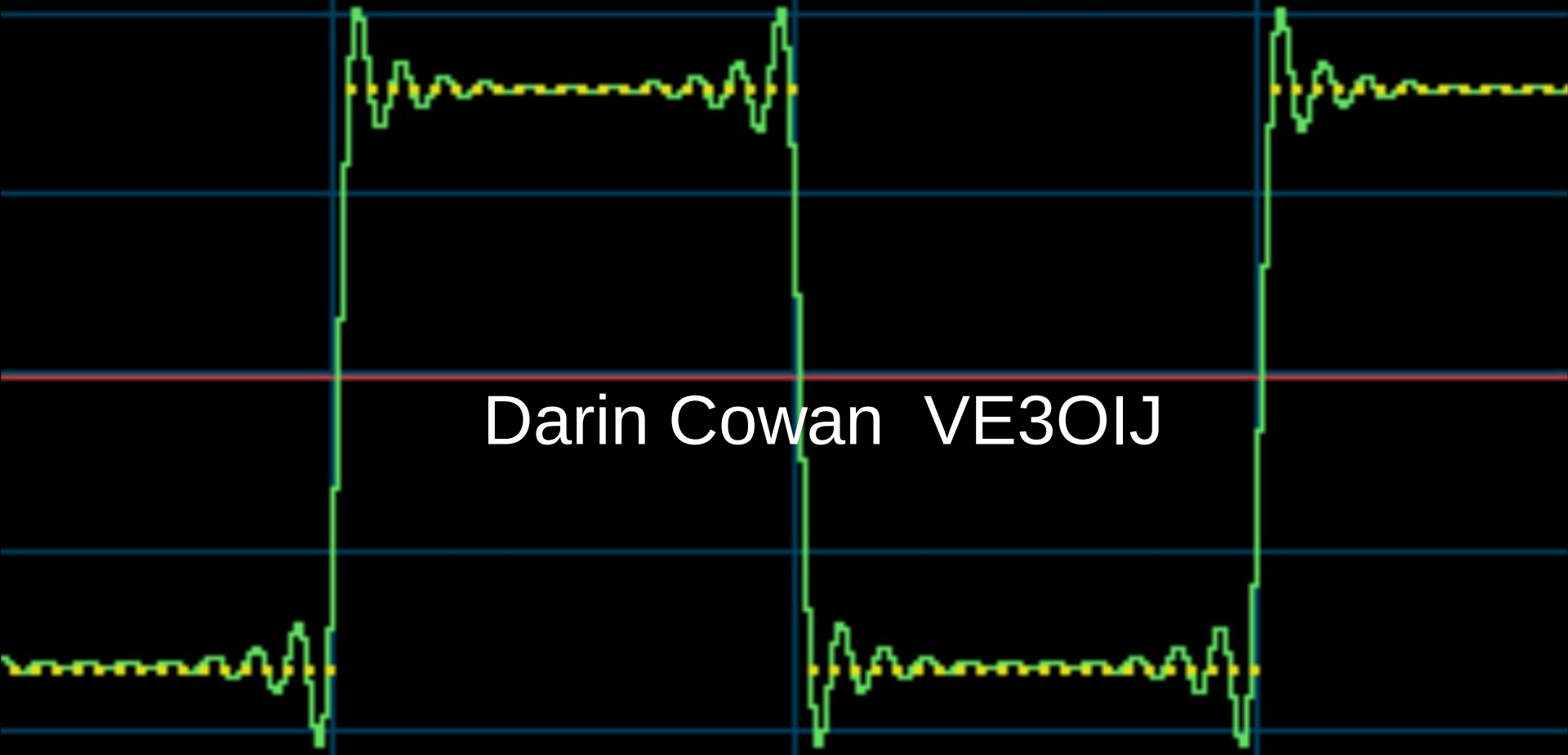
Digital Modes



Darin Cowan VE3OIJ

With revisions/additions
by George Kaneff
N2GWK

Digital

adjective

(of signals or data) expressed as a series of the digits 0 and 1, typically represented by values of a physical quantity such as voltage or magnetic polarization

(Google)

Background

- First popular digital mode for communication 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: telegraphy = remote writing
- Some people prefer do it manually to this day
- Modern, inexpensive computers allow access to digital signal processing - other modes possible

Pros and Cons of Digital Modes

Pros and Cons

- Cons
  - Most require special equipment, and generally a knowledge of computers
  - Semi-necessary to know how to type (30WPM or better to get the best results on most digital modes)

Pros and Cons

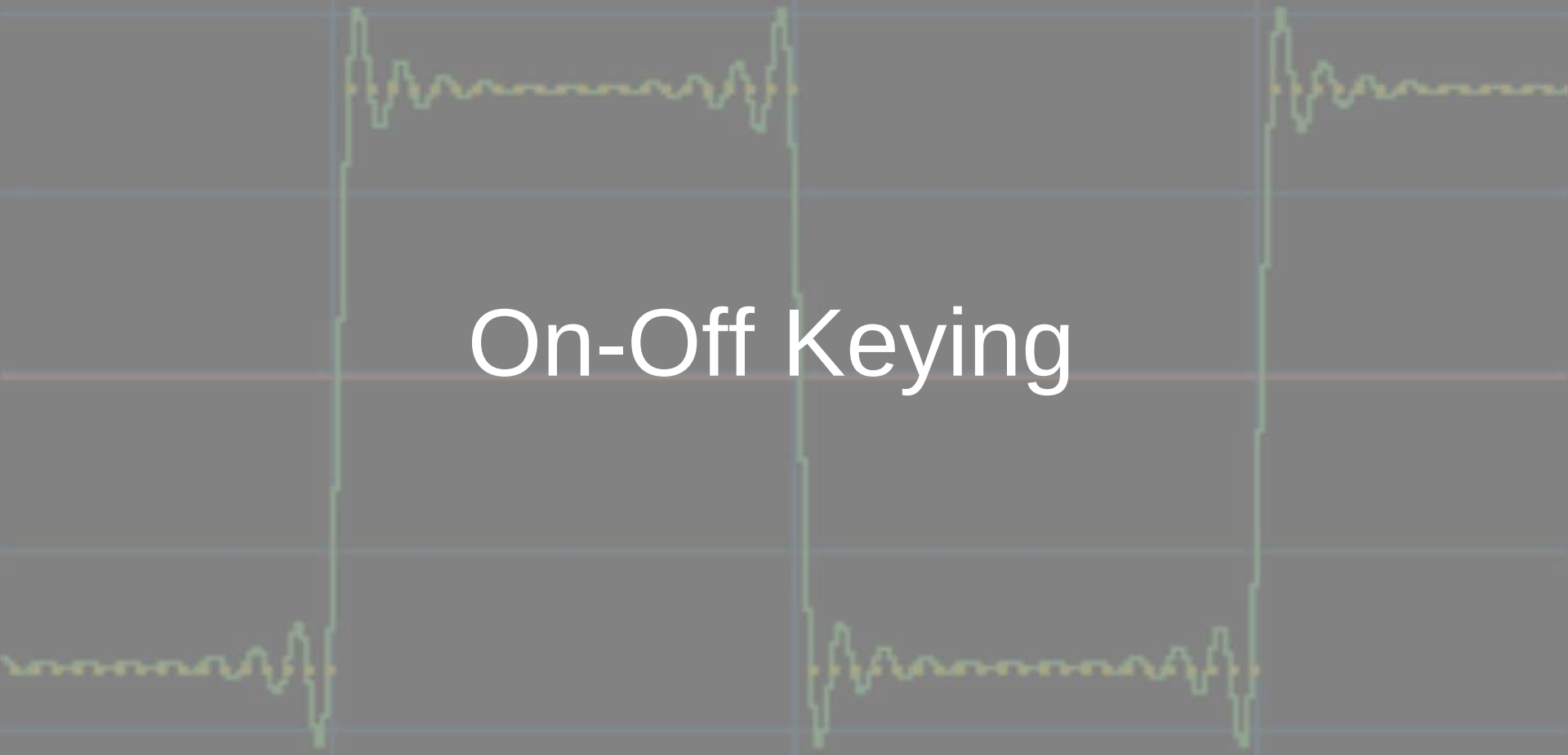
- Pros
  - Speeds much faster than Morse code
  - Can be error corrected for perfect copy
  - Low power
  - Efficient use of spectrum – even high speed modes use less bandwidth than a typical voice communication
  - Excellent for hearing impaired
  - Learning to type 30 WPM is generally easier than learning to do Morse code at that speed. (30 WPM was the standard for Gr. 9 typing class in 1978).
  - High speed - Experienced typists can manage 100 WPM, not possible with (manual) Morse code. Other data modes even faster.
  - Multi-media: video, audio, text

Emissions and Modes

Emissions

- OOK
  - On-off Keying
    - CW / Morse Code
    - Feld-Hell
- PSK
  - Phase Shift Keying
    - BPSK, QPSK, OPSK
    - 31, 63, 125, 250, 500
- FSK
  - Frequency Shift Keying
    - RTTY, Pactor
- MFSK
  - Multiple Frequency Shift Keying
    - MFSK16, Olivia, MT63 (MT63-NBEMS), WSJT
- 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

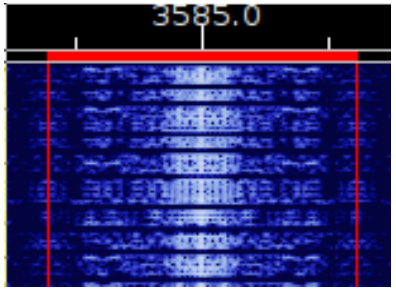
On-Off Keying



On-Off Keying Modes

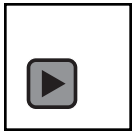
- Morse Code (CW)
  - Can be done manually without special equipment
  - Can be challenging to decode manual code by machine depending on skills of sender
    - Machine decoding reveals the “fist” of a human sender. Most people don’t conform to standards as well as they think, but some people are awesome.
  - 50-100 Hz nominal bandwidth
  - 80+ WPM by machine, 40-50 WPM by hand with the best operators
  - Good power density, excellent in poor band condx

On-Off Keying Modes



- Feld-Hell (Helleschreiber)
  - Facsimile – sends pictures of the letters

  - Named after inventor, Rudolf Hell. Devised in late 1920s, now emulated with sound cards on computers
  - Originally printed on paper tape
    - Always two lines to ensure readable on tape regardless of sync
    - Used with Enigma in WW2
  - Decoded by eye, OK in mediocre conditions
  - ~35 WPM
  - 75 Hz minimum bandwidth (245 Hz filter standard)



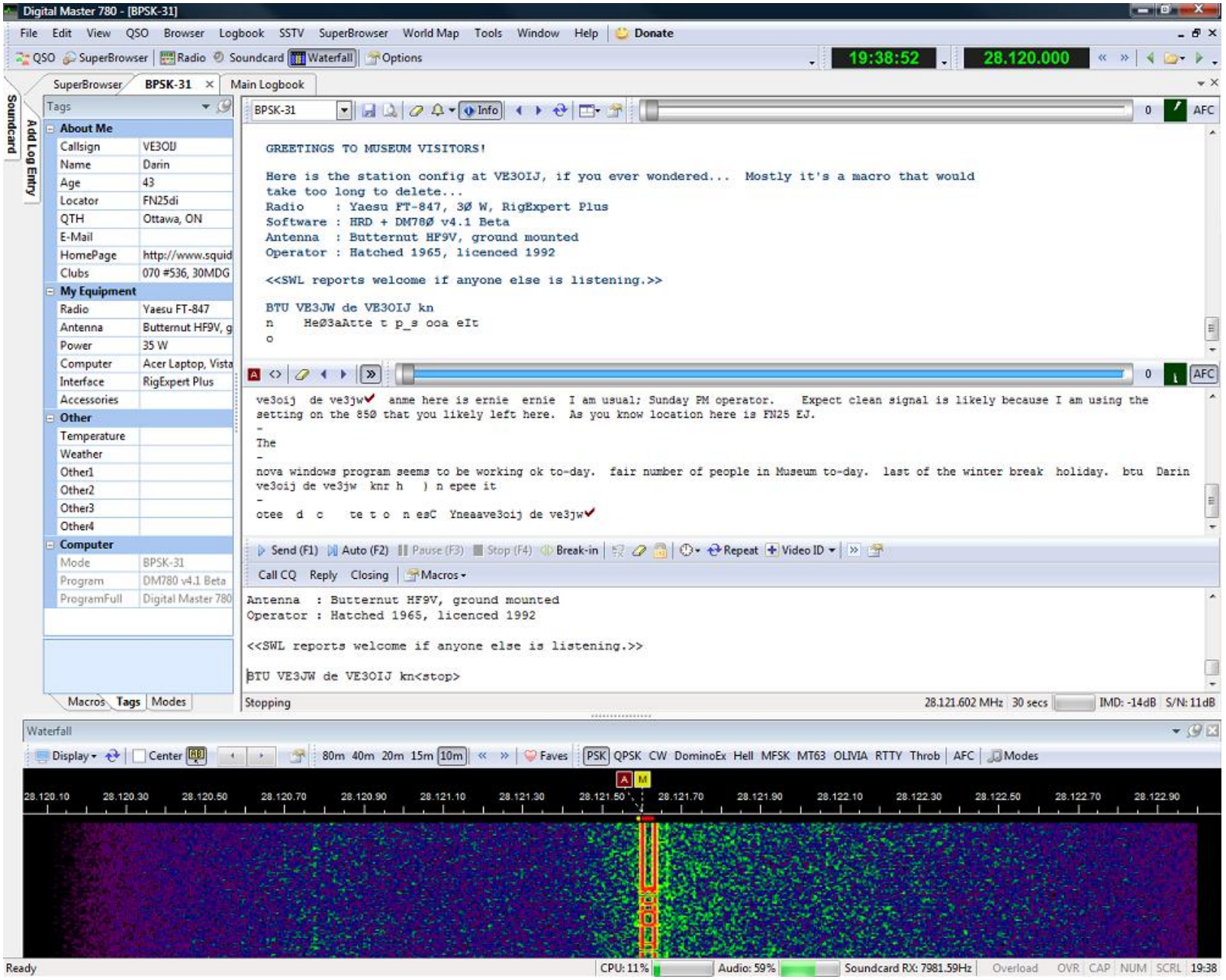
Phase Shift Keying

Phase Shift Keying Modes

- Very common digital mode
- BPSK - Two-level code
- BPSK31: 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
- PSK sounds like a whistle with a slight warble and a beat frequency.

Phase Shift Keying Modes

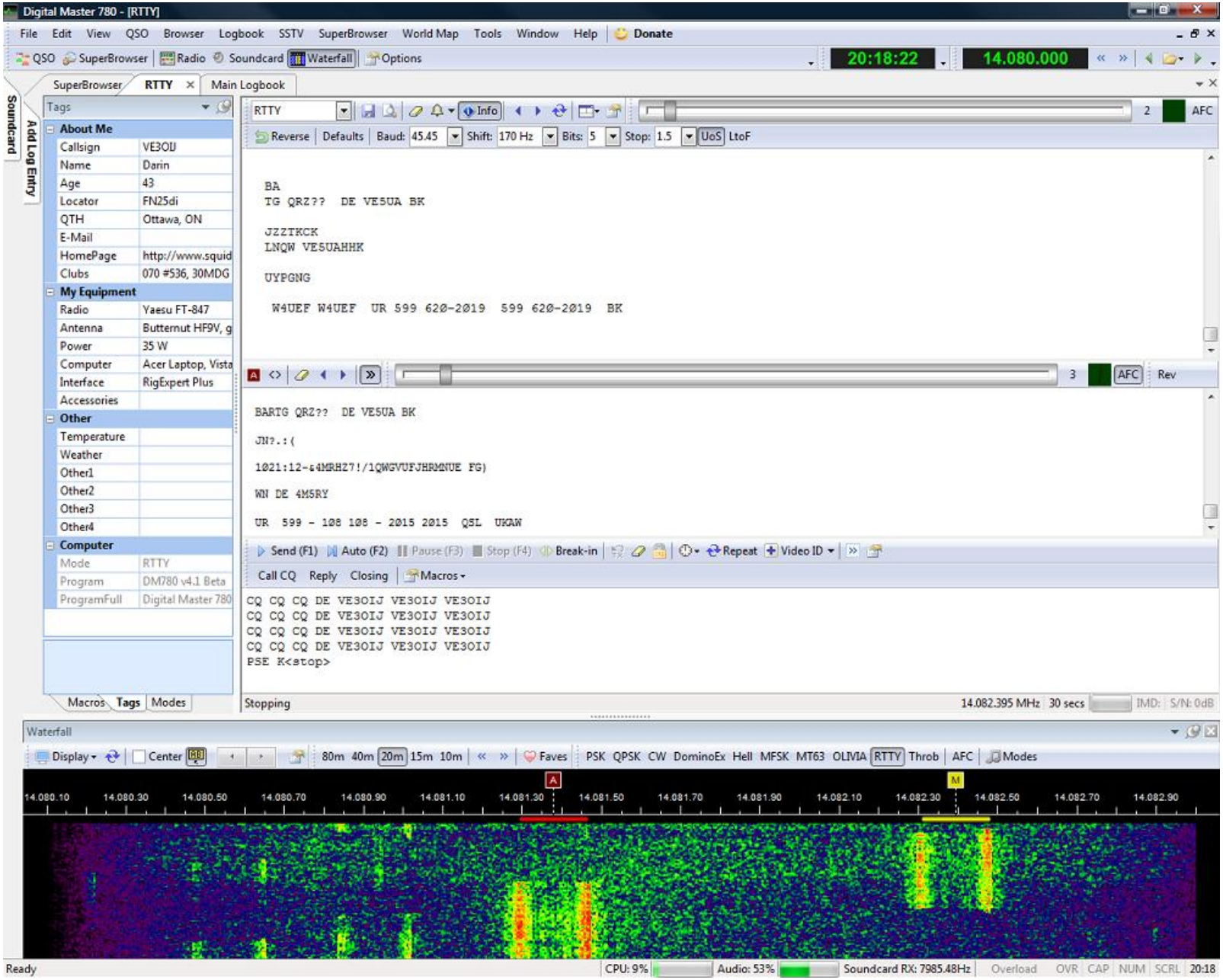
- BPSK63, BPSK125, etc.
  - More bandwidth for increased speed
  - BPSK63: ~100 WPM
  - BPSK125: ~200 WPM
- QPSK31 etc.
  - 4-phases
  - Extra levels used for error correction
  - Seldom seen, but useful depending on condx
  - USB / LSB matters
- -6 dB S/N minimum


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 anme 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

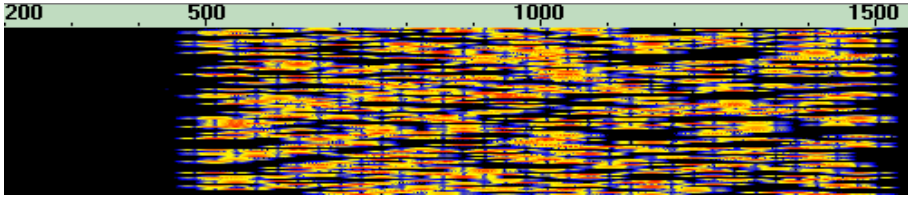
Frequency Shift Keying Modes

- RTTY – Radio Teletype, very common
- You can still do this with TTY machines
- Normally 2 frequencies (mark / space), 170 Hz apart
- 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

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

Multiple 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

Making It Happen

Equipment

- Receive – You'll need:
  - An SSB receiver
  - A computer (or other device) with a sound card/processor (cables / interfaces etc)
  - Software to decode the signal

- Transmit – You'll need:
  - 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 SSB transmitter (mic works, TNC is better)

Getting Started

Minimum:

- simple computer
- some kind of sound capability
- a method to get that sound into your radio

Could be as simple as a tablet playing out the speaker to your radio microphone.

Getting Started

- Decent computer is better
  - Better signal processing capabilities
  - Multi-core CPU - 2 GHz
  - Windows: >= 6 GB, Windows 7 or higher
  - Linux: >= 4 GB
  - Mac: good luck, hope you’re a DIY person.
  - 2 monitors really helps
- Internet connection helps
  - Most s/w does logging to eQSL, LotW, etc.
  - DX spots, solar info, APRS
  - Can you bring your internet in via amateur radio too?

A Digital Station

- Quad Core, 2.4 GHz laptop, Win 8.1
- 12 GB RAM
- External monitor
- RigExpert Plus
- Kantronics KPC 3+

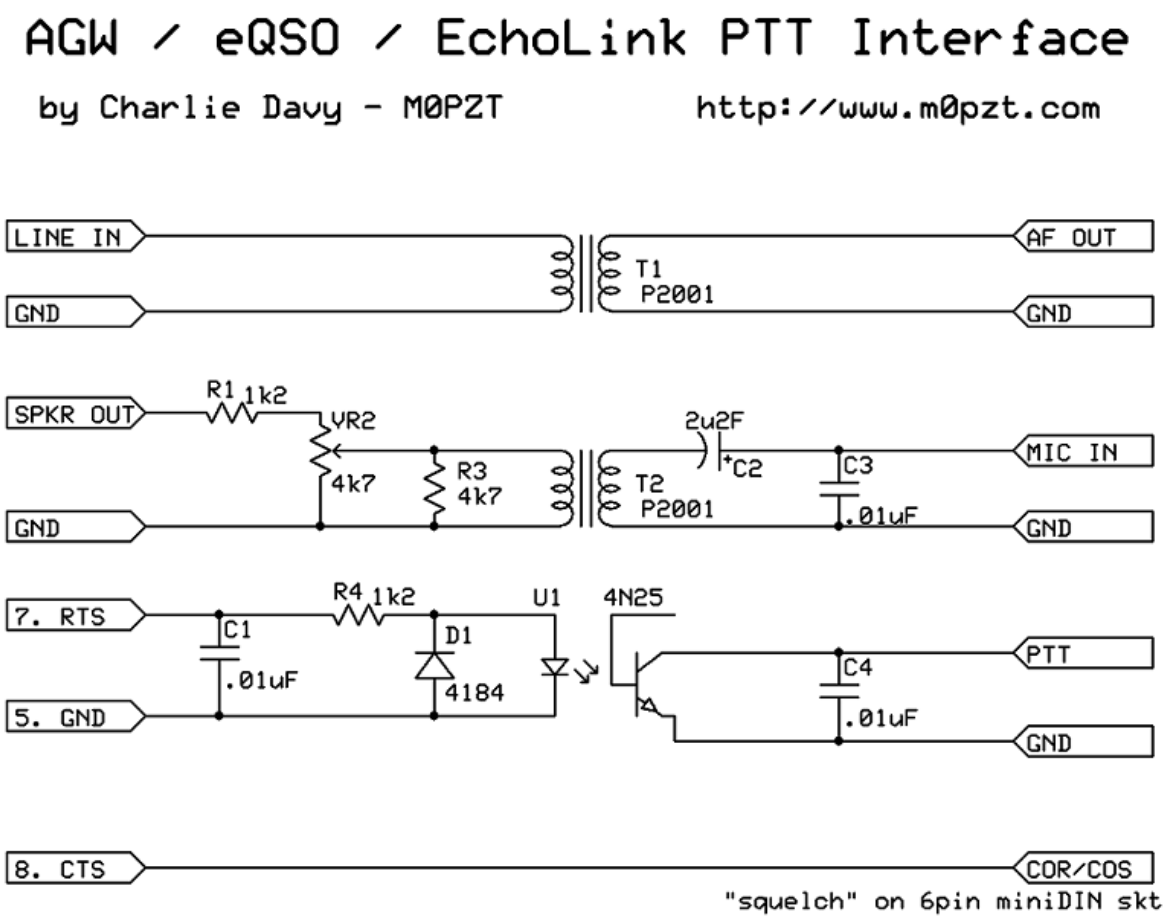
Do it yourself

- Sound card interfaces are an excellent starter project
- Google “amateur radio home brew sound card interface”

Design and Construction Manual for an Isolating Sound Card Interface for SSB Transceivers

- http://bit.ly/1x9tpeZ

Do it yourself



NUE-PSK

- Plug in a keyboard and a radio and go
- Available pre-built or as a kit
- Small 7" x 4" x 1" standalone, battery-operated

Fully Assembled US/CAN: $220
Full Kit US/CAN: ~ $175

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

RigExpert Models

Complete Set - RigExpert TI5 with prewired cable $340.00
Complete Set - RigExpert Standard and prewired cable $240.00

http://www.rigexpert.net

RIGblasters

RIGblaster

- RIGblaster pro USB/Serial Complete $380
- RIGblaster plus II USB/Serial Complete USB and Serial Port RS232 $200
- RIGblaster Nomic USB/Serial Complete USB and Serial Port RS232 $75
- RIGblaster Data Jack plug & play Complete USB only $150

SignaLink USB

- Simple interface
- $120

Software

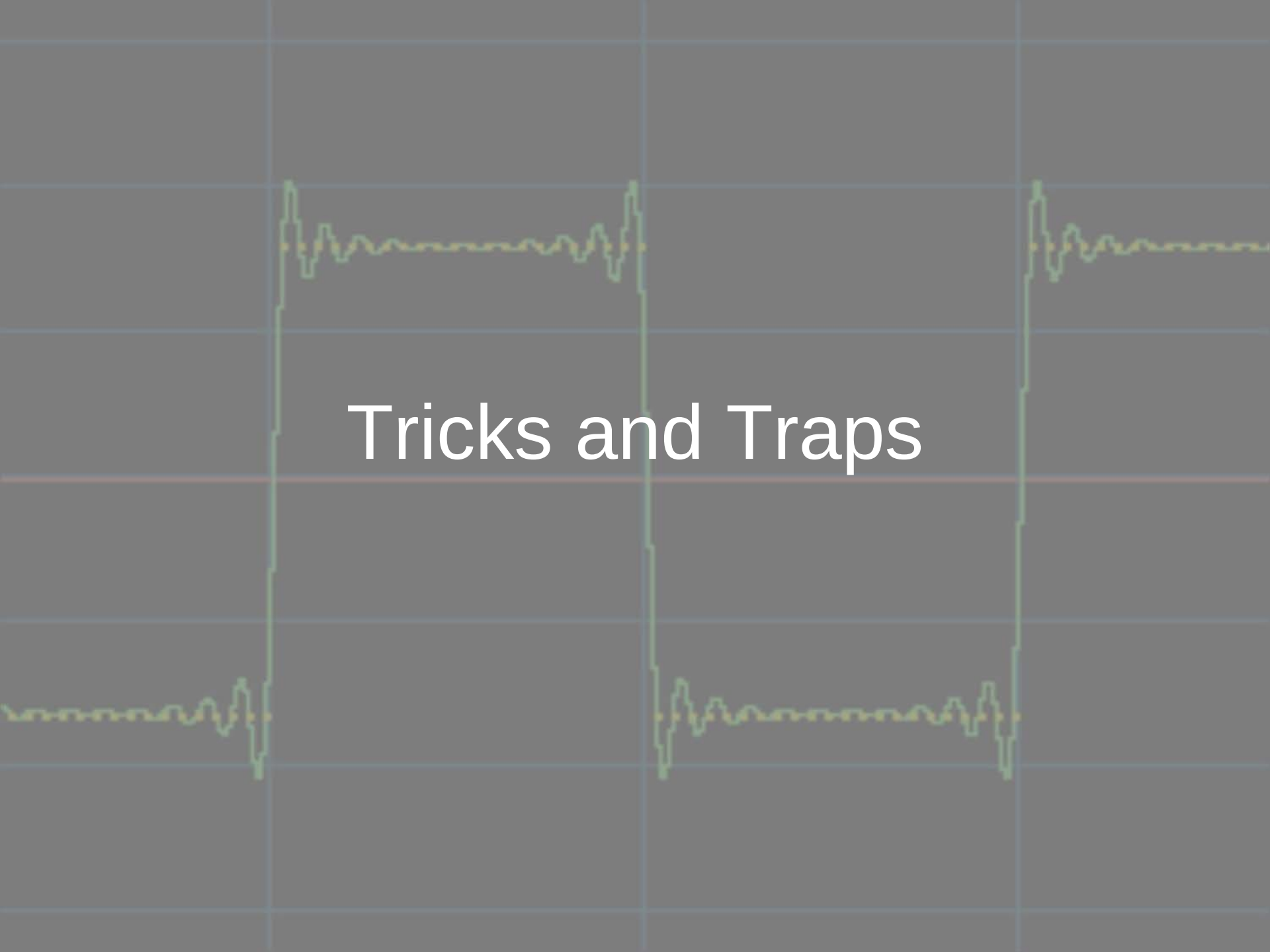
Software

- **Ham Radio Deluxe**
  - Approx $100 ($50/yr for ongoing support)
  - Advanced rig control and digital modes software
  - Excellent logging features

- **MixW**
  - Approx $70
  - 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, and then some
  - Very steep learning curve
  - Poor documentation
  - Shareware. Paid version has extra features

- **Fldigi**
  - Linux
  - Free

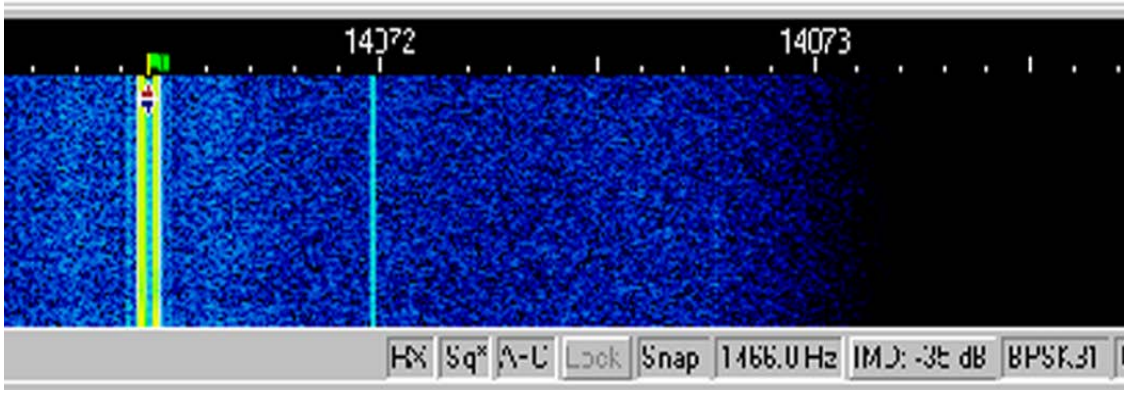

Tricks and Traps

Tricks and Traps

- Transmitter Power
  - Except for SSTV, seldom require huge power
  - If you're not reaching for other galaxies, leave your amp off.
- Duty Cycle
  - Some modes are high duty cycle (RTTY, SSTV)
  - Think about your finals, especially if you tend to be "verbose"
- Normally USB, all bands, even 160 / 80 / 40
  - BPSK doesn't care
  - Some modes can be "reversed" for LSB
- Most are audio-based so they can be played into FM, AM, etc. and still work if the other end listens the same way.
- Upper/lower case – In some modes (Morse code, RTTY) everything is upper case. **In other modes (BPSK, QPSK) using all upper case slows you down substantially.**

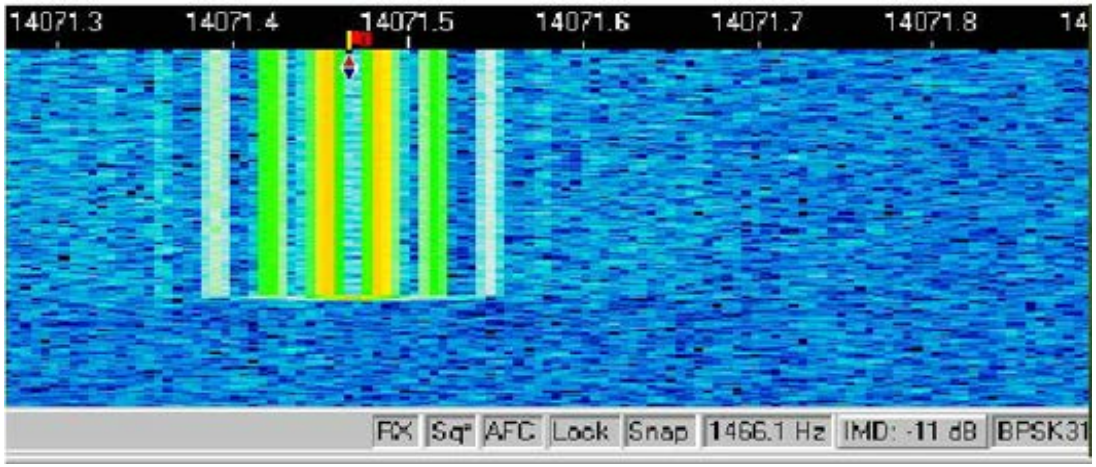
Tricks and Traps

- Clean signals!
- **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, and meter to ALC
  - ***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, 3576 (JT65)
- 40m – 7070 USB (USA), 7032.5 (Olivia), 7076 (JT65)
- 30m – 10132 USB (SSTV-N), 10140+ USB (other), 10138 (JT65)
- 20m – 14070 (PSK), 14073+ (MFSK), 14063+ (Hell), 14080 (RTTY), 14230 SSTV, 14076.4 (Olivia), 14076 (JT65)

Where to find?

- 17m – 18100, 18101
- 15m – 21070, 21076
- 12m – 24920
- 10m – 28120
- 6m – 50290
- Olivia is often used in pre-agreed channels
  - http://hflink.com/olivia/

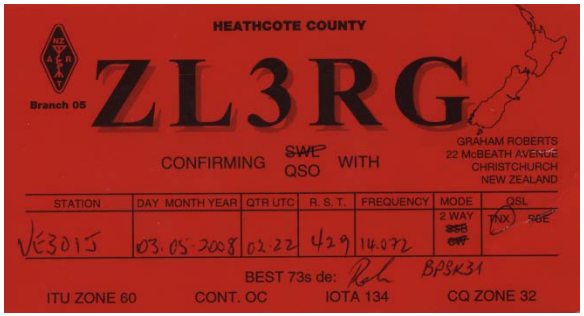
Resources

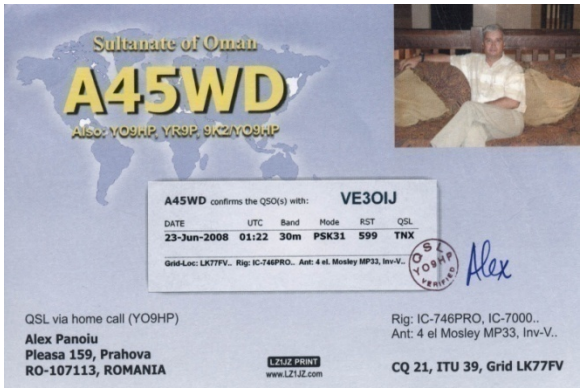
Resources

- 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

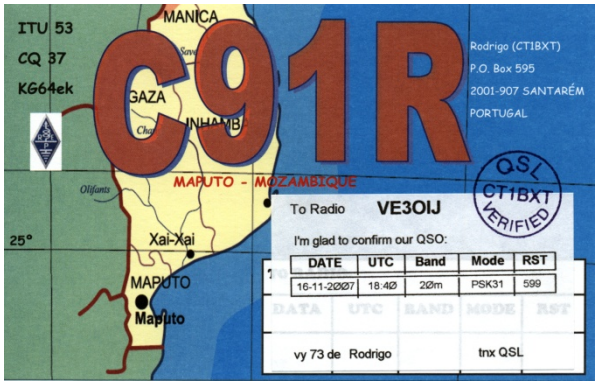

HEATHCOTE COUNTY
Branch 05
ZL3RG
CONFIRMING QSO WITH
GRAHAM ROBERTS
22 McBEATH AVENUE
CHRISTCHURCH
NEW ZEALAND
STATION | DAY MONTH YEAR | QTR UTC | R. S. T. | FREQUENCY | MODE | QSL
VE3OIJ | 03.05.2008 | 02.22 | 429 | 14.072 | 2 WAY | TNX
BEST 73s de: BPSK31
ITU ZONE 60 CONT. OC IOTA 134 CQ ZONE 32

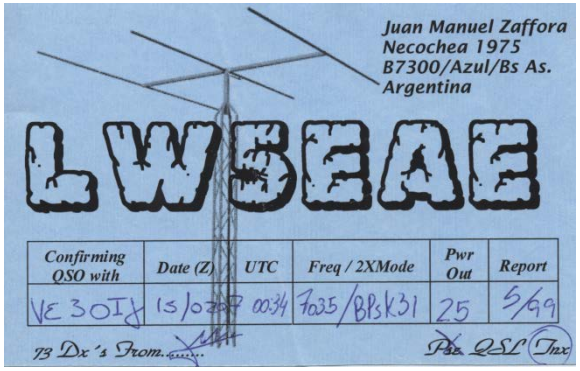

Sultanate of Oman
A45WD
Also: YO9HP, YR9P, 9K2/YO9HP
A45WD confirms the QSO(s) with: VE3OIJ
DATE UTC Band Mode RST QSL
23-Jun-2008 01:22 30m PSK31 599 TNX
Alex
QSL via home call (YO9HP)
Alex Panoiu
Pleasa 159, Prahova
RO-107113, ROMANIA
Rig: IC-746PRO, IC-7000..
Ant: 4 el Mosley MP33, Inv-V..
CQ 21, ITU 39, Grid LK77FV

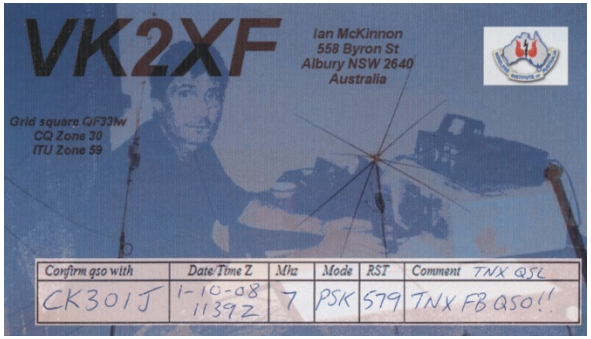

HOKKAIDO JAPAN
ZONE 25. IOTA:AS-078. GL:QN12KW
JA8GLZ
JCG# 01022
CONFIRMING QSO WITH | DATE DAY MONTH YEAR | UTC | MHz | RST | MODE 2-WAY
VE3OIJ | 06 NOV 2006 | 21:30 | 18.000 | 599 | PSK31
PSE QSL TNX
RIG / Kenwood TS-680S
ANT / 4EL YAGI
Printed by LOG4DX
'YUU' Yuuichi Kawata
7-74 S Mikage Shimizu-Cho Kamikawa-Gun
Hokkaido 089-0357 JAPAN
Yuu

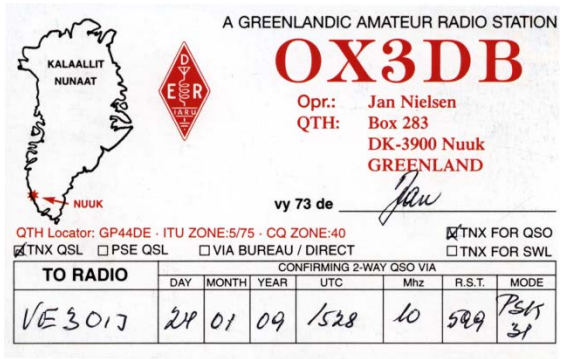

UKRAINE
CQ 16 - ITU 29 - Obl LU-02 - QRA KN98OR
US7MM
UDXC # 85
IOTA
URDXA HR#1 AGCW#2364 UDXC DIG#4487 5BDXCC KDR#16 AGB#61
5B WAZ DXCC HR WPX HR USA CA WAIS - Trophy MF Super Trophy
WAB Trophy WAB 13917, 15373 G-QRP-C 9329 UR-QRP-C #3 Veteran #15
Confirming QSO with | Day Month Year | UTC | MHz | Mode 2Way | RST
CG3OIJ | 9 1. 07 | 1301 | 18 | PSK31 | 579
TNX QSL PSE
ex RB5MT
P. Box 22, Schastie, 91480, Ukraine
DARin, Thank You For new one! 73, Willy

Questions?


ITU 53
CQ 37
KG64ek
C91R
Rodrigo (CT1BXT)
P.O. Box 595
2001-907 SANTARÉM
PORTUGAL
MANICA
GAZA
INHAMB
MAPUTO - MOZAMBIQUE
Xai-Xai
MAPUTO
Maputo
25°
QSL CT1BXT VERIFIED
To Radio VE3OIJ
I'm glad to confirm our QSO:
DATE | UTC | Band | Mode | RST
16-11-2007 | 18:40 | 20m | PSK31 | 599
vy 73 de Rodrigo
tnx QSL


Juan Manuel Zaffora
Necochea 1975
B7300/Azul/Bs As.
Argentina
LW8EAE
Confirming QSO with | Date (Z) | UTC | Freq / 2XMode | Pwr Out | Report
VE3OIJ | 15/07 | 0034 | 7035/BPSK31 | 25 | 5/99
73 Dx's From
Pse QSL Tnx


VK2XF
Ian McKinnon
558 Byron St
Albury NSW 2640
Australia
Grid square QF33lw
CQ Zone 30
ITU Zone 59
Confirm qso with | Date/Time Z | Mhz | Mode | RST | Comment
CK3OIJ | 1-10-08 11392 | 7 | PSK | 579 | TNX FB QSO!!


A GREENLANDIC AMATEUR RADIO STATION
OX3DB
KALAALLIT NUNAAT
NUUK
Opr.: Jan Nielsen
QTH: Box 283
DK-3900 Nuuk
GREENLAND
vy 73 de
QTH Locator: GP44DE · ITU ZONE:5/75 · CQ ZONE:40
TNX QSL PSE QSL VIA BUREAU / DIRECT
TNX FOR QSO
TNX FOR SWL
TO RADIO | CONFIRMING 2-WAY QSO VIA | DAY | MONTH | YEAR | UTC | Mhz | R.S.T. | MODE
VE3OIJ | 24 | 01 | 09 | 1528 | 10 | 599 | PSK 31