Digital Mode Presentation

General Knowledge

Digital communication is the exchange of digital data over the air

- Email, Digital files, Keyboard-to-keyboard (chat), and others

Protocols on today's menu

- RTTY, PACTOR, JT9/65, PSK31, FSQCall, Olivia

Communication = digital mode if info is exchanged as individual characters encoded as digital bits.
Example:
A = ASCII 01000001
Some consider CW a digital mode. (an A = di-dah)

Some modes are old, like radio-teletype, invented in the 1930's.
Some modes are new, like FSQ, invented in the mid-2015's.

Where?

- Look at an amateur band chart (80 meters and 20 meters)
- Look at a band plan (2-4, 2-17, 6-2)
- Show CW, PSK31 (3.570 & 14.070) and RTTY
- Look at http://bandplans.com

Definitions

Air Link – the part of the communication system involving radio transmissions and reception of signals.
Bit – fundamental unit of data; a 0 or 1 in binary
Bit rate – number of bits per second sent from one system to another.
Symbol – signal characteristics that make up each distinct state of the transmitted signal

- CW symbols = on and off
- RTTY symbols are tones
- Baudot or ASCII (simple methods) encode one bit in each symbol
- Sophisticated codes use complex audio signals to carry the data and encode more than one bit in each symbol

Baud – number of symbols per second that are sent from one system to another.
Duty cycle – ratio of transmitting to total on/off time

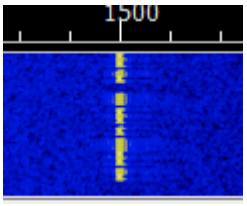
- Important to know duty cycle of mode because most transmitters are not designed to operate at full power for extended periods of time.
- CW = 50%
- SSB = 25%
- PSK31 & RTTY = 100%

Protocol – rules that control the method used to exchange data
Mode – combination of the protocol and the modulation

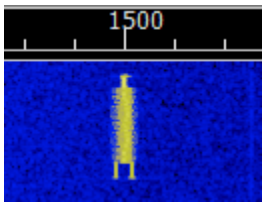
Bandwidth of a digital signal changes with the symbol rate. As symbol rate increases, bandwidth increases. (ex. Olivia: more tones, more symbols, more bandwidth)

Digital Modes

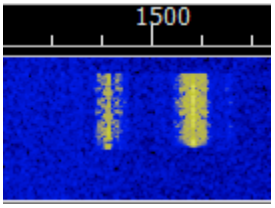
Software
FLDigi: http://sourceforge.net/projects/fldigi/files/fldigi/
FSQCall: http://www.qsl.net/zl1bpu/MFSK/FSQweb.htm (NW8L/KA4CDN FSQCall V0.24.6, US Edition)
JT65-HF: http://sourceforge.net/projects/jt65hfhb9hqxedi/?source=directory
RMS Express: http://www.winlink.org/RMSExpress (rms_express_install_1-3-7-0.zip link at bottom of page)
(Other software Ham Radio Deluxe, MultiPSK, MixW)



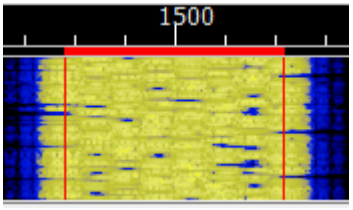
CW (10 WPM)



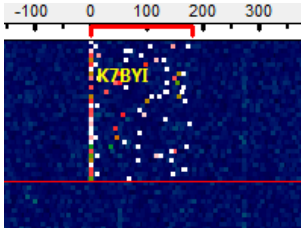
PSK31



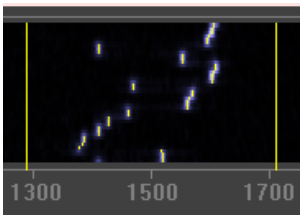
RTTY-45



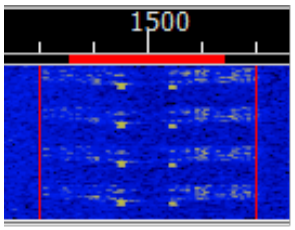
Olivia (8-500)



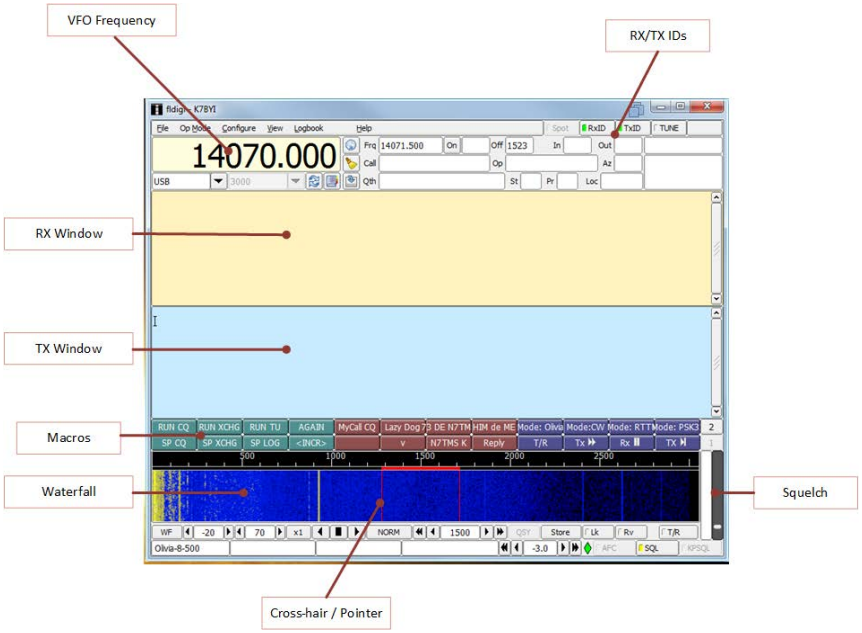
JT65



FSQ (6-baud)



Packet (Winlink)



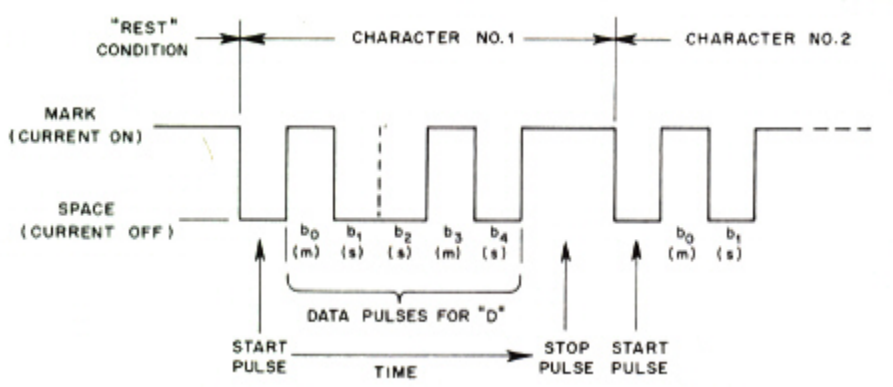
Introducing the Waterfall Display

X-axis = frequency
Y-axis = time
Intensity = strength of signal

RTTY

Radioteletype
One of the oldest modes, developed in 1930's
Uses ASFK (Audio Frequency Shift Keying), LSB
Encodes data using Baudot (origin of Baud)

- Each character encoded in 5 bits
- Initial start bit and inter-character pause (stop bit) are used to synchronize the stations
- 5 bits = 32 characters (not enough for ALL upper- and lower-case letters and numbers and punctuation)
    - Uses two special codes to switch between characters sets = 62 characters



Mark (2125 Hz) and space (2295 Hz)
Difference = signal shift (most common shift = 170Hz)
The rate of shifting determines the character speed

- 60, 75, 100 WPM = 45, 56, 75 baud

Can't decode?

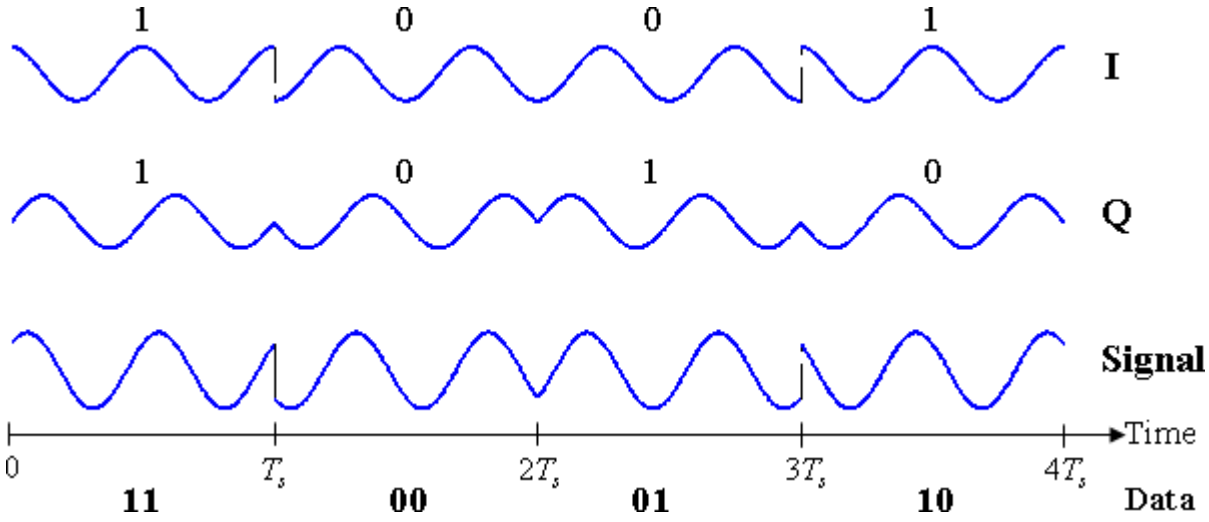
- Mark/shift reversed
- Wrong baud rate
- Wrong side-band

Approximate bandwidth = 200 Hz

PSK31

Phase Shift Keying

- Signals out of phase
- Information is encoded in the differences of the phases



"31" is the symbol rate, 31.25 baud
Variable length character code – varicode

- Uses shorter codes for more common characters.
- Uppercase characters utilize more bits (and more time) to send.

Vertical lines adjacent to PSK31 signal is over-modulation (demonstrate w/ high volume?)

PSK31 transmissions generally located at the bottom of the data bands, below RTTY, 20 meters = 14.070 MHz

Approximate Bandwidth = 50 Hz

JT9/65

AFSK protocol, uses USB
Excels at getting an extremely weak signal through atmospheric noise and ionospheric distortion

9 or 65 tones audio tones
Waterfall looks like the music for a player-piano
Transmissions are time-synced

- Start at :00
- Transmit for 48 seconds
- Off for 12 seconds
- Stations take turns in even and odd minutes transmitting and receiving
- 13 characters per minute (0.2 characters per second)

Approximate Bandwidth = 350 Hz

Olivia

Designed to work in difficult conditions on HF bands (although it also works as well on VHF/UHF). The signal can be decoded even when it is 10-14 dB below the noise floor (i.e. when the amplitude of the noise is slightly over 3 times that of the signal). It can also decode well under other noise, QSB, QRM, flutter (polar path) and auroral conditions.

Olivia formats defined by bandwidth and tone count
Possible tones: 2, 4, 8, 16, 32, 64, 128, or 256
Possible bandwidths: 125, 250, 500, 1000, or 2000 Hz

Examples:
Olivia 8-500 = Olivia protocol, 8 tones, 500 Hz bandwidth
Olivia 16-1K = Olivia protocol, 16 tones, 1000 Hz bandwidth

About 98% of all current Olivia HF activity is one of the 7 following configurations: 1000/32, 1000/16, 500/16, 500/8, 250/8, 250/4, and 125/4.

PACTOR

Packet basics
Anatomy

- Header – routing, control, status, error correction
- Data – information
- Trailer – status and error detection

Error Detection

- Most common = Cyclic Redundancy Check (CRC)
- Calculated and transmitted with data
- Receiving station calculates and compares
    - If correct, receiving stations sends ACK
    - If not correct, receiving stations sends NAK
    - Example of Automatic Repeat reQuest (ARQ)
- Forward Error Correction (FEC)
    - Goes beyond error *detection*
    - Includes redundant encoded information so that receiver can self-correct certain types of errors.
- Maybe be an interfering signal if…
    - Many retries or timeouts
    - Long pauses
    - Failure to establish a connection

Approximate Bandwidth = 2300 Hz

Pactor (packet in general) is a point-to-point interaction. There is no breaking in or three way conversations. You can tell if a “channel” is busy by putting your software in monitor mode or watching the waterfall.

Winlink

RTTY was not designed to manage transmission errors.
Text is frequently garbled

Teletype Over Radio (TOR) systems developed to send short bursts of characters with error correction.
More reliable, but originals (AMTOR and G-TOR) were quite slow.

PACTOR (Packet-based TOR) and WINMOR (Windows Messaging Over Radio) were developed to extend the capabilities of TOR modes.

Winlink is an amateur radio email system. It is a common system that uses the Internet to transfer messages.
In order to establish a connection, send a message to a published frequency.
You're most likely contacting an automatically controlled station.

- (Can't expect an operator to be manning his station 24x7!)

Speaking of automatically controlled stations…

- Automatically controlled stations can communicate with other automatically controlled stations
    - Anywhere above 222 MHz (1.25 meters)
    - Specified segments in 80 meters through 2 meters.

FSQCall

One of the newest modes, developed in 2015
Keyboard to keyboard transmissions; some file transfer

MFSK, 33 tones, 6 baud, about 60 WPM
Signal bandwidth = 300 Hz

- Information can be requested and automatically received from receiving stations. For example, in a net situation, stations can be instructed to download a specific file from net control. Alternately, net control can send the file to all listening stations.
- Directed mode allows for "private" conversations. You can monitor all transmissions, even private ones, but only *allcall* or directed message will appear on your main display. A separate monitor window records all received signals.
- You can set the call sign field to a tactical identifier and messages can be directed to the stations using those tactical identifiers. (In this mode, it would be necessary for the operators to periodically manually identify themselves with their FCC call signs according to regulations.)
- FSQCall software may not run well on low-spec netbook type computers or older single core Pentium systems as the processing power required for reception is high.