Overview of NBEMS modes using FLDIGI

K3EUI Barry

Overview

K3EUI - "know your subject/subjects"

Digi Modes - can you identify them by sound

Hardware needed to receive / transmit

Modulation basics: AM, FM, PM

Bandwidth vs. Speed (baud, symbols,tones)

Software: FLDIGI, FLMSG, FLAMP

Quiz - yes

Setup your laptop

Digital Modes: What are They?

Modulation - adds information or content to a radio frequency (RF) electromagnetic wave by altering the amplitude, frequency, or phase of the radio's wave

Binary information - analog vs. digital ?

Is CW a "digital" mode?

Can CW (on/off keying) be sent by a computer which determines when and for how long the "key" is down? If so, then is CW a "digital" mode?

Dot/dash ratio - commonly 3:1

Spaces between dots/dashes?

Spaces between characters?

Spaces between words?

Fahrnsworth spacing?

Hardware

Interface between computer and radio

Sound Card INPUT - from speaker/headphone
or DATA jack (constant vol)
Sound Card OUTPUT – to MIC or Data jack
PTT - usb/serial or VOX (SignaLink)
GND - common ground cable

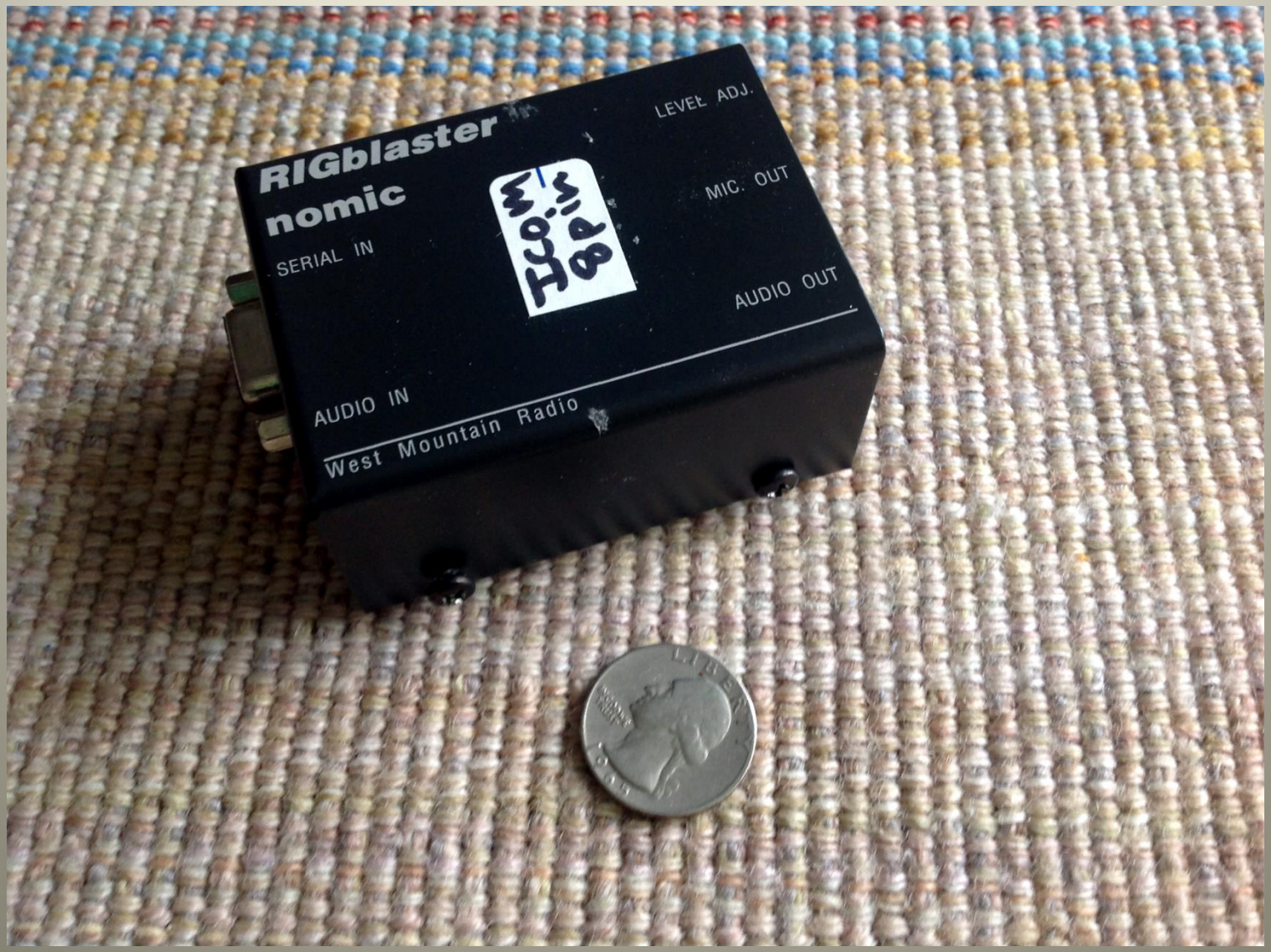
Goals: set proper RX and TX levels,
optical isolation of audio lines
avoid RF feedback

Tigertronics SignaLink (usb)

Rigblaster using sound chips in computer, PTT circuit

Rigblaster "Advantage" usb port with built-in sound card

Simple Rigblaster "NOMIC"



External USB Sound Blaster

Simple shielded cable with TX and RX audio via 1:1 isolation transformers

What is the “best” interface?

Answer

The one that works, has clean audio, is easy to set up and maintain, allows you to adjust the RX and TX audio, allows you to operate all digi modes, and is FREE.

Modulation Methods

What do AM and CW have in common?

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

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

Modulation Methods

What do
Clover, Pactor III and G-Tor
all have in common?

Emission Types

CW	A1A	on/off amplitude shift keying (ASK)
AM	A3E	voice, carrier plus both usb and lsb
SSB	J3E	voice, single sideband, suppressed carrier
SSB	J2D	data, multi-carrier (MT63)
FM	F3E	voice, frequency modulation
FM	F1B	data, frequency modulation (FSK RTTY)
FM	F2B	data, frequency modulation (AFSK RTTY)
PM	G3E	voice, phase modulation
PM	G1B	data, phase modulation (PSK)

Common Modes used with FLDIGI

CW	(on/off keying of a carrier)
RTTY	(two tone freq shift, 170 Hz, 45 baud)
PSK	(phase shifts, 180 degrees)
PSKR	(phase shift multi-carrier)
MFSK	(multiple tones, frequency shift)
Olivia	(multiple tones, frequency shift)
Thor	(multiple tones, frequency shift)
MT 63	(64 sub-carriers, 180 deg phase shift)
8PSK	(45 degree phase-shifts)

Baud and Symbol rates

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

More choices – is that better?

MFSK 16 has 16 possible "tones" or symbols, <u>sent one at a time</u>, so it has

$16 = 2^4 = \mathbf{4}$ **bits per symbol**

Can more information can be sent with 16 tones than with 2 tones …. ?

MFSK 32? MFSK 128?

How close can the tones be to each other?

CW at 24 wpm = 20 baud = 10 dit/sec
PSK31 = 31 baud = 50 wpm
PSK63 = 63 baud = 100 wpm
PSK125RC16 = 125 baud = 1760 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

Occupied Bandwidth

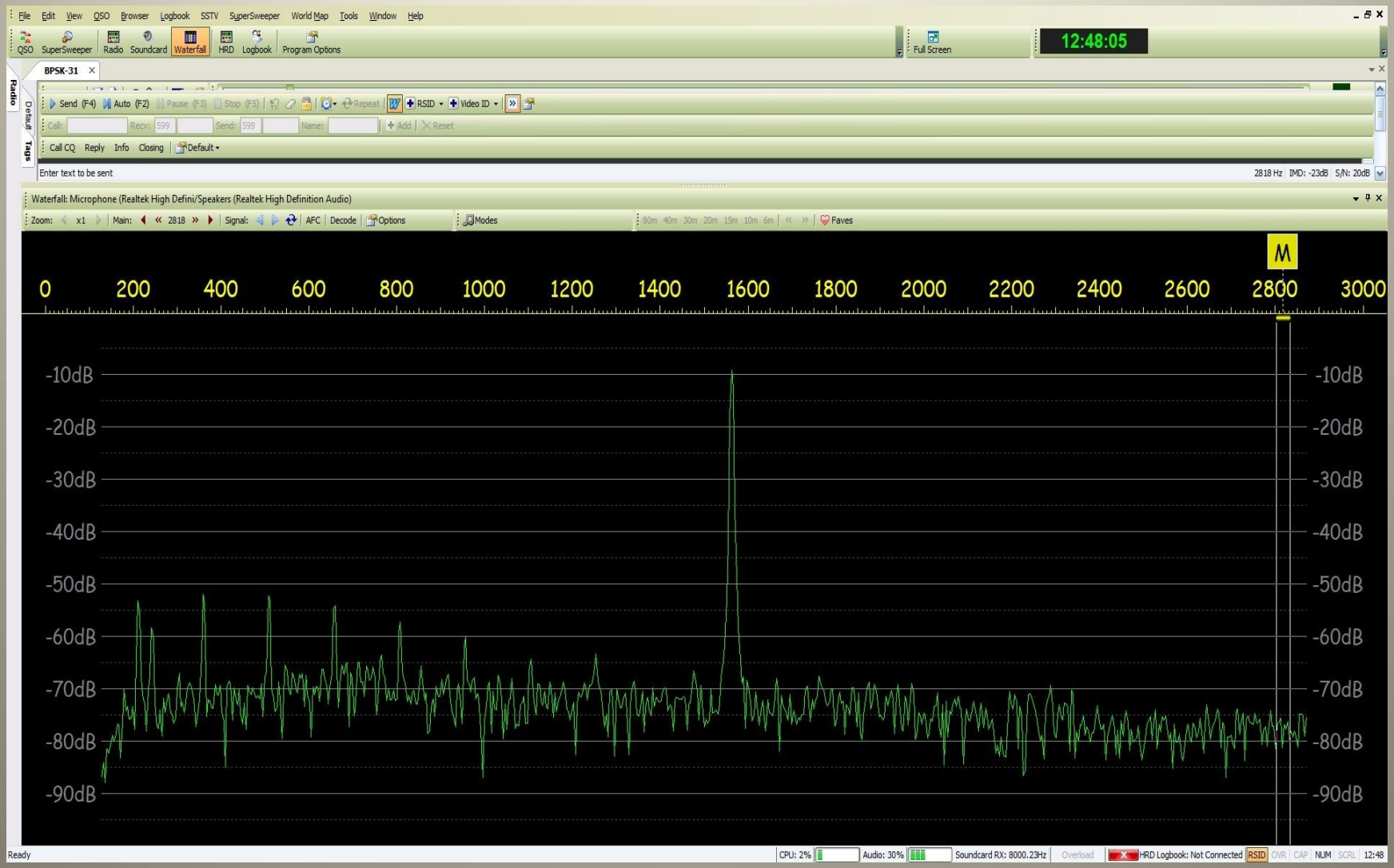
The spectra necessary to send each mode (containing 99% of the energy)

AM	=	6 kHz (double sideband)
SSB	=	3 kHz (often 2.4 or 2.2 kHz)
CW	=	100 - 200 Hz
PSK 31	=	31 Hz
Olivia 8/500	=	500 Hz
JT65	=	165 Hz
JT9	=	15 Hz

RF Carrier WAVE

What is the bandwidth of a CW signal, with the key held down continuously?

RF carrier with **no modulation** has a very narrow bandwidth



CW (Morse Code)

What is the bandwidth of a typical CW signal sent at 20 wpm speed?

CW Bandwidth

The bandwidth of any "keyed" CW signal is the equivalent bandwidth of an ON/OFF **AM** signal, including "**sidebands**".

CW is really an "amplitude shifted wave".

Question: how much time is required for the RF wave to go from zero amplitude to full amplitude or 100% power?

CW keying waveshape

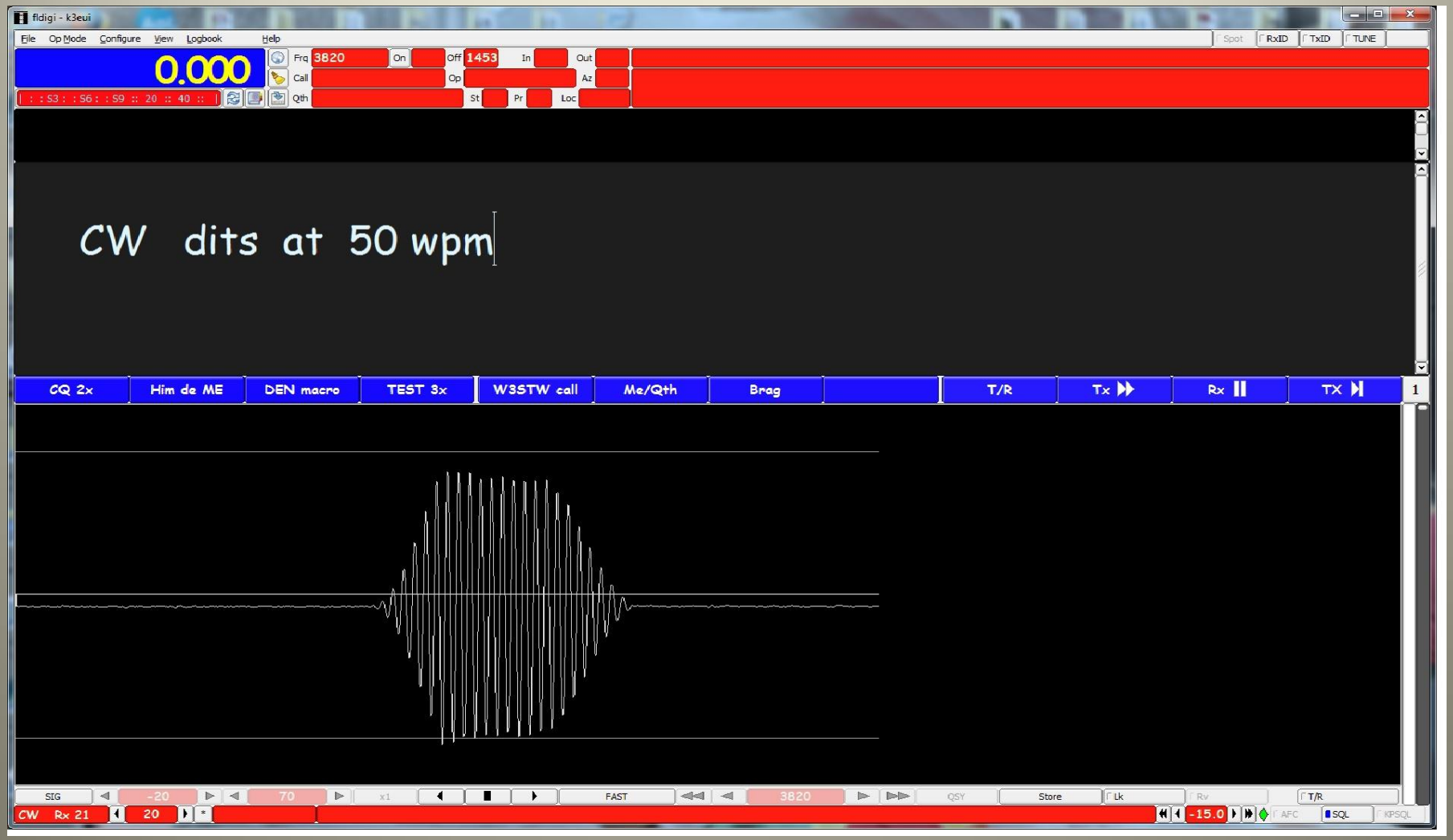
Turning on/off of an RF wave very quickly results in wider bandwidth and key "clicks" (harmonics) common in older rigs.

Turning on/off of an RF wave very slowly results in a narrow bandwidth but a "mushy" sounding signal which is hard to tell when it starts/stops, making copy very difficult

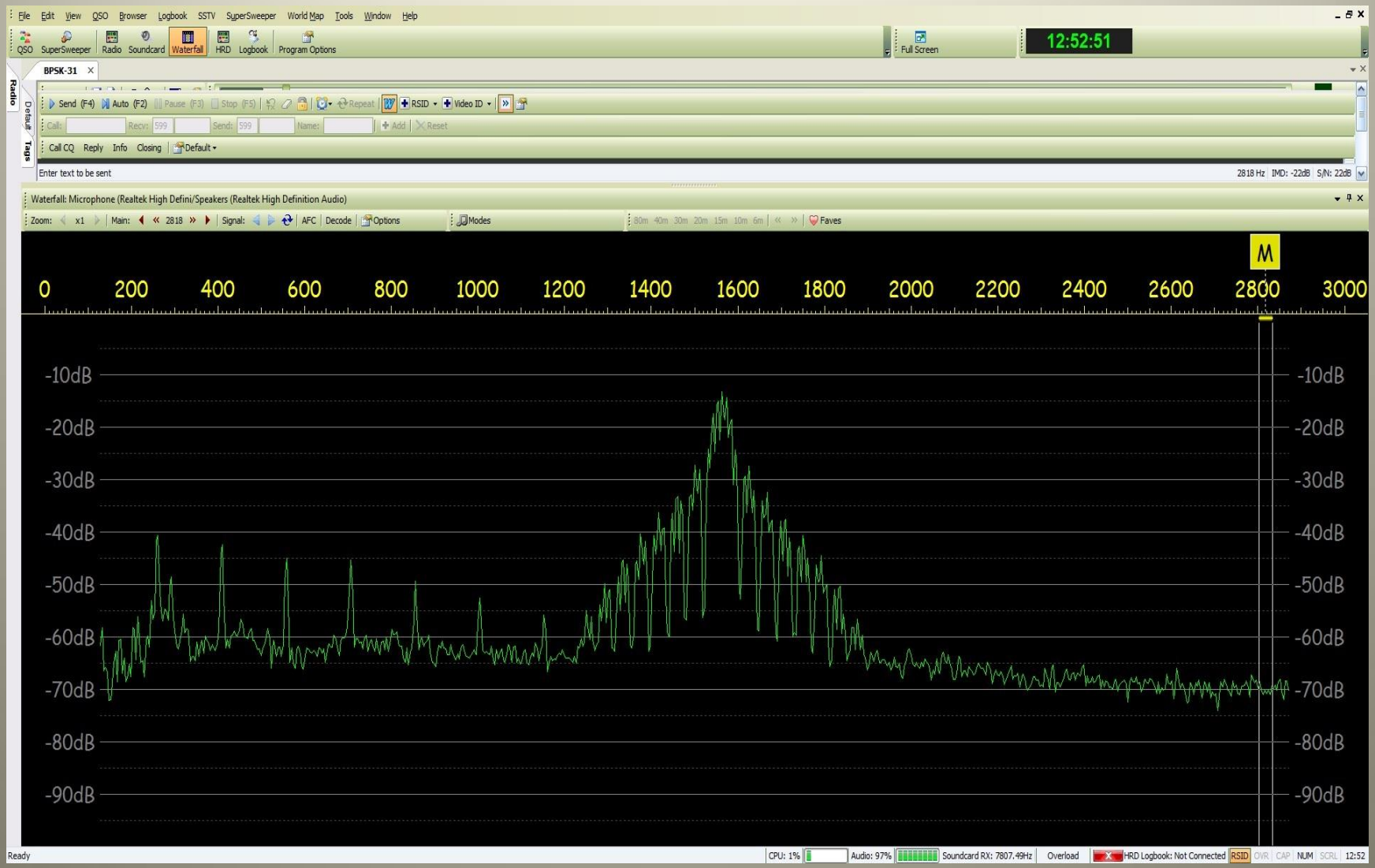
CW time plot of one "dit"

note the rise and fall times referred to as "shaping"

Amplitude (Y) vs. Time (X)



Bandwidth of a MCW signal (using HRD as a spectrum analyzer



QST display: CW keying bandwidth Kenwood TS 590 at 60 wpm

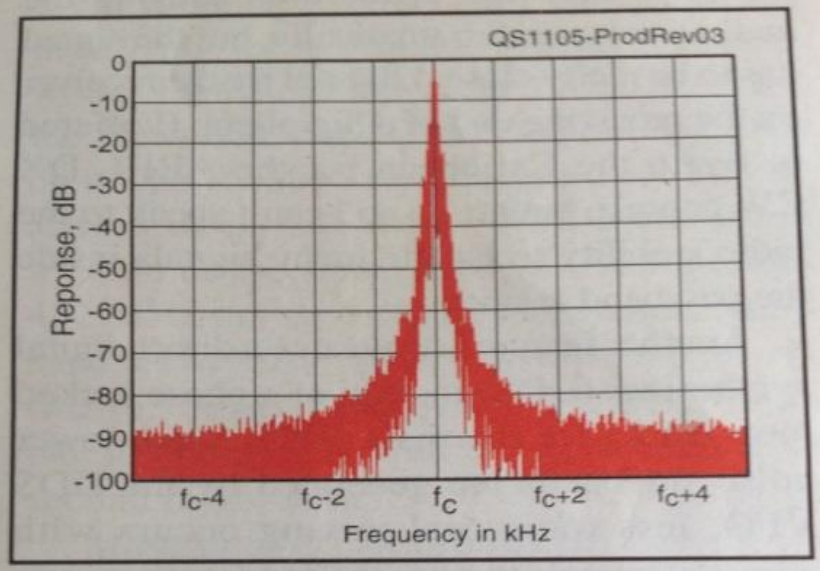


Figure 3 — Spectral display of the TS-590S transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 100 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

RTTY (Radio Teletype)

RTTY is an older form of modulation in which the 0's and 1's are transmitted on two different radio frequencies, often called the "**mark**" and "**space**" tones (170 Hz shift)

RTTY can be generated by shifting the VFO frequency (**FSK**) by data (F1B) or by shifting the audio frequency (**AFSK**) by sound card (F2B) in SSB mode

The results are (usually) identical.

RTTY basics

RTTY uses a BAUDOT code where each character (letter, number, printer code) is represented by a **5 digit code**, plus one start bit and one or two stop bits

2^5 = 32 different characters are possible with

LETTERS key and FIGURES key to switch between letters and numbers

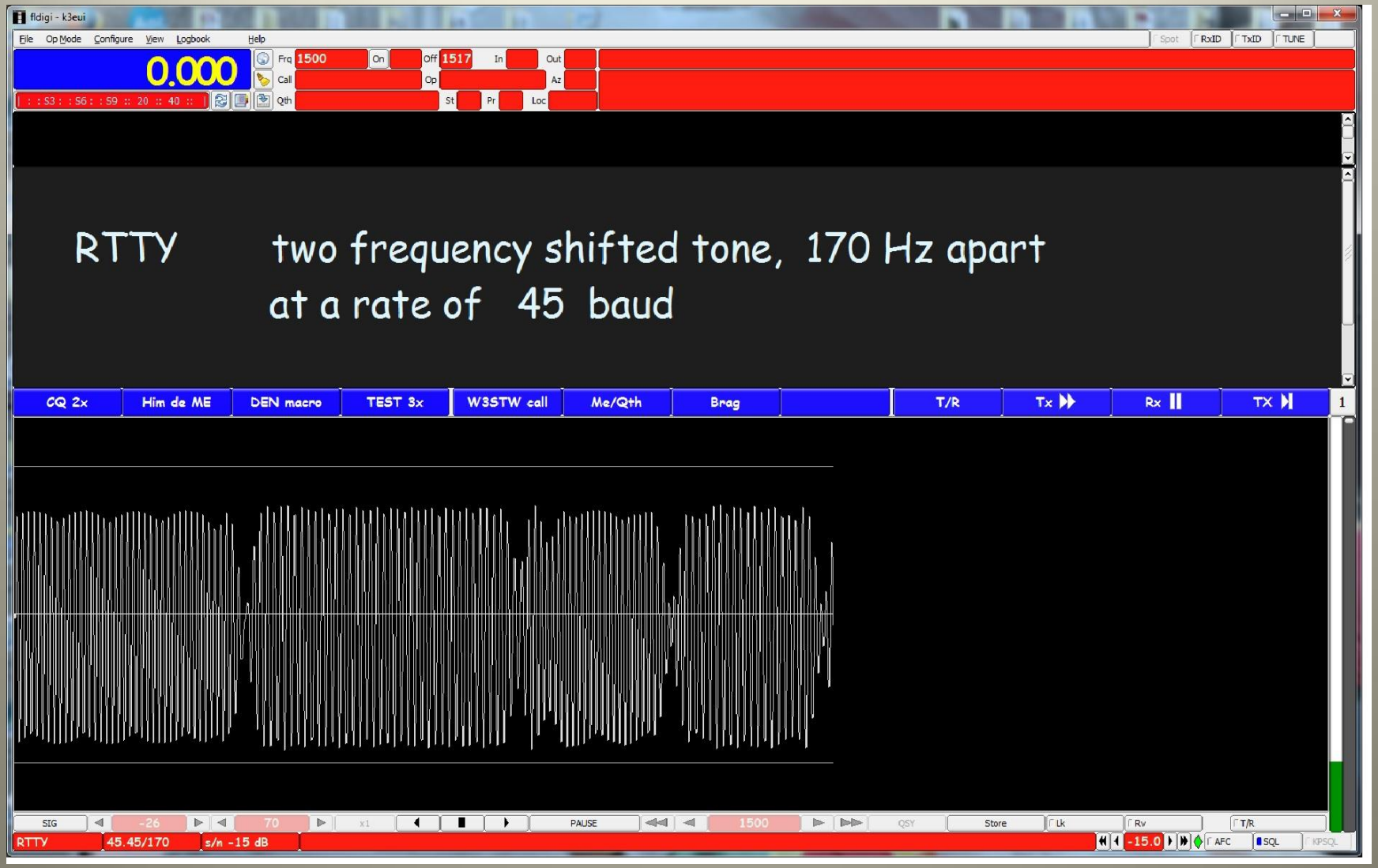
Limitations: UPPER case only, no error detection,

Used mostly now in contests

Has been replaced by BPSK31 for casual chats on HF

RTTY 45 time plot

22 milliseconds per individual tone = 45 baud



PHASE shifted signals

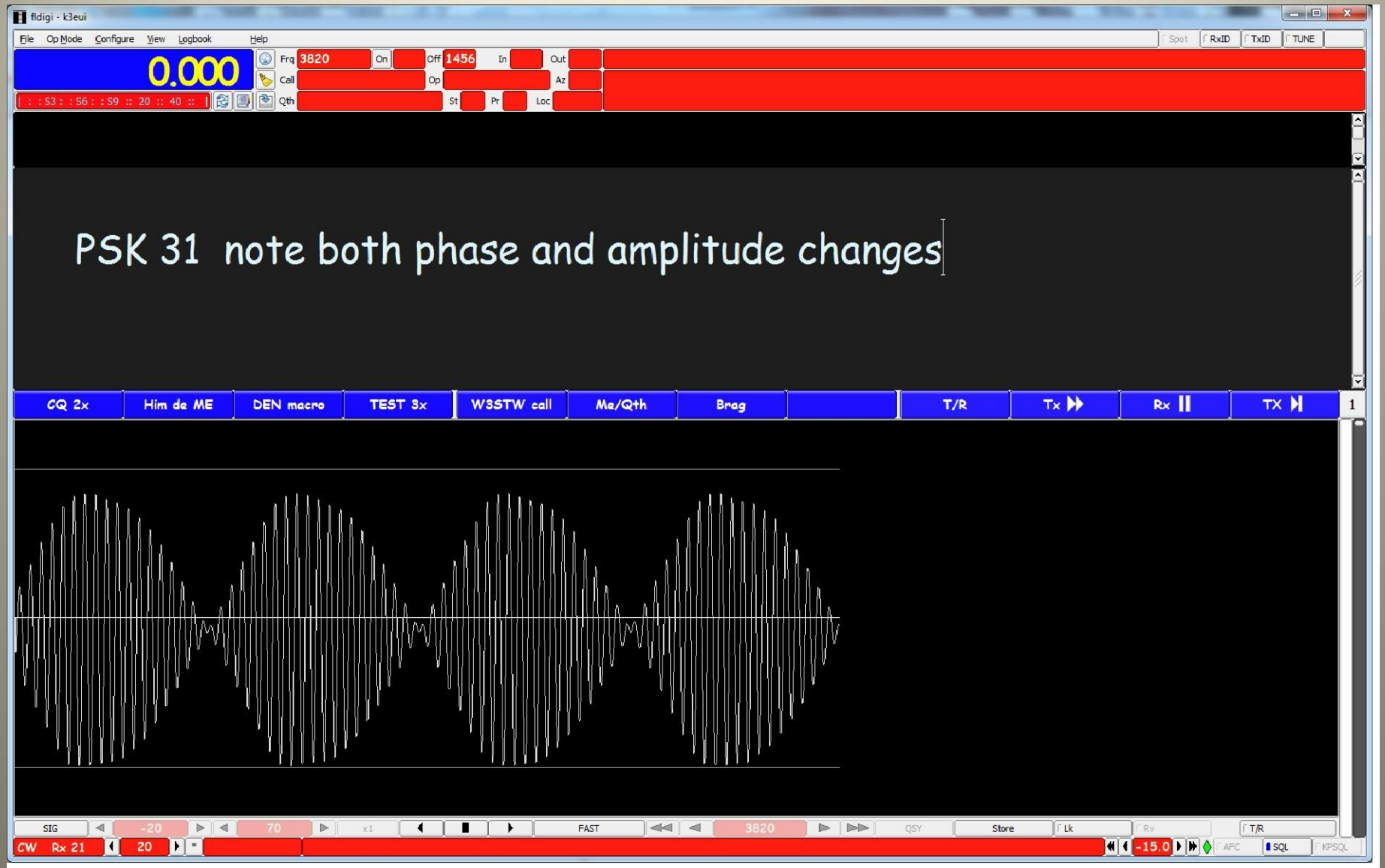
Another way of "modulating" a carrier is to shift the PHASE of the carrier to represent 0's and 1's

BPSK - **b**inary **p**hase **s**hifted **k**eying

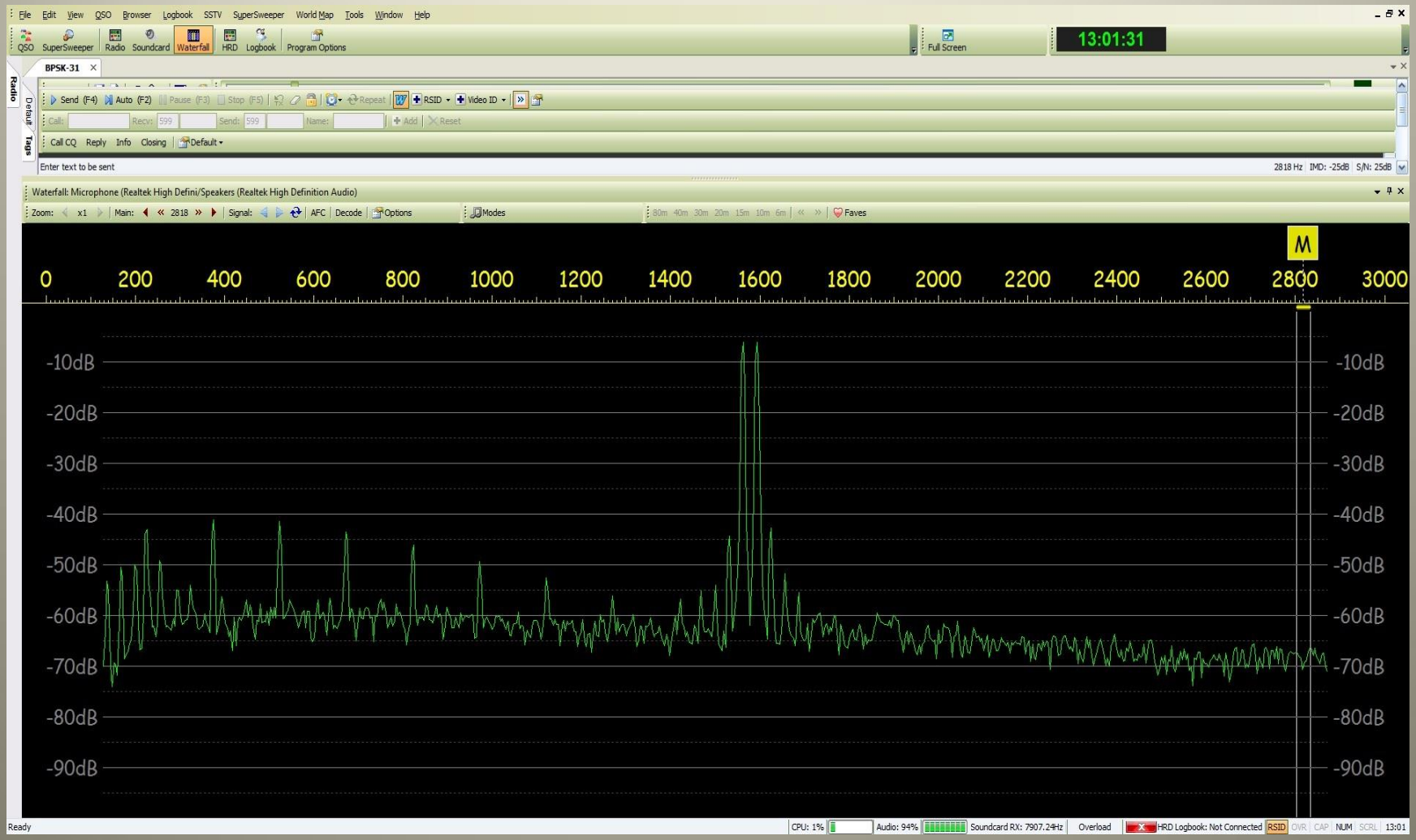
Or "Polarity Phase Shifted Keying"

- In BPSK the phase is shifted 0 or 180 degrees
- The phase shifts occur when the amplitude is zero

BPSK 31 time plot
phase shifts occur every 31 Hz in the "idle" signal

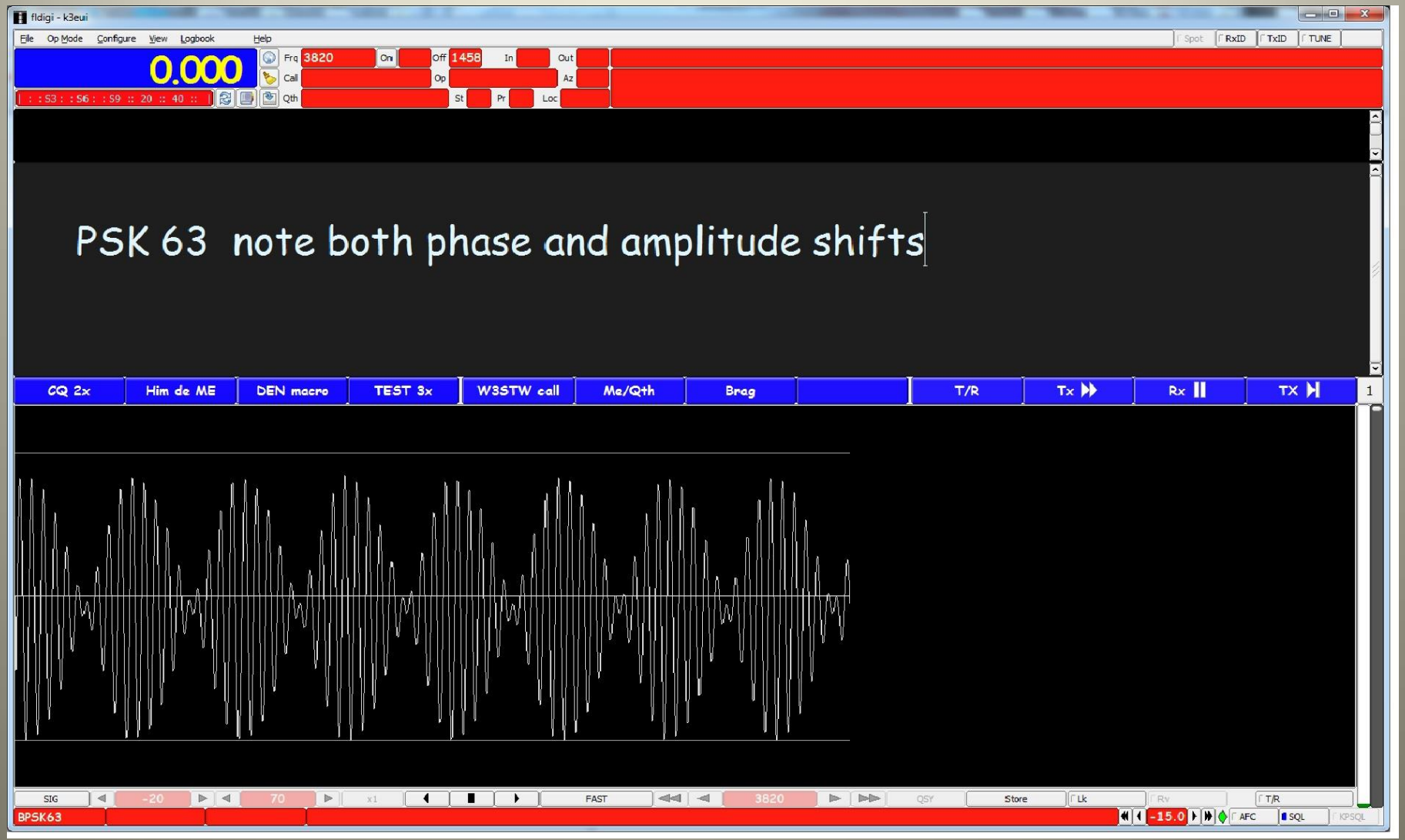


BPSK 31 frequency plot
(note the two sidebands above/below the main signal)
looks like a 2-tone SSB signal



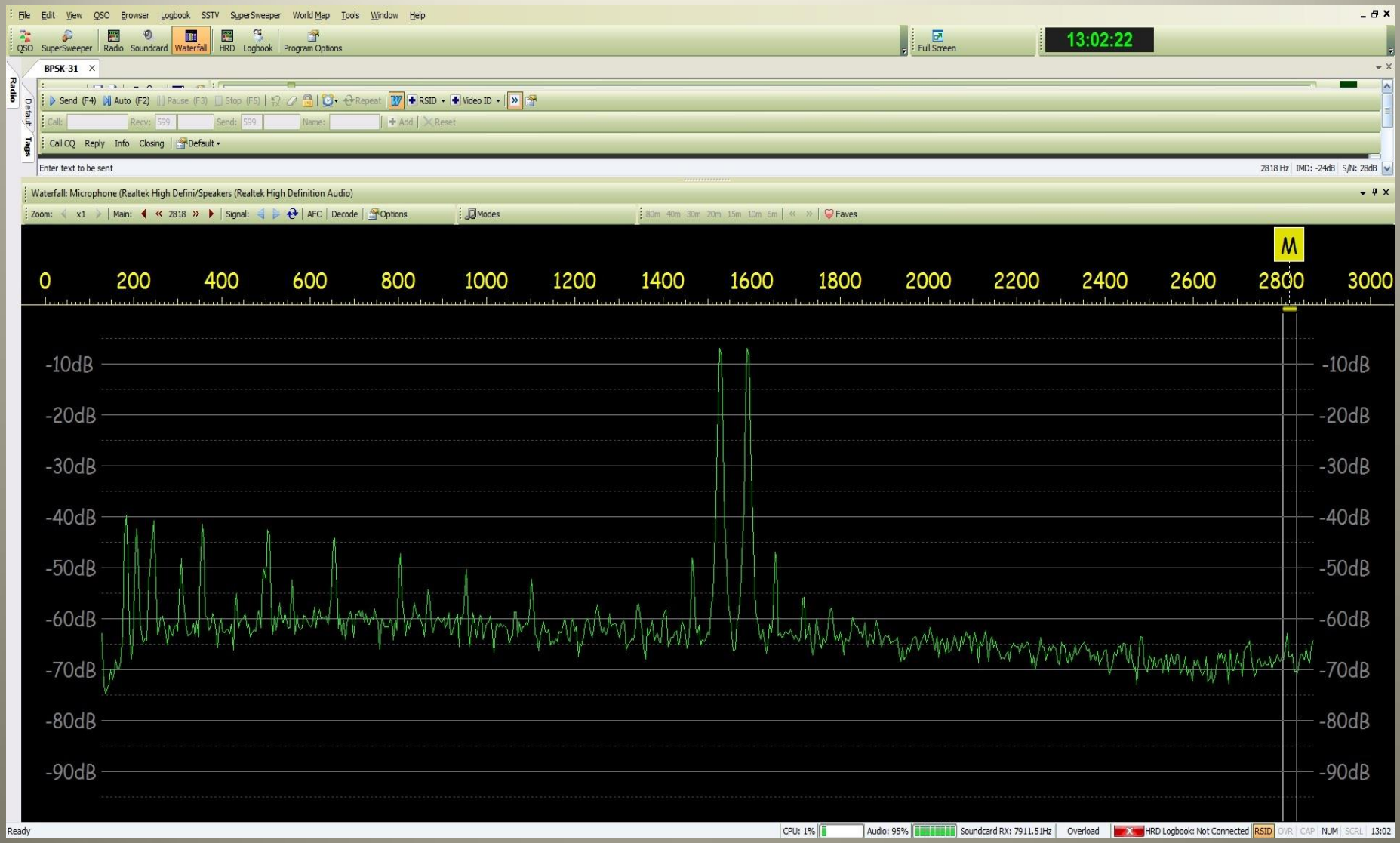
PSK 63 time plot

note more changes per second which results in a faster but wider signal

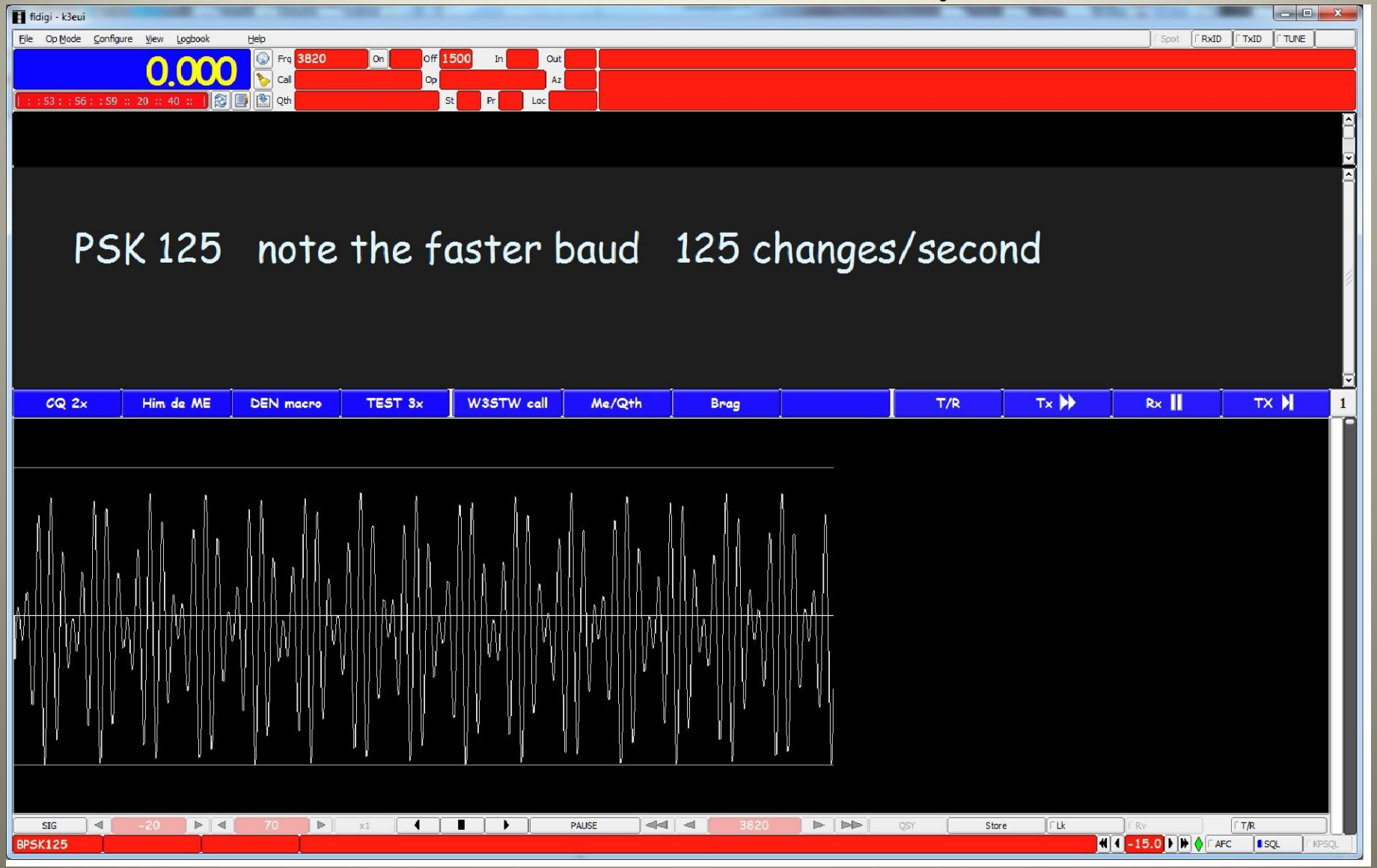


PSK 63 spectrum plot

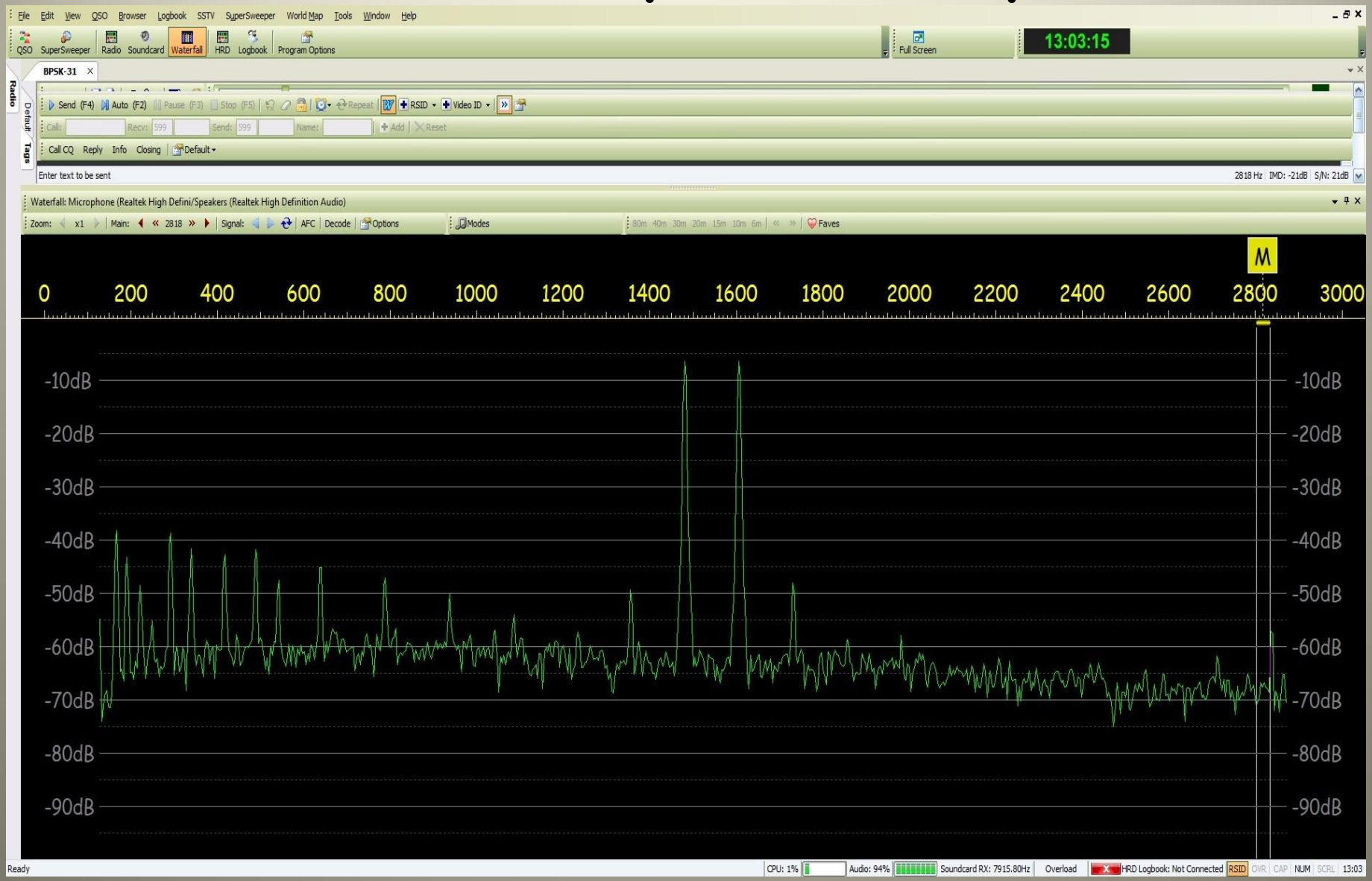
harmonics down -40 dB



PSK 125 time plot



PSK 125 spectrum plot



Multiple PSK subcarriers

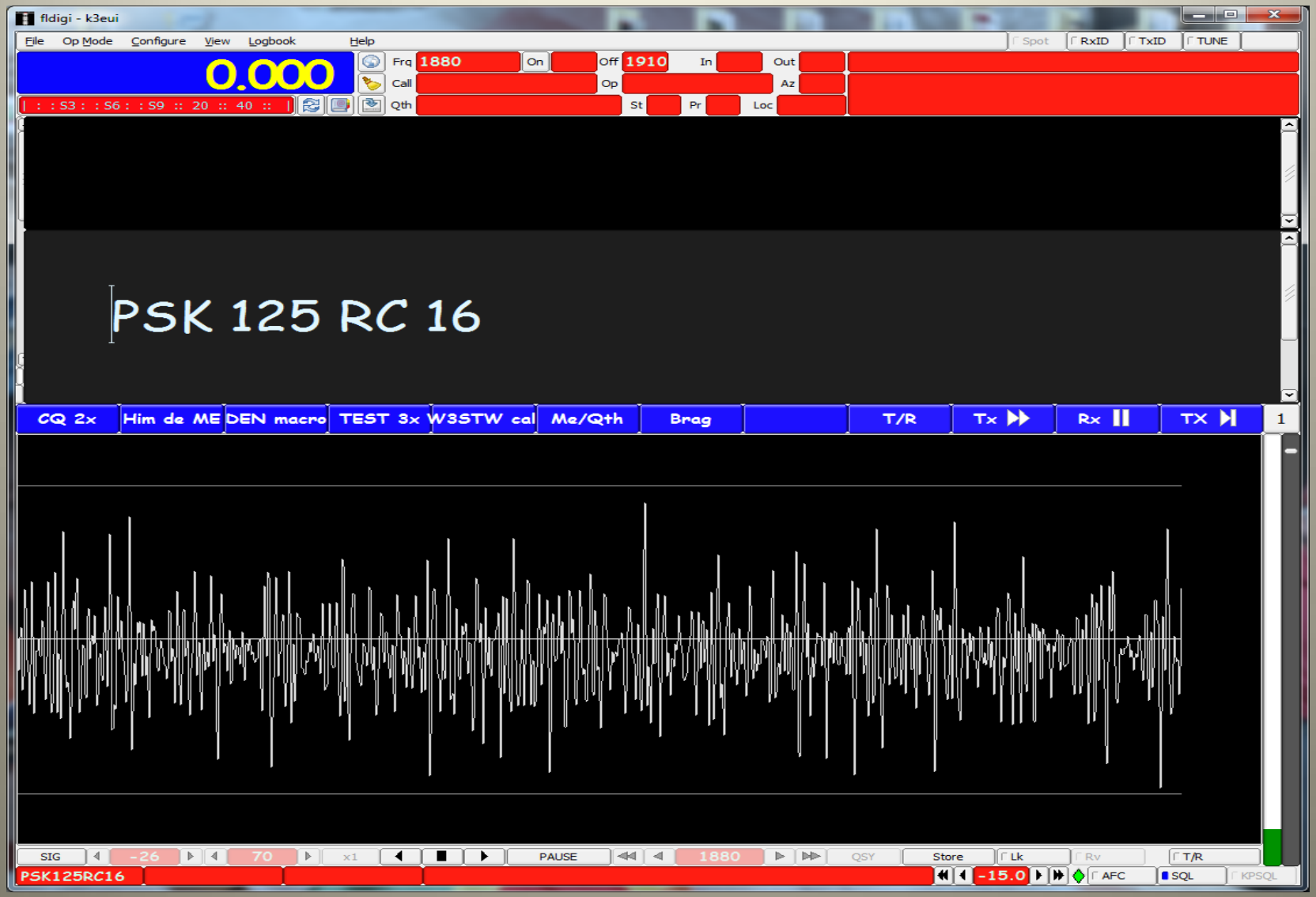
What would happen if we were to modulate **multiple** sub-carriers at once?

Each sub-carrier (a line on the waterfall) could be phase-shifted independently from its neighbor, but at a common baud

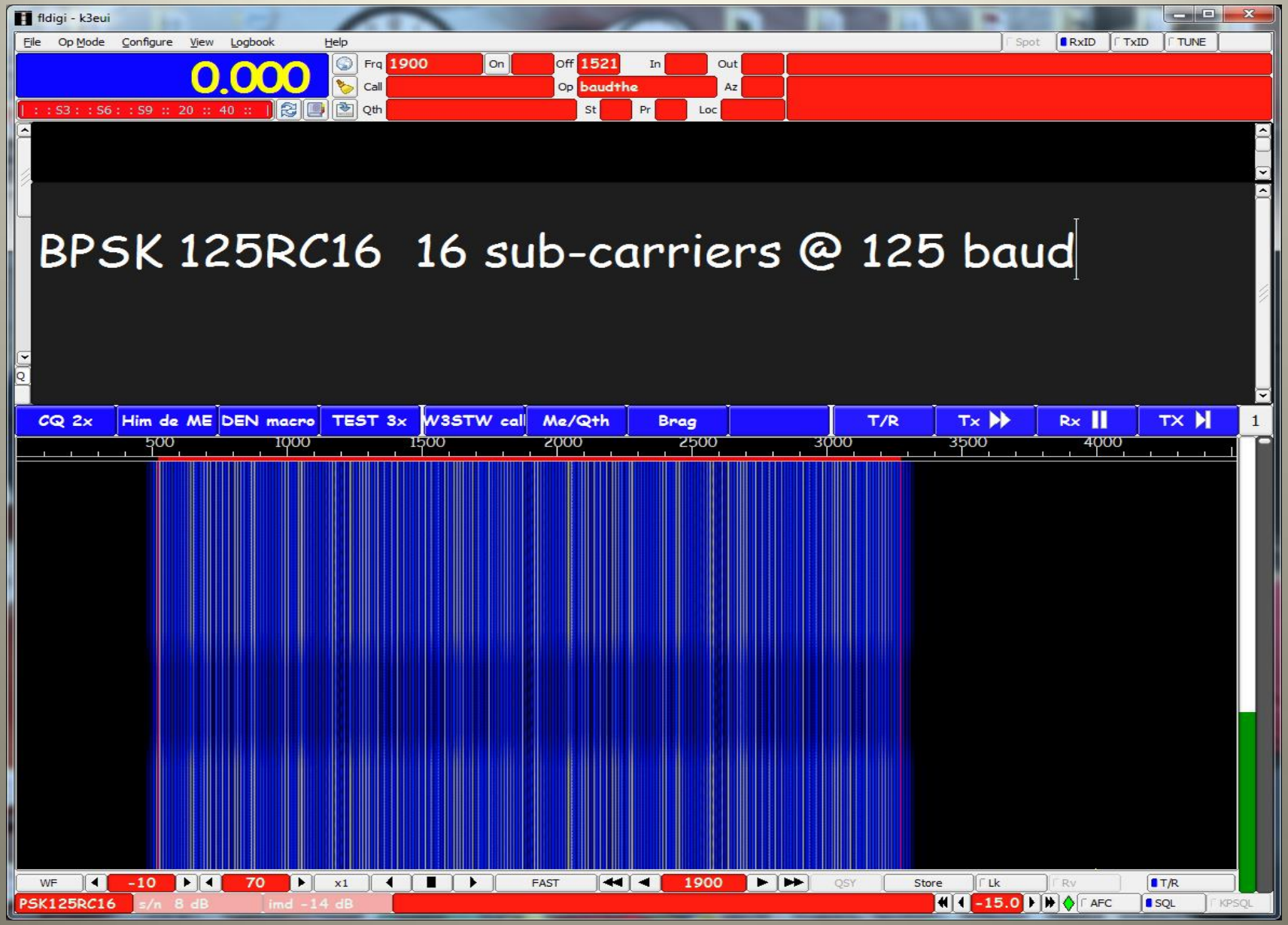
Thus, more information per second ….

PSK125RC16 time plot

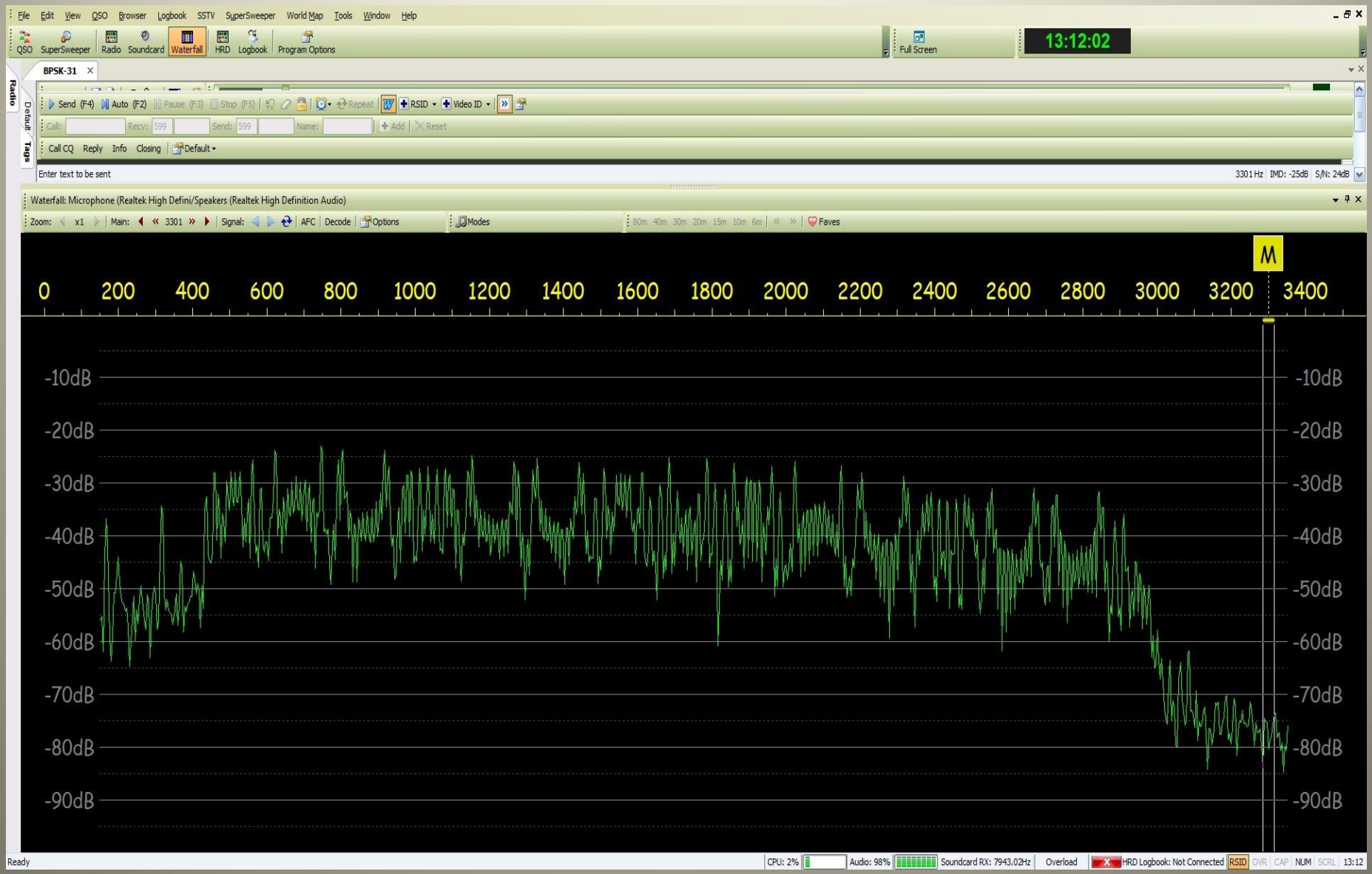
16 subcarriers, 125 baud each, 1760 wpm, 2750 Hz bandwidth
note the tremendous PEAK to AVERAGE signal amplitudes



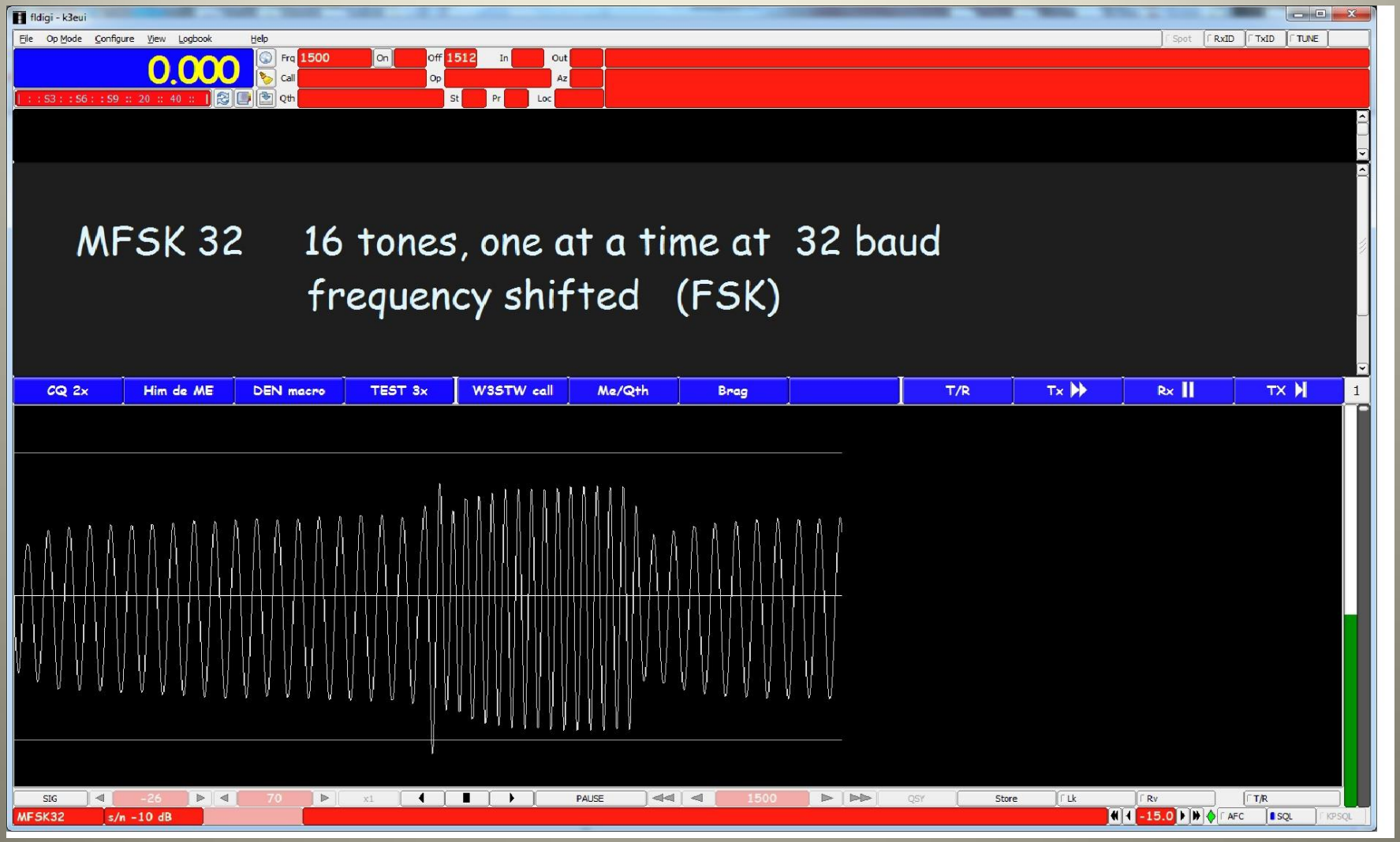
PSK125RC16 waterfall display



PSK125RC16 Spectrum
16 subcarriers 1760 wpm
bandwidth 2750 Hz



MFSK 32 time plot
Is there safety in numbers?



Multiple Frequency Shifts

RTTY is a TWO-FREQUENCY wave

What would happen if we could shift the frequency of the wave by 8 or 16 values?

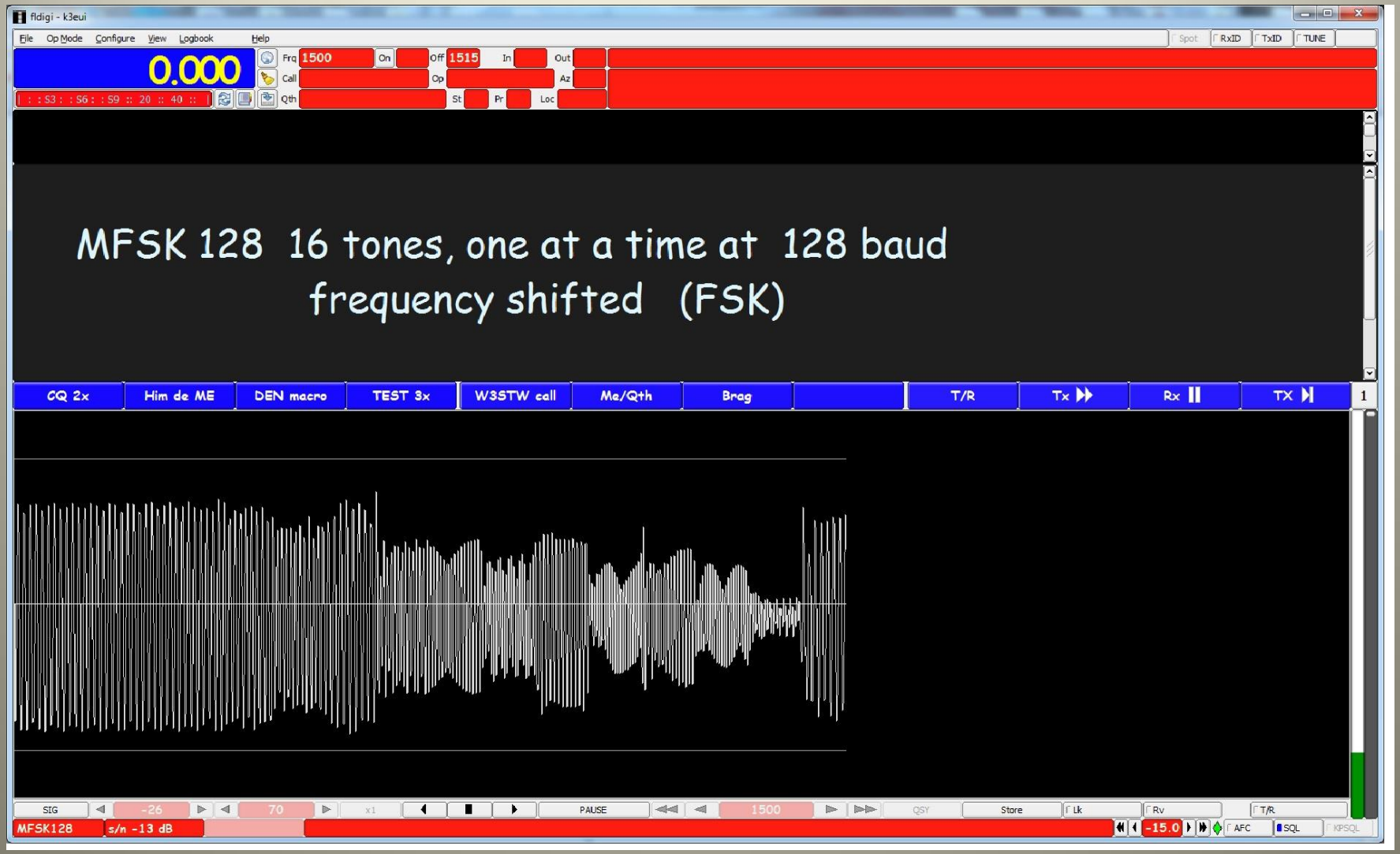
Each shift could contain more information

MFSK 16 = 16 tones (one at a time)

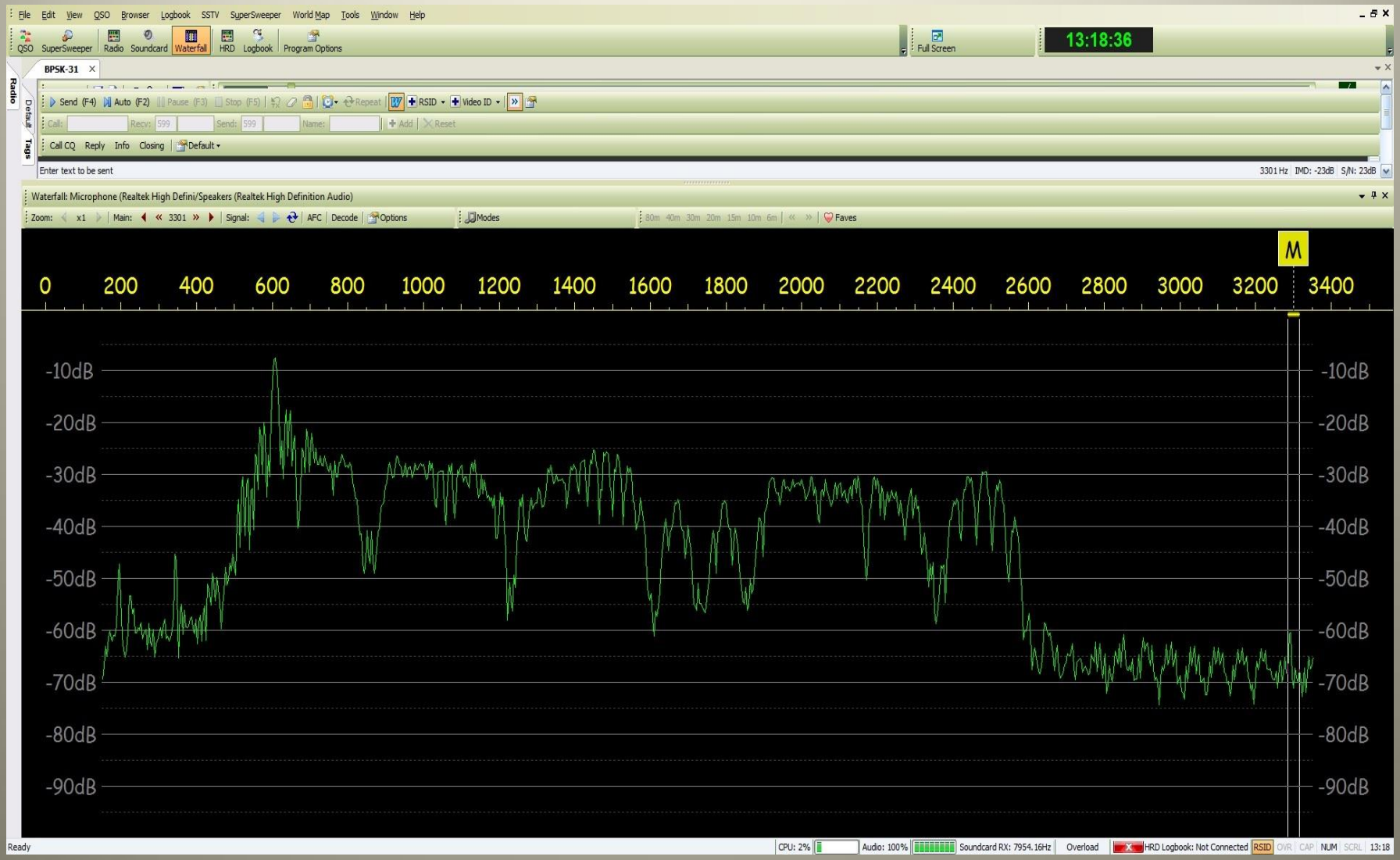
MFSK 8 = 32 tones (one at a time)

MFSK 32 frequency plot

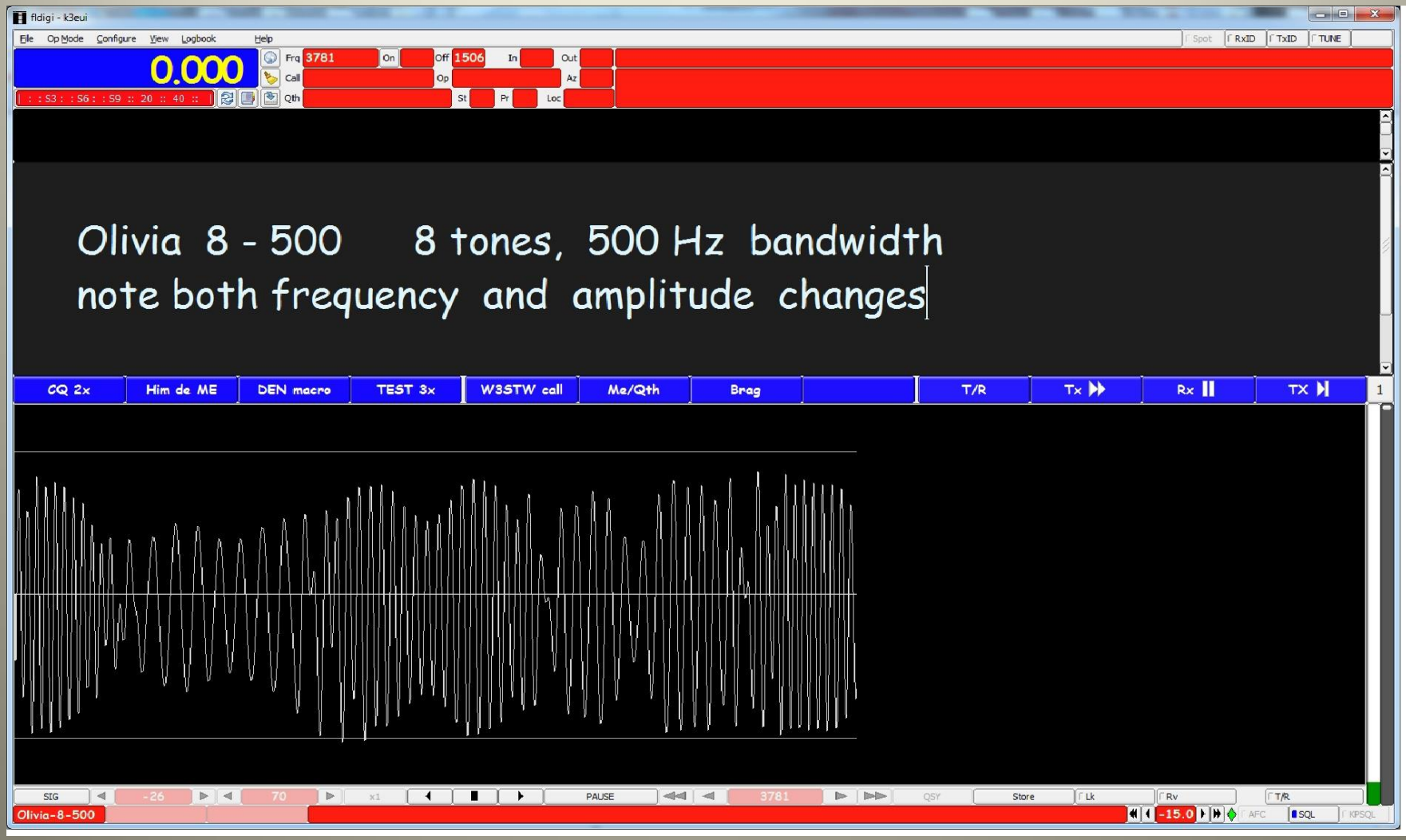
MFSK 128 time plot



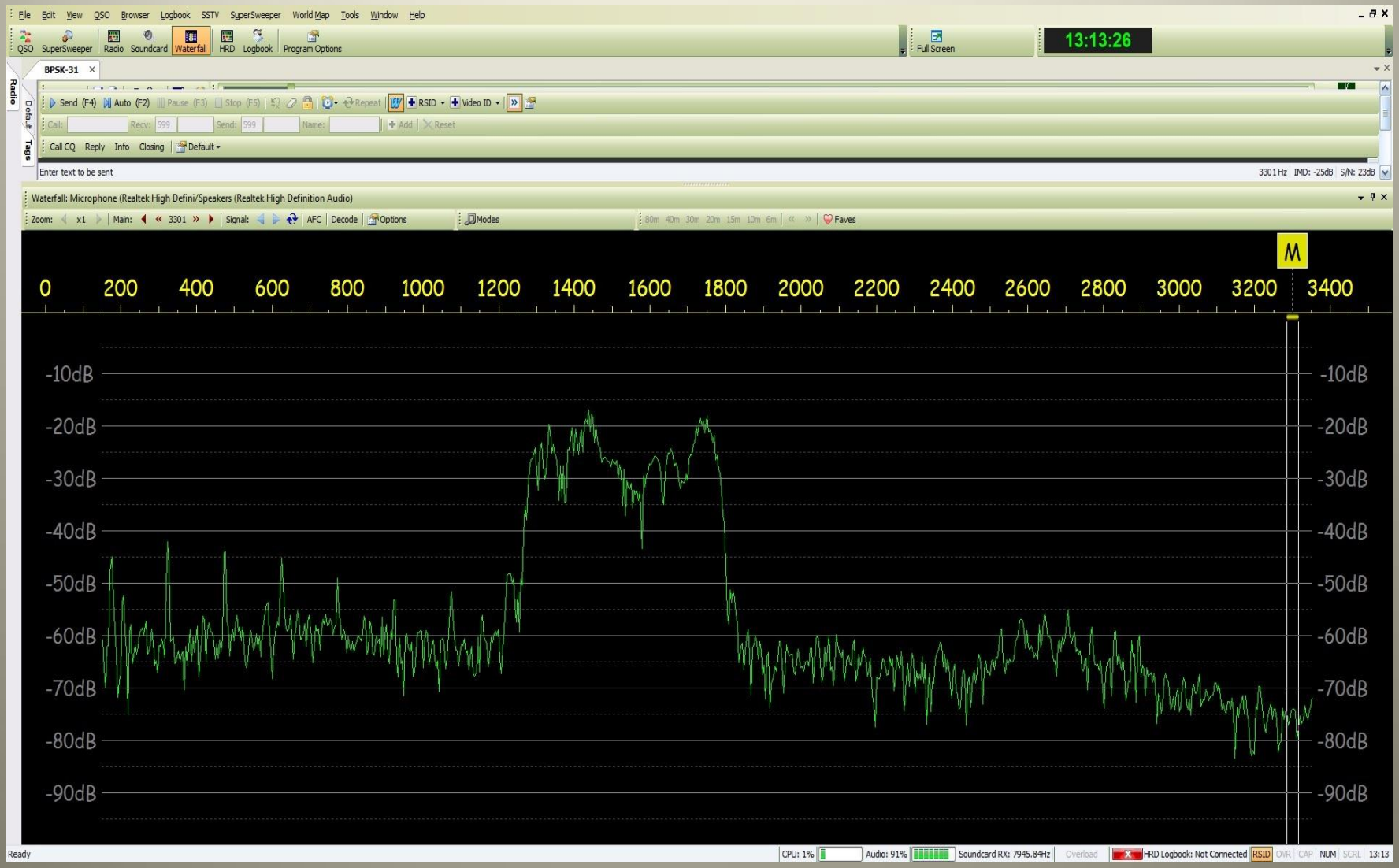
MFSK 128 frequency plot



Olivia 8/500 time plot
8 tones, one at a time
500 Hz, 63 baud = 30 wpm

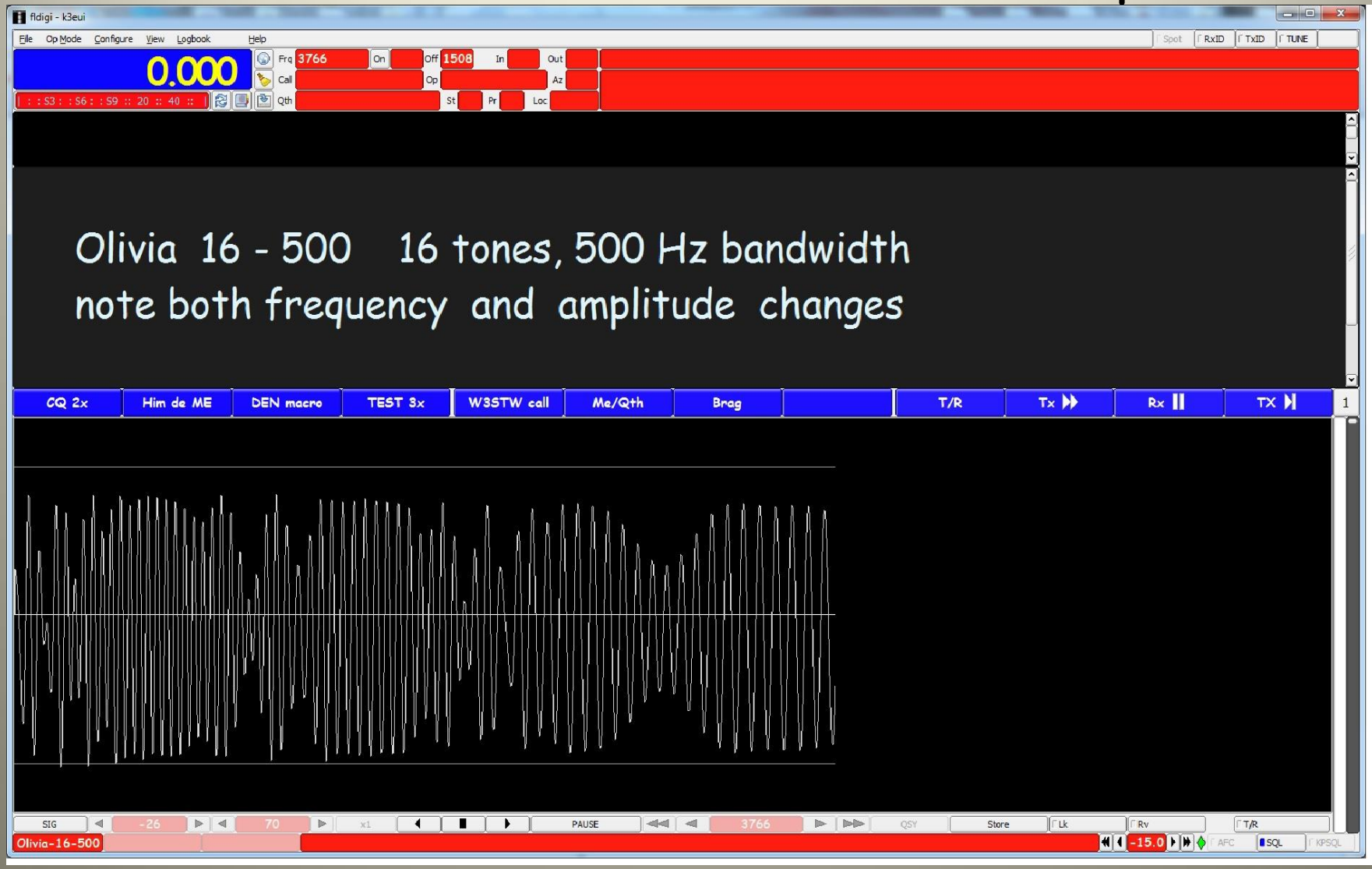


Olivia 8/500 spectrum



Olivia 16/500 time plot

16 tones, 500 Hz, 31 baud = 20 wpm



Olivia on 40 meters NBEMS

Olivia 8/500 is the most common mode now heard on the PA, NJ, NY NBEMS nets on Saturday and Sunday mornings

Listen or check in: 1500 Hz waterfall

7036 kHz (NY) Saturday at 10 am

7072.5 kHz (NJ) Sunday 9:30

(PA) Sunday 11:00 am

Olivia

Olivia has a forward error correction **FEC** which helps get correct copy

Very sensitive: S/N ratio of about -13 dB

Has a delay in characters appearing on your screen after you hear them

THOR and IFK shift

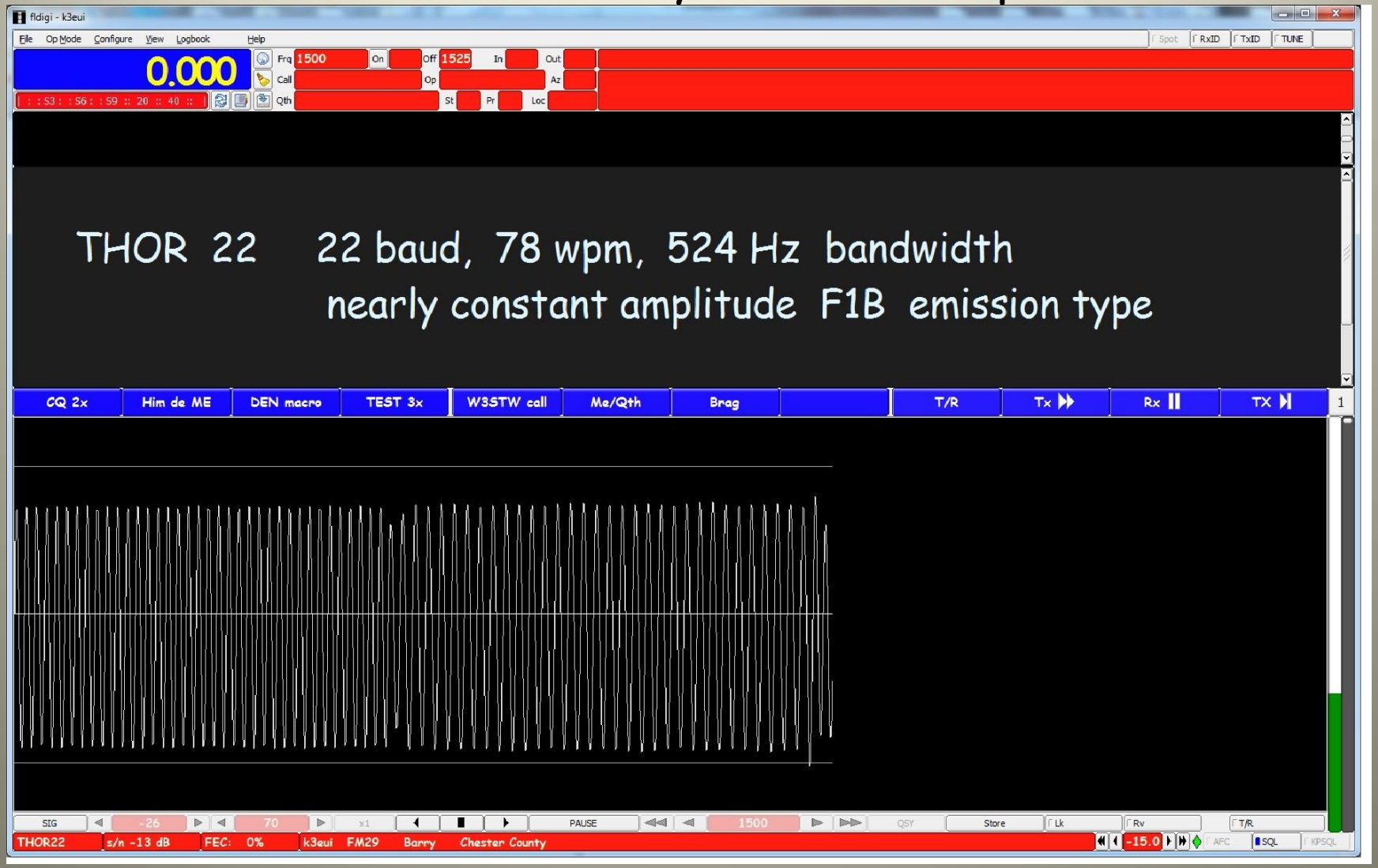
THOR uses "**incremental frequency shift**" whereby the CHANGE in frequency from one tone to the next tone determines the characters to be printed on screen

THOR has FEC (forward error correction)

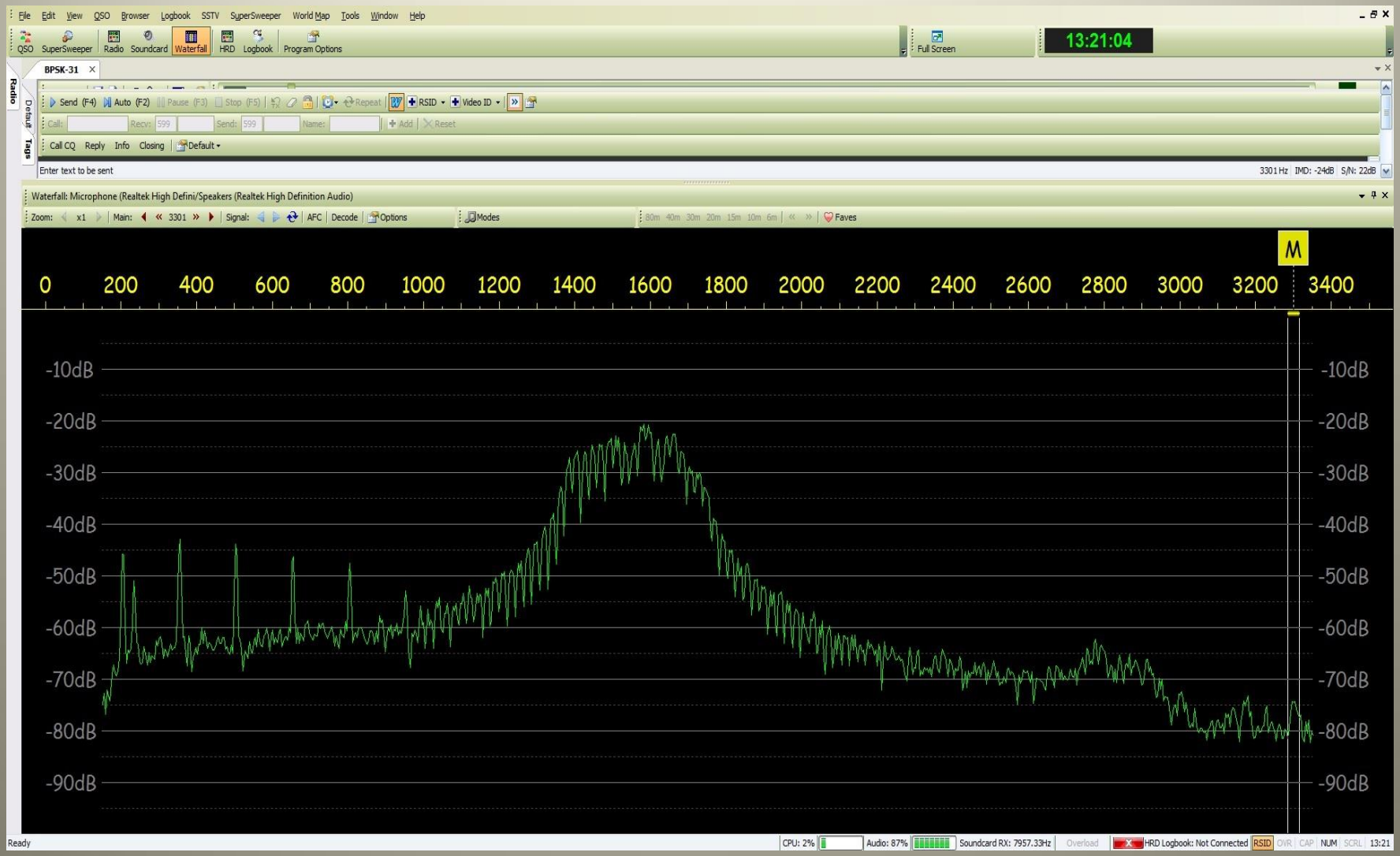
THOR has a "second" audio channel where you can display your call, name, qth

THOR 22 time plot

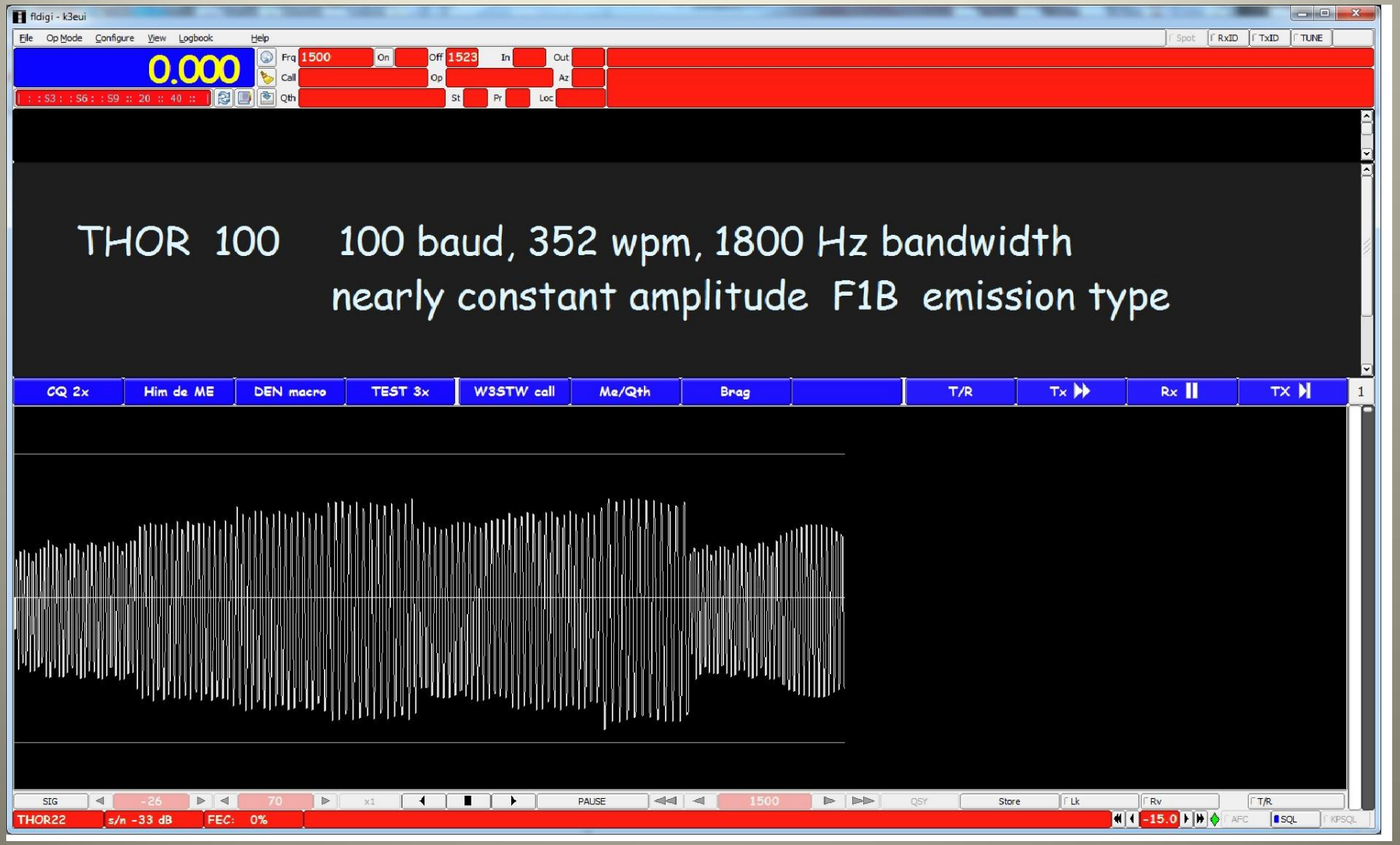
note THOR is nearly constant amplitude



THOR 22 spectrum



THOR 100


fldigi - k3eui
File Op Mode Configure View Logbook Help
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Frq 1500 On Off 1523 In Out
Call Op Az
Qth St Pr Loc
THOR 100 100 baud, 352 wpm, 1800 Hz bandwidth
nearly constant amplitude F1B emission type
CQ 2x
Him de ME
DEN macro
TEST 3x
W3STW call
Me/Qth
Brag
T/R
Tx
Rx
TX
SIG
-26
70
PAUSE
1500
Store
THOR22
s/n -33 dB
FEC: 0%
-15.0
SQL

THOR 100

Useful for sending longer files via
FLAMP and FLMSG

Used extensively on the PhilMont Mobile Radio Club Digital Education Net

Can be "mistuned" by 100 Hz and still get 100% copy

NEW modes for higher speed

What if we were to "phase shift" in smaller increments, like 45 degrees, rather than BPSK 180 degrees

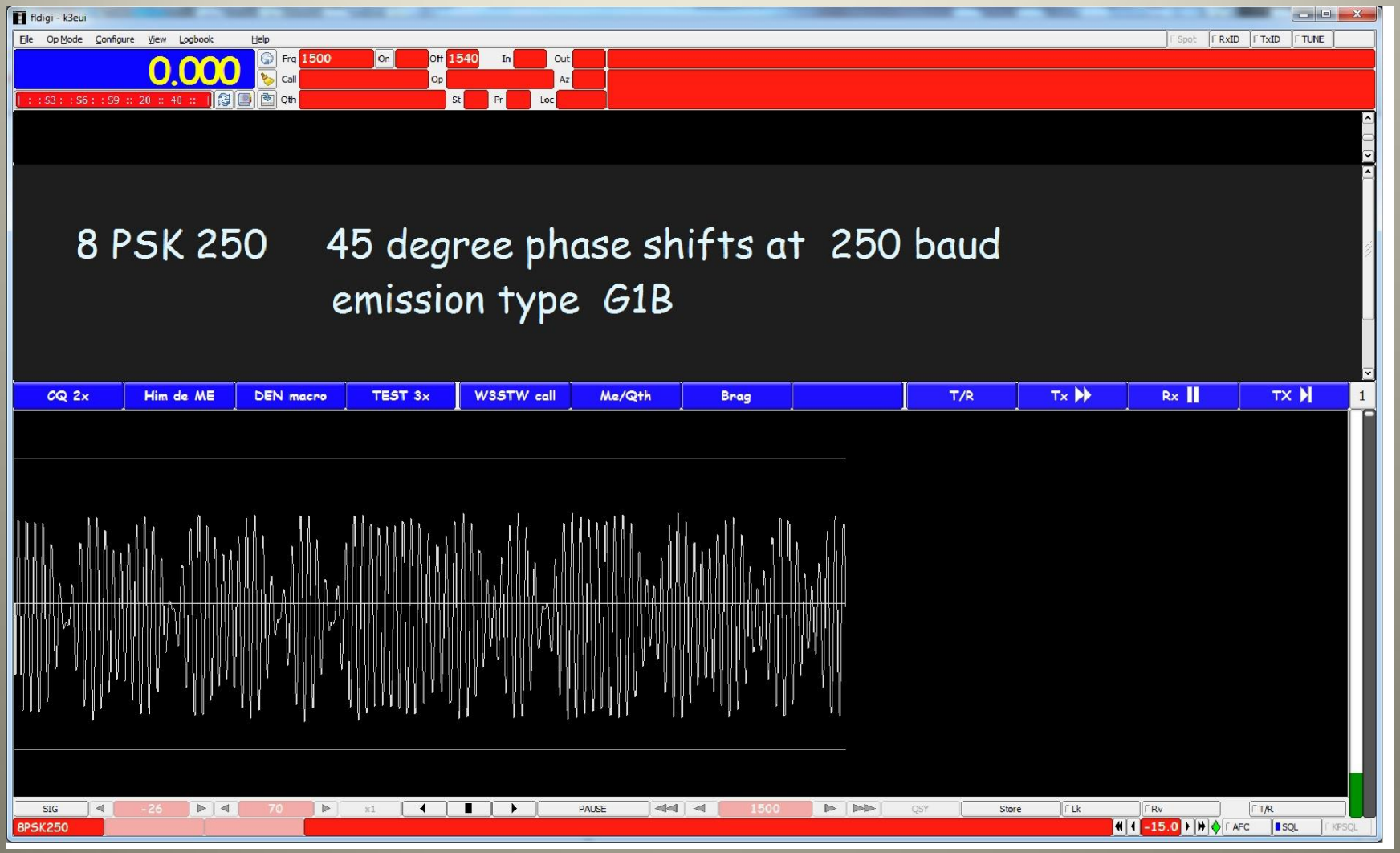
QPSK 90 degrees?

We could have more "states" per symbol so a 45 degree shift = 8 states/symbol

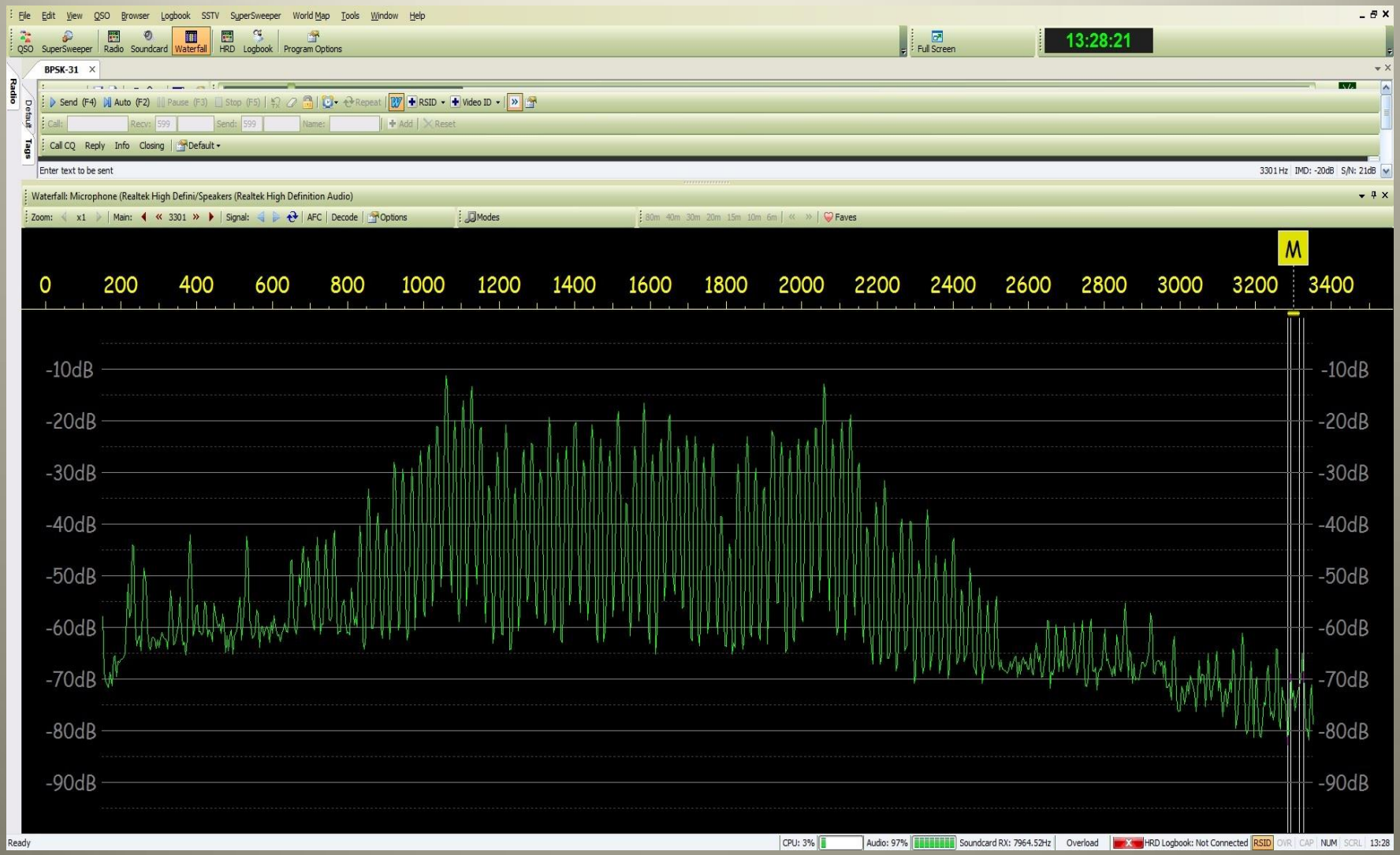
Thus, 8PSK is a higher "data rate" but requires a greater bandwidth

8 PSK 250

45 degree phase shifts
emission type G1B



8 psk 1000F spectrum
1000 baud = 3386 wpm



What is the "best" mode?

Depends on your goal: speed vs. accuracy?

Depends on QRN, QRM, QSB, S/N ratio
state of the ionosphere

FM (repeater) vs. SSB (HF)

Some modes have a high **PEAK/AVERAGE** signal level like multi-psk modes and MT63 so keep audio levels LOW to **avoid clipping**

CONCLUSIONS

MT63 2k seems to work very well in a noisy environment, even with "acoustic coupling" (no direct radio/sound card) but is limited to about 200 wpm

Multi-PSK modes like PSK125RC16 work well most of the time but stay above 500 Hz and below 3200 Hz if possible and keep audio levels at optimum level

FM and over-deviation

FM radios tend to “limit” the audio volume levels (good on voice) on RX and TX

Yet many of the FLDIGI modes have significant amplitude changes, so FM radios and FM repeaters will tend to modify the audio.

FM radios

Pre-emphasis (adds treble to the TX)
De-emphasis (reduces treble to the RX)

This is designed to REDUCE noise (on voice)

Does this create issues for digital modes?

HF SSB audio passband

Keep the RX bandpass as narrow as possible to avoid noise and qrm (500 Hz is good)

Do **not** use RX "noise blanker" or "noise reduction processing" in the newer radios

Turn OFF any Windows 7/8 "noise reduction"

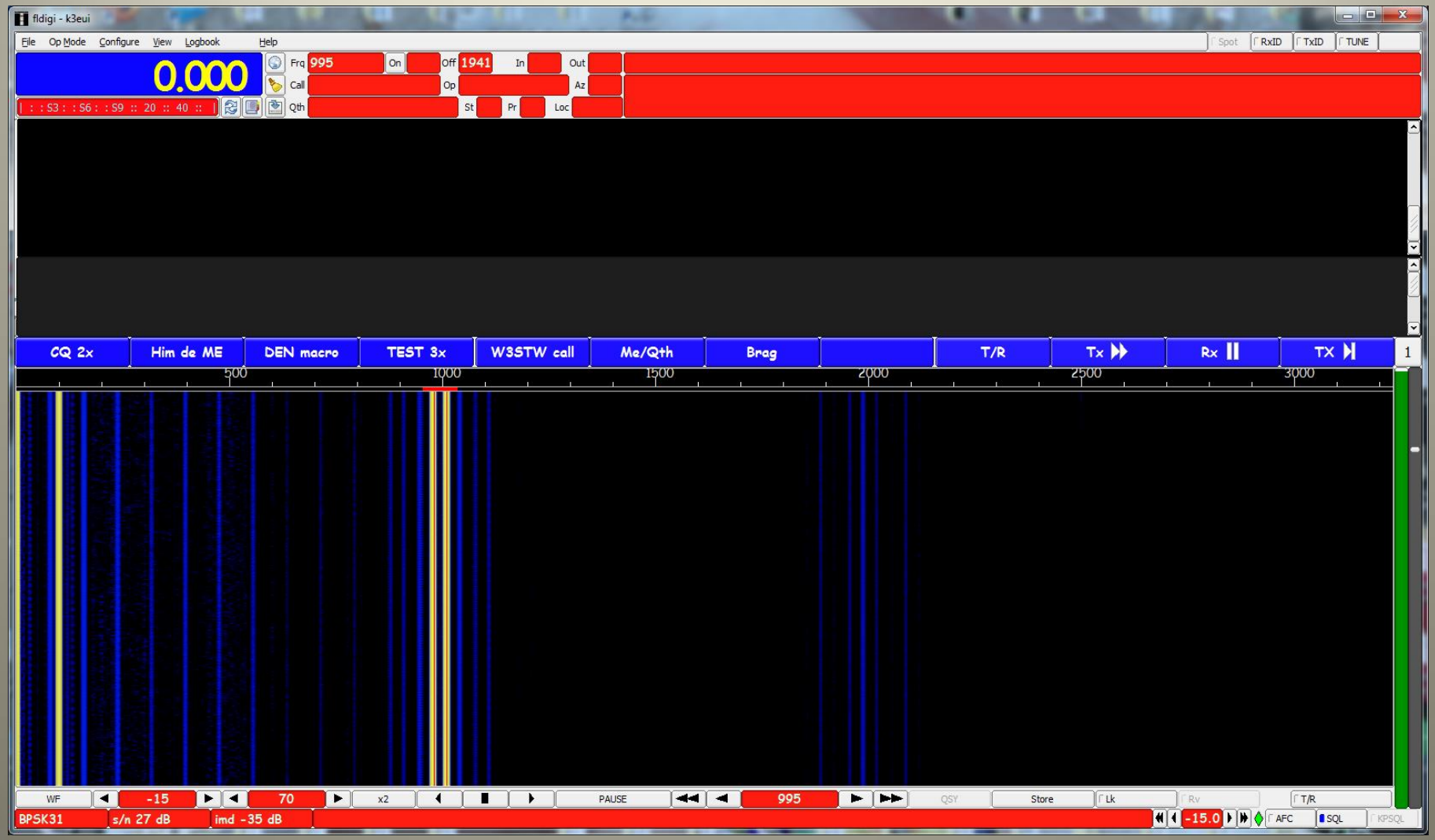
Do not drive TX audio into ALC action

FM and PL tones

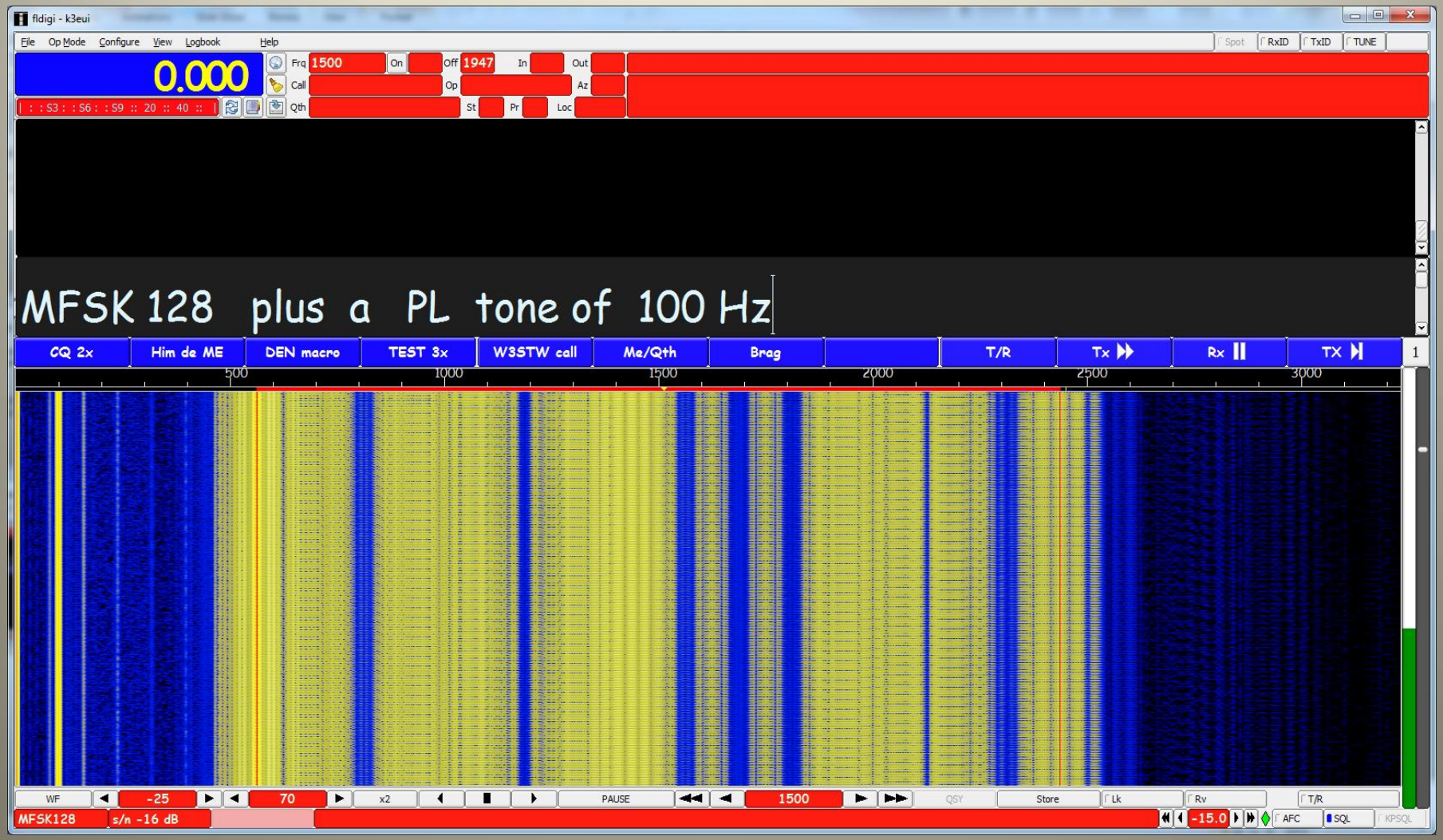
The constant PL tone needed to access FM repeaters CAN mix with the desired audio signal to give intermodulation.

A PL of 100 Hz can mix with a 1000 Hz FLDIGI signal to give new signals at 900 Hz and 1100 Hz, 1900 Hz and 2100 Hz

PL tone of 100 Hz and a PSK31 signal at 1000 Hz



PL tone of 100 Hz with a MFSK 128 wide band signal



FLDIGI TX levels

W1HKJ states that

"no mode will have a greater amplitude than the TUNE signal, so use TUNE to adjust your TX audio"

CHECK your TX audio

Send out a TUNE (single sine wave) at a waterfall frequency of 1000 Hz

Ask a friend to look for “harmonics” at 2000 Hz and 3000 Hz

Reduce your TX audio if necessary

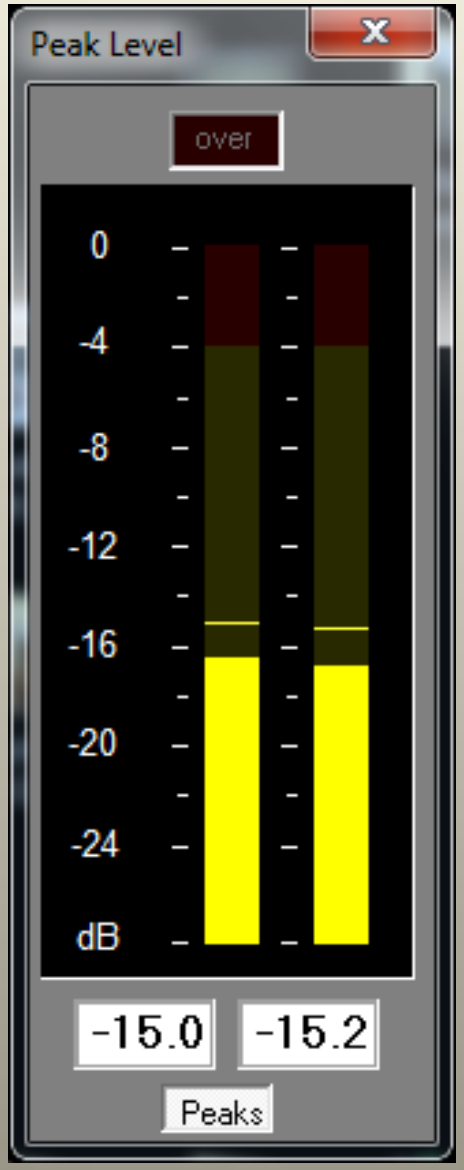
HUMAN EARS

Your ears are not very good at estimating the proper audio level, as human hearing is dependent on frequency (pitch) and many of the PSK digital modes have a high

PEAK / AVERAGE signal level

Your ears are sensitive to the AVG sound, not the PEAK sound

Add a Peak Reading Meter



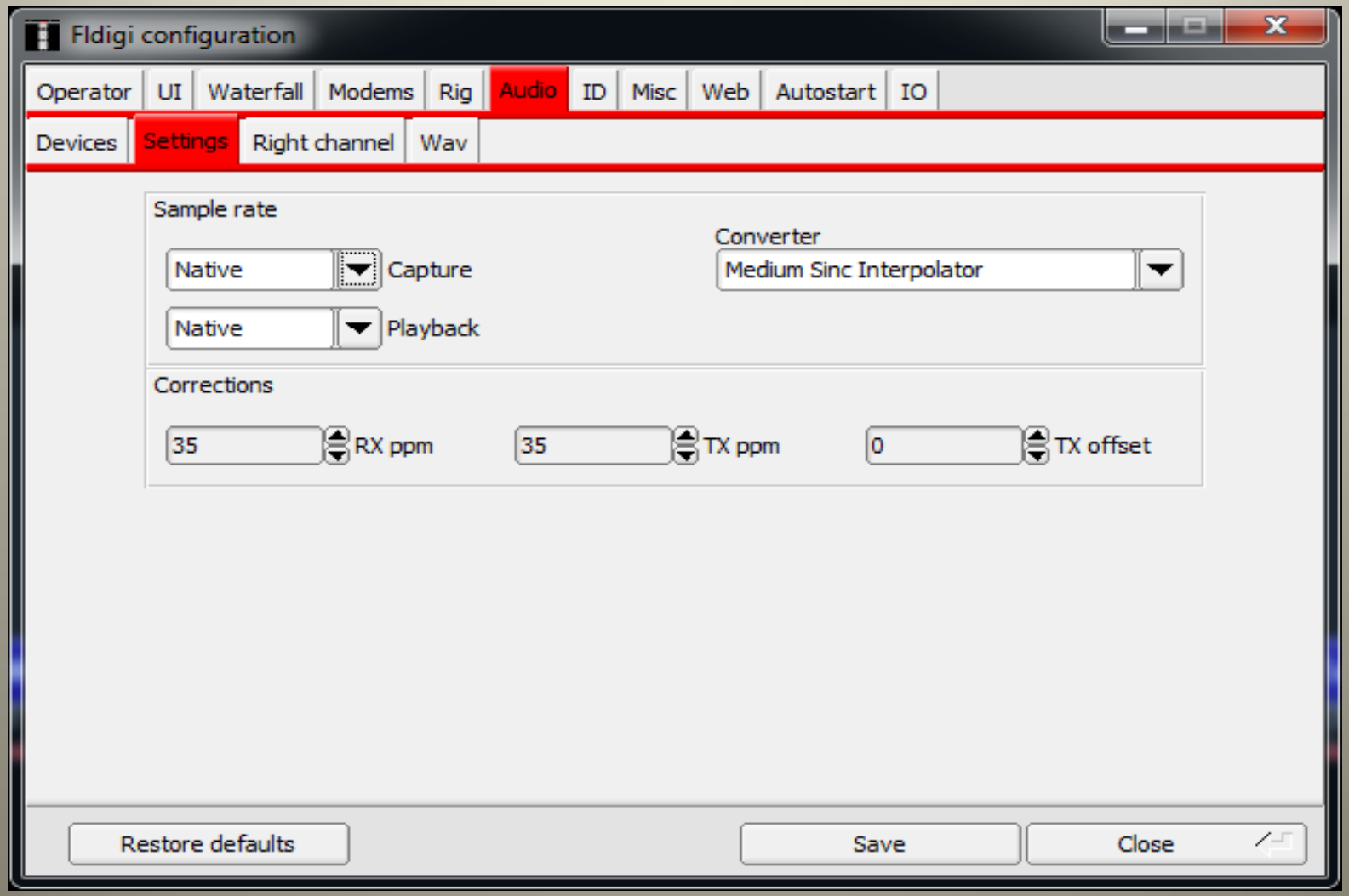
Sound Card Calibration

It is important to "calibrate" your sound card using the "native" sample rate

The RX and TX corrections are in ppm (parts per million)

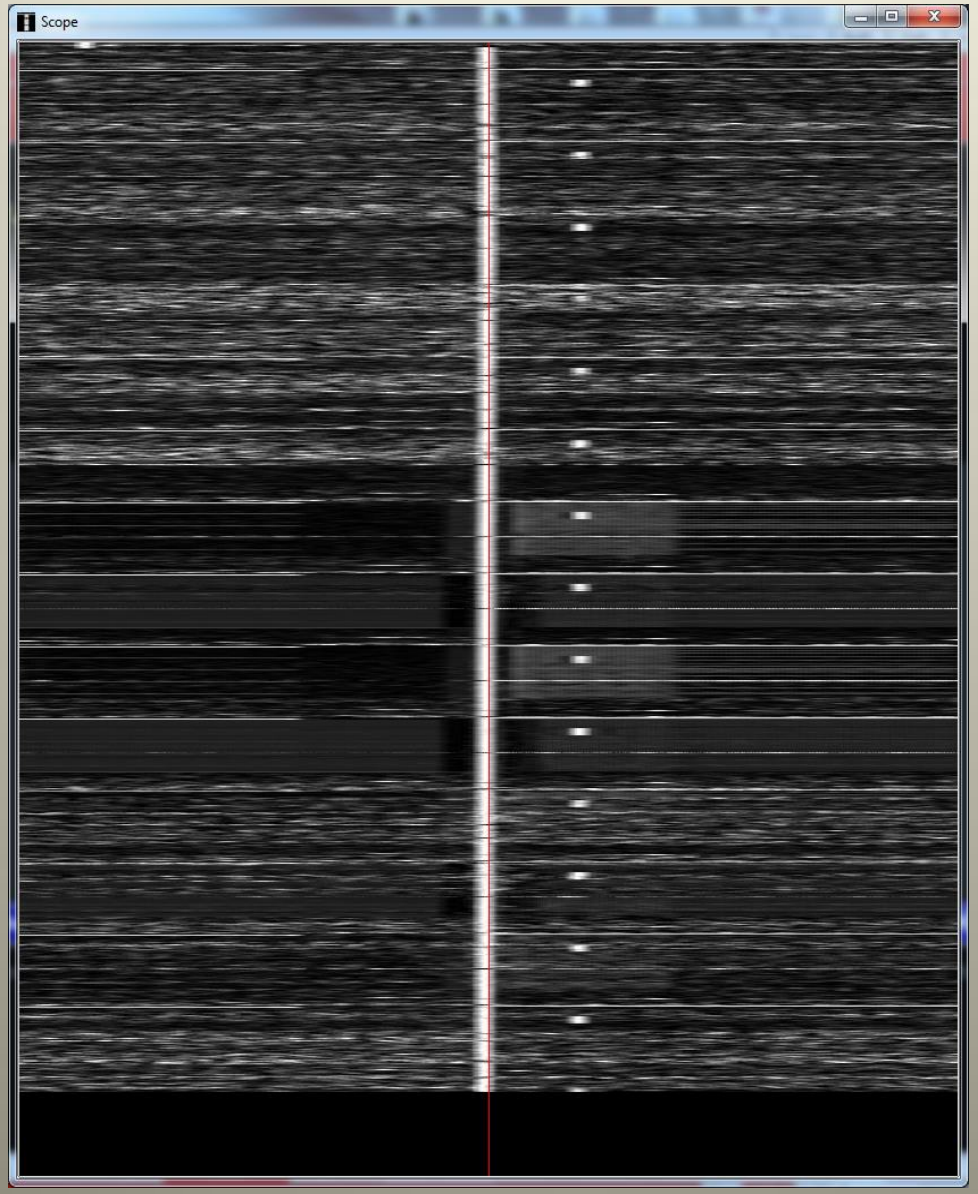
This may affect copy of high speed modes and affect the "slant" of slow-scan photos

Sound Card Settings and sample rates with "corrections"



WWV signal on 15.0 MHz and FLDIGI WWV mode

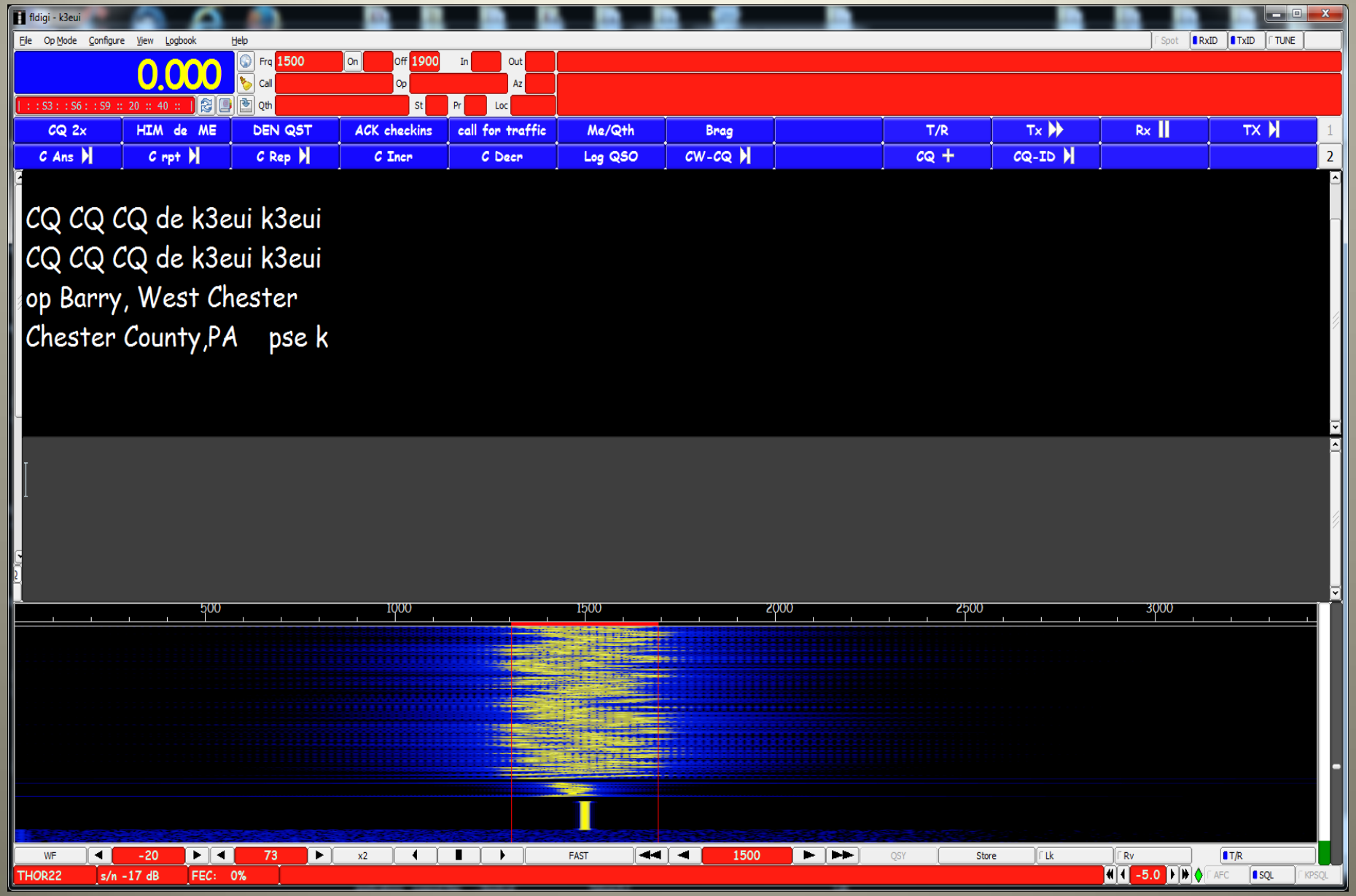
If line of dots is slanted you NEED to change the sound card calibration numbers



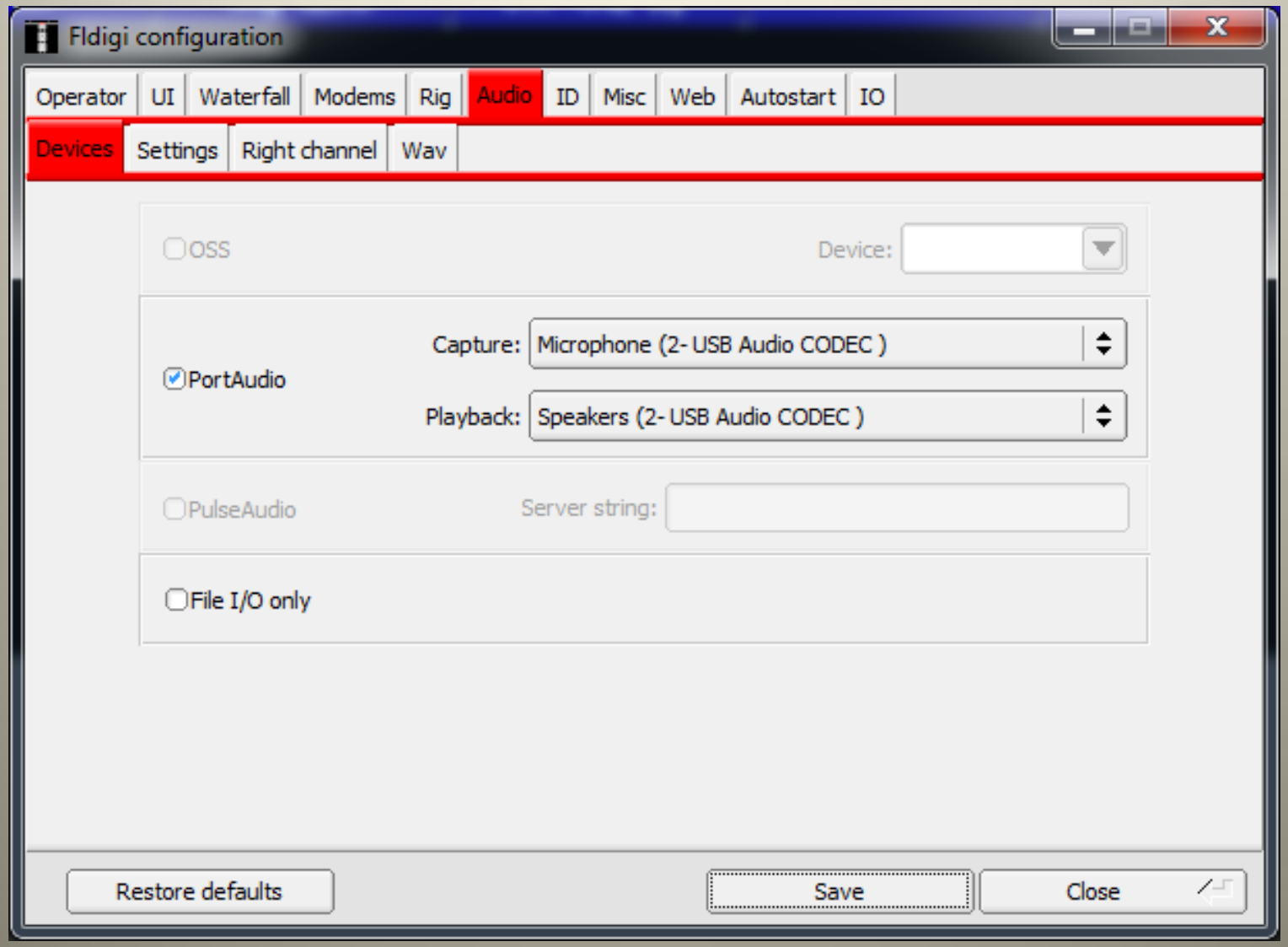
FLDIGI www.w1hkj.com

FREE - sound card modes
(psk, mfsk, olivia, cw, rtty, thor)
Works on Windows, Linux, Macs
Updated regularly
Good for casual qso
Does not take up a lot of memory
Works on older laptops/desktops
Does NOT do Packet, Pactor, JT modes

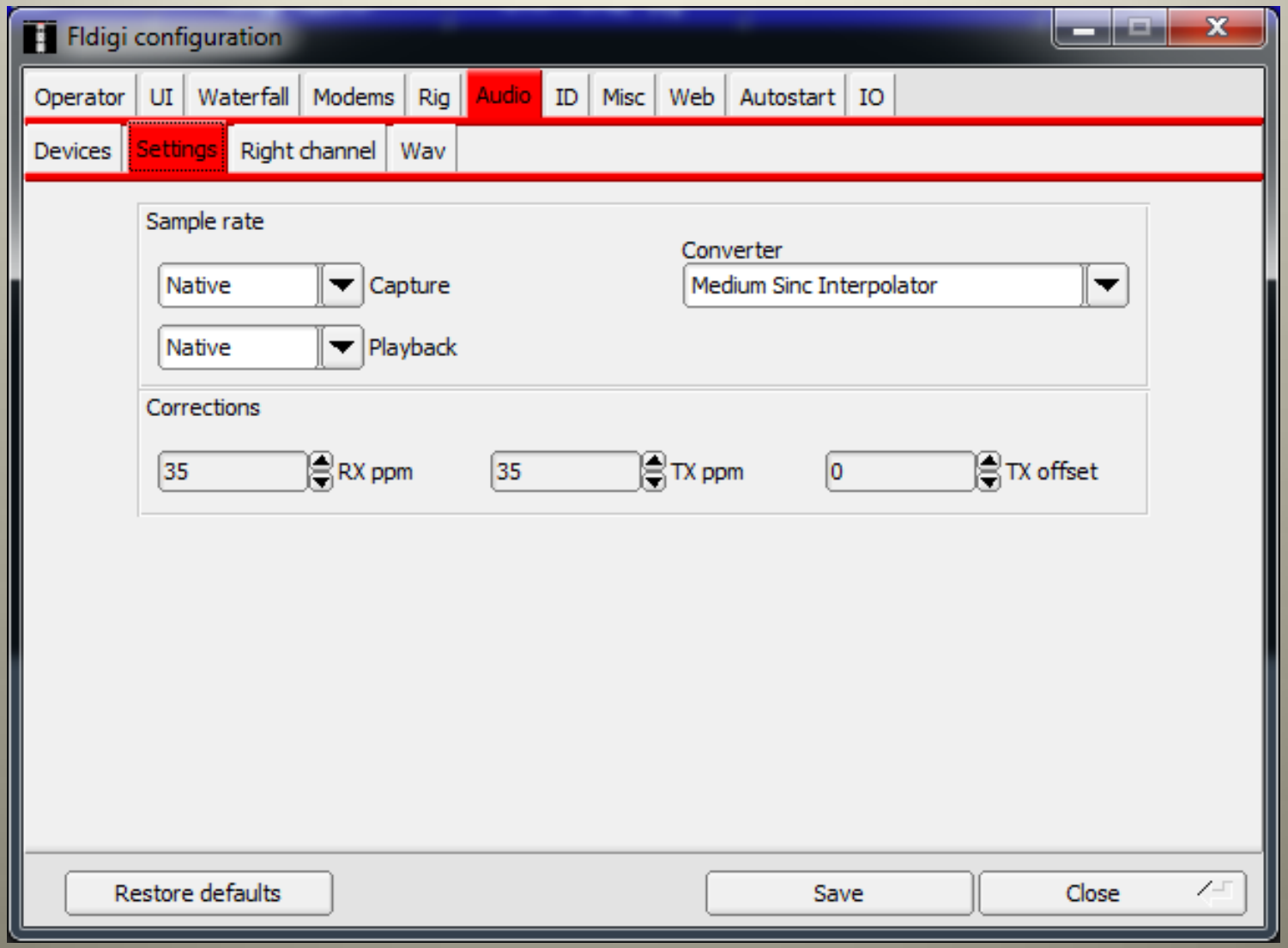
Typical FLDIGI window



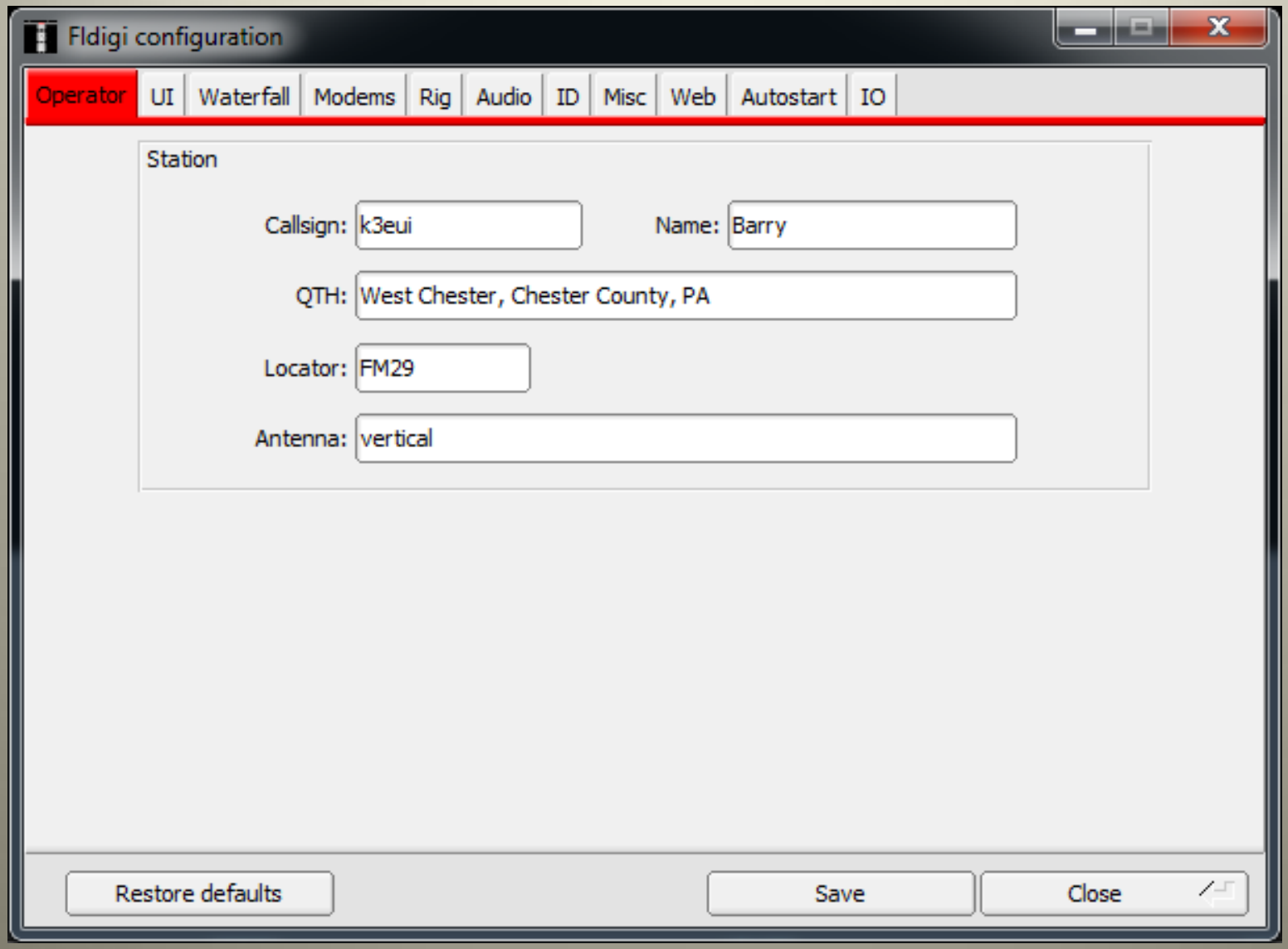
Pick your sound card



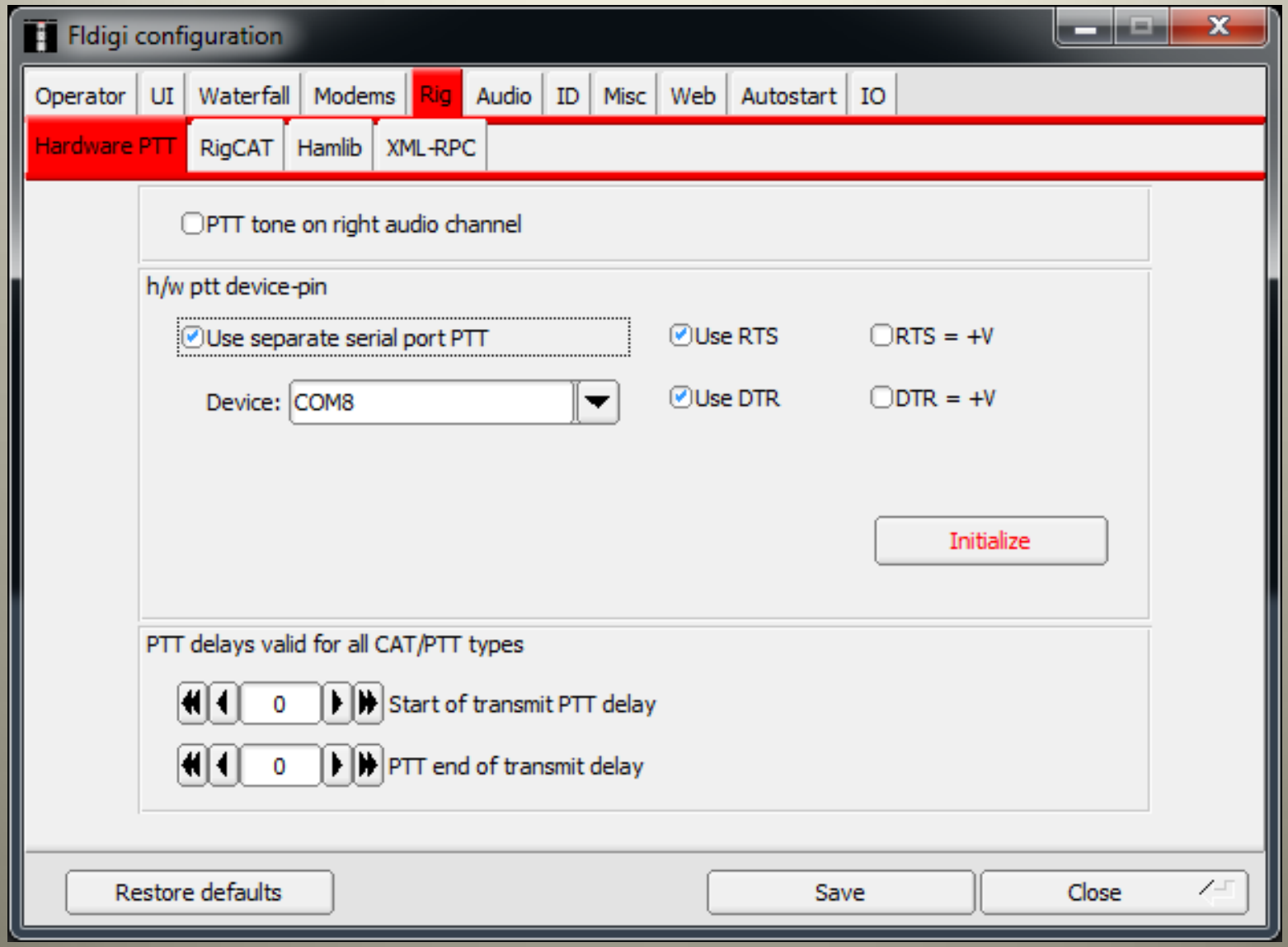
Check your sampling rate and add corrections (if known)



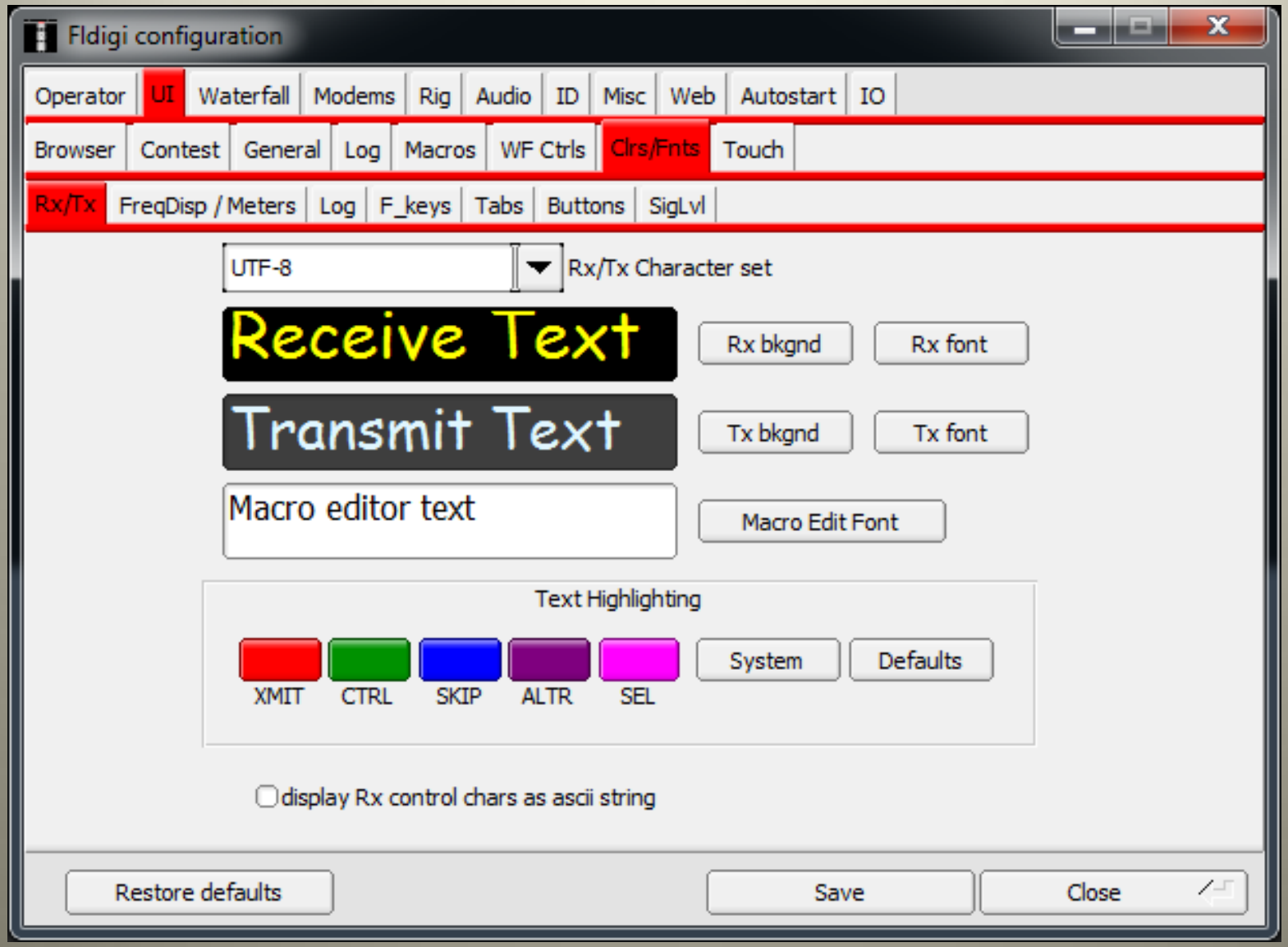
Add your call and basic info



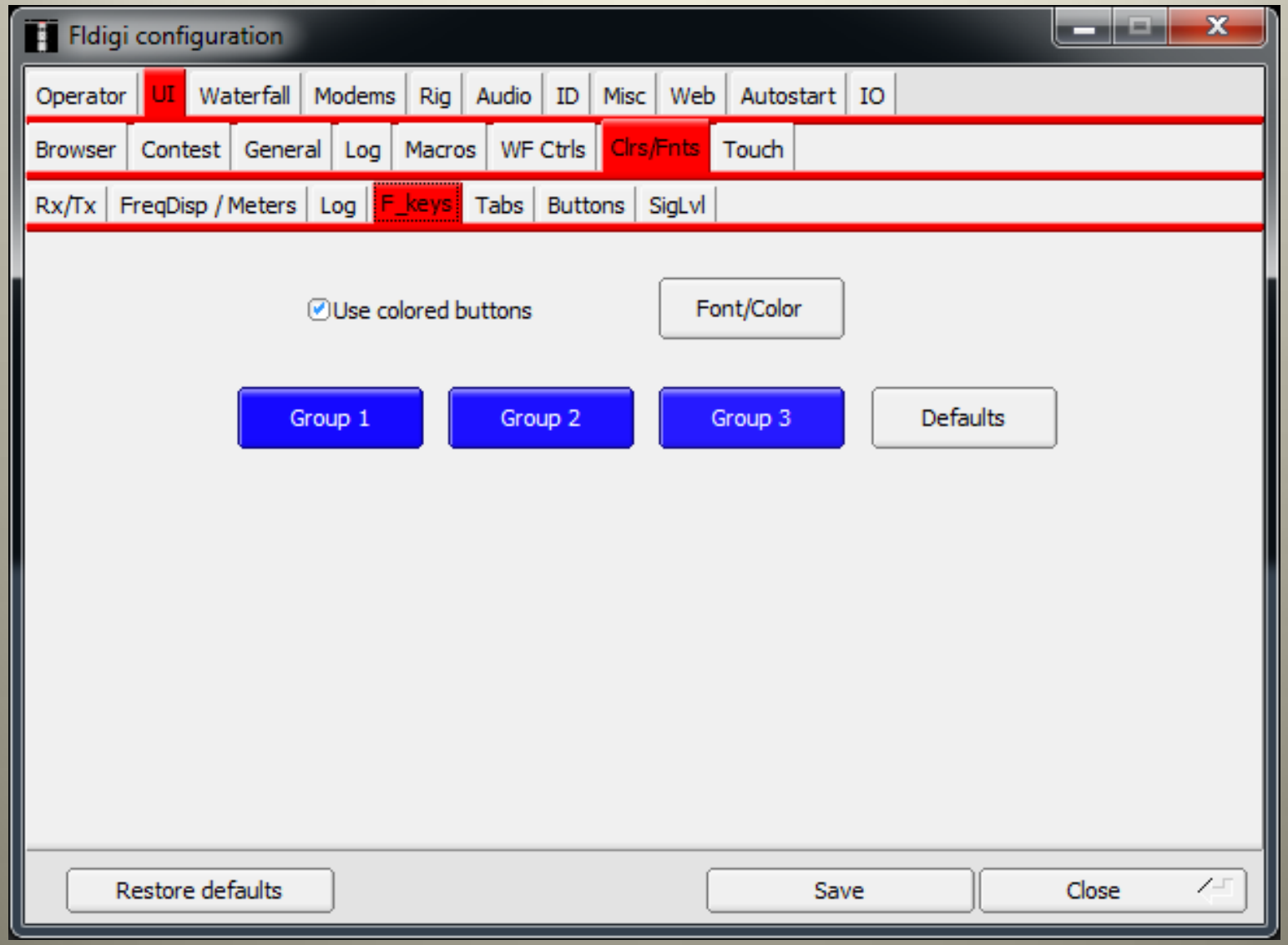
Add Rig Control (optional)



Pick the colors/fonts you like



Set up macros color/font



Edit the macros: CQ

Macro editor - C:\Users\bfeierman\fldigi.files\macros\Barry DEN macros.mdf

Macro Text

```
<TX>
CQ CQ CQ de <MYCALL> <MYCALL>
CQ CQ CQ de <MYCALL> <MYCALL>
op Barry, West Chester
Chester County,PA    pse k
<RX>
```

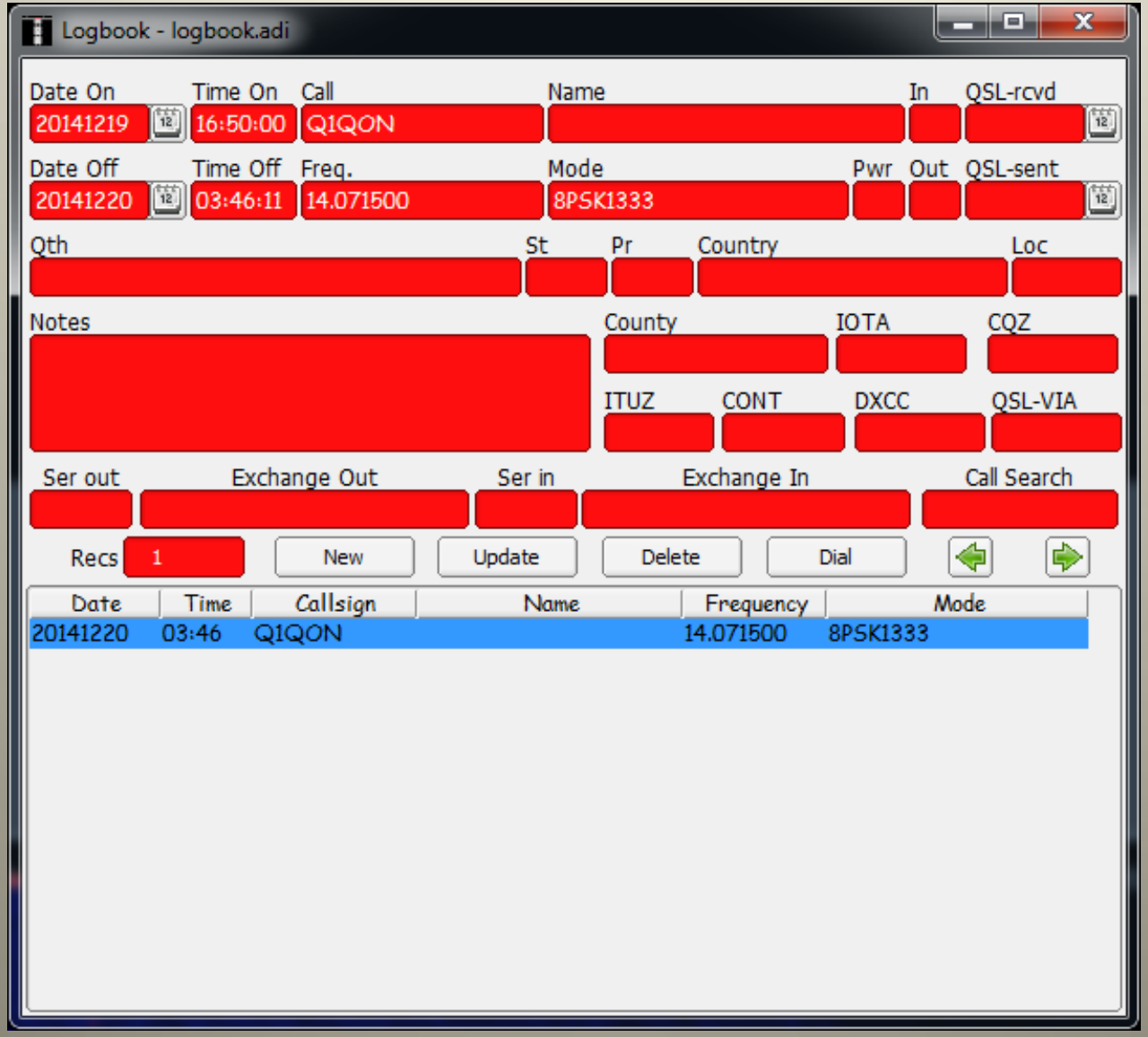
Select Tag

<FREQ>	my frequency
<MODE>	mode
<MYCALL>	my call
<MYLOC>	my locator
<MYNAME>	my name
<MYQTH>	my QTH
<MYRST>	my RST
<ANTENNA>	my antenna
<BAND>	operating band
<VER>	Fldigi version
<CALL>	other call
<INFO1>	S/N etc.
<INFO2>	IMD etc.
<LOC>	other locator
<NAME>	other name
<QTH>	other QTH
<RST>	other RST
<QSONBR>	# QSO recs
<NXTNBR>	next QSO rec #
<MAPIT>	map on google
<MAPIT:adr/lat/loc>	map by value
<CLRRX>	clear RX pane
<CLRTX>	clear TX pane
<GET>	text to NAME/QTH
<TALK:on|off|t>	Digitalk On, Off, Toggle
<CLRLOG>	clear log fields
<LOG>	save QSO data
<LOG:msg>	saveQSO data, append msg to notes
<LNW>	log at xmt time
<LNW:msg>	saveQSO data, append msg to notes
<EQSL>	log eQSL
<EQSL:[msg]>	log eQSL optional msg
<QSOTIME>	QSO time (HHMM))
<ILDT>	LDT in iso-8601 format
<LDT>	Local datetime
<IZDT>	ZDT in iso-8601 format

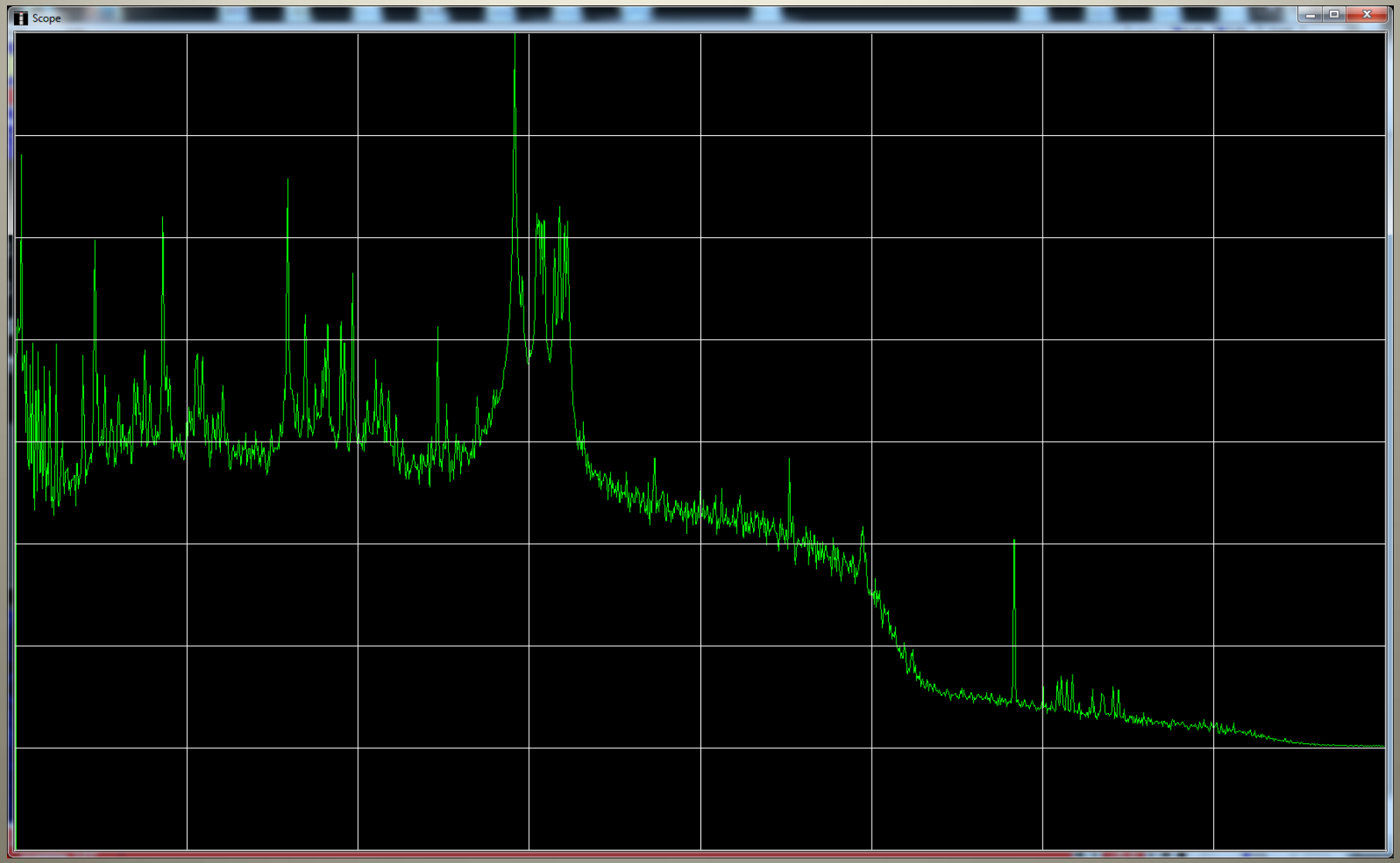
Macro Button Label CQ 2x

Apply Close

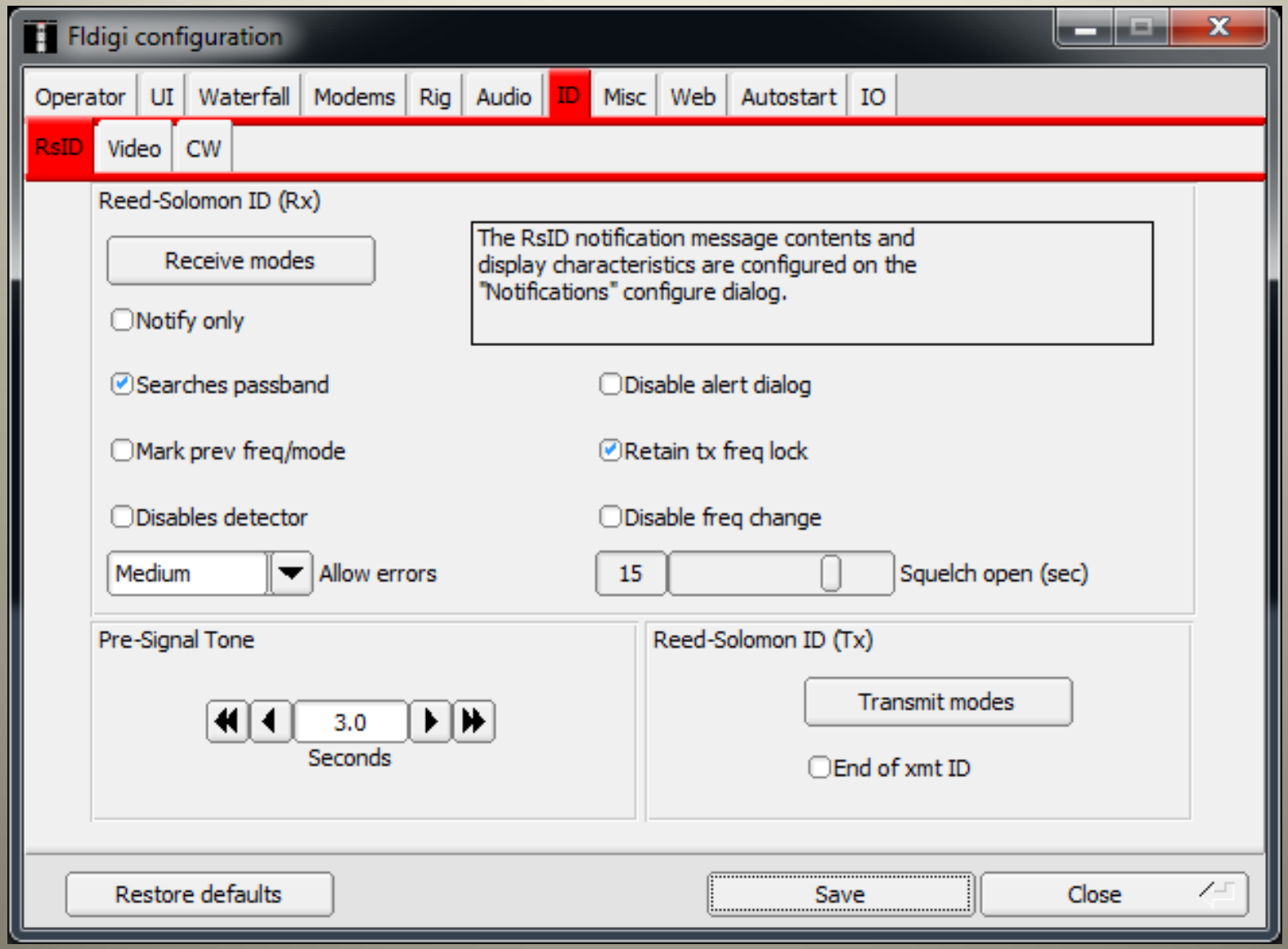
Use the LOGBOOK feature



Do a spectral scan of your passband audio 0 - 4000 Hz 10dB vert (JT65 sample)



Automatically identify modes by TxID and RxID feature



FLMSG: what is it good for?

You can send messages that have been "**wrapped**" for **error detection** and in a format specific for the event such as

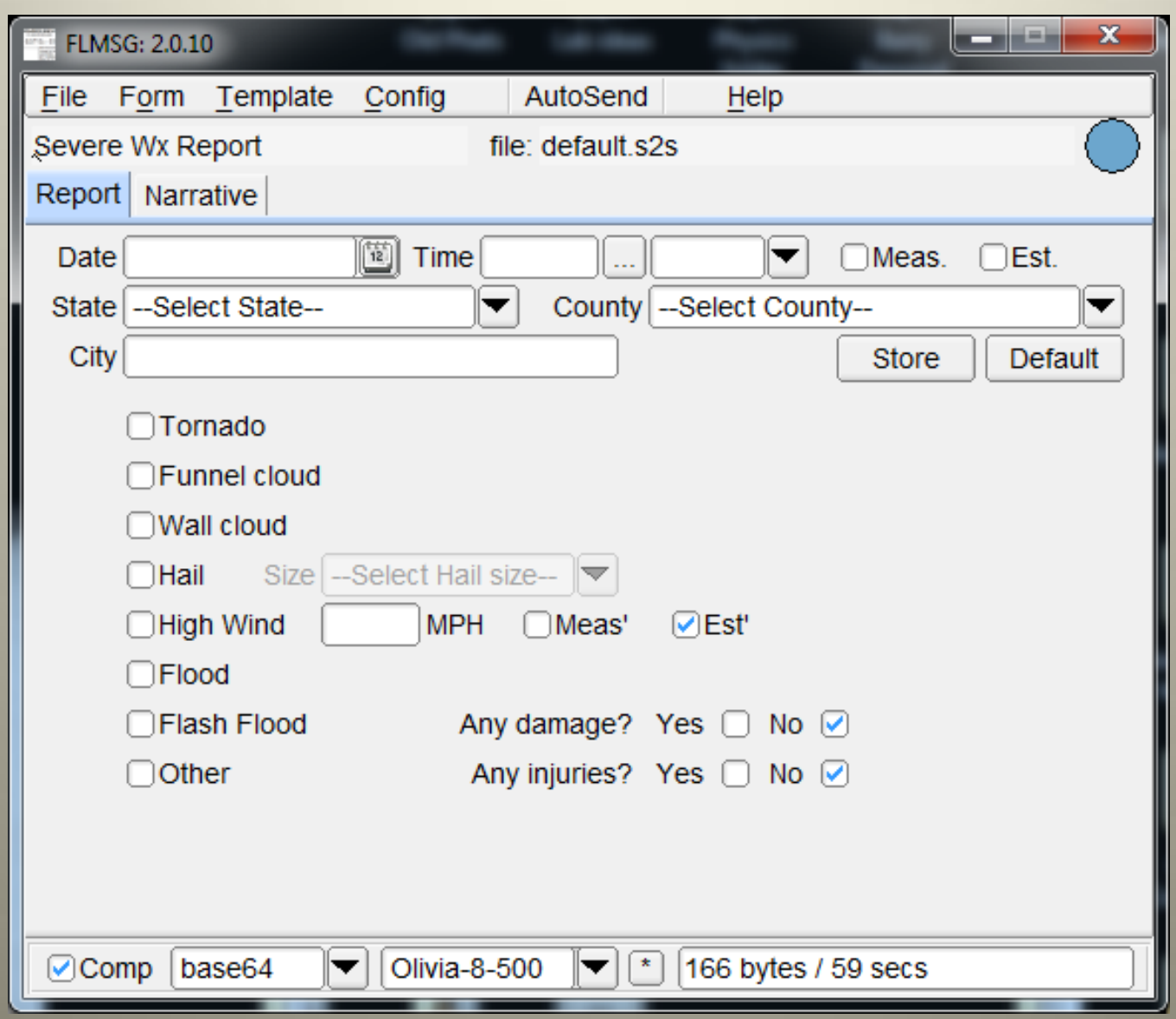
Weather reports

ARRL Radiograms

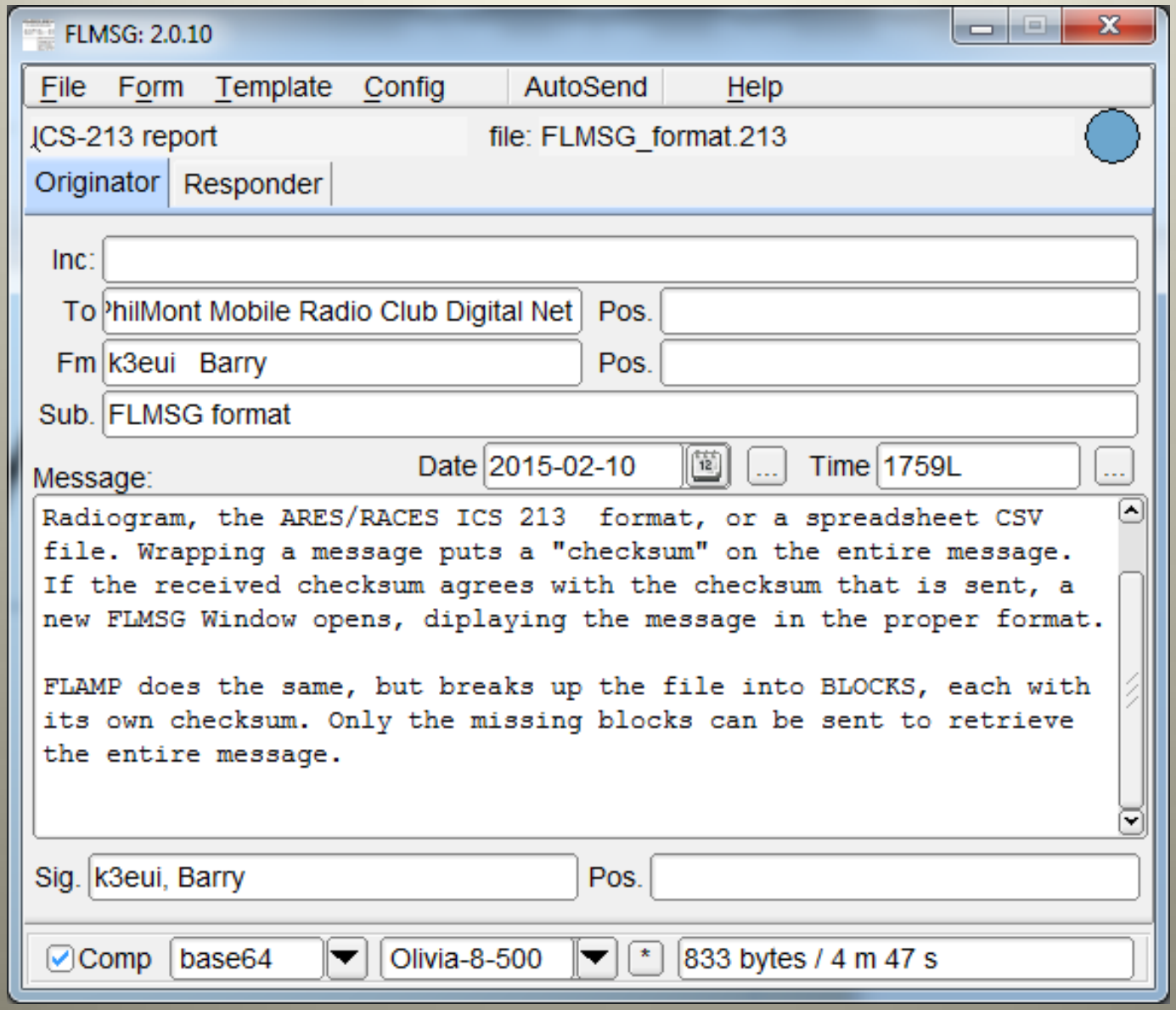
ICS emergency messages

Spreadsheets

Weather Reports FLMSG



ICS emergency messages



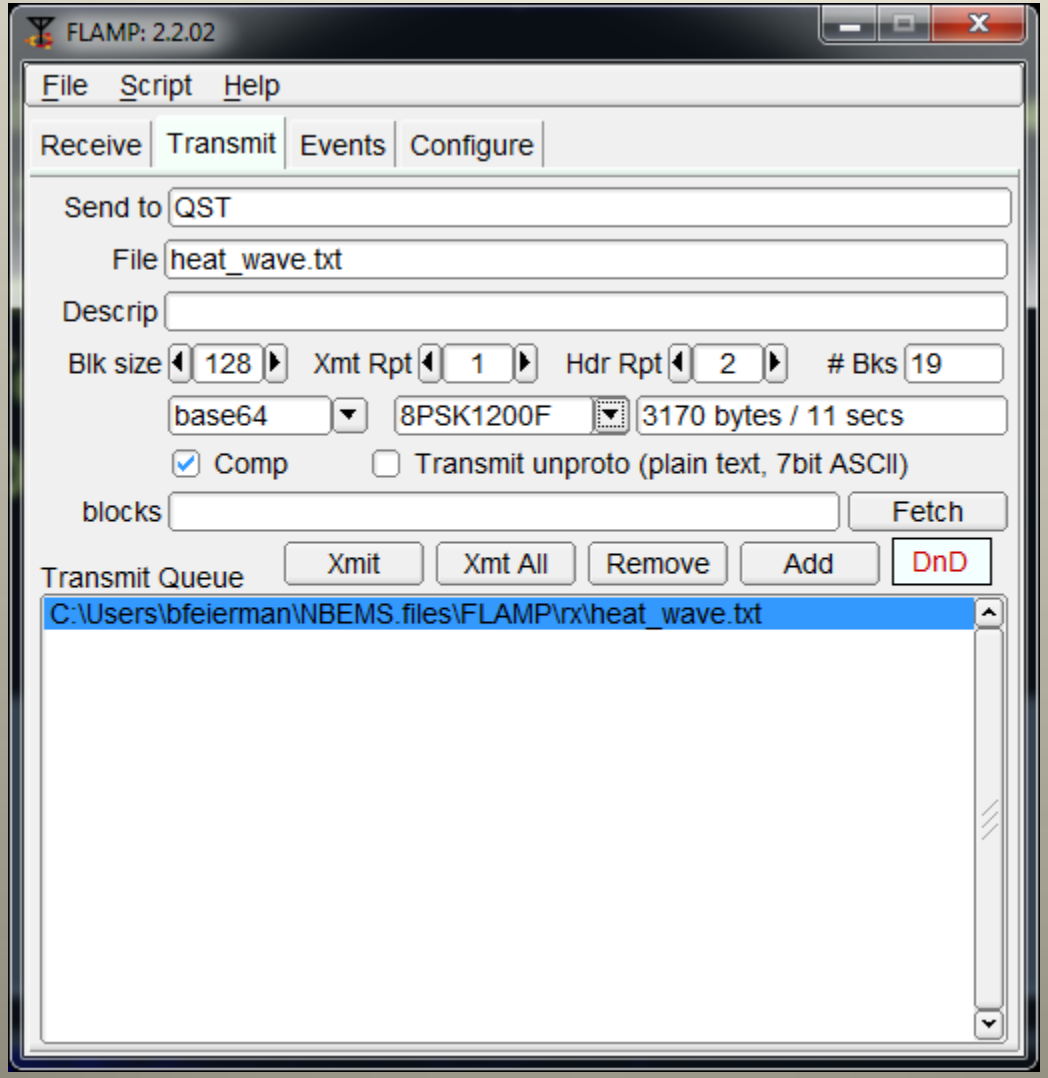
Spreadsheets (csv files)

CSV Viewer

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

Close

FLAMP: breaks a longer message into smaller "blocks"



Come join the fun

Philmont Mobile Radio Club sponsors
The Digital Educational Net (DEN)

Every Tuesday evening 7:00pm on
The Jim Spencer Memorial Repeater
147.030 (+) PL 91.5

Net controls: W3STW, K3EUI