



# HF Digital Communications

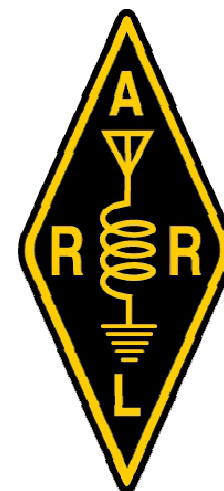
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How to work those strange  
sounds you hear on the air

John Clements    KC9ON  
Joe Miller        KJ8O  
Brian Johnston    W8TFI

Stephen H. Smith  
John Mathieson

WA8LMF  
AC8JW  
1 May 2014





# Contents

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- Introductions
- Why Digital?
- Digital Modes of Operation
- Hardware : Radio, Computer, and interfaces



# Contents

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- Software
- Tips and Tricks
- Q&A



# Introductions

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- John Clements      KC90N
  - Licensed in 1979 at age 16
  - Retired from electronics manufacturing and IT systems
  - Active experimenter and home brewer
  - [jwc123@gmail.com](mailto:jwc123@gmail.com)



# Introductions

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- Stephen Smith    WA8LMF
  - Land-Mobile-Radio Systems & Field Engineer
  - Ham since 1964
  - [WA8LMF@wa8lmf.net](mailto:WA8LMF@wa8lmf.net)



# Introductions

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- Joe Miller KJ80
  - SWL since 1967, first licensed in 2006 and collects QSL cards
  - President of OCARS (W8TNO)
  - Certified Public Accountant
  - [kj80.ham@gmail.com](mailto:kj80.ham@gmail.com)



# Introductions

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- Brian Johnston W8TFI
  - Licensed in 1976
  - Computer operator for a major newspaper
  - Avid experimenter and home brewer
  - [w8tfi@arri.net](mailto:w8tfi@arri.net)



# Introductions

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- John Mathieson AC8JW
  - Licensed since about 2005
  - Active in CW and digital modes
  - [jspokes@yahoo.com](mailto:jspokes@yahoo.com)





# Why Digital?

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- Send and receive text, images, data, and audio
- Some modes work very well in noisy and weak signal environments
  - If you can't hear them you can't work them is no longer true!



# Why Digital?

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- Some modes can provide error free or reduced error transmissions.
  - Good for Emergency Communications



# Why Digital?

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- Many modes use smaller bandwidths than voice
- 97.1(b) contribute to the advancement of the radio art.
- 97.313(a) use the minimum transmitter power necessary to carry out the desired communications.



# Digital Modes of Operation

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- There are more digital modes than you can shake a stick at!
  - RTTY, PSK, QPSK, MFSK, Olivia, MT63, JT65, Contestia, Hellschreiber, Throb, Packet, WSPR, SSTV, FreeDV and many many more!

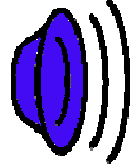


# Digital Modes of Operation

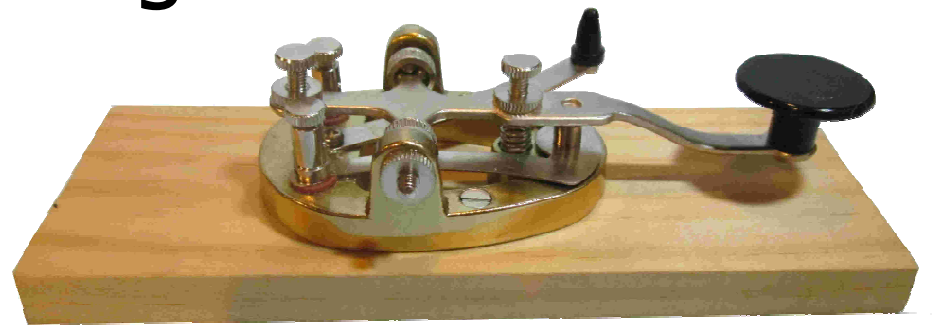
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- Each have their own good and bad
- We will just look at a few popular ones.....

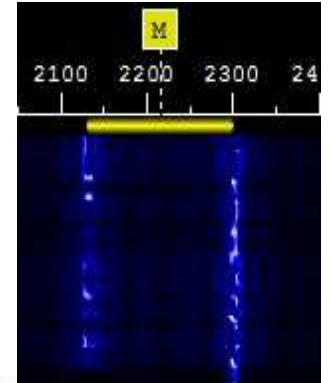
# The Old Timers of Digital CW



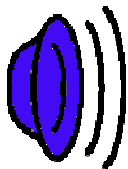
- CW is the oldest digital mode
  - Started before the birth of radio
  - Computers are not required
  - From QRSs in seconds per 'dit'
  - To QRQ speeds greater than 150WPM



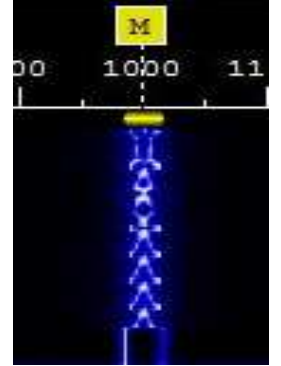
# The Old Timers of Digital RTTY (Radio Teletype)



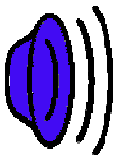
- Became popular in the 1950's using WWII surplus equipment.
- 60WPM / 45 baud (changes per second)
- FSK - Shifts between 2 frequencies, typically 170Hz apart.
- Sensitive to QSB and QRN, no error correction.



# PSK31

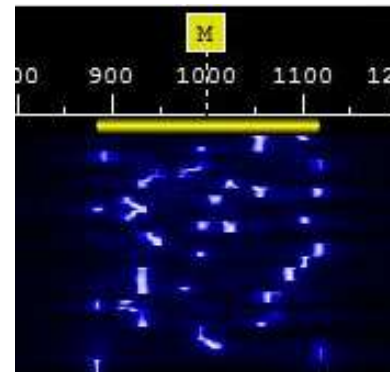


- One of the first sound card modes
- Popular for keyboard to keyboard
- Narrow 31Hz bandwidth
- 5 conversations fit in the same space as RTTY
- 30% slower than RTTY
  - 40WPM / 31 baud
- Sensitive to QSB and QRN, No error correction but outperforms RTTY

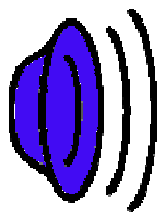




# MFSK16



- Like RTTY but uses 16 different frequency shifts
- Old technology mode - required complicated hardware before sound card software was available
- Speed of 78WPM / 62.5 baud with a 316 Hz bandwidth
- ARRL Bulletins are transmitted in MFSK16

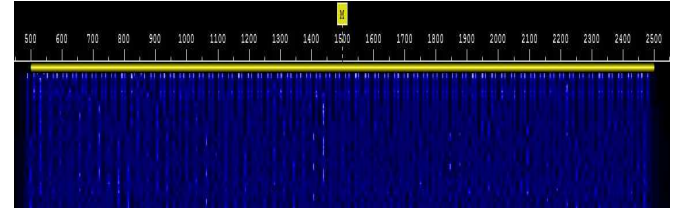




# MFSK16

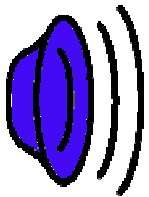
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- Uses forward error correction (FEC)
- Typically this is done by sending redundant data
- The cost penalty is extra time to send the data multiple times
- Result is greatly reduced errors from QSB, QRN and Multipath propagation



# MT63

- MFSK Variation using 64 frequency shifts
- Great for sending large amounts of data
- Forward error correction, can lose up to 25% and still have perfect copy

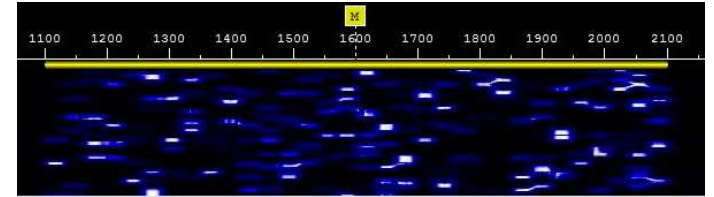




# MT63

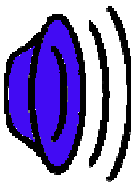
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- 3 Modes of operation
  - MT63-500 50WPM 500Hz BW
  - MT63-1000 100WPM 1KHz BW
  - MT63-2000 200WPM 2KHz BW
- Typically MT63-2000 is used by EMCOMM and MARS



# Olivia

- Another MFSK Variant
- Has forward error correction like MT63
- Good with QSB, QRM
- Will decode 10-14dB below the noise floor



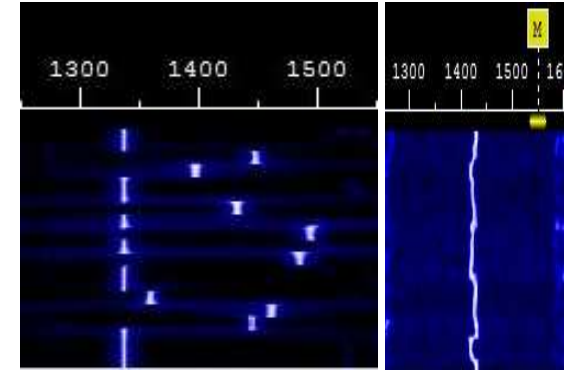


# Olivia

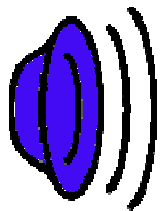
- Common bandwidth, shifts, and speeds

Mode	BW	Shifts	WPM
500/16	500	16	20
1000/32	1000	32	24

# JT65/JT9



- QRPp & EME Weak signal mode
- JT65 uses 65 shifts in a 355Hz bandwidth
- JT9 – Fairly new mode
  - Uses 9 shifts in only 15.6Hz bandwidth
  - Sounds like a constant tone





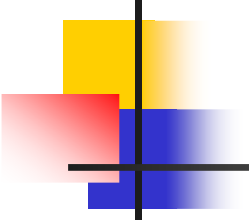
# JT65/JT9

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- Very slow mode!
  - 45 seconds long to send 72 bits or  $\sim 13$  characters
  - Standard messages typically contains two call signs, a grid locator or signal report, the message type.



# JT65/JT9

- 
- Now also used on HF
  - W6CQZ wrote “JT65-HF” that makes HF operation easy, especially for low power stations.
  - <http://sourceforge.net/projects/jt65-hf/files>

# JT65/JT9

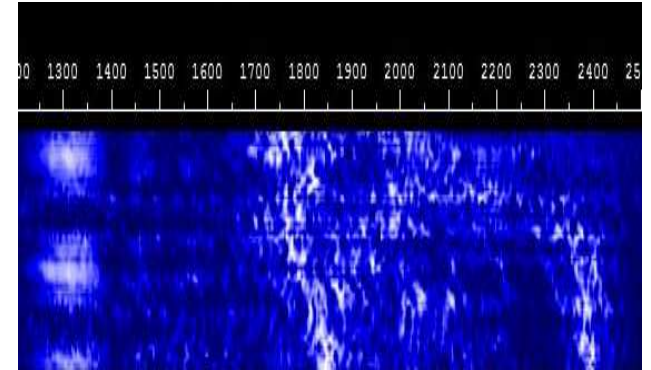
The screenshot displays the JT65-HF software interface. At the top, the title bar reads "JT65-HF Version 1.0.9.3 [ WABLMF QRV ]". The main window is divided into several sections:

- Audio Input Levels:** Shows levels for L3 and R4. Optimum input level is 0 with only background noise present. Digital Audio Gain is set to 0 for both L and R.
- Waterfall Plot:** A spectral display showing signal activity across a frequency range from -1K to +1K Hz. The current operation is "Receiving".
- Message To TX:** No message entered. TX is currently OFF. Options include TX Text (13 Characters) and TX Generated (TX Even or TX Odd).
- Log Table:** A table of received messages with columns for UTC, Sync, dB, DT, DF, and Exchange. Several entries are highlighted in green.
- Controls:** Includes buttons for "Clear Decodes", "Decode Again", "DT Offset", and "Restore Defaults". A "Color-map" dropdown is set to "Linrad".
- Call CQ and answer callers:** Buttons for "Call CQ", "Answer Caller", and "Send RRR".
- Answering CQ:** Buttons for "Answer CQ" and "Send Report".
- TX DF and RX DF:** Both set to 519. Options include "TX DF = RX DF", "AFC", "Noise Blank", "Single BW", "Multi BW", "Enable Multi", "Enable RB", and "Enable PSKR".

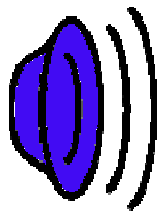
UTC	Sync	dB	DT	DF	Exchange
20:52	4	-14	-0.7	-659	B CQ CU5AQ HM58
20:52	4	-13	-0.9	-894	B ON7ZJ KD5IUN EM13
20:51	5	-18	-0.4	939	B CE4RWS R TU73
20:51	3	-22	-1.2	393	K NS9I RRR 73
20:51	1	-25	0.3	140	K CQ K6NLX DM14
20:51	6	-17	-0.4	-275	B DK7OM KC1BAA -08
20:51	5	-7	-1.0	-896	B CQ ON7ZJ DX
20:50	4	-7	-0.4	140	B K6NLX KD5IUN EM13
20:50	1	-14	-0.9	-275	B KC1BAA N4MTT EM05

- Actual off-the-air RX in central MI with mobile whip on 20 meters.

# SSTV



- Started with dedicated hardware using surplus long-persistence RADAR CRT's; now all done with sound-card software.
- Commonly called a "digital" mode, but most SSTV is analog, except for "EasyPal" which is actually a general-purpose digital-file-transfer-over-radio program.
- Various formats of SSTV exist but most software automatically detects and handles formatting

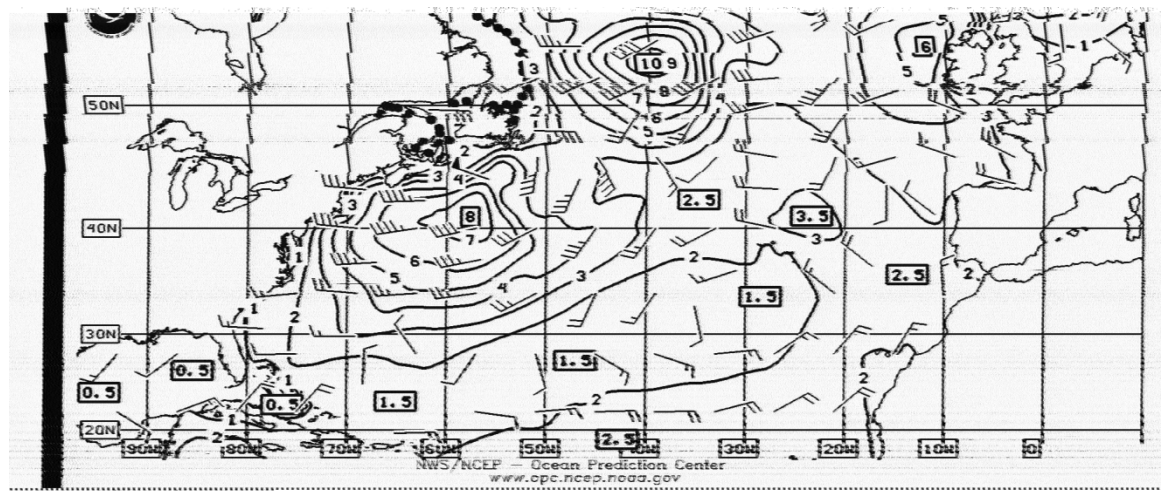




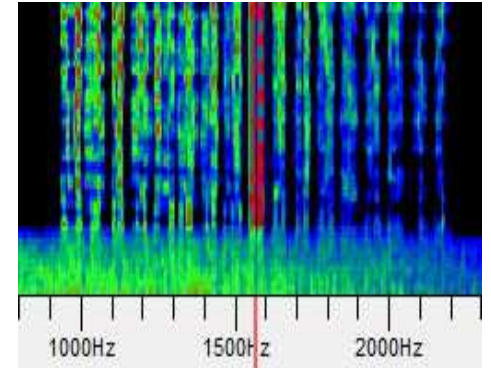
# SSTV



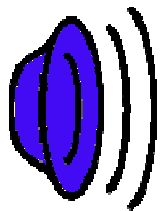
- Weather Fax (WeFax) is a similar mode, not used in amateur radio but can be found on the SW bands.



# Digital Voice



- The future of radio??
- About 1/2 the bandwidth
  - 1.25KHz wide using a 16QPSK signal
- FM-quality noiseless voice on HF!
- Most activity on 14.236MHz
- Free software at:  
<http://freedv.org>





# Digital Voice

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- Requires 2 sound cards
  - One for radio-to-speaker (RX)
  - One for mic-to-radio (TX)
- USB sound cards are cheap
  - From \$1.80 to \$25

# Hardware



- Only 3 components needed
  - Radio
  - Computer
  - Audio / PTT Interface
- Optionally a **Computer Aided Tuning (CAT)** interface
  - Not required but nice to have if the radio supports it



# Hardware



- How much does it cost?
  - Assuming you have the radio and computer.....
  - Build your own interface from free to \$25
  - Buy commercial interfaces from \$60-300





# Hardware Radio

- Almost any USB HF Transceiver
  - Older mechanical analog VFO rigs may NOT be stable enough for narrow modes like PSK31 but work well on modes like RTTY and SSTV.
- Newer radios with stable frequency synthesizers are best.
- Some high end rigs have PSK and RTTY built in!

# Hardware Computer



- Big and fast not required
- Most “XP” computers work fine!
- Minimum Requirements
  - Available USB or RS-232 port
  - Sound Card
  - 1GHz CPU, 100MB free RAM
  - 300MB Drive space
  - Depends on software - YMMV



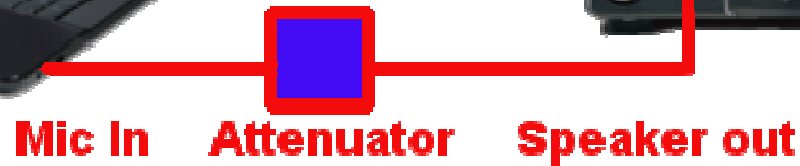
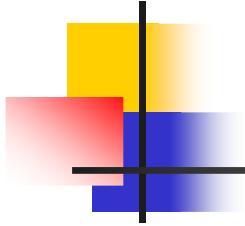
# Interfaces

## Receive

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- Start today with a simple attenuator cable
- Parts are about \$10 at Radio Shack, cheaper elsewhere!
- [wa8lmf.net/miscinfo/Universal-Sound-Card-Cable.pdf](http://wa8lmf.net/miscinfo/Universal-Sound-Card-Cable.pdf)

# Interfaces Receive





# Interfaces

## Transmitting

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- Transmitting is a little more complex
  - PTT keying
  - Isolate the audio to prevent ground loop issues



# Interfaces Commercial

- Several Manufacturers
  - MFJ
  - West Mountain (Rig Blaster)
  - TigerTronics
- Some models include cables
- Other models require purchasing cables for your rig

# Interfaces Commercial



- Better models include a sound card built in
  - Your internal PC sound card is available for regular use
- Prices from \$60 - \$300



# Interfaces Commercial

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- Older models only handle the TX side
  - These models use a straight RX cable and the PC LINE-IN instead of the MIC jack!
  - An RX attenuator cable is still required to go into the PC Mic jack



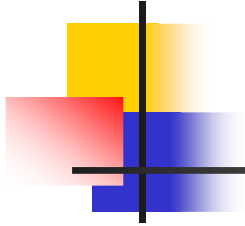


# Interfaces Homebrew

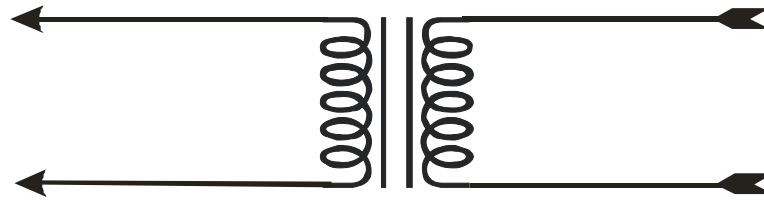
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- As basic as two 600-600 ohm audio transformers, a few resistors, and a \$1.00 opto-isolator chip for PTT keying.

# Interfaces Homebrew

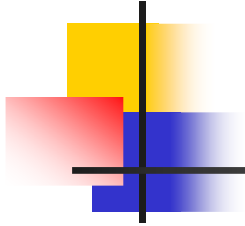


Computer  
Audio In

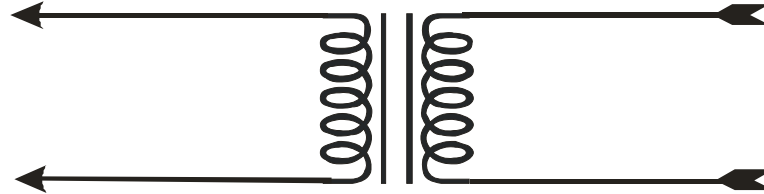


Radio  
Receive  
Audio Out

# Interfaces Homebrew

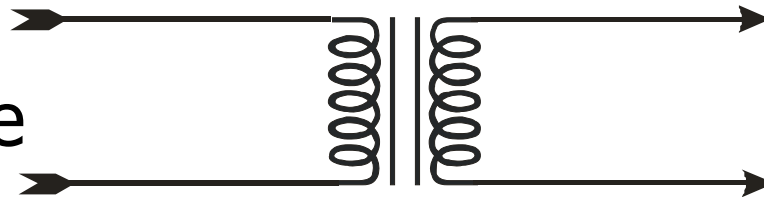


Computer  
Audio In



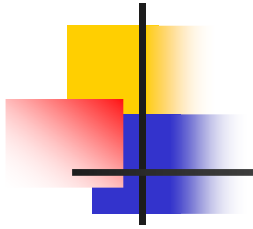
Radio  
Spkr/Aux  
Audio Out

Computer  
Speaker/Line  
Audio Out

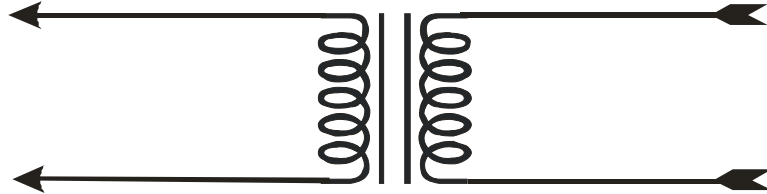


Radio  
Mic/Aux  
Audio In

# Interfaces Homebrew

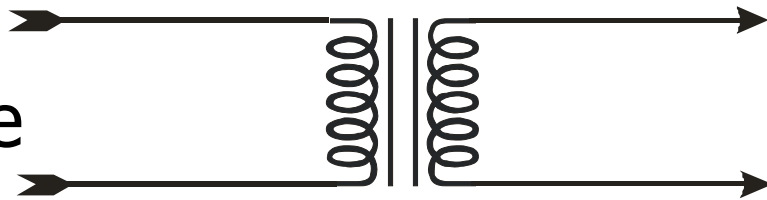


Computer  
Audio In



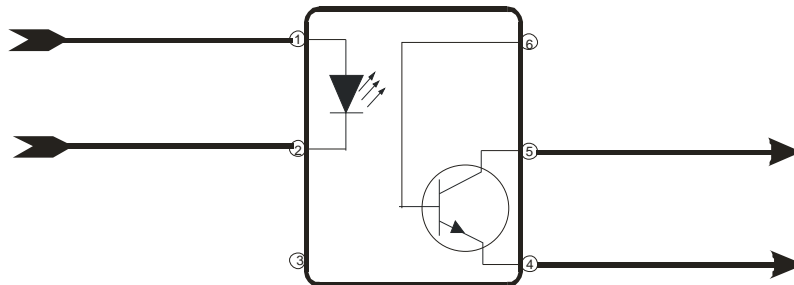
Radio  
Spkr/Aux  
Audio Out

Computer  
Speaker/Line  
Audio Out



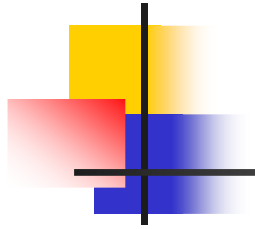
Radio  
Mic/Aux  
Audio In

Serial Port  
RTS Pin



Radio PTT  
Line

# Interfaces Typical Setup



# Software

## Ham Radio Deluxe

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- Ham Radio Deluxe includes a program called Digital Master 780 (DM780)
- Current Commercial version 6 \$100
- Older version 5 is free!
- Handles most modes including SSTV



# Software

## Ham Radio Deluxe

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- Also contains:
  - Integrated radio (CAT) control
  - Log book
  - Satellite Tracking
  - PSK31 super sweeper
  - Remote Control
  - And more.....

# Software Ham Radio Deluxe

The screenshot displays the Ham Radio Deluxe software interface. At the top, the menu bar includes File, Edit, View, QSO, Browser, Logbook, SSTV, SuperSweeper, World Map, Tools, Window, and Help. Below the menu bar, a toolbar contains icons for QSO, SuperSweeper, Radio, Soundcard, Waterfall, HRD, Logbook, and Program Options. The main window is titled "MFSK-16" and features a "Reverse" button and a "TX Picture" button. The central pane shows a call log with the following text:

```
ZCZC AG32
QST de W1AW
ARRL Bulletin 32 ARLB032
From ARRL Headquarters
Newington CT December 2, 2013
To all radio amateurs
SB QST ARL ARLB032
ARLB032 ARRL Files Erratum to "Symbol Rate" Petition for Rule Making
The ARRL has filed an Erratum with the FCC to correct an error in
its "symbol rate" Petition for Rule Making (PRM), filed November 15
with the FCC and put on public notice for comment as RM-11708 a few
days later. The League's petition asks the FCC to delete the symbol
rate limit in 27.307(f) of its Amateur Service rules and
replace it with a maximum bandwidth for data emissio
```

Below the call log, there are buttons for "Send (F1)", "Auto (F2)", "Pause (F3)", "Stop (F4)", and "Repeat". The bottom of the main window shows the text "Enter text to be sent" and "1656 Hz IMD: S/N: -7dB".

The bottom section of the interface is the "Waterfall" display, which shows a frequency spectrum from 100 to 3000 kHz. The current frequency is 1656 kHz, and the mode is set to "AFC". The waterfall shows a signal at 1656 kHz. The status bar at the bottom indicates "Ready", "CPU: 5%", "Audio: 54%", "Overload", "HRD Logbook: Not Connected", and "21:24".





# Software

## FLDigi

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- FLDigi is FREE!
- Handles most modes including SSTV and WeFax
- Also contains a log book and radio control



# Software

## FLDigi

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- The program of choice for EMCOMM
- Handles radiogram and ICS forms
  - Note: additional software needed for these on the FLDigi site.

# Software FLDigi

The screenshot shows the FLDigi software interface for station KC9ON. The main window contains a text area with the following text:

```
a1AW  
ARRL Bulletin 32 ARLB032  
From ARRL Headquarters  
Newington CT December 2, 2013  
To all radio amateurs  
  
SB QST ARL ARLB032  
ARRL032 ARRL Files Erratum to "Symbol Rate" Petition for Rule Making  
  
The ARRL has filed an Erratum with the FCC to correct an error in  
its "symbol rate" Petition for Rule Making (PRM), filed November 15  
with the FCC and put on public notice for comment as RM-11708 a few  
days la
```

Below the text area is a large blue area, likely for a log or another text window. At the bottom of the interface is a waterfall display showing frequency from 500 to 4500 kHz. The display shows a strong signal around 1661 kHz. The interface also includes a menu bar (File, Op Mode, Configure, View, Logbook, Help), a toolbar with various controls, and a status bar at the bottom with parameters like "WF", "MFSK16", "s/n 12 dB", "NORM", "1661", "QSY", "Store", "Lk", "Rv", "T/R", "-3.0", "AFC", and "SQL".



# Software Others

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- Special modes such as JT65/JT9 and digital voice require their own software
- Many other software program exists – both free and commercial



# Software Others

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- MultiPSK, Digipan, MixW, mmSSTV, and WinPSK are a few
- Most choices are personal preference



# Comparison of modes found in DM780 versus FLDigi

---

PSK	both	Olivia	both
QPSK	both *	RTTY	both
PSKR	<b>FLDigi</b> *	RTTYM	<b>DM780</b> *
Contestia	both	Thor	both *
CW	both	Throb	both *
DominoEX	both *	WEFAX	<b>FLDigi</b>
Hellschreiber	both	Navtex	<b>FLDigi</b>
MFSK	both	SITOR	<b>FLDigi</b>
MT63	both	WWV	<b>FLDigi</b>

# Tips and Tricks

## Power

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- Reduce your power!
  - Unlike SSB, these modes either run at 100% duty cycle, or use multiple tones sensitive to intermodulation distortion!
  - Be kind to your finals!
  - Keep **peak** power out well below key-down CW maximum to minimize distortion.
  - Keep ALC to zero
- Turn off speech processing or compression

# Tips and Tricks

## Jacks

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- Use the Auxiliary, Accessory, “Data”, or “Packet” jacks on the radio.
  - Most radios from the major manufacturers have one or more of these jacks on the rear panel
  - May have constant audio input, output, and PTT lines



# Tips and Tricks Jacks

- Typical Jacks

6-pin Mini-DIN



13-Pin Full-size DIN



# Tips and Tricks Jacks



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- No need to adjust the volume or mic gain all the time
- No need to unplug the speaker to hear the radio
- No need to swap the mic in and out
  - You may need a mic switch!

# Tips and Tricks

## Jacks

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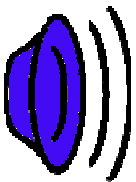
- Some radios have an audio out line in the microphone jack. This can help reduce extra cables.

# Tips and Tricks

## RSID

- Use Reed-Solomon Identification

- Short code at the beginning of a transmission which identifies the mode
- Several programs automatically detect this and pop up a box





# Tips and Tricks

## Sound Device

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- Check your sound card settings in the control panel!
  - Turn off special effects
  - Turn off pass-thru or “Listen to this device” modes
  - Set rate to 16 bit 48000Hz

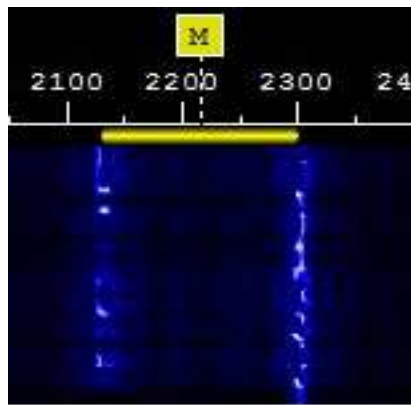


# Tips and Tricks Sound Device

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- Use the mixer to adjust your transmit audio using a dummy load and short 5-10 second intervals

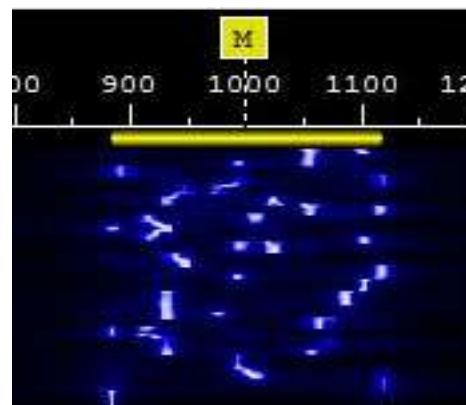
# Tips and Tricks Waterfalls



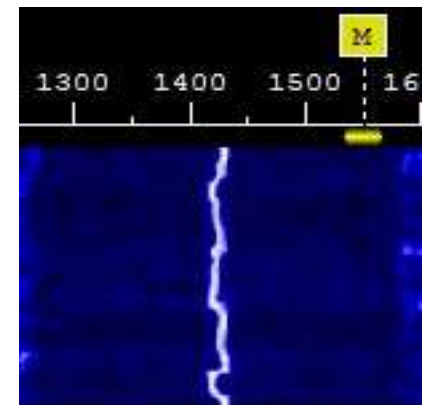
RTTY-45



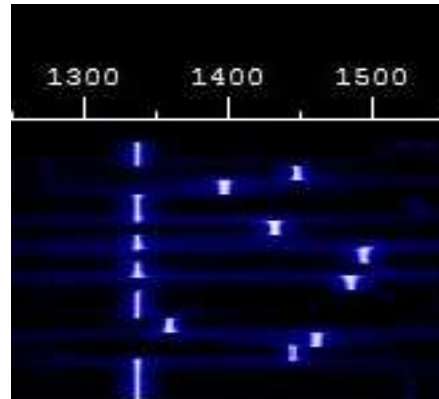
PSK31



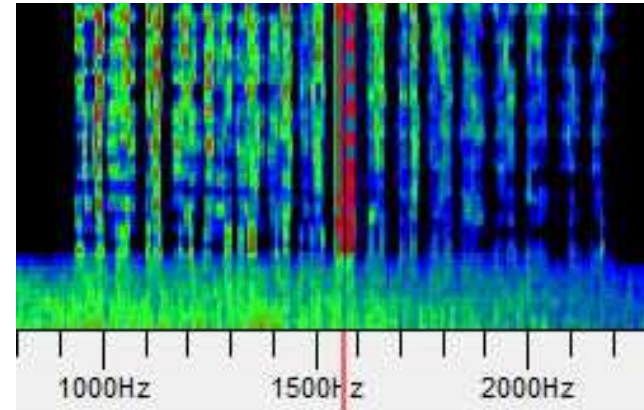
MFSK16



JT9

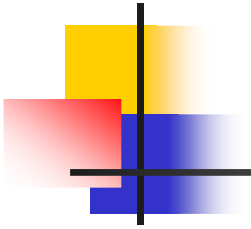


JT65

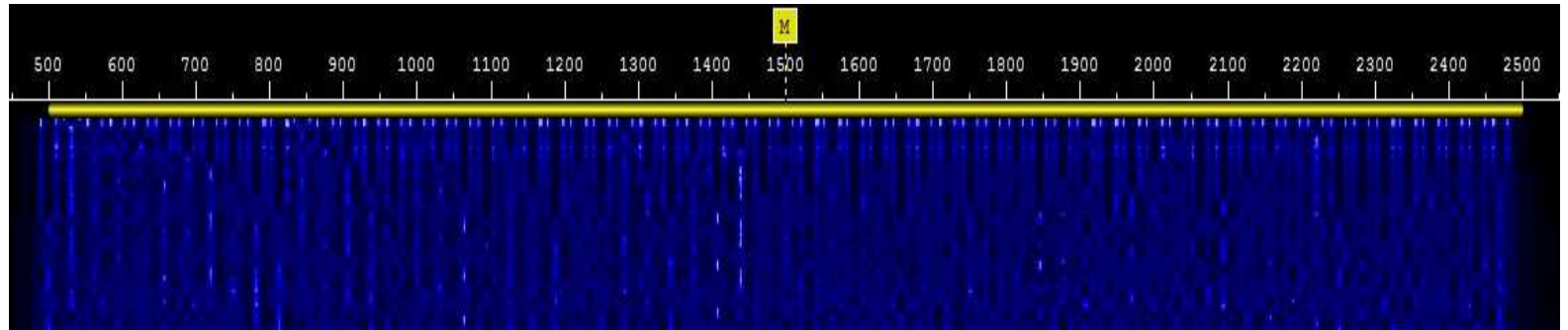


Digital Voice

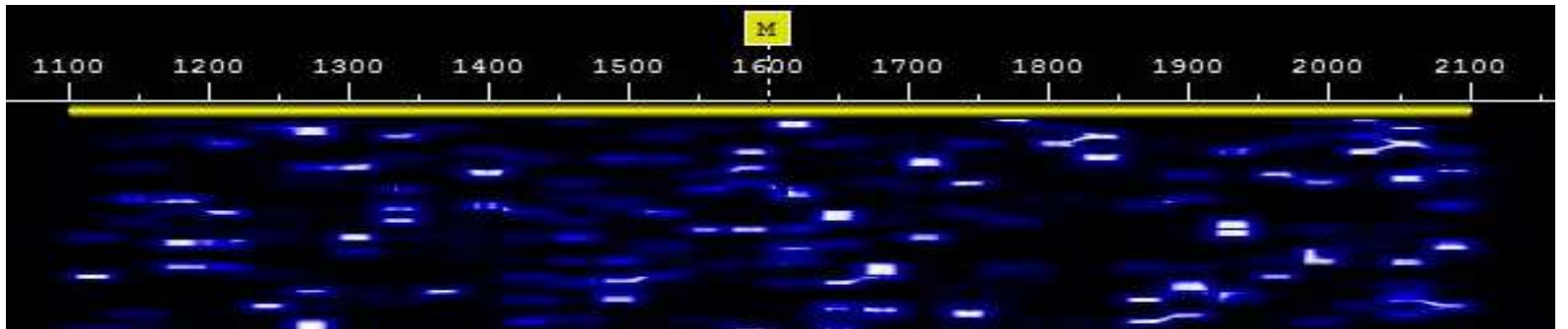
# Tips and Tricks Waterfalls



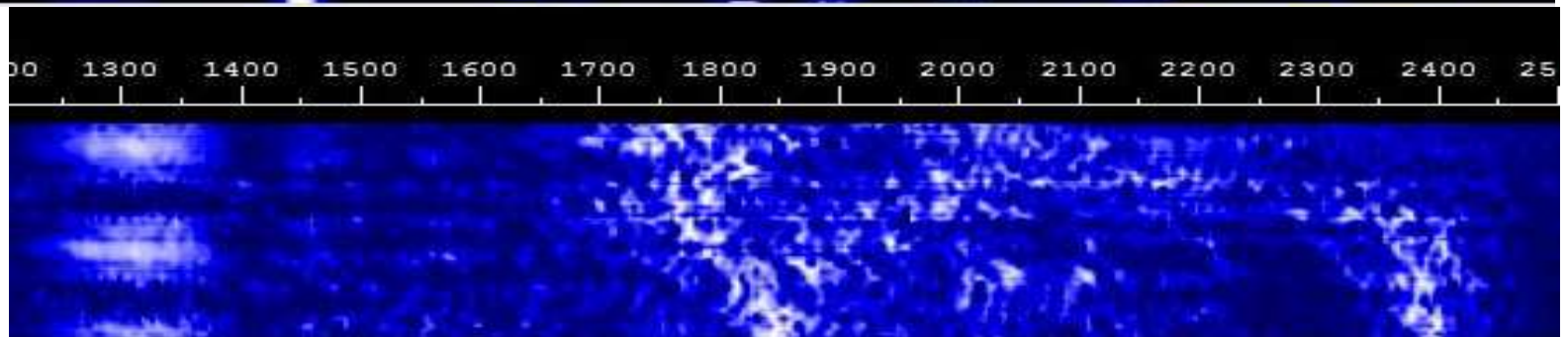
MT63



Olivia



SSTV







# Tips and Tricks Frequencies

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- Common PSK31 frequencies

1.828	10.140	21.070
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3.580	14.070	24.920
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7.035	18.100	28.120
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- Other modes are usually a few KHz from this area



# Tips and Tricks Frequencies

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- SSTV 14.230 is popular
- Digital Voice 14.236
- MI Digital Traffic Net (MIDTN)
  - 3.583Mhz Olivia 8/500
  - Tu, Th, & Sa 8PM local
  - <http://www.midtn.ws/>



# Tips and Tricks

## References

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- ARRL [www.arrl.org/hf-digital](http://www.arrl.org/hf-digital)
- Ham Radio Deluxe – Free V5
  - [www.amateurlogic.tv/MISC/HRD/HRD\\_Archives.htm](http://www.amateurlogic.tv/MISC/HRD/HRD_Archives.htm)
- FLDigi
  - [www.w1hkj.com/Fldigi.html](http://www.w1hkj.com/Fldigi.html)

# Tips and Tricks

## References

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- JT65/JT9 [hflink.com/jt65/](http://hflink.com/jt65/)
  - [www.physics.princeton.edu/pulsar/K1JT/wsjsx.html](http://www.physics.princeton.edu/pulsar/K1JT/wsjsx.html)
- FreeDV (Digital Voice)
  - [www.freedv.org](http://www.freedv.org)
- Olivia [www.oliviamode.com](http://www.oliviamode.com)



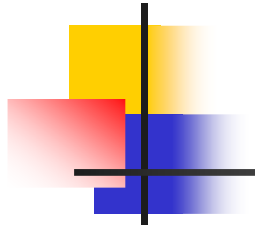
# Tips and Tricks

## References

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### Commercial Sites

- Software:
  - Ham Radio Deluxe V6  
[www.hrdsoftwarellc.com](http://www.hrdsoftwarellc.com)
- Interfaces
  - MFJ [www.mfjenterprises.com](http://www.mfjenterprises.com)
  - RigBlaster [www.westmountainradio.com](http://www.westmountainradio.com)
  - SignalLink [www.tigertronics.com](http://www.tigertronics.com)



# Getting started on FLDigi

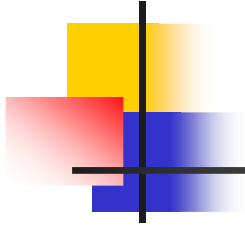
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Home: <http://www.w1hkj.com/>

Downloads: <http://www.w1hkj.com/download.html>

Beginners' guide:

<http://www.w1hkj.com/beginners.html>



Questions?



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- This presentation and other notes can be found here:
  - <http://kc9on.com/ham-radio/hf-digital-modes/>
  - <http://WA8LMF.net/miscinfo>