PSK-31

What is it?

What do I need?

How do I use it?

Randy Hall

K7AGE

First, a little bit about me

I was first licensed in 1968

I've been around video since high school

- **Built a TV camera as high school electronics project**
- **Worked on remote TV broadcast as cameraman and engineer**
- **Worked at college TV studio, Rochester Institute of Technology**

Work for broadcast equipment manufacturers

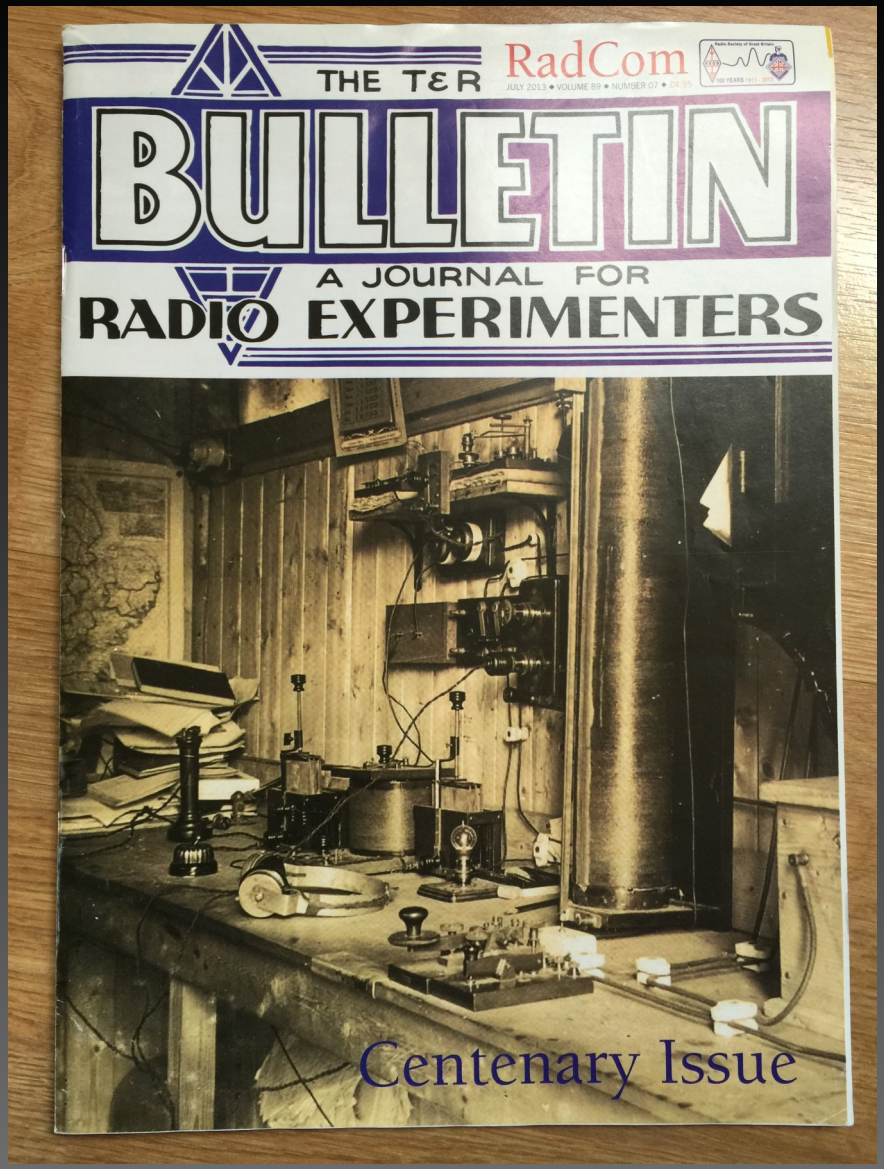
- **Grass Valley/Belden/Miranda/NVISION and Grass Valley Group**

First Youtube video in August 2006, now over 11 years

150+ videos

Over 4,300,00 total views

Over 27000+ subscribers



July 2013

PSK31: A New Radio-Teletype Mode

By Peter Martinez, G3PLX

I have been active on RTTY since the 1960s, and was instrumental in introducing AmTOR to amateur radio at the end of the '70s. This improved the reliability of the HF radio link and paved the way to further developments which have taken this side of the hobby more into data transfer, message handling, and computer linking, but further away from the rest of amateur radio which is based on two-way contacts between operators.

There is now a gap opening up between the data transfer enthusiasts using the latest techniques and the two-way contact fans who are still using the traditional RTTY mode of the '60s, although of course using keyboard and screen rather than teleprinter. There is scope for applying the new techniques now available to bring RTTY into the 21st century.

This article discusses the specific needs of 'live QSO' operating, as opposed to just transferring chunks of error-free data, and describes the PSK31 mode which I have developed specifically for live contacts, which is now becoming popular using low-cost DSP kits, and which could become even cheaper as the art of using PC sound cards is developed by amateur radio enthusiasts.

FIGURE 1: Showing the word 'ten' keyed in ASCII, RTTY, Morse and Varicode.

WHAT IS NEEDED?

I believe that it is the error-correcting process used in modern data modes which make them unsuitable for live contacts. I have identified several factors; the first revolves around the fact that all error-correcting systems introduce a time-delay into the link. In the case of an ARQ link like AmTOR or PacTOR, there is a fixed transmission cycle of 450ms or 1.25sec or more, which will delay any keypress by as much as one cycle-period, and by more if there are errors. With forward-error correction systems there is also an inevitable delay, because the information is spread out over a period of time. In a live two-way contact, the delay is doubled at the point where the transmission is handed over. I believe that these delays make such systems unpleasant to use in a two way conversation.

This is not so much a technical problem as a human one. Another factor in this category is concerned with the way that the quality of the information content varies as the quality of the radio link varies. In an analogue transmission system such as SSB or CW, there is a linear relationship between the two. The operators are aware of this all the time and take account of it subconsciously: they change the speed and tone of voice instinctively, and even choose the topic of conversation to suit the conditions.

FIGURE 2: Showing the waveform of BPSK sending the Varicode 'space' symbol.

In a digital mode the relationship between the signal-to-noise ratio on the air and the error rate on the screen is not so smooth. The modern error-correcting digital modes are particularly bad at this, with copy being almost perfect while the SNR is above a certain level and stopping completely when the SNR drops below this level. The effect is of no consequence in an automatic mailbox forwarding link, but can badly inhibit the flow of a conversation.

A third factor is a social one; with error correcting modes you only get good copy when you are linked to one other station. The copy is decidedly worse when not linked, such as when calling CQ or listening to others. This makes it difficult "getting to know' other people on the air, and there is a tendency to limit contacts to a few close friends or just mailboxes.

These factors lead me to suggest that there is a case for a transmission system that is *not* based on the use of error-correcting codes, when the specific application is that of live contacts. The continued popularity of traditional RTTY, using the start-stop system, is proof of this hypothesis: there is minimal delay (150ms), the flow of conversation is continuous, the error-rate is tolerable, and it is easy to listen-in and join-in.

IMPROVING ON RTTY

How, then, do we go about using modern techniques that were not available in the '60s, to improve on traditional RTTY? First of all, since we are talking about live contacts, there is no need to discuss any system that transmits text any faster than can be typed by hand.

Secondly, modern transceivers are far more stable in frequency than they were in the '60s, so we should be able to use much narrower bandwidths than in those days. Thirdly digital processors are much more powerful than the rotating cams and levers of the mechanical teleprinter, so we could use better coding. The drift-tolerant technique of frequency-shift keying, and the fixed-length five-unit start-stop code still used today for RTTY are a legacy of the limitations of technology 30 years ago. We can do better now.

December 1998

First published in *RadCom* December 1998 and January 1999

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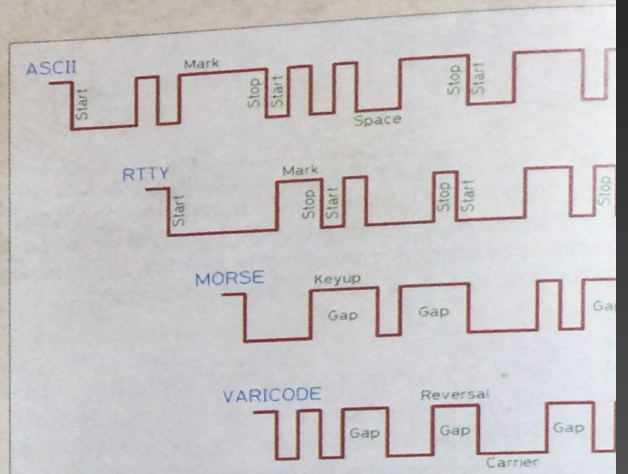

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What is PSK-31?

PSK-31 is a digital mode developed by

Peter Martinez, G3PLX

- ***Introduced in 1998, 18 years ago***

PSK's advantages include:

- **Less bandwidth, more stations**
- **Better than the popular RTTY at that time**

PSK-31 uses

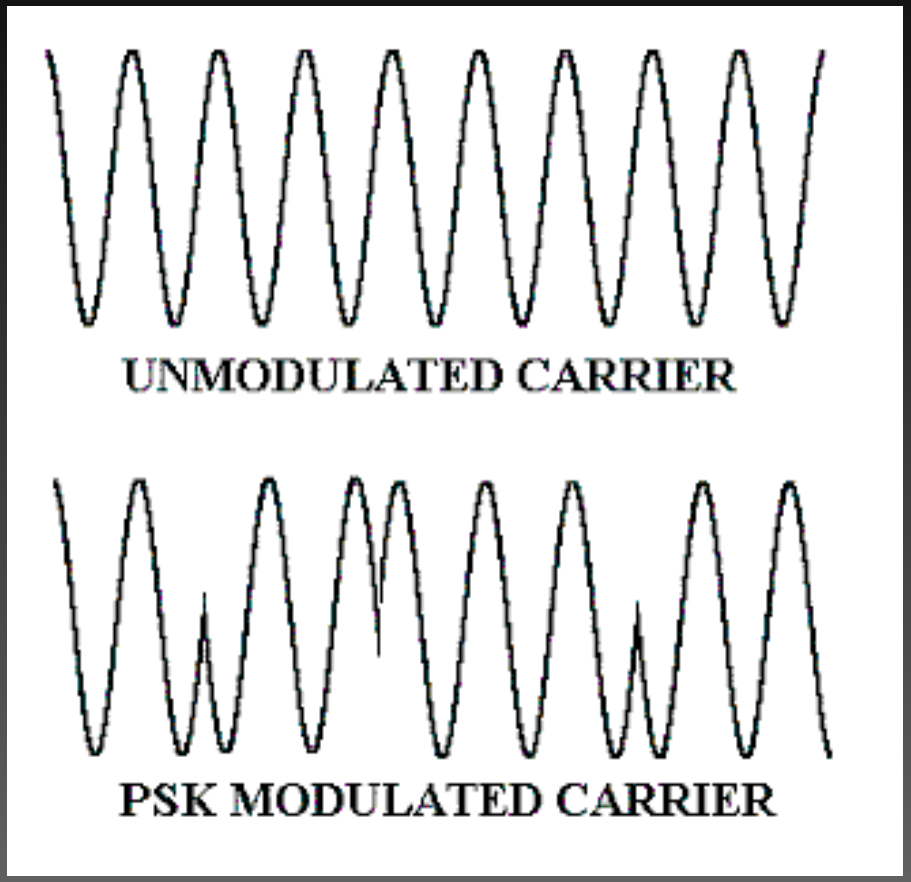
- **phase shift keying , not frequency shift like RTTY**
- **Coded using Varicode, variable bit length**
- **Sound Card interface that was becoming popular in PCs**

Phase Shift Keying

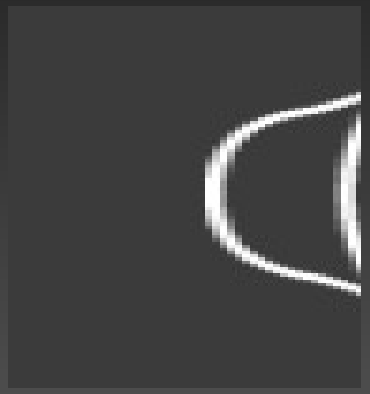
PSK-31 uses Binary Phase Shift Keying (BPSK)

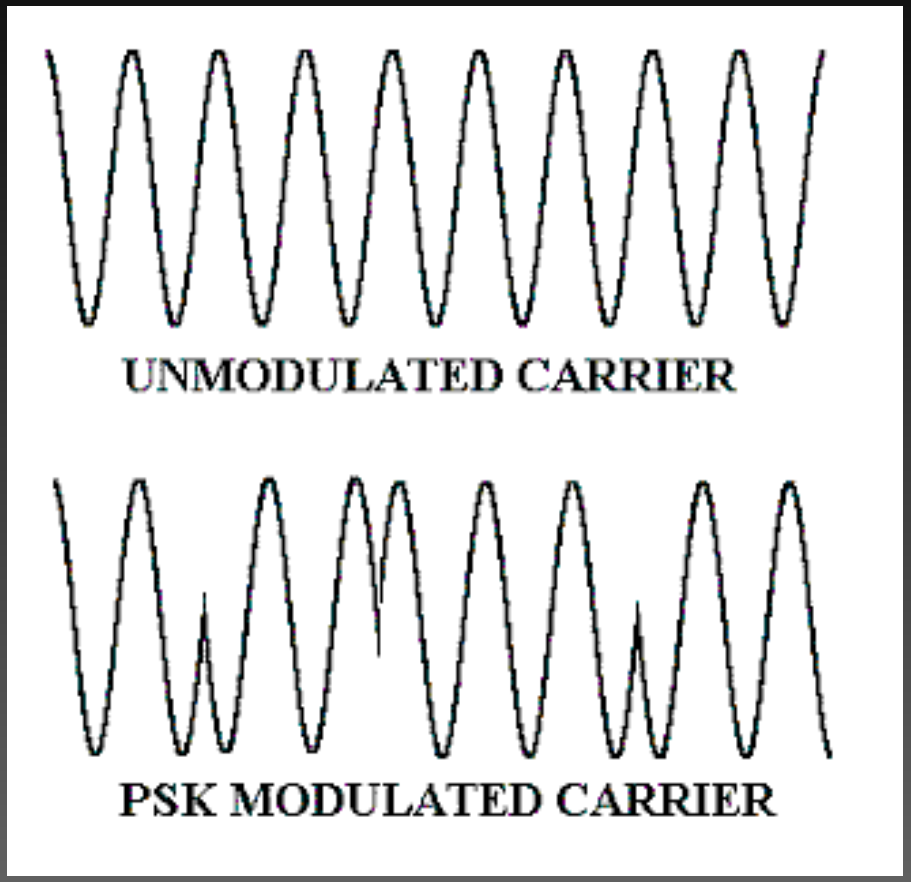
The keying rate is 31.25 bits/sec

The effective speed for plain English text is approximately 50 words/minute



Phase Shift Keying





Phase Shift Keying

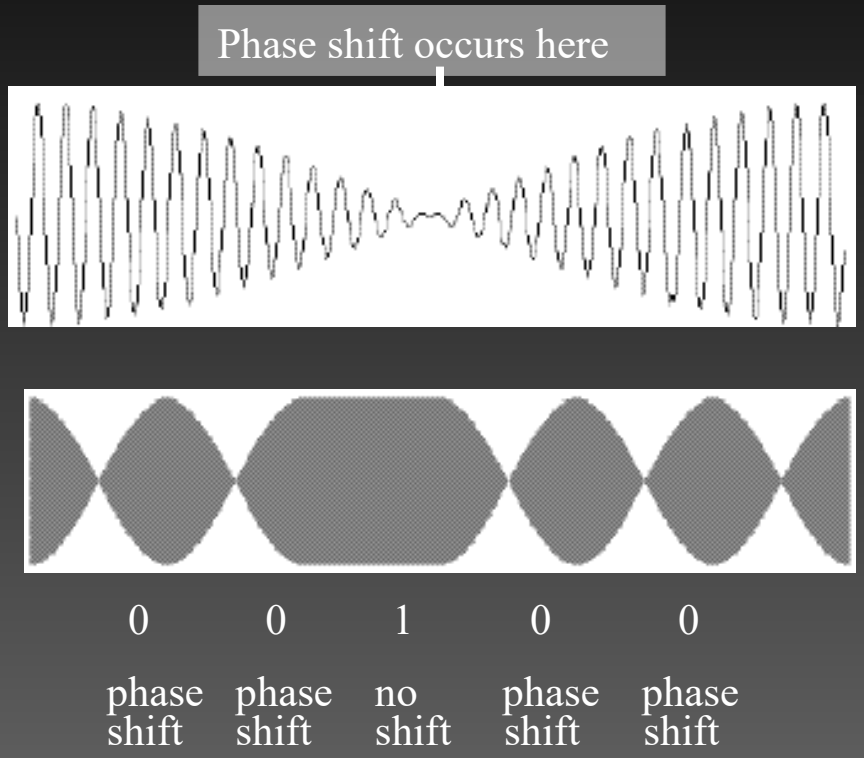
Why 31.25 bits/sec?

- **This frequency is easily derived from the sound card's 8000 Hz clock frequency**

To reduce the bandwidth of the PSK signal, the signal is shaped so that phase transitions occur only when the signal amplitude is zero

A "0" (space) is a 180 degree phase shift

A "1" (mark) is no phase shift



Varicode

Developed by Peter Martinez G3PLX

The most frequently used characters use the least number of bits

- **e uses fewer bits than Z**
- **Lower case uses fewer bits than UPPERCASE**

Unlike the Baudot fixed length code used for RTTY,

Varicode supports

- **127 character ASCII character set,**
- **which includes upper and lower case letters, @**
- **numbers and punctuation.**
- **And BACKSPACE!**

Printable characters

Varicode	Oct	Dec	Hex	Glyph
1	040	32	20	SP
111111111	041	33	21	!
101011111	042	34	22	"
111110101	043	35	23	#
111011011	044	36	24	$
1011010101	045	37	25	%
1010111011	046	38	26	&
101111111	047	39	27	'
11111011	050	40	28	(
11110111	051	41	29	)
101101111	052	42	2A	*
111011111	053	43	2B	+
1110101	054	44	2C	,
110101	055	45	2D	-
1010111	056	46	2E	.
110101111	057	47	2F	/
10110111	060	48	30	0
10111101	061	49	31	1
11101101	062	50	32	2
11111111	063	51	33	3
101110111	064	52	34	4
101011011	065	53	35	5
101101011	066	54	36	6
110101101	067	55	37	7
110101011	070	56	38	8
110110111	071	57	39	9
11110101	072	58	3A	:

Varicode	Oct	Dec	Hex	Glyph
1010111101	100	64	40	@
1111101	101	65	41	A
11101011	102	66	42	B
10101101	103	67	43	C
10110101	104	68	44	D
1110111	105	69	45	E
11011011	106	70	46	F
11111101	107	71	47	G
101010101	110	72	48	H
1111111	111	73	49	I
111111101	112	74	4A	J
101111101	113	75	4B	K
11010111	114	76	4C	L
10111011	115	77	4D	M
11011101	116	78	4E	N
10101011	117	79	4F	O
11010101	120	80	50	P
111011101	121	81	51	Q
10101111	122	82	52	R
1101111	123	83	53	S
1101101	124	84	54	T
101010111	125	85	55	U
110110101	126	86	56	V
101011101	127	87	57	W
101110101	130	88	58	X
101111011	131	89	59	Y
1010101101	132	90	5A	Z

Varicode	Oct	Dec	Hex	Glyph
1011011111	140	96	60	`
1011	141	97	61	a
1011111	142	98	62	b
101111	143	99	63	c
101101	144	100	64	d
11	145	101	65	e
111101	146	102	66	f
1011011	147	103	67	g
101011	150	104	68	h
1101	151	105	69	i
111101011	152	106	6A	j
10111111	153	107	6B	k
11011	154	108	6C	l
111011	155	109	6D	m
1111	156	110	6E	n
111	157	111	6F	o
111111	160	112	70	p
110111111	161	113	71	q
10101	162	114	72	r
10111	163	115	73	s
101	164	116	74	t
110111	165	117	75	u
1111011	166	118	76	v
1101011	167	119	77	w
11011111	170	120	78	x
1011101	171	121	79	y
111010101	172	122	7A	z

PSK-31
Upper - Lower Case
Sending Comparison
K7AGE

K7AGE *HD*

Real-World Performance of PSK-31

The power in a PSK-31 signal is concentrated

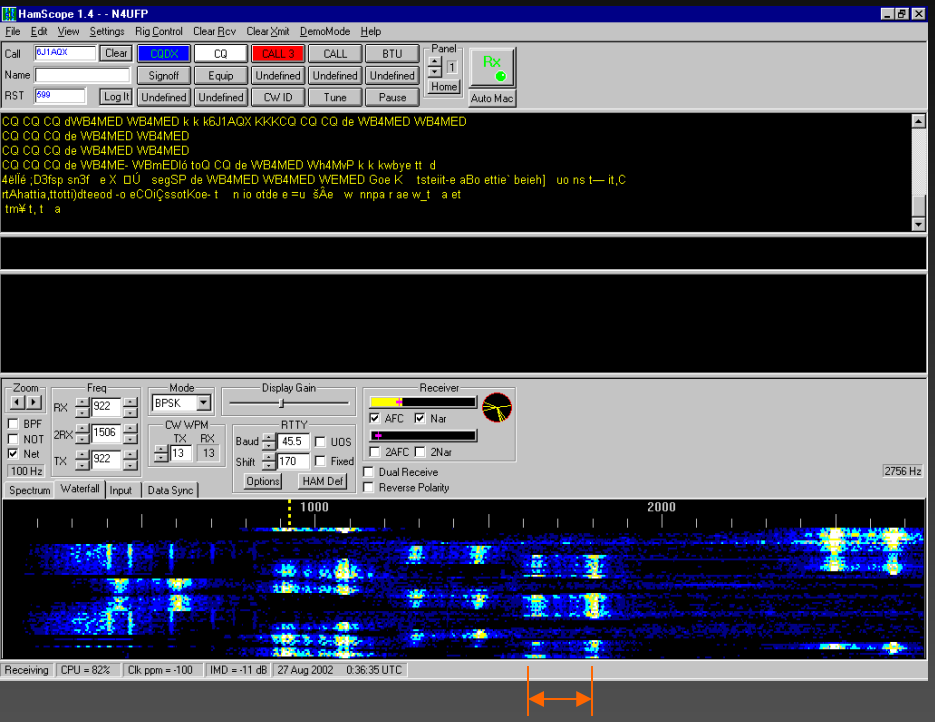
- **in a 31 Hz bandwidth,**
- **versus 250 Hz for RTTY**

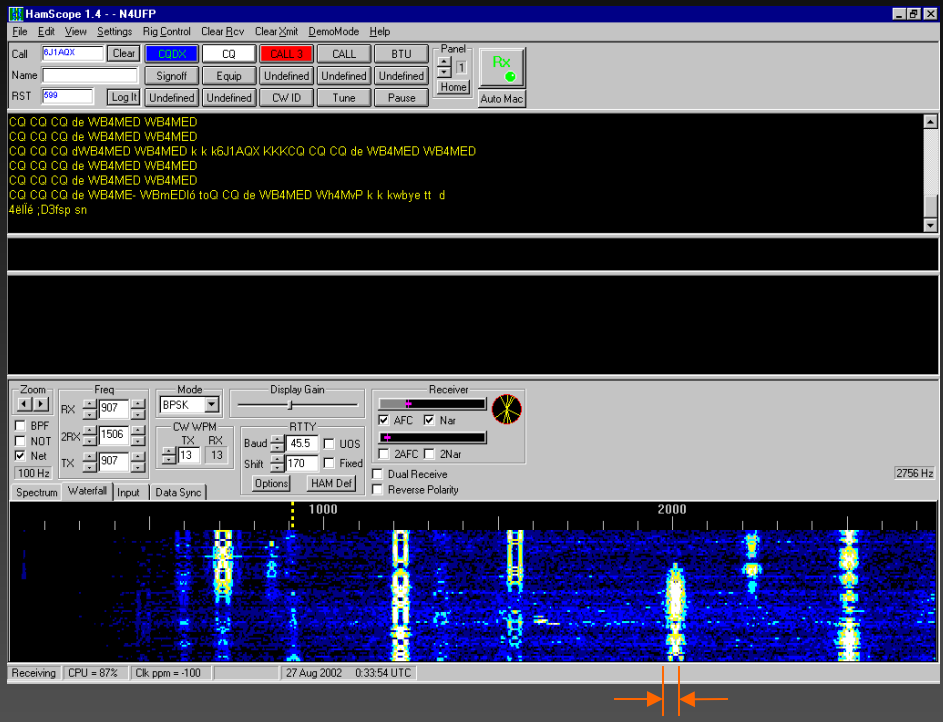
PSK is very power efficient

Transcontinental QSO's using PSK-31 are possible using much less than 50 W

- **QSOs with 5 watts are common**
- **PSK-31 is a great QRP mode for those of us non-CW ops**

Bandwidth Utilization





Waterfall display on the left shows several RTTY signals

Waterfall display on the right shows many PSK-31 signals

For the same character rate (~ 50 wpm) PSK uses 1/5 the bandwidth

A 3 kHz SSB channel can support 10 or more PSK QSO's

PSK-31 Station Requirements

1. Amateur transceiver that has low frequency drift
   - **Any modern solid state rig is fine (IC-706, IC-746, TS-940, TS2000, FT-1000, Omni VI, etc.)**
2. PC (90 MHz Pentium 1 or faster or a Mac)
   - **Most PSK-31 software is compatible with any version of Windows**
     - Popular on Linux, Raspberry Pi - Fldigi
   - **Sound card (16 bit Sound Blaster or better) is required**
   - **Old junk PC will work**
3. An interface that connects the PC and the transceiver
   - **Homebrew, easy to build your own**
   - **Commercially made (Tigertronics, RigBlaster, RASCAL, etc.)**
4. Computer Software
   - **Digipan, simple and free**
   - **FLDigi – Linux, Windows, & MAC, supports many digital modes, free**
   - **Ham Radio Deluxe – DM780, $$$ fully featured, many modes, more complex**

The PC Soundcard Interface

The interface provides matching and isolation between the audio inputs and outputs of the PC and the transceiver

The interface may also provide connections between the computer's serial port and the PTT input of the transceiver

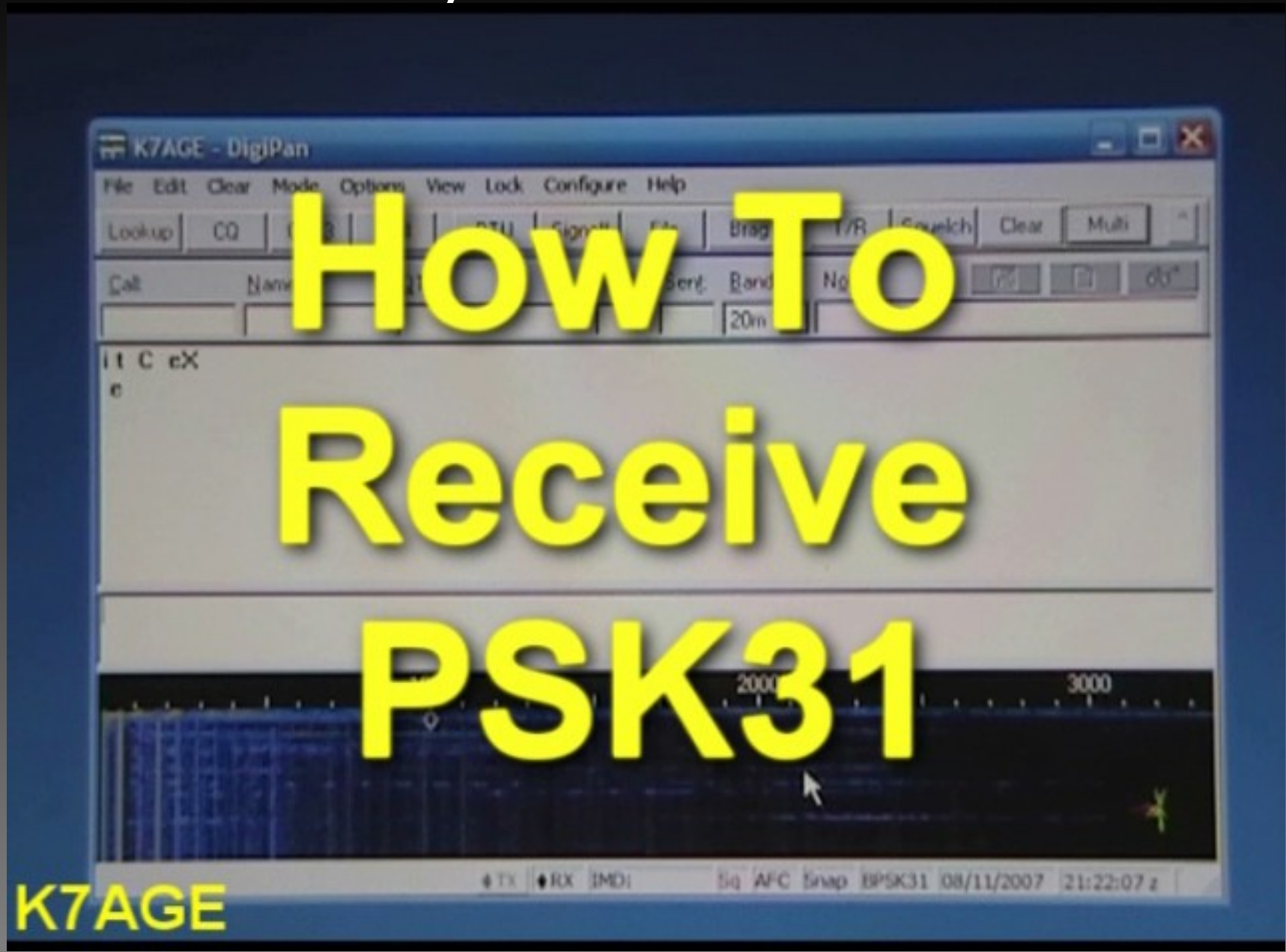
Commercially made interfaces provide lots of functions and are very easy to install.

A simple homebrew interface can normally be built for less than $10.

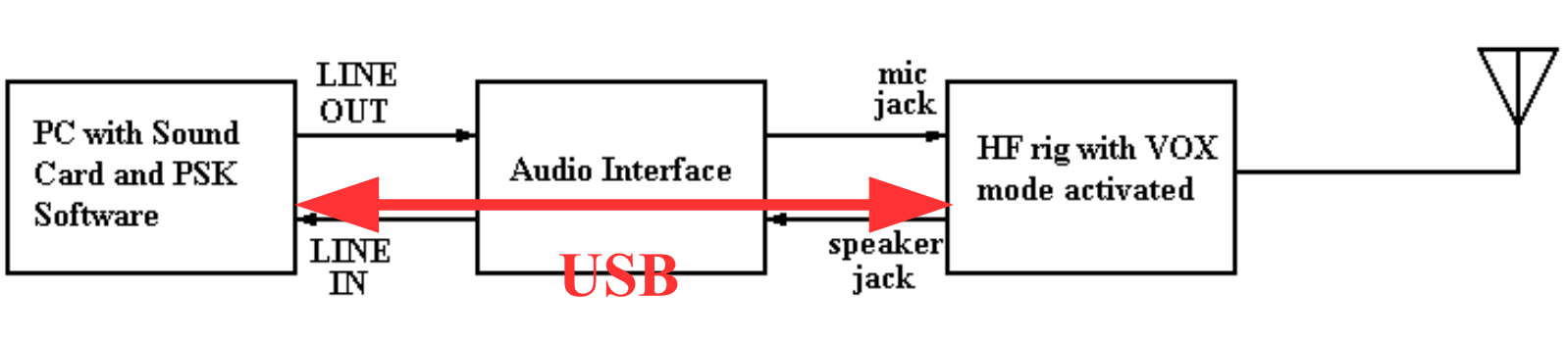
Many of the newer transceivers can be connected directly to the PC's USB port for sound card and control interface

ICOM 7100, 7300, 7600, & 7700 has built in sound card, USB cable to PC

My Video Demo



Basic PSK-31 Station Set-Up



The HF rig should be in the USB mode.

The VOX should be activated

Output power should be set to 30 – 50 W

The transmit level should be set using the level controls in the software or the rig's mic gain control so that the ALC level is in the desired range. Do not overdrive

The receive level should be adjusted to a level that does not overdrive the sound card

Audio Interface Circuits

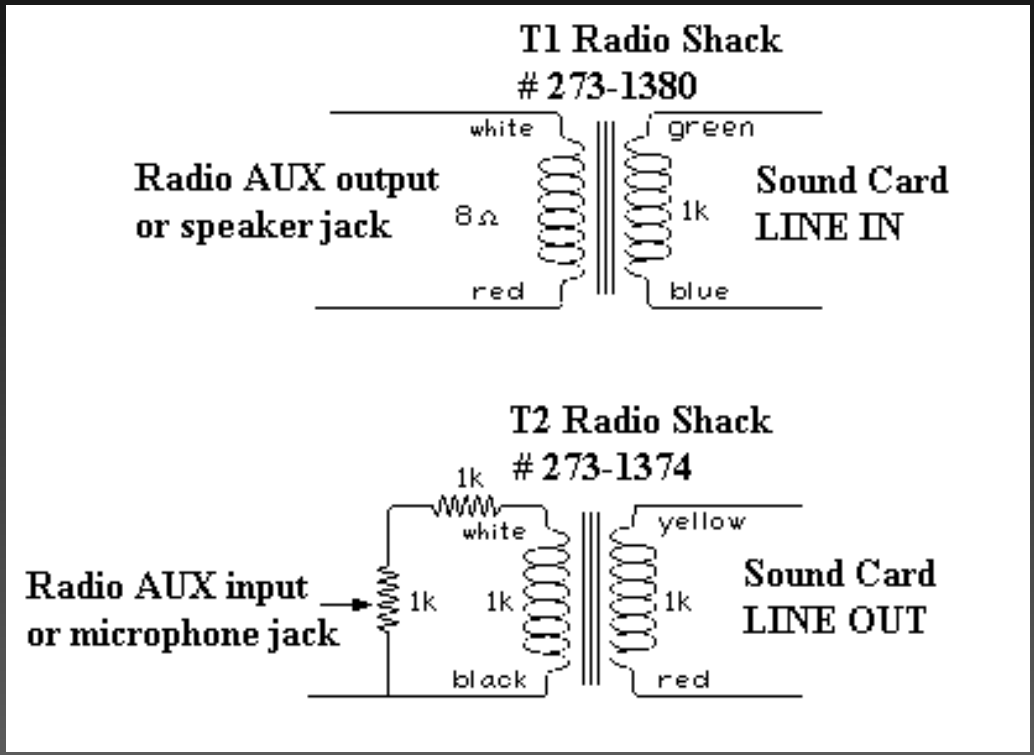
1. Acoustic Coupling

- **Rig's speaker is placed near the PC's microphone**
  - *As seen in K7AGE's video!*
- **Rig's microphone is placed next to the PC's speaker**
  - *I received emails from hams doing this!*
- **VOX is used for T/R switching**
- **Advantages**
  - Easy to try, no extra equipment required.
- **Disadvantages**
  - Transmit levels can be tricky to adjust
  - Ambient noise degrades signal

Audio Interface Circuits

2. Audio Coupling

- **Audio transformers, a resistor, and a potentiometer are required**
- **Provides good isolation**
- **Potentiometer is used to set audio drive level for the transceiver**

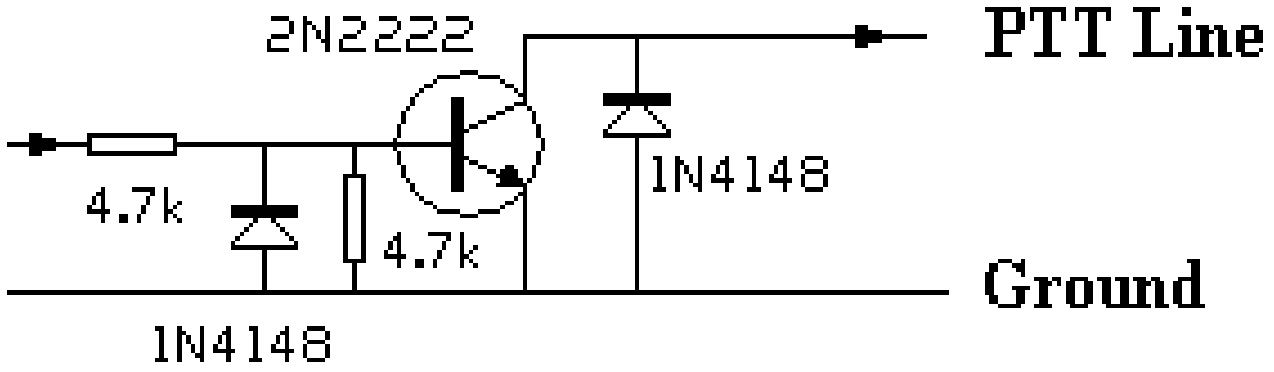


PTT/RS-232 Interface Circuit

- **If you are good,**
  - **You can build this into a DB9 connector hood.**

RTS Line
pin 4 on DB25
pin 7 on DB9

Ground
pin 7 on DB25
pin 5 on DB9



VOX Switching

2. VOX operation

- **Extremely simple; no connection is required between the RS-232 port and the rig**
- **VOX gain, delay and ANTI-VOX must be adjusted for proper T/R switching**
- **Applies only to transceivers that have VOX circuits**
- **Provides good isolation between rig and computer**
- **Leaves the serial port free for rig control**
-
- **Not all radio allow VOX to be used with rear audio connectors**

Setting up your Station for PSK31

Set-up of receive audio levels

- **Adjust the "Line In" that gives the best looking waterfall display in the PSK 31 software**

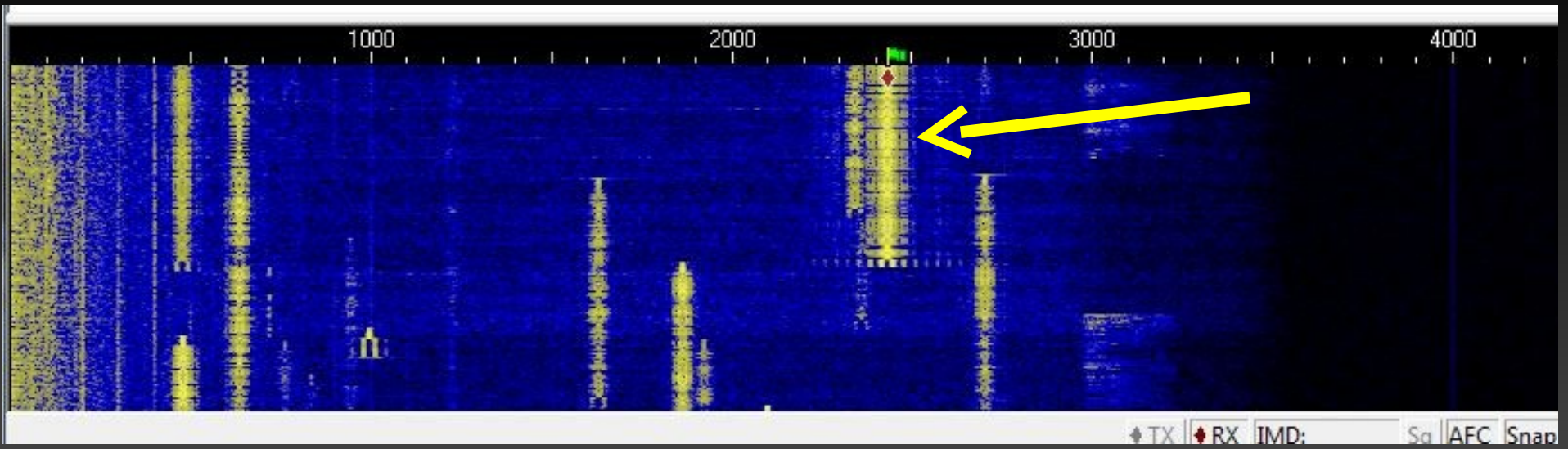
Set-up of transmit audio levels

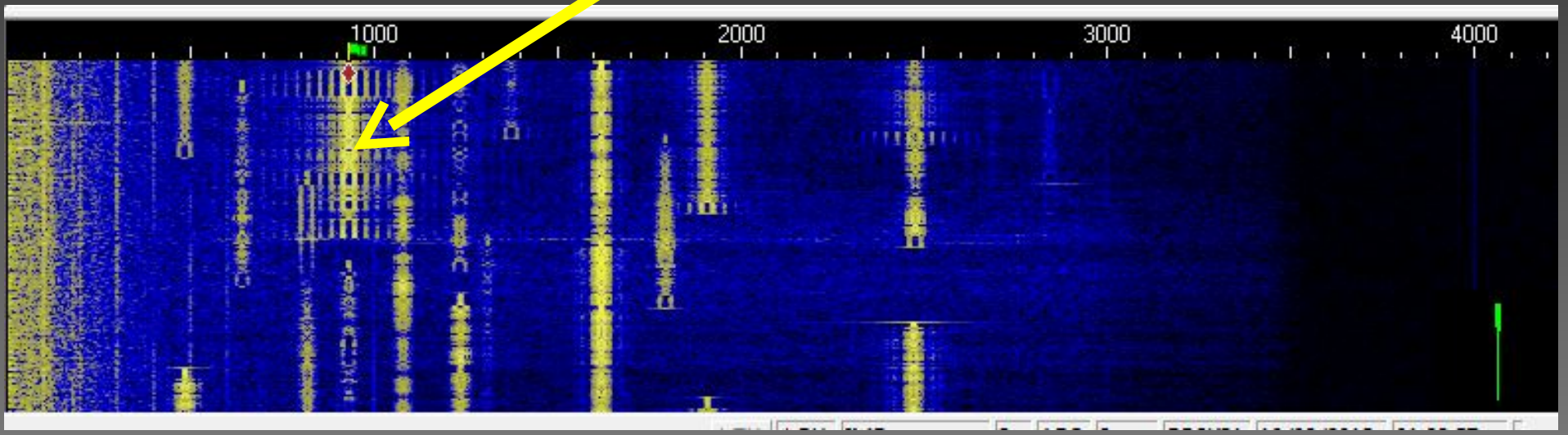
- **This is done through MS Windows' audio mixer or application.**
- **Transmit an idle PSK31 signal into a dummy load and monitor the RF power.**
- **Increase level until RF power stops increasing, then back off a little**
- **Read your radio's manual for correct ALC setting**

Watch out for "You Got Mail" blasting on 20 meters!

- **Shut down programs that make noise**
- **If using second sound card, configure it for only radio sounds!**

This is what over driving looks like





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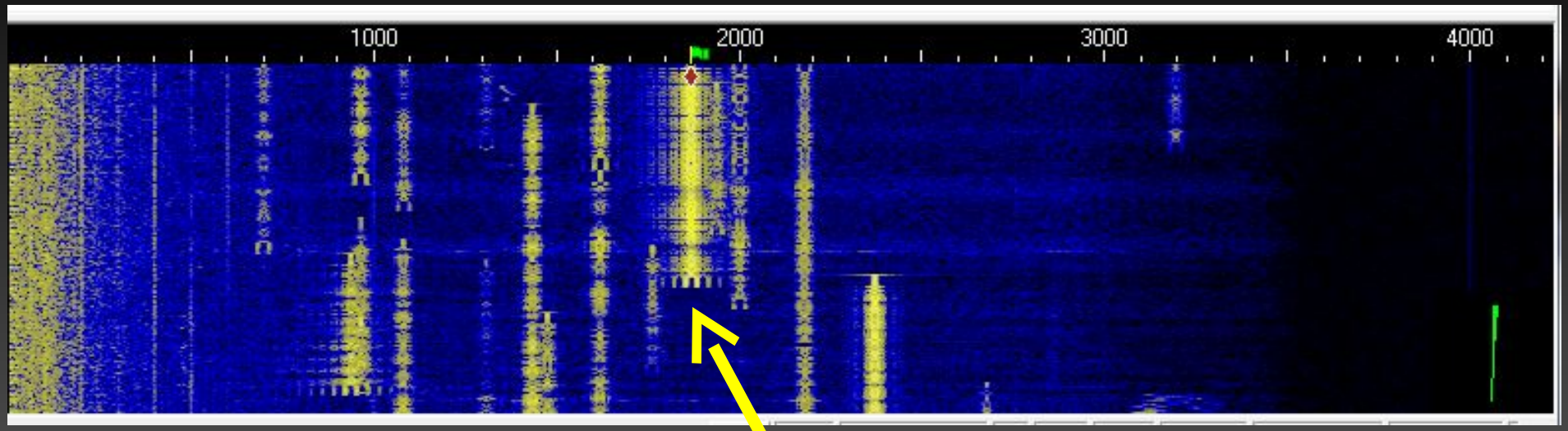
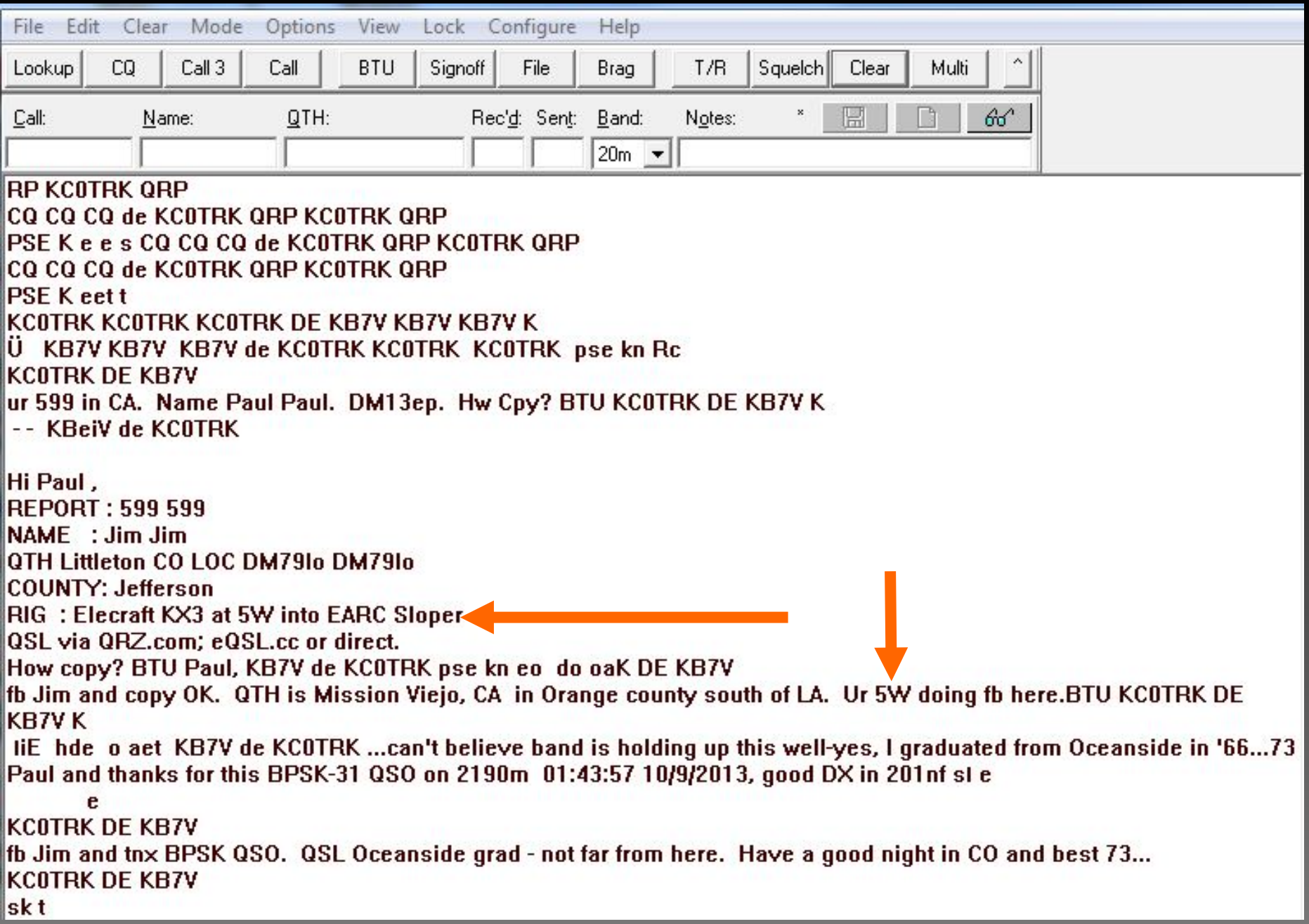


Even QRP can be wide
5 watts from a KX3 station


File Edit Clear Mode Options View Lock Configure Help
Lookup CQ Call 3 Call BTU Signoff File Brag T/R Squelch Clear Multi
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REPORT : 599 599
NAME : Jim Jim
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COUNTY: Jefferson
RIG : Elecraft KX3 at 5W into EARC Sloper
QSL via QRZ.com; eQSL.cc or direct.
How copy? BTU Paul, KB7V de KC0TRK pse kn eo do oaK DE KB7V
fb Jim and copy OK. QTH is Mission Viejo, CA in Orange county south of LA. Ur 5W doing fb here.BTU KC0TRK DE KB7V K
IiE hde o aet KB7V de KC0TRK ...can't believe band is holding up this well-yes, I graduated from Oceanside in '66...73 Paul and thanks for this BPSK-31 QSO on 2190m 01:43:57 10/9/2013, good DX in 201nf sI e
e
KC0TRK DE KB7V
fb Jim and tnx BPSK QSO. QSL Oceanside grad - not far from here. Have a good night in CO and best 73...
KC0TRK DE KB7V
sk t

Where to hear PSK-31?

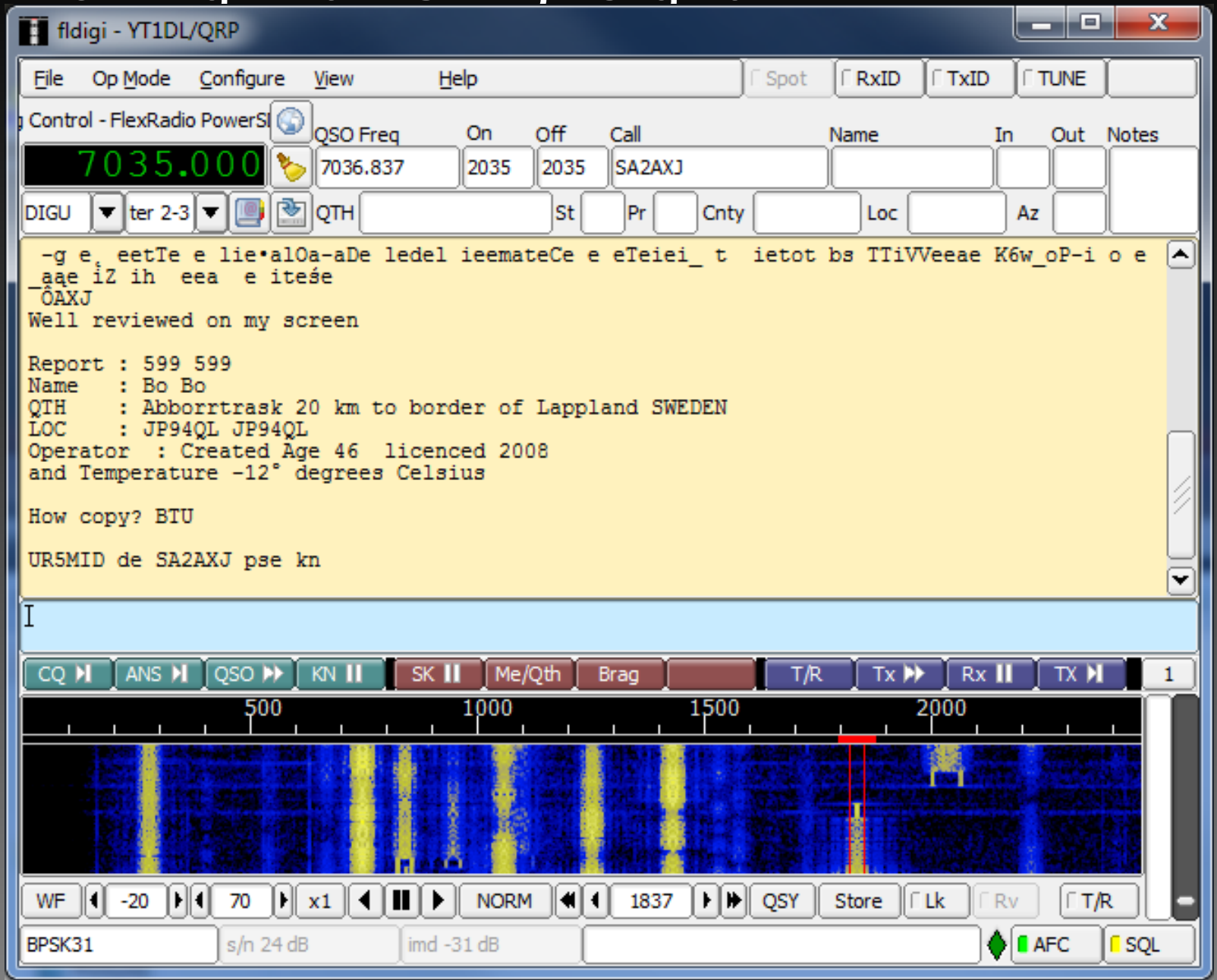
PSK-31 activity is concentrated around the following frequencies:

DIAL Display

USB Mode

- **1.83815 MHz**
- **3.580 MHz**
- **7.035 MHz**
- **14.070 MHz, most popular**
- **18.100 MHz**
- **21.070 MHz**
- **24.920 MHz**
- **28.120 MHz**
- **50.290 MHz**

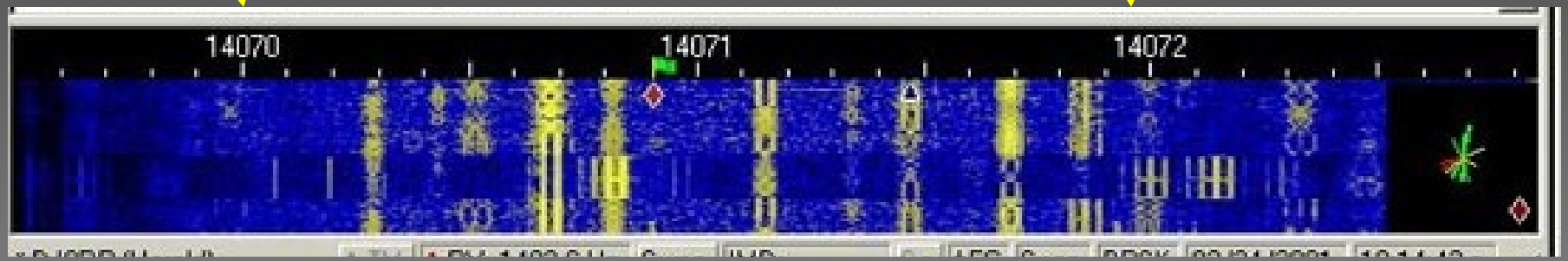
Tuning in a PSK-31 signal



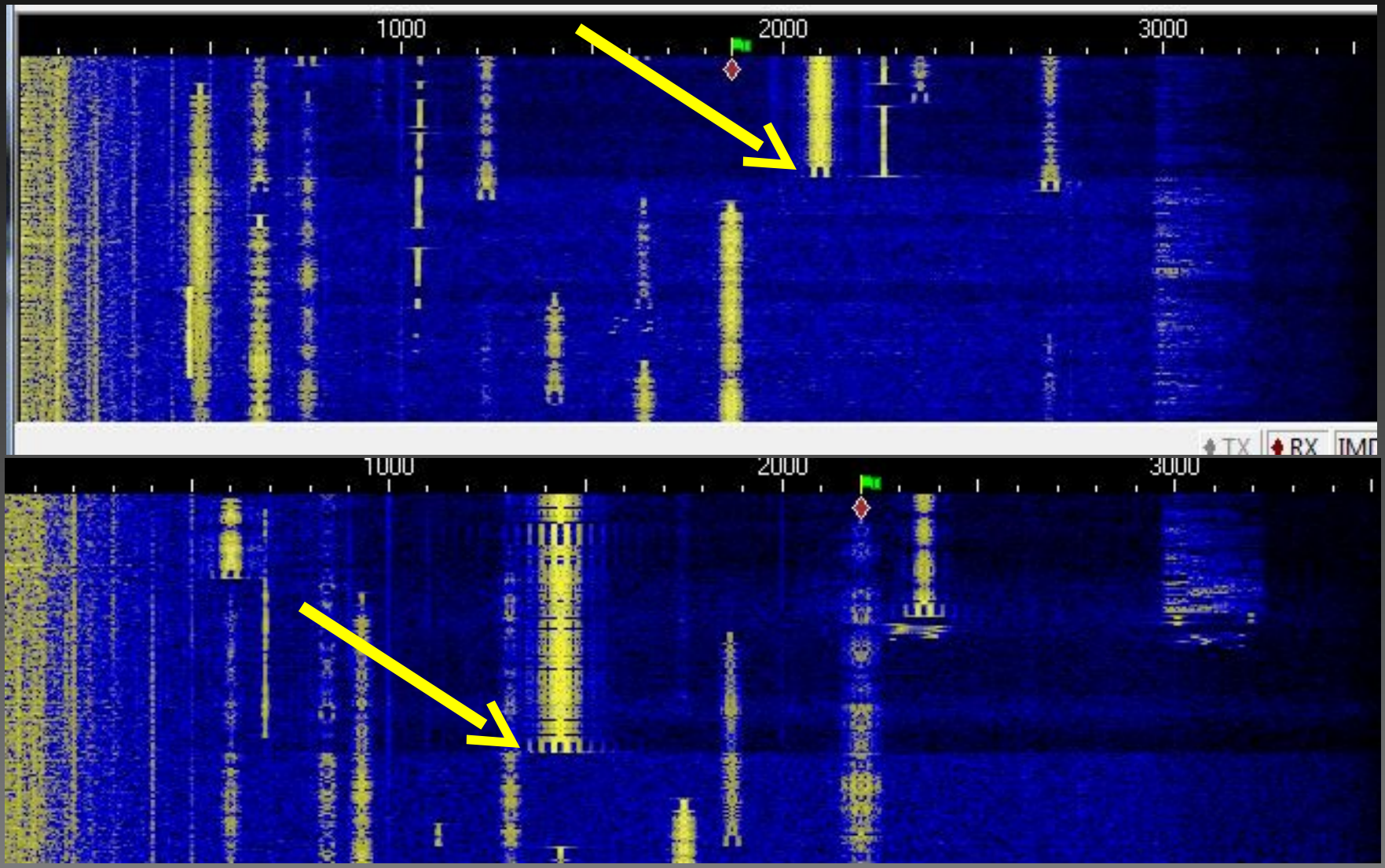
Tuning in a PSK-31 signal

by clicking the waterfall, not by turning the knob

- 14.070 MHz Dial Display USB suppressed carrier
- 1 KHz tone = 14.071 frequency
- 2 KHz tone = 14.072 frequency

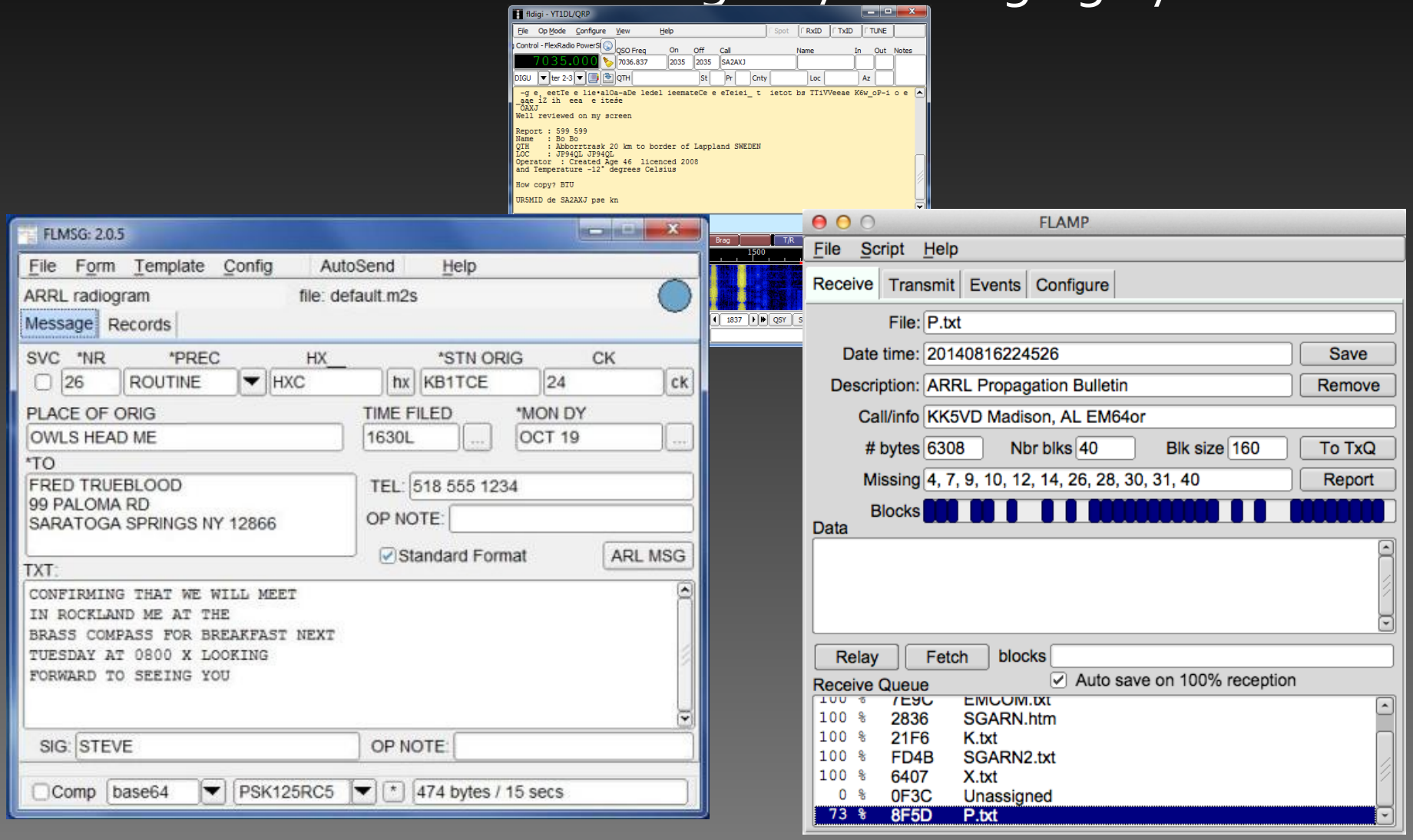


Receiver AGC action
Background changes with strong station



Fldigi NBEMS

Narrow Band Emergency Messaging System



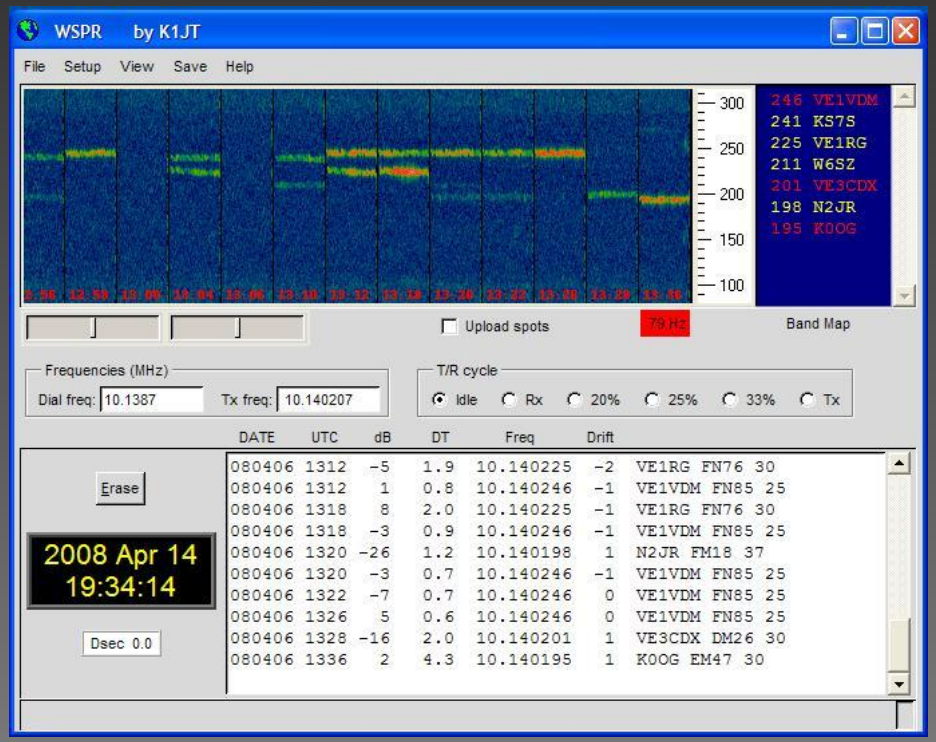
Other Sound Card Modes

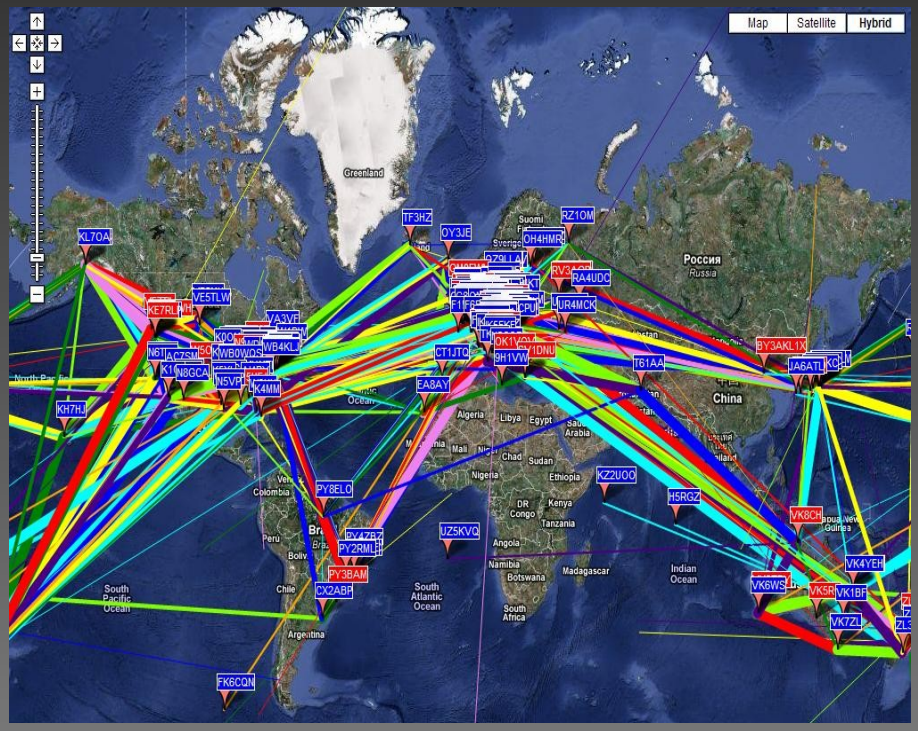
- *WSPR*
- *JT-65HF*
- *SSTV*
- *Digital SSTV*
- *Free DV*
- *Hellschreiber*

WSPR

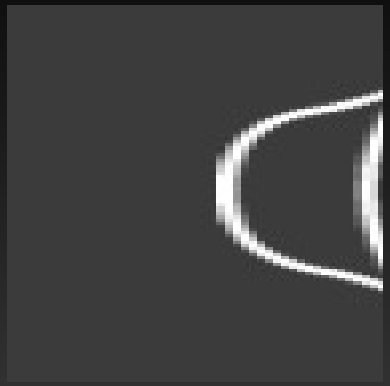
- *Weak Signal Propagation Reporter*

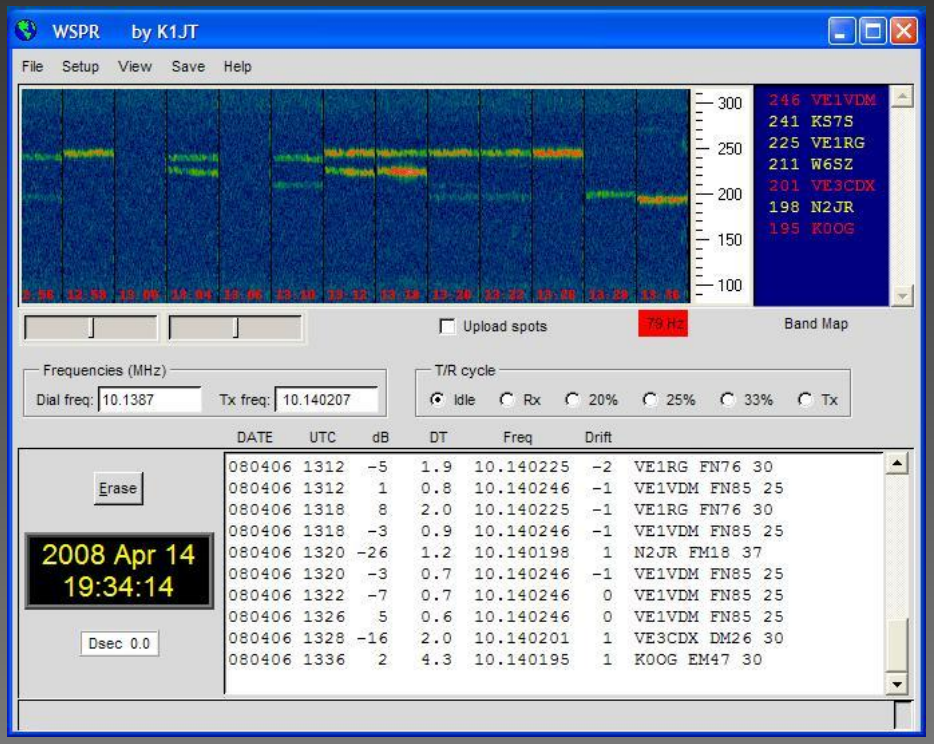
WSPR implements a protocol designed for probing potential propagation paths with low-power transmissions. Normal transmissions carry a station's callsign, Maidenhead grid locator, and transmitter power in dBm. The program can decode signals with S/N as low as -28 dB in a 2500 Hz bandwidth. Stations with internet access can automatically upload their reception reports to a central database called WSPRnet, which includes a mapping facility. 20 Meters 14.0956

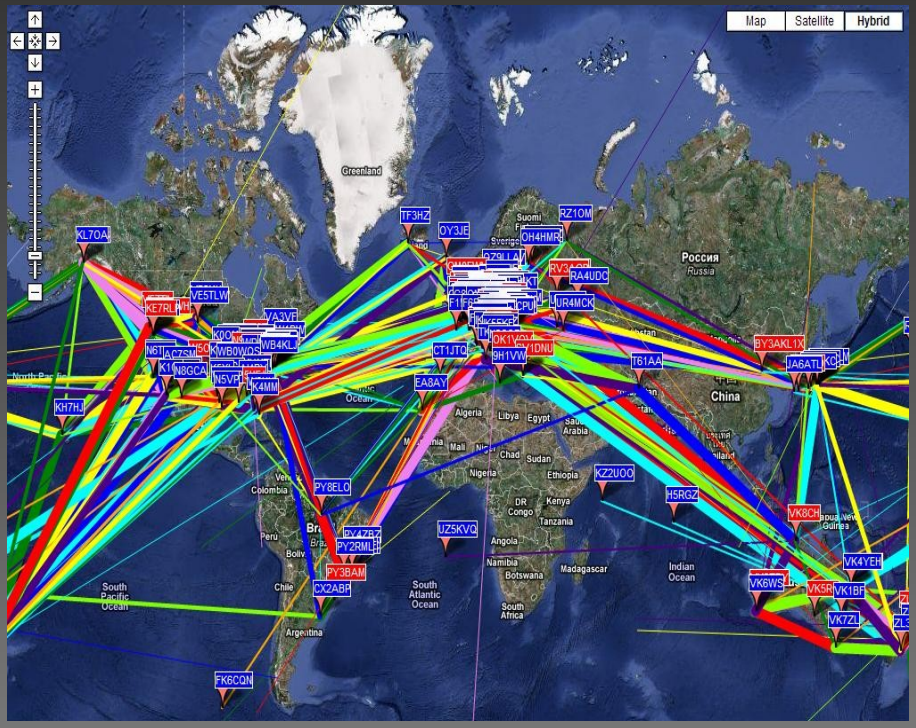




WSPR



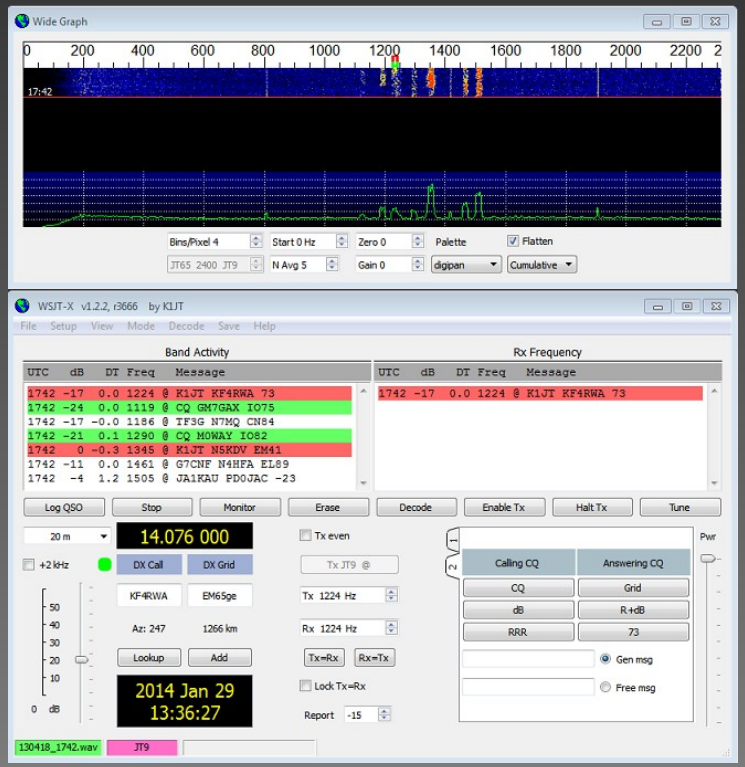

WSPR by K1JT
File Setup View Save Help
246 VE1VDM
241 KS7S
225 VE1RG
211 W6SZ
201 VE3CDX
198 N2JR
195 K0OG
300
250
200
150
100
Upload spots
79 Hz
Band Map
Frequencies (MHz)
Dial freq: 10.1387
Tx freq: 10.140207
T/R cycle
Idle Rx 20% 25% 33% Tx
DATE UTC dB DT Freq Drift
080406 1312 -5 1.9 10.140225 -2 VE1RG FN76 30
080406 1312 1 0.8 10.140246 -1 VE1VDM FN85 25
080406 1318 8 2.0 10.140225 -1 VE1RG FN76 30
080406 1318 -3 0.9 10.140246 -1 VE1VDM FN85 25
080406 1320 -26 1.2 10.140198 1 N2JR FM18 37
080406 1320 -3 0.7 10.140246 -1 VE1VDM FN85 25
080406 1322 -7 0.7 10.140246 0 VE1VDM FN85 25
080406 1326 5 0.6 10.140246 0 VE1VDM FN85 25
080406 1328 -16 2.0 10.140201 1 VE3CDX DM26 30
080406 1336 2 4.3 10.140195 1 K0OG EM47 30
Erase
2008 Apr 14
19:34:14
Dsec 0.0


Map
Satellite
Hybrid
Greenland
Россия
Russia
China
Indian Ocean
South Atlantic Ocean
South Pacific Ocean
Algeria
Libya
Egypt
Nigeria
Chad
Sudan
Ethiopia
Kenya
Tanzania
Angola
Namibia
Botswana
Madagascar
South Africa
Argentina
Chile
Peru
Colombia
Mali
Saudi Arabia
TF3HZ
OY3JE
KL7OA
VE5TLW
K4MM
EA8AY
CT1JTC
9H1VW
T61AA
KH7HJ
PY8ELO
PY2RMI
PY3BAM
CX2ABP
FK6CQN
KZ2UOO
H5RGZ
VK8CH
VK4YEH
VK1BF
VK5RI
VK6WS
VK7ZL

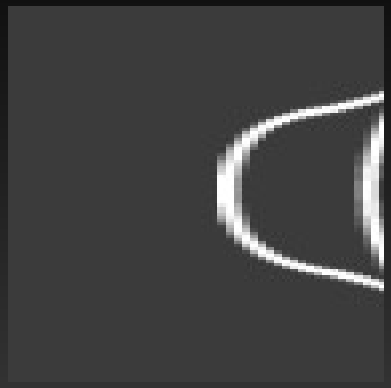
JT-65/9HF WSJT-X

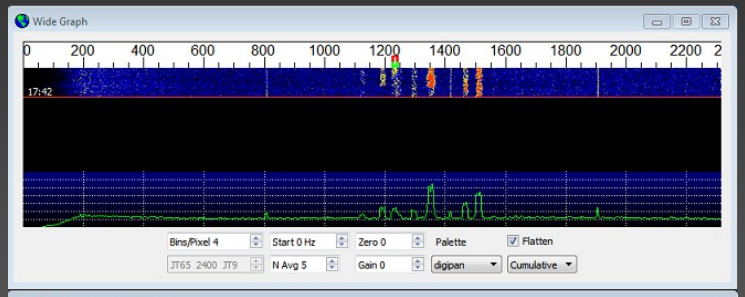
Weak Signal Communication, by K1JT

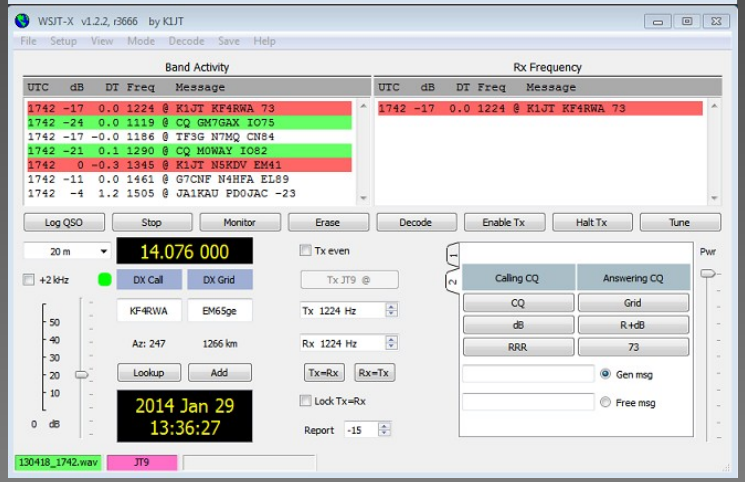
WSJT offers specific digital protocols optimized for EME (moonbounce), meteor scatter, and ionospheric scatter, at VHF/UHF, as well as for HF skywave propagation. The program can decode fraction-of-a-second signals reflected from ionized meteor trails and steady signals 10 dB below the audible threshold. Check the WSJT page and links therein for details about modes JTMS, FSK441, ISCAT, JT6M, JT65, and JT4. 20 Meters: 14.076



JT-65HF




Wide Graph
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2
17:42
Bins/Pixel 4
Start 0 Hz
Zero 0
Palette
Flatten
JT65 2400 JT9
N Avg 5
Gain 0
digipan
Cumulative


WSJT-X v1.2.2, r3666 by K1JT
File Setup View Mode Decode Save Help
Band Activity
UTC dB DT Freq Message
1742 -17 0.0 1224 @ K1JT KF4RWA 73
1742 -24 0.0 1119 @ CQ GM7GAX IO75
1742 -17 -0.0 1186 @ TF3G N7MQ CN84
1742 -21 0.1 1290 @ CQ M0WAY IO82
1742 0 -0.3 1345 @ K1JT N5KDV EM41
1742 -11 0.0 1461 @ G7CNF N4HFA EL89
1742 -4 1.2 1505 @ JA1KAU PD0JAC -23
Rx Frequency
UTC dB DT Freq Message
1742 -17 0.0 1224 @ K1JT KF4RWA 73
Log QSO
Stop
Monitor
Erase
Decode
Enable Tx
Halt Tx
Tune
20 m
14.076 000
Tx even
+2 kHz
DX Call
DX Grid
Tx JT9 @
KF4RWA
EM65ge
Tx 1224 Hz
Az: 247
1266 km
Rx 1224 Hz
Lookup
Add
Tx=Rx
Rx=Tx
2014 Jan 29
13:36:27
Lock Tx=Rx
Report
-15
Calling CQ
Answering CQ
CQ
Grid
dB
R+dB
RRR
73
Gen msg
Free msg
Pwr
130418_1742.wav
JT9

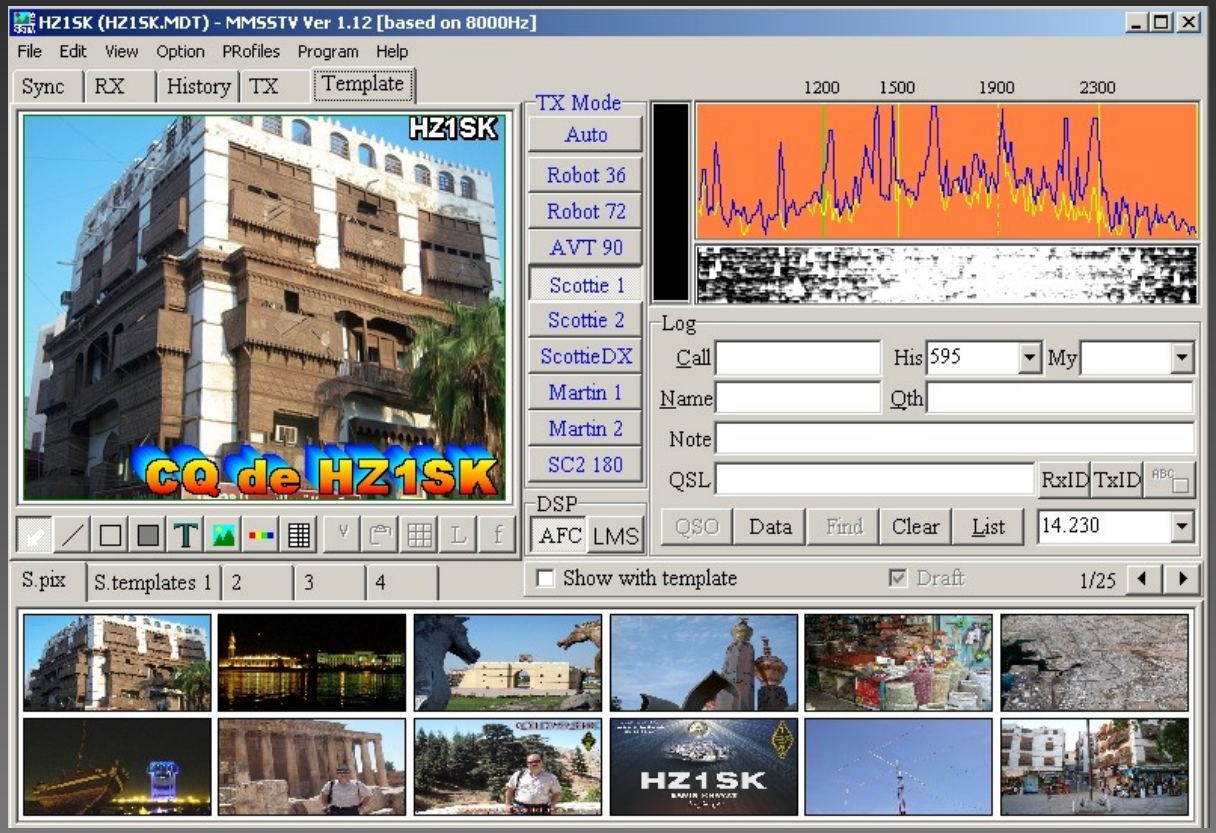

On 20m , show signals rcvd by the callsign K7AGE using JT65 over the last 1 hour
No recent reception reports. Automatic refresh in 5 minutes. Large markers are monitors.
There are 256 active JT65 monitors on 20m. Show all JT65 on all bands. Show all on all bands. Legend
Greenland
Iceland
Russia
Canada
Mexico
North Pacific Ocean
North Atlantic Ocean
Venezuela
Colombia
Peru
Brazil
Bolivia
Chile
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Kazakhstan
Mongolia
China
Turkey
Iran
Iraq
Afghanistan
Pakistan
India
Thailand
Algeria
Libya
Egypt
Saudi Arabia
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Kenya
Tanzania
Angola
Namibia
Botswana
Madagascar
South Africa
Monitor: ER1LG Loc KN46jx
in Moldova
Receiving: JT65 on 14.079 MHz (20m)
Using: WSJT-X v1.6.0-devel r5210
Show all seen by ER1LG
PSK Reporter

SSTV

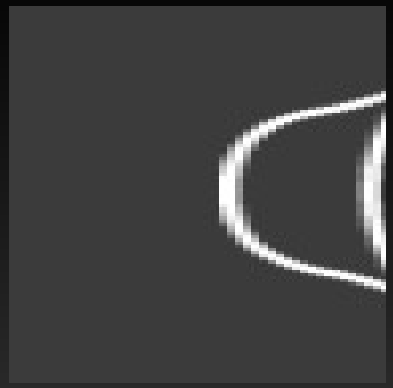
Slow Scan TV

Developed back in the 50s, provides sending and receiving still picture over a voice circuit.

MMSSTV, free and popular, 20 Meters 14.230



SSTV

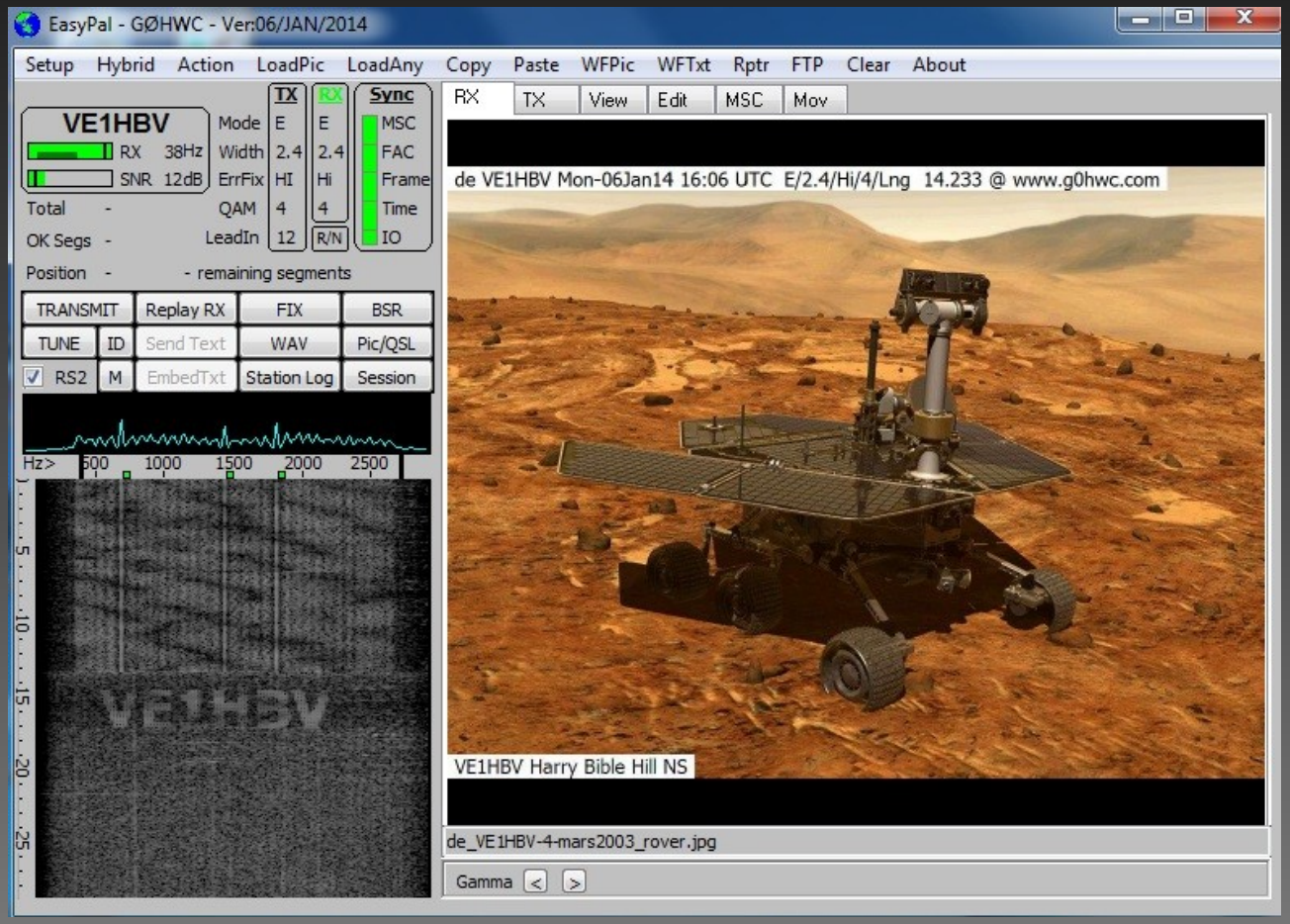



HZ1SK (HZ1SK.MDT) - MMSSTV Ver 1.12 [based on 8000Hz]
File Edit View Option PRofiles Program Help
Sync RX History TX Template
HZ1SK
CQ de HZ1SK
TX Mode
Auto
Robot 36
Robot 72
AVT 90
Scottie 1
Scottie 2
ScottieDX
Martin 1
Martin 2
SC2 180
DSP
AFC LMS
1200 1500 1900 2300
Log
Call His 595 My
Name Qth
Note
QSL RxID TxID
QSO Data Find Clear List 14.230
S.pix S.templates 1 2 3 4
Show with template Draft 1/25
HZ1SK

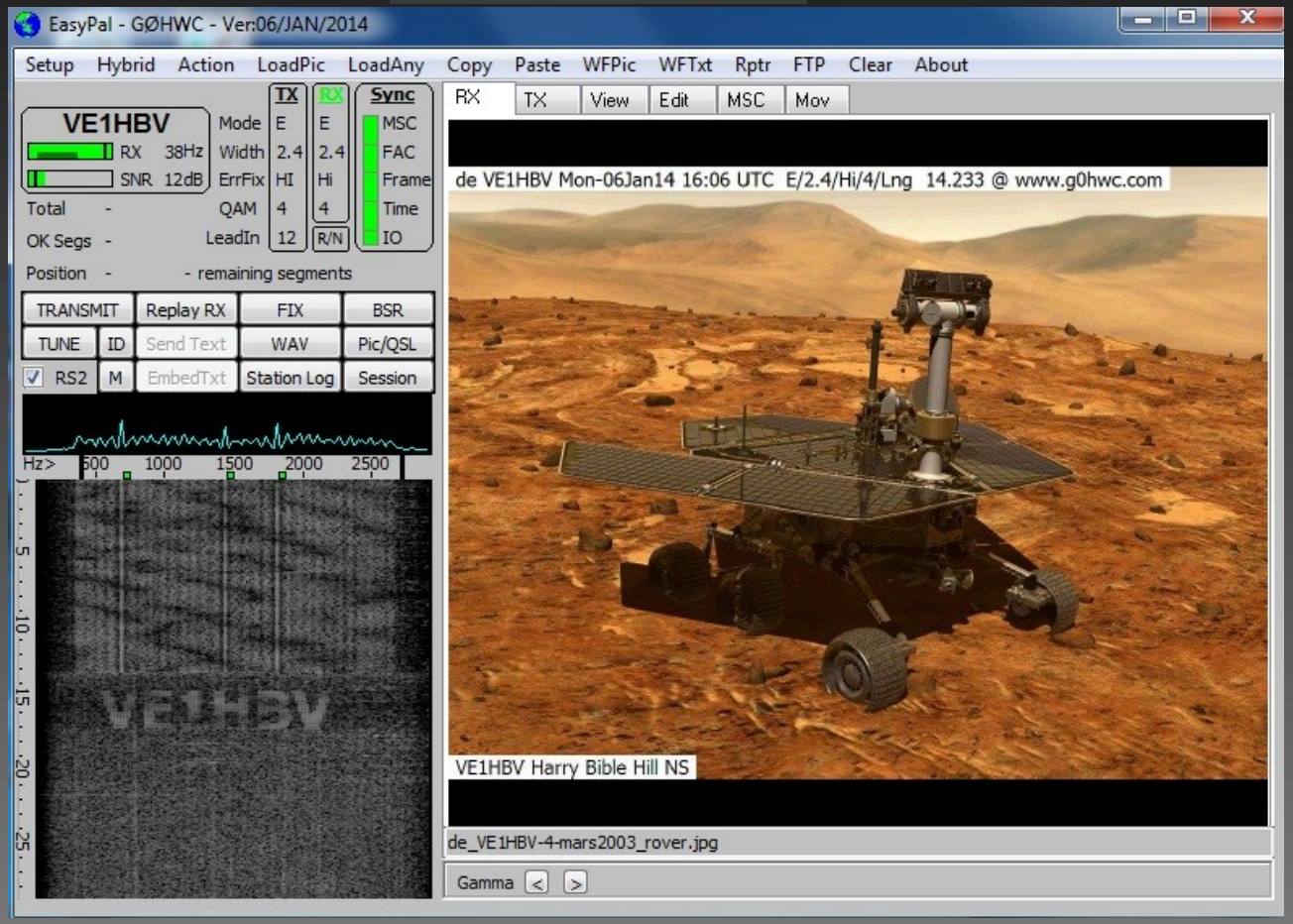
Digital SSTV

Digital picture file transfer

EasyPal, free and popular, 20 Meters 14.233



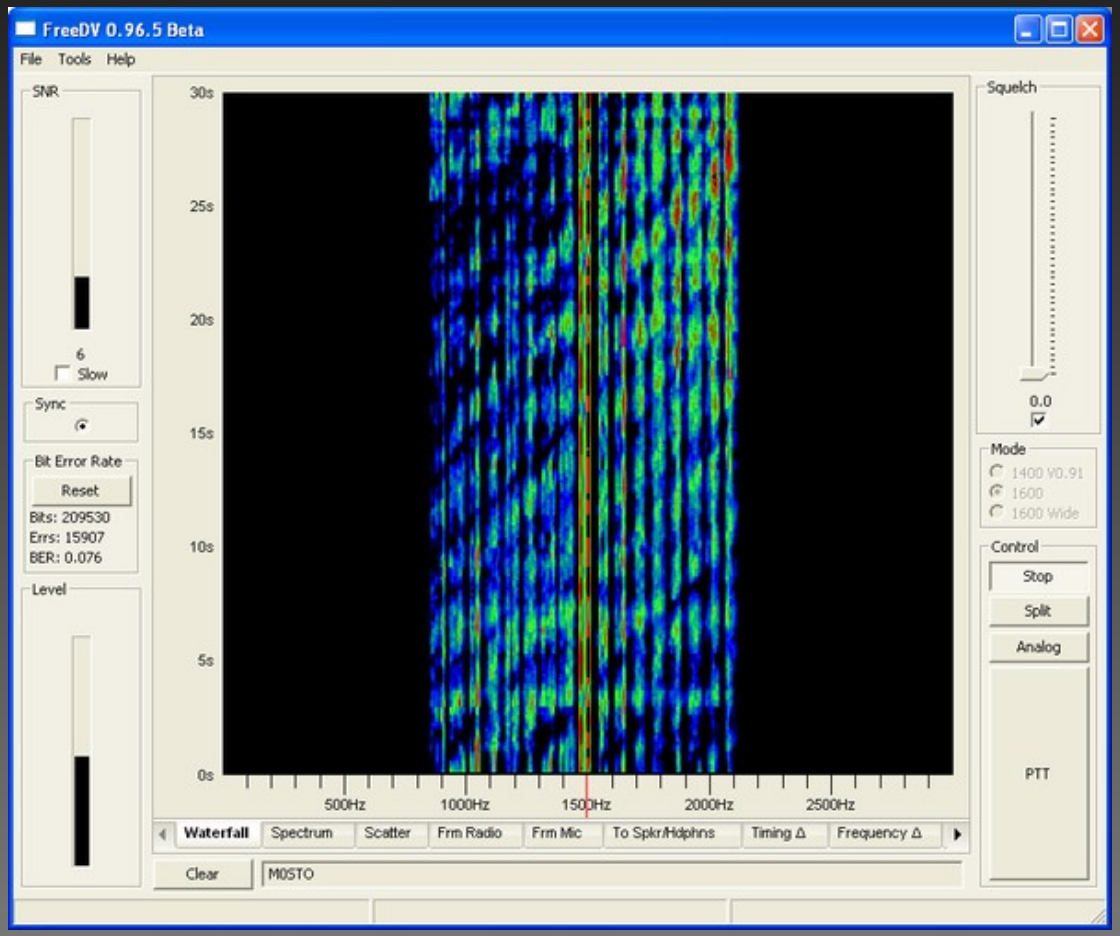
Digital SSTV



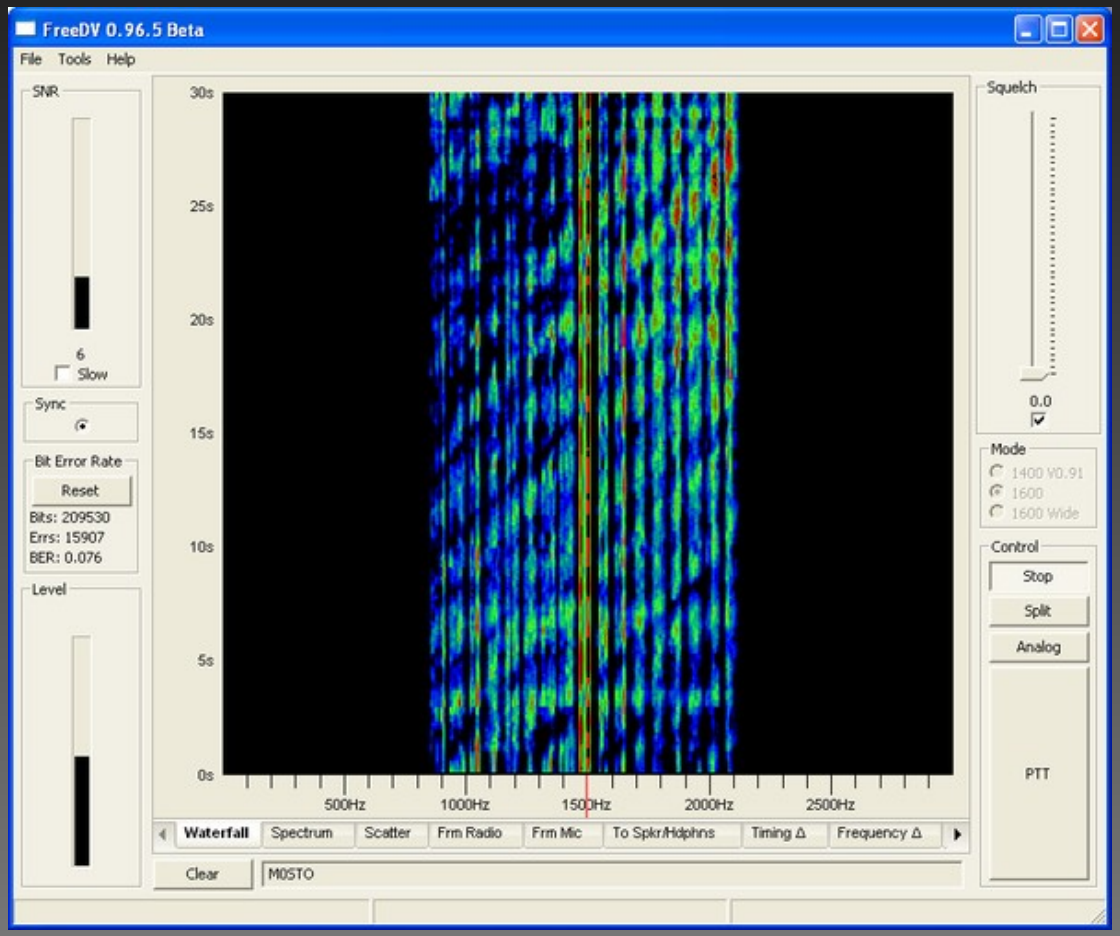
Free DV

Digital voice on HF

Free DV, free and popular, needs two sound cards, 20 Meters 14.236



Free DV

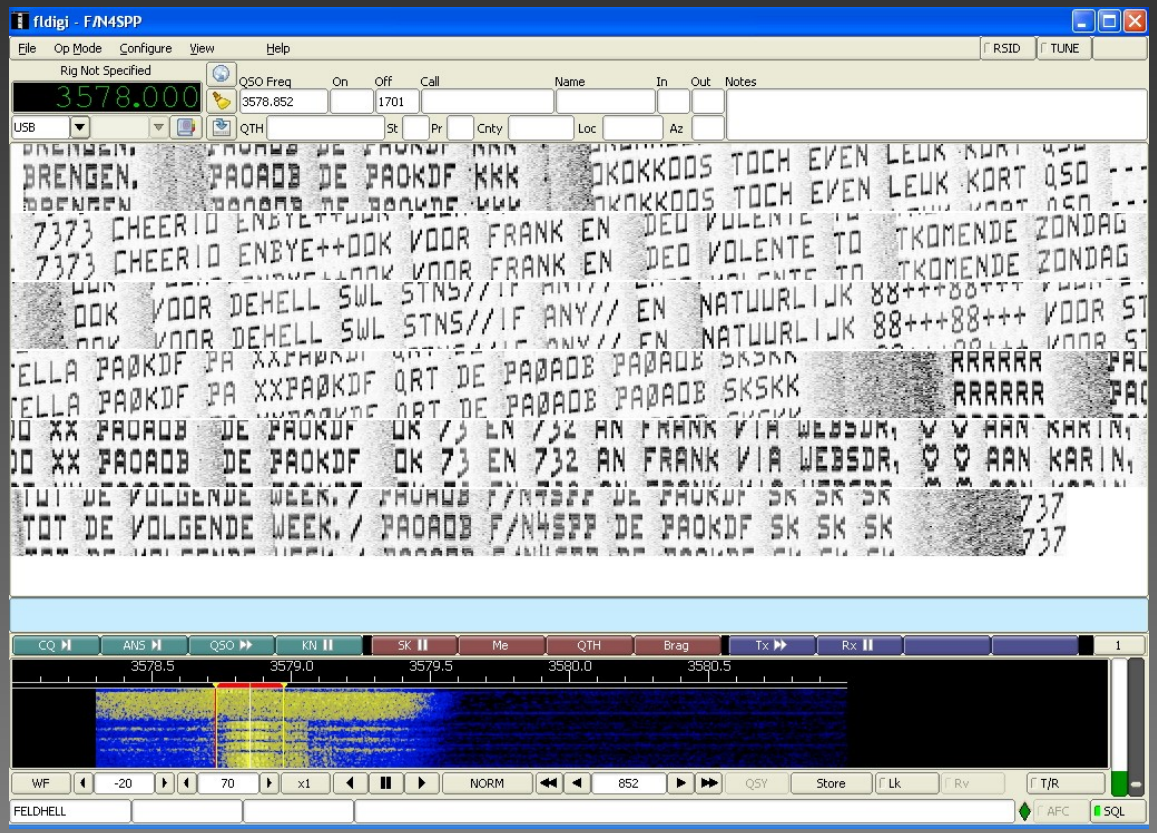

FreeDV 0.96.5 Beta
File Tools Help
SNR
6
Slow
Sync
Bit Error Rate
Reset
Bits: 209530
Errs: 15907
BER: 0.076
Level
30s
25s
20s
15s
10s
5s
0s
500Hz
1000Hz
1500Hz
2000Hz
2500Hz
Waterfall
Spectrum
Scatter
Frm Radio
Frm Mic
To Spkr/Hdphns
Timing Δ
Frequency Δ
Clear
M0STO
Squelch
0.0
Mode
1400 V0.91
1600
1600 Wide
Control
Stop
Split
Analog
PTT

Hellschreiber

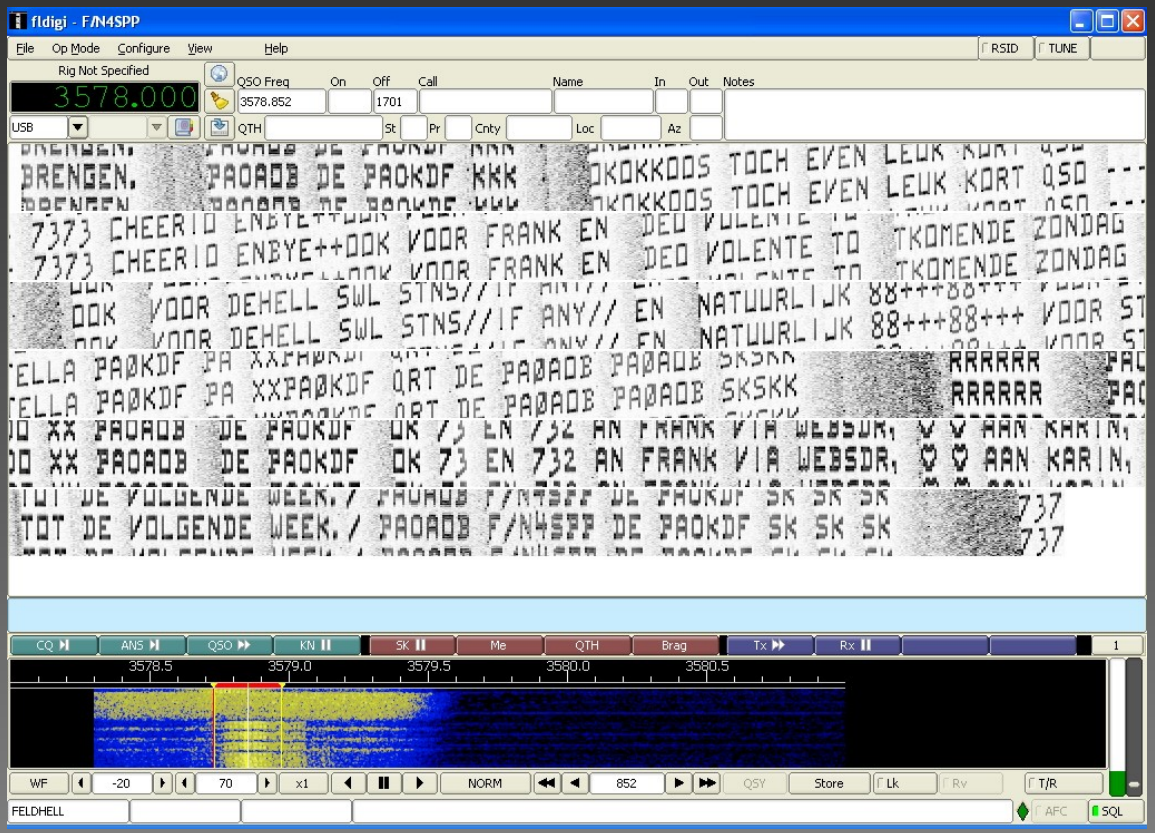
Fax mode from back in the 20s

Feld Hell Club, monthly sprint contests

FLDigi , 20 Meters 14.063



Hellschreiber



Where to Find More Information

- PSK31 Guide
  - bpsk31.com/
- Official home page
  - aintel.bi.ehu.es/psk31.html
- Steve Ford's original QST article
  - arrl.org/tis/info/HTML/psk31 ()
- Google – PSK-31
- *And, I have many PSK-31 videos*

K7AGE

Thanks for listening
Randy, K7AGE

Twitter @k7age

k7age@k7age.com

Get on the air

Be Radio Active