Amateur Radio
and
Digital Modes

Scott Simpson, KF5WAY

Amateur Radio?

- “Ham Radio”
- Communication via radio waves
- Licensed by FCC in USA
- International Coordination via ITU
- Utilized for Emergency Communication

What Do I Need?

- License
- Radio
- Antenna

Amateur Radio Classes

- Technician
- General
- Amateur Extra

What Can I Do?

- Technician:
  - VHF, UHF (Very/Ultra High Frequency)
- General:
  - All Technician + some HF (High Frequency)
- Amateur Extra
  - All General + all HF

Amateur Radio Modes

- CW (Continuous Wave) aka Morse Code
- Phone (FM, AM, SSB)
- Digital (RTTY, PSK, etc)*

*More on this in a bit

UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND

- AERONAUTICAL MOBILE
- AERONAUTICAL MOBILE SATELLITE
- AERONAUTICAL RADIONAVIGATION
- AMATEUR
- AMATEUR SATELLITE
- BROADCASTING
- BROADCASTING SATELLITE
- EARTH EXPLORATION SATELLITE
- FIXED
- FIXED SATELLITE
- INTER-SATELLITE
- LAND MOBILE
- LAND MOBILE SATELLITE
- MARITIME MOBILE
- MARITIME MOBILE SATELLITE
- MARITIME RADIONAVIGATION
- METEOROLOGICAL AIDS
- METEOROLOGICAL SATELLITE
- MOBILE
- MOBILE SATELLITE
- RADIO ASTRONOMY
- RADIODETERMINATION SATELLITE
- RADIOLOCATION
- RADIOLOCATION SATELLITE
- RADIONAVIGATION
- RADIONAVIGATION SATELLITE
- SPACE OPERATION
- SPACE RESEARCH
- STANDARD FREQUENCY AND TIME SIGNAL
- STANDARD FREQUENCY AND TIME SIGNAL SATELLITE

ACTIVITY CODE

- GOVERNMENT EXCLUSIVE
- GOVERNMENT/ NON-GOVERNMENT SHARED
- NON-GOVERNMENT EXCLUSIVE

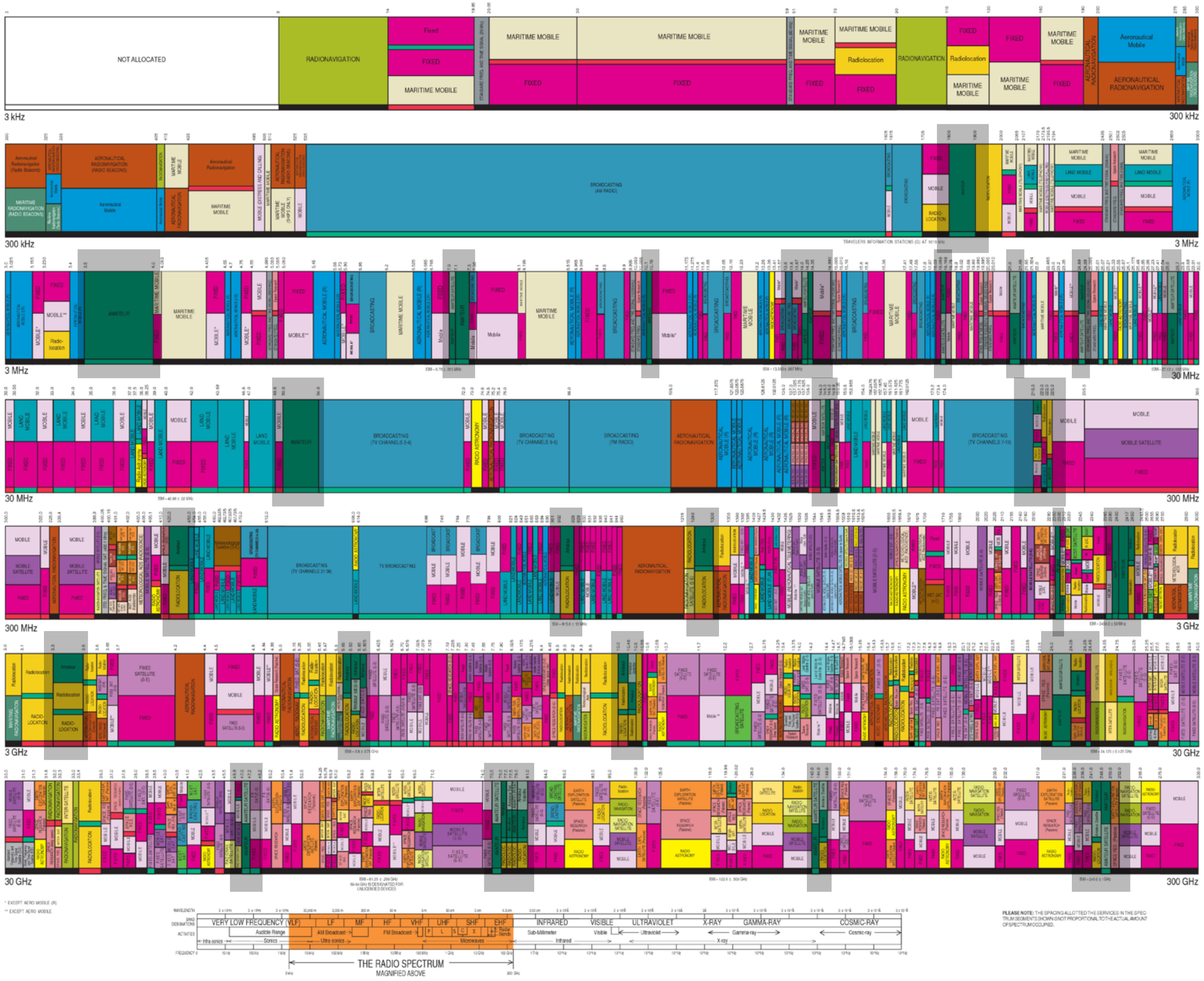
ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	Mobile	1st Capital with lower case letters

This chart is a graphic single-point-in-time portrayal of the Table of Frequency Allocations used by the FCC and NTIA. As such, it does not completely reflect all aspects, i.e., footnotes and recent changes made to the Table of Frequency Allocations. Therefore, for complete information, users should consult the Table to determine the current status of U.S. allocations.

U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Office of Spectrum Management

October 2003



* EXCEPT AERO MOBILE (R)

** EXCEPT AERO MOBILE

PLEASE NOTE: THE SPACING ALLOTTED THE SERVICES IN THE SPECTRUM SEGMENTS SHOWN IS NOT PROPORTIONAL TO THE ACTUAL AMOUNT OF SPECTRUM OCCUPIED.

US Amateur Radio Bands

US AMATEUR POWER LIMITS

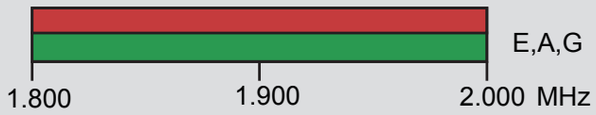
FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.

Effective Date
March 5, 2012

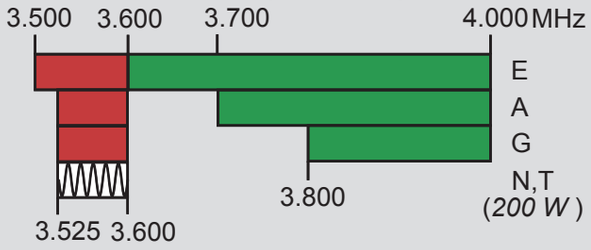
Published by:
ARRL The national association for AMATEUR RADIO®
www.arrl.org
225 Main Street, Newington, CT USA 06111-1494

160 Meters (1.8 MHz)

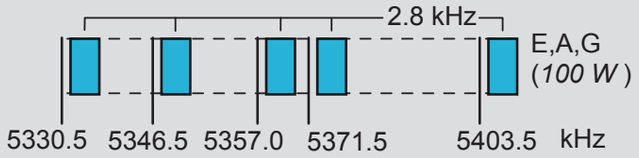
Avoid interference to radiolocation operations from 1.900 to 2.000 MHz



80 Meters (3.5 MHz)

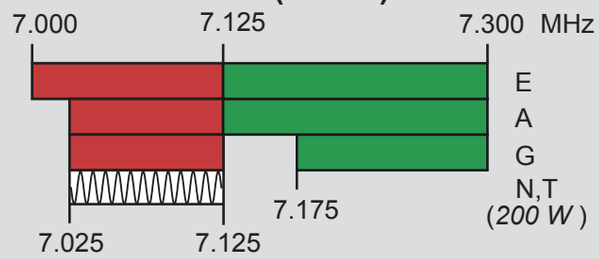


60 Meters (5.3 MHz)



General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated output of 100 W PEP. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III as defined by the FCC Report and Order of November 18, 2011. USB is limited to 2.8 kHz centered on 5332, 5348, 5358.5, 5373 and 5405 kHz. CW and digital emissions must be centered 1.5 kHz above the channel frequencies indicated above. Only one signal at a time is permitted on any channel.

40 Meters (7 MHz)



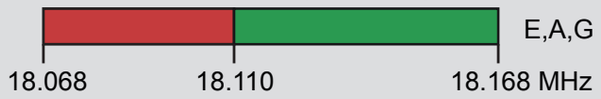
Phone and Image modes are permitted between 7.075 and 7.100 MHz for FCC licensed stations in ITU Regions 1 and 3 and by FCC licensed stations in ITU Region 2 West of 130 degrees West longitude or South of 20 degrees North latitude. See Sections 97.305(c) and 97.307(f)(11).
Novice and Technician licensees outside ITU Region 2 may use CW only between 7.025 and 7.075 MHz and between 7.100 and 7.125 MHz. 7.200 to 7.300 MHz is not available outside ITU Region 2. See Section 97.301(e). These exemptions do not apply to stations in the continental US.

30 Meters (10.1 MHz)

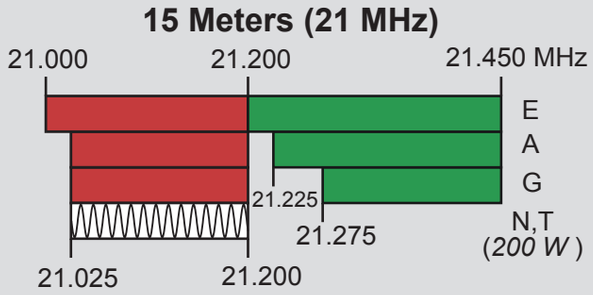
Avoid interference to fixed services outside the US.

20 Meters (14 MHz)

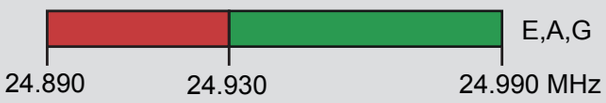
17 Meters (18 MHz)



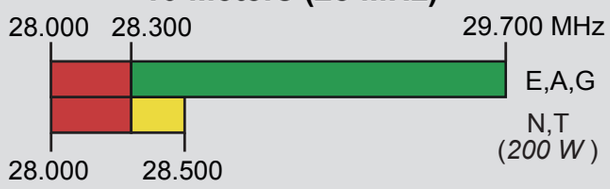
15 Meters (21 MHz)



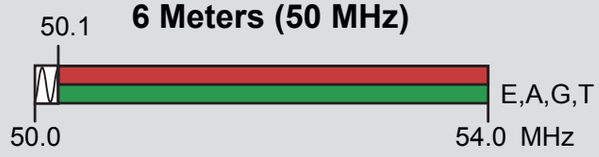
12 Meters (24 MHz)



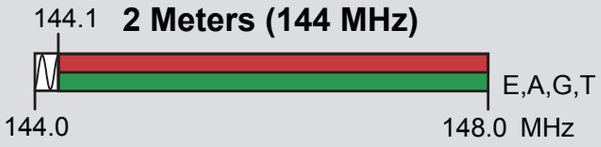
10 Meters (28 MHz)



6 Meters (50 MHz)



2 Meters (144 MHz)



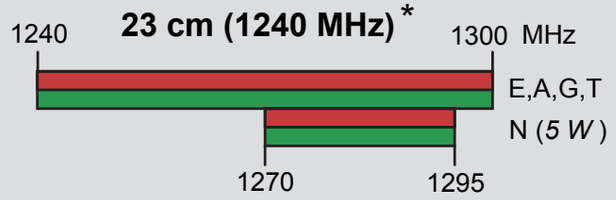
1.25 Meters (222 MHz)

*Geographical and power restrictions may apply to all bands above 420 MHz. See *The ARRL Operating Manual* for information about your area.

70 cm (420 MHz)*

33 cm (902 MHz)*

23 cm (1240 MHz)*



All licensees except Novices are authorized all modes on the following frequencies:

2300-2310 MHz	10.0-10.5 GHz *	122.25-123.0 GHz
2390-2450 MHz	24.0-24.25 GHz	134-141 GHz
3300-3500 MHz	47.0-47.2 GHz	241-250 GHz
5650-5925 MHz	76.0-81.0 GHz	All above 275 GHz

* No pulse emissions

KEY

Note:
CW operation is permitted throughout all amateur bands.

MCW is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz.

Test transmissions are authorized above 51 MHz, except for 219-220 MHz

- = RTTY and data
- = phone and image
- = CW *only*
- = SSB phone
- = USB phone, CW, RTTY, and data
- = Fixed digital message forwarding systems *only*

E = Amateur Extra
A = Advanced
G = General
T = Technician
N = Novice

See *ARRLWeb at www.arrl.org* for detailed band plans.

ARRL
We're At Your Service

ARRL Headquarters:
860-594-0200 (Fax 860-594-0259)
email: hq@arrl.org

Publication Orders:
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Toll-Free 1-888-277-5289 (860-594-0355)
email: orders@arrl.org

Membership/Circulation Desk:
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Toll-Free 1-888-277-5289 (860-594-0338)
email: membership@arrl.org

Getting Started in Amateur Radio:
Toll-Free 1-800-326-3942 (860-594-0355)
email: newham@arrl.org

Exams: 860-594-0300 email: vec@arrl.org

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Amateur Radios

- Kits
  - Elecraft, YouKits
- Commercially Purchased
  - Kenwood, Yaesu, Icom, Elecraft, Alinco

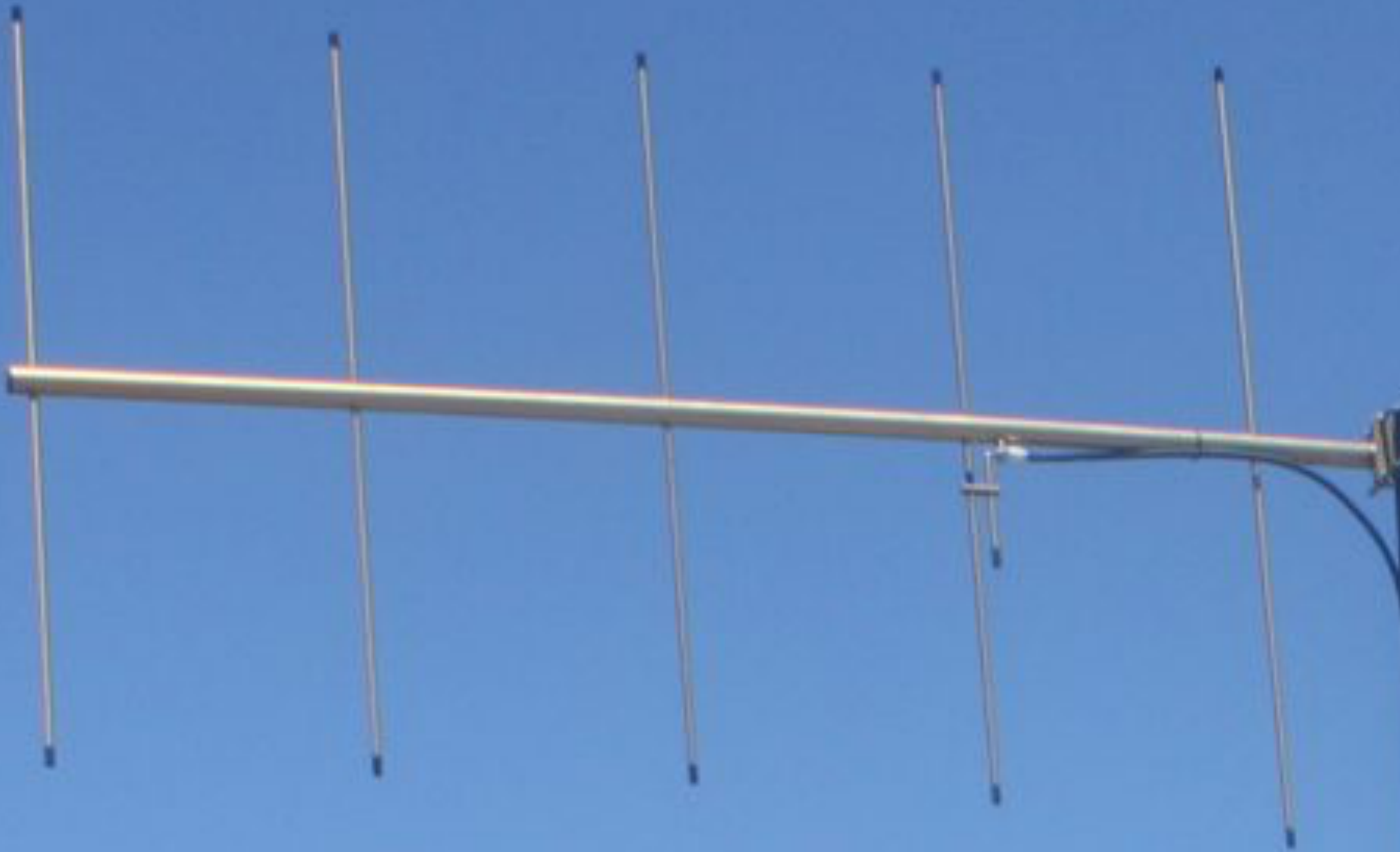
ELECRAFT KX3 TRANSCEIVER
14.285.000
USB
SPLT
14.290.00
ANT1
PRE
AGC-S
XFIL
FL3
RX
TX
BAND+
M►V
BAND-
V►M
FREQ ENT
SCAN
MSG
REC
ATU TUNE
ANT
XMIT
TUNE 0
AF / RF
PBT
KEYER
MON
NORM
PWR
PRE
ATTN
APF
SPOT
CMP
DLY
NR 1
NB 2
NTCH 3
CWT 4
PITCH 5
VOX 6
TX
MODE
A / B
ALT
REV
DATA
A►B
TEXT
SPLIT
RIT
XIT
PF1
PF2
CLR
RATE
DISP
KHZ
MENU
Δf

146.520
MY
ME
64 km/h
A
446.500

ICOM
GPS
ICOM
ID-51
5:43
FM
145.000
PSKIP
000
MAIN DV
439.500
PSKIP
000
DUAL BAND TRANSCEIVER
MENU
RX→CS
V/MHz
CLR LOW
CD
CS
MODE
SCAN
M/CALL
S.MW
DR
MAIN
DUAL
QUICK
SPCH
DIGITAL

Antennas

- Most basic:
  - Dipole
  - Vertical
- More advanced:
  - Yagi
  - Hexbeam



Digital Modes

Digital Modes

- What is a “Digital Mode”?
- Examples
- Where can I find them?
- How do I use them?

What is a “Digital Mode”?

- CW was the first digital mode
- Frequency or Phase Shift Keying
- Encodes data as signals
- Decodes signals to text

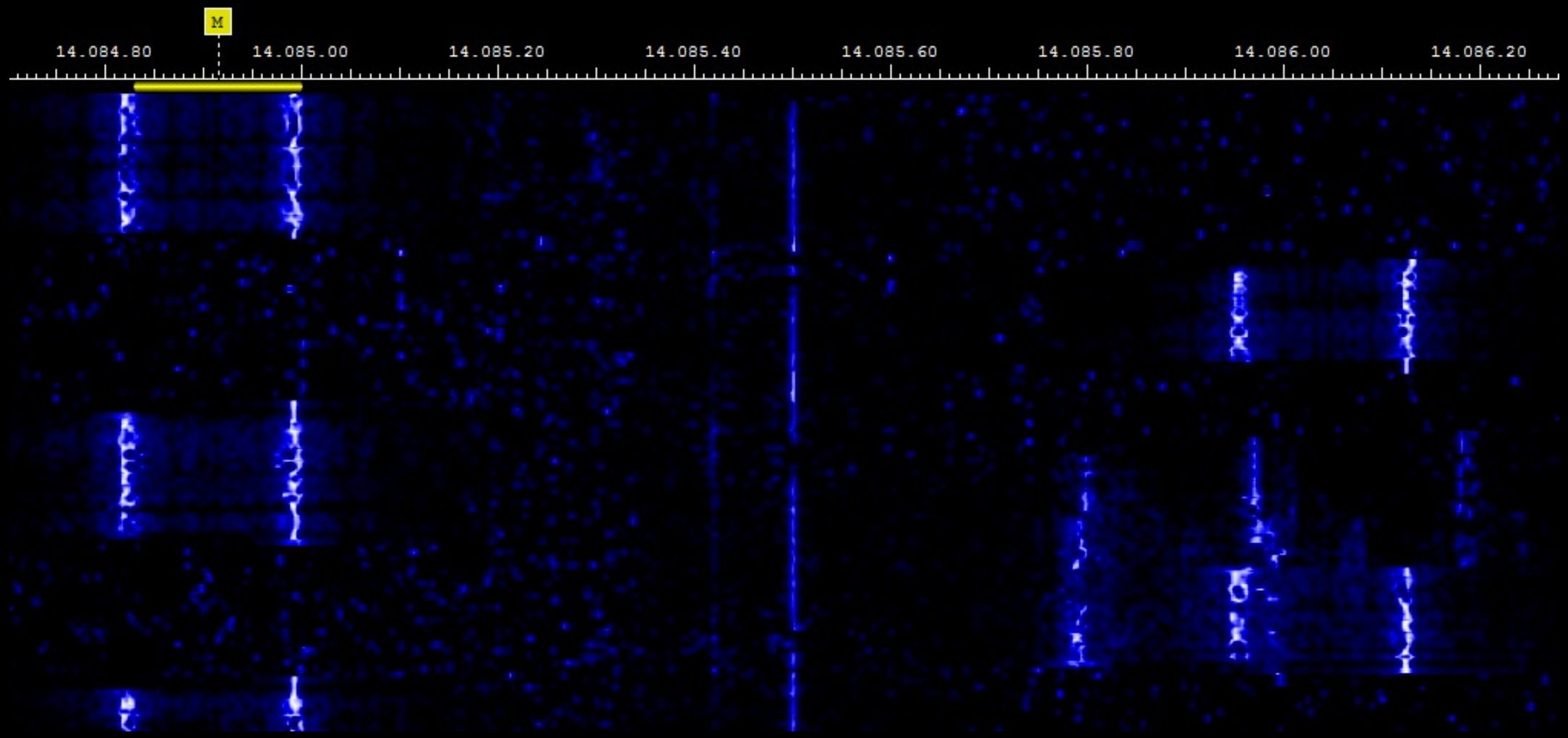
Popular Examples on HF

- RTTY
- PSK (31/63/125)
- JT65/JT9
- Olivia

RTTY

- RadioTeleTYpe
- FSK and AFSK
  - Frequency Shift Keying
- Based on Baudot coding
- Low spectral efficiency
- No error correction
- 170 Hz bandwidth

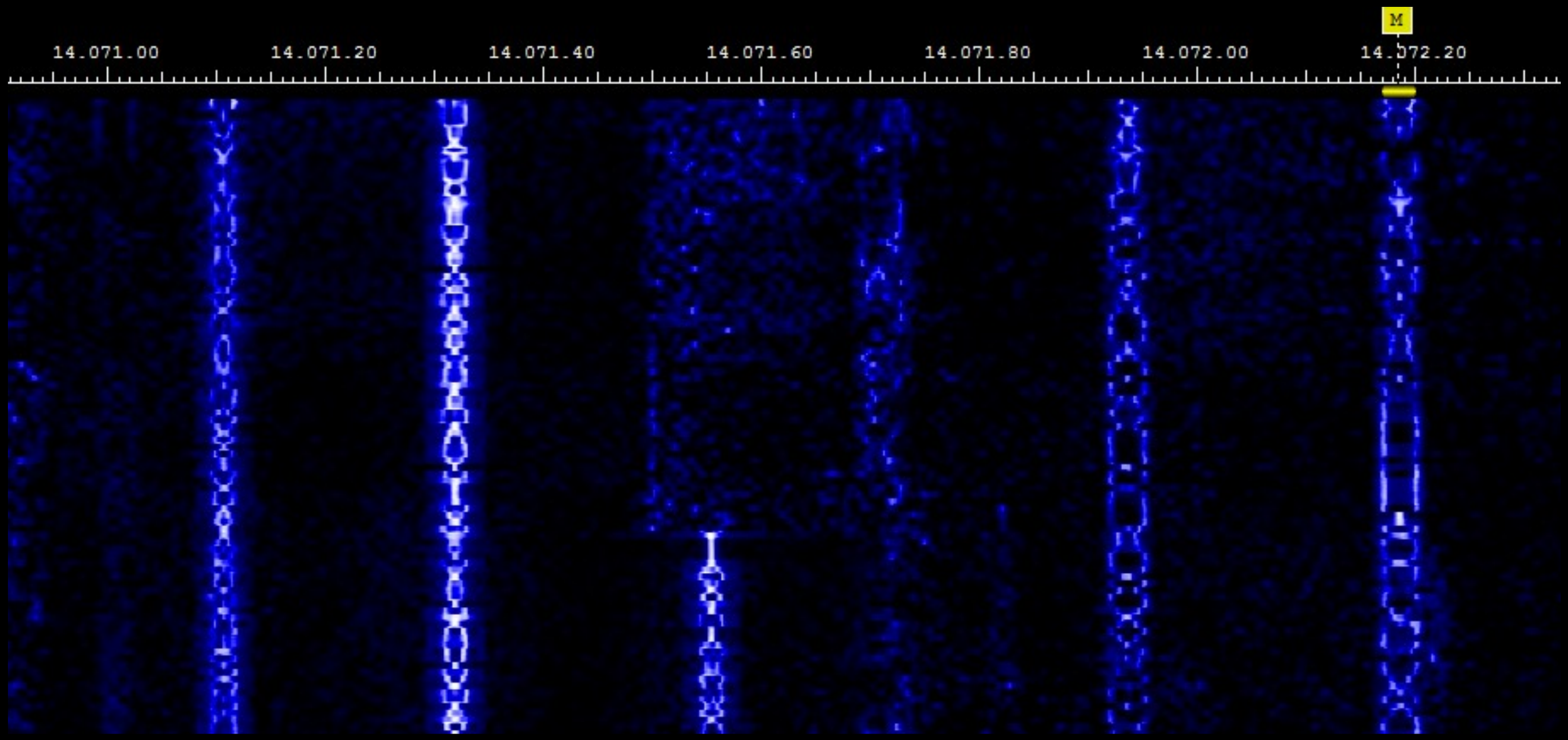
RTTY


M
14.084.80
14.085.00
14.085.20
14.085.40
14.085.60
14.085.80
14.086.00
14.086.20

PSK

- Phase Shift Keying
- Binary and Quadrature PSK
- Common Baud Rates for BPSK
  - 31
  - 63
  - 125
- No error correction
- 30-130 Hz bandwidth
- QPSK faster in same bandwidth

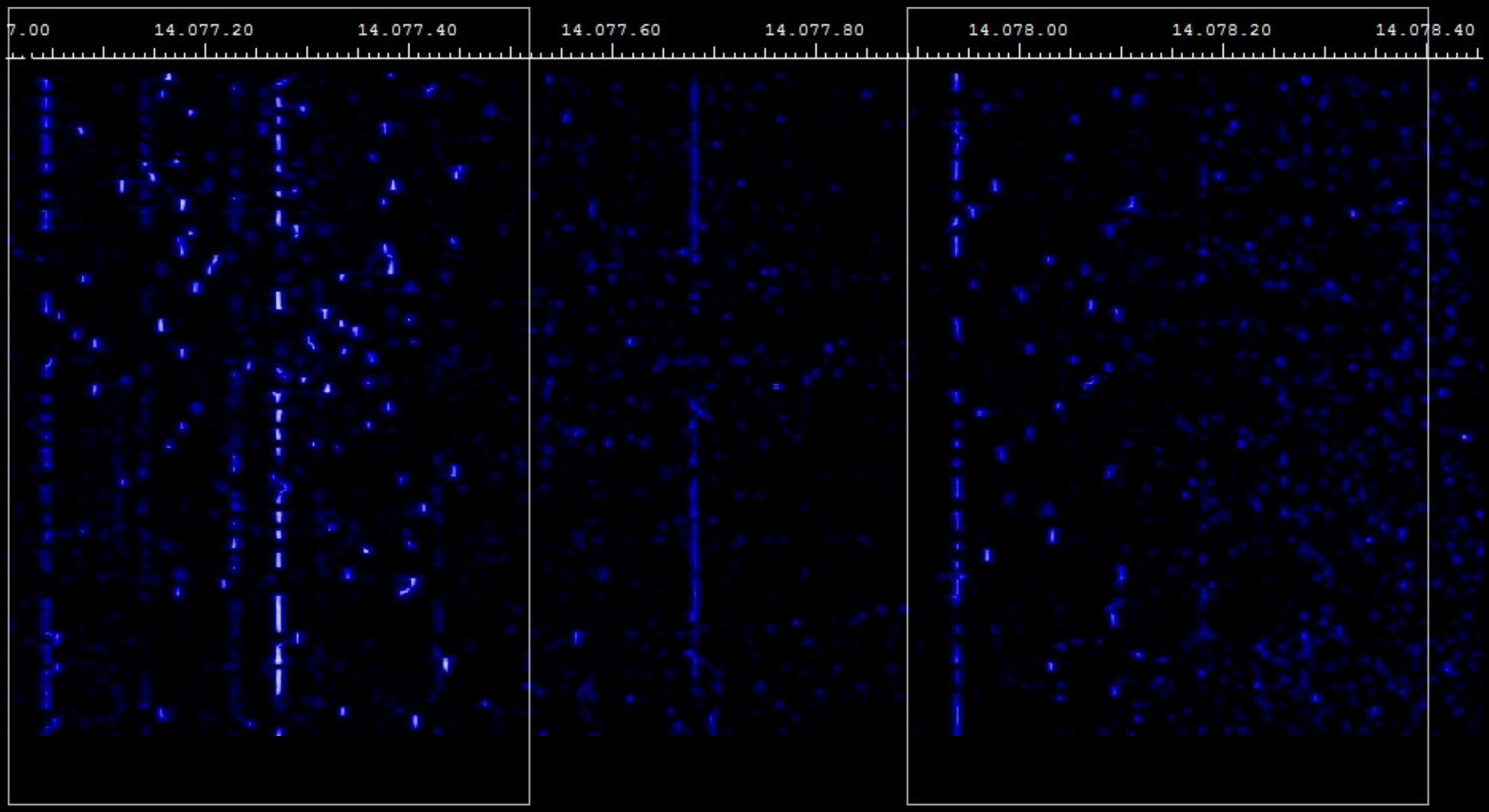
PSK


M
14.071.00
14.071.20
14.071.40
14.071.60
14.071.80
14.072.00
14.072.20

JT65

- Multiple Frequency Shift Keying (MFSK)
- Weak signal mode
- Intended for EME or Troposcatter
- Highly synchronized in minute intervals
- No error correction

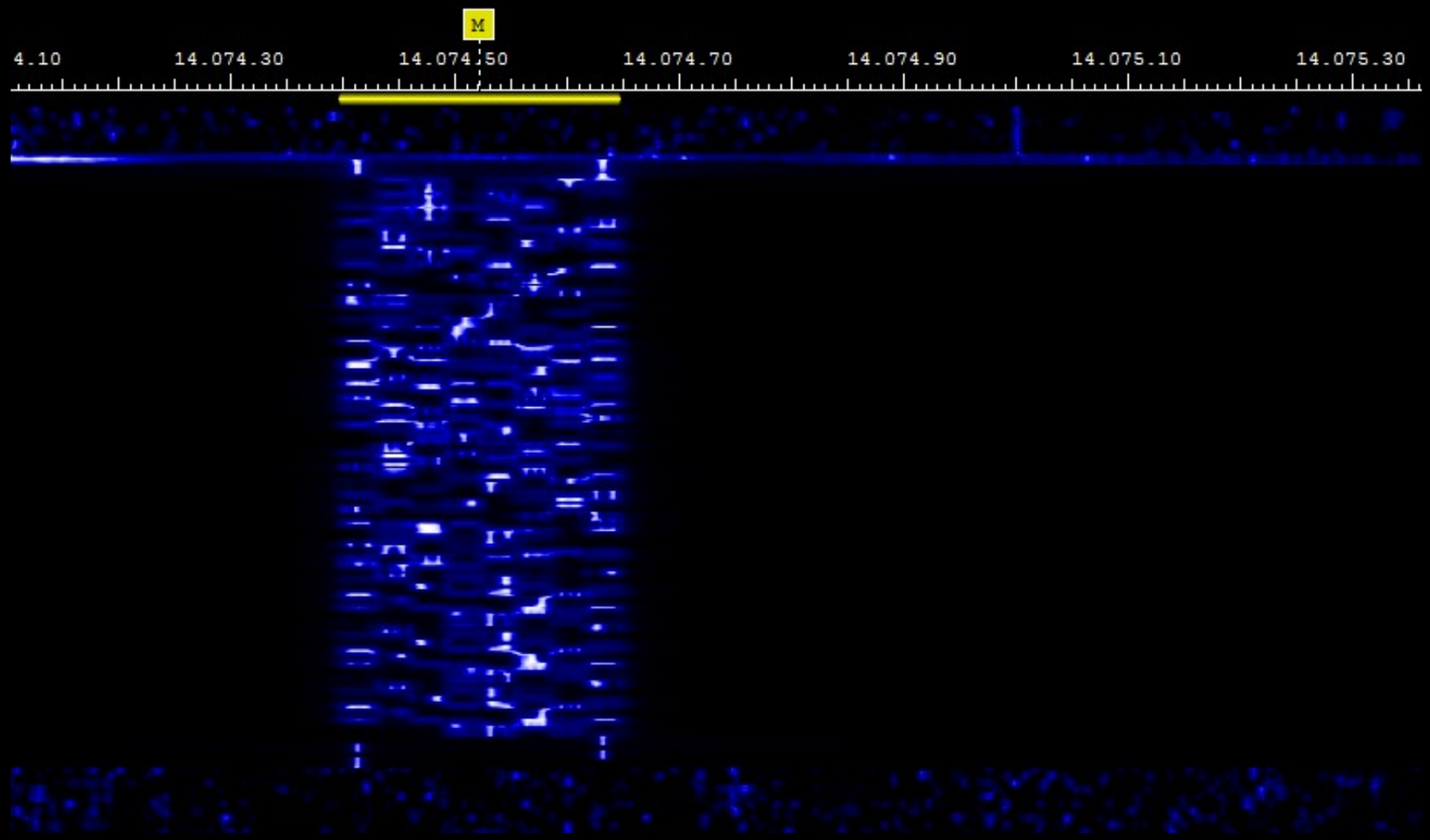
JT65


7.00
14.077.20
14.077.40
14.077.60
14.077.80
14.078.00
14.078.20
14.078.40

Olivia

- Multiple Frequency Shift Keying (MFSK)
- # of tones/bandwidth
  - ex Olivia 16/500 or 8/250
  - more tones == more redundancy
  - more tones == slower transmission
- Great in difficult conditions
  - 10-14dB below NF
- Error Correcting

Olivia 8/250



Other modes

- Contestia
- Pactor/Winlink
- Hellschreiber (Hell)
- Throb
- Domino
- Thor
- WSPR
- APRS

Where can I find them?

- Look at the ARRL band plans.
- Digital Modes fall in Data/RTTY space

Example for 3 bands			
Band	PSK	RTTY	JT65
10 m	28.070	28.070-28.150	28.076
15 m	21.070	21.070-21.100	21.076
20 m	14.070	14.070-14.095	14.076

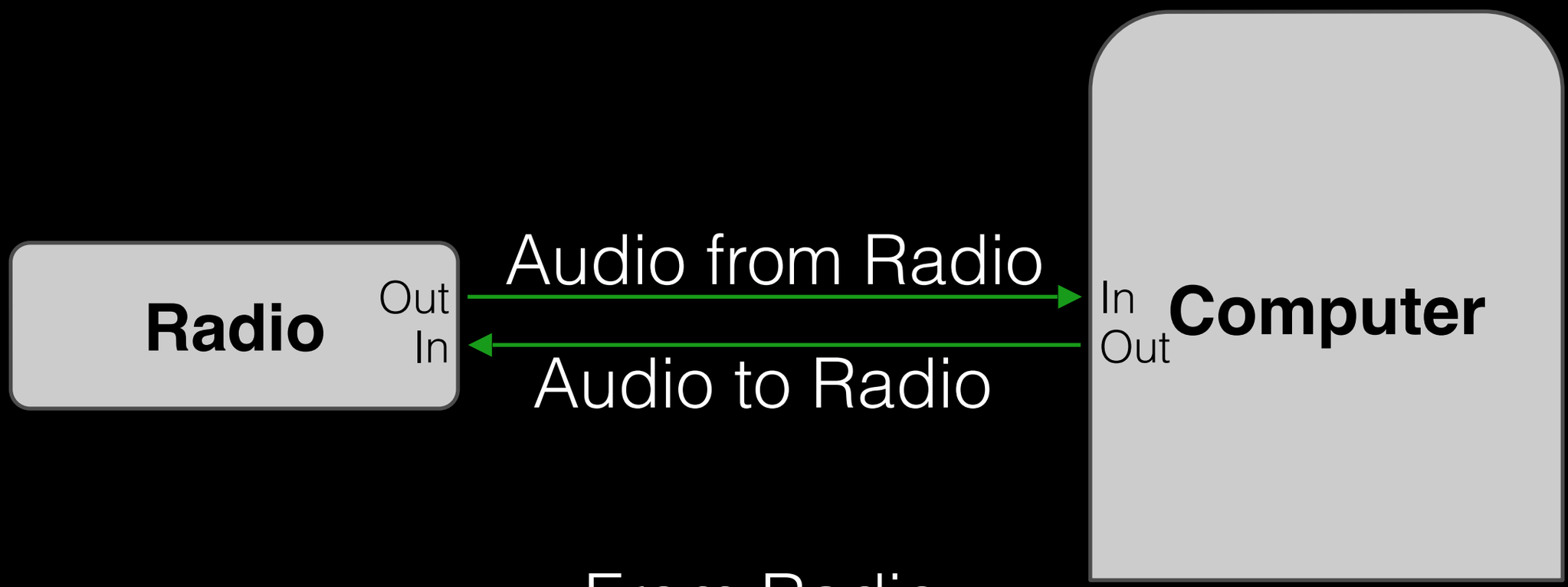
How do I use them?

- You need:
- Radio
- Computer with sound card
- Digital Mode Software
- Optional:
- external sound card or SignaLink

Sound Interface

- USB or Internal
- SignaLink
- Custom

Basic Setup



From Radio

Audio Out == Data Out

Audio In == Data In

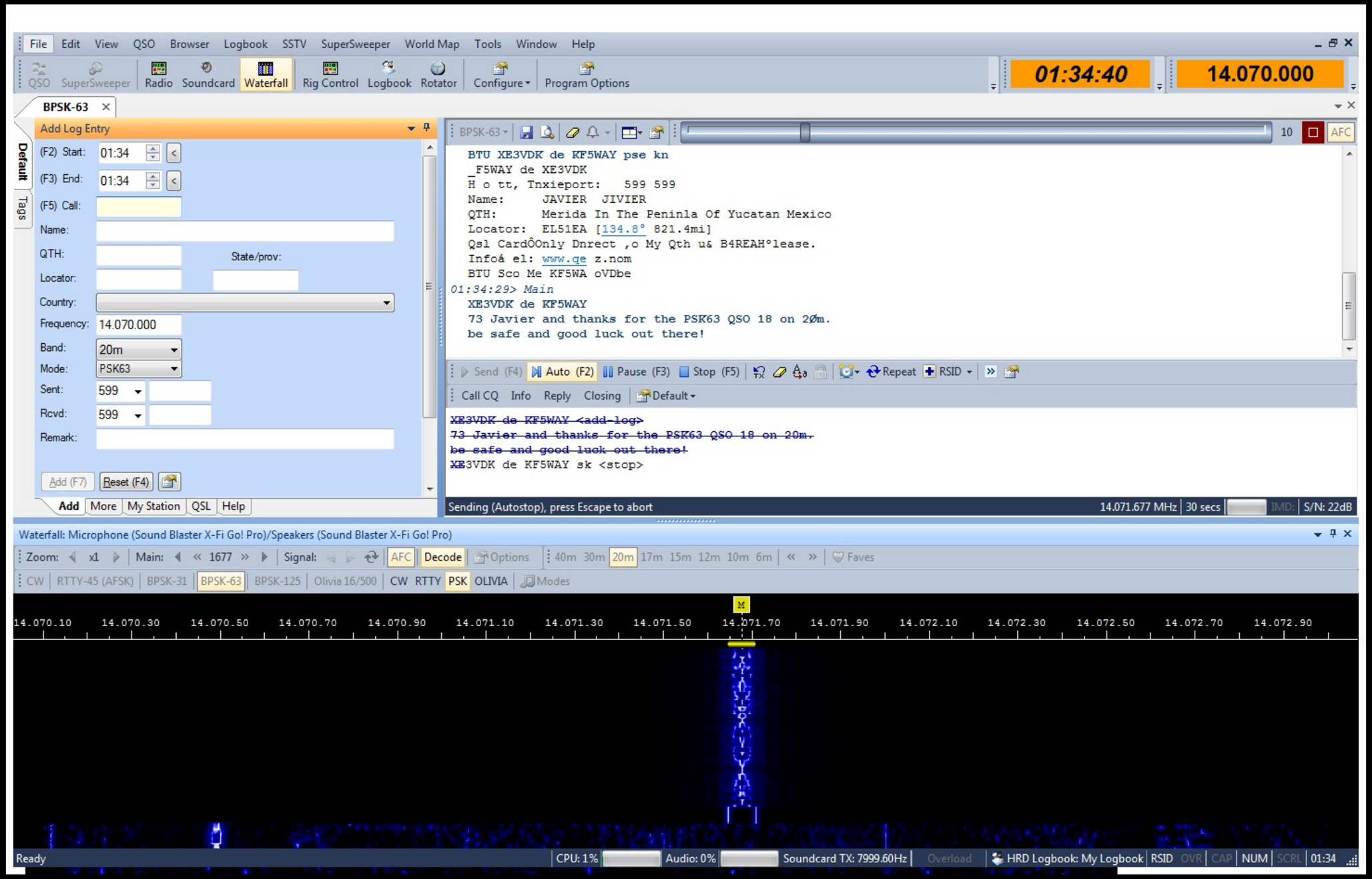
Software

- Ham Radio Deluxe
  - v6+ $99
  - v5 Free
- FLDigi
  - OpenSource aka Free
- DXLab
  - Freeware

Ham Radio Deluxe

- Ham radio software package includes:
  - Radio control app
  - Digital modes app
  - Logging app
  - Satellite tracking app
  - Rotator control app
  - http://www.ham-radio-deluxe.com/

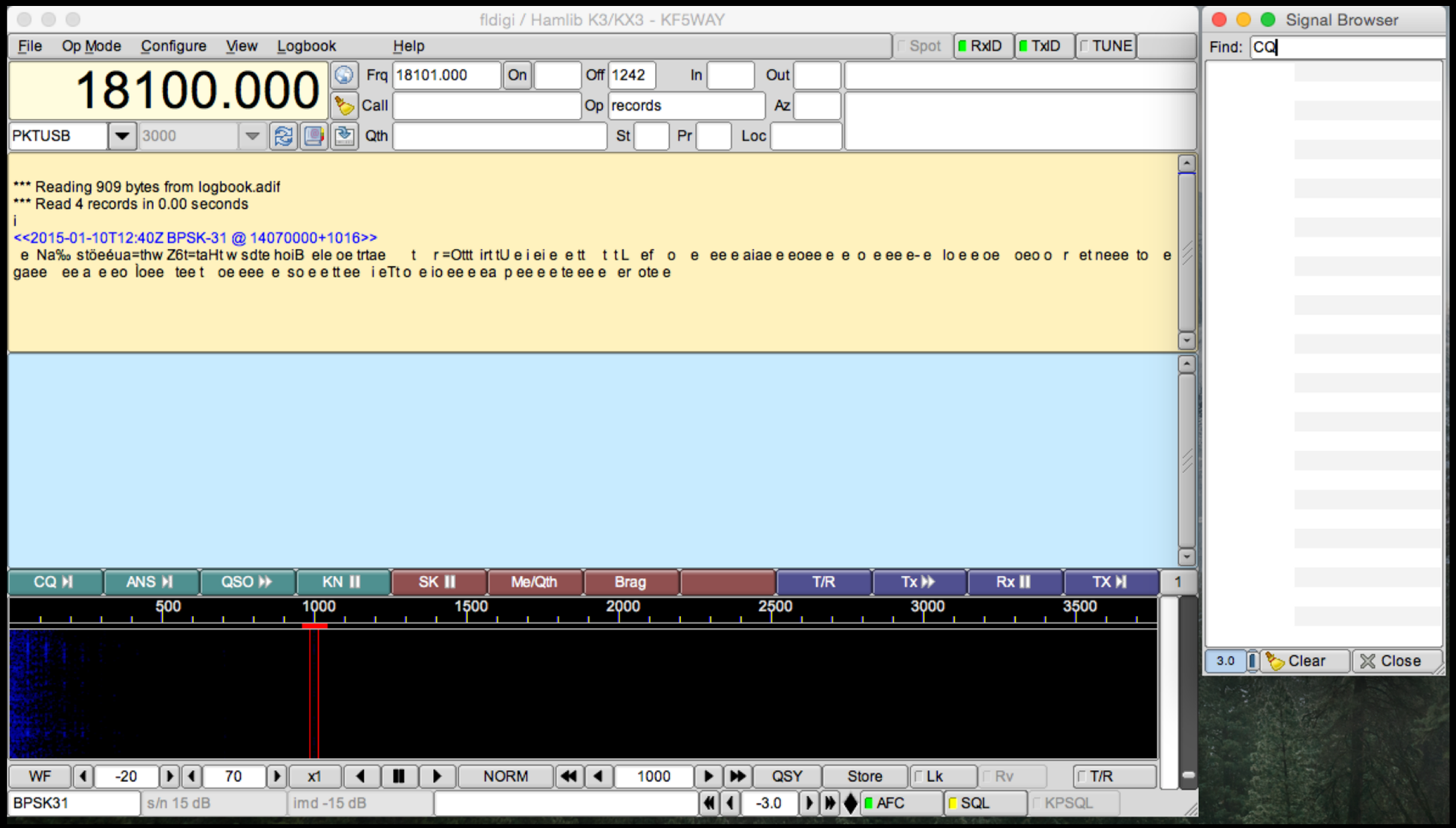
Ham Radio Deluxe



fldigi

- Open Source aka Free
- Has many apps to help hams:
  - fllog - Logging
  - flrig - Rig Control
  - flkey - interface to Winkeyer

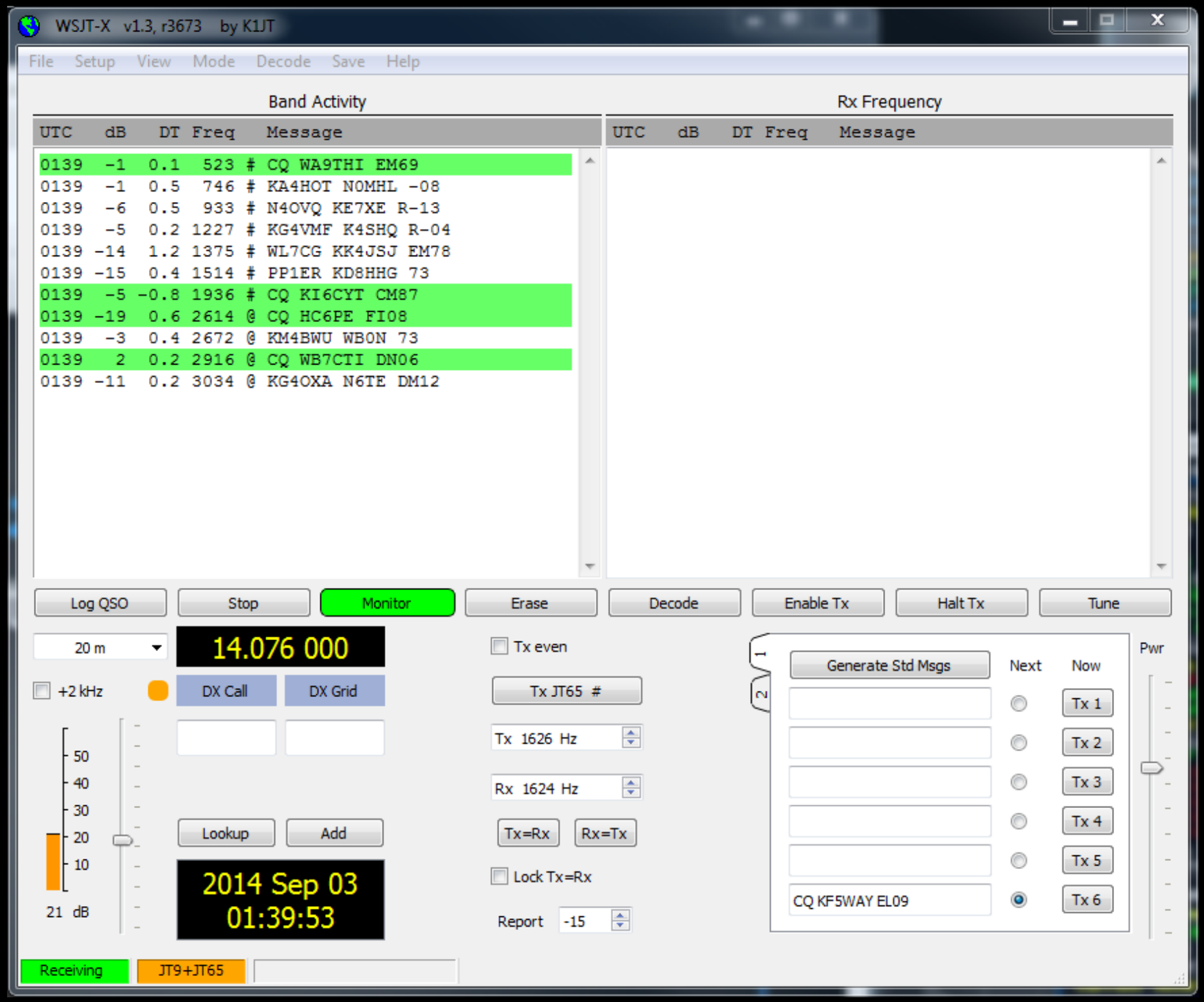
fldigi


fldigi / Hamlib K3/KX3 - KF5WAY
File Op Mode Configure View Logbook Help
Spot RxID TxID TUNE
18100.000
Frq 18101.000 On Off 1242 In Out
Call Op records Az
PKTUSB 3000 Qth St Pr Loc
*** Reading 909 bytes from logbook.adif
*** Read 4 records in 0.00 seconds
i
<<2015-01-10T12:40Z BPSK-31 @ 14070000+1016>>
CQ ANS QSO KN SK Me/Qth Brag T/R Tx Rx TX 1
500 1000 1500 2000 2500 3000 3500
WF -20 70 x1 NORM 1000 QSY Store Lk Rv T/R
BPSK31 s/n 15 dB imd -15 dB -3.0 AFC SQL KPSQL
Signal Browser
Find: CQ
3.0 Clear Close

JT65 Software

- wsjtx
  - http://physics.princeton.edu/pulsar/K1JT/wsjtx.html
- JT65-HF
  - http://jt65-hf.sourceforge.net/

wsjtx


WSJT-X v1.3, r3673 by K1JT
File Setup View Mode Decode Save Help
Band Activity
UTC dB DT Freq Message
0139 -1 0.1 523 # CQ WA9THI EM69
0139 -1 0.5 746 # KA4HOT N0MHL -08
0139 -6 0.5 933 # N4OVQ KE7XE R-13
0139 -5 0.2 1227 # KG4VMF K4SHQ R-04
0139 -14 1.2 1375 # WL7CG KK4JSJ EM78
0139 -15 0.4 1514 # PP1ER KD8HHG 73
0139 -5 -0.8 1936 # CQ KI6CYT CM87
0139 -19 0.6 2614 @ CQ HC6PE FI08
0139 -3 0.4 2672 @ KM4BWU WB0N 73
0139 2 0.2 2916 @ CQ WB7CTI DN06
0139 -11 0.2 3034 @ KG4OXA N6TE DM12
Rx Frequency
UTC dB DT Freq Message
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 JT65 #
Tx 1626 Hz
Rx 1624 Hz
50
40
30
20
10
21 dB
Lookup
Add
Tx=Rx
Rx=Tx
2014 Sep 03
01:39:53
Lock Tx=Rx
Report -15
Generate Std Msgs
Next
Now
Tx 1
Tx 2
Tx 3
Tx 4
Tx 5
Tx 6
CQ KF5WAY EL09
Pwr
Receiving
JT9+JT65

Useful Links

- Digital Modes, sound and pictures (http://hfradio.org.uk/html/digital_modes.html)
- ARRL Digital Modes (http://www.arrl.org/digital-modes)
- Digital Modes audio samples (http://www.kb9ukd.com/digital/)
- PSKReporter (http://pskreporter.info)

More Links

- Passband Modulation (http://en.wikipedia.org/wiki/Modulation)
- FLDigi (http://www.w1hkj.com)
- DX Lab Suite (http://www.dxlabsuite.com)
- Tigertronics, SignaLink (http://www.tigertronics.com)
- KF5WAY Blog (http://blog.kf5way.com)

Free Technician Class

- Hosted by KARS, Ken Nichols KD3VK
- At Schneider Engineering, Boerne, TX
- September 9th, 2015 1900 CST
- 8 Classes

Questions?