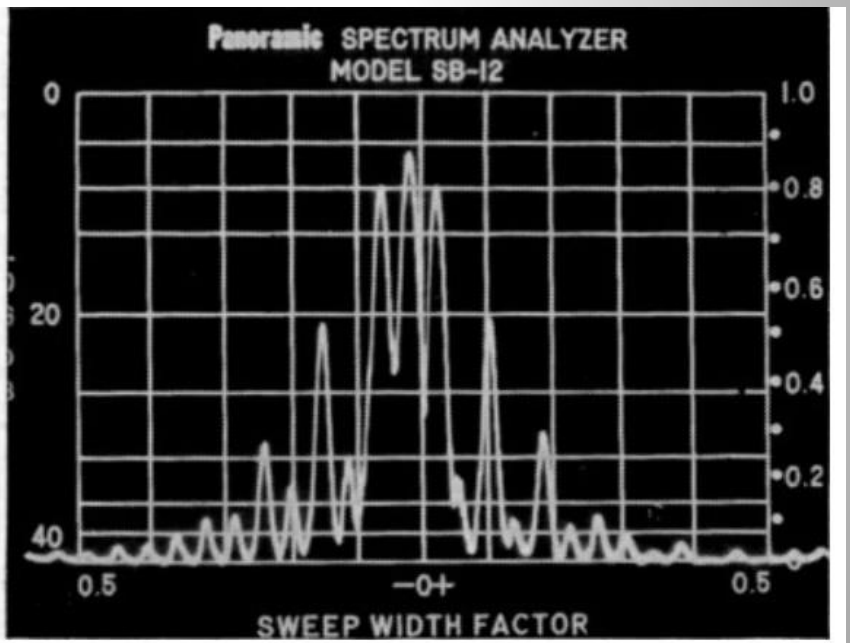
CW or ASK or OOK

(amplitude shift keying, on/off keying)

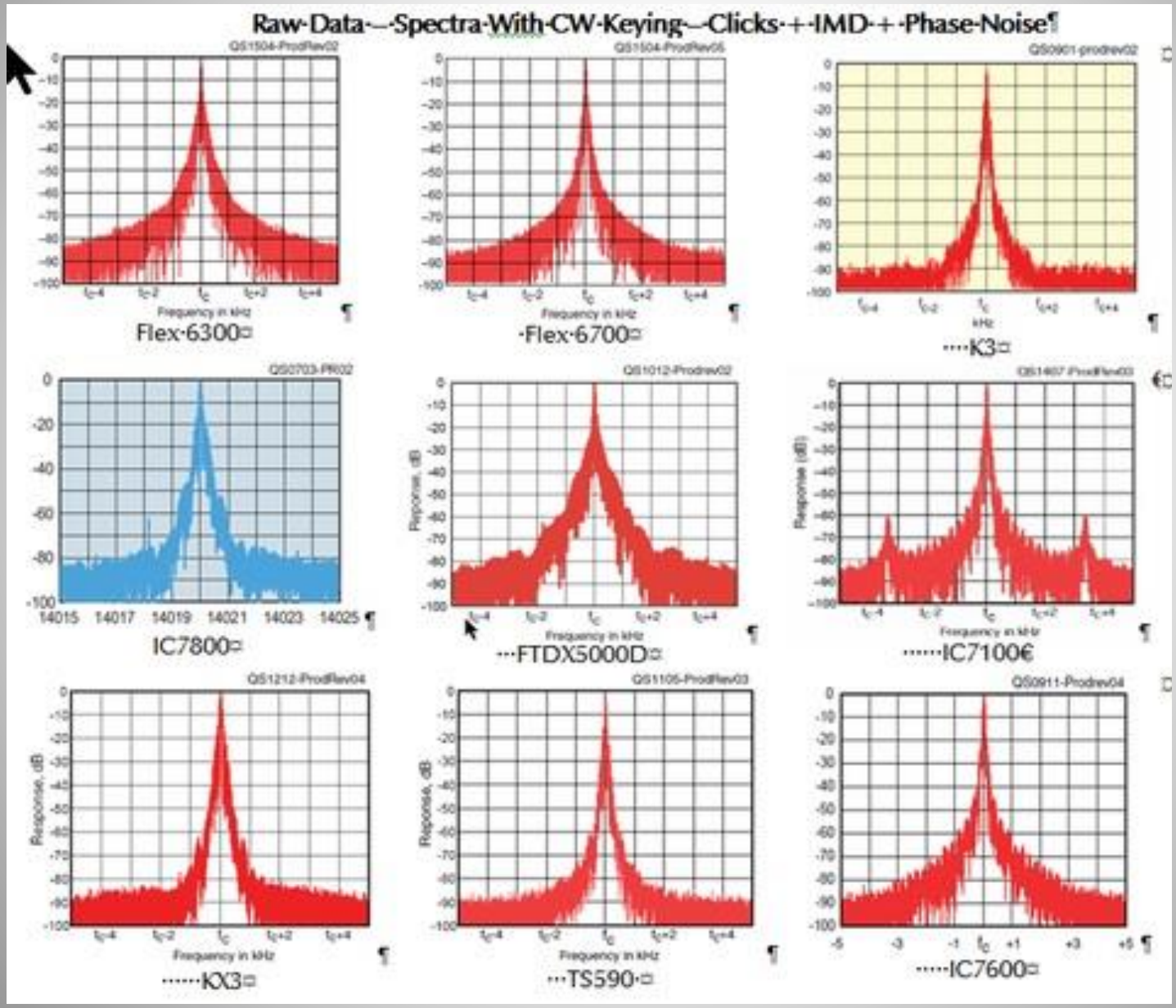


CW keying **shape** and **bandwidth**
Rise and Fall times of RF about 4 milliseconds

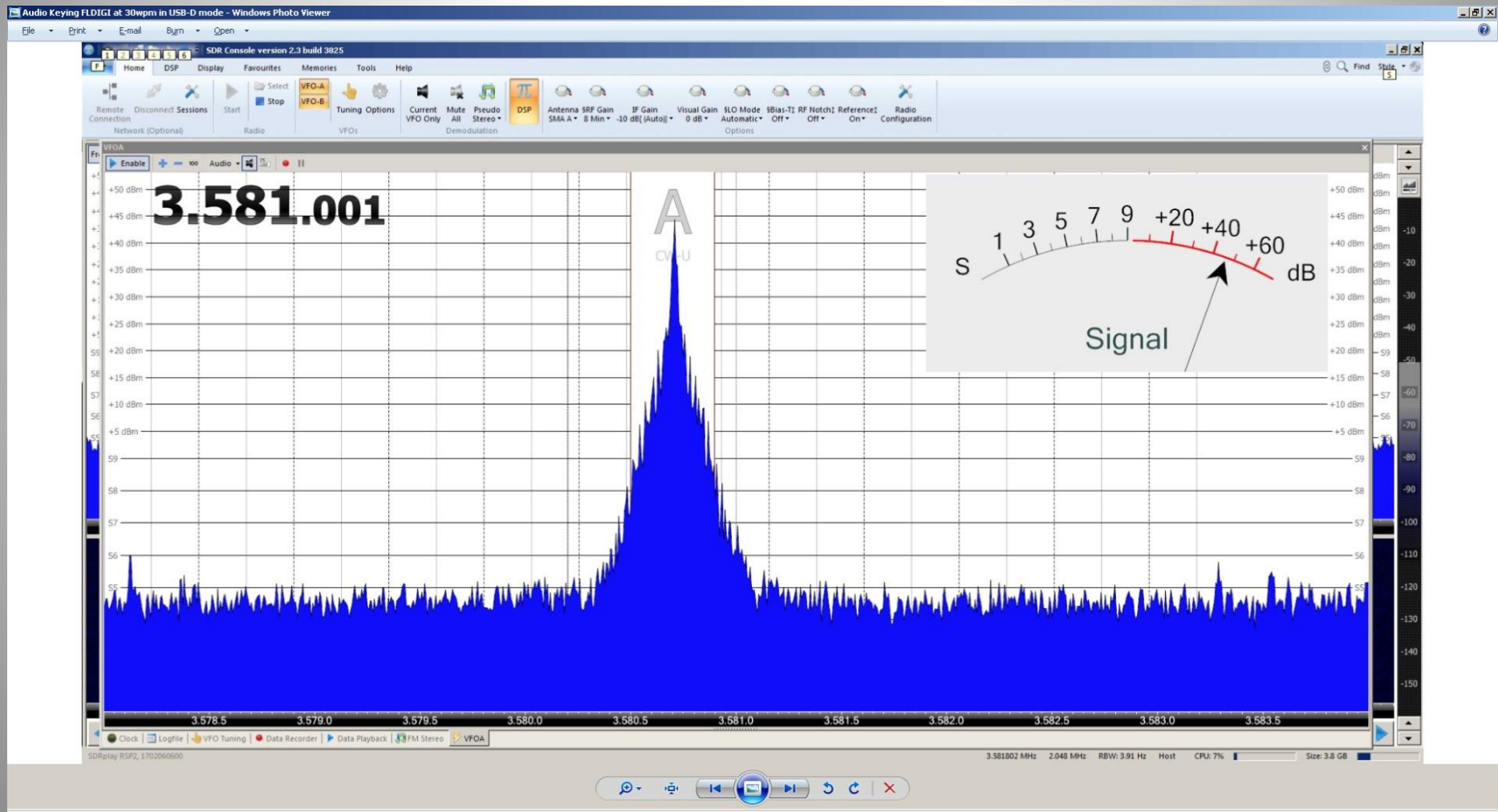




Keying Bandwidth varies from rig to rig



SDRplay capture of W1AW CW RF signal received at k3eui on 3581.5 kHz



What makes CW a digital mode?

CW is binary because

0 = no RF (silence)

1 = RF (sound)

The dit (short sound) is represented by **1**

The dah (long sound) is represented by **111**

standard dash/dot radio is a 3:1

You need the 0 to represent <u>silence</u>

Binary nature of CW

E = 1

I = 101

S = 10101

H = 1010101

T = 111

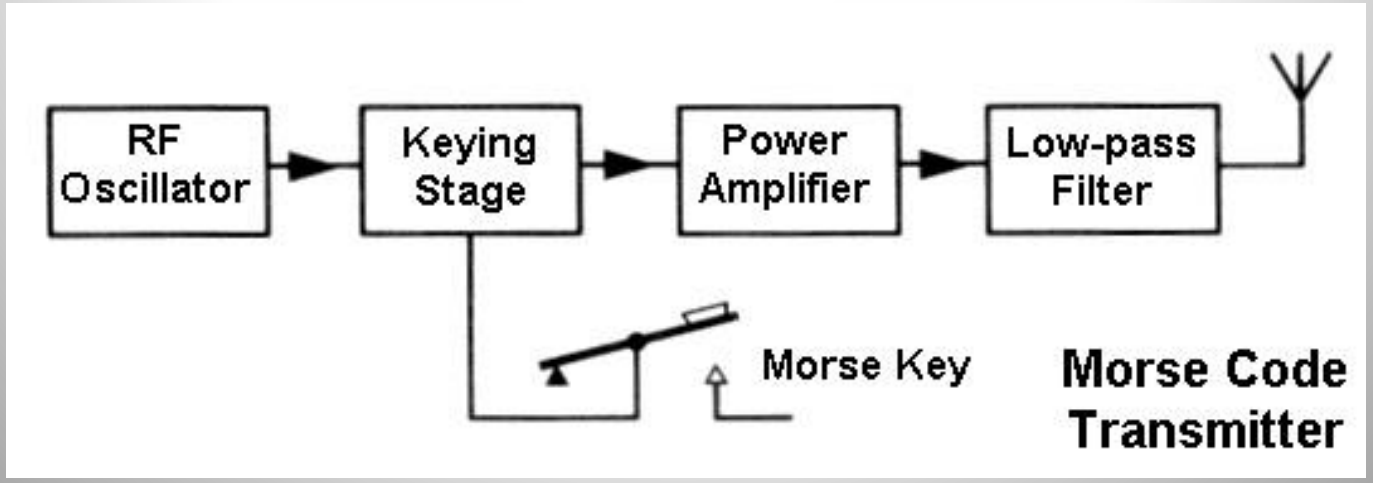
M = 1110111

O =11101110111

Longer spaces between letters: 000

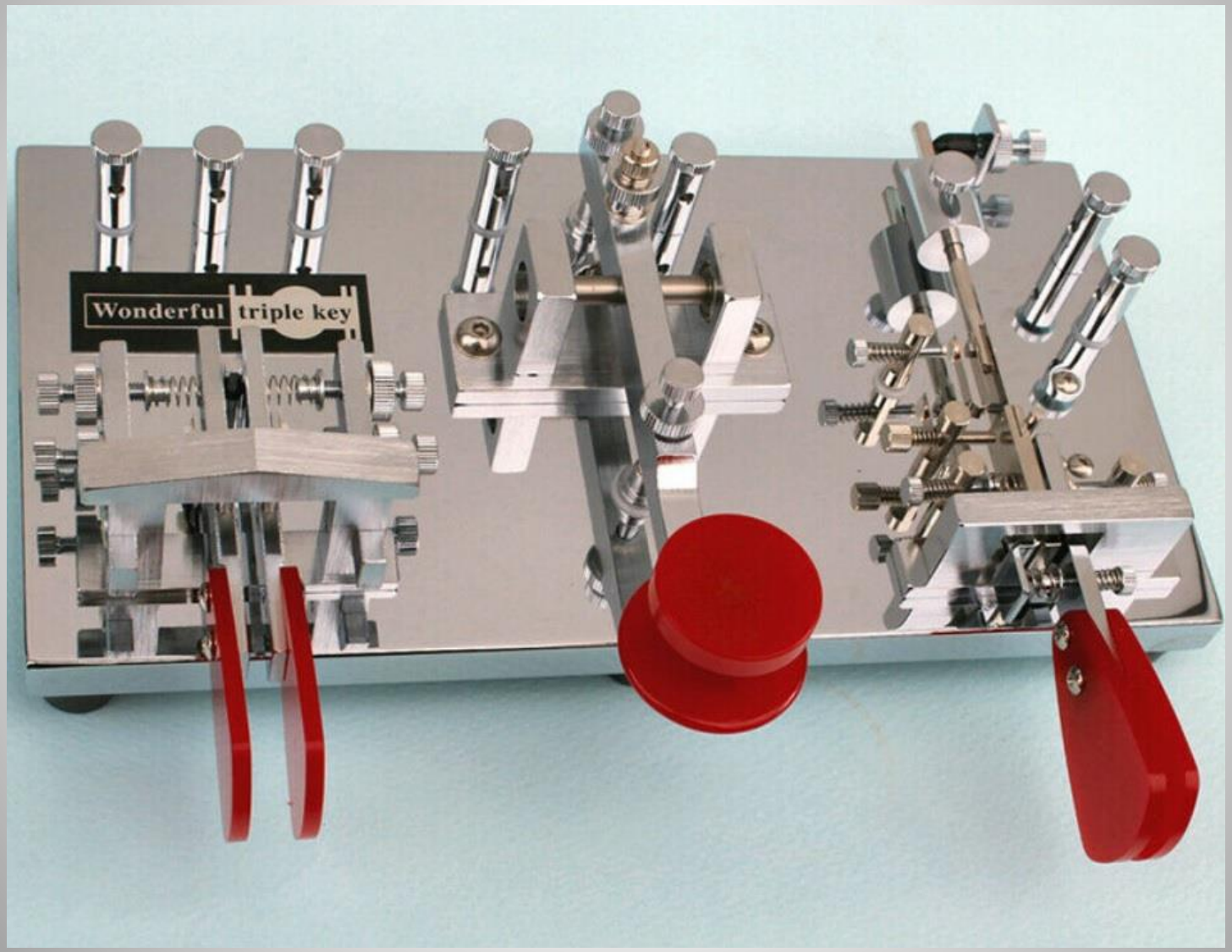
Longer spaces between words: 00000

Typical method of generating a CW signal
Turn RF on/off by a mechanical switch



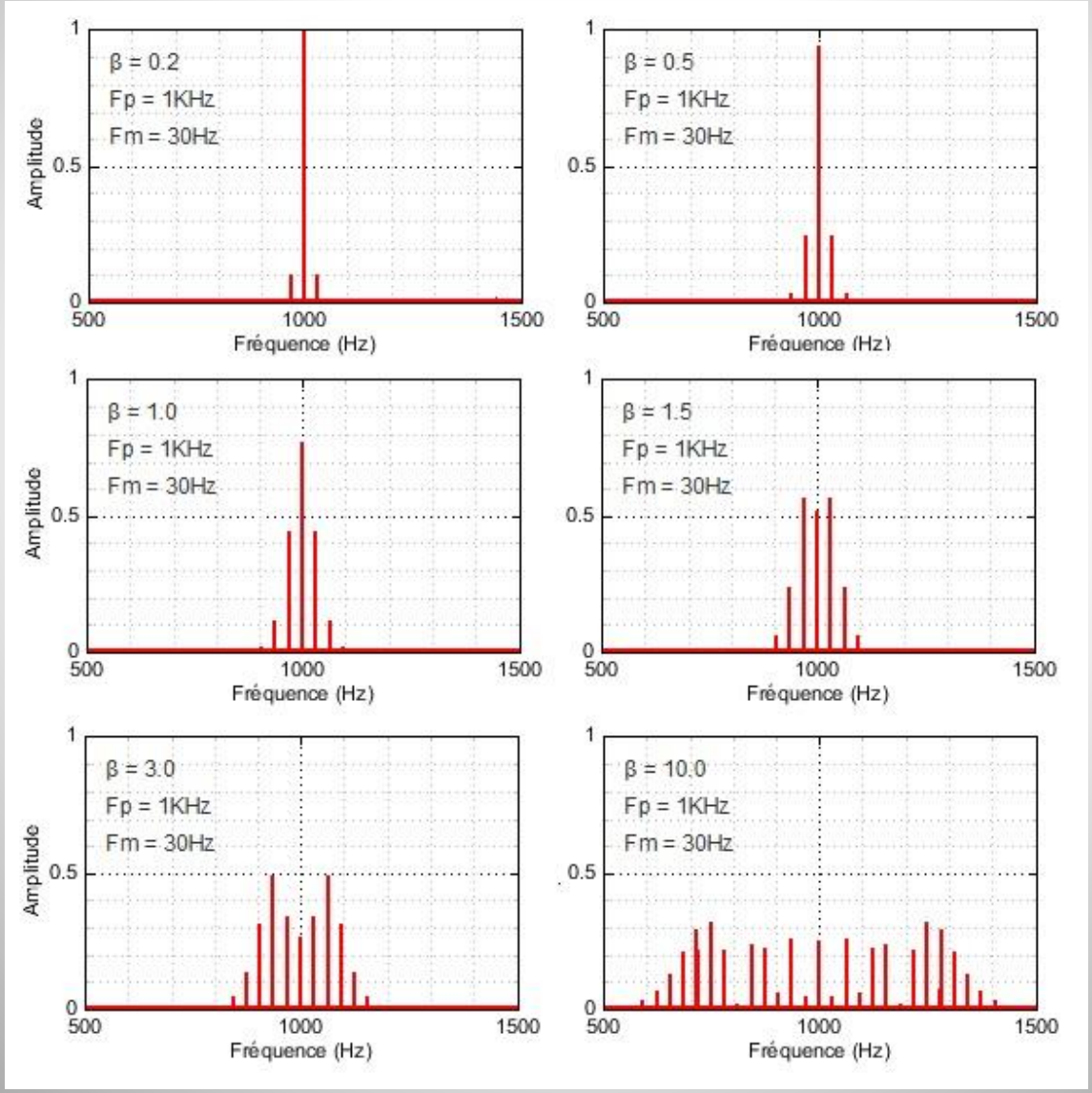
More advanced: mechanical "bug" (sliding weight controls speed of the dits)

For those who like a choice

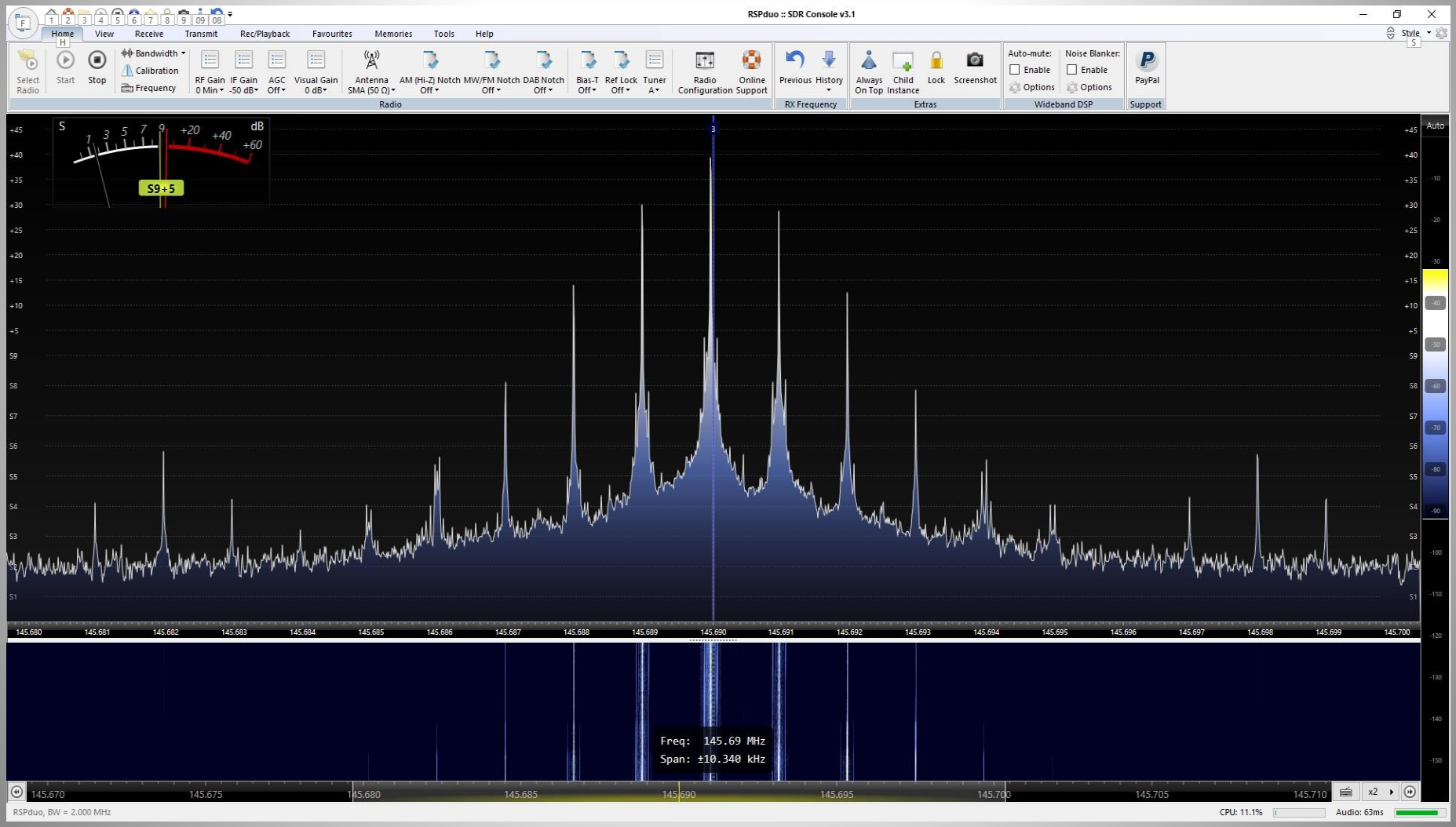


What does the RF spectrum look like for a **FREQUENCY modulated** signal with a single audio tone?

RF carrier: FREQUENCY modulated by an single audio tone at different levels (amplitude) LOUDER audio ==> more harmonics ==> wider bandwidth



FM signal (145.690 MHz) with 1 kHz audio
note: multiple sidebands out to 10 kHz



DEVIATION

The "deviation" of an FM signal is proportional to the

AMPLITUDE

of the audio signal

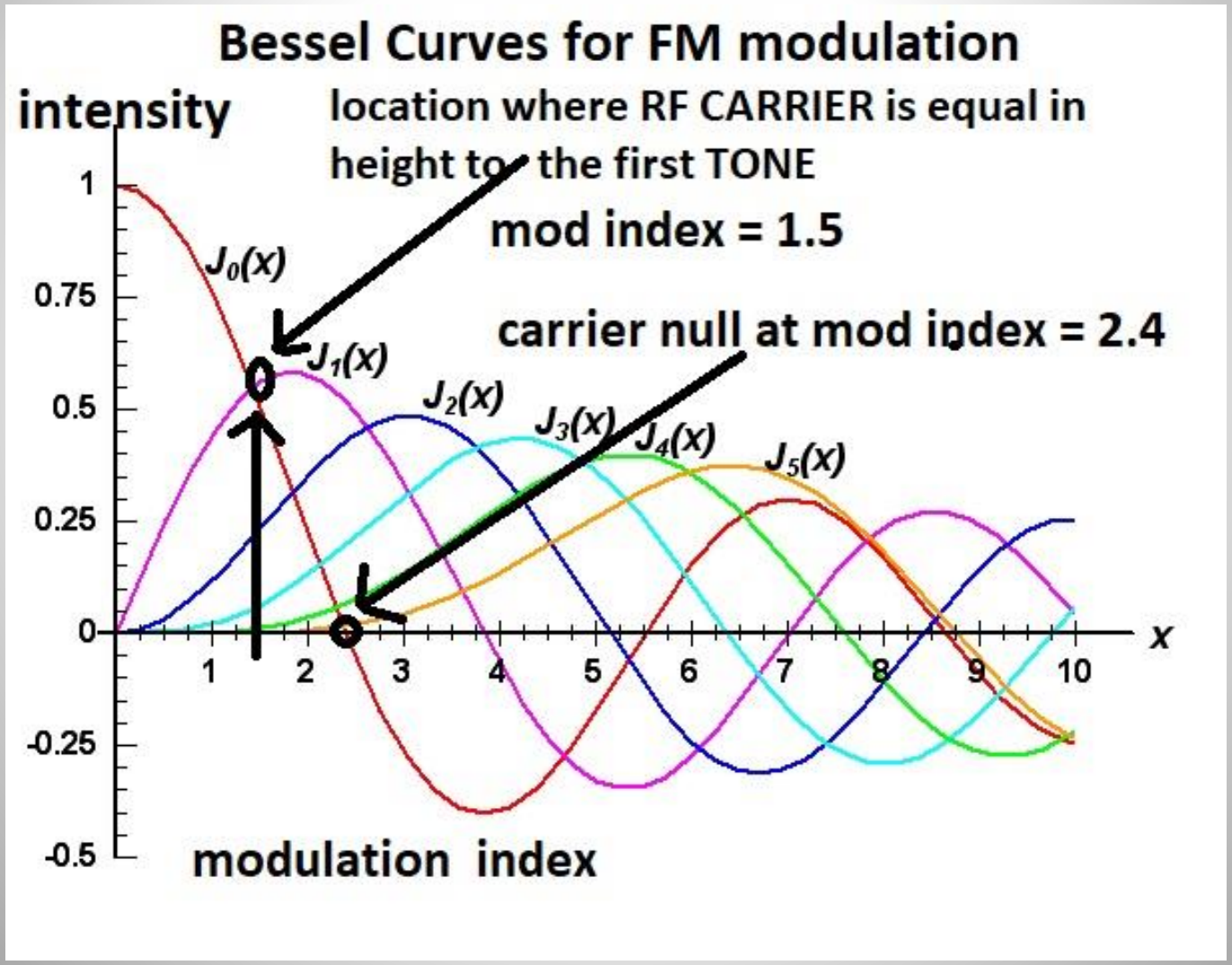
Narrow Band FM ==> <**5 kHz** deviation

Deviation is related to modulation index

Deviation (kHz) =

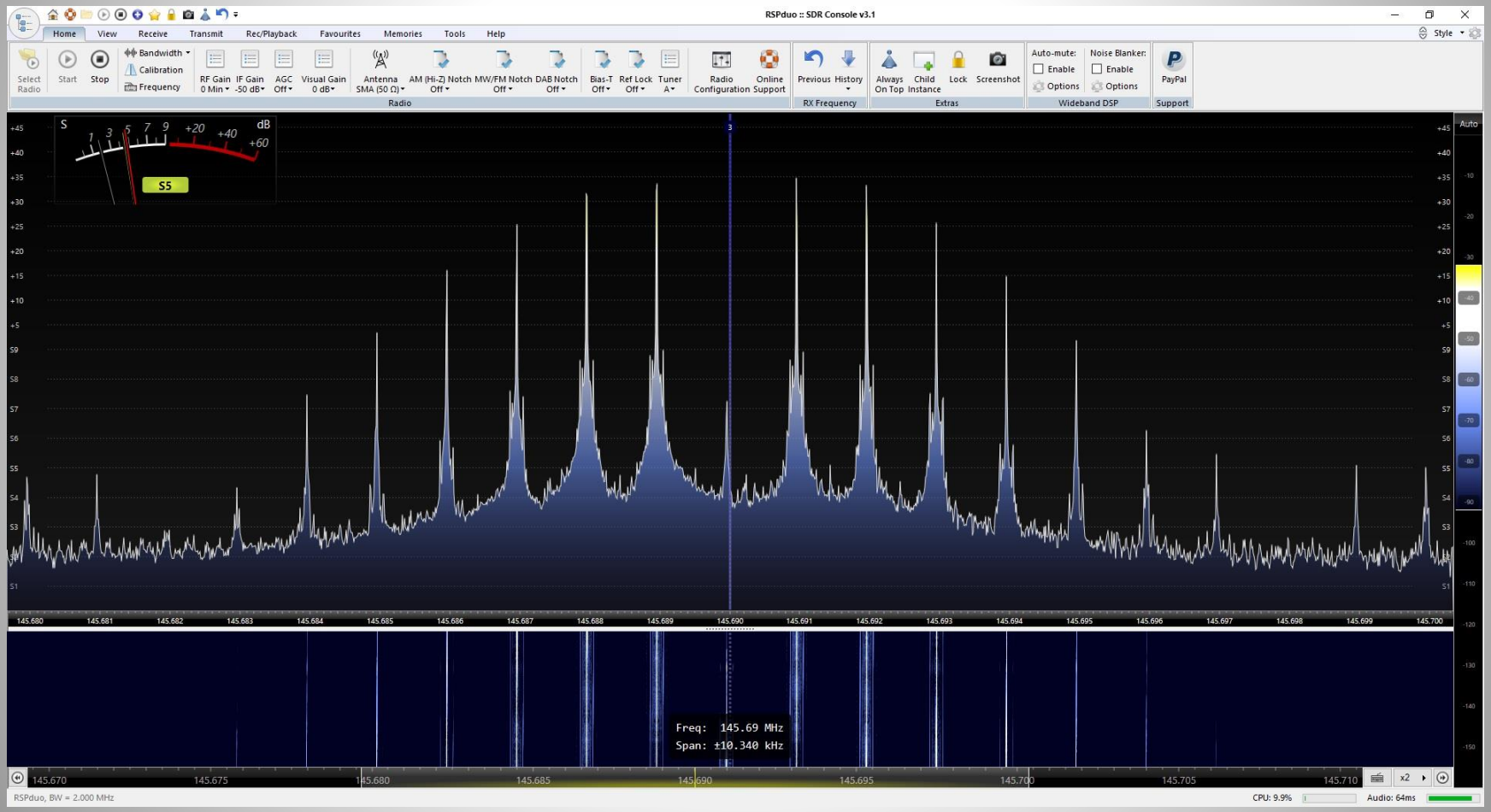
Modulation Index x Audio frequency (kHz)

Bessel curves for FM

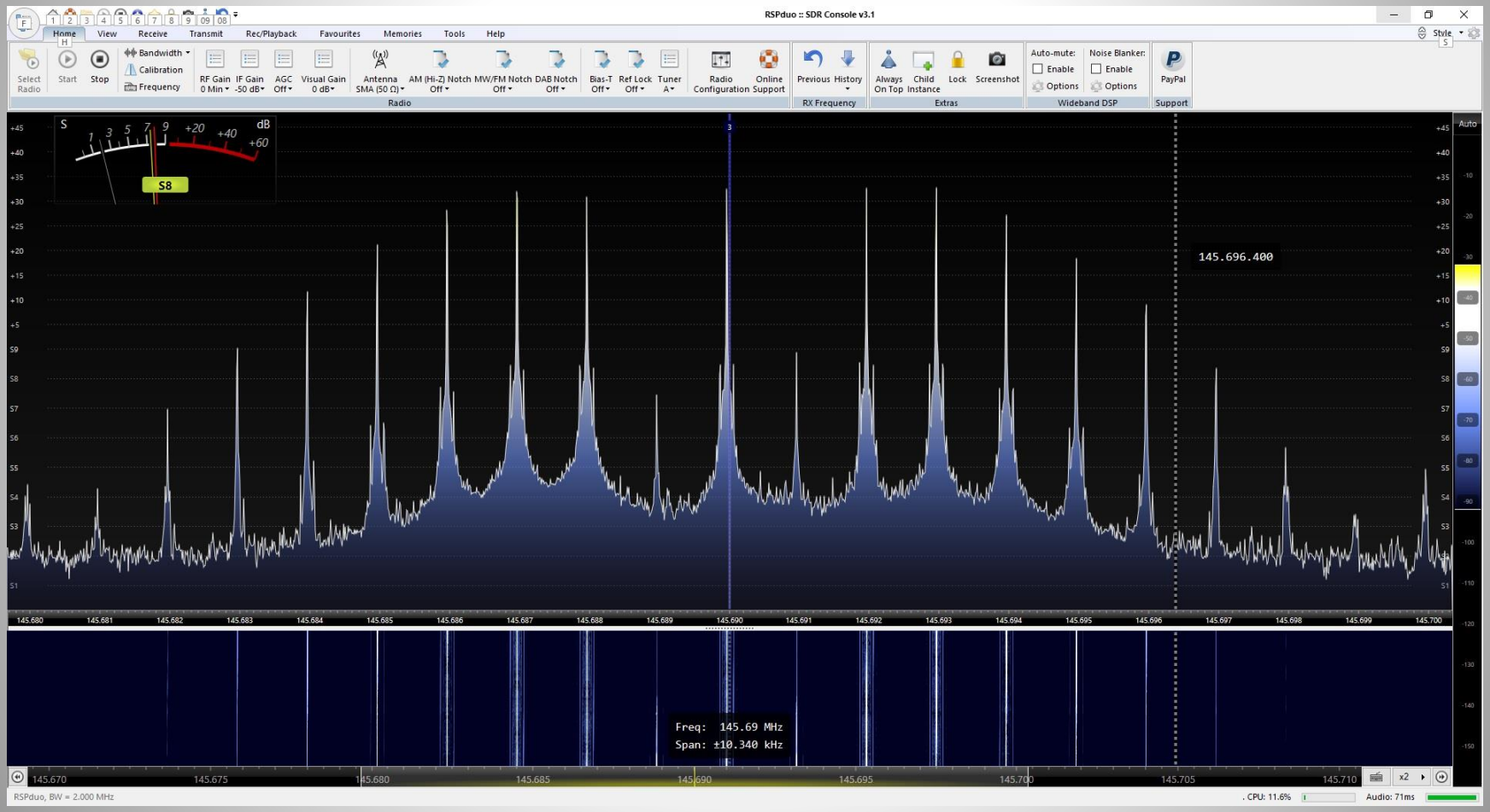


FM signal with a 1 kHz audio tone and **modulation index of 2.4**

note: carrier nearly disappears !!



FM signal with 1 kHz audio overmodulated to distortion note bandwidth about 18 kHz



Pre-emphasis (transmit audio)
De-emphasis (receive audio)

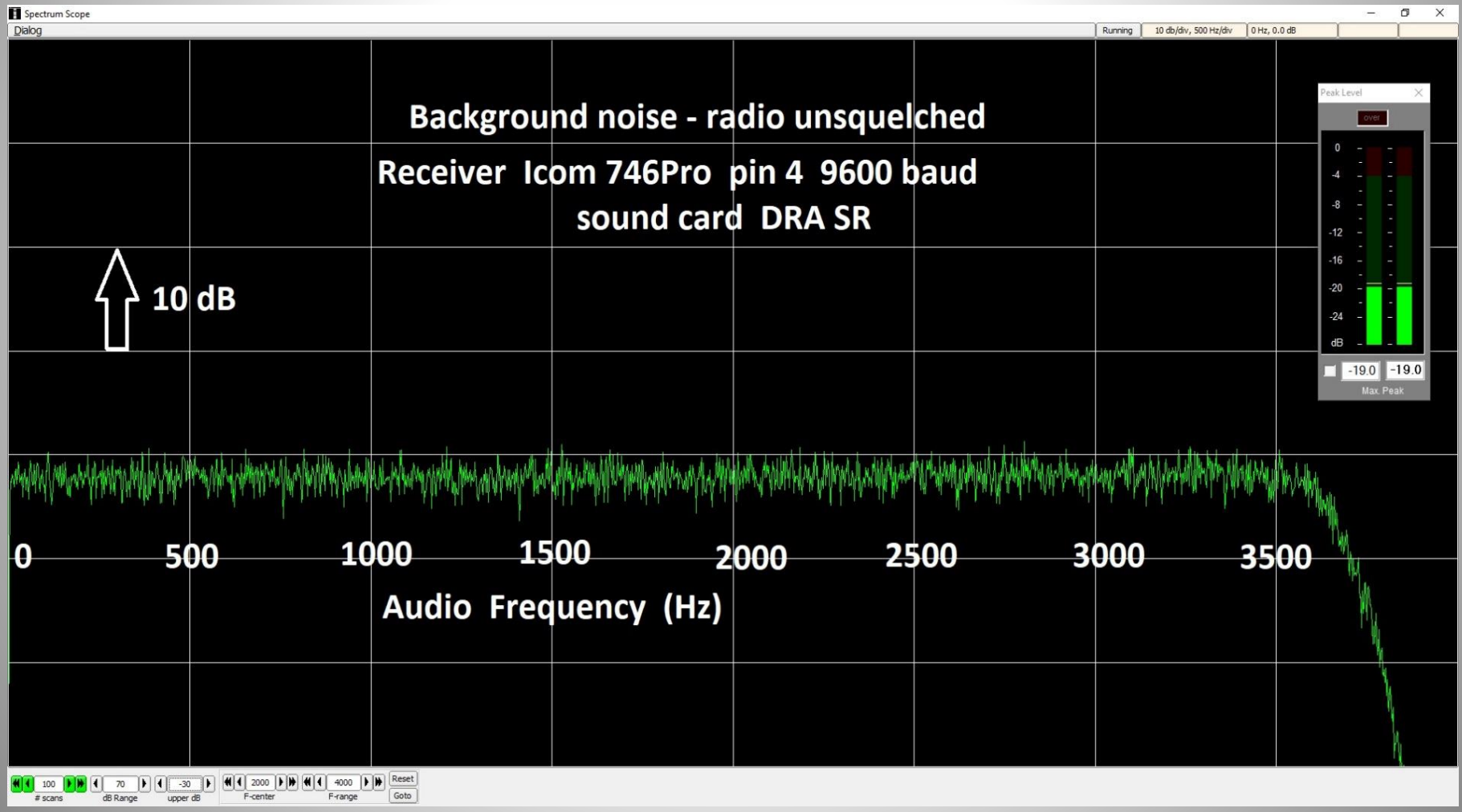
FM radios employ an **audio filter** on both the TX and RX to improve S/N

TX - boost the high audio frequencies

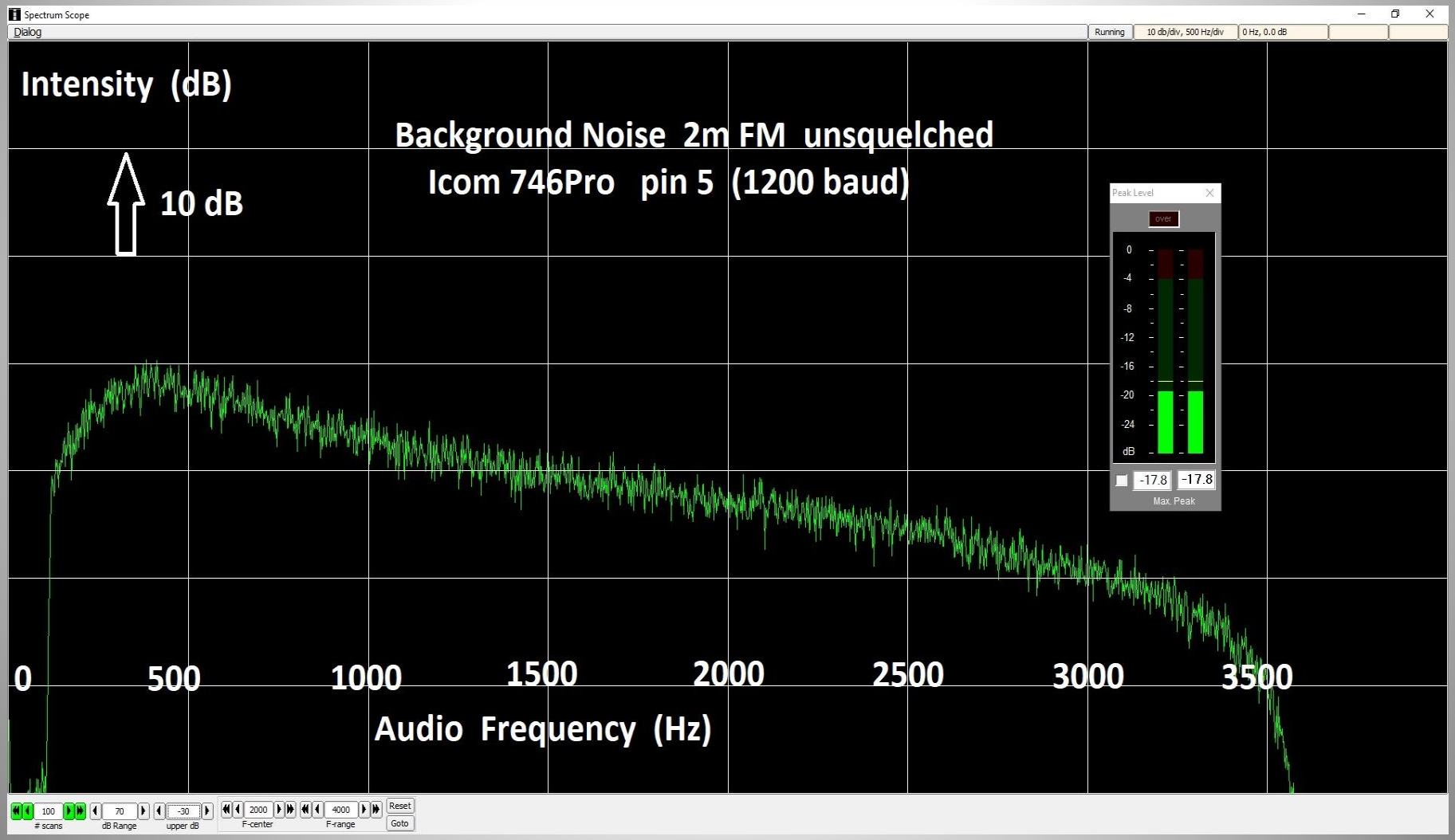
Rx - reduce the high audio frequencies

Overall ===> "flat audio"

Background Noise sampled 2m FM radio unsquelched audio at discriminator – 9600 baud path



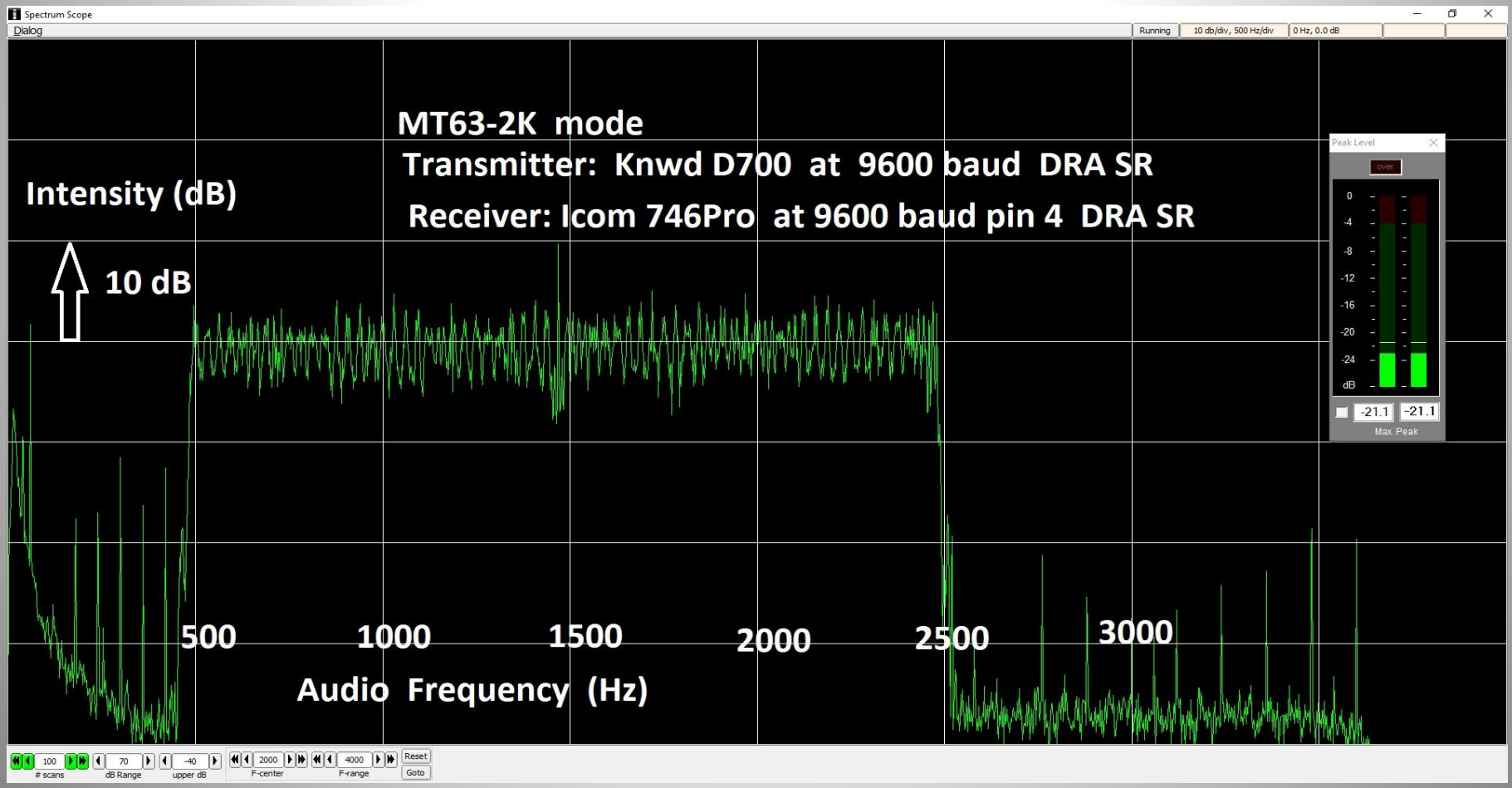
Background Noise 2m FM unsquelched
Icom 746 Pro pin 5 (1200 baud)



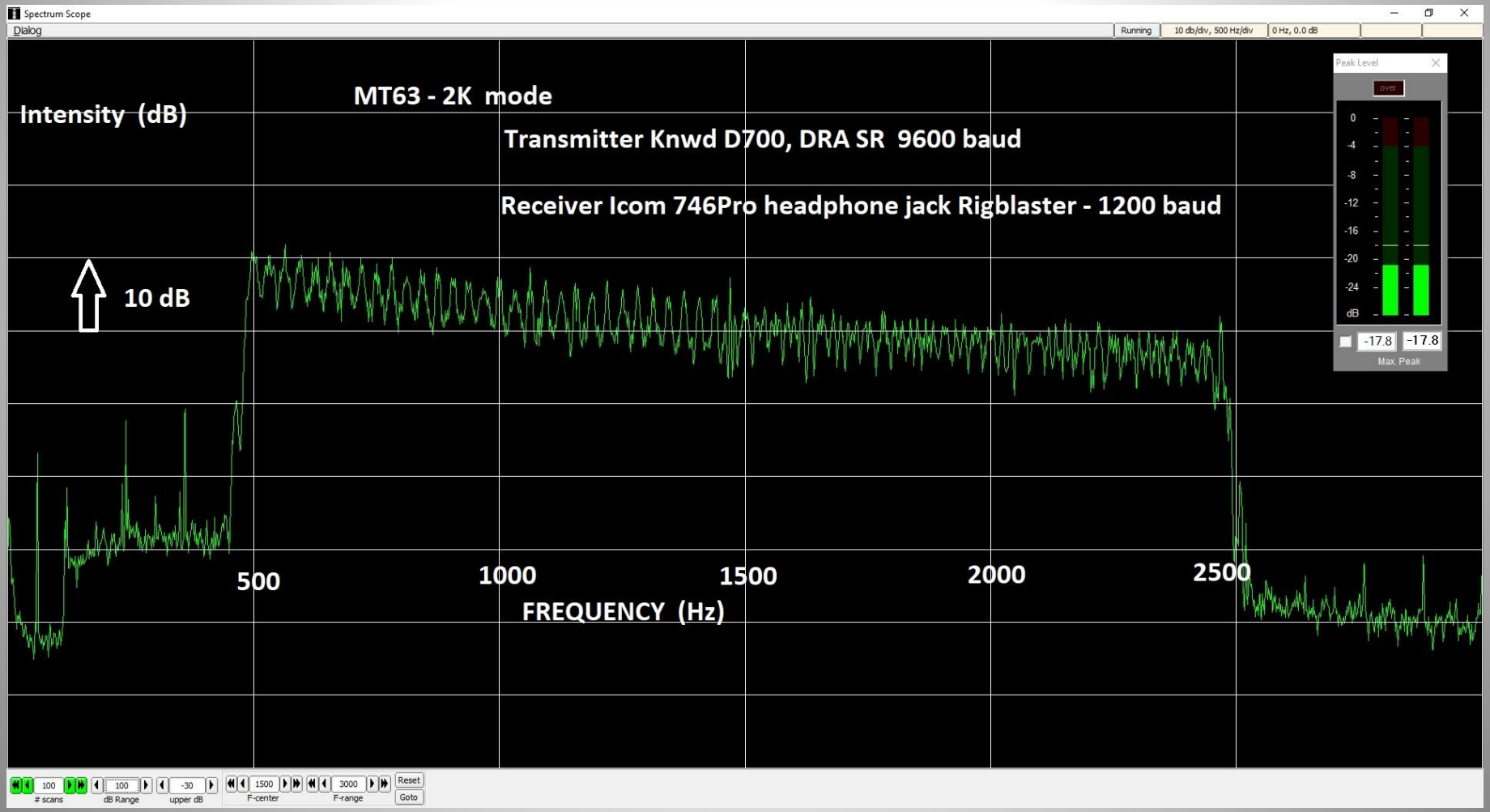
Reception at 9600 baud (flat)
vs.
Reception at 1200 baud (filtered)

How will processing of TX and RX audio affect various digital modes?

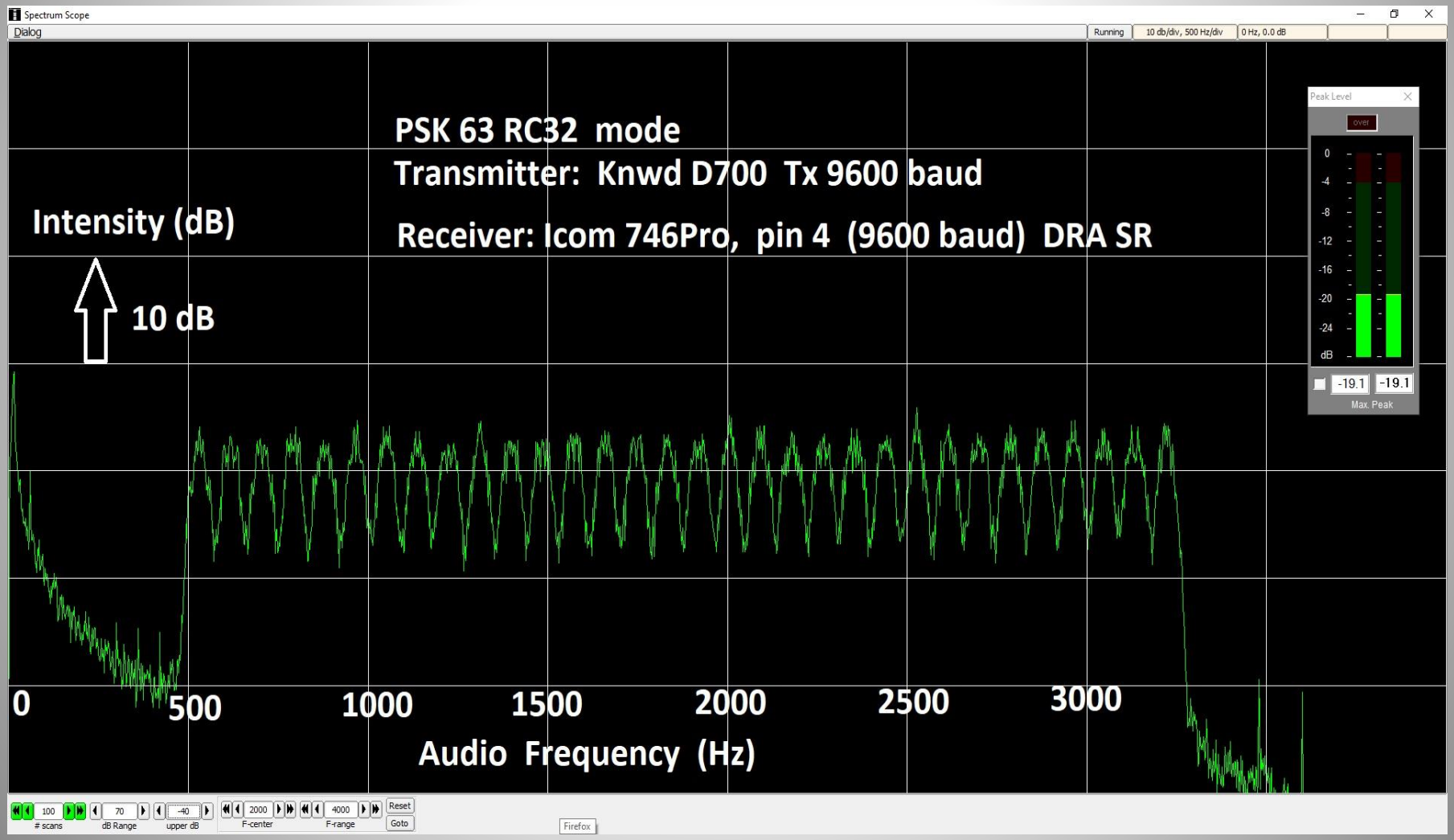
MT63 – 2K mode - bandwidth 500-2500 Hz
64 carriers – each PSK mod
Received with FLAT (9600) audio



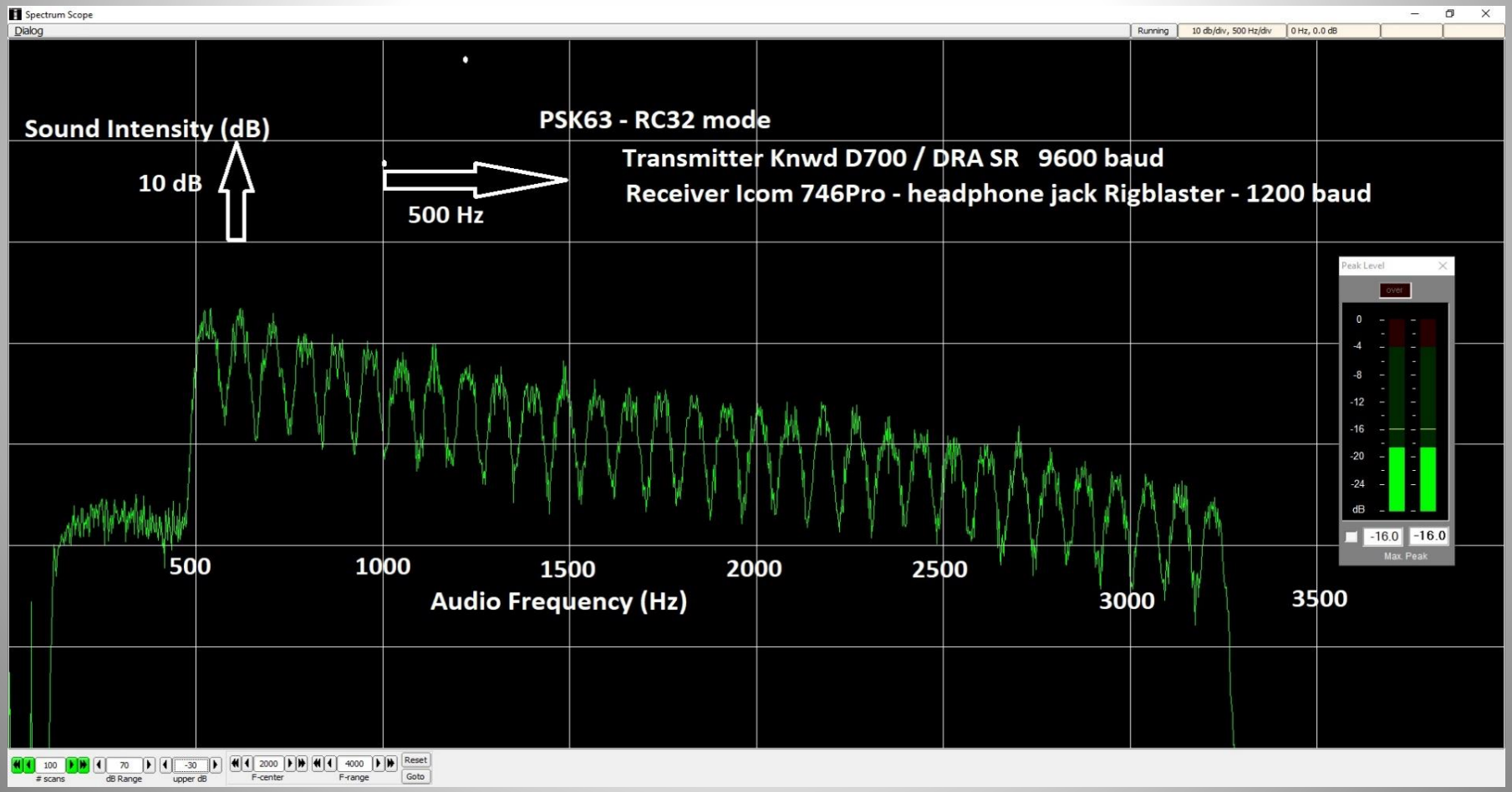
MT63 – 2K mode: bandwidth 2000 Hz
64 carriers – each PSK mod
Now received at 1200 baud path
higher pitch 15 dB reduced



PSK63- RC32 very wideband signal: 500 – 3200 Hz
Received at 9600 baud (FLAT audio)
Receiver Icom 746Pro pin 4



PSK63- RC32 wideband signal 500 – 3200 Hz
Received at 1200 baud (de-emphasized audio)
Receiver Icom 746Pro pin 5
higher pitch audio 15 dB reduction



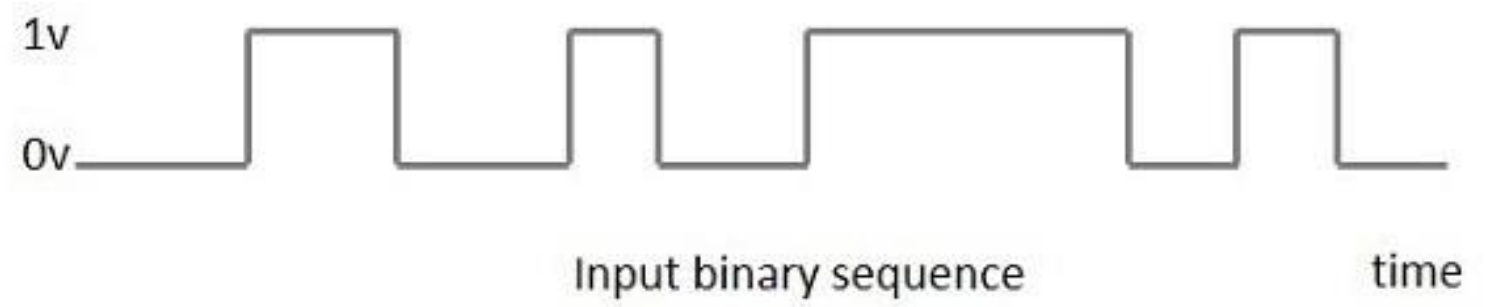
Emission Types

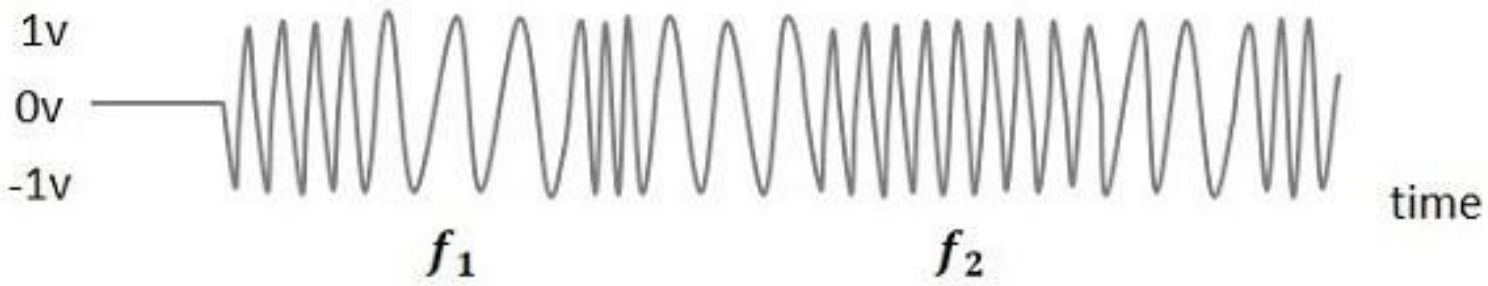
CW	**A1A**	on/off amplitude shift keying (ASK)
SSB	**J2D**	data, multi-carrier (MT63, VARA)
FM	**F1B**	data, frequency modulation (FSK RTTY)
FM	**F2B**	data, frequency modulation (AFSK RTTY)
PM	**G1B**	data, phase modulation (PSK, 4PSK, 8PSK)

FREQUENCY modulation

0 = F1 1 = F2 (one at a time)

note: there is no time of silence





FSK Modulated output wave

Two methods to generate RTTY

FSK - **RTTY** - **direct** frequency shift keying by **DATA** pulses **TNC**
VFO changes by 170 Hz: MARK / SPACE
Note: not all HF rigs have FSK keying option

AFSK - **RTTY** - **audio** frequency shift keying
sound card emits two different audio frequencies (pitch)
audio fed to any **SSB rig** (either USB/LSB mode)

Results: FSK and AFSK are nearly identical (sort of)
(watch that transmitter ALC reads zero with AFSK)

Early "teletype" mechanical printer (1940)

Typical RTTY station of the 1950's
mechanical RTTY printer
(extra credit: name the receiver, transmitter, and mic)

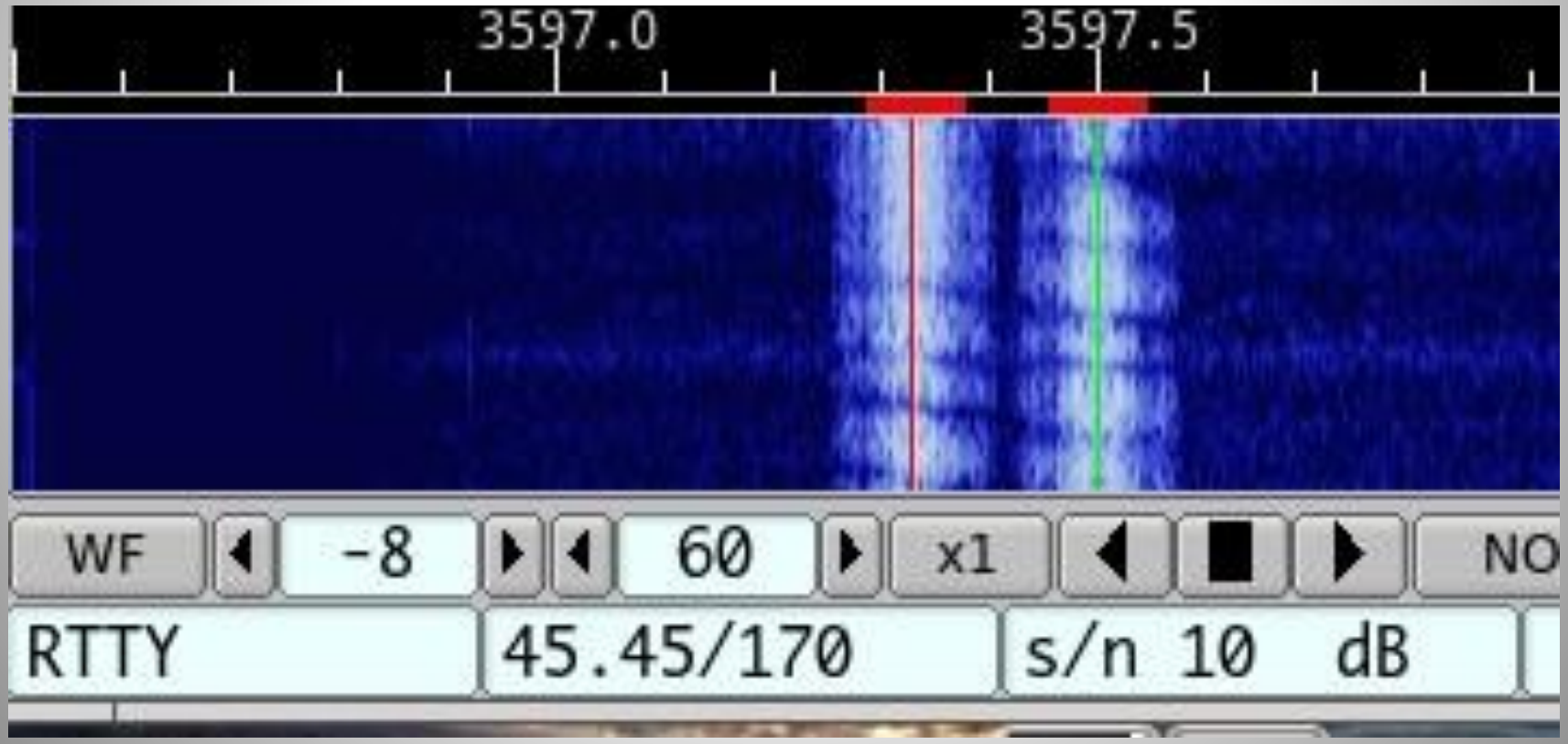
1990's Multi-mode TNC (CW, Pactor, Amtor, RTTY) could hook up to a "dumb" terminal

Common **AFSK RTTY** - waterfall image

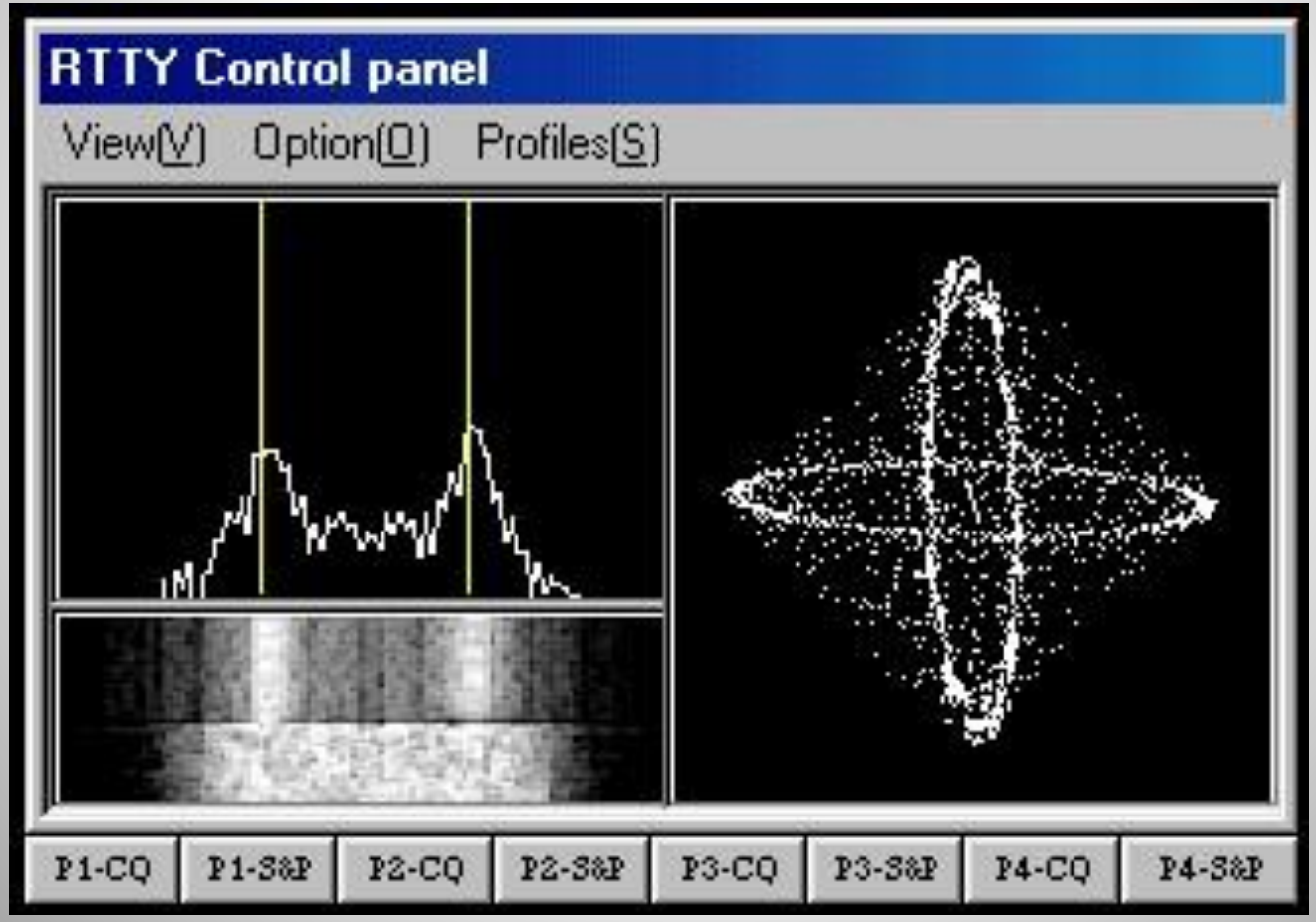
AFSK RTTY: **two** audio tones converted **two RF waves**

2 parallel tracks, 170 Hz separation

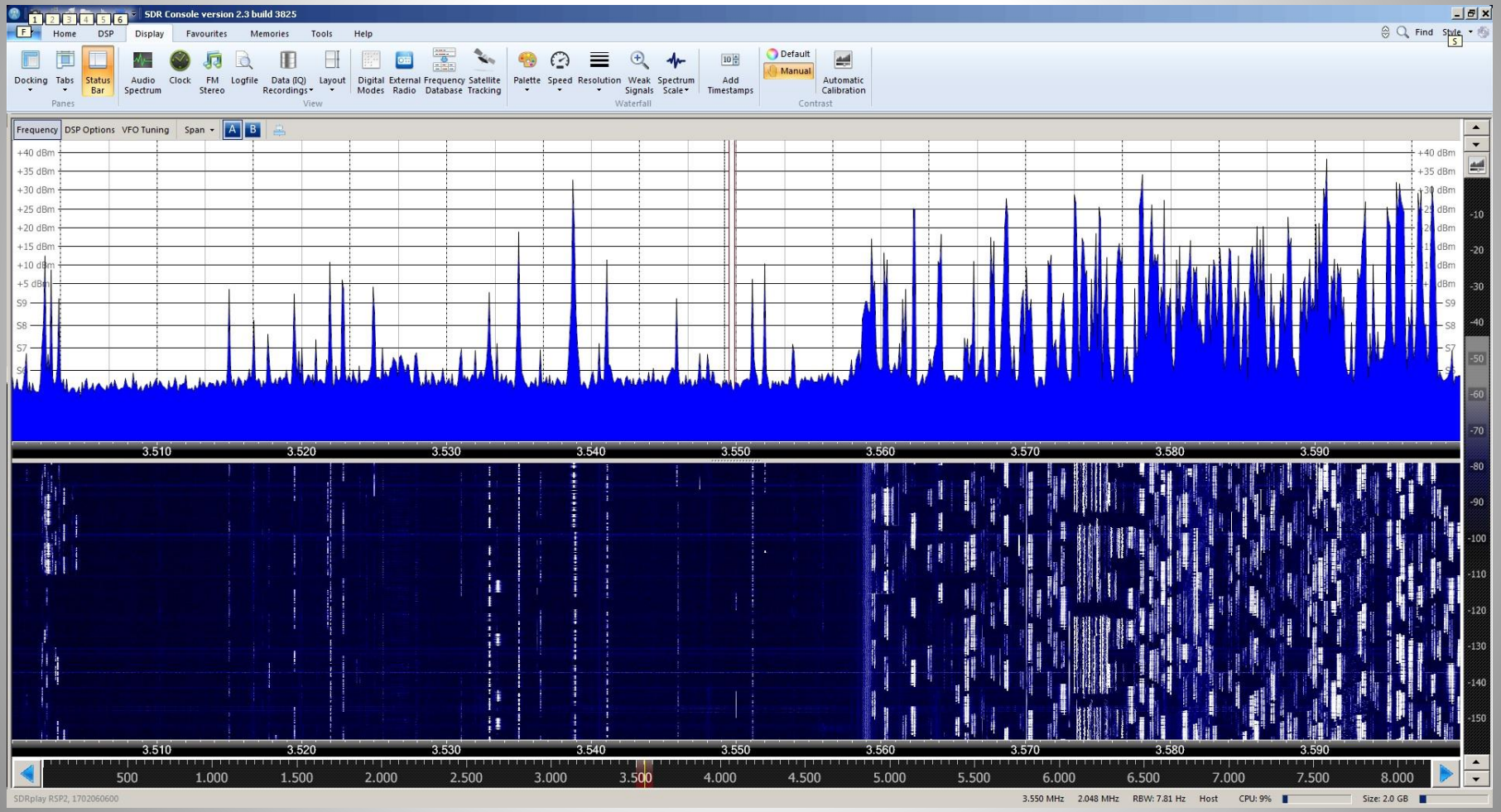
45.45 baud, 60 wpm



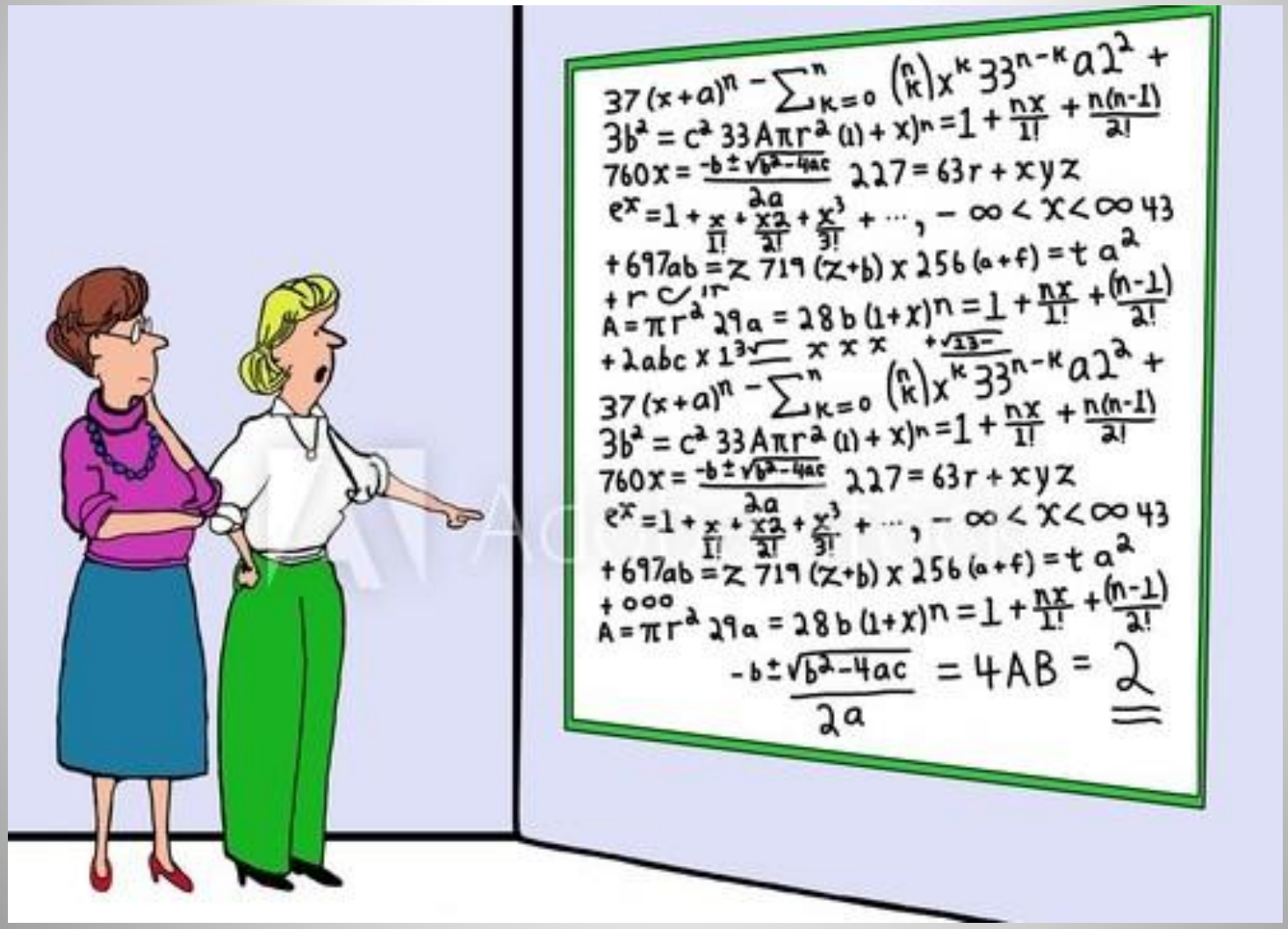
MMTTY - popular app in 1990's (free)
FSK or AFSK RTTY signal using your sound card
2 tones, 170 Hz shift



Was this a RTTY contest? 80 meters



Symbols, Baud, Bits and Speed



Baud: number of **changes per second** made to a radio carrier's amplitude, frequency or phase

Also called "**symbol rate**"
(in a two-state system like RTTY or CW)

Current legal baud (rate) on HF **< 300 baud**

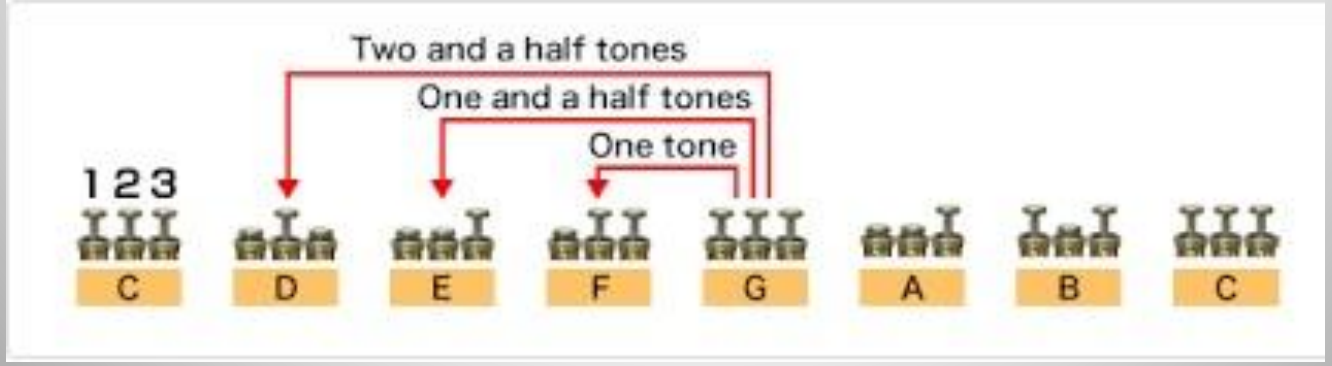
Current debate with FCC rules: **baud vs. bandwidth**

BAUD and Word/minute

CW	20 baud	=	24 wpm
PSK31	31 baud	=	50 wpm
RTTY 45	45 baud	=	60 wpm
Olivia 8 / 500	63 baud	=	30 wpm
MFSK 32	32 baud	=	120 wpm
THOR 22	22 baud	=	78 wpm
8PSK 1000F	1000 baud	=	3386 wpm

Why can a TRUMPET play more notes than a BUGLE ?

Valves change LENGTH of tubing changes wavelength of the resonance sound



Multiple Tone Modes
can send more data per second

JT 65, FT8, FT4

MFSK

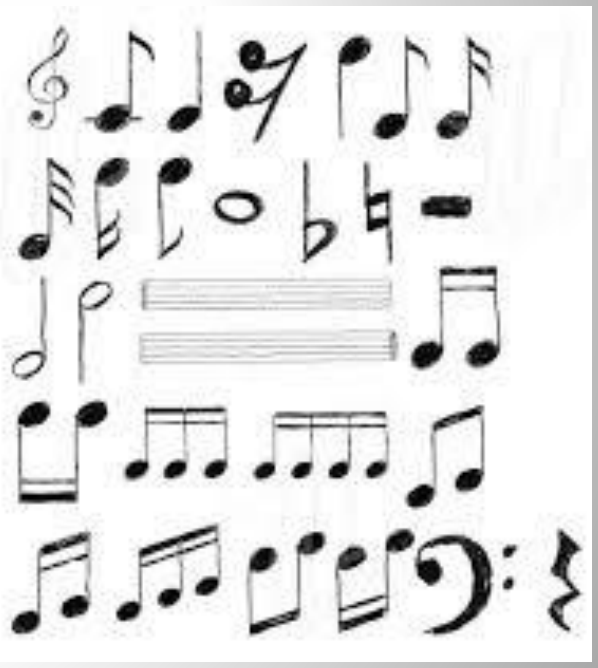
THOR

OLIVIA

MMSSTV

VARA

OFDM



Bandwidth (99% of energy)

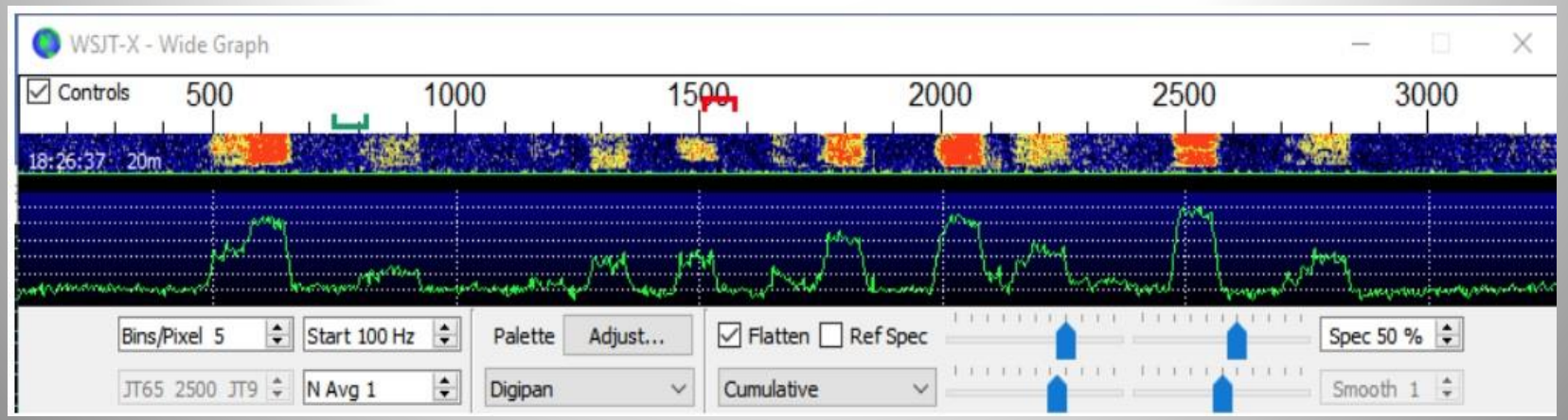
AM phone	=	6 kHz (double sideband)
SSB phone	=	2-3 kHz
CW	=	100 – 300 Hz
PSK 31	=	50 Hz
Olivia 8/500	=	500 Hz
FT8	=	50 Hz
MT63-2K	=	2000 Hz
THOR 100	=	1800 Hz
MFSK 128	=	1920 Hz
Pactor III	=	2400 Hz
VARA	=	500 Hz or 2300 Hz

JT modes (one tone at a time)

JT65 - **65 tones**, 1 minute transmissions
copy down to -24 dB S/N
175 Hz bandwidth

FT8 - **8 tones**, 15 second transmissions
copy down to - 20 dB S/N (2500 BW)
50 Hz bandwidth

FT4 - 8 tones, 7 seconds, narrow bandwidth



JT modes
https://physics.princeton.edu/pulsar/k1jt/

JOE TAYLOR, K1JT

- Joe Taylor is a professor at Princeton University, and obtained the Nobel Prize in Physics back in 1993 for his work in pulsars.
- Significant research in Moon-bounce (EME)
- WSJT (Weak Signal Joe Taylor)
- WSPR (Weak Signal Propagation Reporter, pronounced "Whisper")
- FSK441, JT-65, JT-9, FT8

https://www.nobelprize.org/prizes/physics/1993/taylor/auto-biography/

Joe Taylor K1JT

Ideal Digital DX Mode

Copy under weak S/N
Print reliably with QRM, QRN, QSB
Reject noise
Narrow bandwidth
Low power
Work with common sound cards
Print at a reasonable speed
No COST and works on any platform

FT8 Positive Features

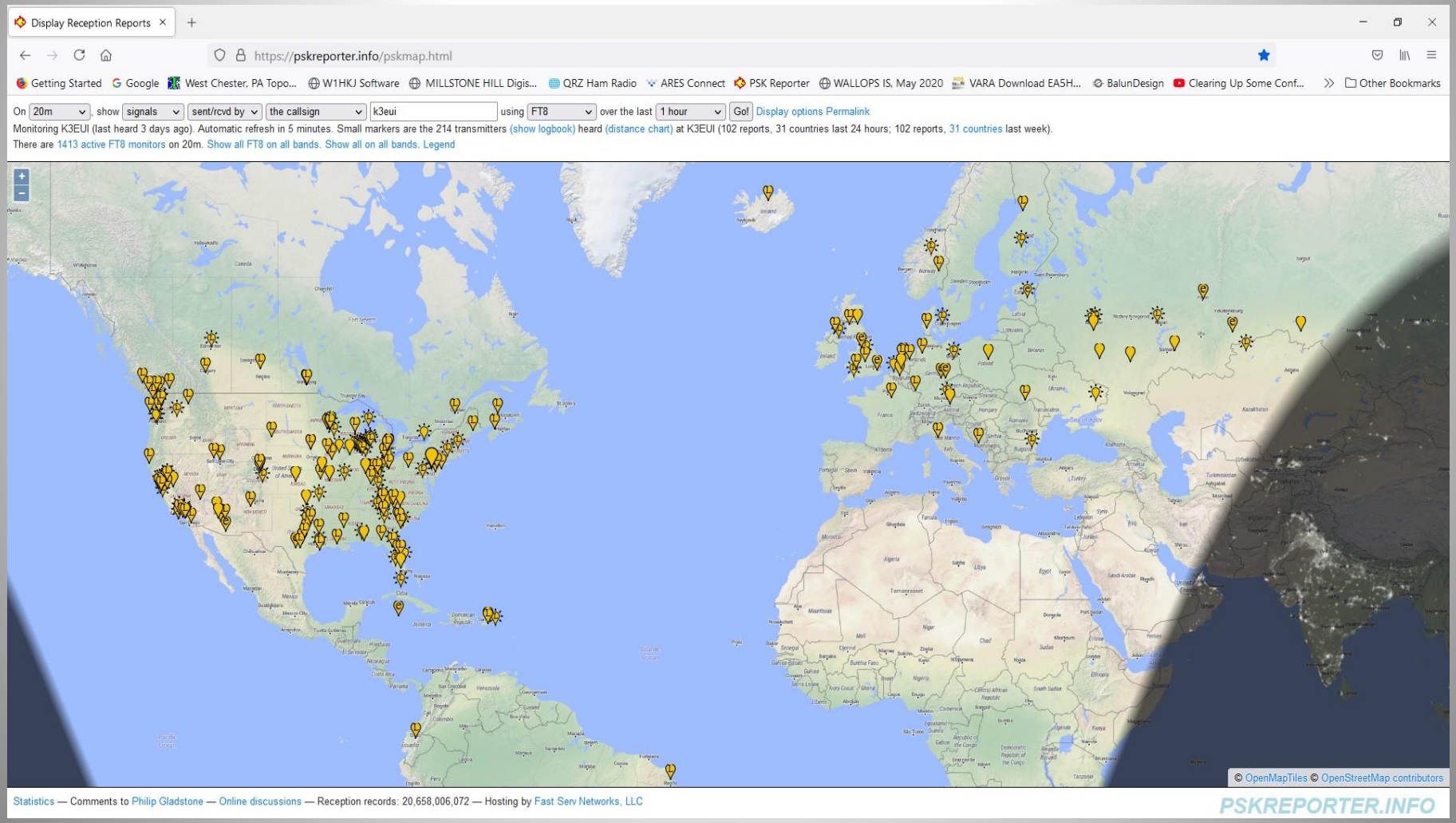
Can work the world with 1 watt and simple antennas

Software is free and works on multiple platforms

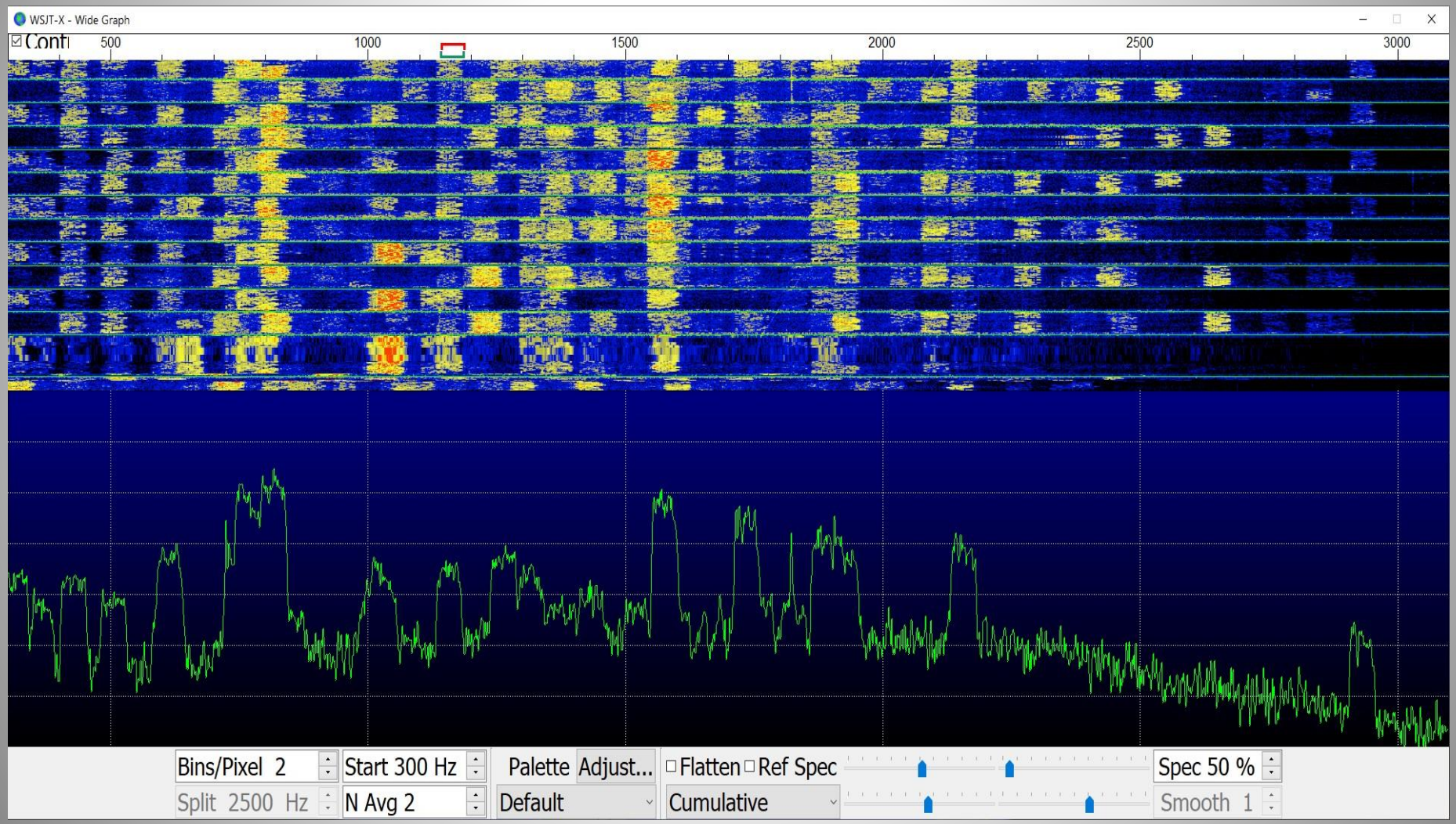
Bandwidth about 50 Hz and S/N to - 20 dB copy

Can complete a QSO (call, grid, signal report, confirm) in about two minutes

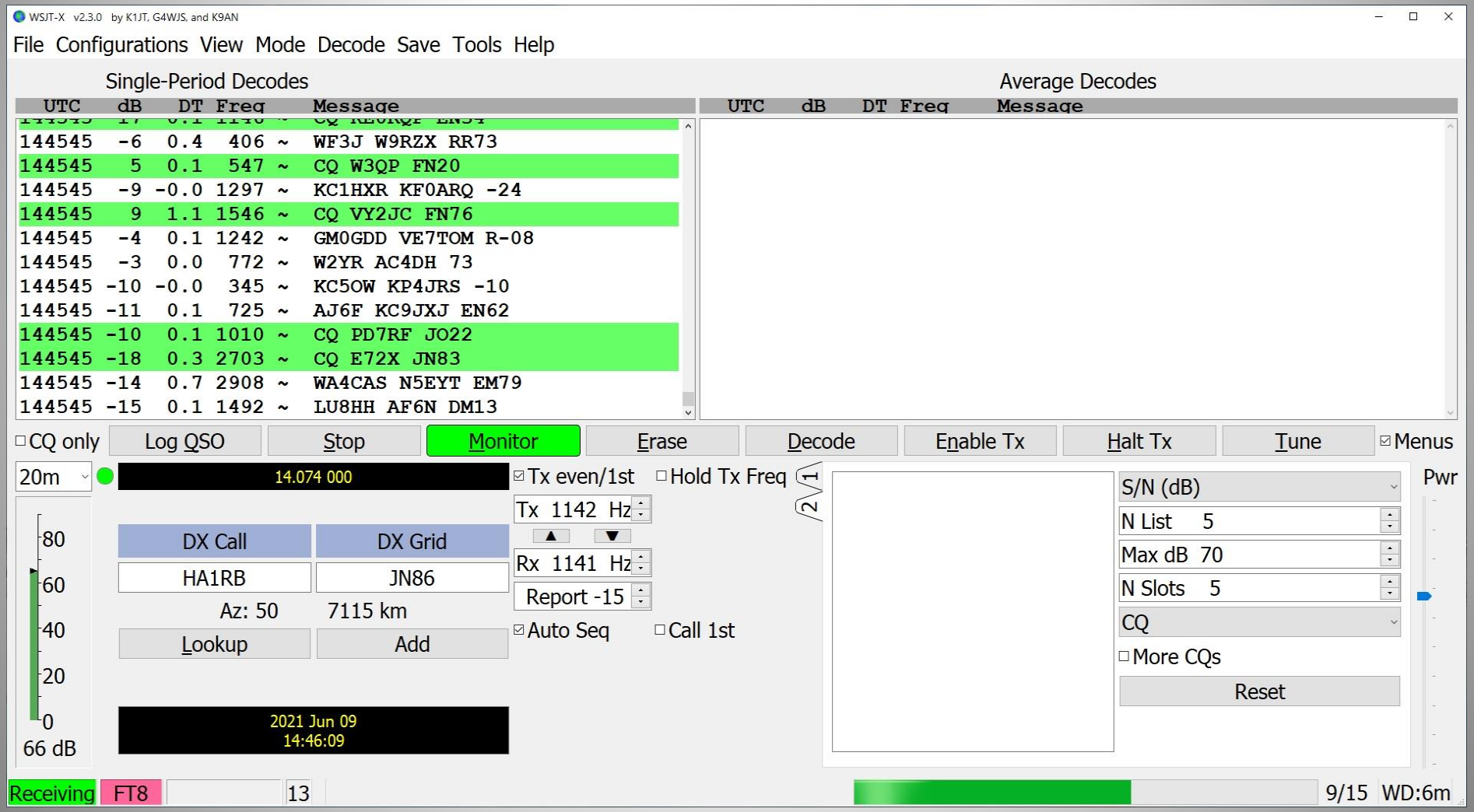
All of these FT8 stations were heard on 20 meters by K3EUI at 10 am on Jun 09 2021 with a simple HF SSB rig and vertical antenna



FT8 can decode **ALL** of these FT8 signals at the same time over 3 kHz passband



Signals decoded during a 15 second interval at K3EUI on June 09 at 1400 hr UTC



Where to look for FT8 signals

Table 1
FT8 Frequencies

All frequencies are upper sideband (USB).

Band (Meters)	Frequency (MHz)
160	1.840
80	3.573
40	7.074
30	10.136
20	14.074
17	18.100
15	21.074
12	24.915
10	28.074
6	50.313

QSO K3EUI with VK3LDB Australia

40 meters, 10 watts, home made vertical antenna
note time (UTC) and signal strength (dB) received by me
DT (time difference) and Audio Frequency of our QSO

			Rx Frequency	
UTC	dB	DT	Freq	Message
105330	-5	-0.7	1495 ~	CQ VK3LDB QF21
105345	Tx		1495 ~	VK3LDB K3EUI FM29
105400	-6	-0.7	1430 ~	K3EUI VK3LDB -13
105415	Tx		1430 ~	VK3LDB K3EUI R-06
105430	-6	-0.7	1430 ~	K3EUI VK3LDB RRR
105445	Tx		1430 ~	VK3LDB K3EUI 73
105500	-6	-0.7	1430 ~	K3EUI VK3LDB 73

FT8 concerns

Low Speed 12 word/minute equivalent

Limit to 13 characters per transmission

15 second transmissions @ 0,15,30,45 seconds

Need to synchronize clock to +/- 1 sec UTC

Limited frequencies (watering holes) unlike CW

3.574, 7.074, 14.074 MHz

Not much of a conversation possible

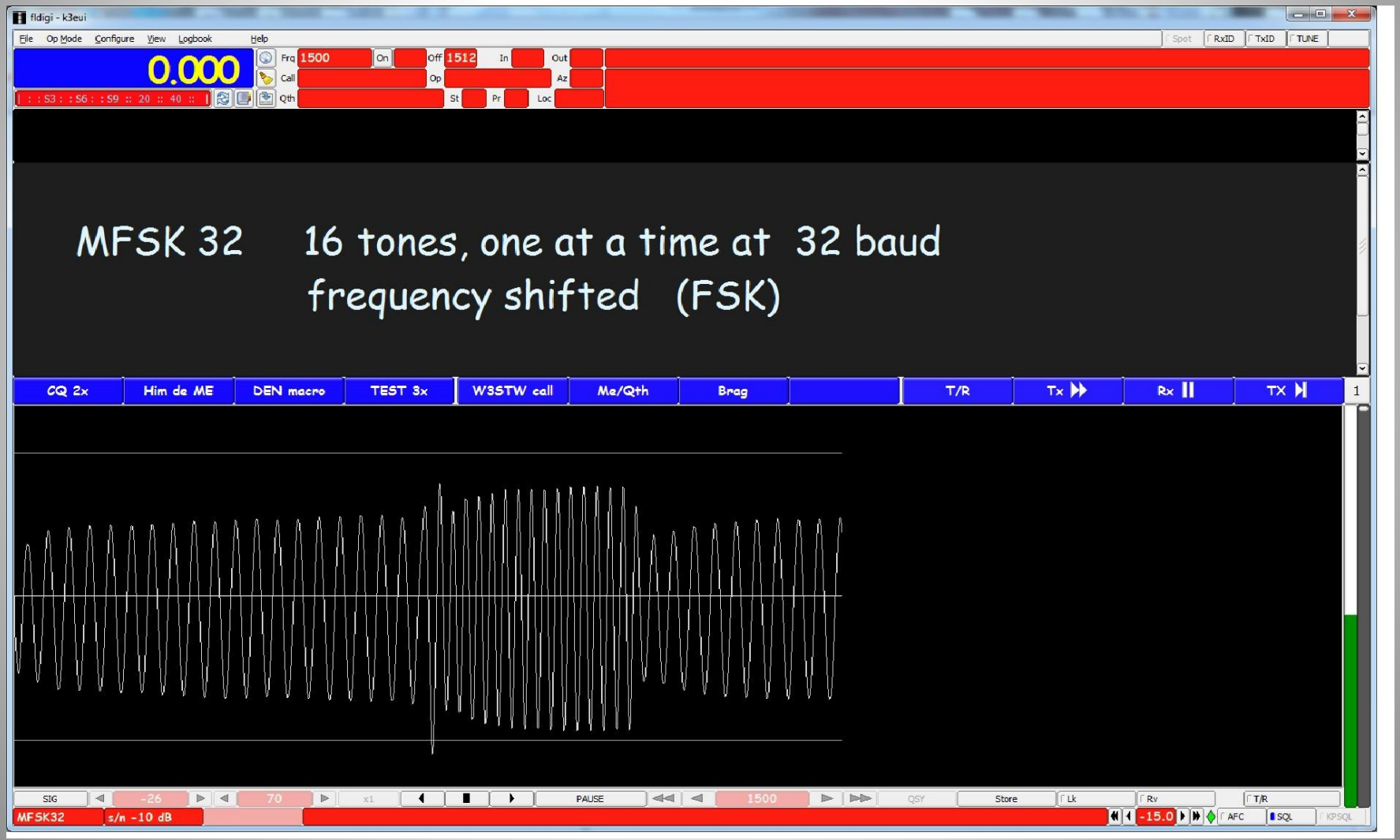
might get boring after some time

Other Multiple Tone modes common on HF SSB compare time to send a 1.6 kB file (Gettysburg Address txt file)

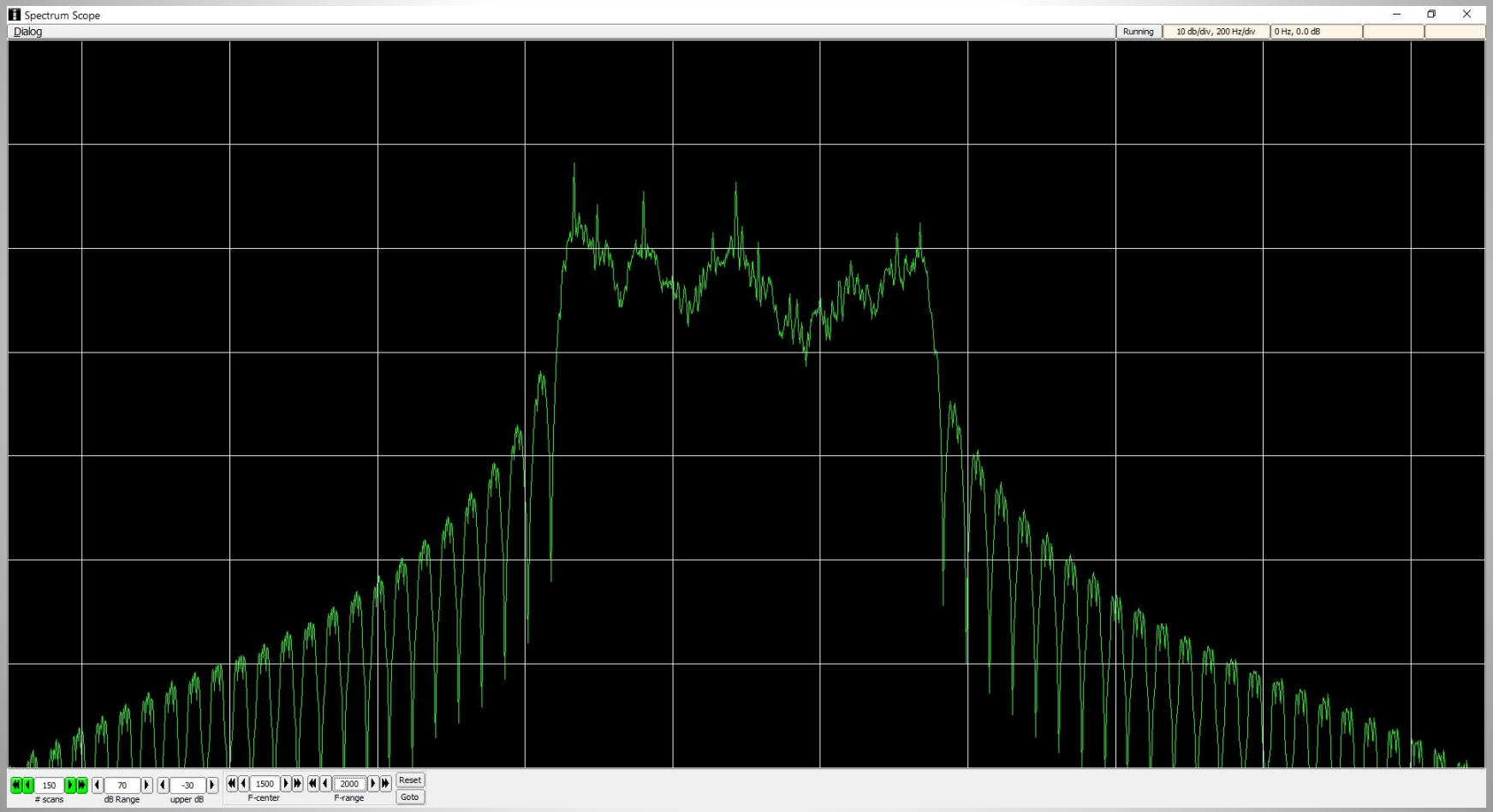
MODE	FILE size	Time	Bandwidth (Hz)	Emission Type
MFSK16	1.6 kB	4m 40s	316	16 FSK
MFSK32	1.6 kB	2min 20s	630	16 FSK
MFSK64	1.6 kB	1m 10s	1260	16 FSK
MFSK128	1.6 kB	36 s	1920	16 FSK
THOR 16	1.6 kB	4m 38s	355	18 carriers
THOR 22	1.6 kB	3m 22s	524	18 carriers
THOR 50x1	1.6 kB	1m 31s	900	18 carriers
THOR 25x4	1.6 kB	3m 02s	1800	18 carriers
THOR 100	1.6 kB	46s	1800	18 carriers
OFDM500F	1.6 kB	51	500	4-PSK
OFDM750F	1.6 kB	30	750	3-PSK

MFSK 32 32 baud, 120 wpm F1B emission type

16 different tones = 2^4 = **4 bits/symbol**



MFSK32 audio spectrum
630 Hz bandpass

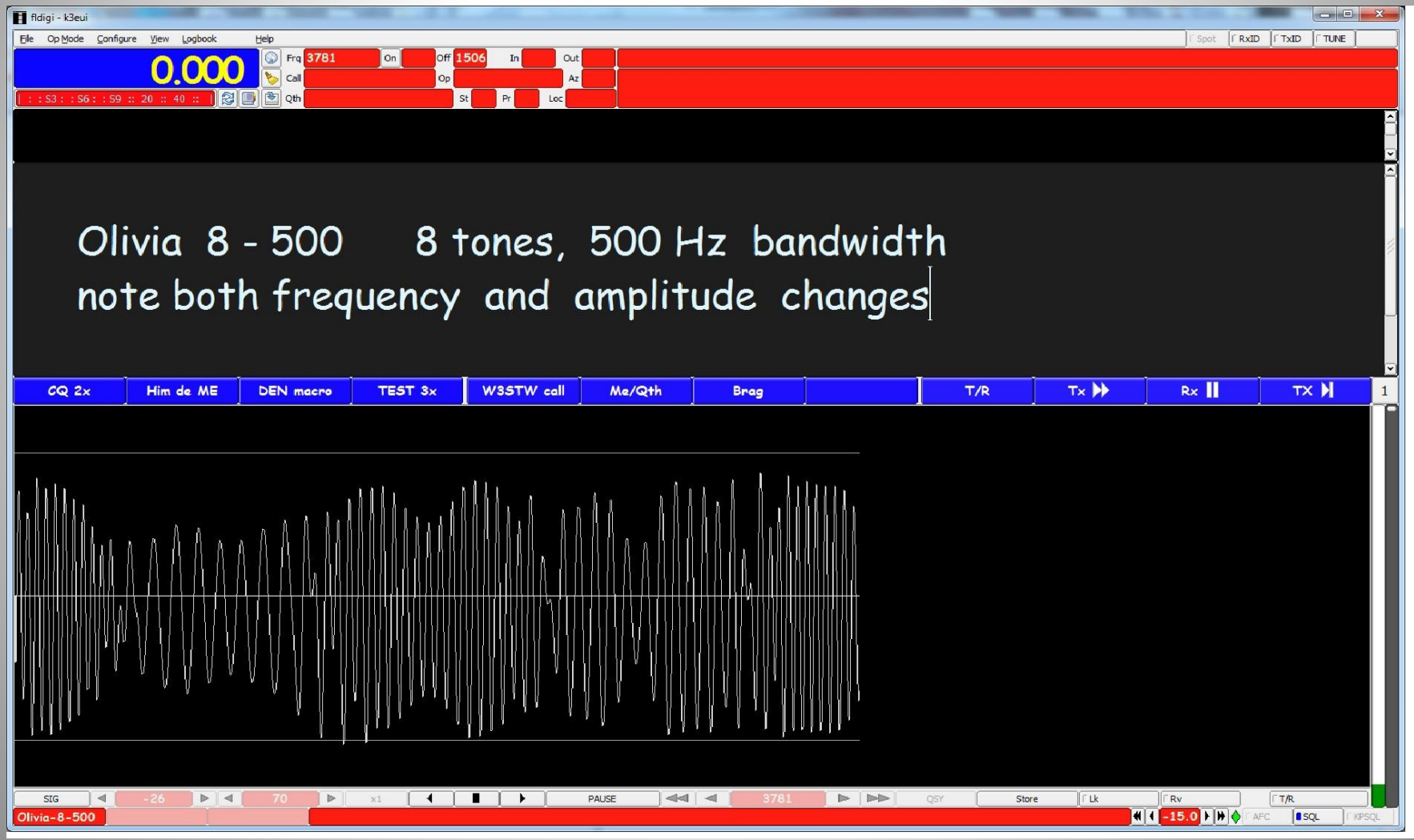


Small image sent with MFSK128 on 2m FM in 2 minutes

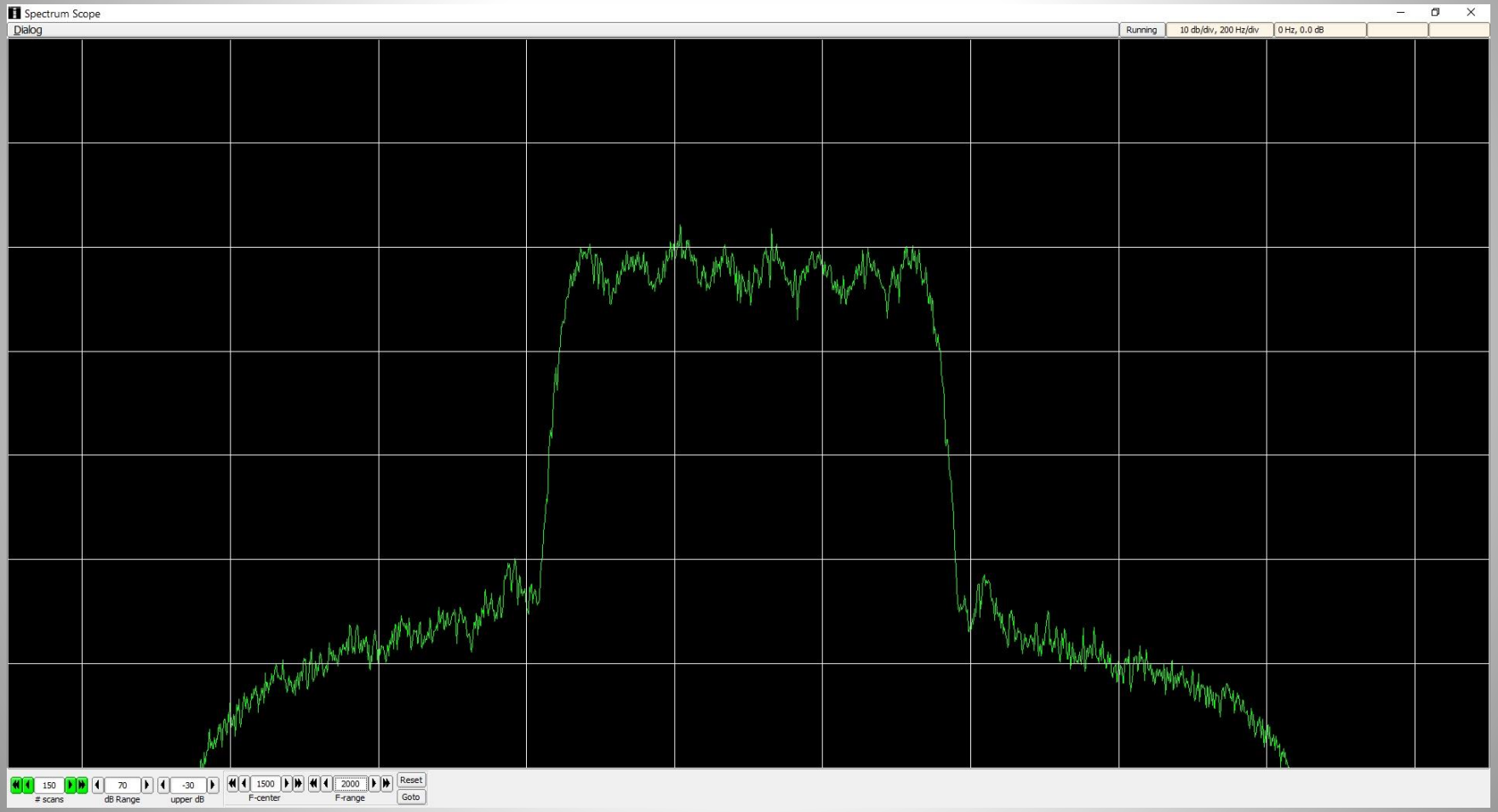
Olivia 8/500 8-FSK very robust in noise

8 tones, sent one at a time

500 Hz, 63 baud = 30 wpm



Olivia 8/500 8-FSK F1B emission
can copy with S/N = - 14 dB



THOR (18 tones) and IFSK modulation

THOR - "**incremental frequency shift keying**"
CHANGE in frequency from one tone to the next tone determines the characters to be printed on screen

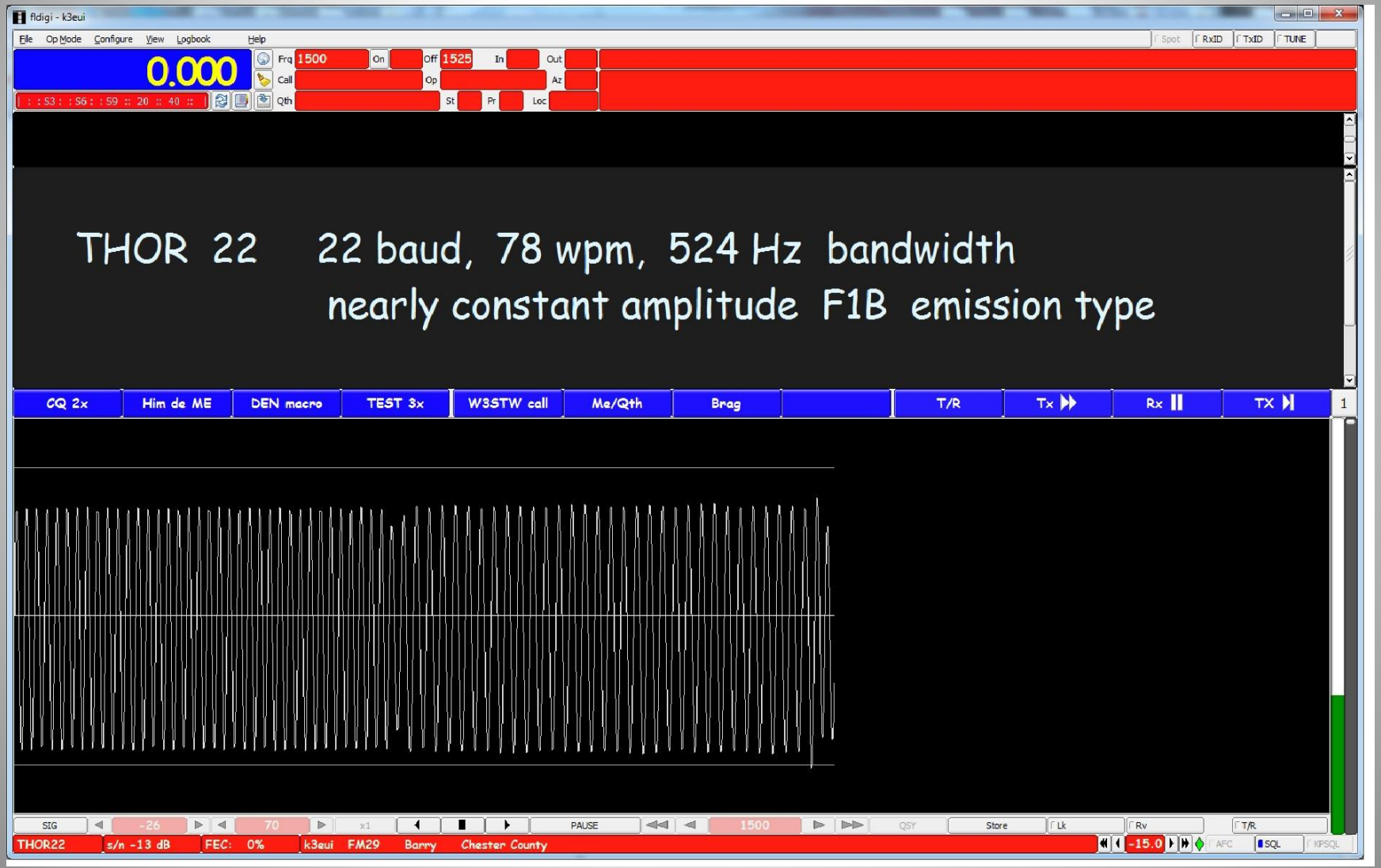
THOR has FEC (forward error correction)

THOR has a "second" audio channel where you can display your call, name, qth

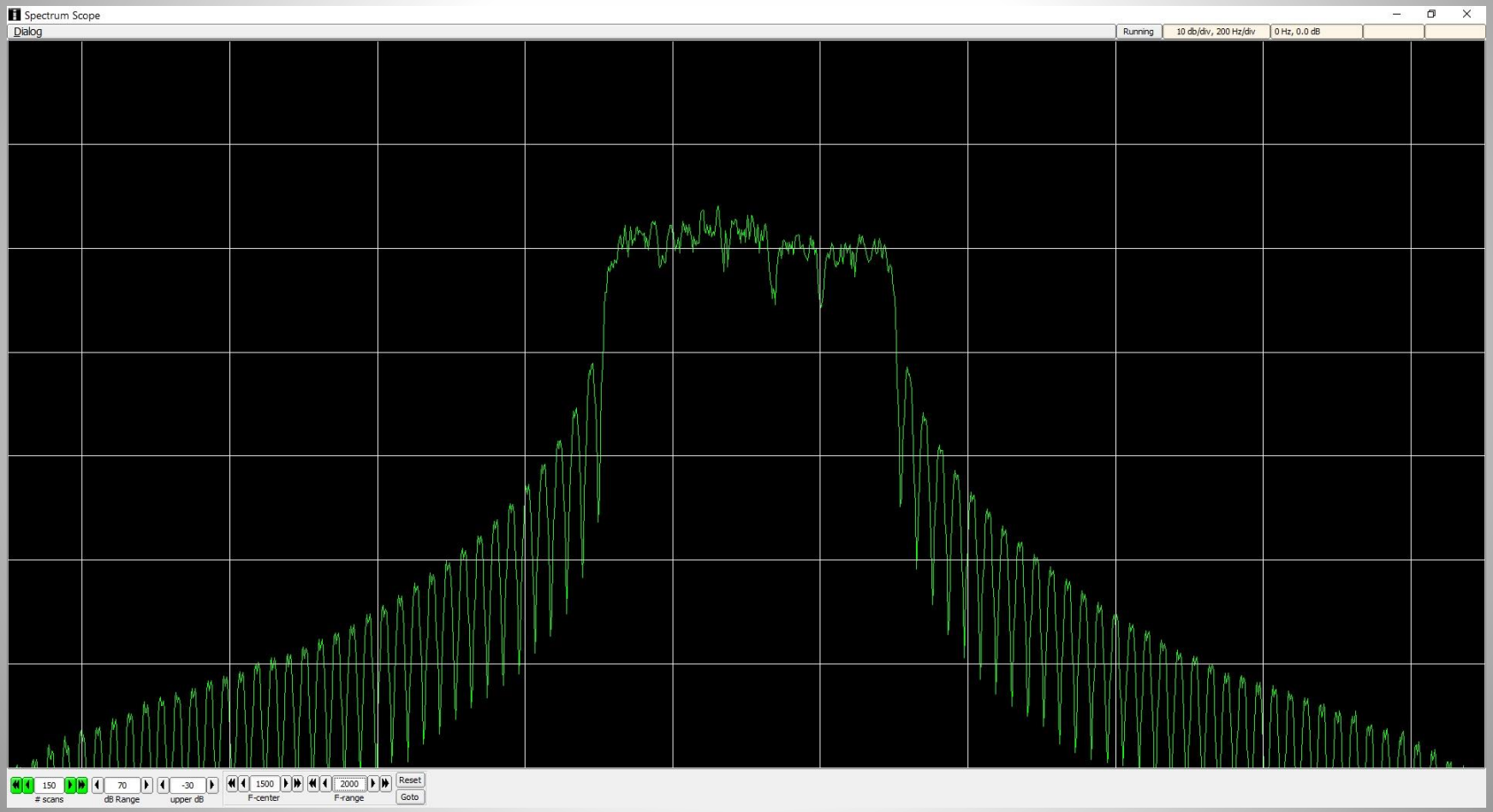
Thor can send small images

THOR 22 F1B emission

THOR is nearly constant amplitude



THOR 22 audio spectrum
525 Hz bandpass

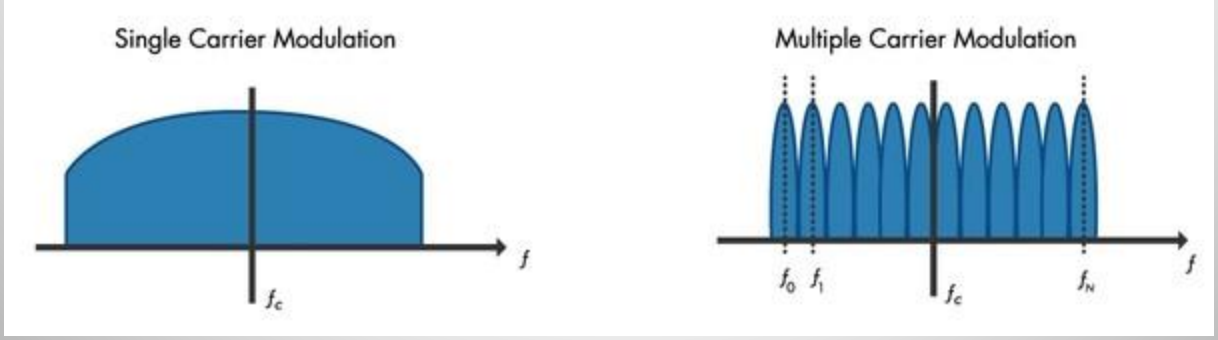


Multiple PSK "carriers"

multiple sub-carriers (parallel signals)

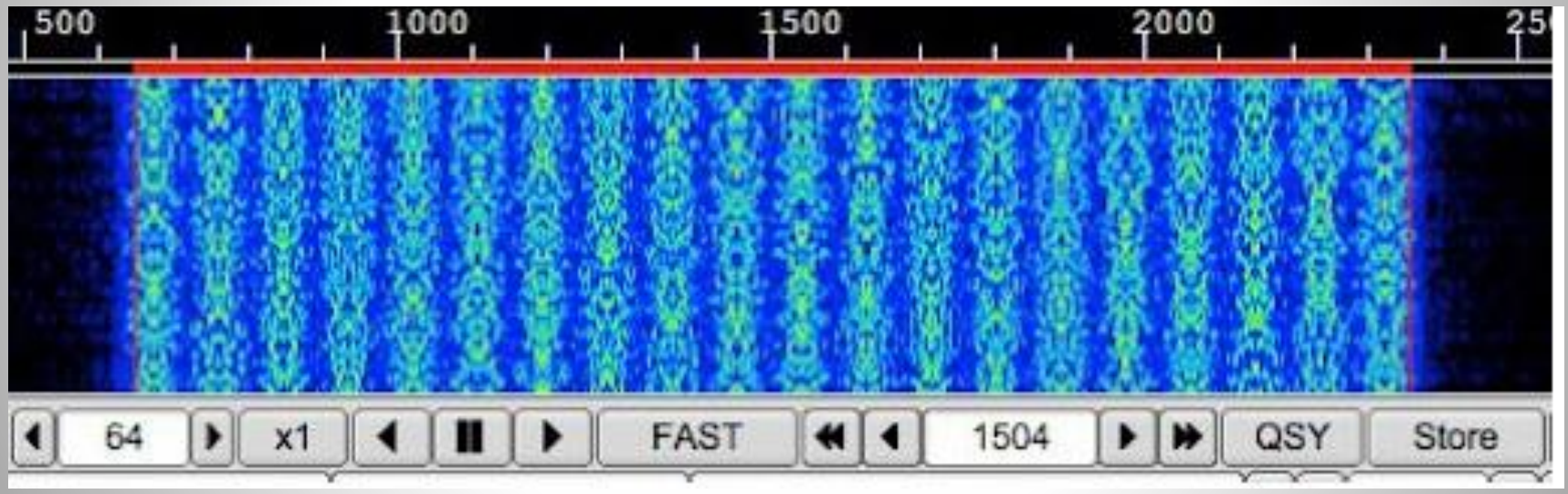
Each sub-carrier could be phase-shifted independently from its neighbor, but at a common baud

Thus, more information per second …. And more BW !

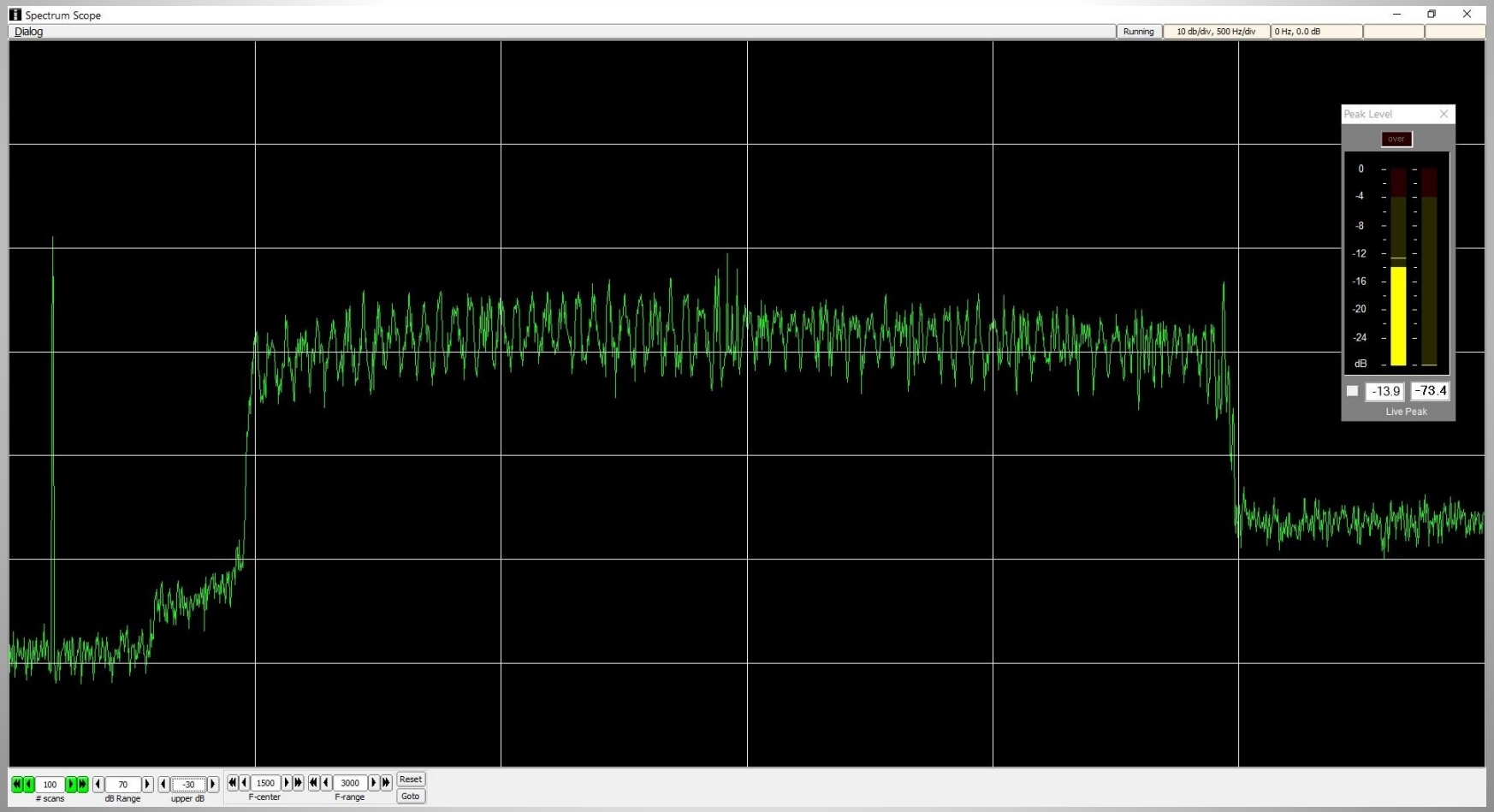


PSK modulation with 20 carriers

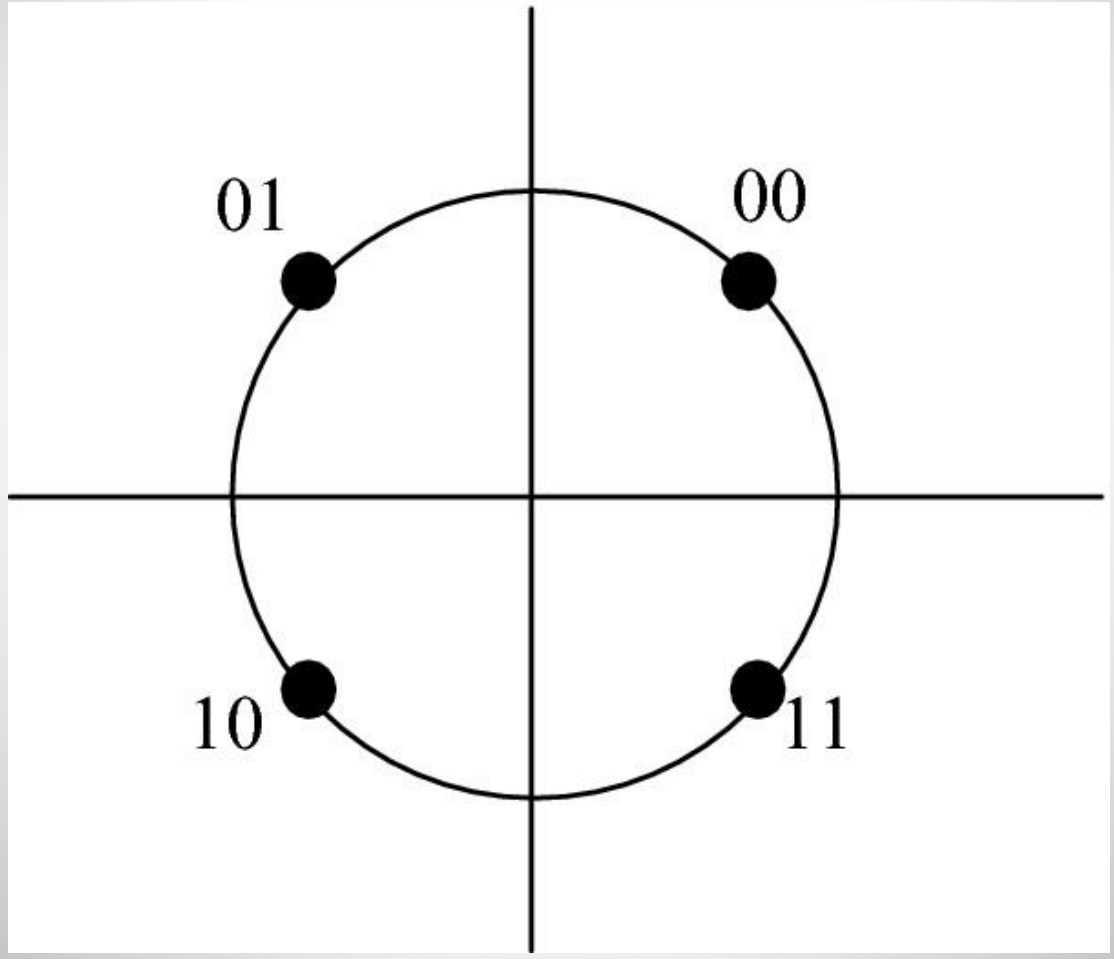
More data per second but at a cost of greater bandwidth



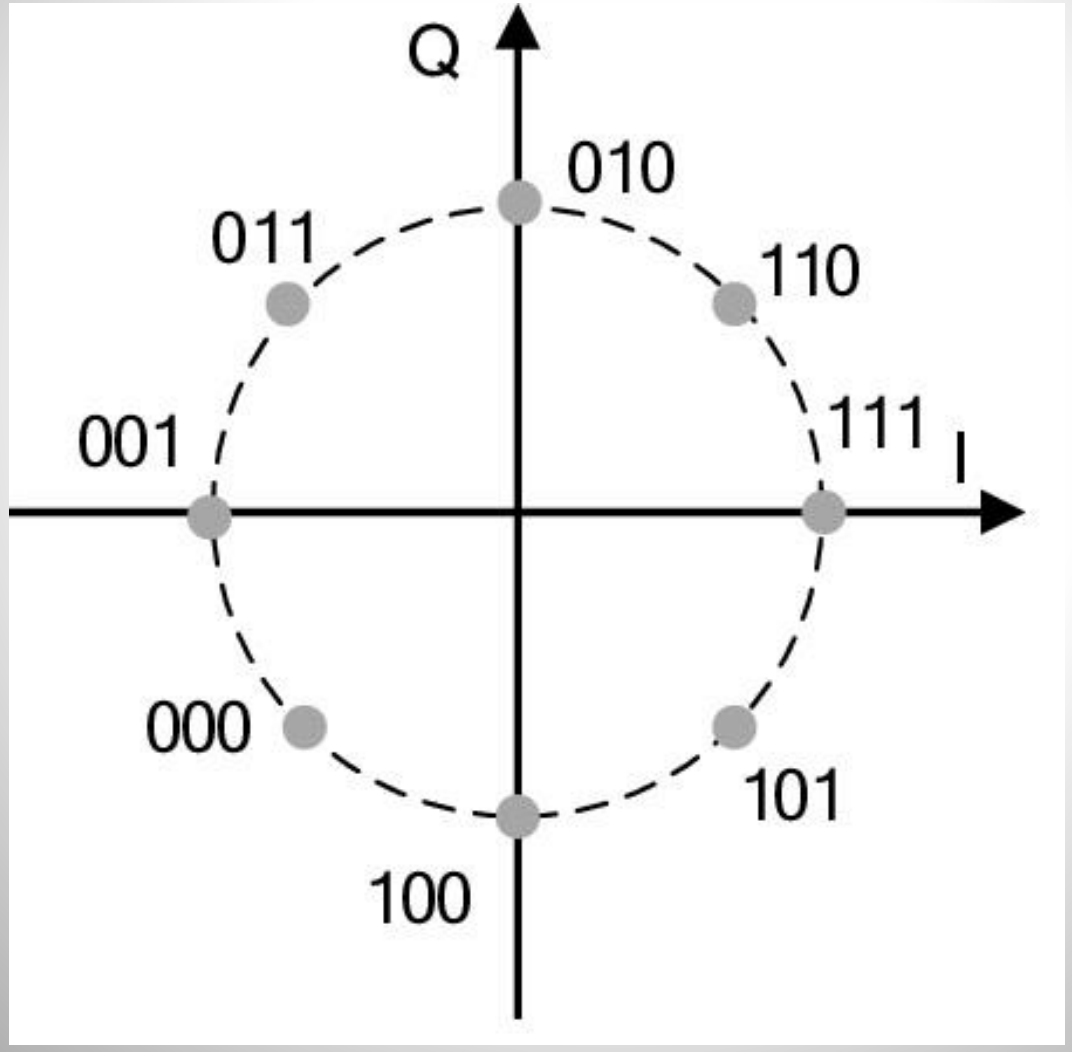
MT63 2kHz wide
64 carriers – each low-baud PSK



What is QPSK or 4PSK?



8PSK signals show a 45 degree phase change



NEW 8PSK modes for higher speed

BPSK = shifts of 0 or 180 degrees

QPSK = 90 degree phase shifts
(0,90,180,270)

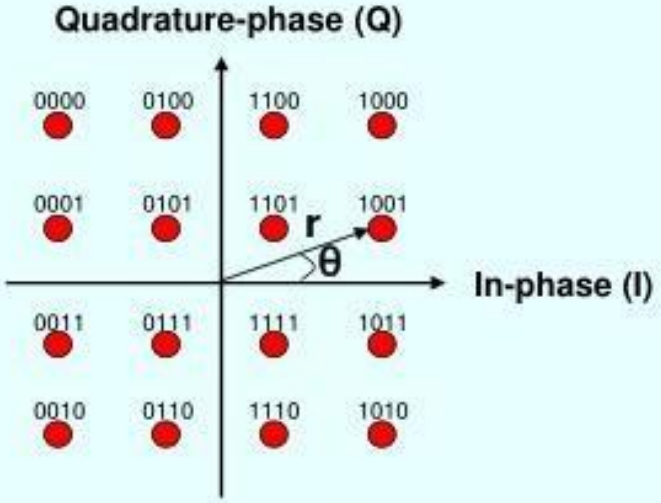
8PSK => 45 degree shifts = 3 states/symbol
8PSK500F, 8PSK1000F, and 8PSK1200F

Thus, 8PSK is a higher "data rate"
requires a greater bandwidth than BPSK
Works well on a noise-free FM circuit

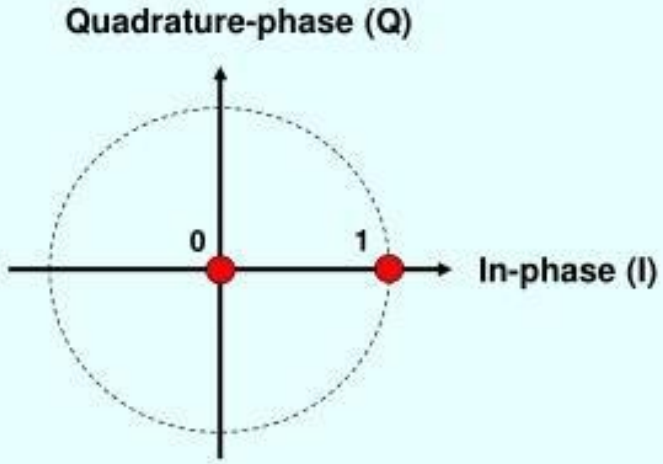
Quadrature Amplitude Modulation (QAM) format

Features of QAM format:

- Two carriers with the same frequency are amplitude-modulated independently.
- The phase of the two carriers is 90 deg. shifted each other.
- 2^N QAM processes N bits in a single channel, so it has N times spectral efficiency compared with OOK.

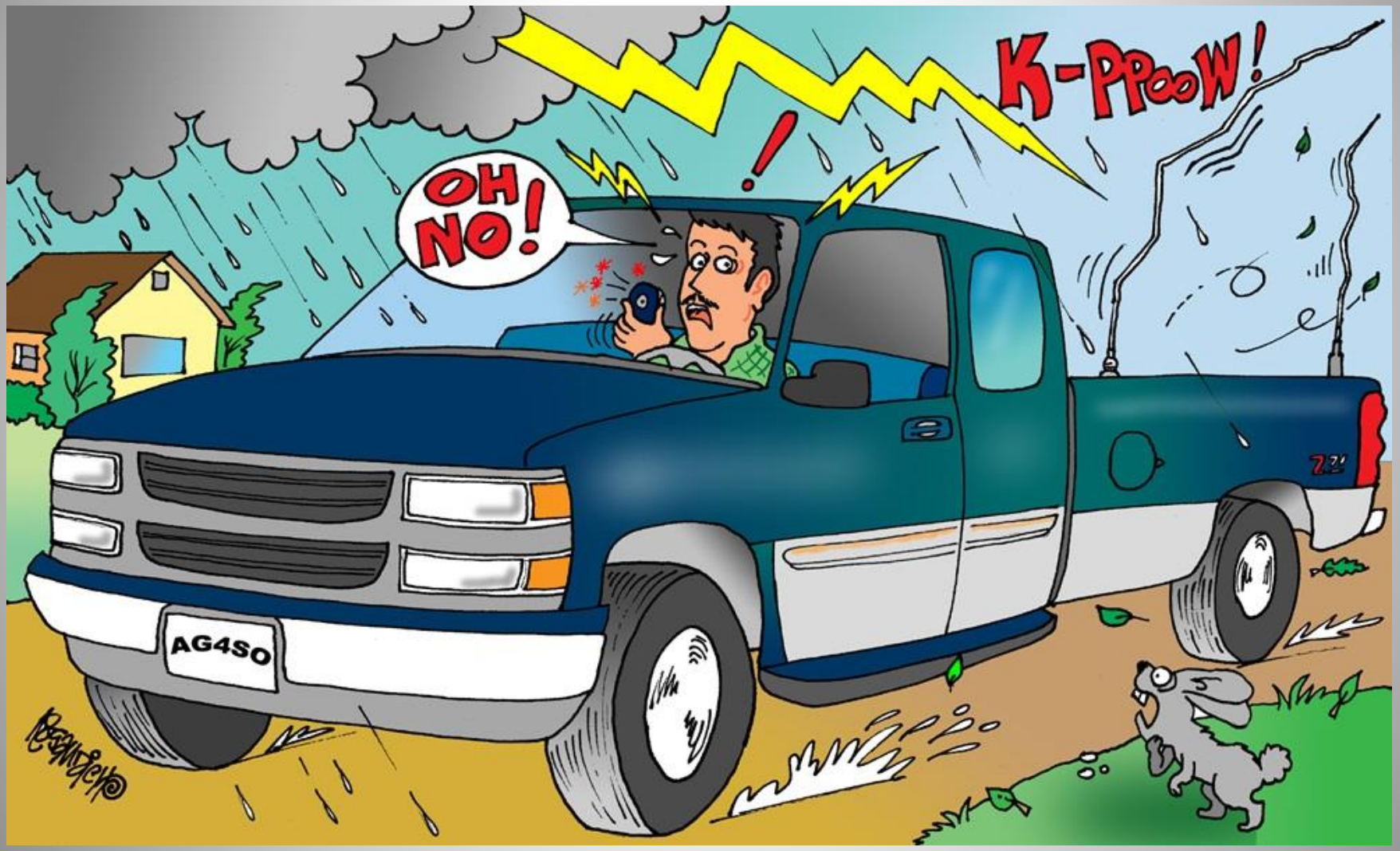


Constellation map for 16 (=2^4) QAM



With OOK

EMCOMM



Popular Modes for EMCOMM

Thor - multi-tone, constant amplitude, strong FEC
MFSK – multi-tone, constant amplitude, strong FEC
Olivia - multi-tone, constant amplitude, strong FEC

MT63: 64 carriers, PSK modulation
3 bandwidths: 500 Hz, 1000 Hz, 2000 Hz
Can work reasonably well with "acoustic coupling"

8PSK - very fast (up to 3000 wpm) for FM VHF/UHF
OFDM – Orthogonal Frequency Division Multiplex
VARA HF SSB and **VARA FM** (VHF/UHF)
Pactor III - requires a special TNC (hardware)

Winlink: RMS Express

(linked modes)

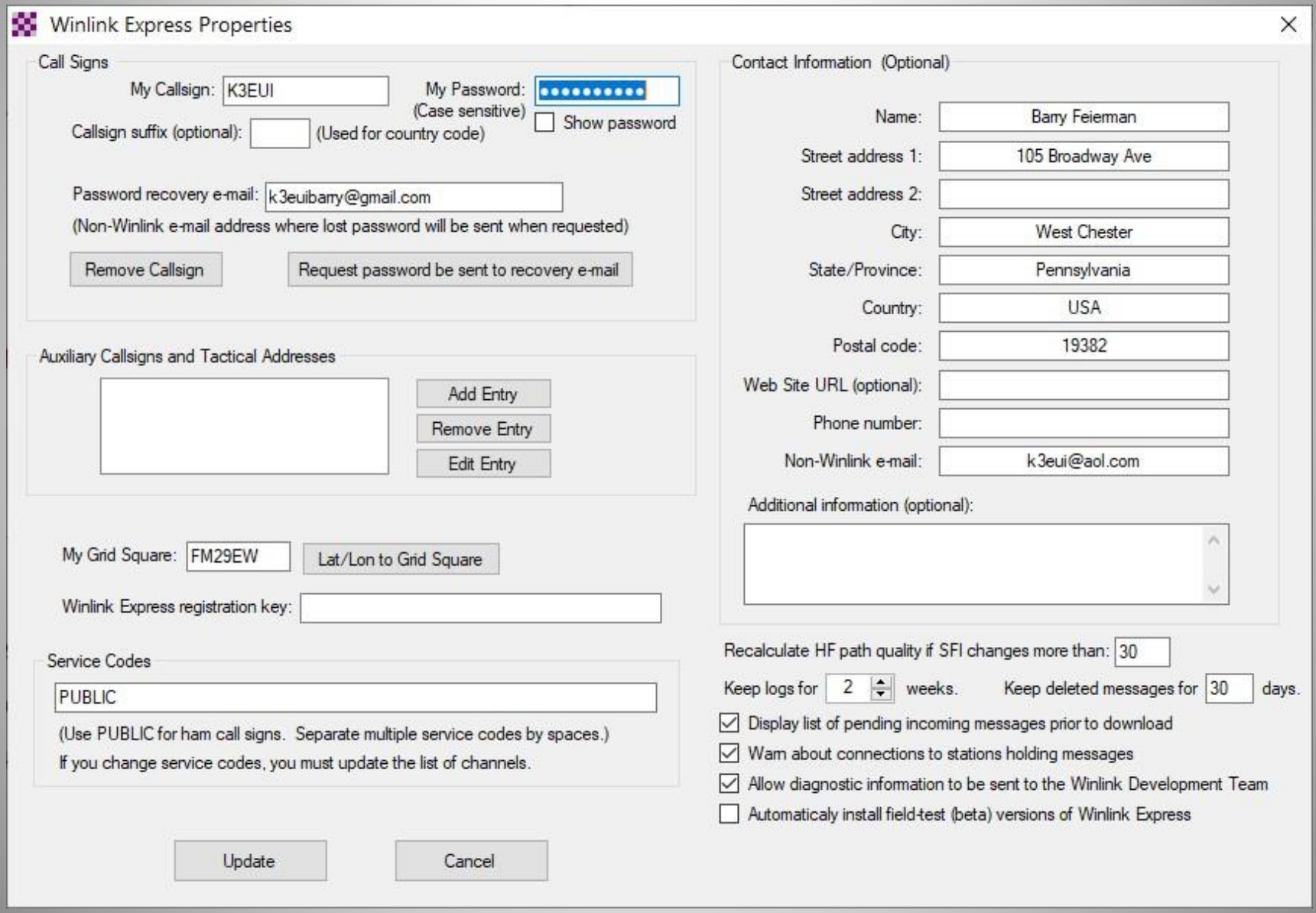
HF SSB:

Pactor II, III (requires TNC)
VARA HF SSB
ARDOP

VHF/UHF FM :

Packet (TNC or Sound Modem)
VARA FM (sound card)

Register your call with Winlink.org



Set your Sound Card device, PTT method and DRIVE level (Tx audio)

EA5HVK | Weak signals Sof | Download - MEGA | VARA FM 4 - VARA FM 4.0 Fe

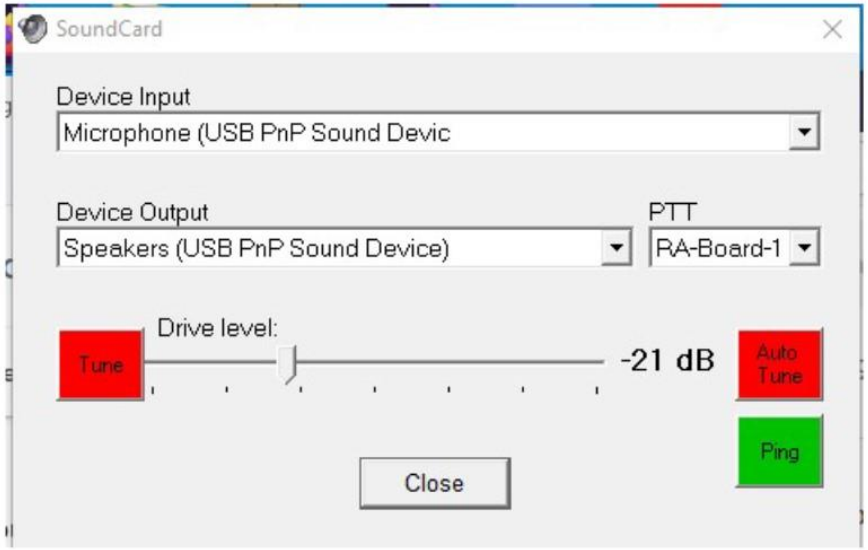
file:///C:/Users/Barry/AppData/Local/Temp/VARA FM 4.0 Features.pdf

Getting Started | Google | West Chester, PA Topo... | W1HKJ Software | MILLSTONE HILL Digis... | QRZ Ham Radio | ARES Connect | PSK Reporter | WALLOPS IS, May 2020 | Other Bookmarks

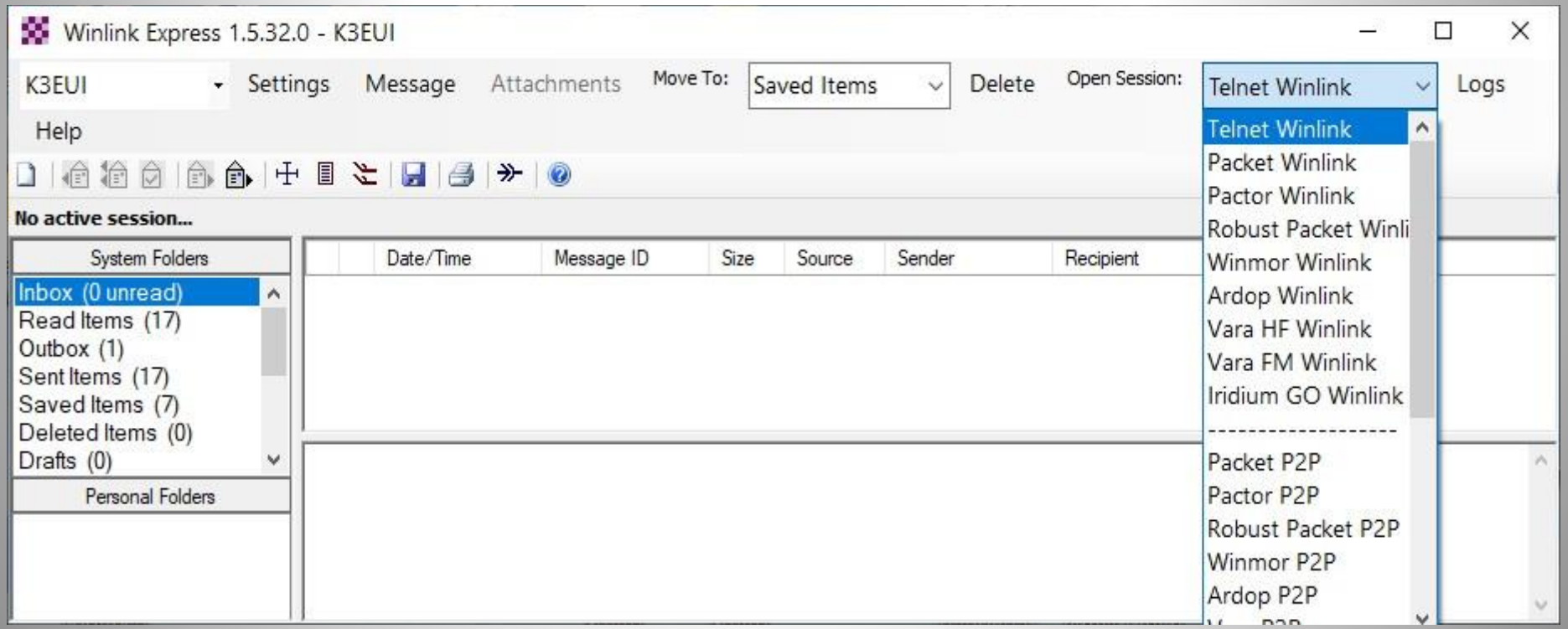
3 of 5 — 160%

Autotune and Ping

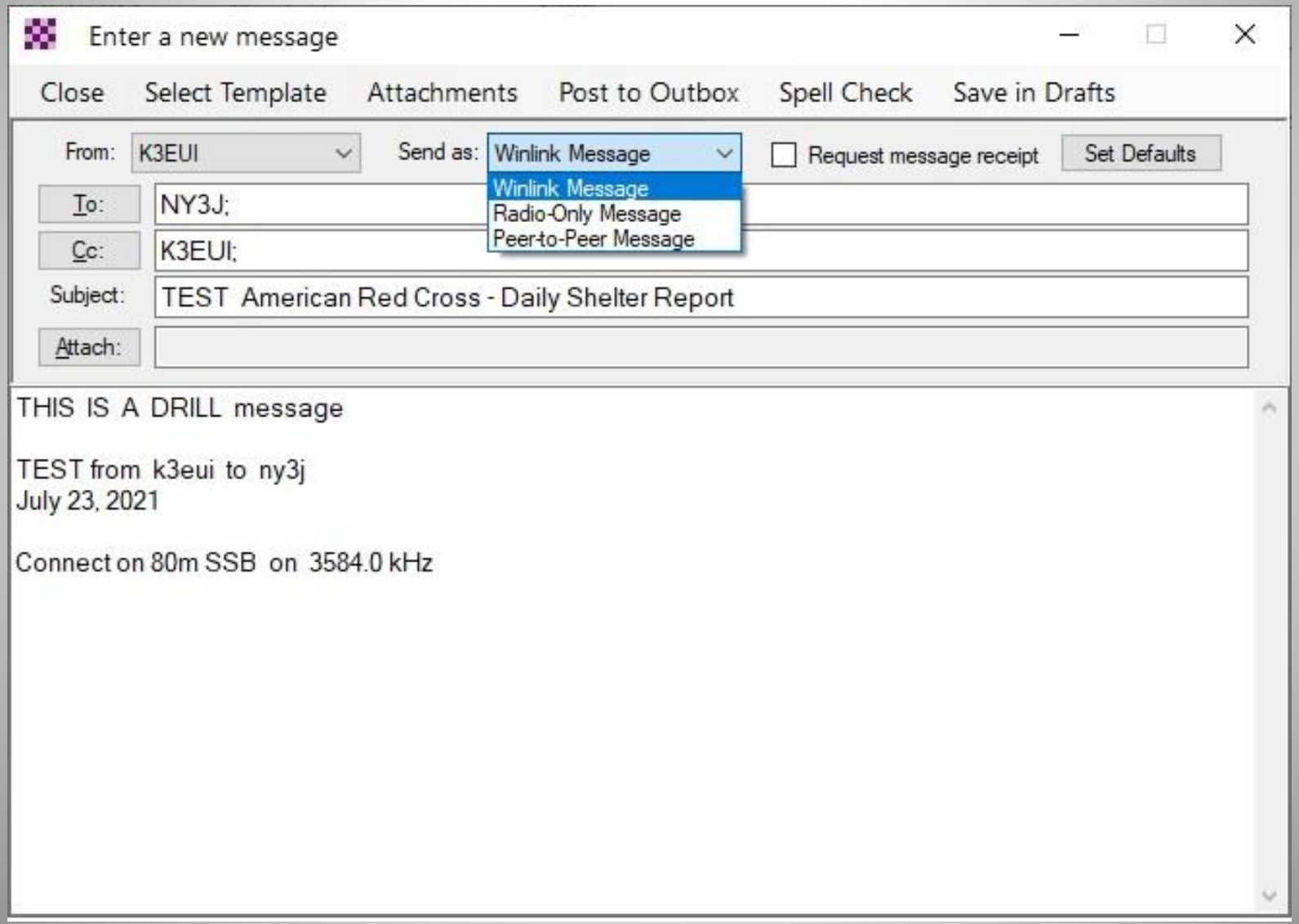
The sound card window has improved Autotune and a Ping feature,to test the digi route.



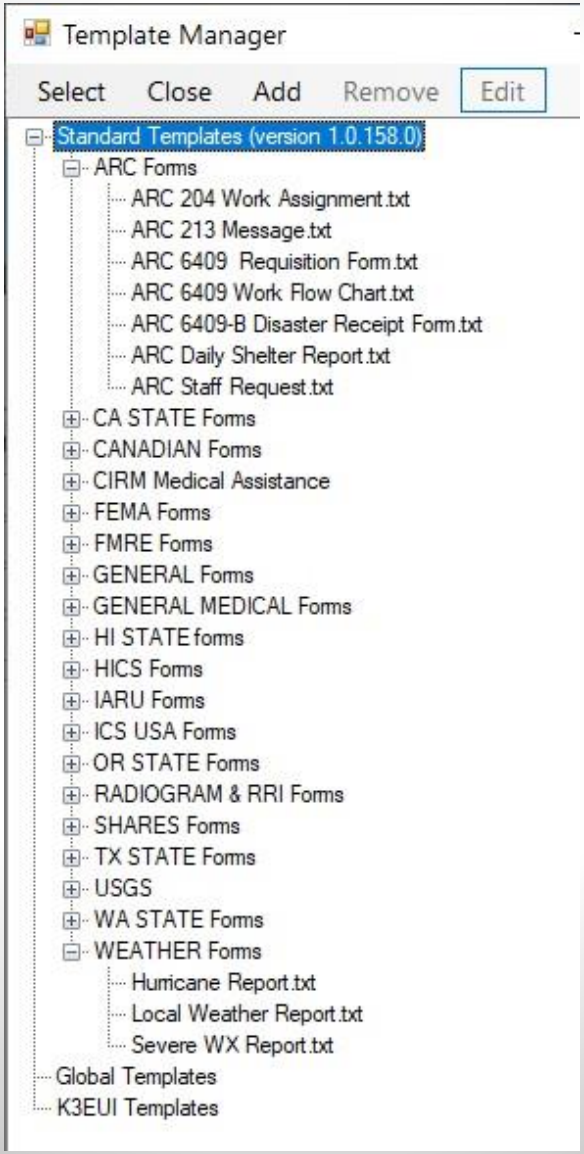
Winlink uses RMS Express software Winlink GATEWAY, or Peer-to-Peer (P2P) variety of "modes" to choose from



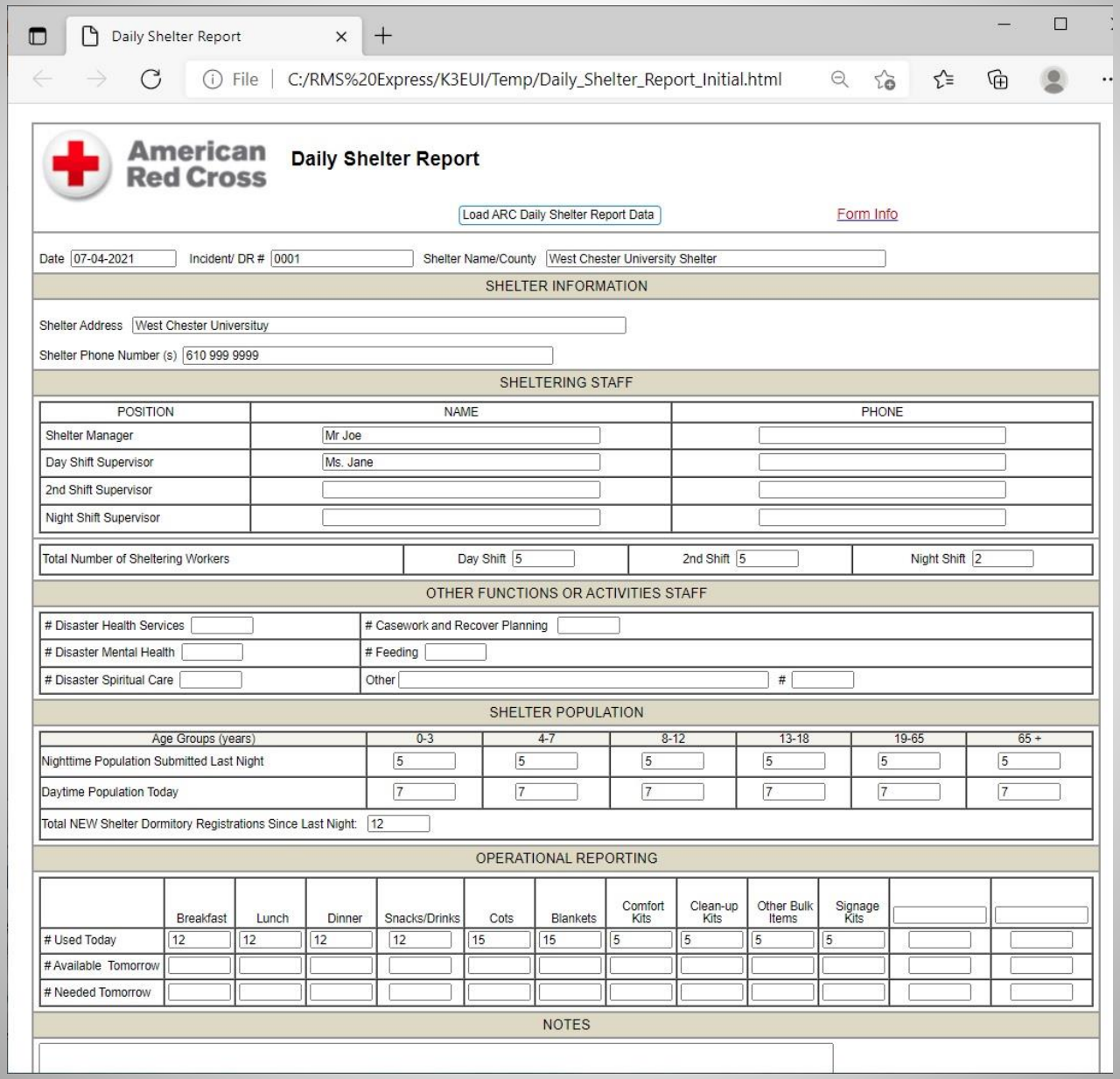
New Message format



Send a TEMPLATE
American Red Cross Templates



American Red Cross Daily Shelter Report



Daily Shelter Report

File | C:/RMS%20Express/K3EUI/Temp/Daily_Shelter_Report_Initial.html

American Red Cross

Daily Shelter Report

Load ARC Daily Shelter Report Data Form Info

Date 07-04-2021 Incident/ DR # 0001 Shelter Name/County West Chester University Shelter

SHELTER INFORMATION

Shelter Address West Chester Universituy

Shelter Phone Number (s) 610 999 9999

SHELTERING STAFF

POSITION	NAME	PHONE
Shelter Manager	Mr Joe	
Day Shift Supervisor	Ms. Jane	
2nd Shift Supervisor		
Night Shift Supervisor		

Total Number of Sheltering Workers	Day Shift 5	2nd Shift 5	Night Shift 2

OTHER FUNCTIONS OR ACTIVITIES STAFF

# Disaster Health Services	# Casework and Recover Planning
# Disaster Mental Health	# Feeding
# Disaster Spiritual Care	Other #

SHELTER POPULATION

Age Groups (years)	0-3	4-7	8-12	13-18	19-65	65 +
Nighttime Population Submitted Last Night	5	5	5	5	5	5
Daytime Population Today	7	7	7	7	7	7

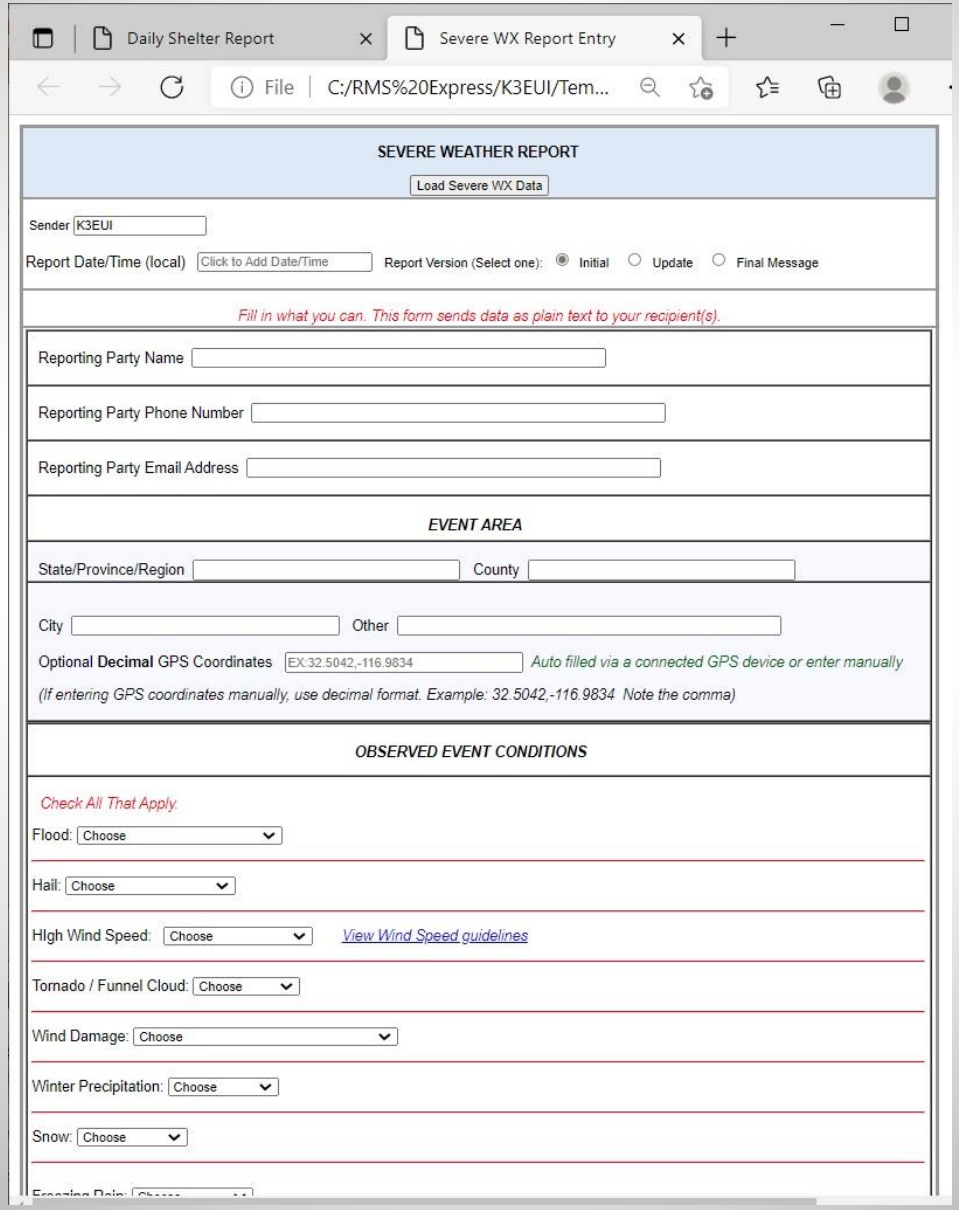
Total NEW Shelter Dormitory Registrations Since Last Night: 12

OPERATIONAL REPORTING

	Breakfast	Lunch	Dinner	Snacks/Drinks	Cots	Blankets	Comfort Kits	Clean-up Kits	Other Bulk Items	Signage Kits		
# Used Today	12	12	12	12	15	15	5	5	5	5		
# Available Tomorrow												
# Needed Tomorrow												

NOTES

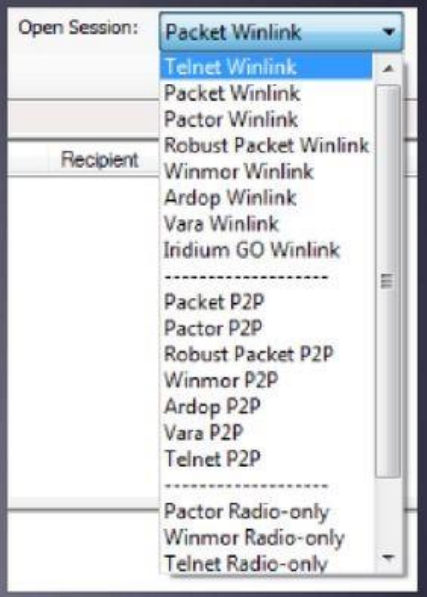
Severe Weather Report



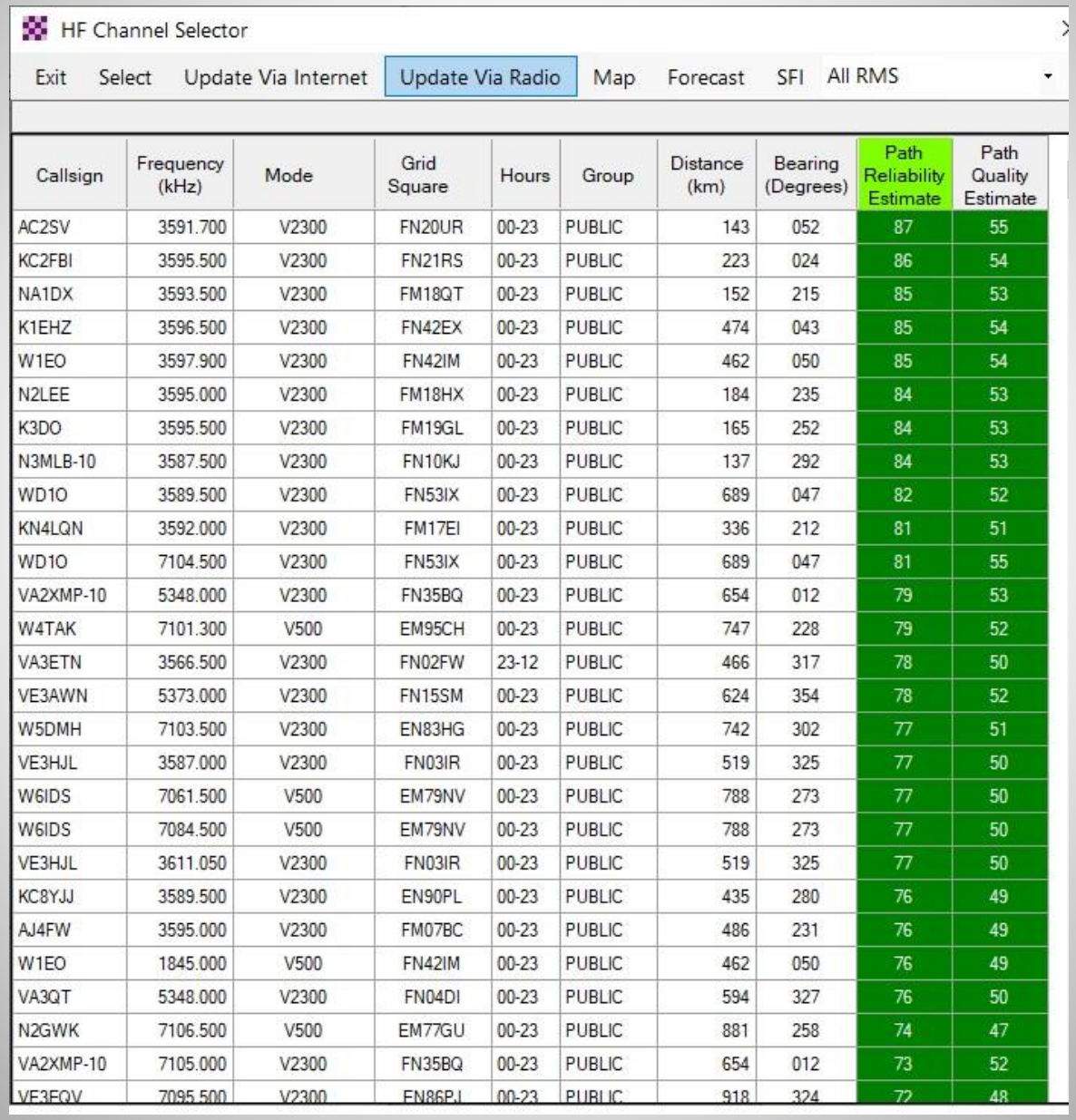
Winlink sends emails via RF to internet GATEWAYS

Winlink Connection Modes

- **HF WINMOR/ARDOP** – "Poor man's Pactor". Not as good as Pactor, but operates with an inexpensive sound card device ($100), speeds between Pactor 2 and 3.
- **HF Pactor ~~1~~, 2, 3 and 4** – Fast and reliable but requires an expensive modem ($1500+). Pactor 4 not permitted in US.
- **Vara** – Muli-carrier OFDM with 2.4kHz bandwidth. HF speeds approaching PACTOR 4 (possible optimization for FM coming)
- All RF modes can be Peer-to-Peer (P2P).

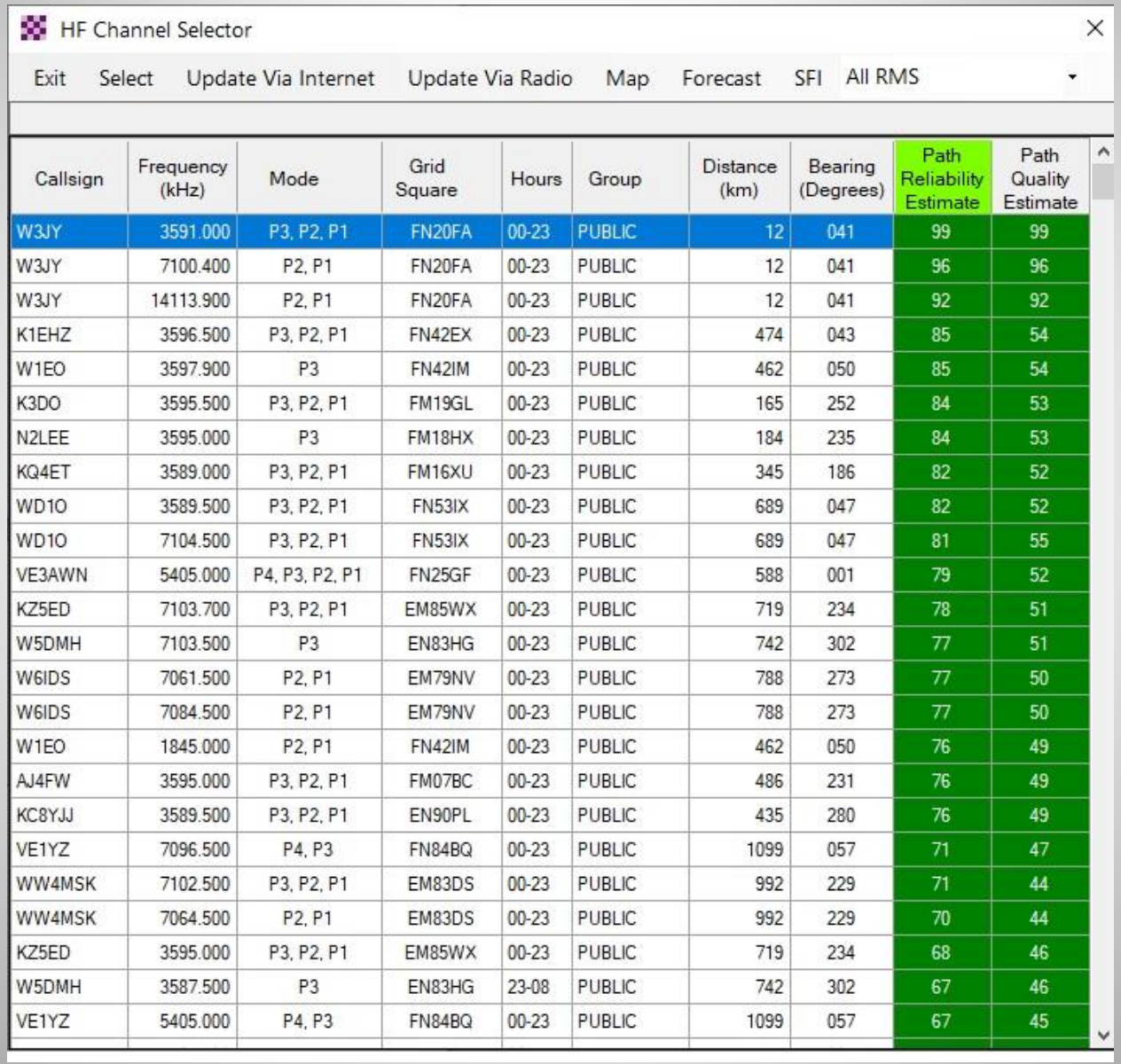


HF SSB VARA Gateways



Callsign	Frequency (kHz)	Mode	Grid Square	Hours	Group	Distance (km)	Bearing (Degrees)	Path Reliability Estimate	Path Quality Estimate
AC2SV	3591.700	V2300	FN20UR	00-23	PUBLIC	143	052	87	55
KC2FBI	3595.500	V2300	FN21RS	00-23	PUBLIC	223	024	86	54
NA1DX	3593.500	V2300	FM18QT	00-23	PUBLIC	152	215	85	53
K1EHZ	3596.500	V2300	FN42EX	00-23	PUBLIC	474	043	85	54
W1EO	3597.900	V2300	FN42IM	00-23	PUBLIC	462	050	85	54
N2LEE	3595.000	V2300	FM18HX	00-23	PUBLIC	184	235	84	53
K3DO	3595.500	V2300	FM19GL	00-23	PUBLIC	165	252	84	53
N3MLB-10	3587.500	V2300	FN10KJ	00-23	PUBLIC	137	292	84	53
WD1O	3589.500	V2300	FN53IX	00-23	PUBLIC	689	047	82	52
KN4LQN	3592.000	V2300	FM17EI	00-23	PUBLIC	336	212	81	51
WD1O	7104.500	V2300	FN53IX	00-23	PUBLIC	689	047	81	55
VA2XMP-10	5348.000	V2300	FN35BQ	00-23	PUBLIC	654	012	79	53
W4TAK	7101.300	V500	EM95CH	00-23	PUBLIC	747	228	79	52
VA3ETN	3566.500	V2300	FN02FW	23-12	PUBLIC	466	317	78	50
VE3AWN	5373.000	V2300	FN15SM	00-23	PUBLIC	624	354	78	52
W5DMH	7103.500	V2300	EN83HG	00-23	PUBLIC	742	302	77	51
VE3HJL	3587.000	V2300	FN03IR	00-23	PUBLIC	519	325	77	50
W6IDS	7061.500	V500	EM79NV	00-23	PUBLIC	788	273	77	50
W6IDS	7084.500	V500	EM79NV	00-23	PUBLIC	788	273	77	50
VE3HJL	3611.050	V2300	FN03IR	00-23	PUBLIC	519	325	77	50
KC8YJJ	3589.500	V2300	EN90PL	00-23	PUBLIC	435	280	76	49
AJ4FW	3595.000	V2300	FM07BC	00-23	PUBLIC	486	231	76	49
W1EO	1845.000	V500	FN42IM	00-23	PUBLIC	462	050	76	49
VA3QT	5348.000	V2300	FN04DI	00-23	PUBLIC	594	327	76	50
N2GWK	7106.500	V500	EM77GU	00-23	PUBLIC	881	258	74	47
VA2XMP-10	7105.000	V2300	FN35BQ	00-23	PUBLIC	654	012	73	52
VE3EQV	7095.500	V2300	EN86PJ	00-23	PUBLIC	918	324	72	48

HF Pactor Gateways


HF Channel Selector

Exit Select Update Via Internet Update Via Radio Map Forecast SFI All RMS

Callsign	Frequency (kHz)	Mode	Grid Square	Hours	Group	Distance (km)	Bearing (Degrees)	Path Reliability Estimate	Path Quality Estimate
W3JY	3591.000	P3, P2, P1	FN20FA	00-23	PUBLIC	12	041	99	99
W3JY	7100.400	P2, P1	FN20FA	00-23	PUBLIC	12	041	96	96
W3JY	14113.900	P2, P1	FN20FA	00-23	PUBLIC	12	041	92	92
K1EHZ	3596.500	P3, P2, P1	FN42EX	00-23	PUBLIC	474	043	85	54
W1EO	3597.900	P3	FN42IM	00-23	PUBLIC	462	050	85	54
K3DO	3595.500	P3, P2, P1	FM19GL	00-23	PUBLIC	165	252	84	53
N2LEE	3595.000	P3	FM18HX	00-23	PUBLIC	184	235	84	53
KQ4ET	3589.000	P3, P2, P1	FM16XU	00-23	PUBLIC	345	186	82	52
WD1O	3589.500	P3, P2, P1	FN53IX	00-23	PUBLIC	689	047	82	52
WD1O	7104.500	P3, P2, P1	FN53IX	00-23	PUBLIC	689	047	81	55
VE3AWN	5405.000	P4, P3, P2, P1	FN25GF	00-23	PUBLIC	588	001	79	52
KZ5ED	7103.700	P3, P2, P1	EM85WX	00-23	PUBLIC	719	234	78	51
W5DMH	7103.500	P3	EN83HG	00-23	PUBLIC	742	302	77	51
W6IDS	7061.500	P2, P1	EM79NV	00-23	PUBLIC	788	273	77	50
W6IDS	7084.500	P2, P1	EM79NV	00-23	PUBLIC	788	273	77	50
W1EO	1845.000	P2, P1	FN42IM	00-23	PUBLIC	462	050	76	49
AJ4FW	3595.000	P3, P2, P1	FM07BC	00-23	PUBLIC	486	231	76	49
KC8YJJ	3589.500	P3, P2, P1	EN90PL	00-23	PUBLIC	435	280	76	49
VE1YZ	7096.500	P4, P3	FN84BQ	00-23	PUBLIC	1099	057	71	47
WW4MSK	7102.500	P3, P2, P1	EM83DS	00-23	PUBLIC	992	229	71	44
WW4MSK	7064.500	P2, P1	EM83DS	00-23	PUBLIC	992	229	70	44
KZ5ED	3595.000	P3, P2, P1	EM85WX	00-23	PUBLIC	719	234	68	46
W5DMH	3587.500	P3	EN83HG	23-08	PUBLIC	742	302	67	46
VE1YZ	5405.000	P4, P3	FN84BQ	00-23	PUBLIC	1099	057	67	45

Local FM 2m Packet 1200 baud Gateways

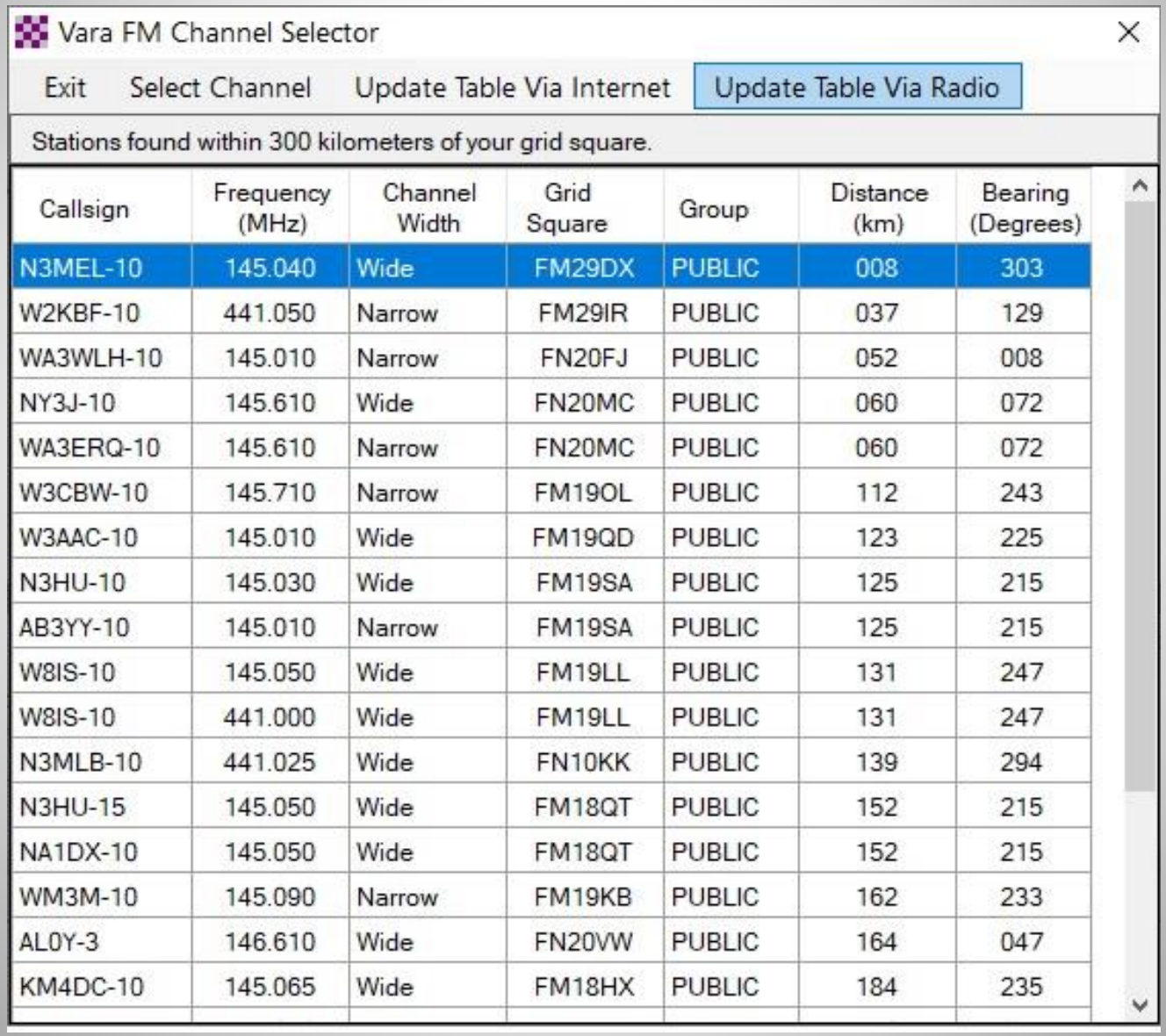
Packet Channel Selector

Exit | Select Channel | Update Table Via Internet | Update Table Via Radio

Stations found within 300 kilometers of your grid square.

Callsign	Frequency (MHz)	Baud	Grid Square	Group	Distance (km)	Bearing (Degrees)
N3MEL-10	145.010	1200	FM29DX	PUBLIC	008	303
W3JY-10	145.010	1200	FN20FA	PUBLIC	012	041
W3DRA-10	145.070	1200	FM29FU	PUBLIC	013	142
W3AVP-10	145.010	1200	FN10WC	PUBLIC	046	293
WA3WLH-10	145.010	1200	FN20FJ	PUBLIC	052	008
K3KH-10	0.146	1200	FN20LE	PUBLIC	057	061
WA3ERQ-10	145.610	1200	FN20MC	PUBLIC	060	072
NY3J-10	145.610	1200	FN20MC	PUBLIC	060	072
KC2TXB-10	145.070	1200	FM29KL	PUBLIC	067	140
K3IR-10	145.030	1200	FN10SE	PUBLIC	076	292
W3HZU-10	145.010	1200	FN10PA	PUBLIC	092	276
KC3MDK-10	145.090	1200	FM19SI	PUBLIC	097	228
K3ARH-10	145.090	1200	FM19VD	PUBLIC	101	210
W3CBW-10	145.710	1200	FM19OL	PUBLIC	112	243
K3CHB-10	145.010	1200	FN10MF	PUBLIC	118	286
K2GE-10	145.050	1200	FN20TL	PUBLIC	122	060
W3AAC-10	145.010	1200	FM19QD	PUBLIC	123	225

Local 2m/70cm FM VARA Gateways



Callsign	Frequency (MHz)	Channel Width	Grid Square	Group	Distance (km)	Bearing (Degrees)
N3MEL-10	145.040	Wide	FM29DX	PUBLIC	008	303
W2KBF-10	441.050	Narrow	FM29IR	PUBLIC	037	129
WA3WLH-10	145.010	Narrow	FN20FJ	PUBLIC	052	008
NY3J-10	145.610	Wide	FN20MC	PUBLIC	060	072
WA3ERQ-10	145.610	Narrow	FN20MC	PUBLIC	060	072
W3CBW-10	145.710	Narrow	FM19OL	PUBLIC	112	243
W3AAC-10	145.010	Wide	FM19QD	PUBLIC	123	225
N3HU-10	145.030	Wide	FM19SA	PUBLIC	125	215
AB3YY-10	145.010	Narrow	FM19SA	PUBLIC	125	215
W8IS-10	145.050	Wide	FM19LL	PUBLIC	131	247
W8IS-10	441.000	Wide	FM19LL	PUBLIC	131	247
N3MLB-10	441.025	Wide	FN10KK	PUBLIC	139	294
N3HU-15	145.050	Wide	FM18QT	PUBLIC	152	215
NA1DX-10	145.050	Wide	FM18QT	PUBLIC	152	215
WM3M-10	145.090	Narrow	FM19KB	PUBLIC	162	233
AL0Y-3	146.610	Wide	FN20VW	PUBLIC	164	047
KM4DC-10	145.065	Wide	FM18HX	PUBLIC	184	235

1990's Pactor I TNC

Pactor II and III (**PSK** modulation)
Higher speed, more robust, higher bandwidth

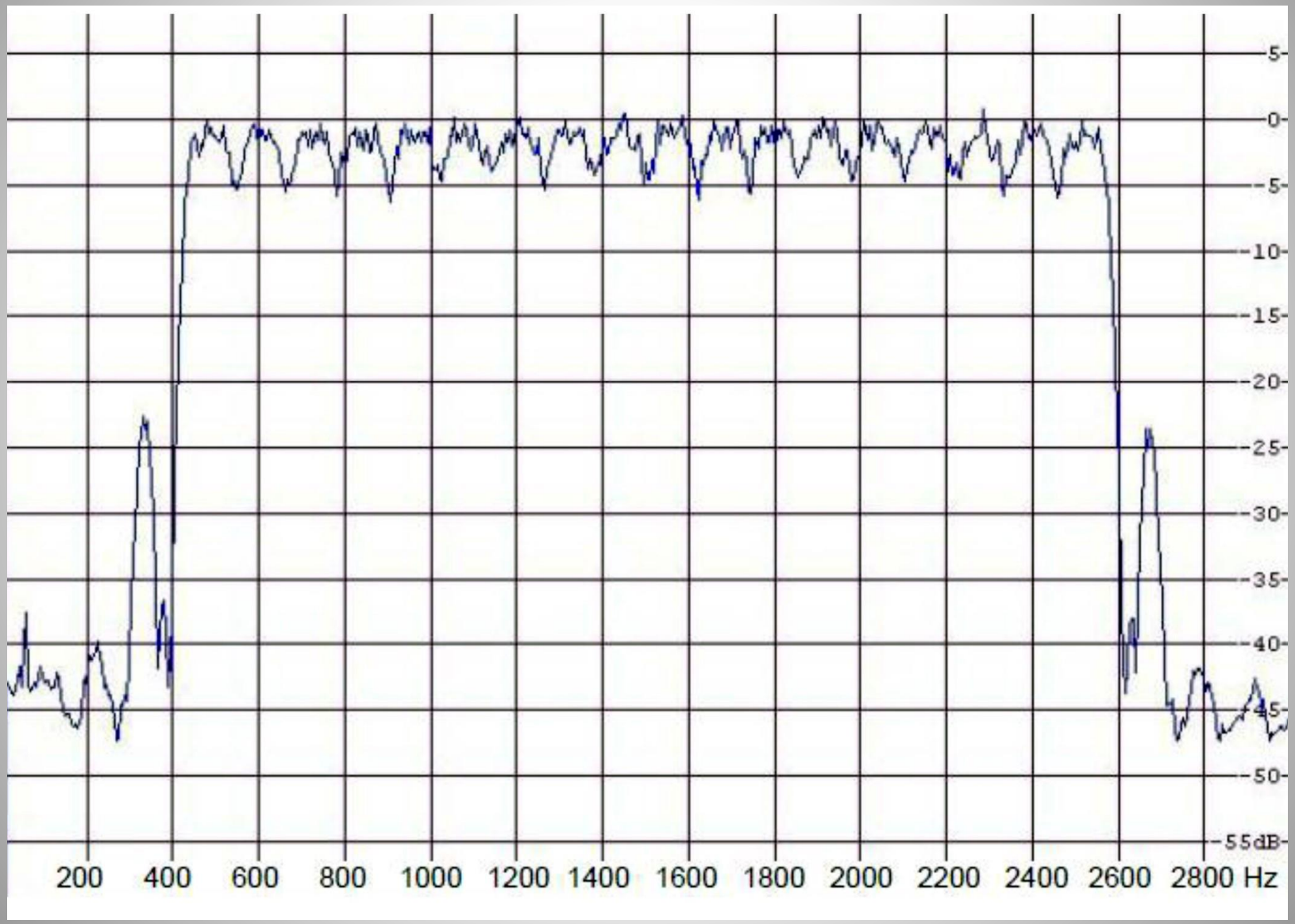
PACTOR III

- Proprietary mode used for message and traffic handling over an HF radio circuit
- Use of Pactor-III protocol is limited for NA hams and some other countries due to the very wide bandwidth
- Only the embedded hardware (modem) from the German company that owns the rights to this mode, is capable of operating Pactor-III.
- No software solution available
- EXPENSIVE modems!

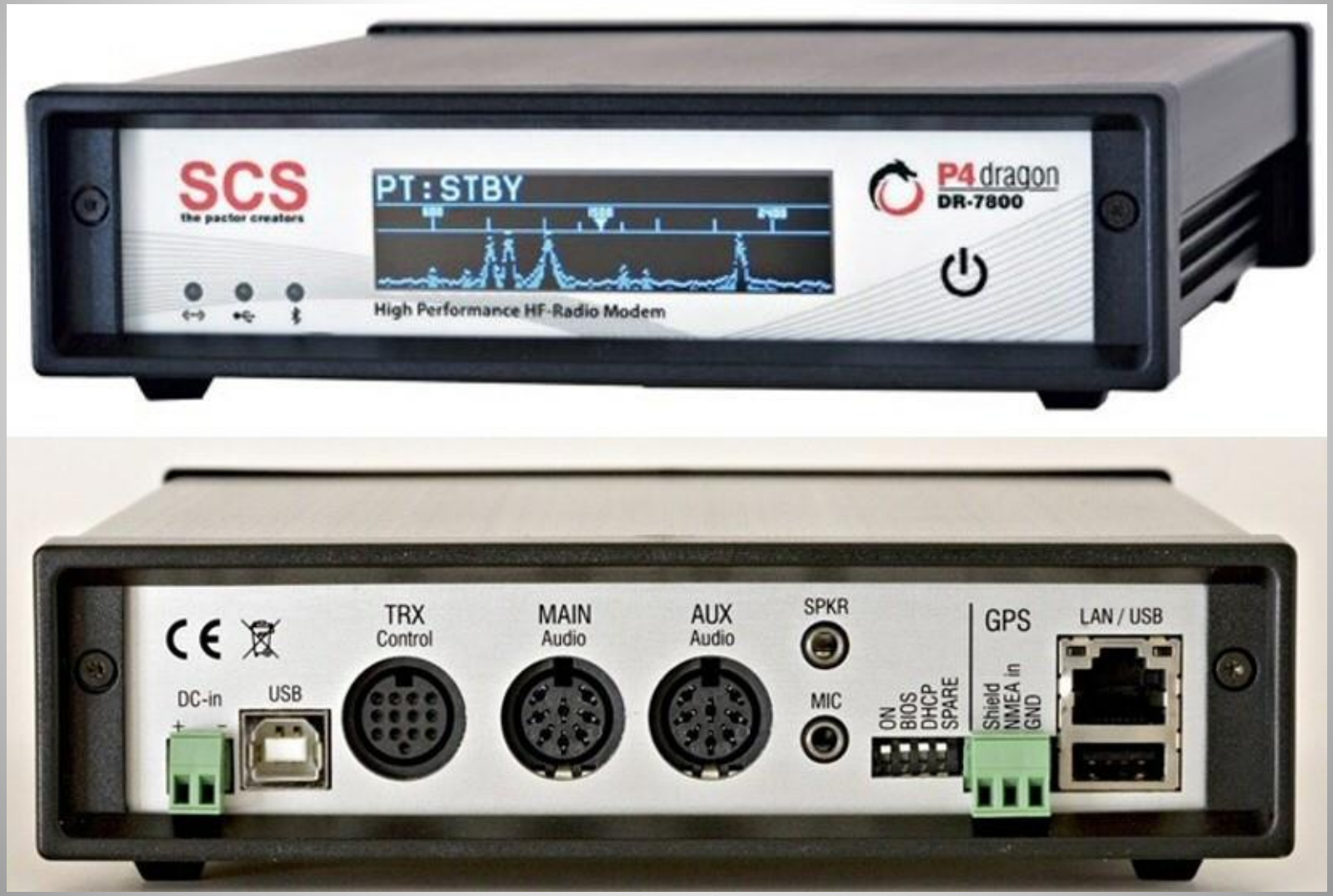
Pactor III modes or speeds (gears)
Requires a TNC

Speedlevel	*Number of tones*	*Code Rate*	*Modulation Type*
1	2	1/2	DBPSK
2	6	1/2	DBPSK
3	14	1/2	DBPSK
4	14	1/2	DQPSK
5	16	3/4	DQPSK
6	18	8/9	DQPSK

Pactor III spectrum: 2.2 kHz 18 PSK carriers



Pactor IV - 1800 baud
(not legal yet in USA)

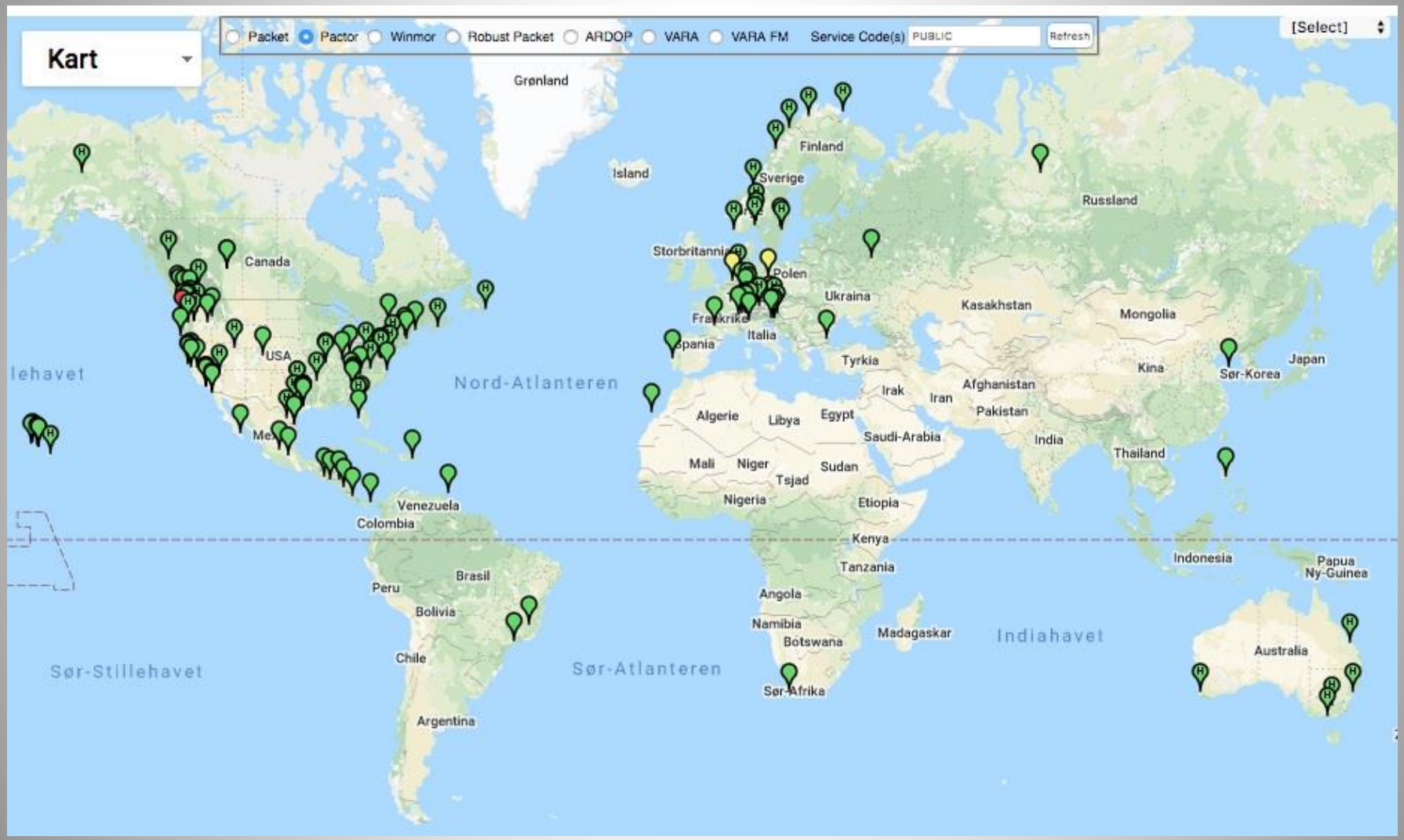


Pactor IV speeds

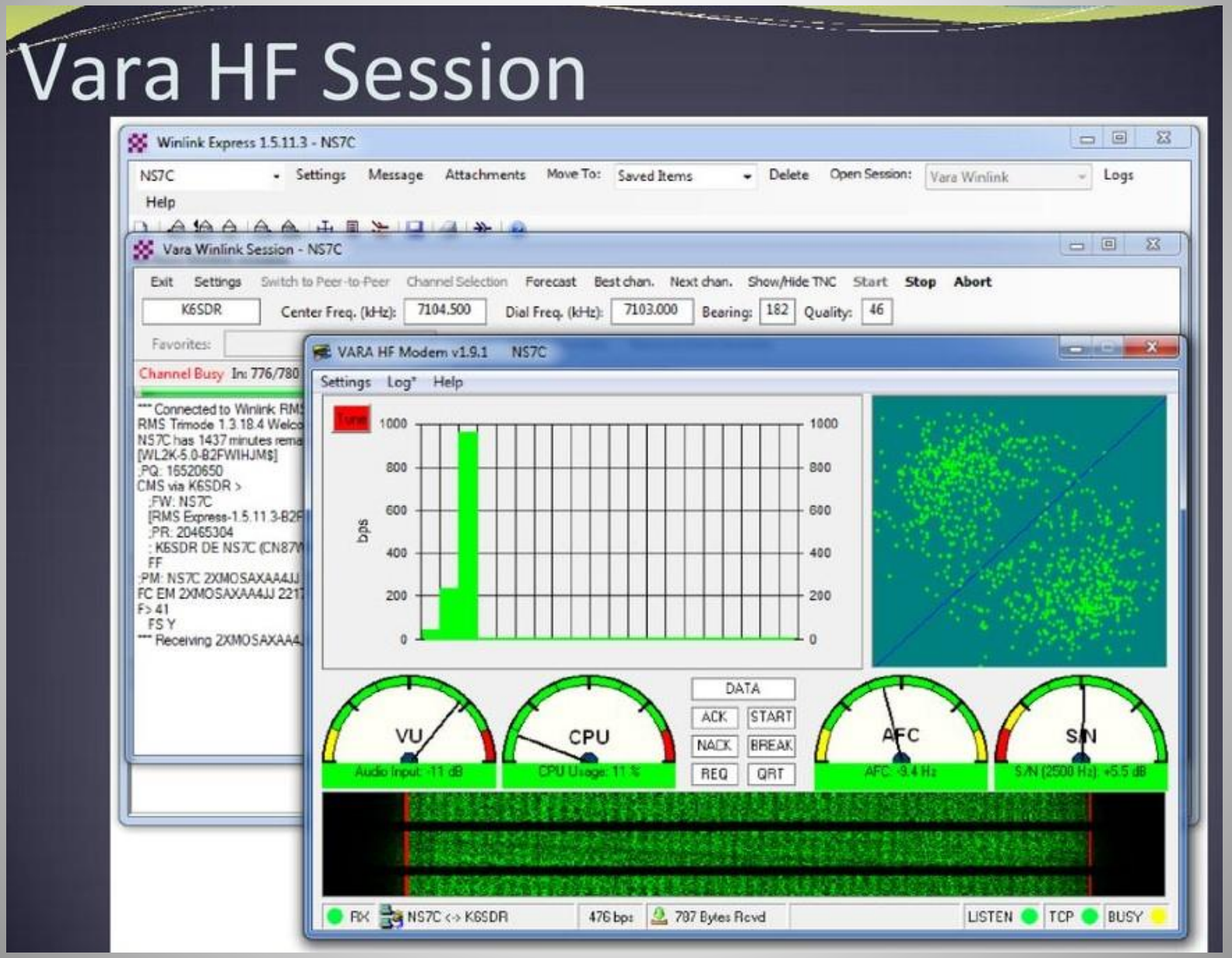
Speedlevel	Modulation	Gross rate	Net rate [bps]
1	2-Ton-Chirp	113	46,9
2	DQPSK, Spread-16	225	85,32
3	DQPSK, Spread-16	225	147,2
4	DQPSK, Spread-8	450	300,8
5	BPSK	1800	433,1
6	BPSK	1800	1096,5
7	QPSK	3600	2199,5
8	8-PSK	5400	3304,5
9	16-QAM	7200	4407,5
10	32-QAM	9000	5512,5

Pactor World Stations

(date unknown)



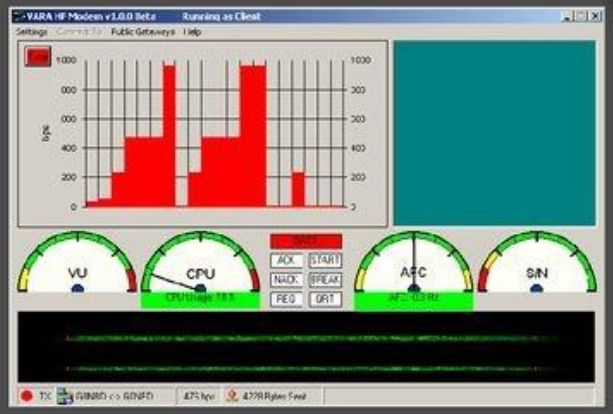
VARA HF/FM uses sound cards



VARA User interface

TX Mode

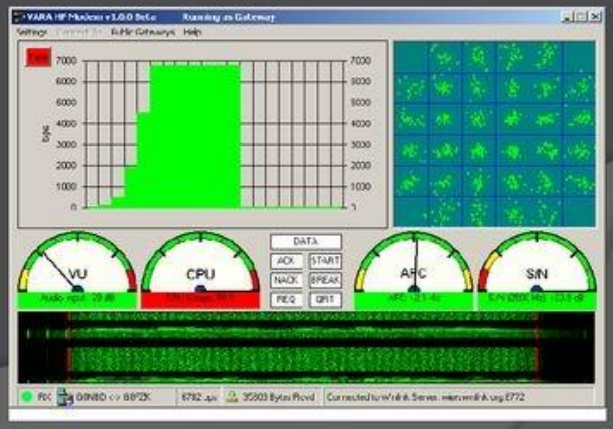
Link throughput and Data block delivery is presented as a dynamic moving time-line display



RX Mode

Received data blocks are shown on the moving time-line display

Signal quality and mode selection is presented as an adaptive **Constellation display**



Winlink's VARA HF SSB (sound card) **wide** 2300 Hz and **narrow** 500 Hz

VARA HF v4.0.0
Speed Levels

	VARA HF 2300				VARA HF 500			
Level	Symbol Rate	Carriers	Mod.	Net Rate (bps)	Symbol Rate	Carriers	Mod.	Net Rate (bps)
1	23	32	FSK	18	23	11	FSK	18
2	47	16	FSK	41	47	11	FSK	41
3	47	16	FSK	82	47	11	FSK	61
4	94	16	FSK	175	94	2	BPSK	88
5	94	3	4PSK	270	94	2	4PSK	177
6	94	4	4PSK	363	94	3	4PSK	270
7	94	6	4PSK	549	42	11	4PSK	441
8	94	8	4PSK	735	42	11	4PSK	588
9	94	10	4PSK	922	42	11	4PSK	705
10	42	49	4PSK	2011	42	11	8PSK	884
11	42	49	4PSK	2682	42	11	8PSK	1060
12	42	49	4PSK	3219	42	11	16QAM	1286
13	42	49	8PSK	4025	42	11	32QAM	1543
14	42	49	8PSK	4830				
15	42	49	16QAM	5872				
16	42	49	32QAM	7050				

Winlink's VARA FM 4.0 VHF/UHF

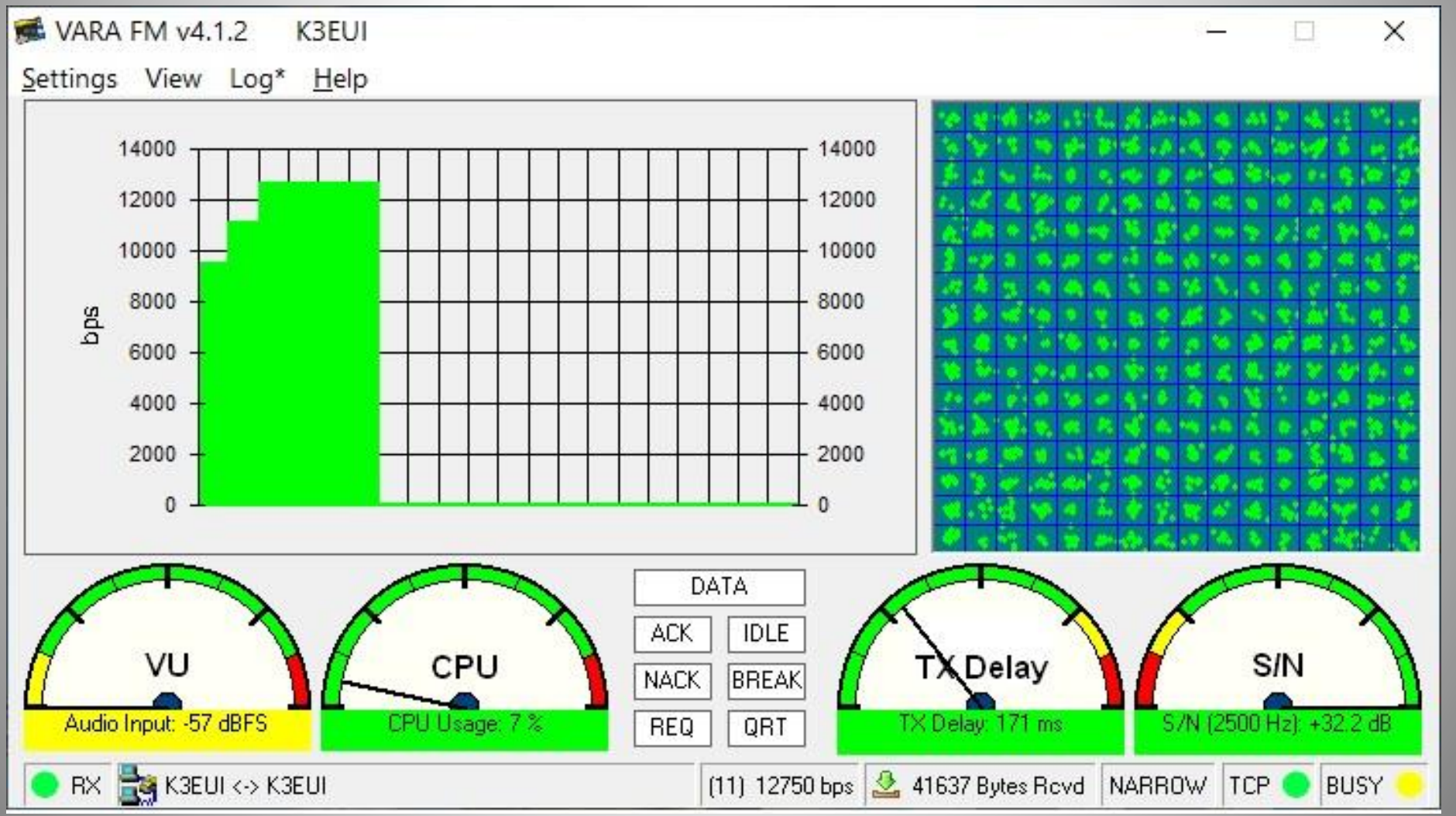
WIDE BW (6 KHz) needs 9600 baud pins

NARROW BW (2 kHz) uses 1200 baud pins

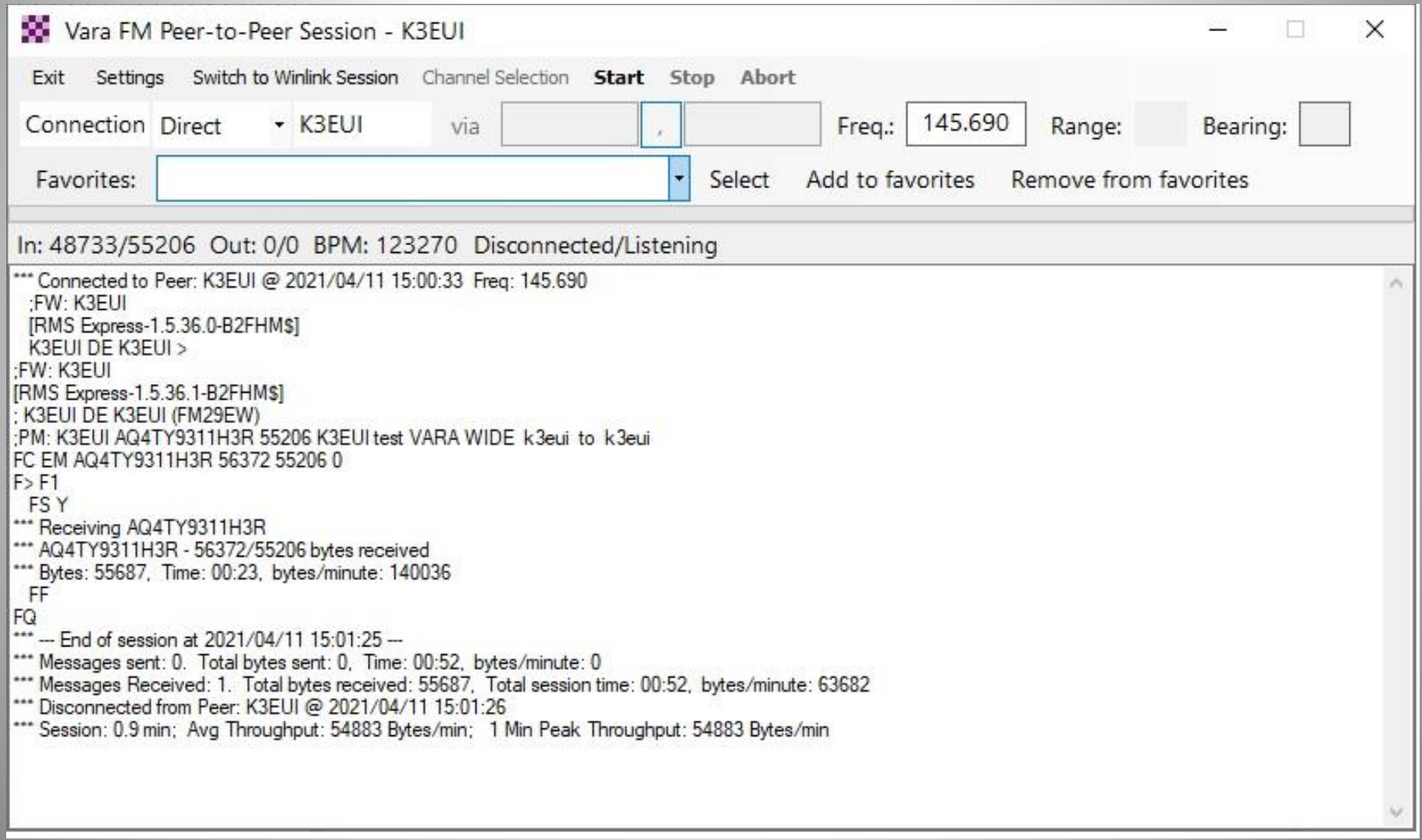
VARA FM v4.0.0
Speed Levels

	VARA FM WIDE				VARA FM NARROW			
Level	Symbol Rate	Carriers	Mod.	Net Rate (bps)	Symbol Rate	Carriers	Mod.	Net Rate (bps)
1	42	14	4PSK	566	42	14	4PSK	549
2	42	29	4PSK	1188	42	29	4PSK	1181
3	42	58	4PSK	2390	42	58	4PSK	2390
4	42	98	4PSK	4040	42	58	4PSK	3188
5	42	98	4PSK	5387	42	58	8QAM	4252
6	42	98	8QAM	7185	42	58	16QAM	5668
7	42	98	16QAM	9580	42	58	32QAM	7087
8	42	116	16QAM	11340	42	58	64QAM	8505
9	42	116	32QAM	14144	42	58	64QAM	9567
10	42	116	64QAM	16932	42	58	128QAM	11162
11	42	116	64QAM	19003	42	58	256QAM	12750
12	42	116	128QAM	22102				
13	42	116	256QAM	25210				

Sample Rx Window VARA FM k3eui connected to k3eui



55kB file sent in 23 sec ==> 140 kB/minute on 2m FM simplex



FLDIGI
(Fast Light Digi)

Narrow Bandwidth
Emergency Message System

FLDIGI www.w1hkj.com

FREE program

Works on Windows, Linux, Macs

Updated regularly

Good for casual qso or EMCOMM

Low memory required

Works on older Win7 laptops/desktops

[Does NOT do Packet, Pactor, JT modes]

Components of FLDIGI

FLDIGI - main sound card program
FLMSG - preformed message types
FLAMP - sends longer files in blocks
FLRIG - CAT or Rig Control options
FLLOG - logging program

FL Message: FLMSG

FILES are "**wrapped**" for **error detection**

Weather reports

American Red Cross messages

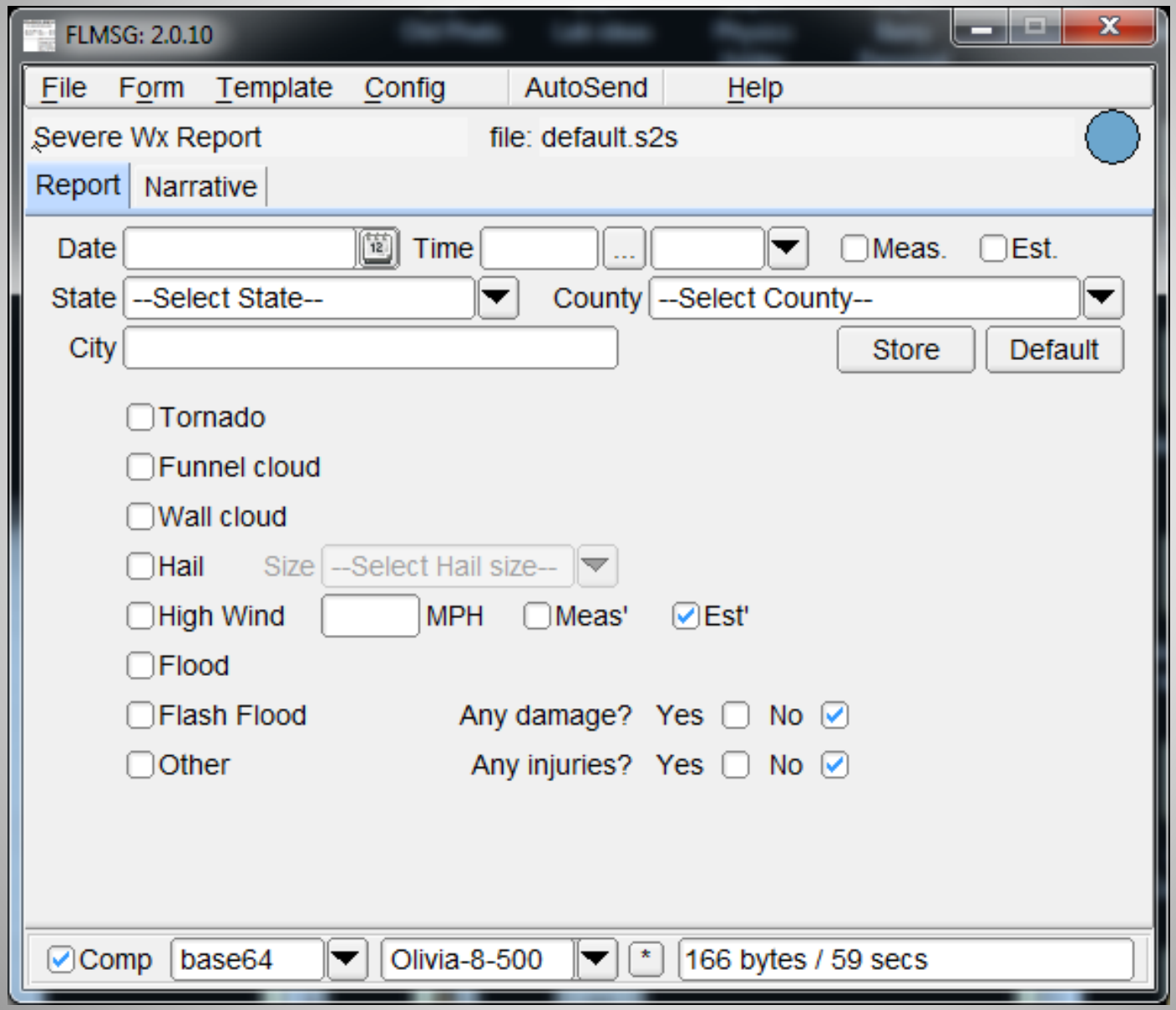
ICS emergency messages

Spreadsheets (CSV files)

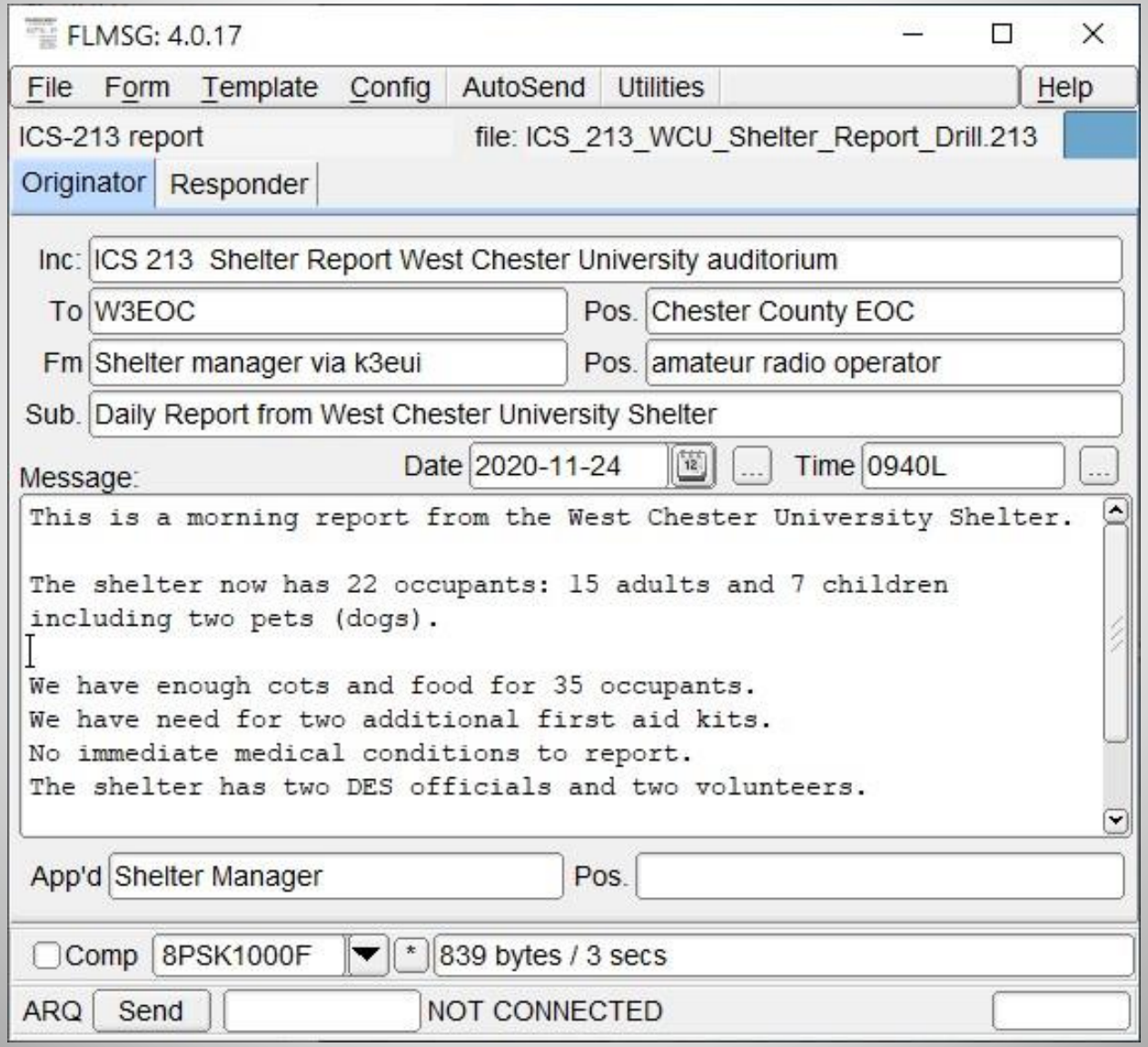
ARRL RadioGram

CUSTOM FORMS - (local WX)

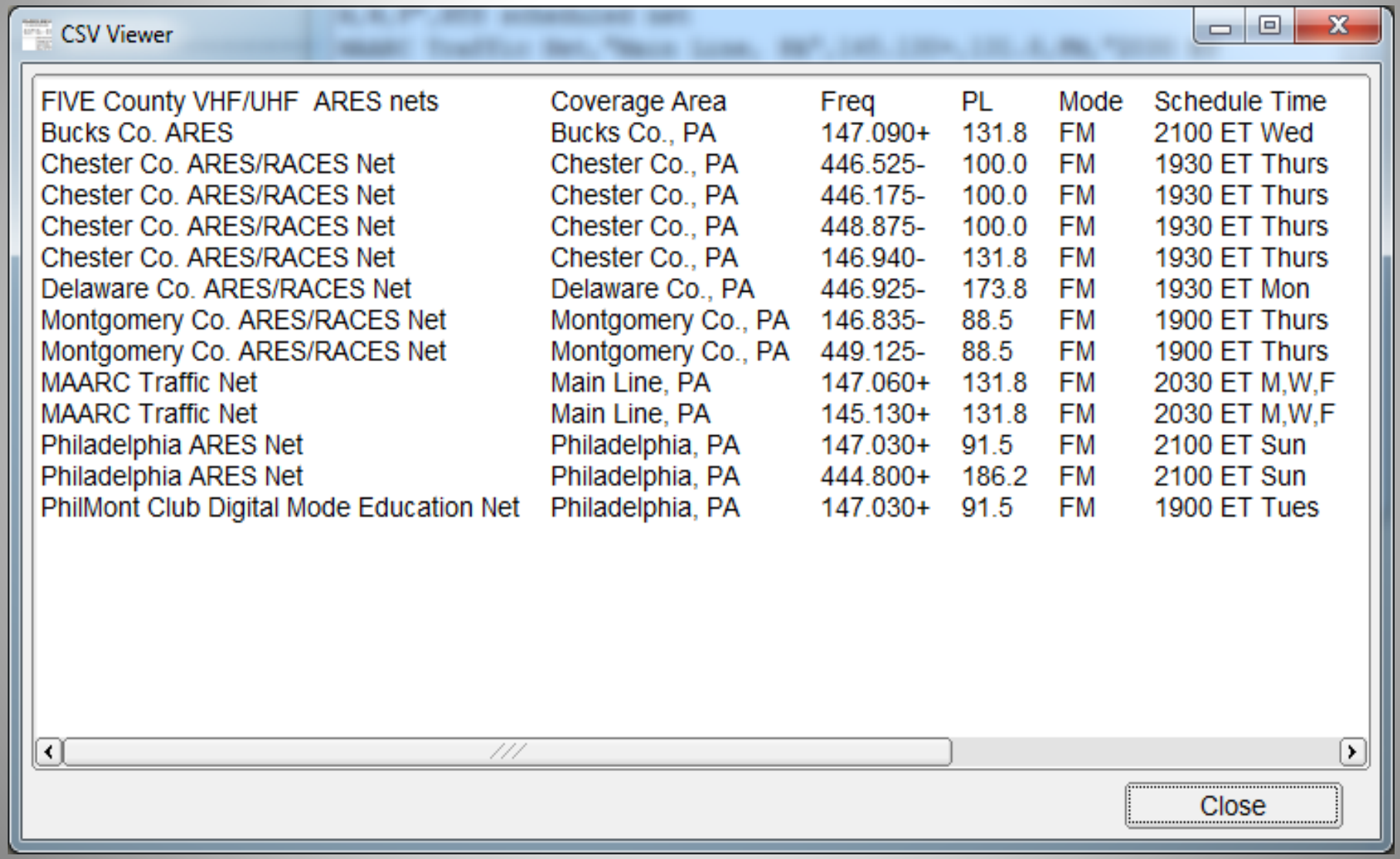
FLMSG: Severe Weather Reports



ICS 213 emergency message

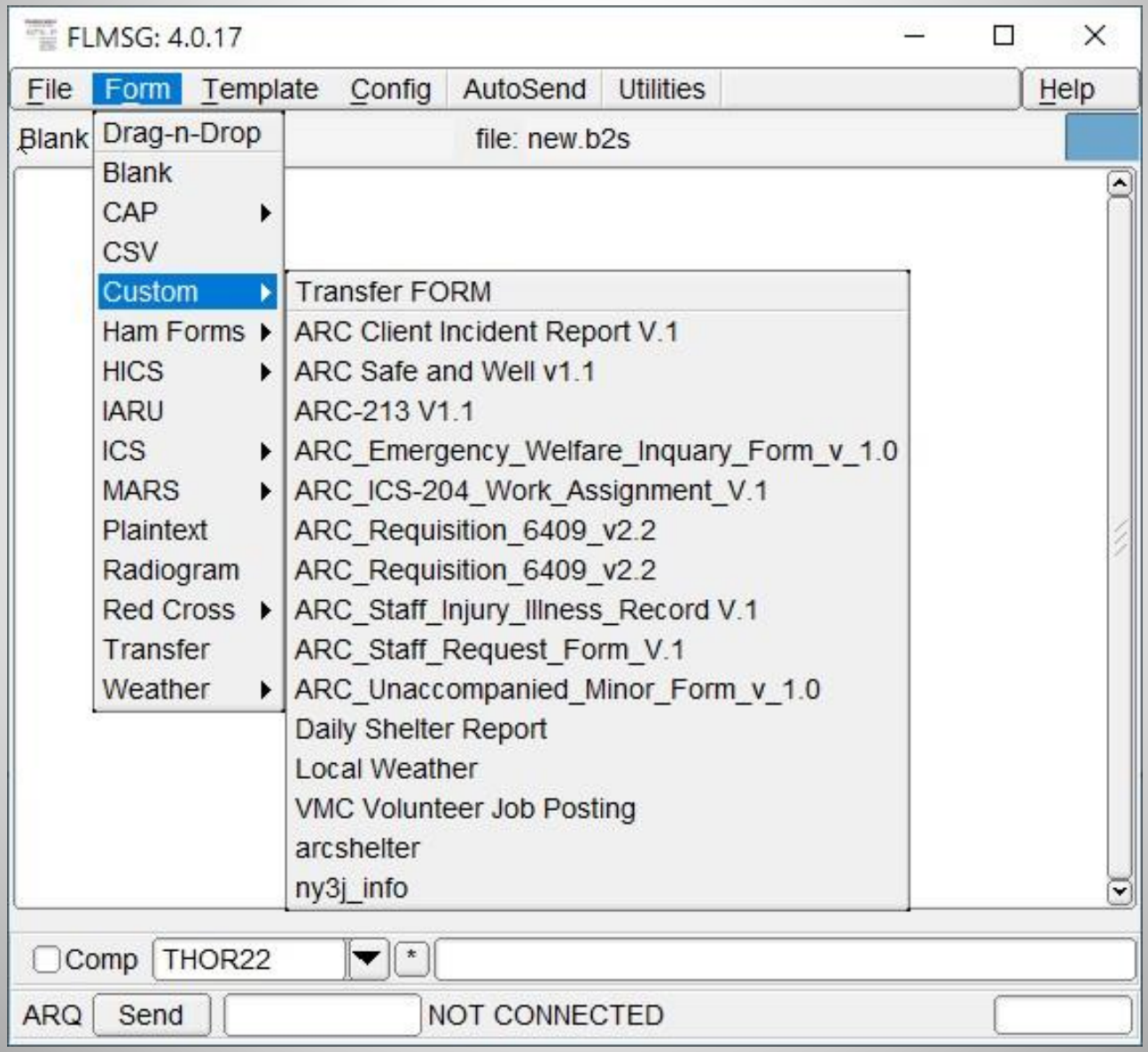


Spreadsheets (csv files)



FIVE County VHF/UHF ARES nets	Coverage Area	Freq	PL	Mode	Schedule Time
Bucks Co. ARES	Bucks Co., PA	147.090+	131.8	FM	2100 ET Wed
Chester Co. ARES/RACES Net	Chester Co., PA	446.525-	100.0	FM	1930 ET Thurs
Chester Co. ARES/RACES Net	Chester Co., PA	446.175-	100.0	FM	1930 ET Thurs
Chester Co. ARES/RACES Net	Chester Co., PA	448.875-	100.0	FM	1930 ET Thurs
Chester Co. ARES/RACES Net	Chester Co., PA	146.940-	131.8	FM	1930 ET Thurs
Delaware Co. ARES/RACES Net	Delaware Co., PA	446.925-	173.8	FM	1930 ET Mon
Montgomery Co. ARES/RACES Net	Montgomery Co., PA	146.835-	88.5	FM	1900 ET Thurs
Montgomery Co. ARES/RACES Net	Montgomery Co., PA	449.125-	88.5	FM	1900 ET Thurs
MAARC Traffic Net	Main Line, PA	147.060+	131.8	FM	2030 ET M,W,F
MAARC Traffic Net	Main Line, PA	145.130+	131.8	FM	2030 ET M,W,F
Philadelphia ARES Net	Philadelphia, PA	147.030+	91.5	FM	2100 ET Sun
Philadelphia ARES Net	Philadelphia, PA	444.800+	186.2	FM	2100 ET Sun
PhilMont Club Digital Mode Education Net	Philadelphia, PA	147.030+	91.5	FM	1900 ET Tues

American Red Cross - Custom forms



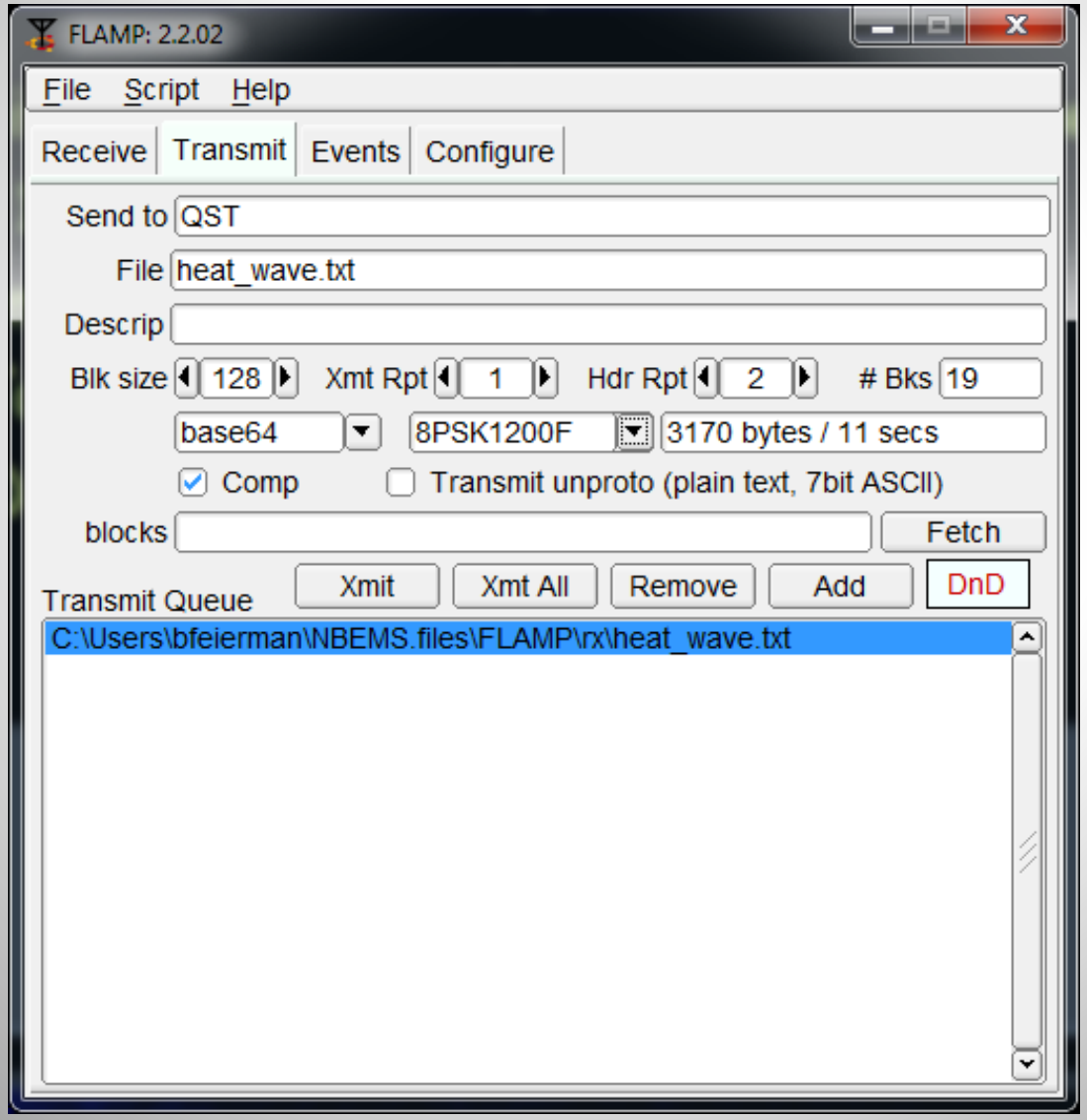
FLAMP

Larger File is broken into multiple smaller **BLOCKS**

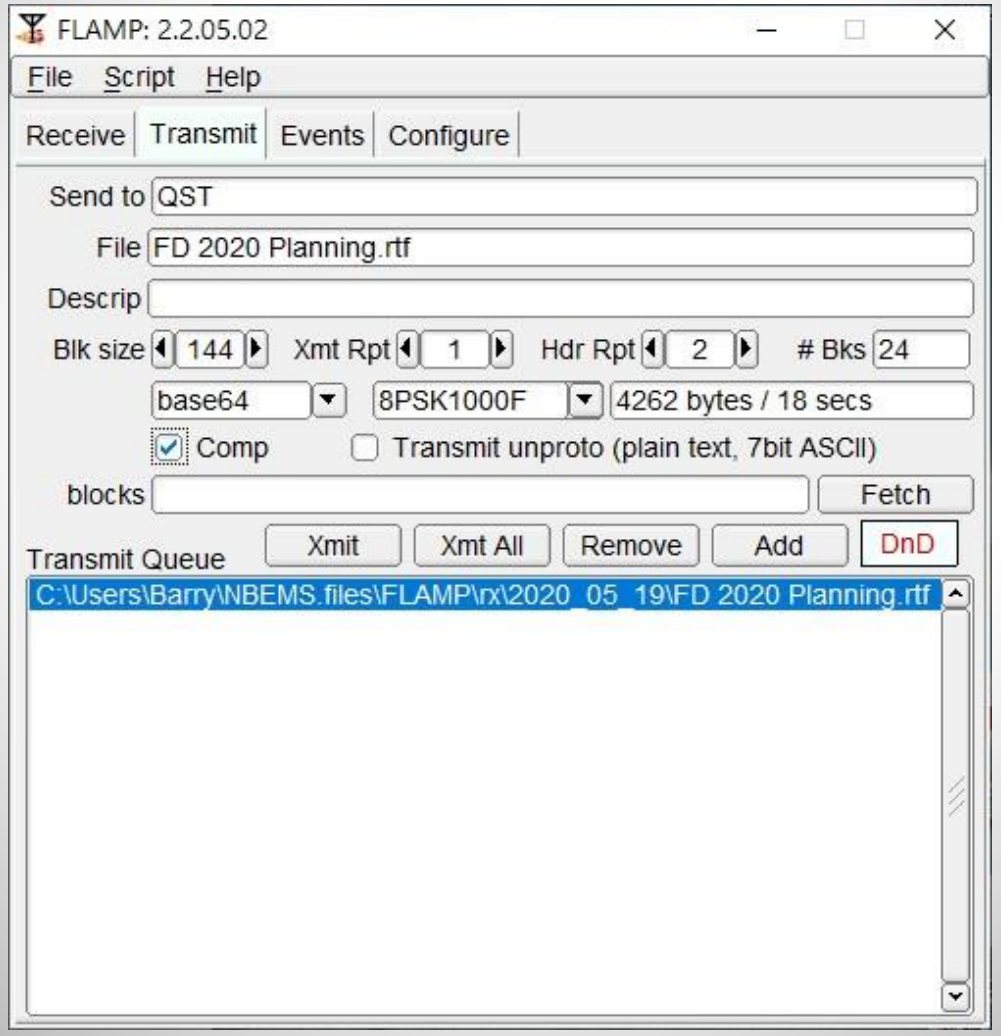
Each "BLOCK" has its own check-sum

Missing Blocks? Send a REPORT
Resend only the "missing blocks"
…… save time

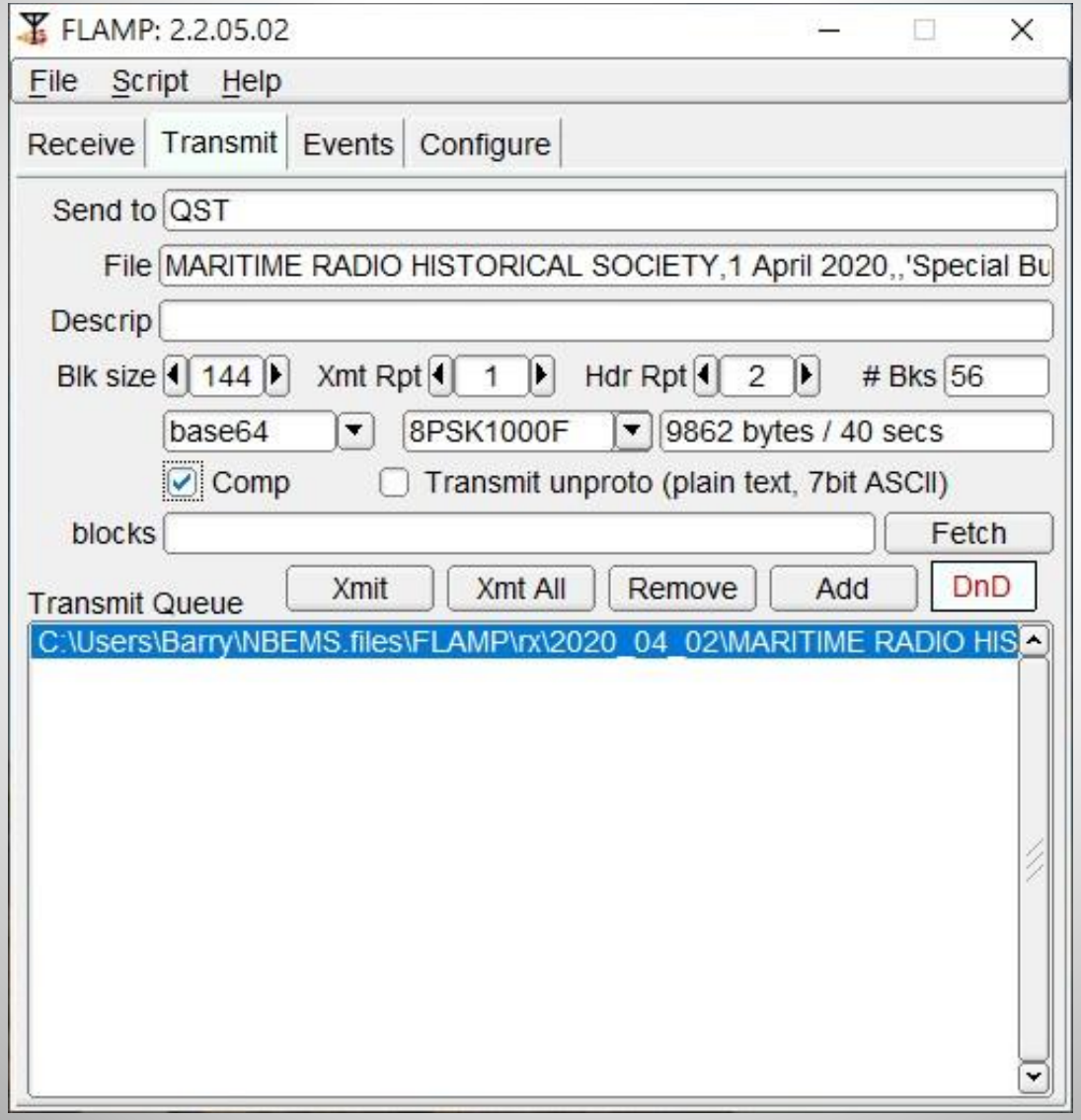
FLAMP: breaks a longer message into "blocks"
3.17 kB file is sent in 11 seconds with 19 "blocks"



FLAMP: Rich Text Format 4.2 kB file (24 blocks) sent compressed via 2m FM repeater by 8PSK1000F in 18 seconds



FLAMP: 9.8 kB email (eml) file sent on UHF FM repeater 56 blocks sent in 40 seconds via **8PSK1000F**



PA NBEMS 80m net

Sunday mornings: 7:30 am to 9 am

Frequency: 3583.0 kHz (USB)

Mode: THOR 22 for check-in

MFSK32 for traffic

experiment with OFDM modes

Propagation: NVIS (skywave) 10-300 miles

PA NBEMS net information

https://groups.io/g/panbems

Net control ops in Eastern PA

NY3J	Ron	Bucks County
K3EUI	Barry2	Chester County
K3UG	Barry4	Chester County

PA NBEMS net

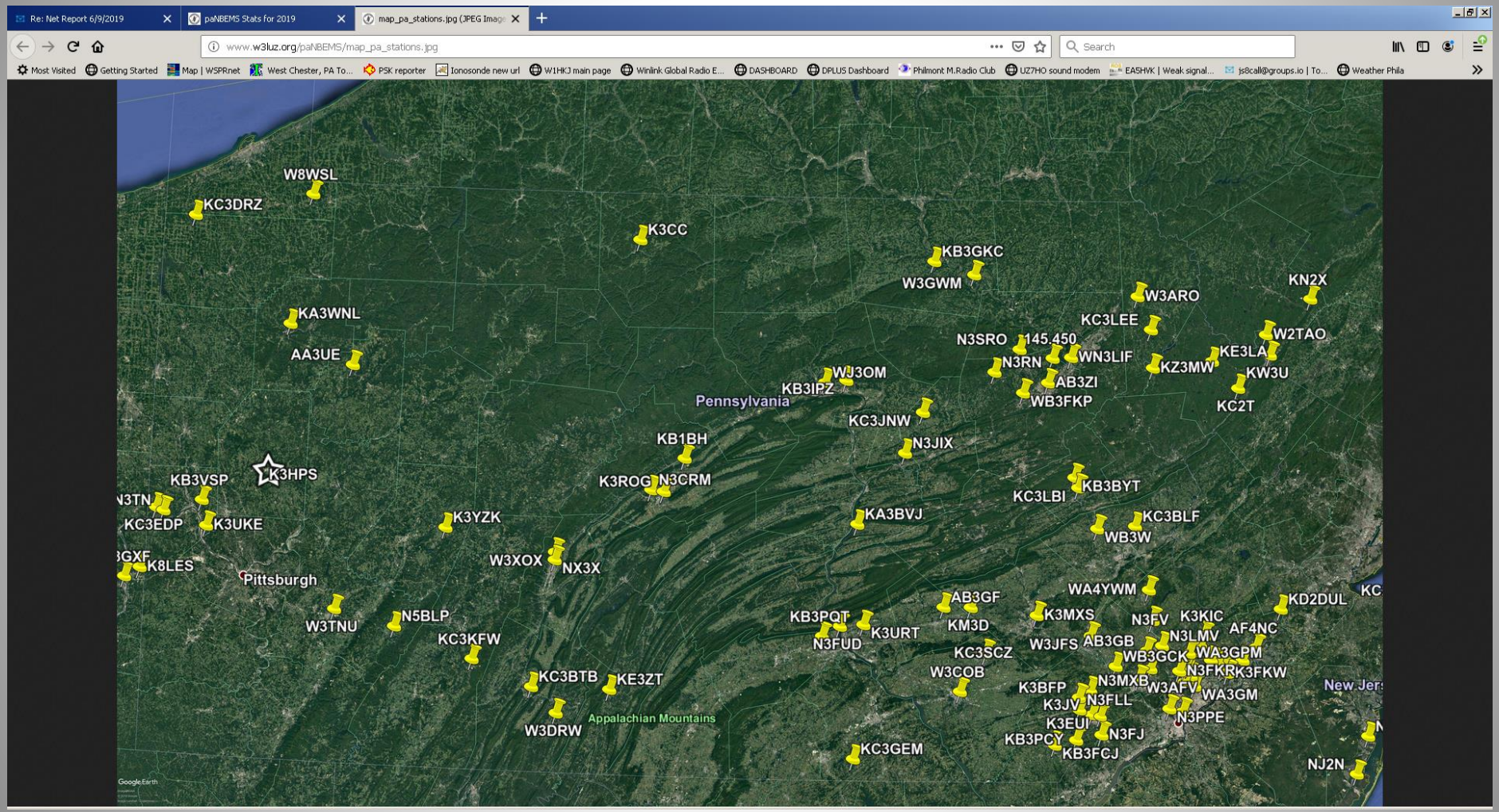
Stations check in first from PA by region
- Emergency, QRP, EOC
- WPA, CPA, and EPA (by county)

then from call regions 1,2,3,4,8,9, Canada

Propagation via NVIS: 10 to 400 miles
Typical Log 50-80 stations

- **Group Email Addresses**
- Post: panbems@groups.io
- Subscribe: panbems+subscribe@groups.io
- Unsubscribe: panbems+unsubscribe@groups.io
- Group Owner: panbems+owner@groups.io
- Help: panbems+help@groups.io

Pa stations checking in regularly on 80m



HF NBEMS regional nets

NY NBEMS

Saturday 8:00 am 3584.0 kHz (USB)

NJ NBEMS

Sunday 9:30 am 3584.5 kHz (USB)

NH Digital Net

Saturday 7:30 am 3582.0 kHz (USB)

SATERN net: Saturdays 20 meter (14.065)

Time for a Coffee Break and Questions

Complete Winlink/NBEMS FLDIGI station

Icom 706MIIG (HF/VHF/UHF) SSB-FM

USB-serial converter COM port PTT and CAT (rig control)

SignaLink usb audio and HF antenna tuner

Pactor III TNC for HF Pactor 3 and VHF PACKET

Hardware needed

RADIO - HF SSB or VHF/UHF FM or HT

TX: input port - MIC or DATA port

RX: output port – speaker/headphone or DATA port

Sound Card - analog/digital conversions

Sound Card **INPUT** - Rx **analog** audio from radio

Sound Card **OUTPUT** – Tx **analog** audio to radio

PTT - COM port or VOX (voice relay)

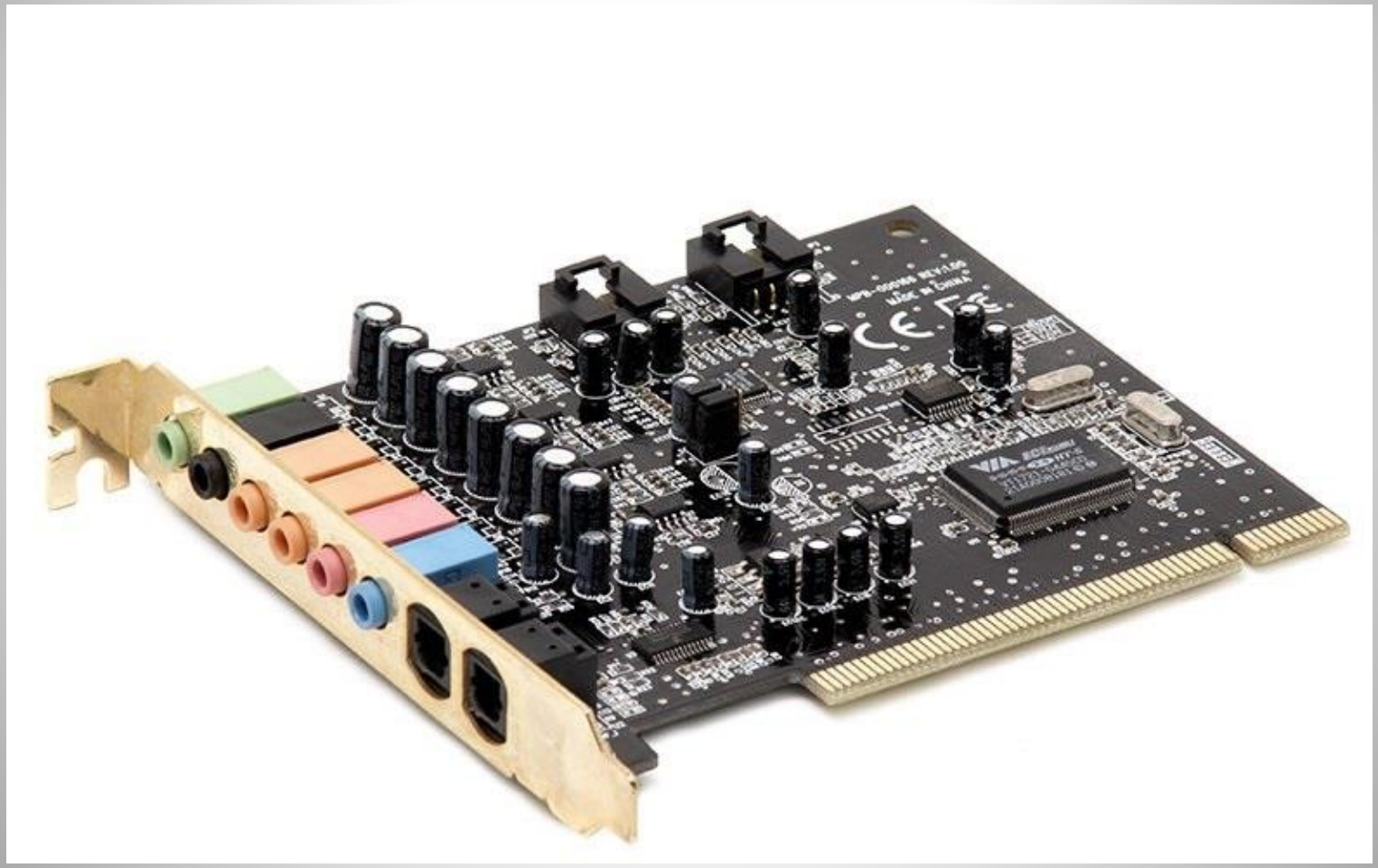
GND - common ground cable

Interface Requirements

Goals: set proper RX and TX levels,
provide a means to SEND (PTT)
avoid RF feedback

Optional Rig Control (CAT)

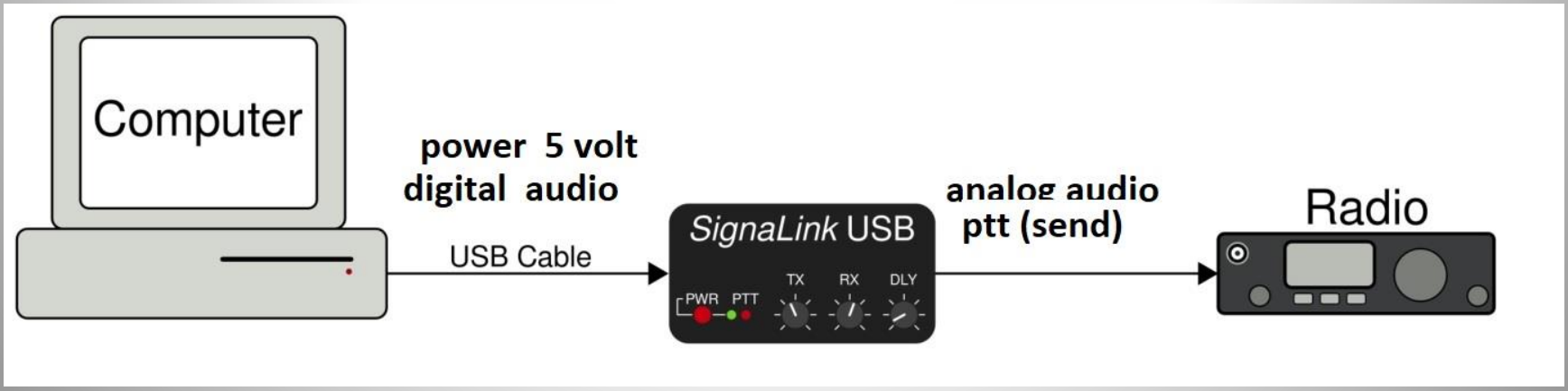
Sound Cards (for older desktops) 1990's



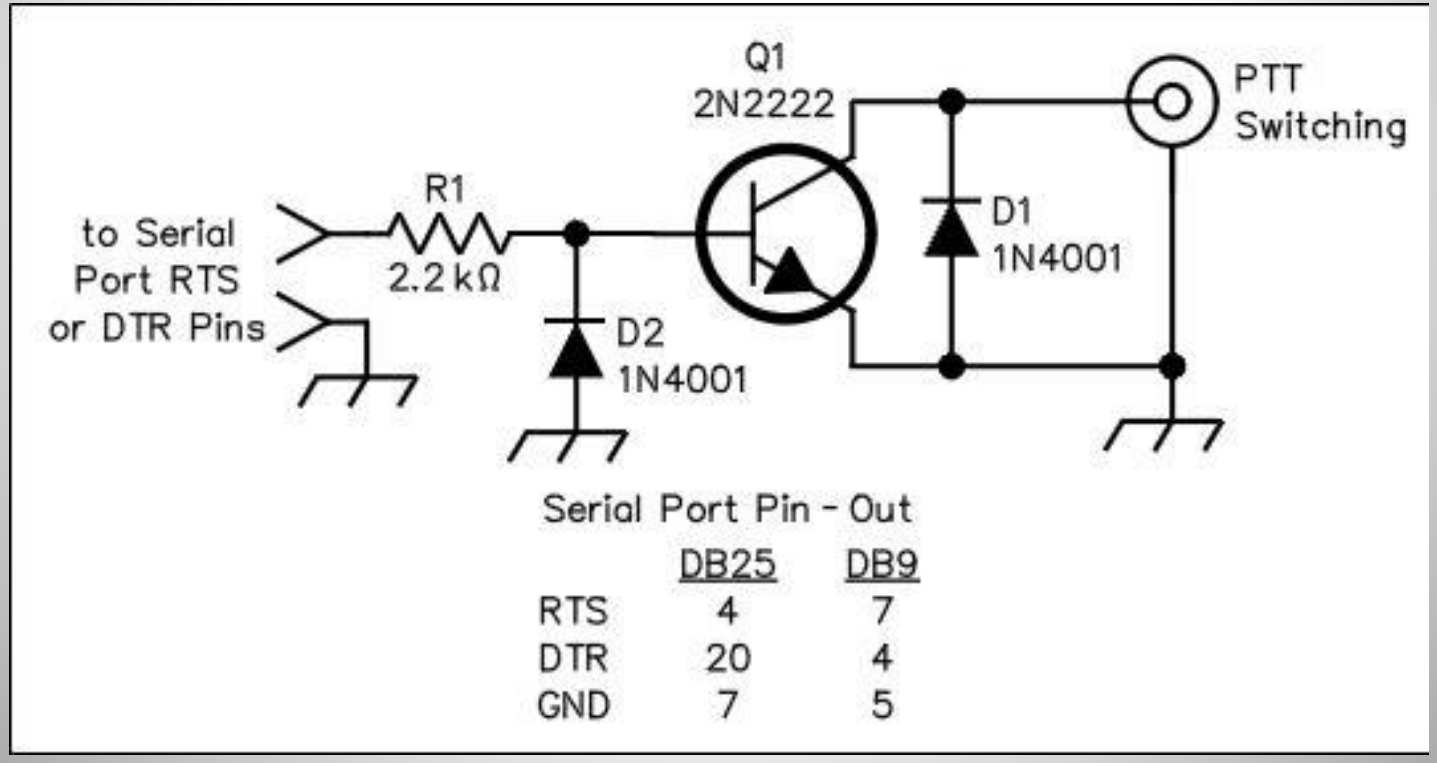
USB audio - getting smaller and smaller
MIC input and HEADPHONE output
VOL control, MONO/STEREO

Typical setup with external sound card
digital - usb cable to computer
analog - audio cable to radio

advantage: PTT by VOX (no COM port)



Simple PTT (send) Circuit using a serial COM port Positive voltage on pins (RTS or DTR) grounds the PTT switching circuit



Serial Port Pin - Out

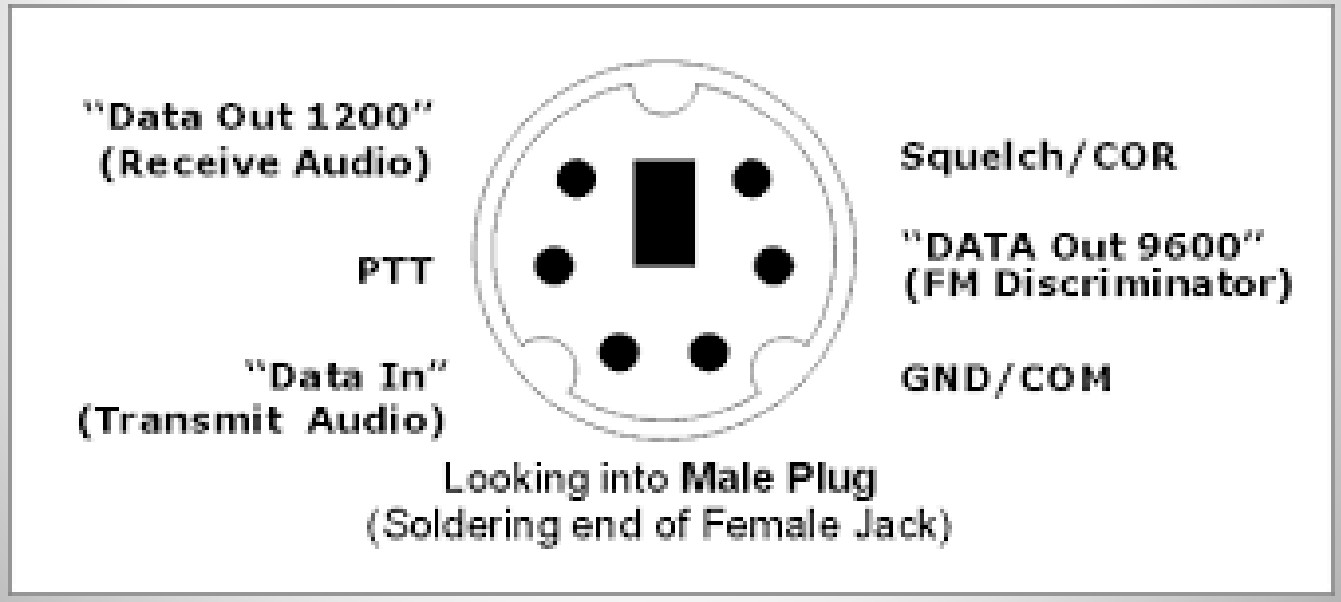
	DB25	DB9
RTS	4	7
DTR	20	4
GND	7	5

Tigertronics - SignaLink (no COM port)

USB sound card: power from usb 5 volts
Has its own VOX circuit for PTT and Delay (hang time)
Rx and TX audio level adjustments

Note (8 pin) RJ45 socket to RADIO
USB port to COMPUTER
MON = listen to TX audio
SPKR/AUX = alternative RX inputs from headphone

6 pin “MINI-DIN” port
common on all dual-band FM rigs
one TX port
one PTT port
TWO RX ports: 1200 or 9600 baud
9600: FLAT audio
1200: processed audio



SignaLink – rear connections

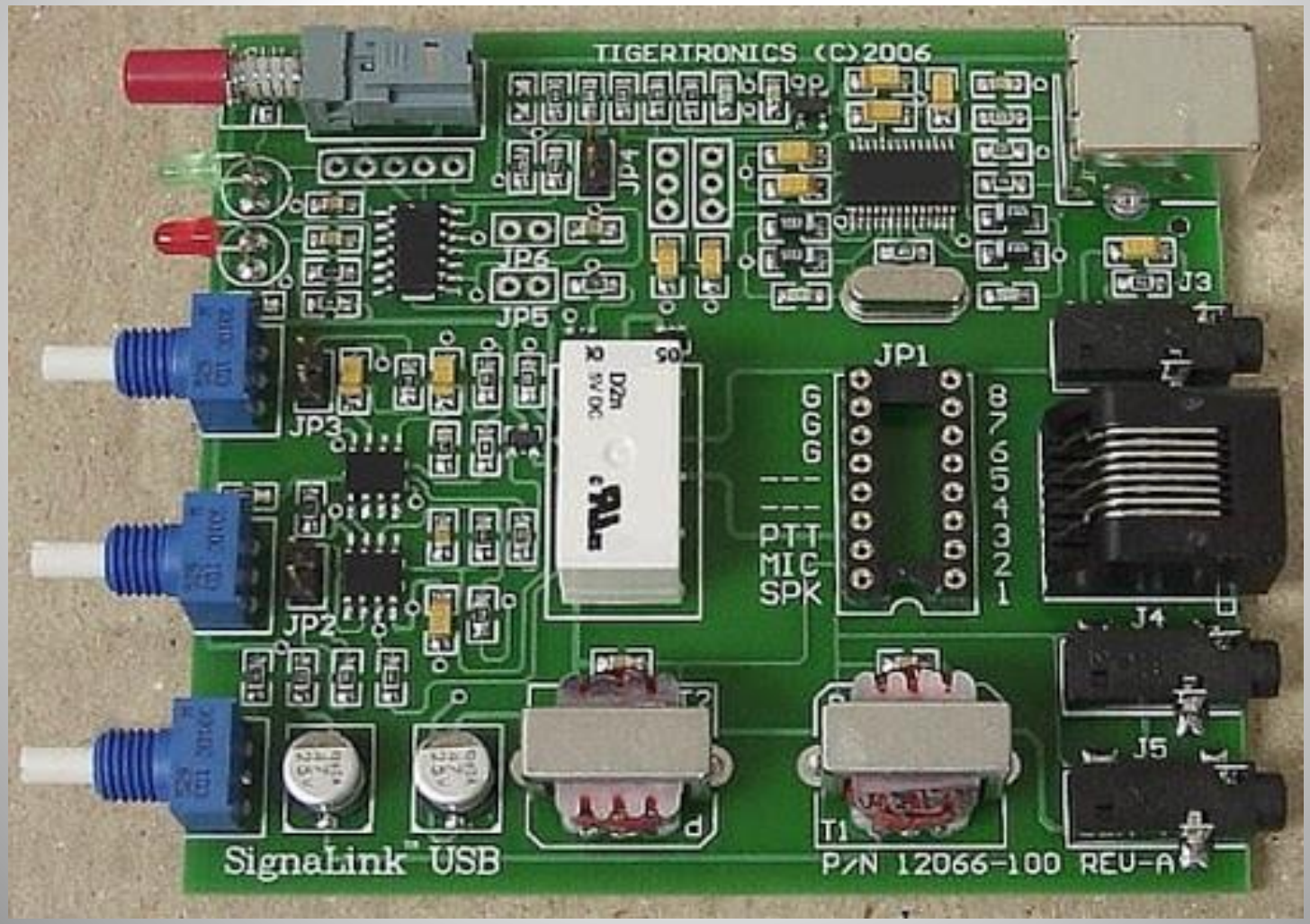
USB power and digital audio to computer

Radio Cable: RJ-45 to specific plug for radio model

MON jack - listen to your **TX audio** in headphones

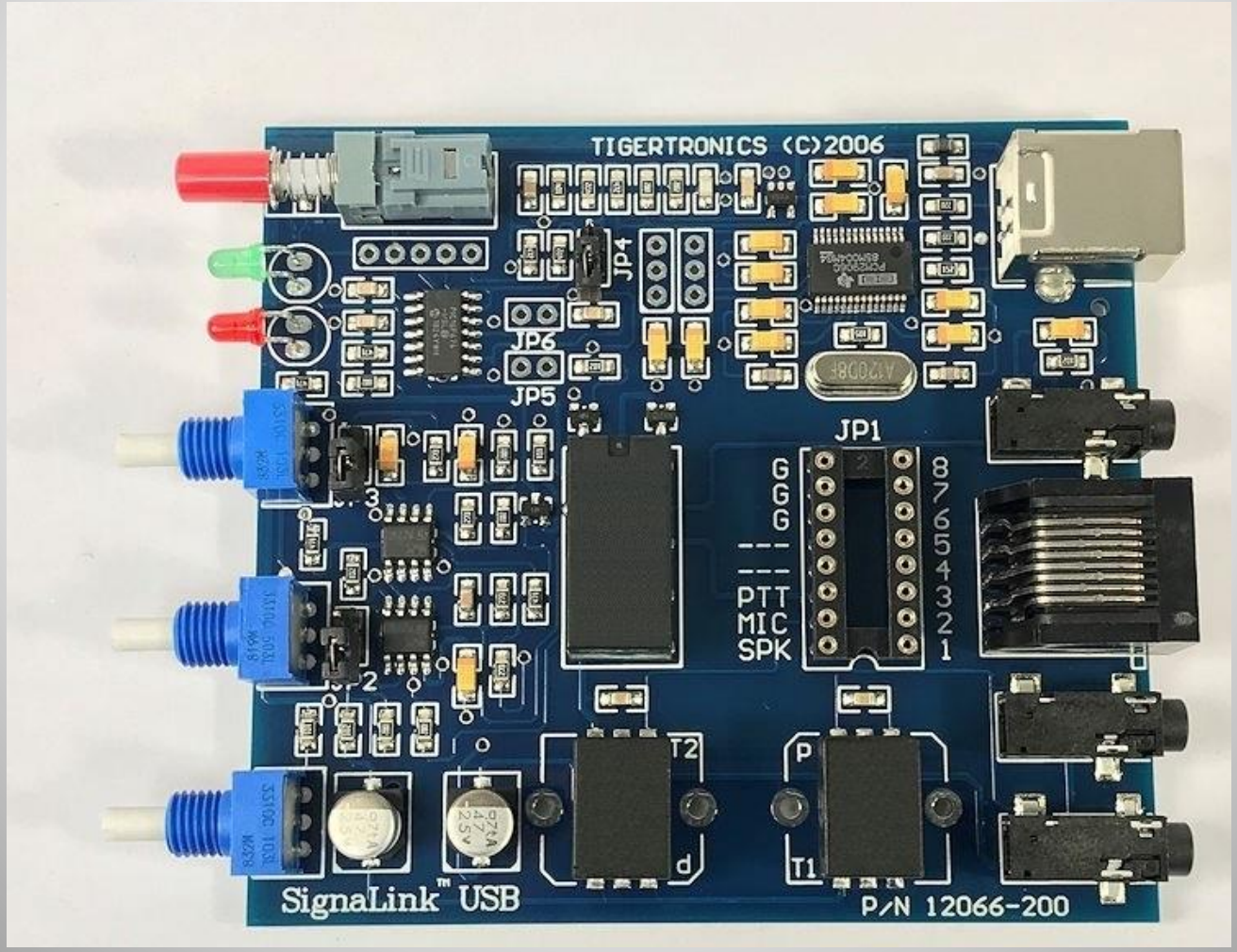
SignaLink: pre 2018 Circuit board

Tx: Left channel only - early transformers limited audio < 3 kHz
mechanical (slow) relay for PTT via VOX
noisy at very low audio frequencies <300 Hz

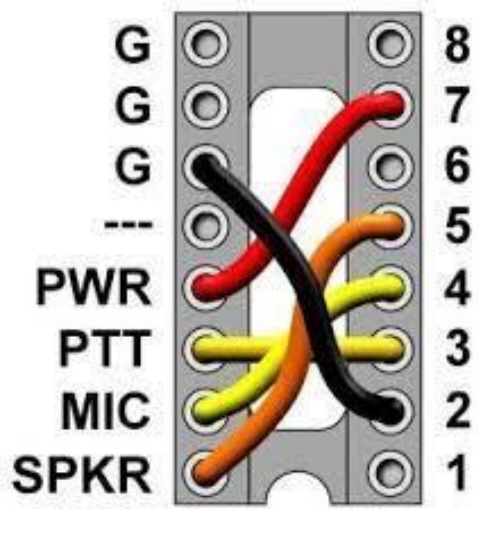


SignaLink post 2018

newer transformers – higher audio response range > 3 kHz
better voltage regulation
still MONO only - Tx/RX - Left channel only



SignaLink connects to variety of radios via Jumper block to set function of pins 1-8



Signalink SLCAB13K Cable Diagram			
RB RJ45 Pin		Kenwood ACC2	Function
1	----------	12	TX Audio Gnd
2	----------	8	PTT Gnd
3	----------	4	RX Audio Gnd
4	----------	13	PTT (Mic Active)
5	---///---	NC	
6	----------	9	PTT (Mic Muted)
7	----------	11	TX Audio
8	----------	3	RX Audio

Rigblaster "interface" (needs external sound card)
Transmit: L/R/both channels with isolation transformer
VOX or Com Port for PTT (send)
TX audio plugs into ANY radio's **<u>microphone</u>** jack

Rigblaster "Advantage"

USB based sound card – very low noise

plugs into any MIC /speaker port, or DATA port

1 **COM port** for: PTT, Rig Control, CW keying, FSK RTTY

TX PTT via VOX or COM port (toggle switch)

Individual GAIN knobs: Tx, Rx, VOX hang time

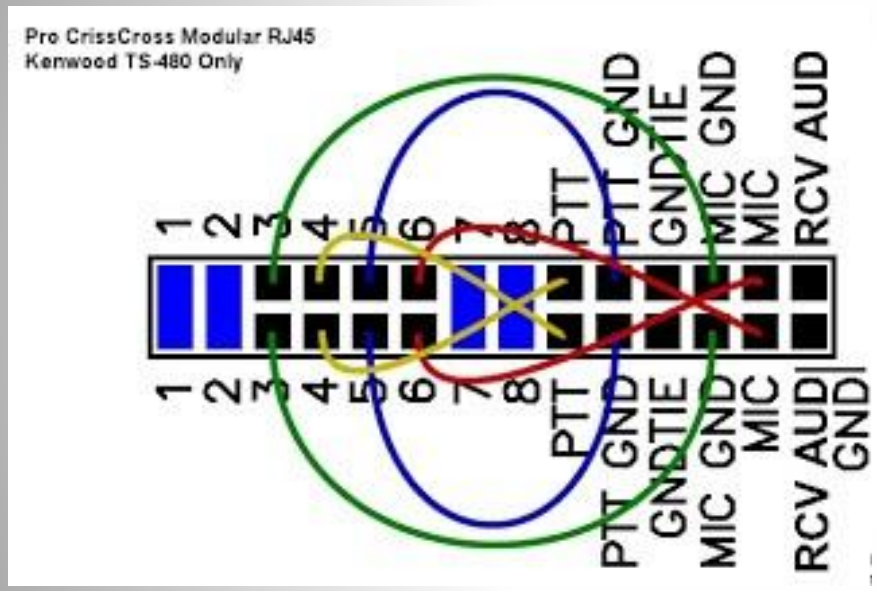
Rigblaster Advantage - rear view

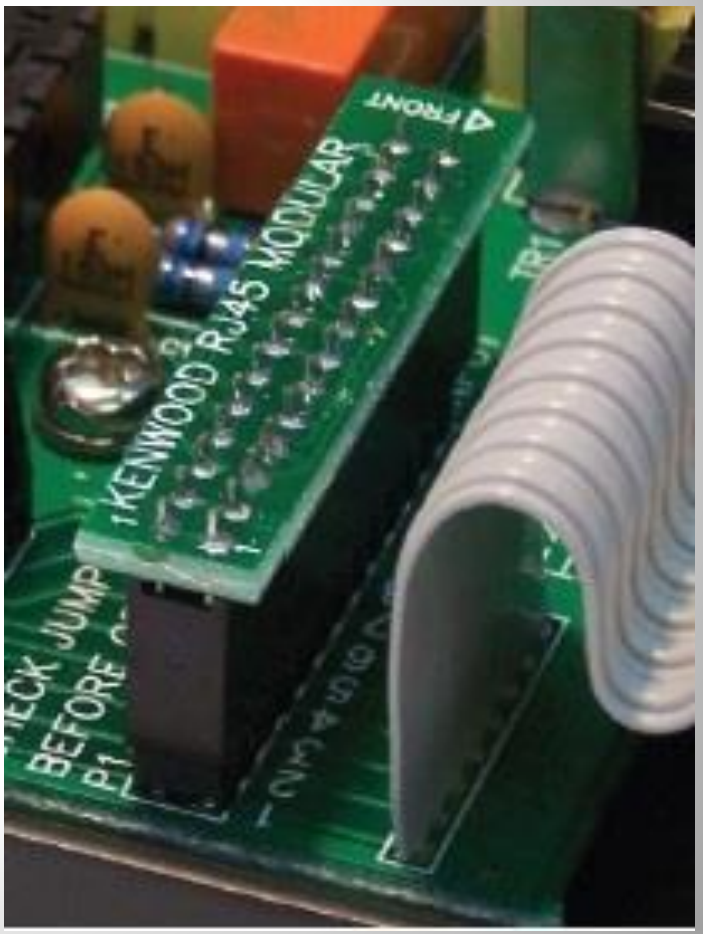
USB or Serial RS232 Com Port
CAT (rig control)
CW keying or FSK keying for RTTY
LINE in (receive audio)
PTT (external switch) and MIC (to radio's MIC jack)

Rigblaster

Unique wiring pattern for each radio cable

plug in jumper blocks make connections easy

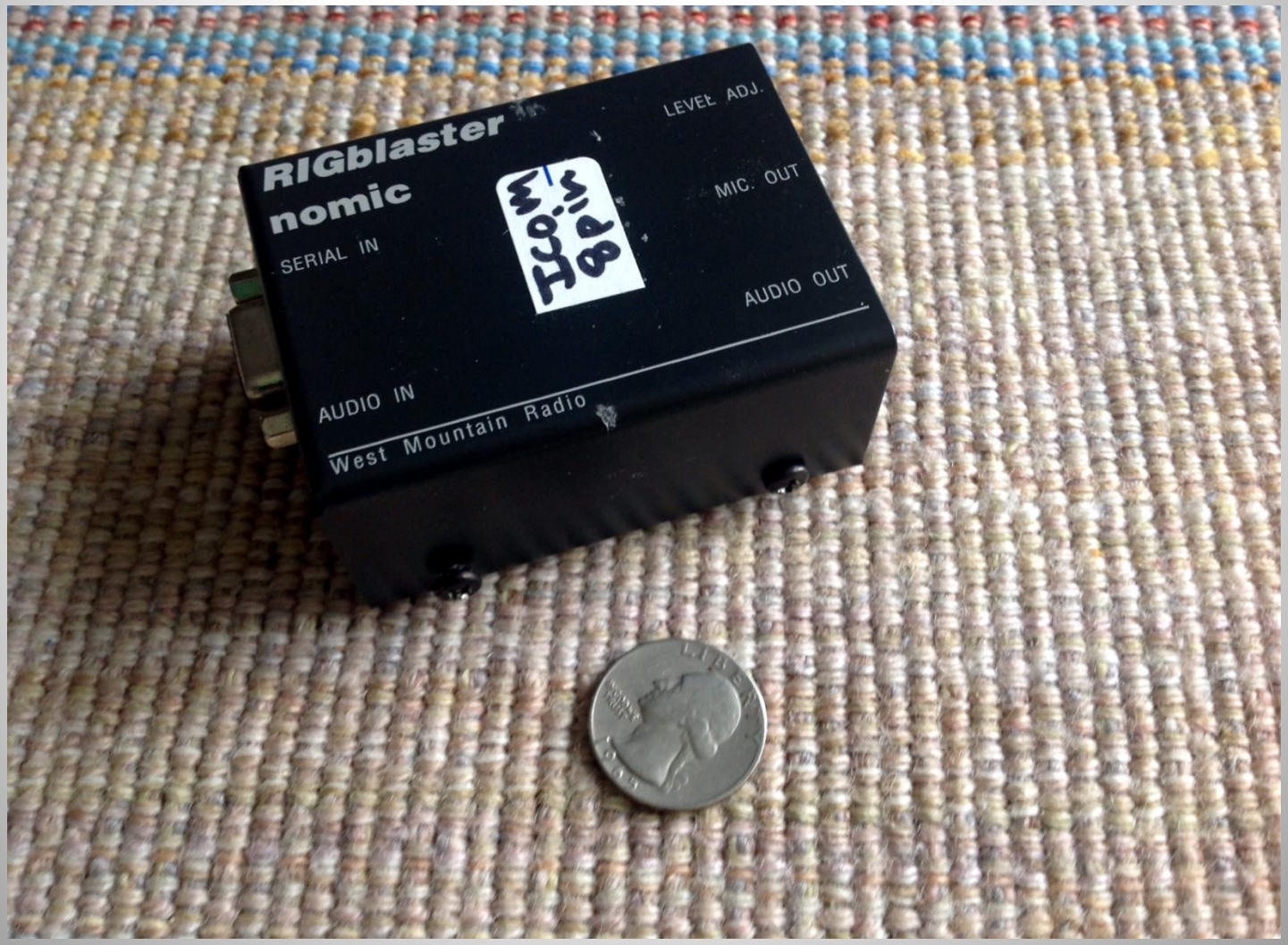




shielded audio style cable
3-conductor cable for Icom's CI-V CAT control
optional for "rig control" by computer app

Rigblaster "NOMIC" (no sound card)

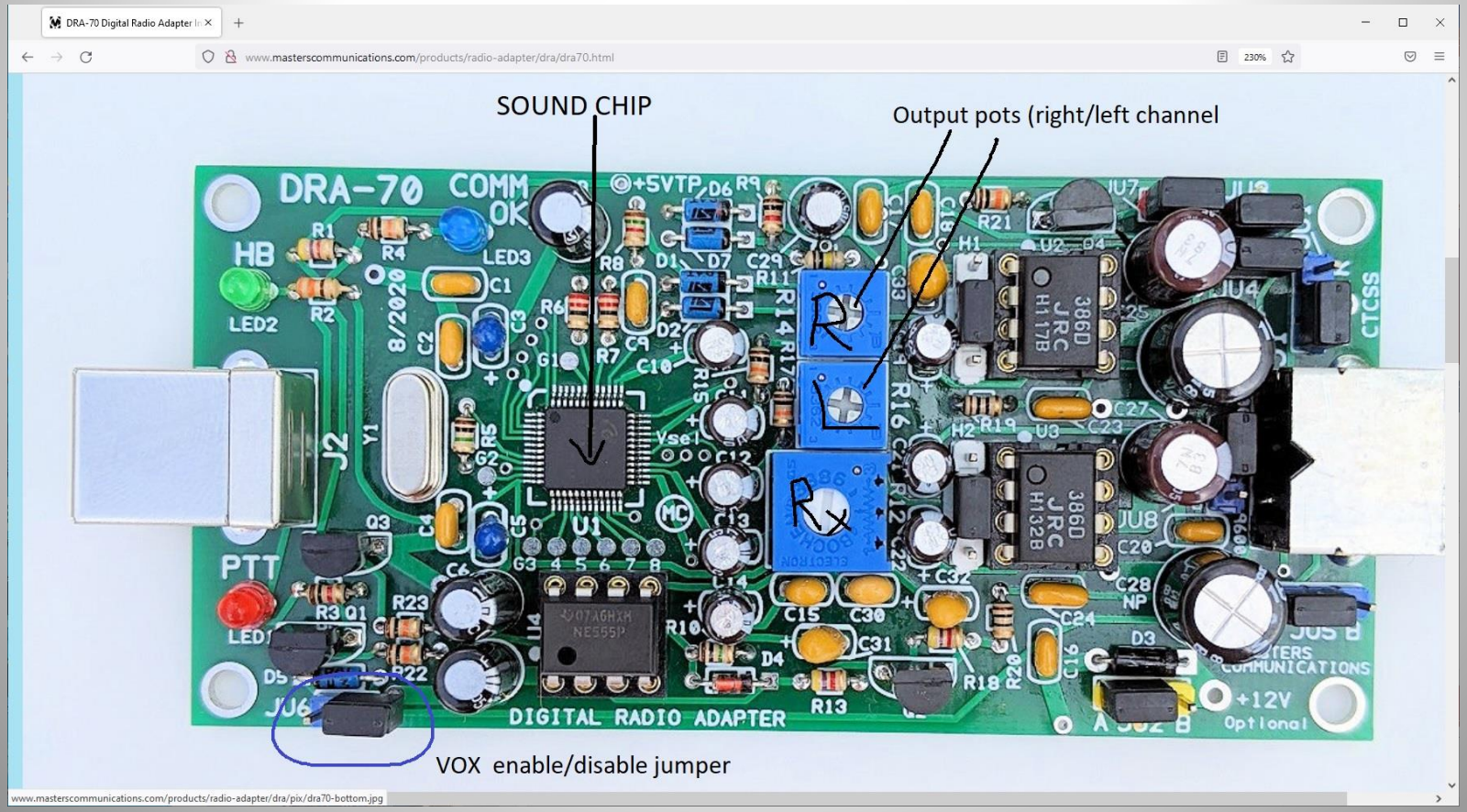
conditions Tx audio and PTT via serial COM port
(you still need a sound-card)



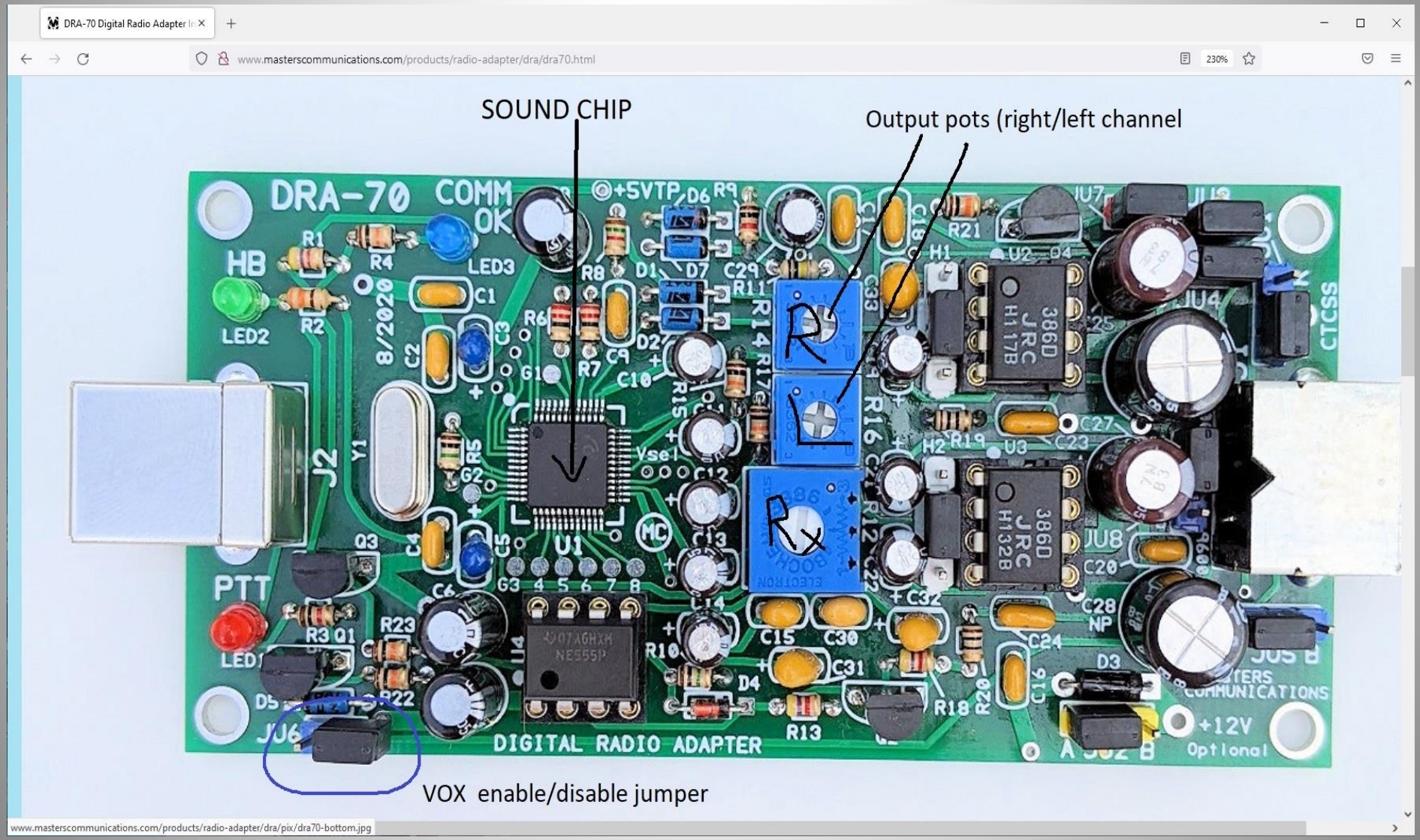
External USB Sound Blaster (low noise, high quality)
need audio cables to fit YOUR rig (Tx/PTT /Rx)

DRA70 sound card – Masters Communications

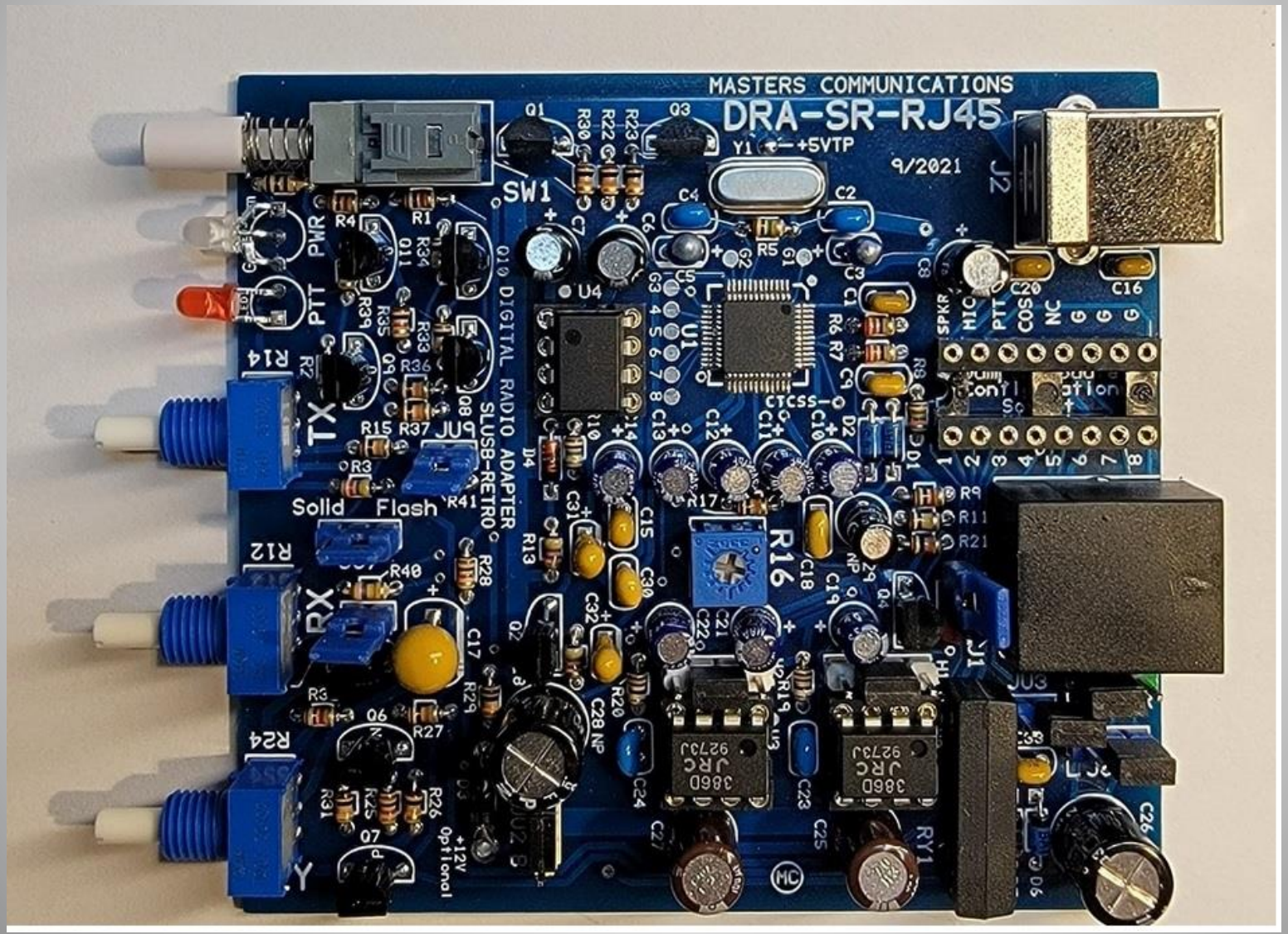
Left and Right Tx channels (small blue potentiometers)
wide bandwidth >10 kHz - no transformers
software asserted PTT by GPIO or VOX (L/R)
narrow and wide bandwidth modes (VARA FM wide)
plenty of power output with LM386 amplifiers on both L/R
USB to computer - 6 pin MINI-DIN to radio

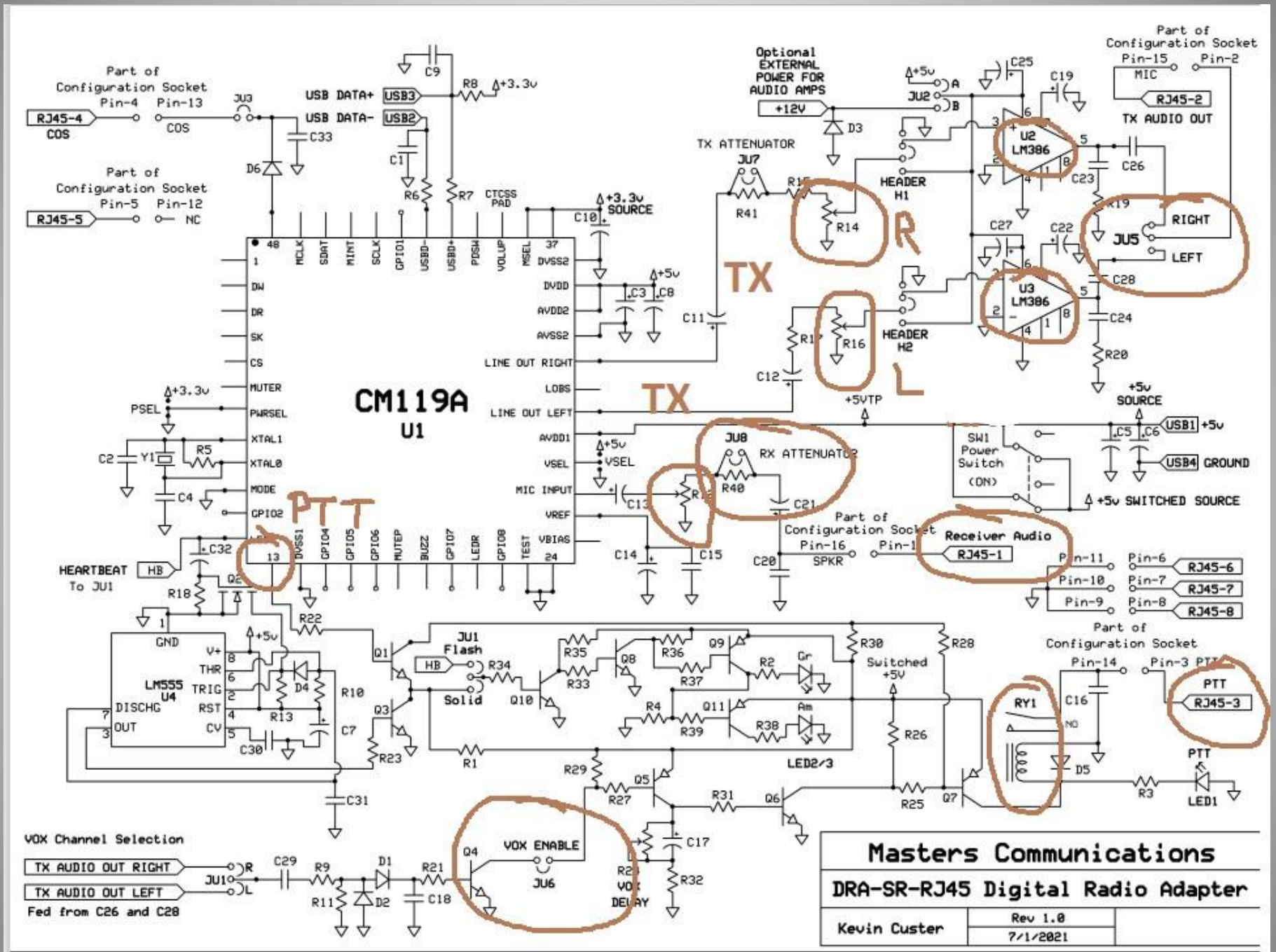


Left and Right Channel VOX enable/disable

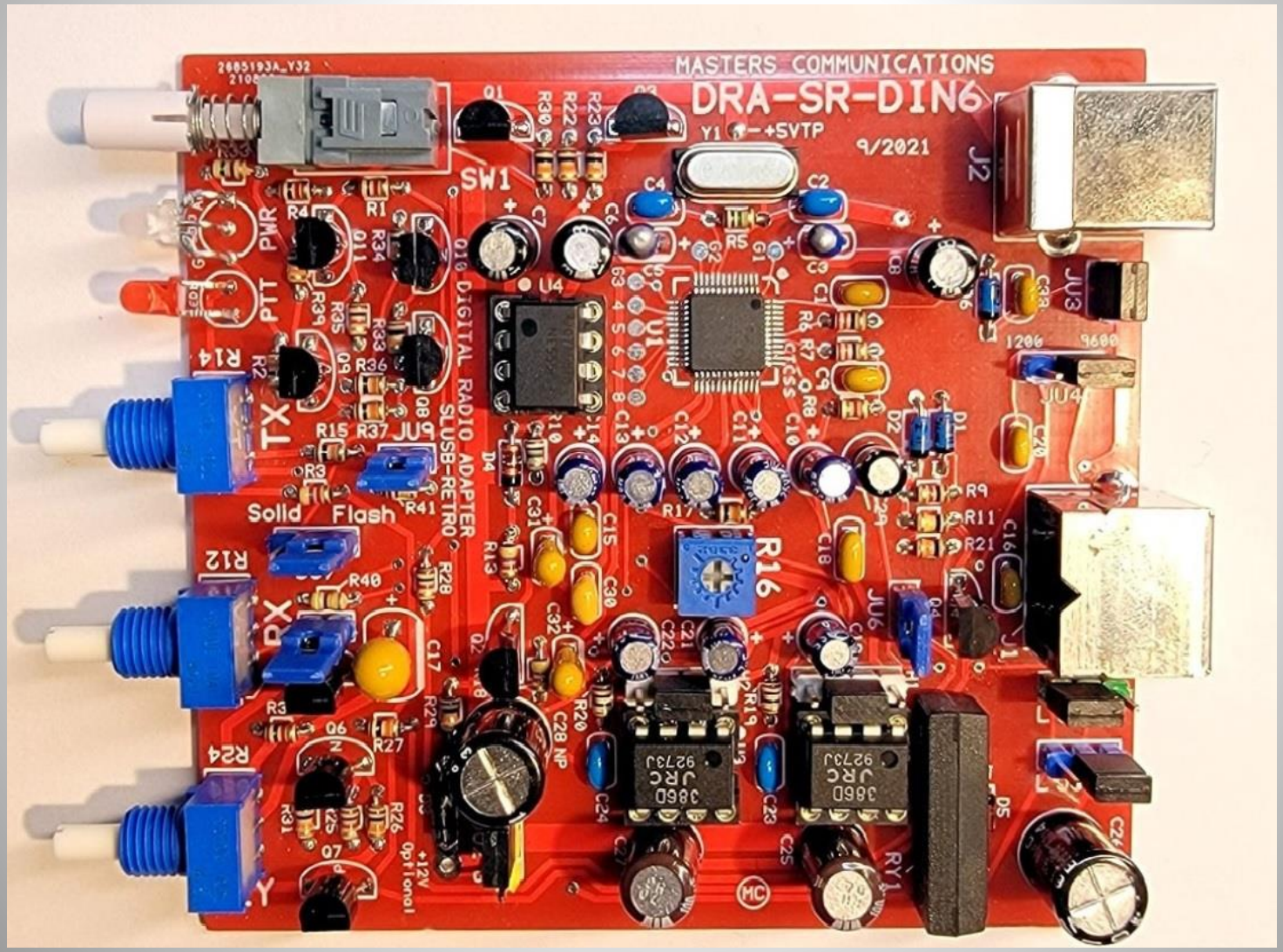


DRA SR RJ45 output socket
fits in SignaLink Box




CM119A
U1
Masters Communications
DRA-SR-RJ45 Digital Radio Adapter
Kevin Custer
Rev 1.0
7/1/2021
PTT
TX
R
L
Part of Configuration Socket
Pin-4 Pin-13
RJ45-4
COS
Part of Configuration Socket
Pin-5 Pin-12
RJ45-5
NC
USB DATA+
USB DATA-
USB3
USB2
+3.3v SOURCE
Optional EXTERNAL POWER FOR AUDIO AMPS
+12V
+5v SOURCE
+5VTP
TX ATTENUATOR
JU7
HEADER H1
HEADER H2
U2 LM386
U3 LM386
JU5
RIGHT
LEFT
Part of Configuration Socket
Pin-15 Pin-2
MIC
RJ45-2
TX AUDIO OUT
JU8
RX ATTENUATOR
SW1 Power Switch (ON)
USB1 +5v
USB4 GROUND
+5v SWITCHED SOURCE
Part of Configuration Socket
Pin-16 Pin-1
SPKR
Receiver Audio
RJ45-1
RJ45-6
RJ45-7
RJ45-8
HEARTBEAT
To JU1
HB
LM555 U4
JU1 Flash
Solid
Switched +5v
LED2/3
RY1
PTT
RJ45-3
LED1
VOX Channel Selection
TX AUDIO OUT RIGHT
TX AUDIO OUT LEFT
Fed from C26 and C28
VOX ENABLE
JU6
VOX DELAY

DRA SR with MINI DIN socket to radio



Other popular sound cards

MINIMUM method: shielded cable with TX and RX audio
1:1 isolation transformers

Many modern rigs have built-in sound cards