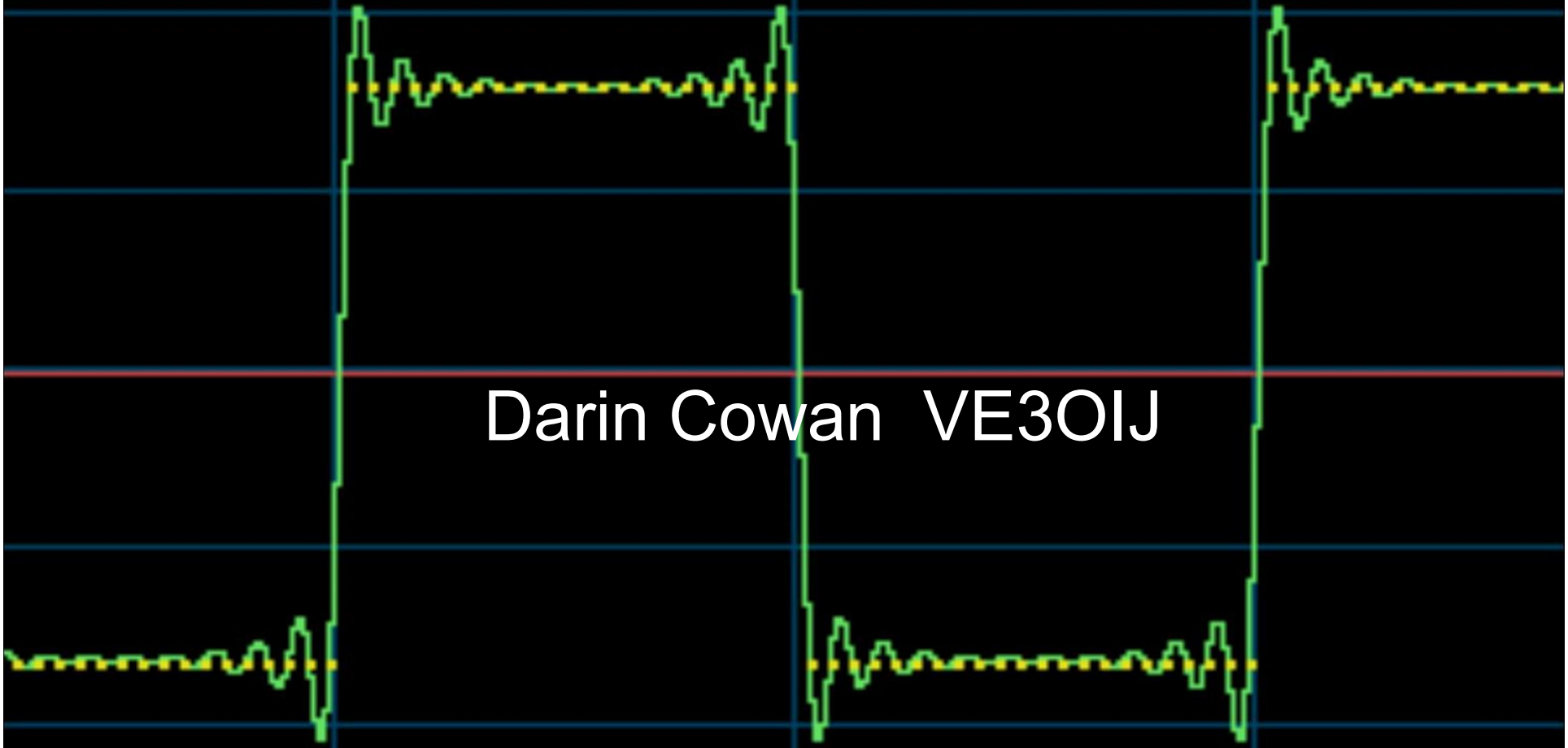
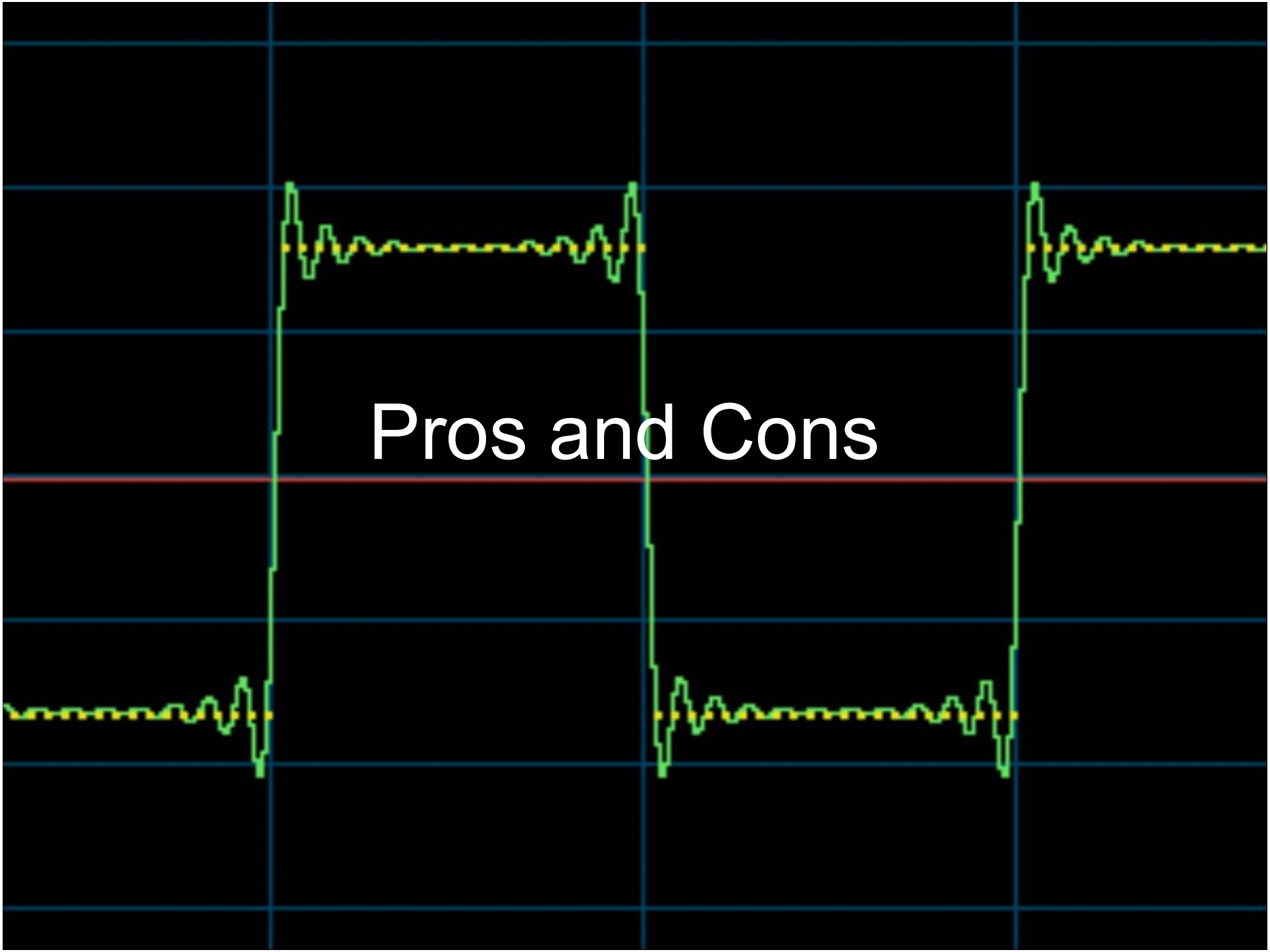
Digital Modes



Darin Cowan VE3OIJ

With minor revisions/additions
by George Kaneff
N2GWK


Pros and Cons

Pros and Cons

- Cons
  - Requires special equipment, and generally a knowledge of computers
  - Semi-necessary to know how to type
  - Received text can be garbled

Pros and Cons

- Pros
  - Can attain speeds much faster than Morse code
  - Can be digitally error corrected for perfect copy
  - Low power
  - Efficient use of spectrum
  - Excellent for hearing impaired
  - Learning to type 30 WPM is generally easier than learning to do Morse code at 30 WPM
  - Experienced typists can manage over 100 WPM, not possible with (manual) Morse code. Some modes (BPSK63, BPSK125, etc.) can go this fast.

Background

- First digital mode invented in 1836, by Samuel Morse
- Standardized in 1865
- Simple rules with 5 components
  - dot, dash (3 dots long), inter-element space (1 dot long), inter-character space (3 dots long), inter-word space (5 dots long)
- Machine copyable, some people prefer do it manually to this day
- Modern, inexpensive computers allow access to digital signal processing - other modes possible

Getting Started Equipment

- Receive – You'll need
  - A radio, preferably SSB
  - A computer (or other device) with a sound card/processor (cables / interfaces etc)
  - Software or firmware to decode the signal
- Transmit – You'll need
  - *USA - General or Higher to Transmit HF Data Modes 12m -160m (Tech may transmit Data Modes in specified bands 10m and up.)*
  - A way of entering messages to have them sent (software or firmware)
  - A way of transferring the sound out of the computer and into the radio (mic works)

Getting Started

- Computer usually does not need a lot of CPU
  - Can be as simple as a PDA held up to the microphone of the radio
  - Can use the sound output of the computer via microphone or directly by interface cable
- NUE-PSK
  - Plug in a keyboard and a radio and go
  - Available pre-built or as a kit
- RigExpert, RigBlaster, SignaLink etc.
  - High-end TNC devices offering more features and control

NUE-PSK

Small 7" x 4" x 1" standalone, battery-operated digital modem (requires a keyboard)
Fully Assembled US/CAN: $199 ***(+ $7 shipping)***
Full Kit US/CAN: $149 *(+ $7 shipping)*
Assembled Cable US/CAN: $9 *(+ $3 shipping)*

http://www.nue-psk.com/

RigExpert

Complete Set - RigExpert Plus with prewired cable $354.00
Complete Set - RigExpert Standard and prewired cable $254.00
RigExpert "Tiny“ $115.00

http://www.rigexpert.net/gettingstarted/description/description.html
http://radioworld.ca/index.php?manufacturers_id=85

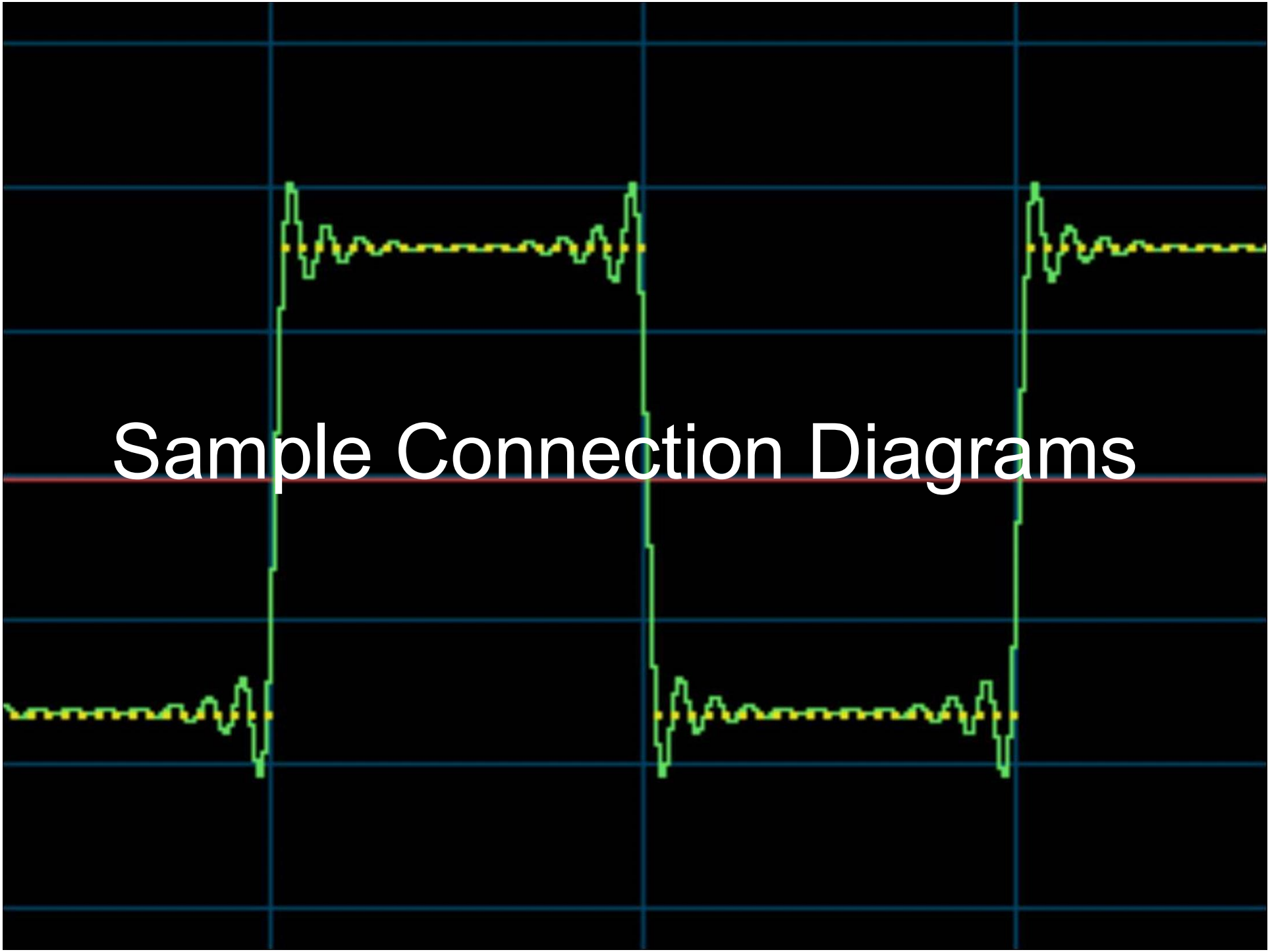
RigExpert Models

TINY

RIGblasters

RIGblaster

- RIGblaster duo USB Complete Two Radio - Station Integration Console $349.95
- RIGblaster pro USB/Serial Complete $299.95
- RIGblaster plus USB/Serial Complete USB and Serial Port RS232 $159.95
- RIGblaster Nomic USB/Serial Complete USB and Serial Port RS232 $59.95
- RIGblaster Data Jack plug & play Complete USB only $119.95


Sample Connection Diagrams

RigBlaster Nomic

Typical ***RIGblaster nomic*** station hookup diagram.

Note: This is only a sample station hookup diagram! What might be used for portable operation with a RIGblaster nomic. A desktop computer would have similar connections with different labels*.

PTT CONTROL: Supplied DB9M to DB9F serial cable connected between the RIGblaster's serial jack and computer's com/serial port. (software MUST be configured properly)

RECEIVE AUDIO: Supplied 3.5mm, 1/8" stereo phone plug patch cord from radio's speaker or fixed level output to computer's mic* input.

TRANSMIT AUDIO: Supplied 3.5 mm, 1/8" stereo phone plug patch cord from computer's headphone* output to RIGblaster's audio in.

MICROPHONE TRANSMIT AUDIO & PTT: Mic. cable supplied with RIGblaster connects to radio's mic. input.

COMPUTER AUDIO MONITOR: Connect computer headphones or amplified computer speakers.

*** For desktop computers use the computer's line input in place of the mic. input and use the line output in place of the headphone output.**

RigBlaster Plus

Basic station hookup diagram.

Note: This diagram is a basic sound card station hookup and does not show a keying connection for CW and/or FSK. That connection is user supplied and requires an 1/8" mini jack to connect the key out of the RIGblaster to the radio's straight key input and/or FSK keying terminals.

PTT, KEYING & SWITCHING: Supplied DB9M to DB9F serial cable connected between the RIGblaster's serial jack and computer's com port. (not needed for VOX)

TRANSMIT AUDIO: Supplied 3.5 mm, 1/8" stereo phone plug patch cord from computer's line* output to RIGblaster's audio in.

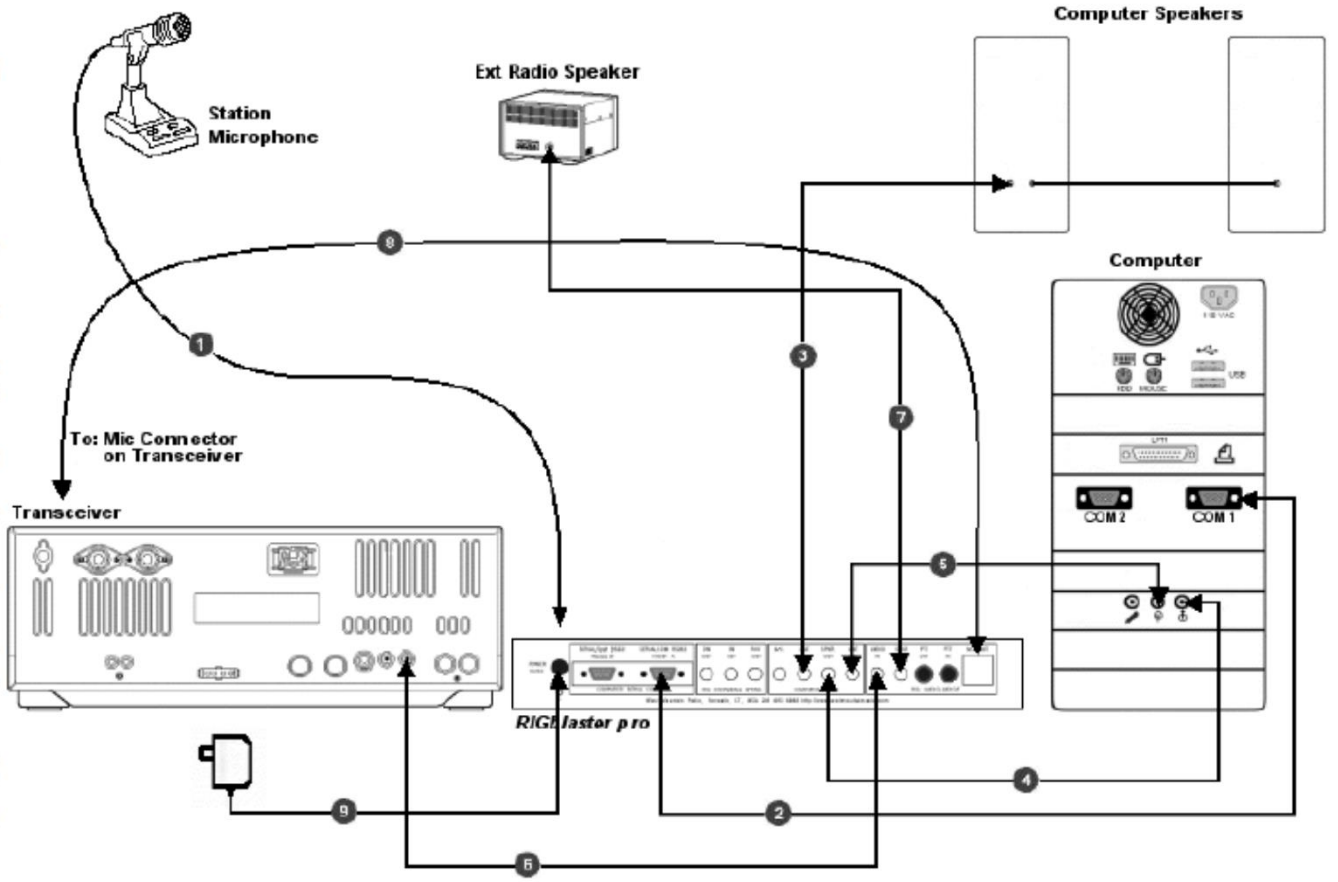
RECEIVE AUDIO: Supplied 3.5mm, 1/8" stereo phone plug patch cord from radio's speaker or line out to computer's line* input.

COMPUTER SPEAKER RE-CONNECT: Cable from computer speaker re-connects to RIGblaster's audio output

MICROPHONE: Mic. cable supplied with RIGblaster. Connection goes to front of RIGblaster for RJ45 modular radios.

*** For laptop computers use the computer's mic. input in place of the line input and use the headphone output in place of the line output.**

RigBlaster Pro



STATION HOOKUP DIAGRAM (basic sound card function)

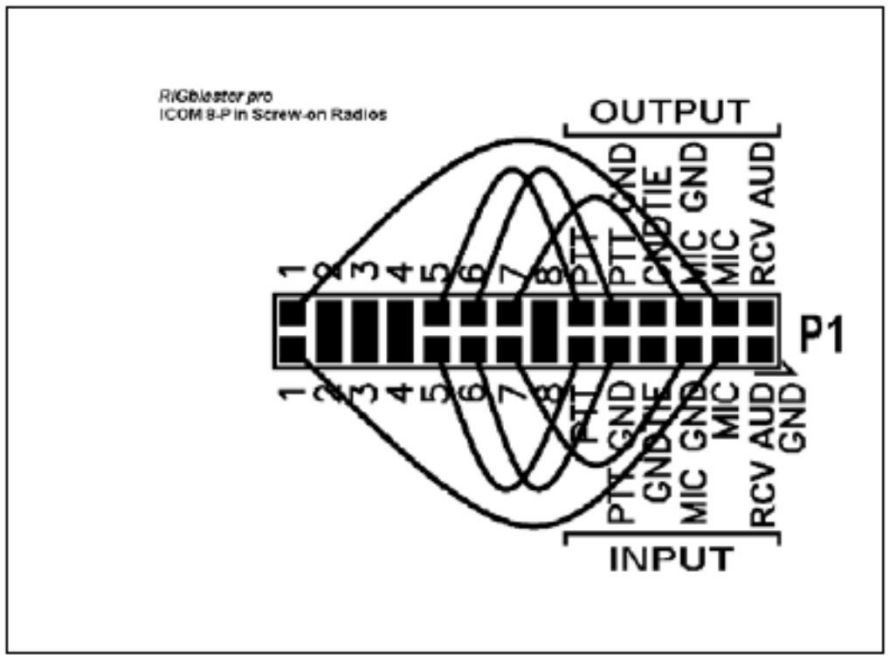
See next page for a description of each numbered wire on this diagram.

Configuration via Jumpers

ICOM with 8 Pin Screw on Microphone Connectors

Pin#	INPUT SIDE	
1	White Jumper to	MIC – INPUT Side
2	Blue Shunt Jumper to	Pin 2 - OUTPUT Side
3	Blue Shunt Jumper to	Pin 3 - OUTPUT Side
4	Blue Shunt Jumper to	Pin 4 - OUTPUT Side
5	White Jumper to	PTT – INPUT Side
6	White Jumper to	PTT GND – INPUT Side
7	White Jumper to	MIC GND – INPUT Side
8	Blue Shunt Jumper to	Pin 8 - OUTPUT Side

Pin #	OUTPUT SIDE	
1	White Jumper to	MIC – OUTPUT Side
5	White Jumper to	PTT – OUTPUT Side
6	White Jumper to	PTT GND – OUTPUT Side
7	White Jumper to	MIC GND – OUTPUT Side



SignaLink USB

FT-817 or

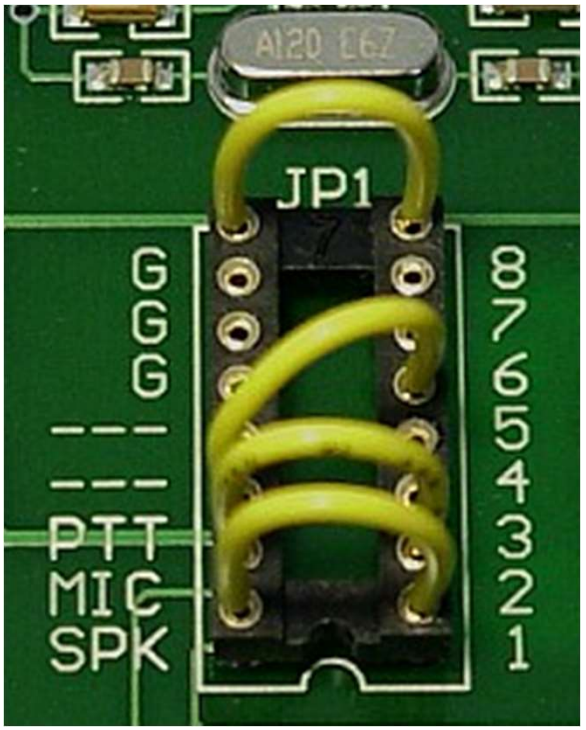
FT-857 or

- Simple interface
- $99.95

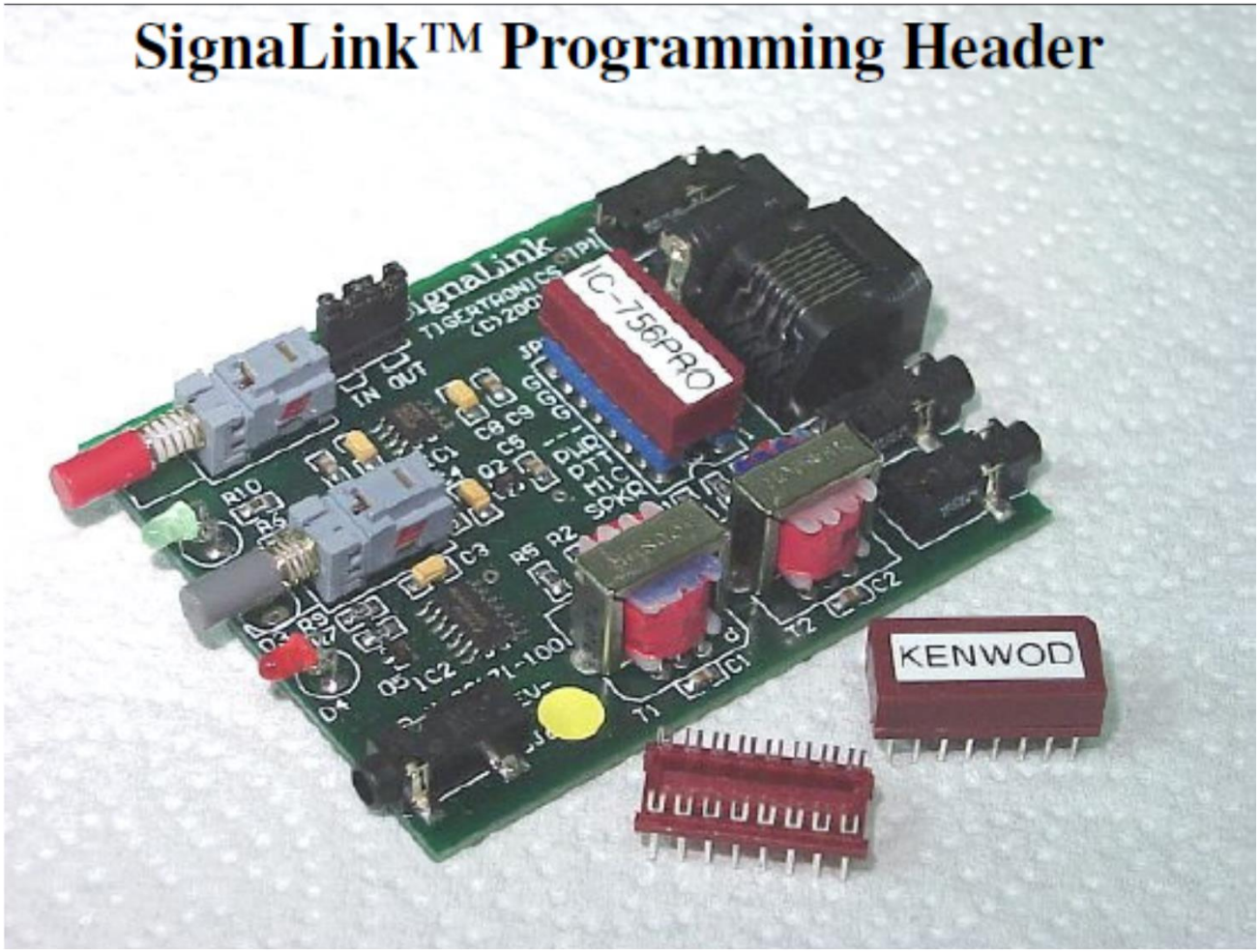
FT-897

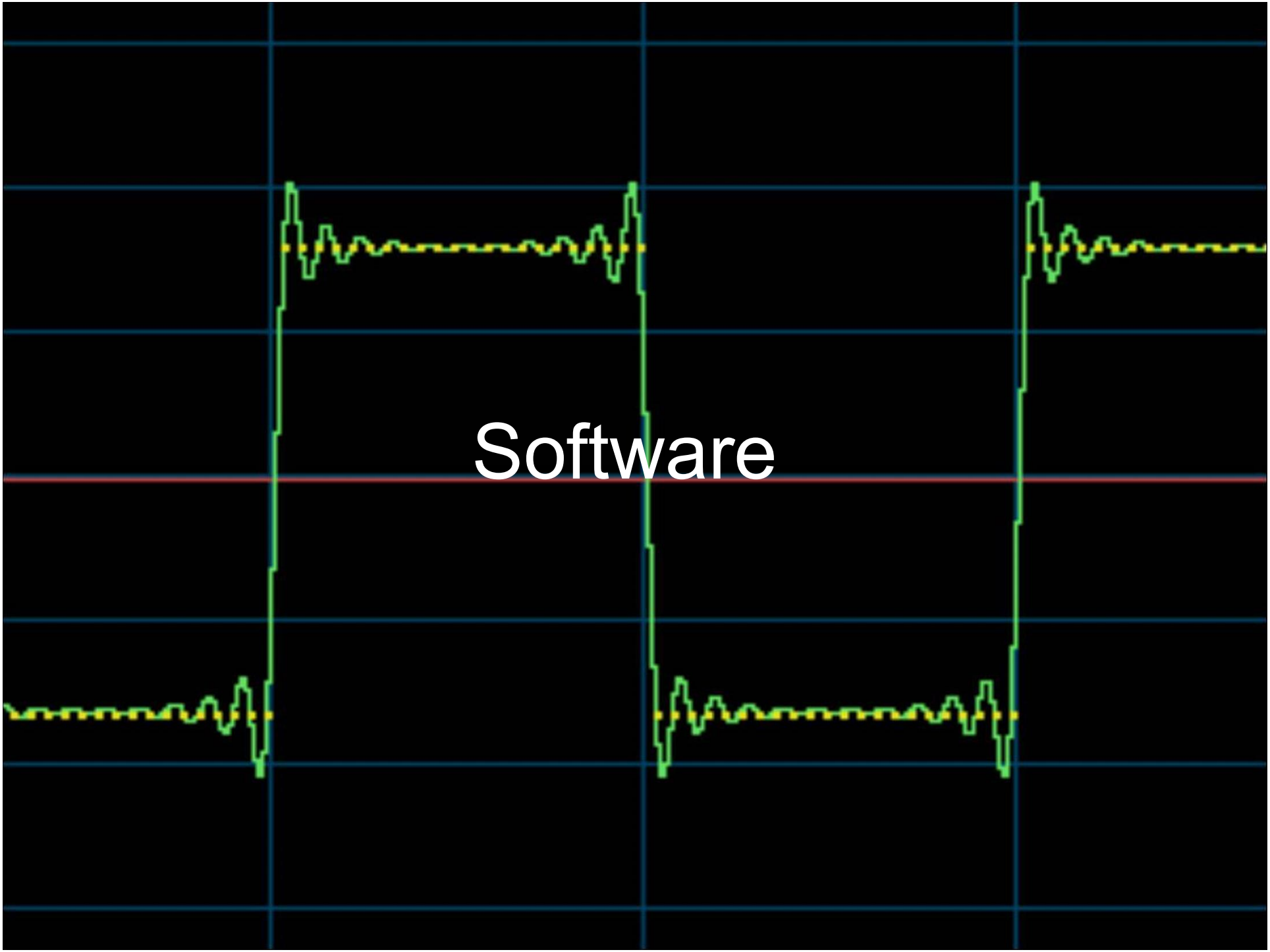
SignaLink

Sample Jumpers



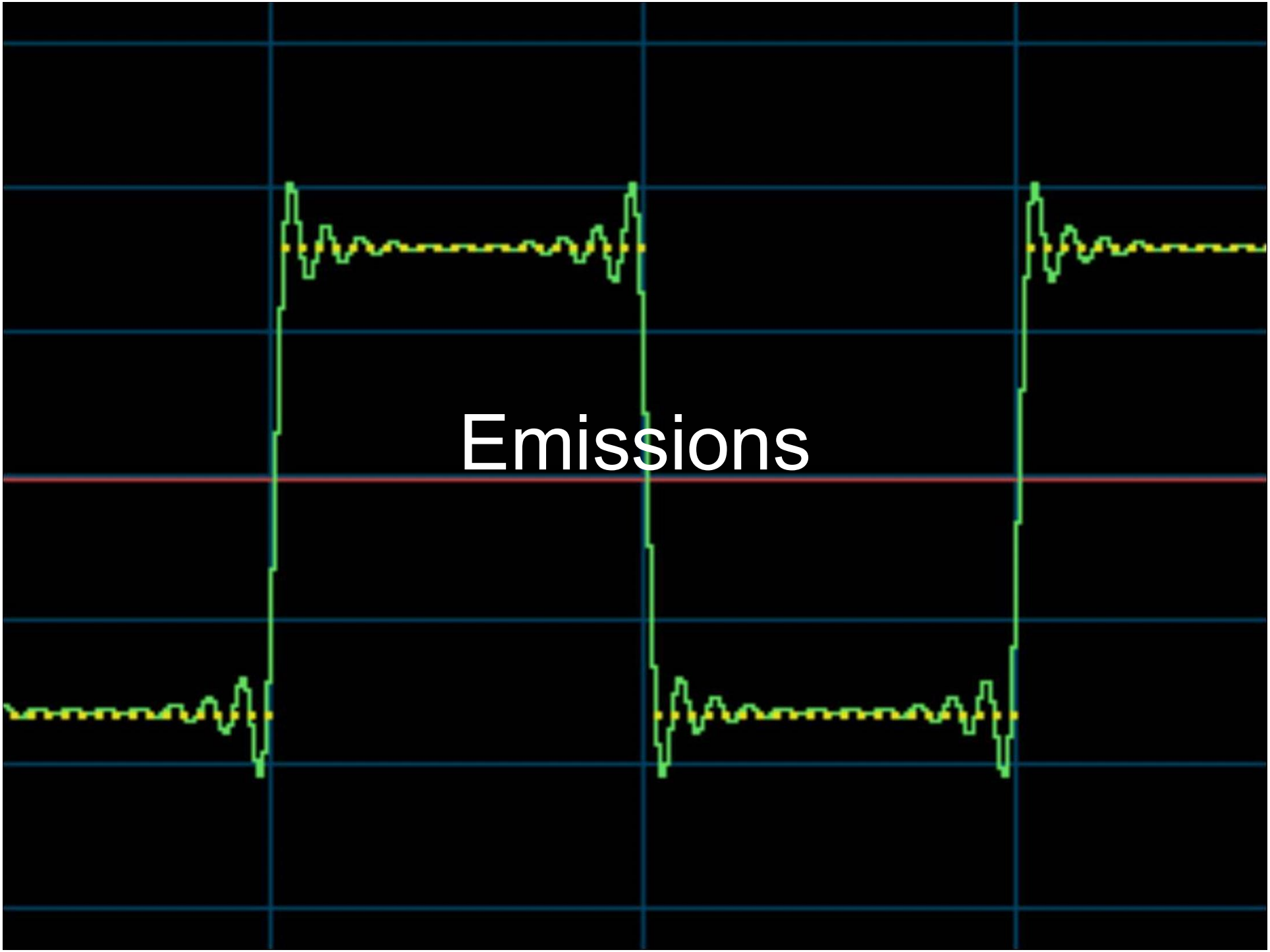
Programming Header




Software

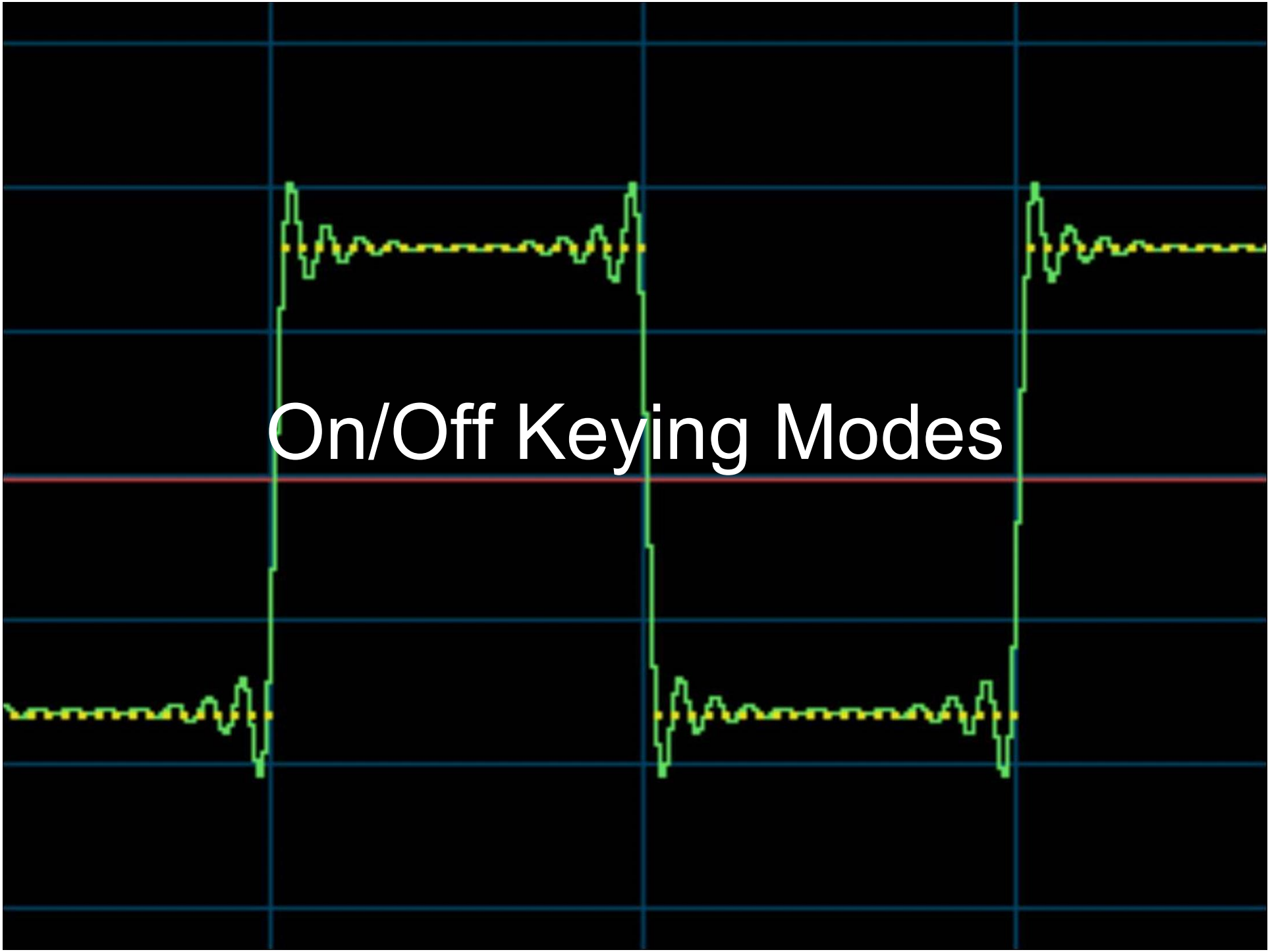
Software

- Ham Radio Deluxe
  - Advanced rig control
  - Comes with Digital Master 780 digital modes software
  - Shareware. Free but solicits donations.
  - Excellent logging features
  - **DM0780 is CPU Intensive**
- MixW
  - Approx $60
  - Produced by RigExpert people, but works with just about any computer configuration
  - Good logging features
- MultiPSK
  - Does pretty much every digital mode you can imagine
  - Very steep learning curve
  - Poor documentation
  - Shareware. Paid version has extra features.
- Digipan
  - Good at PSK, limited functionality otherwise
  - Free


Emissions

Emissions

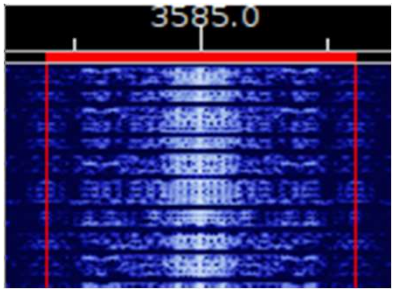
- OOK
  - On-off Keying
    - CW
    - Feld-Hell
- PSK
  - Phase Shift Keying
    - BPSK, QPSK, OPSK
    - 31, 63, 125, 250, 500
- FSK
  - Frequency Shift Keying
    - RTTY, Pactor, WSJT
- MFSK
  - Multiple Frequency Shift Keying
    - MFSK16, Olivia, MT63 (MT63-NBEMS)
- DSS
  - Digital Spread Spectrum
    - Chip-64
- SSTV
  - Slow Scan Television
  - Not really a digital mode, but often part of the software
  - Sometimes seen near digital slices, esp. 30m
  - Some modes have SSTV functionality (MFSK16)
  - MP73-N narrow SSTV


On/Off Keying Modes

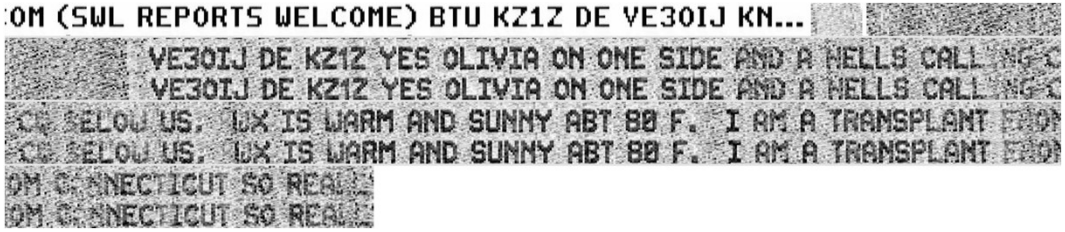
On-Off Keying Modes

- Morse Code (CW)
  - Can be done manually without special equipment
  - Can be challenging to decode manual code by machine depending on skills of sender
    - When it comes to conforming to the standards for spacing and characters, most humans are not as good at sending Morse code as they think they are
  - 50-100 Hz nominal bandwidth
  - 70+ WPM by machine
  - Good power density

On-Off Keying Modes



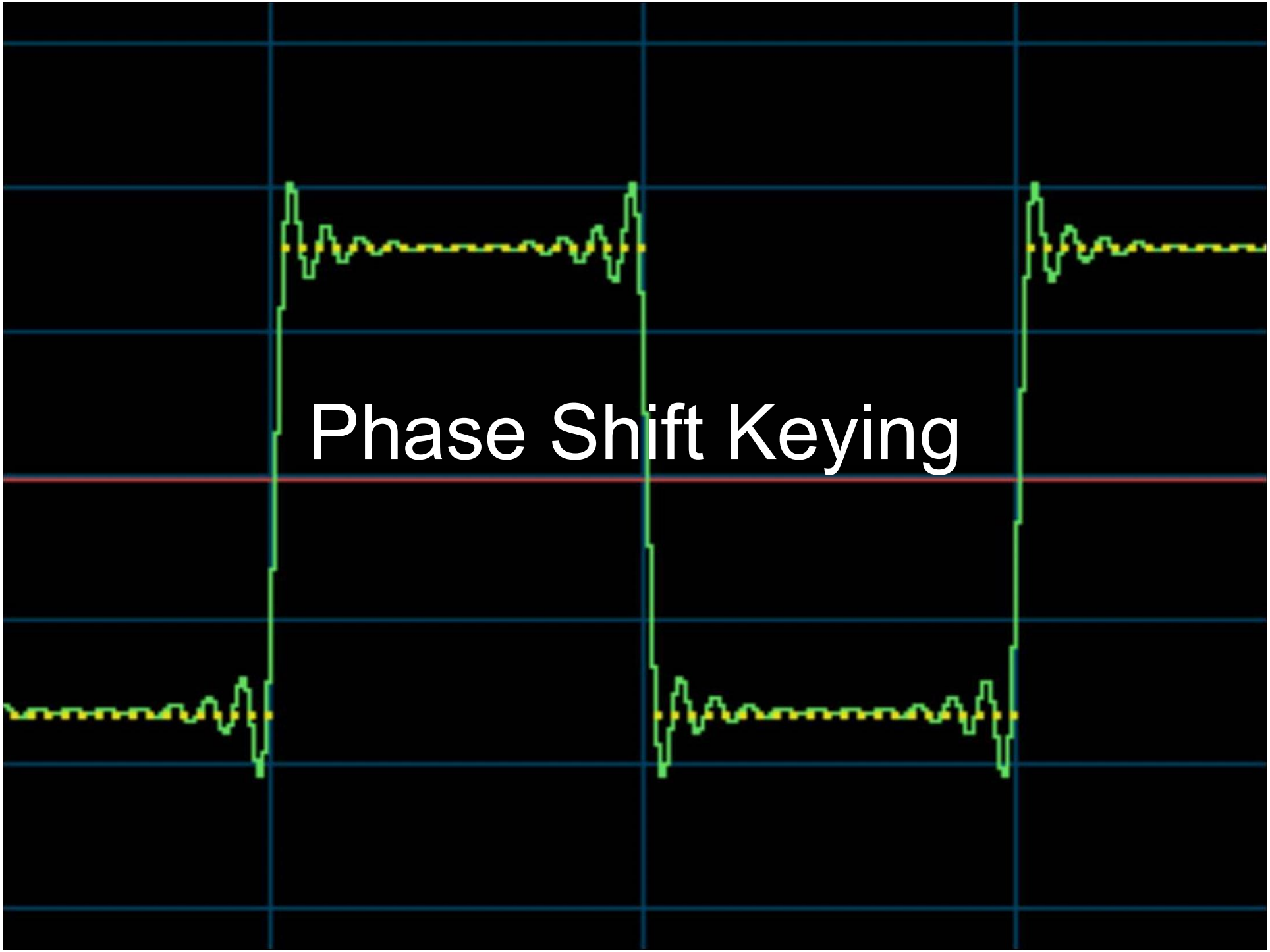
- Feld-Hell (Helleschreiber)
  - Developed by Germany in WWII
- Facsimile – sends pictures of the letters



- Originally printed on paper tape
  - Always two lines
  - Ensured print would be readable on tape regardless of sync
- Decoded by eyeball, fares well in mediocre conditions
- ~35 WPM
- 75 Hz minimum bandwidth (245 Hz filter standard)

Hellschreiber

- The Hellschreiber or Feldhellschreiber was a facsimile-based teleprinter invented by Rudolf Hell. It has since been emulated on computer sound cards by amateur radio operators; the resulting mode is referred to as Hellschreiber, Feld-Hell, or simply Hell. "Hellschreiber" translates into English as "Light Writer," "Bright Writer," or "Clear Writer," and is a pun on the name of its inventor (Hell (the adjective) is German for "light," the adverb is "bright.")
- It was developed at the end of the 1920s, and has the advantage of being capable of providing intelligible communication even over very poor quality radio or cable links. During WW2 it was sometimes used by the German military in conjunction with the Enigma encryption system


Phase Shift Keying

Phase Shift Keying Modes

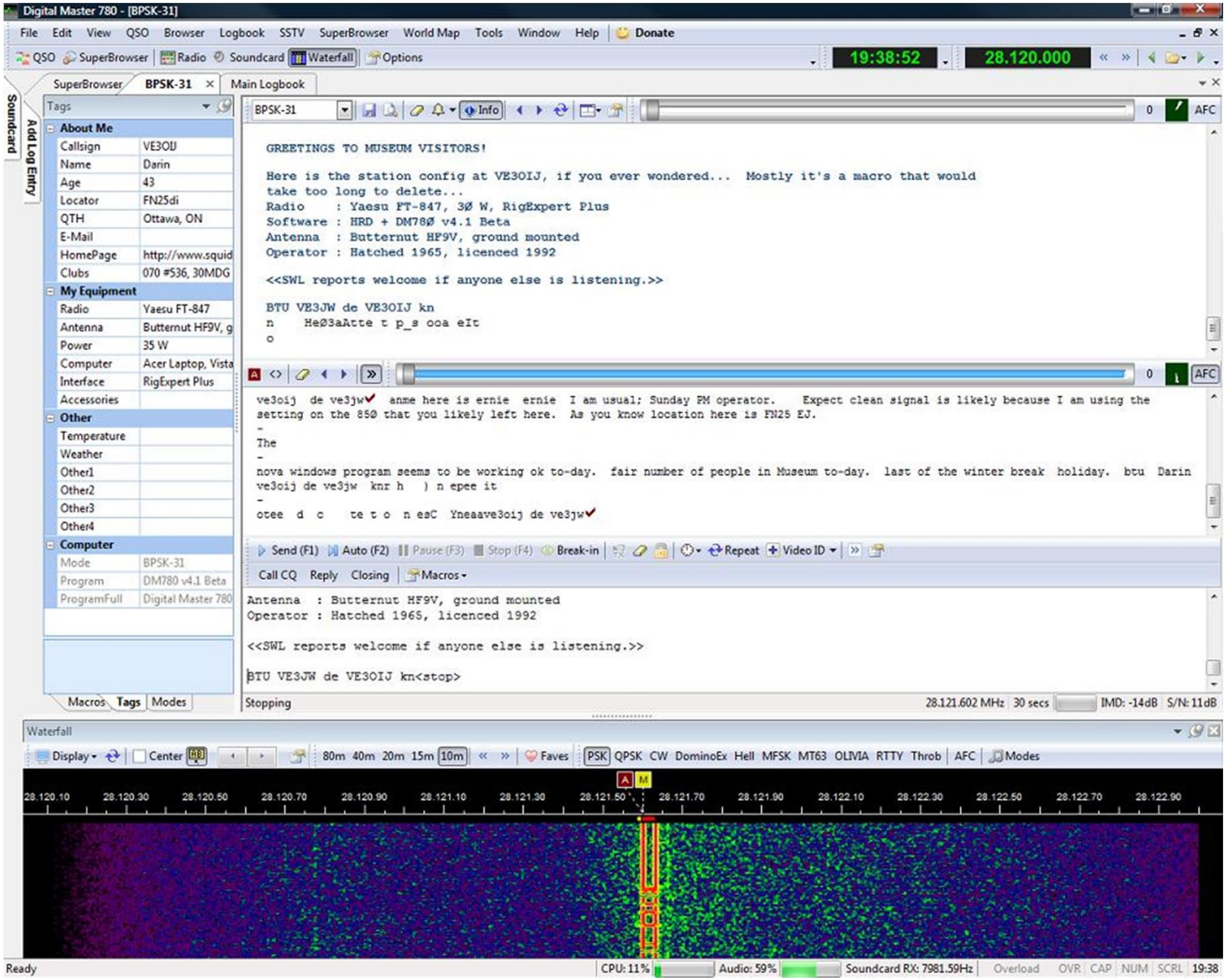
- BPSK31
- Two-level code
- 31 Hz bandwidth (theoretical), ~80 actual
- Varicode, not ASCII
  - Lower case letters are shorter, quicker to send
    characters used most frequently have shorter codes
- ~50 WPM effective speed
- Power density similar to CW
- No error correction
- -9 dB S/N minimum to decode
- BPSK normally USB, but doesn’t matter

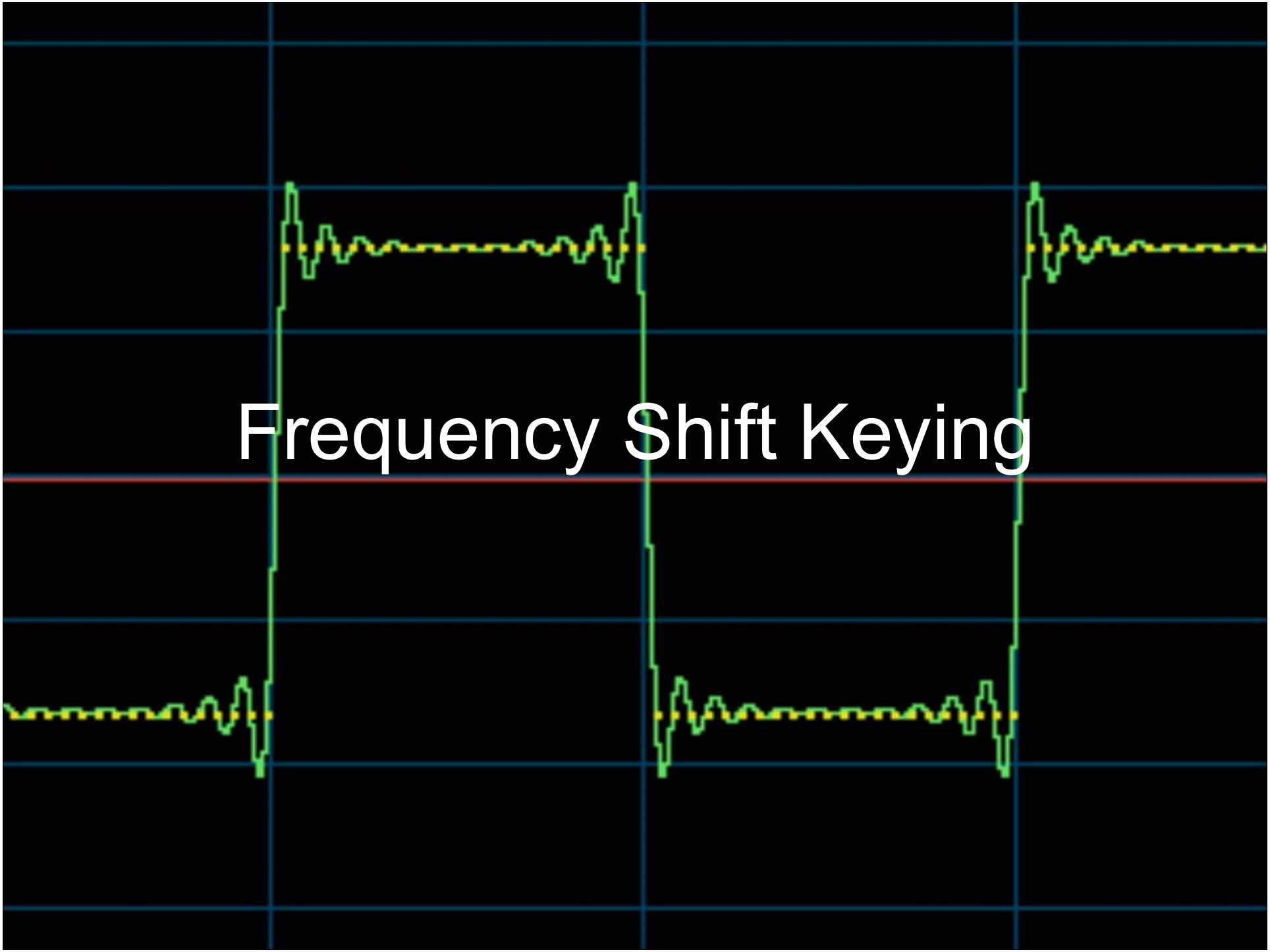
Varicode Sample

11	e
101	t
111	o
1011	a
1101	i
1111	n
10101	r

Phase Shift Keying Modes

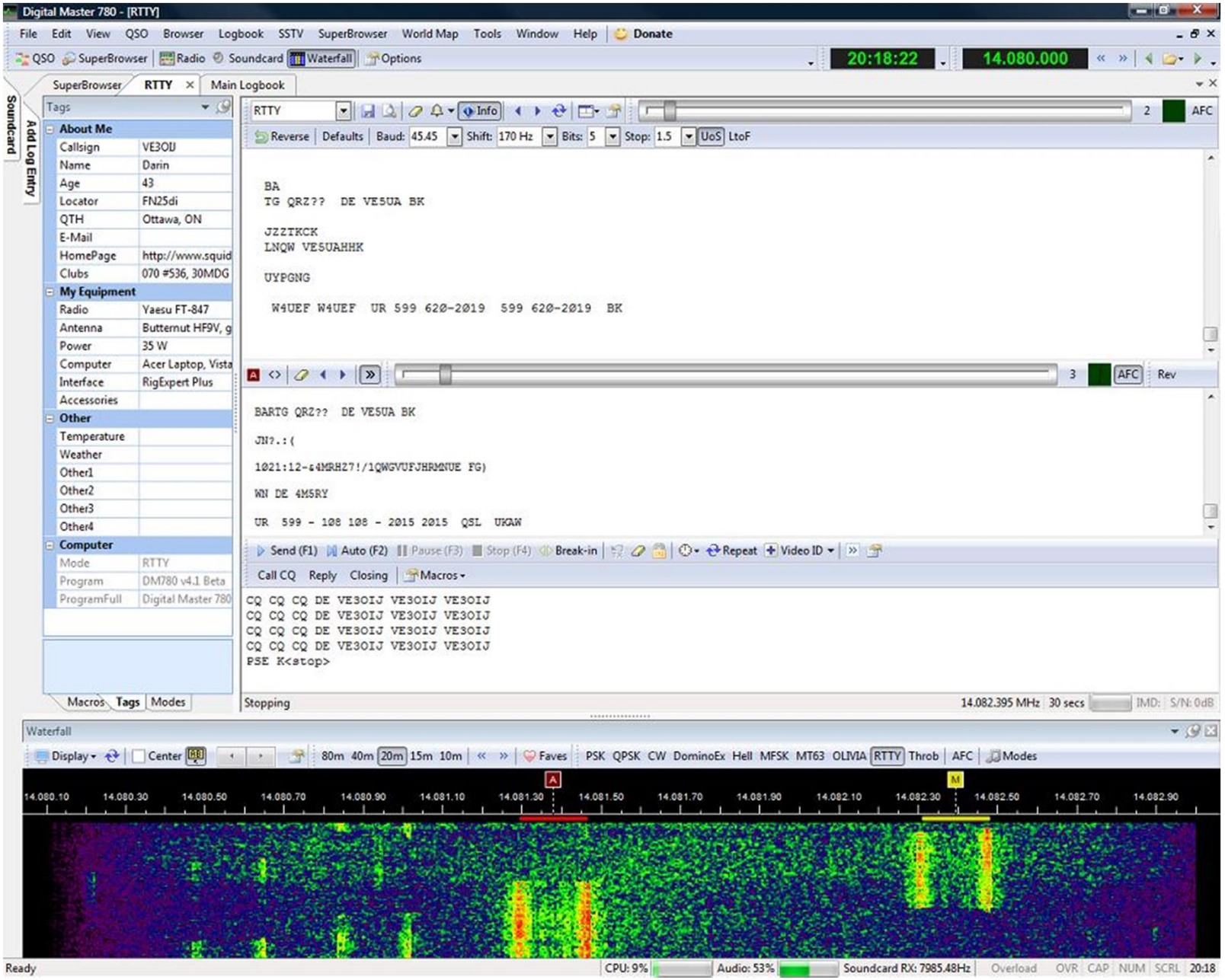
- BPSK63, BPSK125, etc.
  - More bandwidth for increased speed
  - BPSK63: ~100 WPM
  - BPSK125: ~200 WPM
- QPSK31 etc.
  - 4-phases
  - Extra levels used for error correction
  - Seldom seen, but useful depending on condx
  - USB / LSB matters
- -6 dB S/N minimum


Digital Master 780 - [BPSK-31]
File Edit View QSO Browser Logbook SSTV SuperBrowser World Map Tools Window Help Donate
QSO SuperBrowser Radio Soundcard Waterfall Options
19:38:52
28.120.000
SuperBrowser BPSK-31 Main Logbook
Soundcard
Add Log Entry
Tags
About Me
Callsign VE3OIJ
Name Darin
Age 43
Locator FN25di
QTH Ottawa, ON
E-Mail
HomePage http://www.squid
Clubs 070 #536, 30MDG
My Equipment
Radio Yaesu FT-847
Antenna Butternut HF9V, g
Power 35 W
Computer Acer Laptop, Vista
Interface RigExpert Plus
Accessories
Other
Temperature
Weather
Other1
Other2
Other3
Other4
Computer
Mode BPSK-31
Program DM780 v4.1 Beta
ProgramFull Digital Master 780
Macros Tags Modes
BPSK-31
Info
AFC
GREETINGS TO MUSEUM VISITORS!
Here is the station config at VE3OIJ, if you ever wondered... Mostly it's a macro that would take too long to delete...
Radio : Yaesu FT-847, 3Ø W, RigExpert Plus
Software : HRD + DM78Ø v4.1 Beta
Antenna : Butternut HF9V, ground mounted
Operator : Hatched 1965, licenced 1992
<<SWL reports welcome if anyone else is listening.>>
BTU VE3JW de VE3OIJ kn
n HeØ3aAtte t p_s ooa eIt
o
ve3oij de ve3jw anne here is ernie ernie I am usual; Sunday PM operator. Expect clean signal is likely because I am using the setting on the 85Ø that you likely left here. As you know location here is FN25 EJ.
-
The
-
nova windows program seems to be working ok to-day. fair number of people in Museum to-day. last of the winter break holiday. btu Darin
ve3oij de ve3jw knr h) n epee it
-
otee d c te t o n esC Yneaave3oij de ve3jw
Send (F1) Auto (F2) Pause (F3) Stop (F4) Break-in Repeat Video ID
Call CQ Reply Closing Macros
Antenna : Butternut HF9V, ground mounted
Operator : Hatched 1965, licenced 1992
<<SWL reports welcome if anyone else is listening.>>
BTU VE3JW de VE3OIJ kn<stop>
Stopping
28.121.602 MHz 30 secs IMD: -14dB S/N: 11dB
Waterfall
Display Center 80m 40m 20m 15m 10m Faves PSK QPSK CW DominoEx Hell MFSK MT63 OLIVIA RTTY Throb AFC Modes
28.120.10 28.120.30 28.120.50 28.120.70 28.120.90 28.121.10 28.121.30 28.121.50 28.121.70 28.121.90 28.122.10 28.122.30 28.122.50 28.122.70 28.122.90
Ready
CPU: 11% Audio: 59% Soundcard RX: 7981.59Hz Overload OVR CAP NUM SCRL 19:38


Frequency Shift Keying

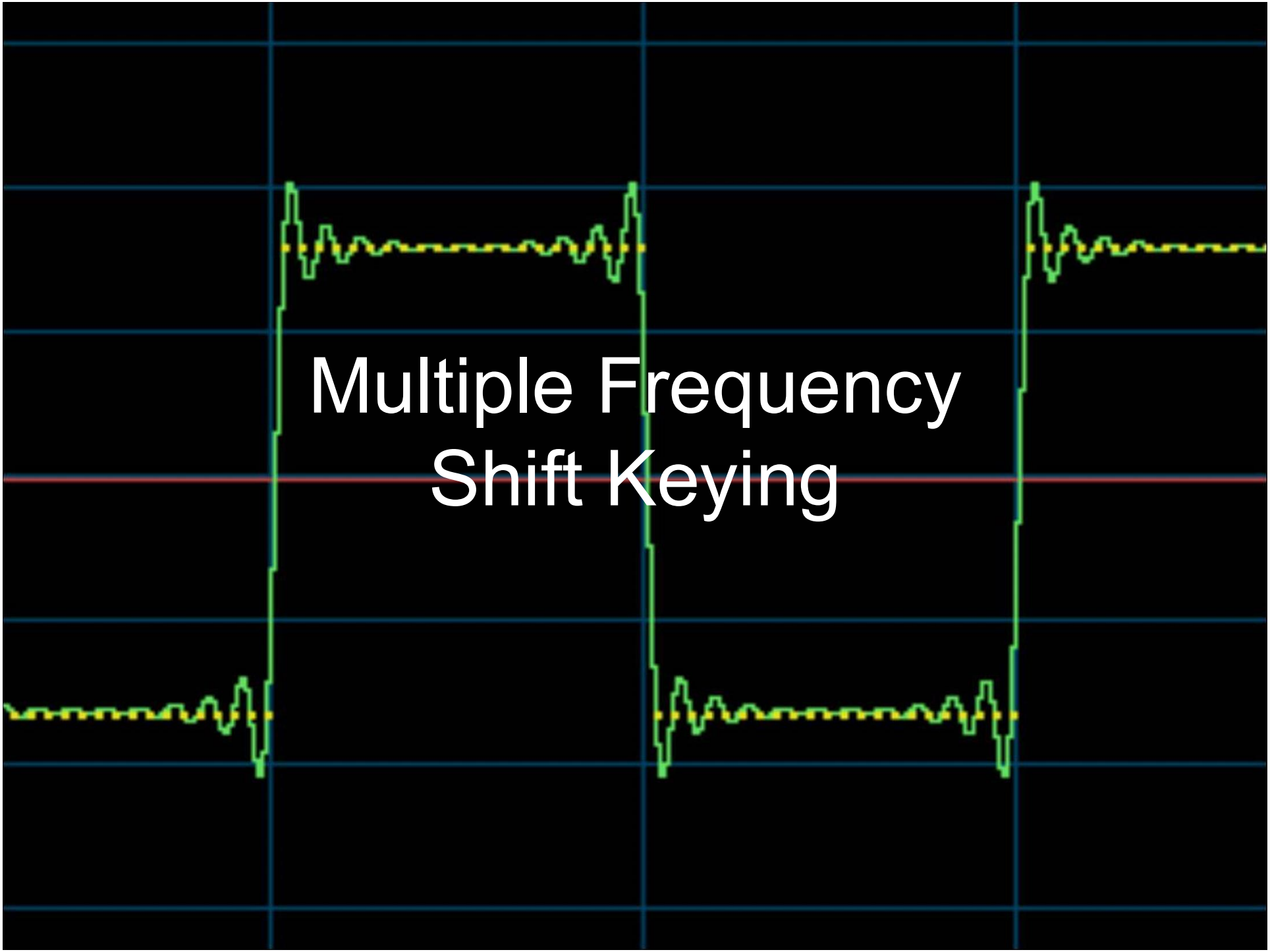
Frequency Shift Keying Modes

- RTTY – Radio Teletype
- If you can find one and hook it up, you can still do this with TTY machines
- Normally 2 frequencies (mark / space), 170 Hz apart
- 5-level code, 2 character sets of 31 characters (plus shift on, shift off)
- Uppercase only, 67 WPM, no error correction
- -5.5 dB minimum S/N
- USB


Digital Master 780 - [RTTY]
File Edit View QSO Browser Logbook SSTV SuperBrowser World Map Tools Window Help Donate
QSO SuperBrowser Radio Soundcard Waterfall Options
20:18:22
14.080.000
SuperBrowser RTTY Main Logbook
Soundcard
Add Log Entry
Tags
About Me
Callsign VE3OIJ
Name Darin
Age 43
Locator FN25di
QTH Ottawa, ON
E-Mail
HomePage http://www.squid
Clubs 070 #536, 30MDG
My Equipment
Radio Yaesu FT-847
Antenna Butternut HF9V, g
Power 35 W
Computer Acer Laptop, Vista
Interface RigExpert Plus
Accessories
Other
Temperature
Weather
Other1
Other2
Other3
Other4
Computer
Mode RTTY
Program DM780 v4.1 Beta
ProgramFull Digital Master 780
Macros Tags Modes
RTTY Info AFC
Reverse Defaults Baud: 45.45 Shift: 170 Hz Bits: 5 Stop: 1.5 UoS LtoF
BA
TG QRZ?? DE VE5UA BK
JZZTKCK
LNQW VE5UAHHK
UYPGNG
W4UEF W4UEF UR 599 620-2019 599 620-2019 BK
AFC Rev
BARTG QRZ?? DE VE5UA BK
JN?.:(
1021:12-&4MRHZ7!/1QWGVUFJHRMNUE FG)
WN DE 4M5RY
UR 599 - 108 108 - 2015 2015 QSL UKAW
Send (F1) Auto (F2) Pause (F3) Stop (F4) Break-in Repeat Video ID
Call CQ Reply Closing Macros
CQ CQ CQ DE VE3OIJ VE3OIJ VE3OIJ
CQ CQ CQ DE VE3OIJ VE3OIJ VE3OIJ
CQ CQ CQ DE VE3OIJ VE3OIJ VE3OIJ
CQ CQ CQ DE VE3OIJ VE3OIJ VE3OIJ
PSE K<stop>
Stopping
14.082.395 MHz 30 secs IMD: S/N: 0dB
Waterfall
Display Center
80m 40m 20m 15m 10m Faves
PSK QPSK CW DominoEx Hell MFSK MT63 OLIVIA RTTY Throb AFC Modes
14.080.10 14.080.30 14.080.50 14.080.70 14.080.90 14.081.10 14.081.30 14.081.50 14.081.70 14.081.90 14.082.10 14.082.30 14.082.50 14.082.70 14.082.90
Ready
CPU: 9%
Audio: 53%
Soundcard RX: 7985.48Hz
Overload OVR CAP NUM SCRL 20:18

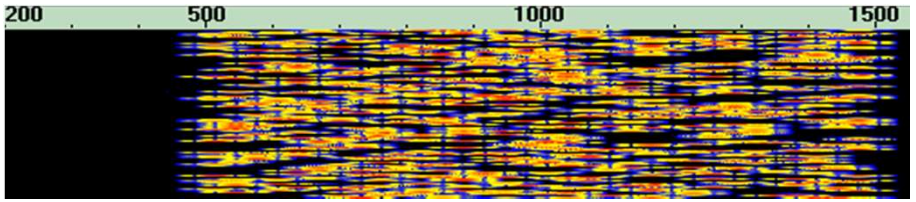
Frequency Shift Keying Modes

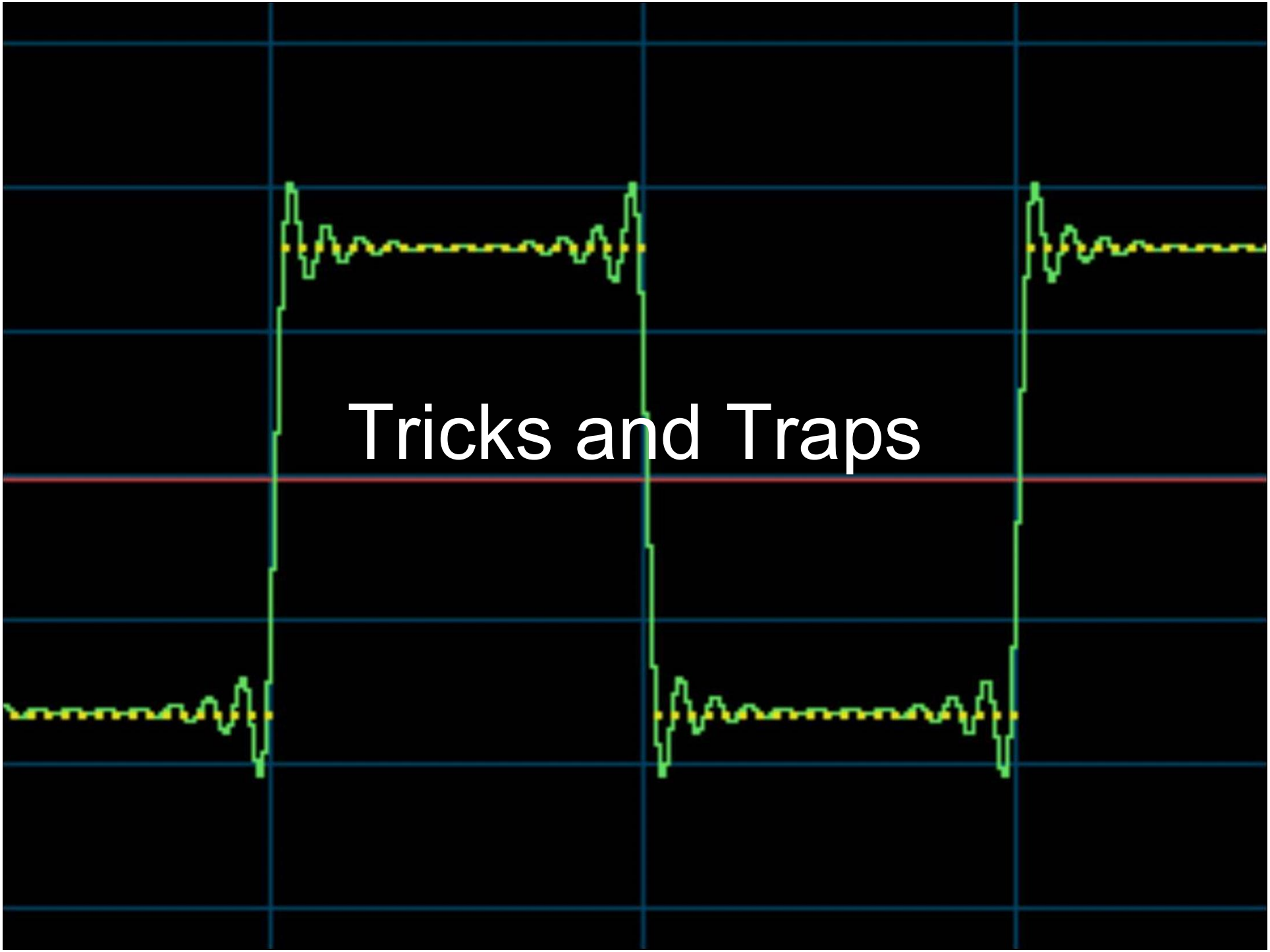
- JT65 (WSJT- Weak Signal JT)(K1JT)
- Used for meteor scatter, moon bounce, weak signal applications
- -30ish dB S/N
- Slow, but not intended for rag chewing


Multiple Frequency
Shift Keying

Multiple Frequency Shift Keying Modes

- Like FSK, but spread the signal out over more frequencies.
- Wider signals:
  - MFSK16: 250 Hz, 42 WPM
  - Olivia: 250 to 1000 Hz, 14-20 WPM
- MFSK16 also has limited SSTV capability
- Forward Error Correction
  - In general, you copy it all, or you get almost nothing
- You can decode even when you can't really see them on the waterfall
  - Olivia: -11 to -14 dB S/N
  - MFSK16: -13 dB S/N
- USB



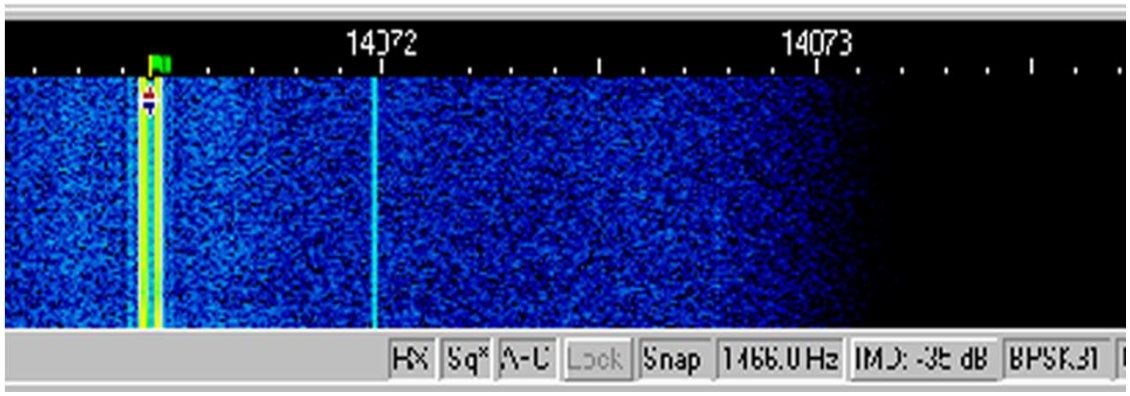

Tricks and Traps

Tricks and Traps

- Transmitter Power
  - Except for SSTV, digital modes seldom require huge power
  - Use your amp sparingly, if at all
  - Adjust for peak output at 40-50% of maximum
- Duty Cycle
  - Some modes are high duty cycle (RTTY, SSTV)
  - Think about your finals
- Normally USB, all bands
  - BPSK doesn't care
  - Some modes can be "reversed" for LSB
  - Helleschreiber has an FM mode
- Most of these modes are audio-based so they can be played into FM, AM, etc. and still work if the other end listens the same way.

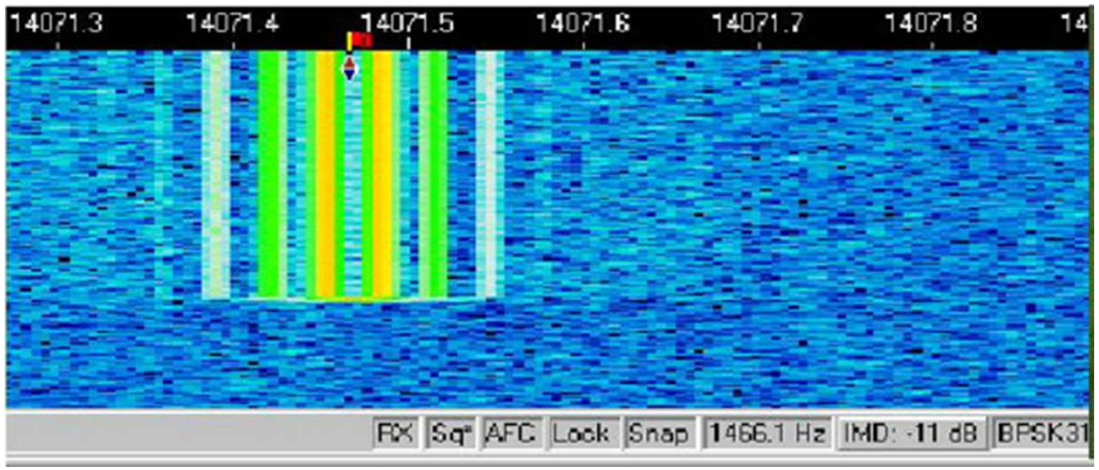
Tricks and Traps

- Clean signals!
- **PSK: if your ALC meter shows movement, your signal is not clean**
- Wide, dirty signals cause QRM, and waste power and bandwidth
- How to tune up for PSK:
  - Set transmitter to maximum power
  - Turn off speech processing
  - Transmit PSK idle tones
  - While transmitting idle tones, adjust audio IN to the radio to show no ALC
  - Adjust audio down below the NO ALC level to show peak power out about 40% of maximum (40 Watts peak on a 100 Watt radio). If you don't have a peak meter, adjust to show average power of 25% of maximum (25 Watts average on a 100 Watt radio).
  - When transmitting text (not idle tones), you should get about 50% max power peak, 35% max power average with this configuration.



Good PSK signal. IMD -35 dB

Notice the signal is only about 40 Hz wide.



Poor PSK signal. IMD -11 dB

This signal is 200 Hz wide.

Tricks and Traps

- If you reduce maximum transmitter power, you will have to adjust audio levels for no ALC, and 40% / 25% of your new power level. You can't just crank down the power and go.
- Once set up for PSK, remember these settings, they are generally appropriate for all digital modes, although your power meter will read differently in other modes.

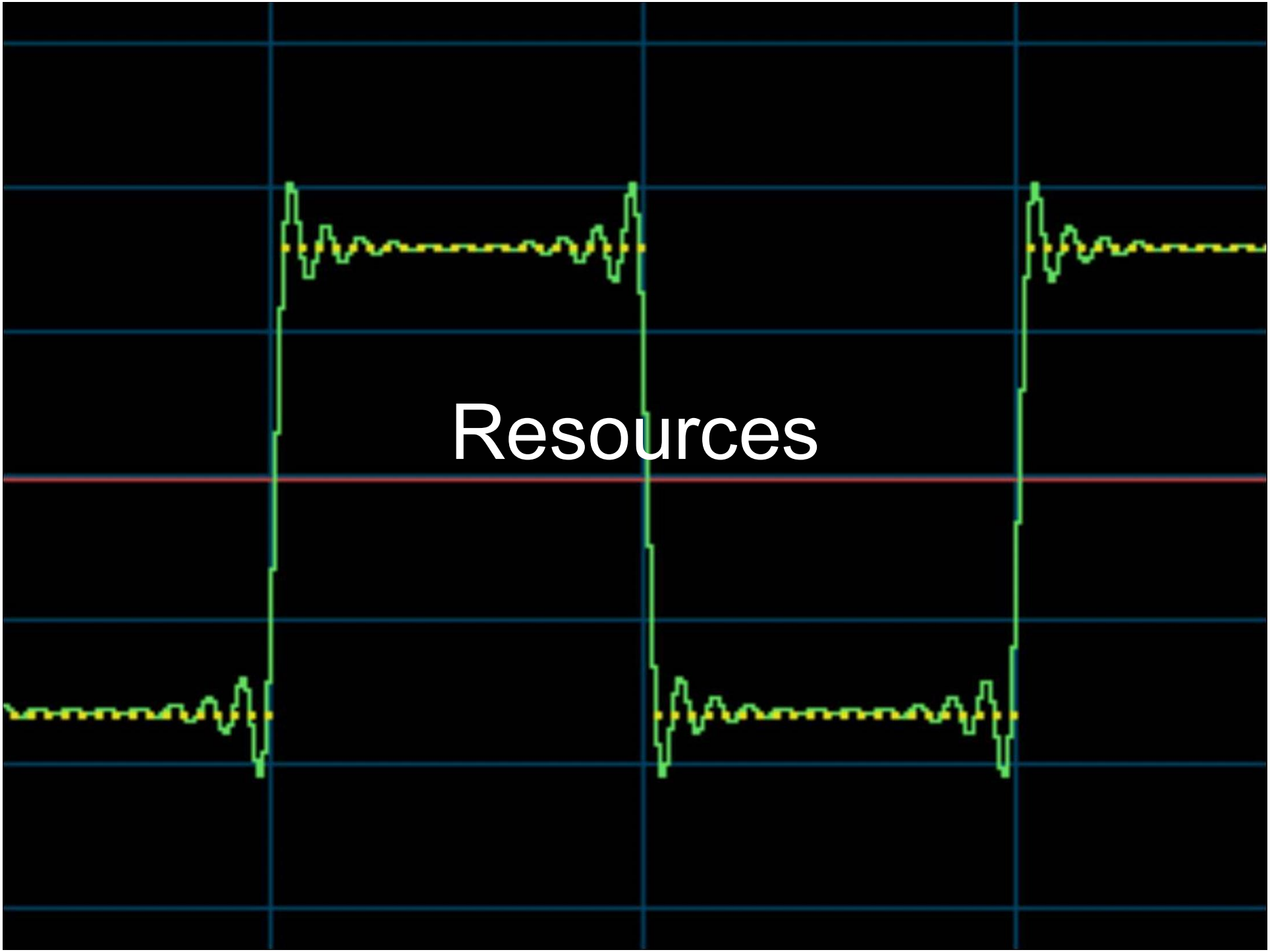

Where To Find

Where to find?

- 160m – 1837 USB
- 80m – 3580 USB +/- depending on W1AW schedule
- 40m – 7035 USB (DX), 7070 USB (USA)
- 30m – 10132 USB (SSTV-N), 10140+ USB (other)
- 20m – 14070 (PSK), 14073+ (MFSK, Hell), 14080 (RTTY), 14230 SSTV

Where to find?

- 17m – 18101
- 15m – 21070
- 12m – 24920
- 10m – 28120
- 6m – 50290
- Olivia is often used in pre-agreed channels
  - http://hflink.com/olivia/

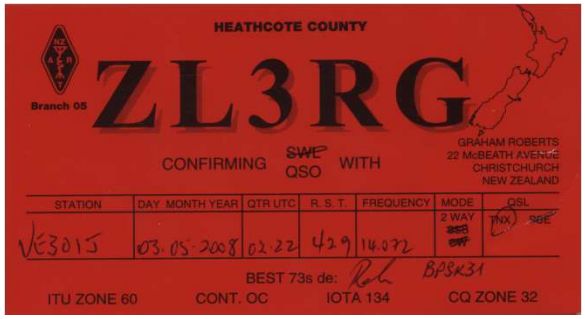

Resources

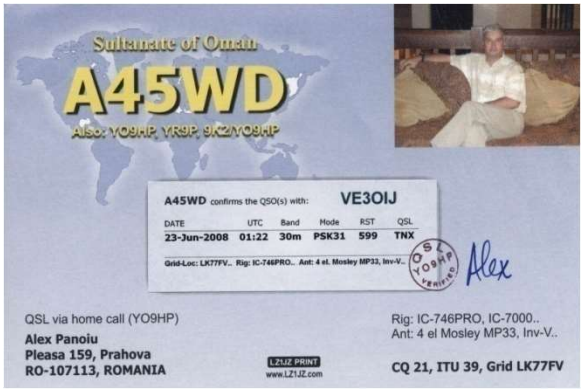
Resources

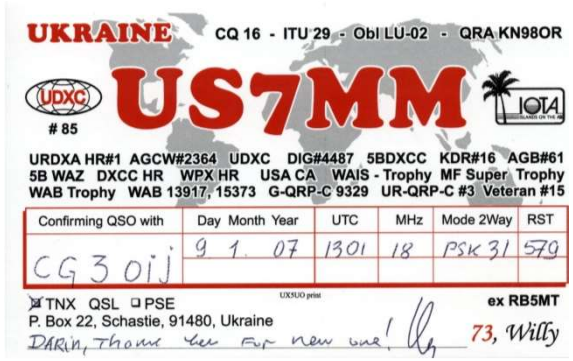
- Useful links
  - Digital mode descriptions
    - http://f1ult.free.fr/DIGIMODES/DIGI.htm (French)
    - http://f1ult.free.fr/DIGIMODES/MULTIPSK/digimodesF6CTE_en.htm (English)
  - Olivia frequencies
    - http://hflink.com/olivia/
  - Ham Radio Deluxe
    - http://www.ham-radio-deluxe.com/

Resources

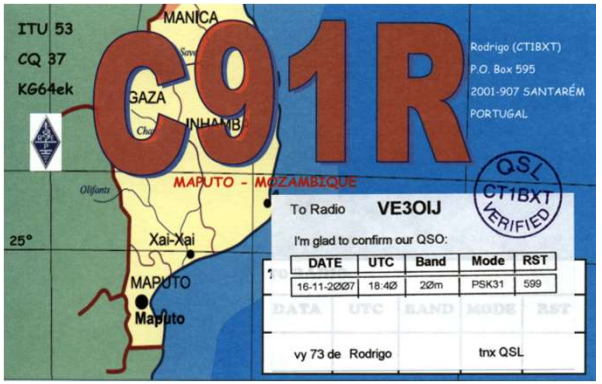
- Useful links
  - Digital modes clubs
    - PODXS 070 Club: http://www.podxs070.com
    - 30 Meter Digital Group: http://www.30meterdigital.org
    - Digital Modes Club: http://www.digital-modes-club.org
    - Feld Hell Club: http://sites.google.com/site/feldhellclub
    - European PSK Club: http://eu.srars.org
  - Digital Sounds
    - http://www.kc0tks.org/index.php?option=com_content&task=view&id=38&Itemid=45

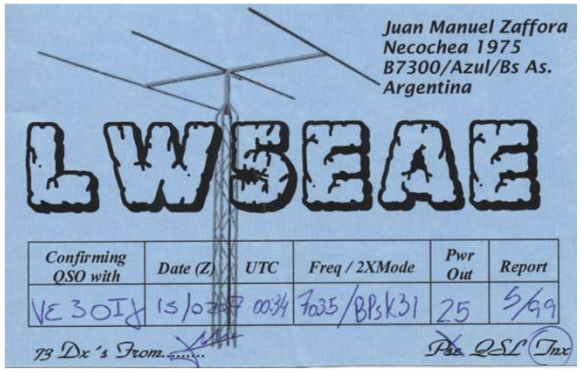


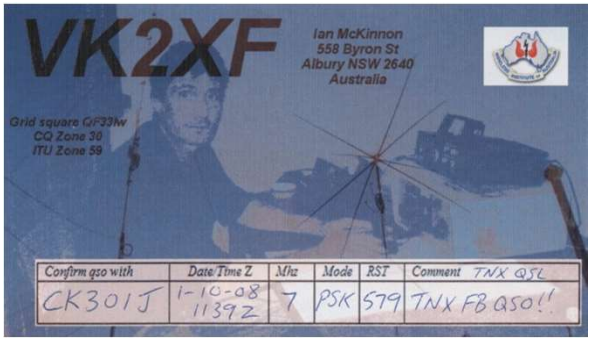


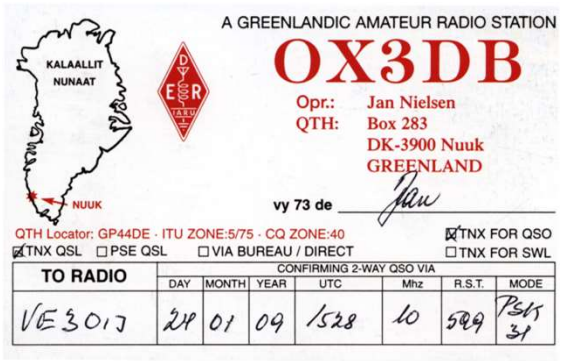


Questions?









Solar minimum? Bah! I say!