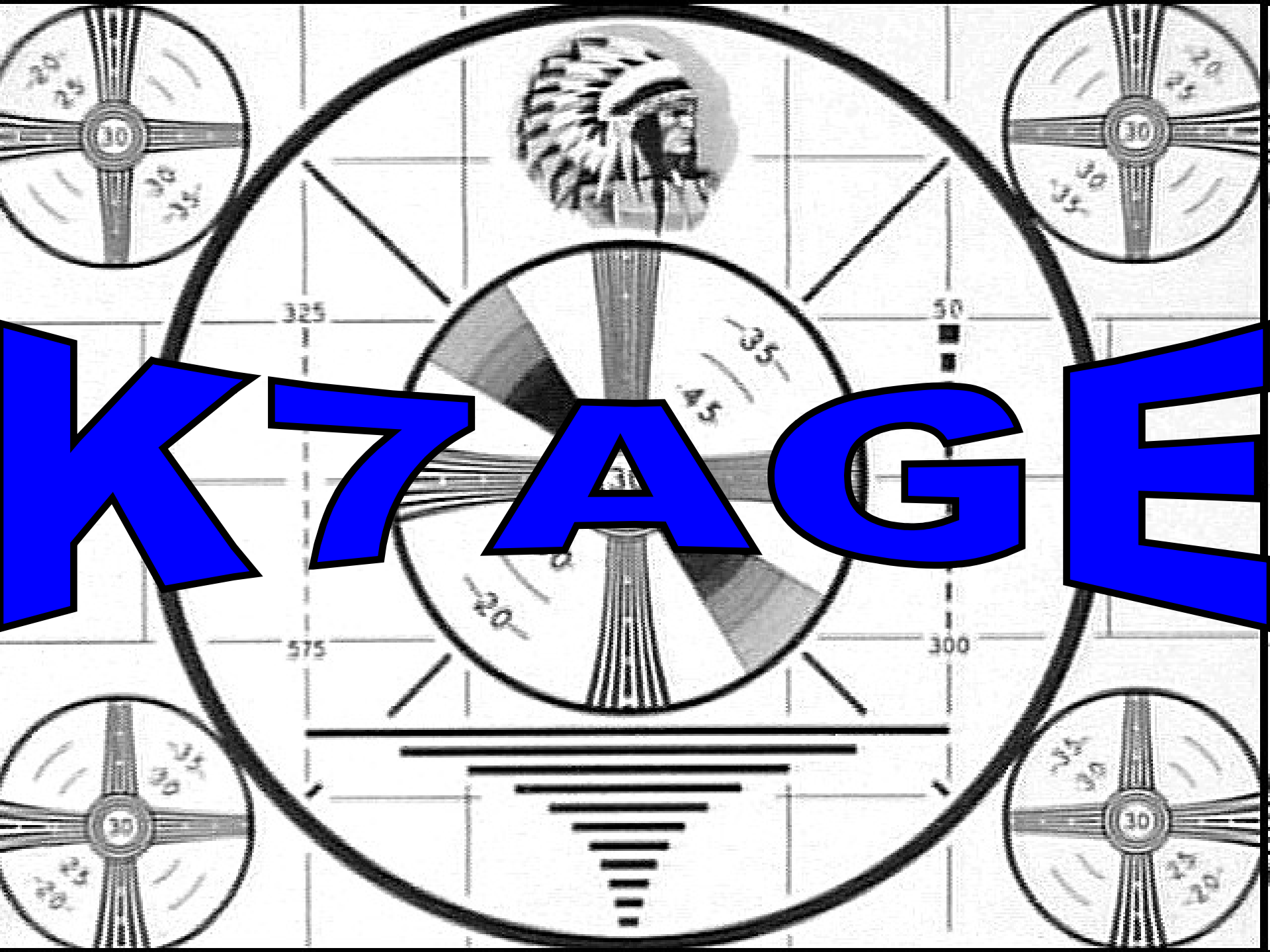

K7AGE

PSK-31

A Digital HF Mode

By N4UFP Marc Tarplee

Tweaks by 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 engin2eer**
- **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 7 years

100+ videos

Over 2,700,00 total views

Over 13000+ subscribers

What is PSK-31?

PSK-31 is a digital mode developed by

Peter Martinez, G3PLX

- ***Introduced in 1998, 15 years ago***

PSK's advantages include:

- **Less bandwidth, more stations**
- **Better error rate than RTTY on noisy channels**
- **Lower RF power requirement, great for QRP ops**

PSK-31 uses

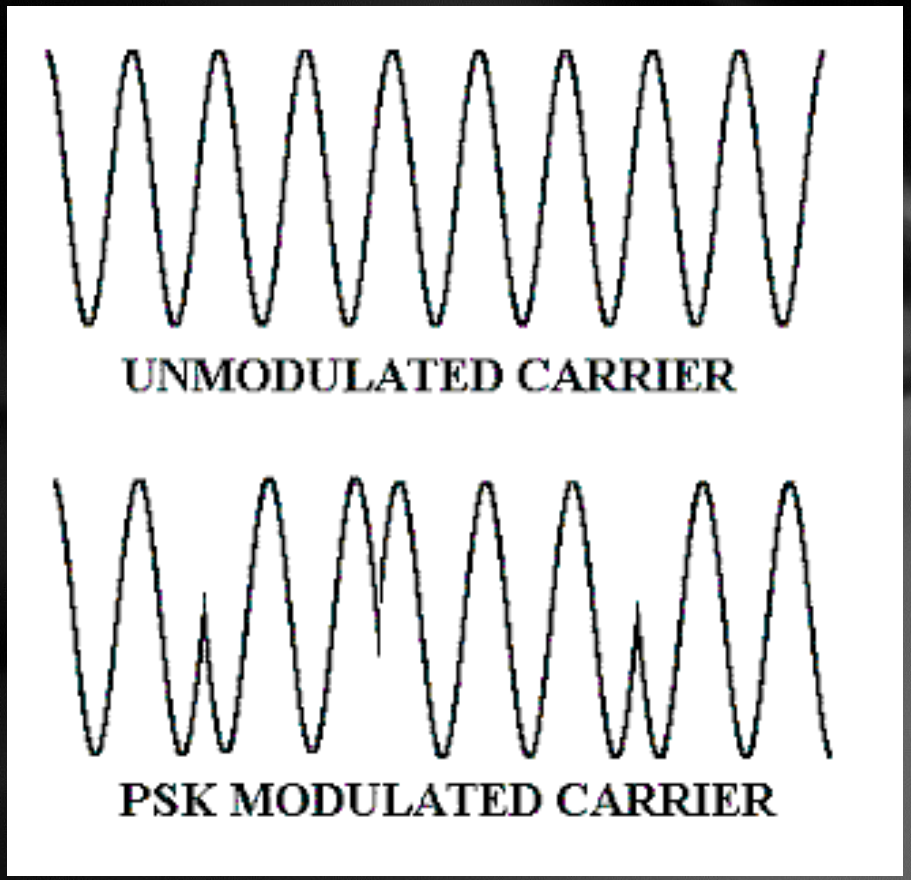
- **phase shift keying , not frequency shift like RTTY**
- **special code , Varicode**
- **Sound Card interface**

Phase Shift Keying

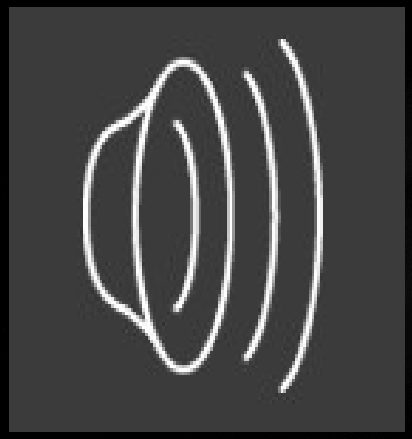
PSK-31 uses Binary Phase Shift Keying (BPSK)

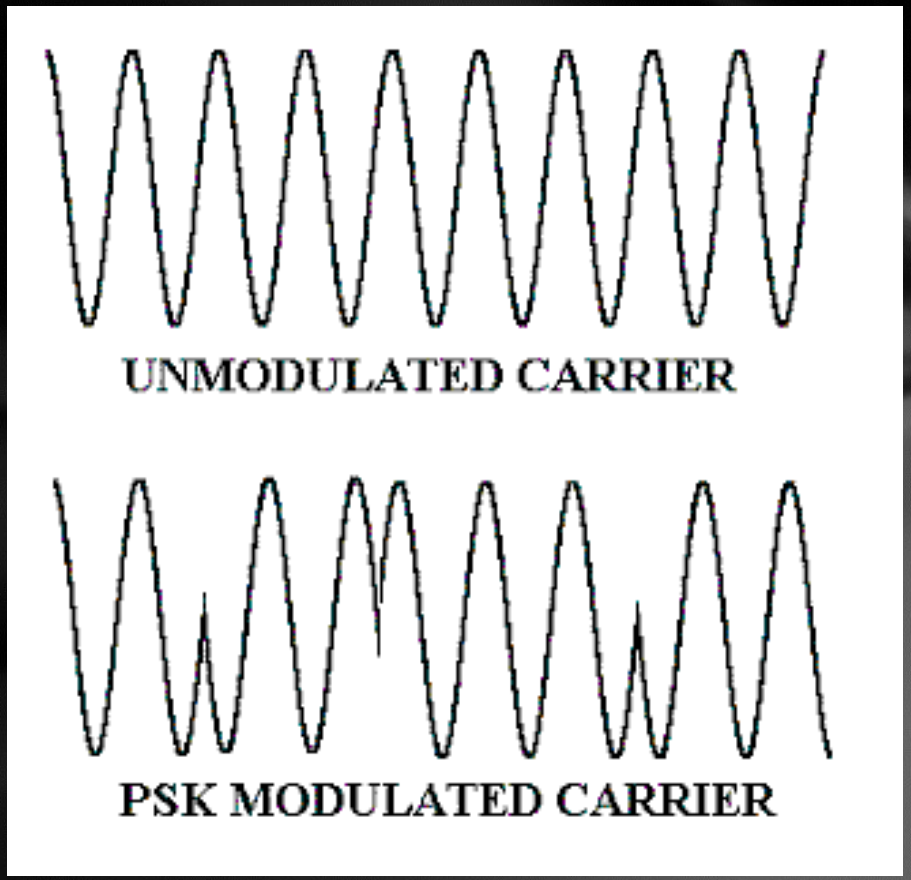
The keying rate is 31.25 bits/sec

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



Phase Shift Keying





Phase Shift Keying

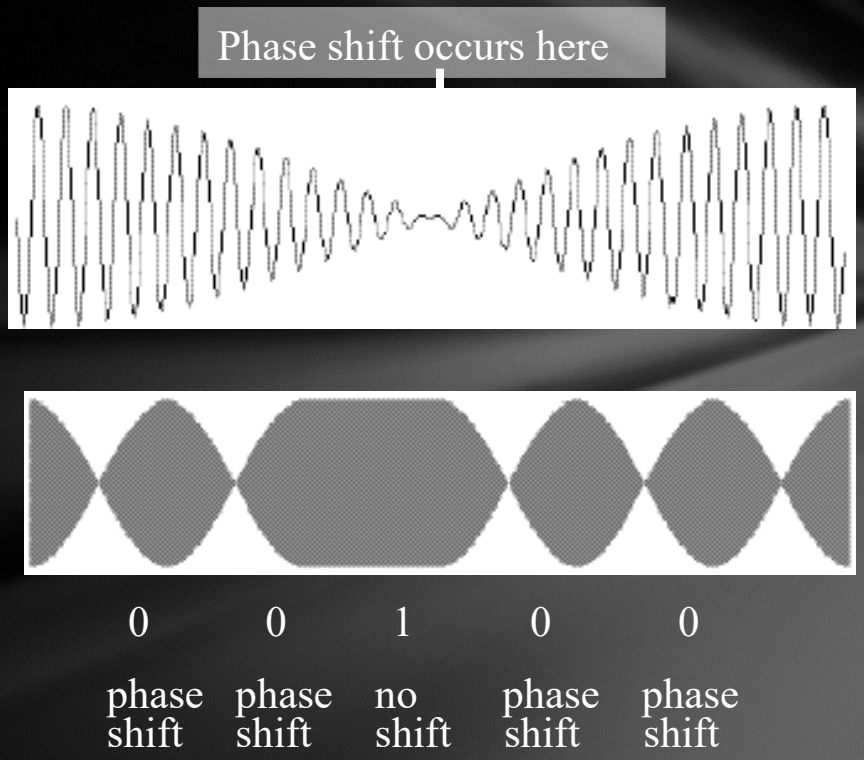
Why 31.25 bits/sec?

- **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 is much shorter than Z**
- **Lower case uses fewer bits than uppercase**

Unlike the Baudot 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

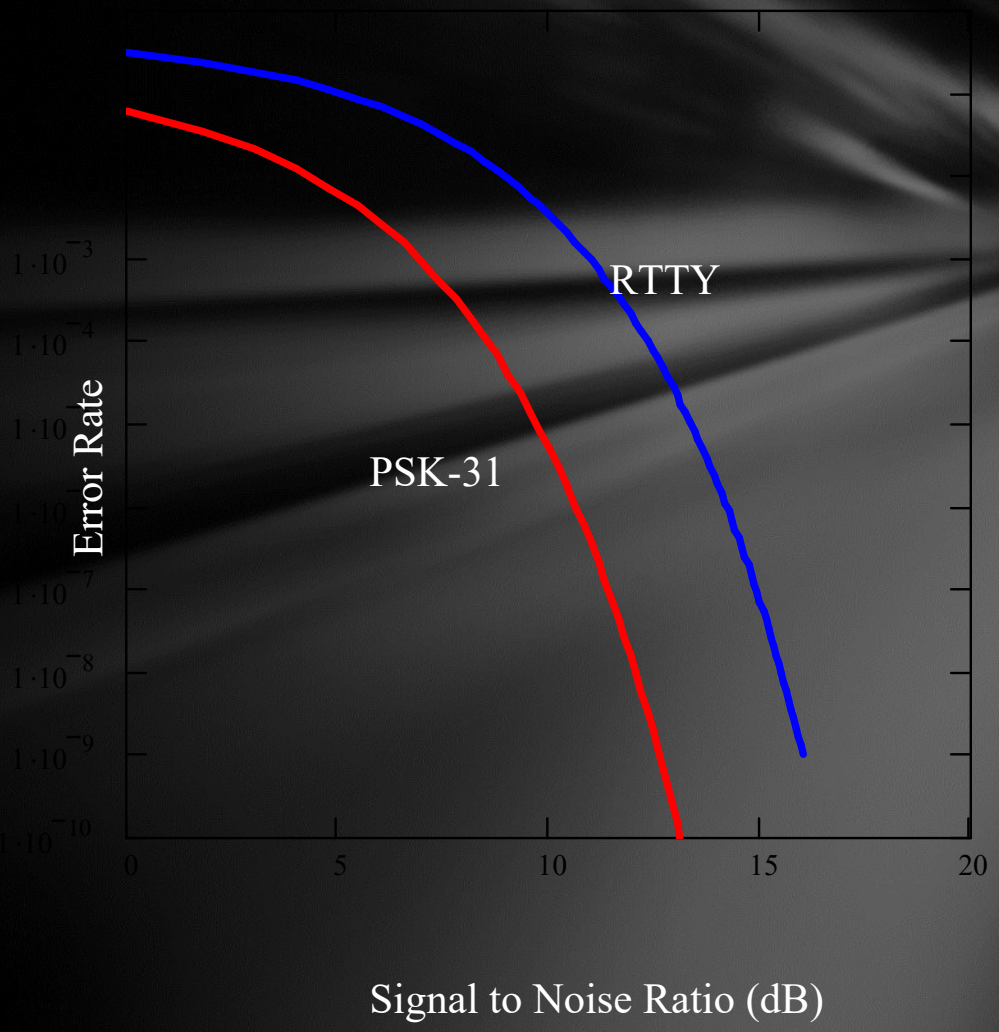
K7AGE *HD*

Real-World Performance of PSK-31

The chart at the left shows the character error rate as a function of signal-to-noise ratio.

For S/N ratios greater than 10 dB, PSK-31 is virtually error free.

At poor S/N ratios the error rate of PSK-31 is ~ 5 times better than RTTY



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**

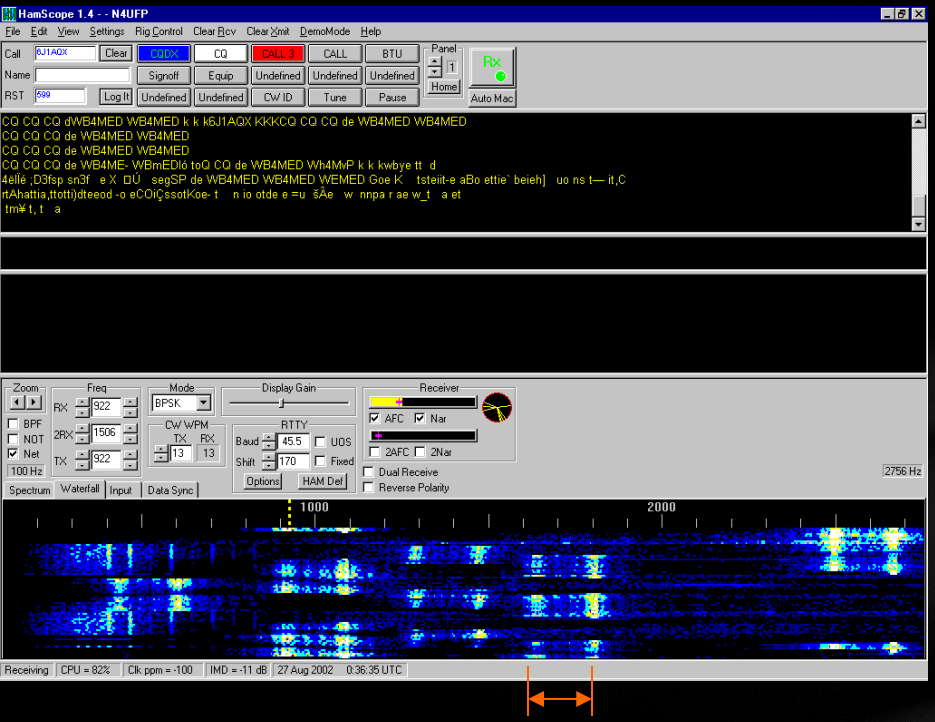
If a 100 W signal provides a 20 dB S/N ratio at the receiver using SSB,

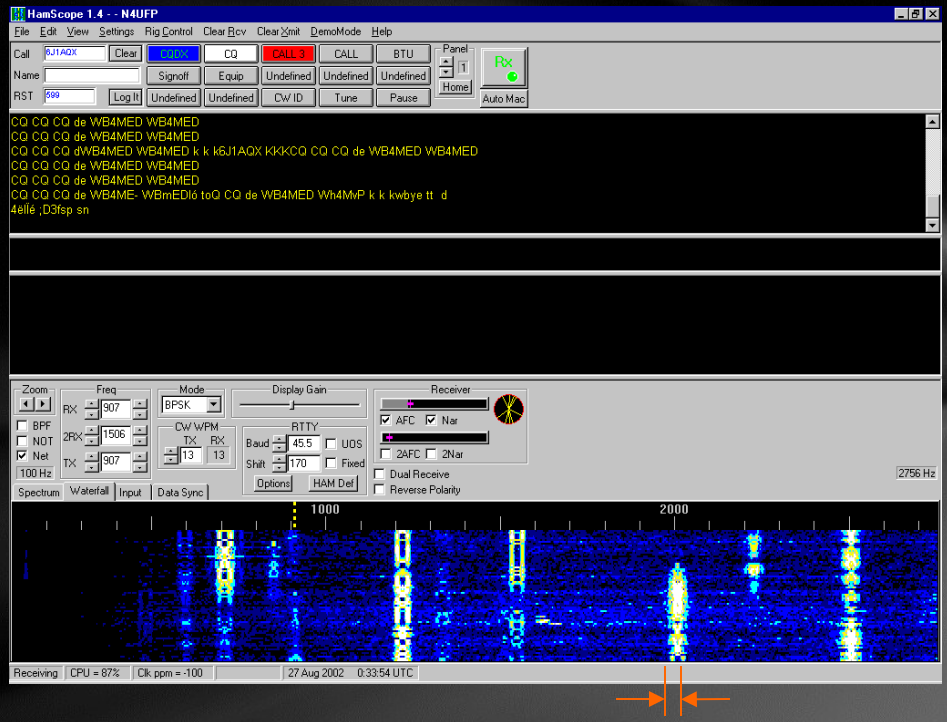
- **the same S/N ratio is achieved with 8W using RTTY**
- **and only 1W using PSK-31!**

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

- **5W QRP PSK-31 contacts are possible to any point on the planet.**

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

Amateur transceiver that has low frequency drift

- **Any modern solid state rig is OK (IC-706, IC-746, TS-940, TS2000, FT-1000, Omni VI, etc.)**

PC (90 MHz Pentium 1 or faster or a Mac)

- **Most PSK-31 software is compatible with any version of Windows**
- **Sound card (16 bit Sound Blaster or better) is required**
- **Old junk PC**

An interface that connects the PC and the transceiver

- **Homebrew, easy to build your own**
- **Commercially made (Tigertronics, RigBlaster, RASCAL, etc.)**

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

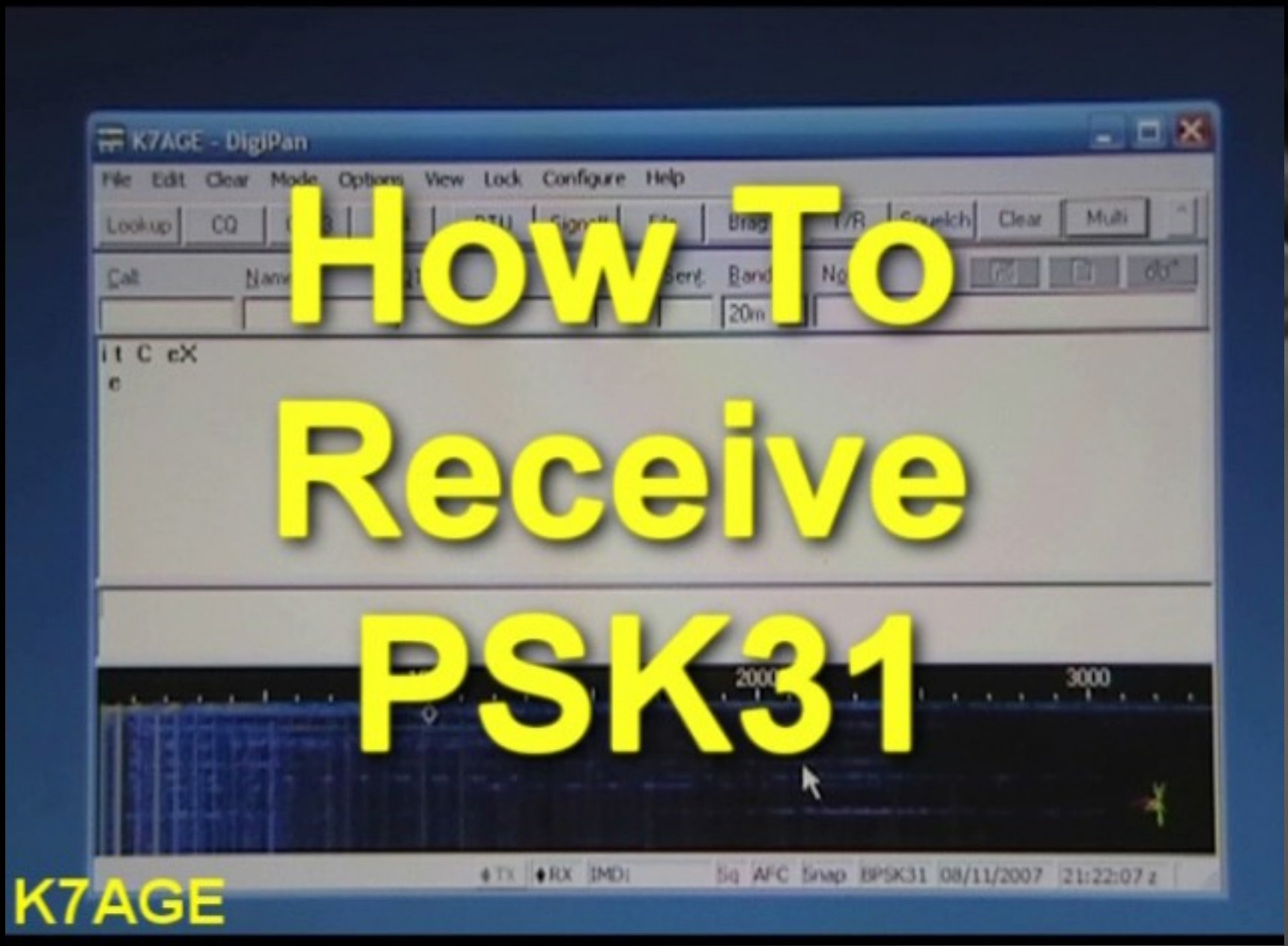
Commercially made interfaces provide lots of functions and are very easy to install.

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

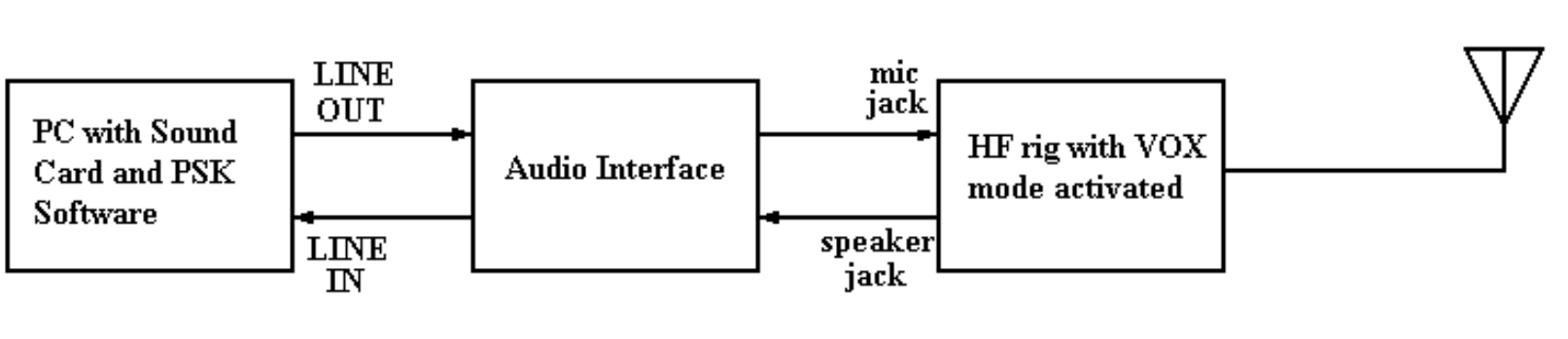
Certain transceivers can be connected directly to a PC:

ICOM 7100, 7200, 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

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

Audio Interface Circuits

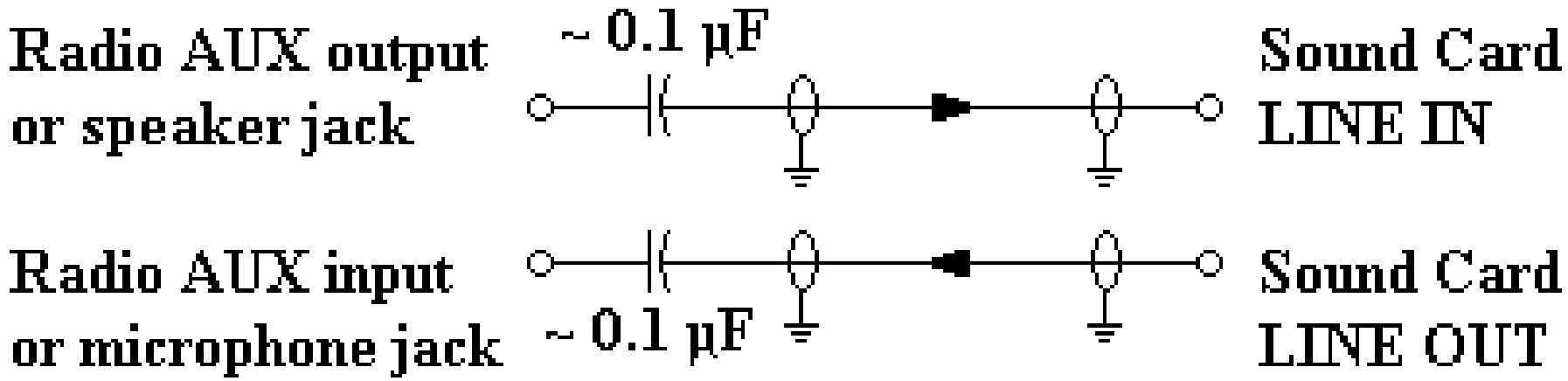
1. Acoustic Coupling

- **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. Capacitive Coupling

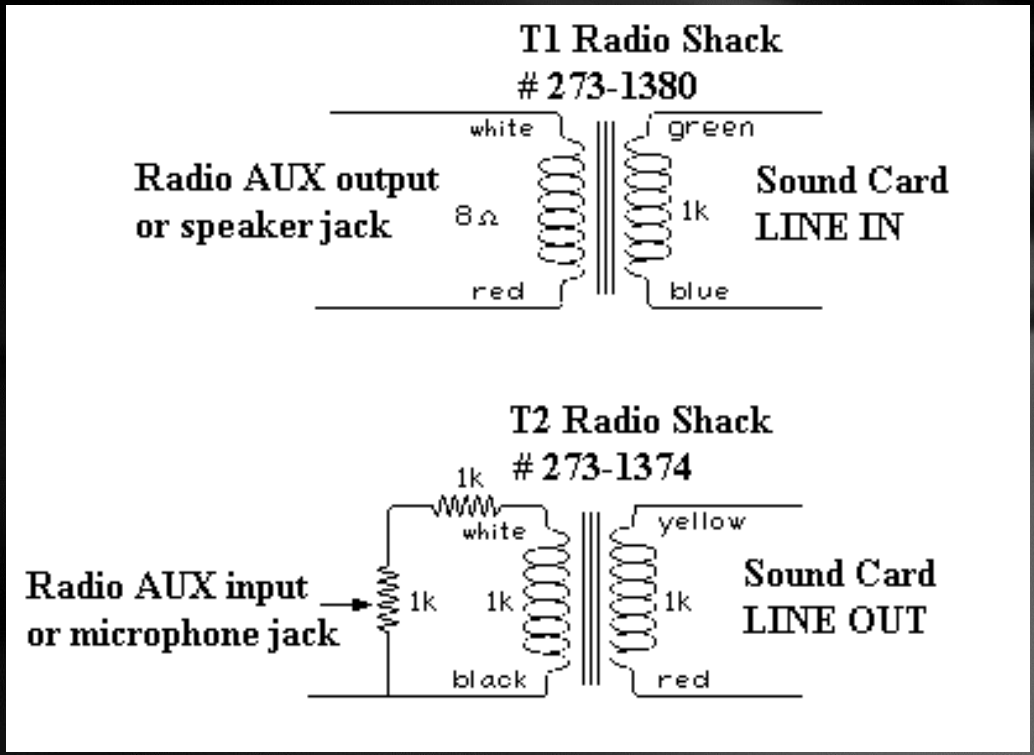
- **Simplest possible circuit**
- **Two capacitors are used to:**
  - Block DC
  - Provide proper audio attenuation (C and input R of rig/PC forms a high pass filter)
- **Capacitor value is approximately 0.1 µF. Some experimentation with other values may be required**



Audio Interface Circuits

3. Inductive Coupling

- **More complex circuit: 2 audio transformers, a resistor, and a potentiometer are required**
- **Provides good isolation**
- **Potentiometer is used to set audio drive level for the transceiver**

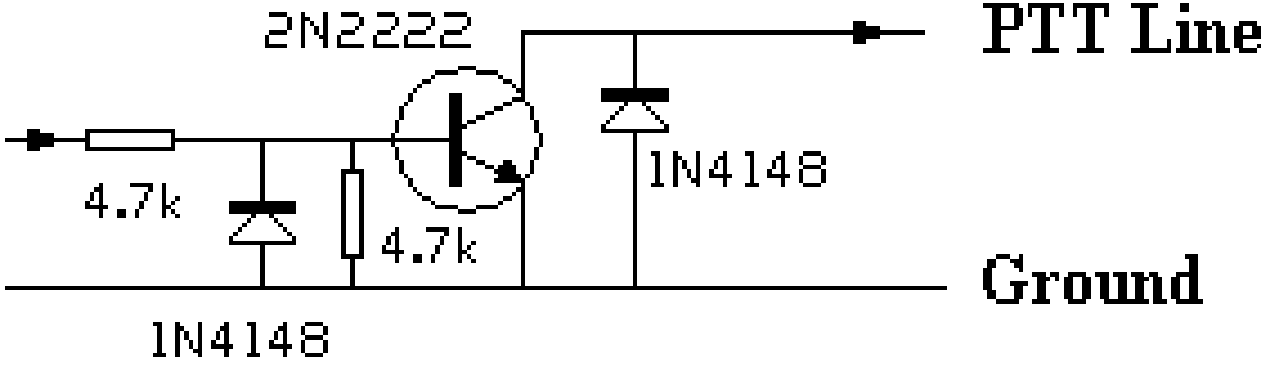


PTT/RS-232 Interface Circuit

- 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**

Setting up your Station for PSK31

Set-up of receive audio levels

- **This is done through MS Windows' audio mixer or application.**
- **Adjust the "Line In" that gives the best looking waterfall display in the PSK 31 software**

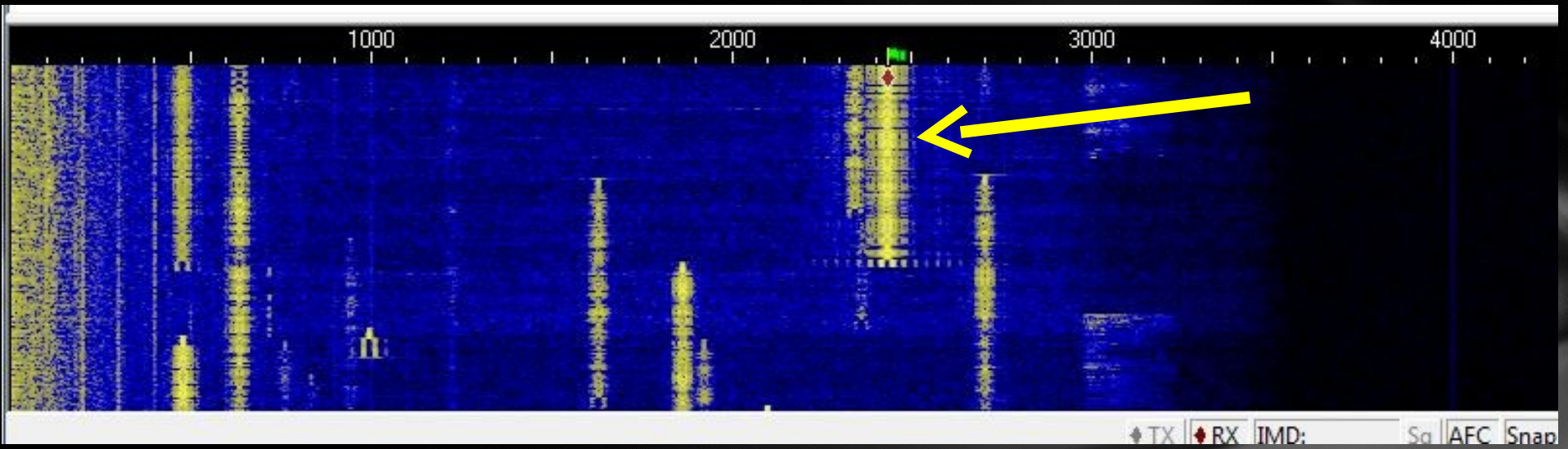
Set-up of transmit audio levels

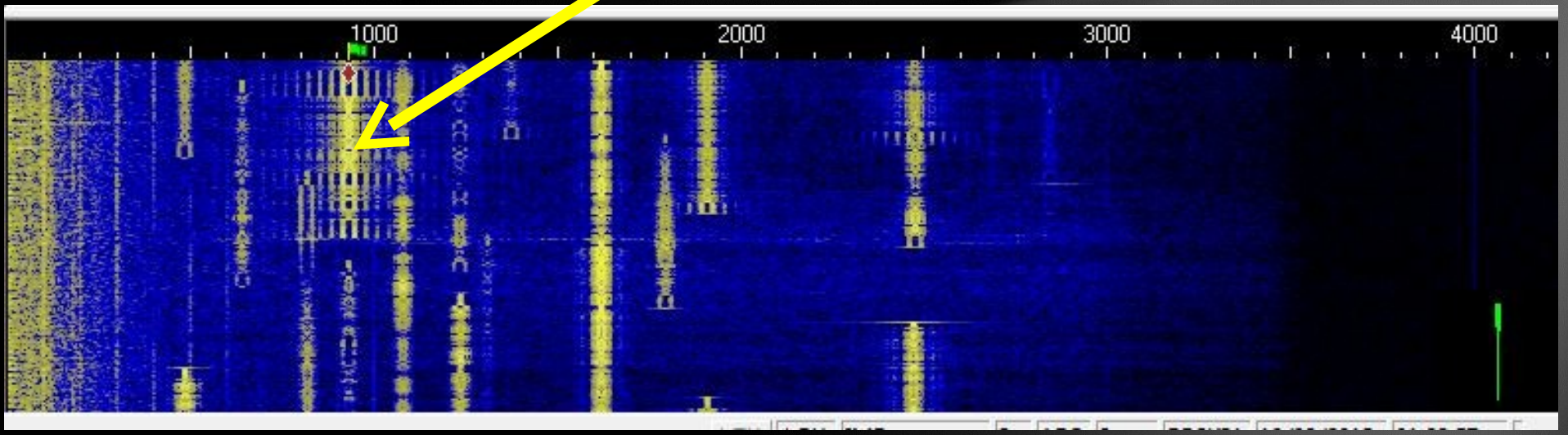
- **This is also done through MS Windows' audio mixer or application.**
- **Transmit an idle PSK31 signal into a dummy load and monitor the RF power.**
- **Increase level until RF power stops increasing, then back off a little**
- **Read your radio's manual for correct ALC setting**

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

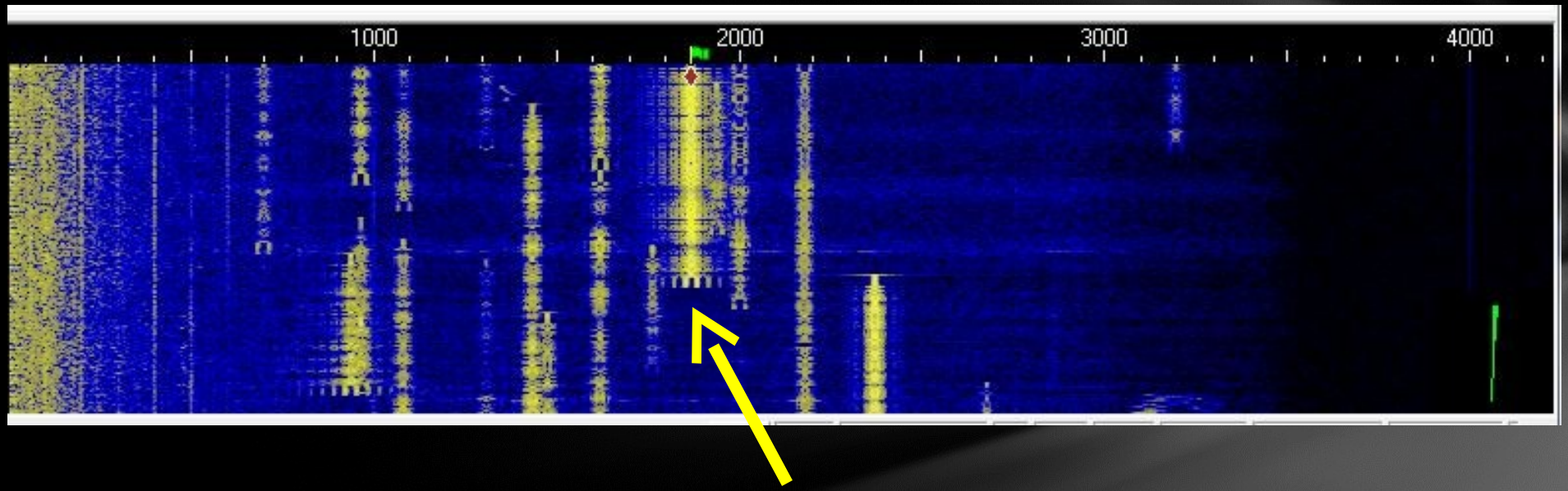
- **Shut down programs that make noise**
- **If using second sound card, configure for only radio sounds!**

This is what over driving looks like

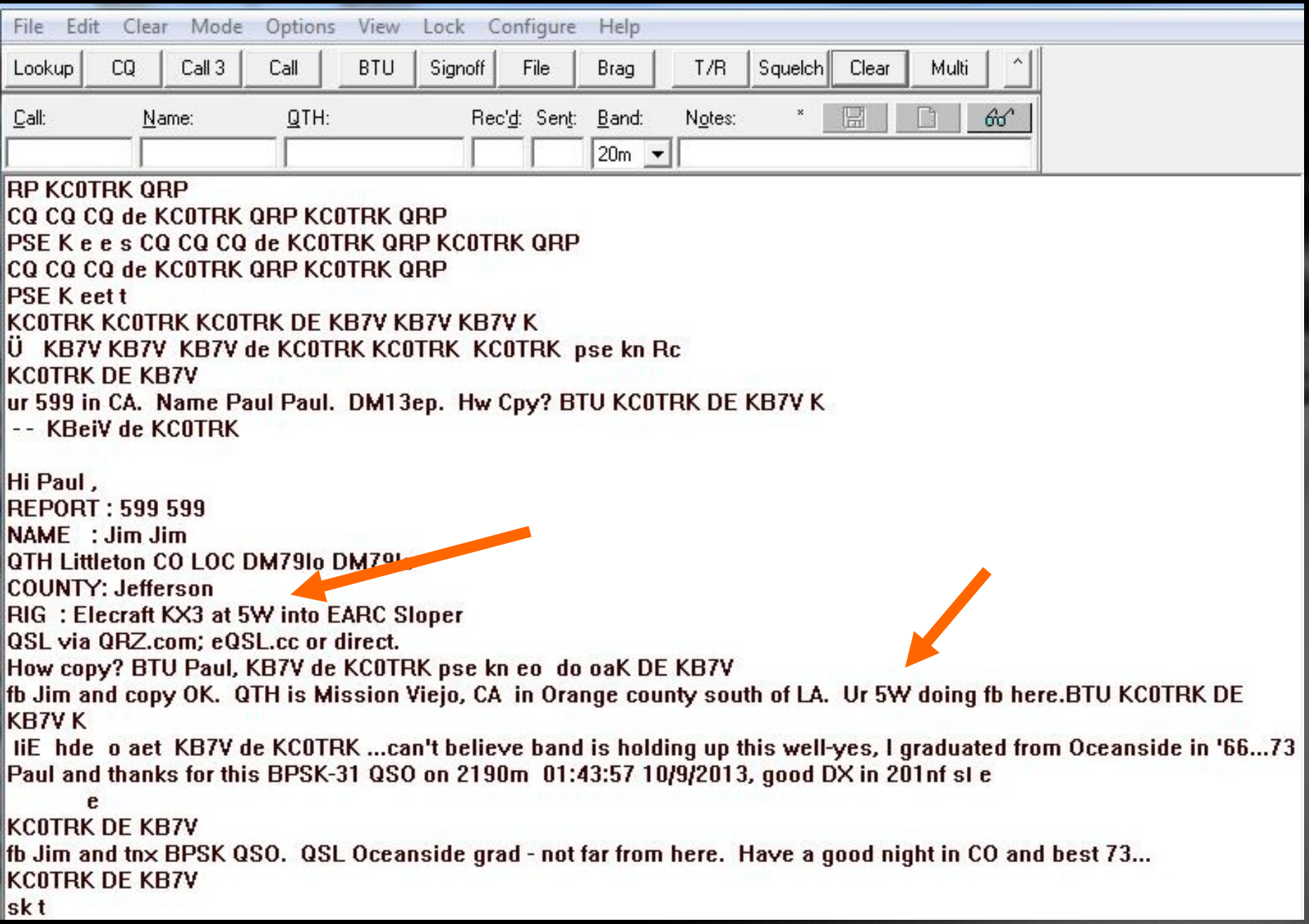




This is what over driving looks like



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
Call: Name: QTH: Rec'd: Sent: Band: Notes:
20m
RP KC0TRK QRP
CQ CQ CQ de KC0TRK QRP KC0TRK QRP
PSE K e e s CQ CQ CQ de KC0TRK QRP KC0TRK QRP
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KC0TRK DE KB7V
ur 599 in CA. Name Paul Paul. DM13ep. Hw Cpy? BTU KC0TRK DE KB7V K
-- KBeiV de KC0TRK
Hi Paul ,
REPORT : 599 599
NAME : Jim Jim
QTH Littleton CO LOC DM79lo DM79
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

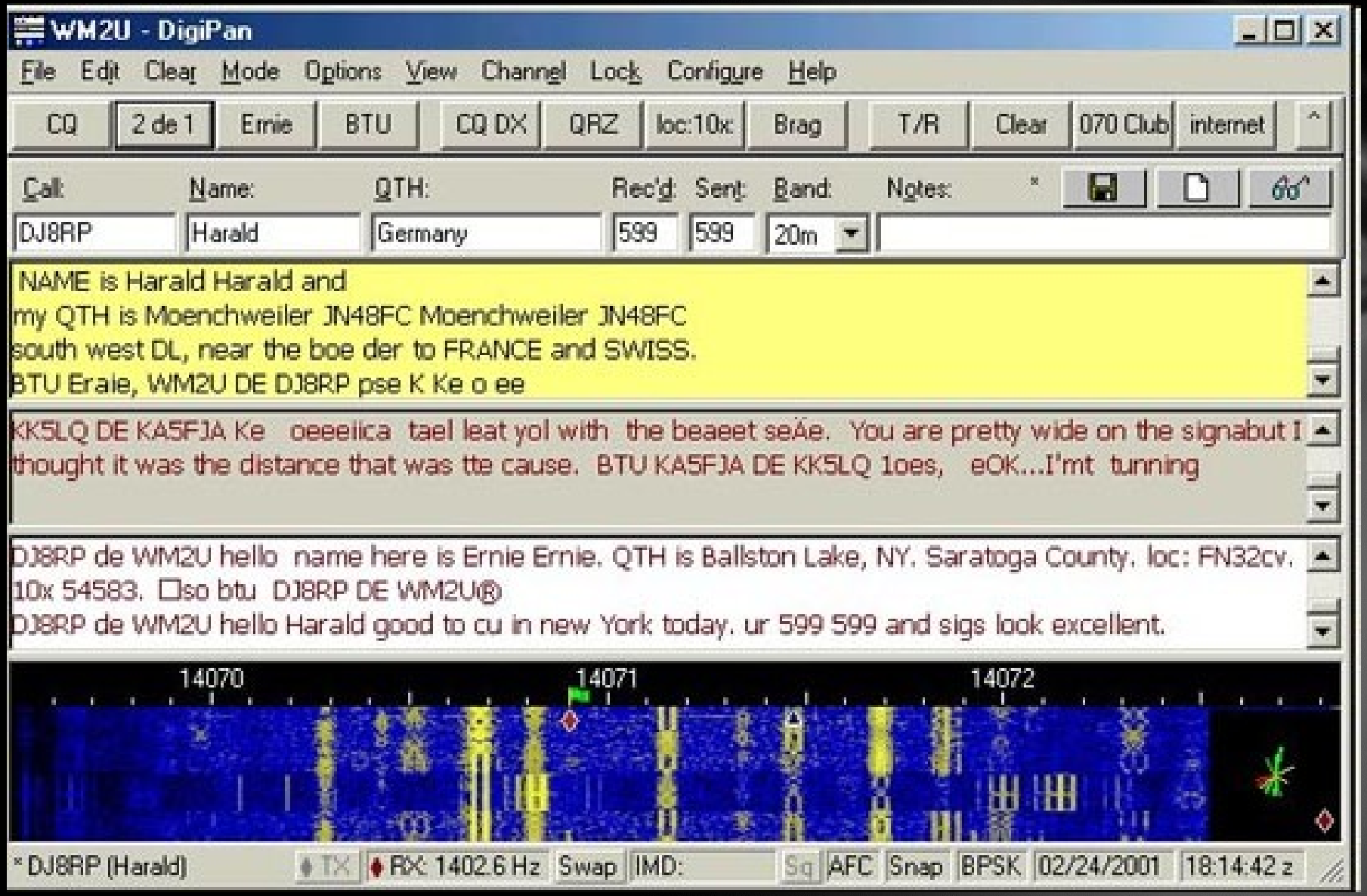
PSK-31 activity is concentrated around the following frequencies:

DIAL Display

USB Mode

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

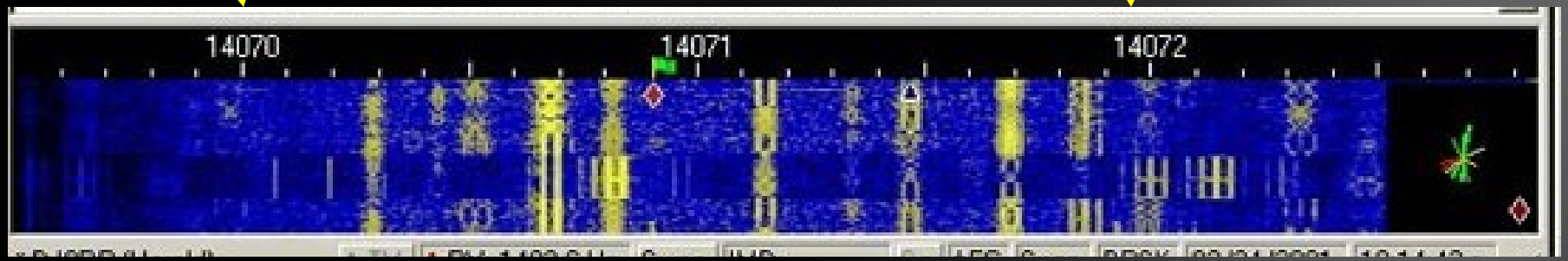
Tuning in a PSK-31 signal



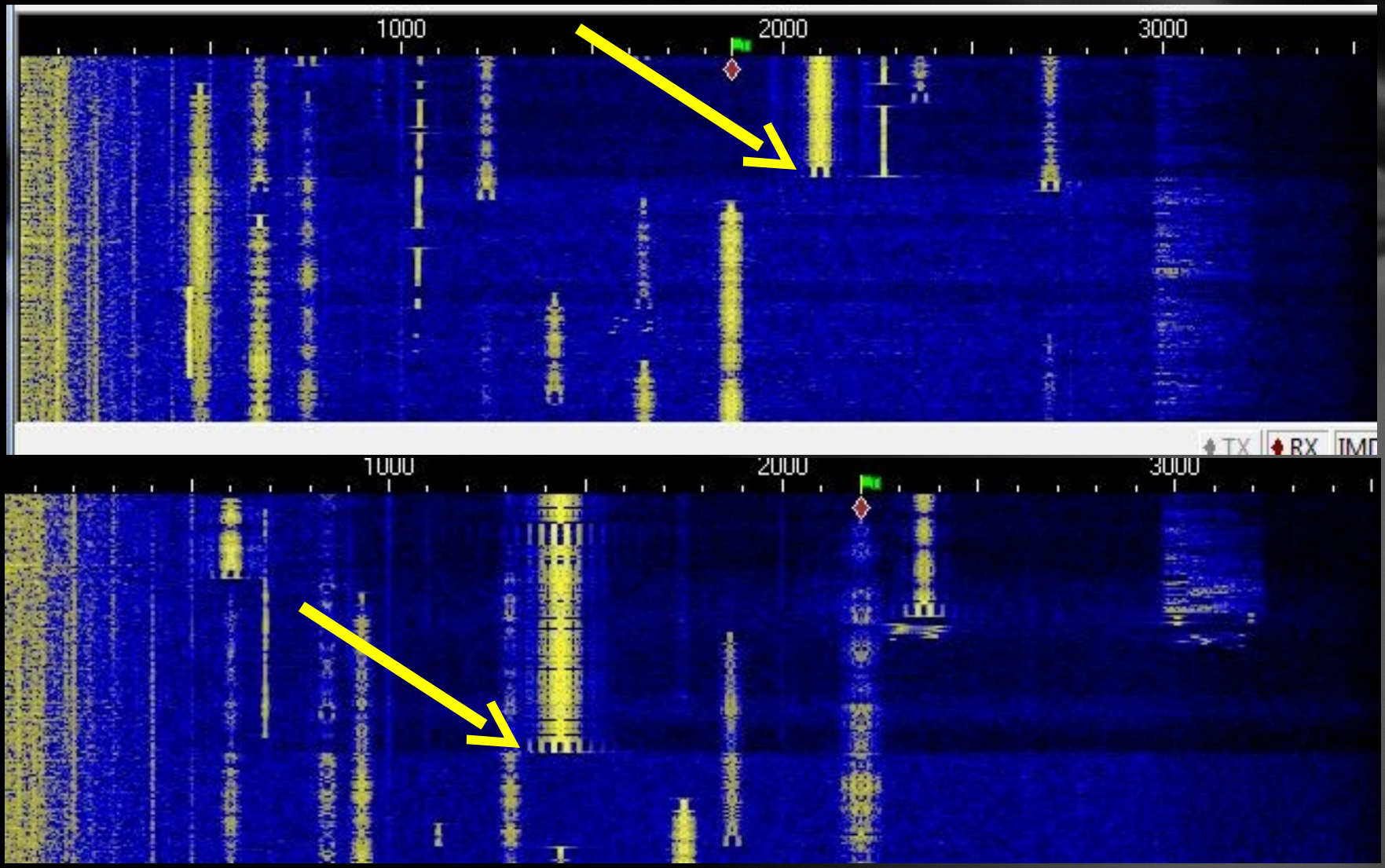
Tuning in a PSK-31 signal

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



Where to Find More Information

- www.arrl.org (members only, search for PSK31)
- http://aintel.bi.ehu.es/psk31.html(“official home page”)
- www.arrl.org/tis/info/HTML/psk31 (Steve Ford’s original QST article)
- Google

K7AGE

Thanks for listening
Randy, K7AGE