TBARC Programs Digital Modes Class

July 27, 2016 Class

By Israel AD7ND & Andy K3WYC

Before We Start…

- **This material was put together as an attempt to fulfill a request from the TBARC Board for a digital training class for our members.**

- **The primary purpose of this presentation is to introduce the basics of digital modes to an audience that is yet to try them.**

- **Due to our approach to keep this material as simple as possible, many other aspects of the applications, as well as explanations, were left out on purpose.**

Acronyms

- **AFSK = Audio Frequency Shifit Keying**
- **ASK = Amplitude Shift Keying**
- **BW = Bandwidth**
- **CAT = Computer Aided Transceiver**
- **FEC = Forward Error Correction**
- **FSK = Frequency Shift Keying**
- **MFSK = Multiple Frequency Shift Keying**
- **NTP = Network Time Protocol**
- **OOK = On-Off Keying**
- **PSK = Phase Shift Keying**
- **QPSK = Quadrature PSK**

Contents

- **Contents**
  1. **What is a digital mode?**
  2. **Reasons to operate digital modes**
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  6. **Connecting radio to computer**
  7. **Windows sound recording & playback devices**
  8. **FLDIGI and WSJT-X installation and configuration**
  9. **Signal level and ALC adjustments**
  10. **Monitoring transmissions**
  11. **Transmitting & Receiving digital modes**
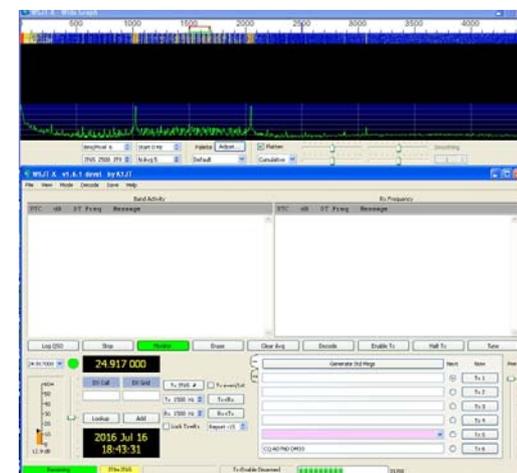 12. **Demonstration**
  13. **Q&A**

- **Thanks to the generosity of hams like Peter Martinez (G3PLX) , David Freeze (W1HKJ) and Joe Taylor (K1JT) as well as many others who support them we can enjoy free digital mode applications like FLDIGI and WSJT-X**
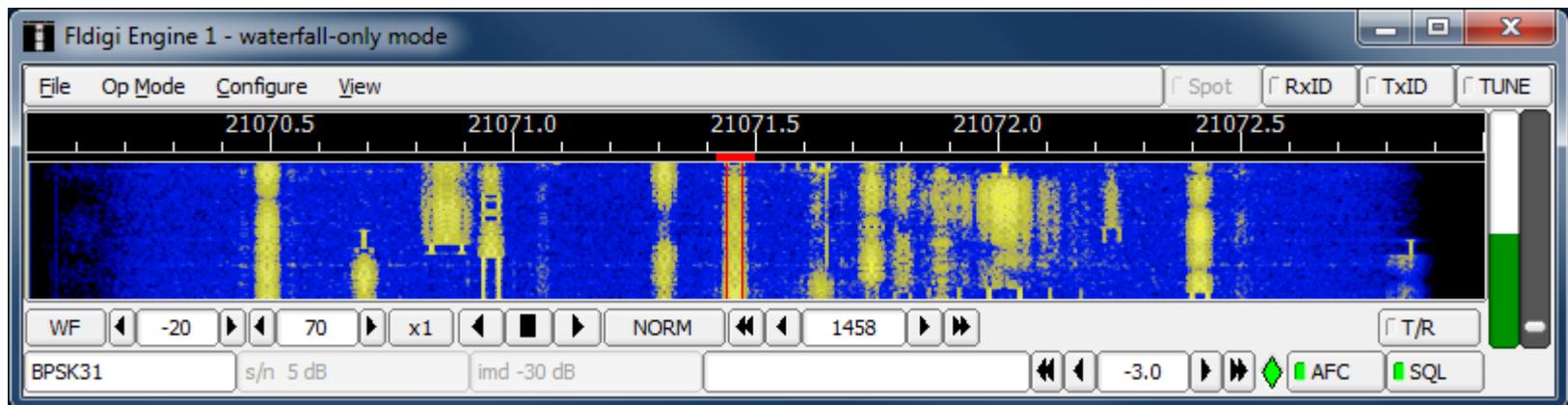
David Freeze W1HKJ
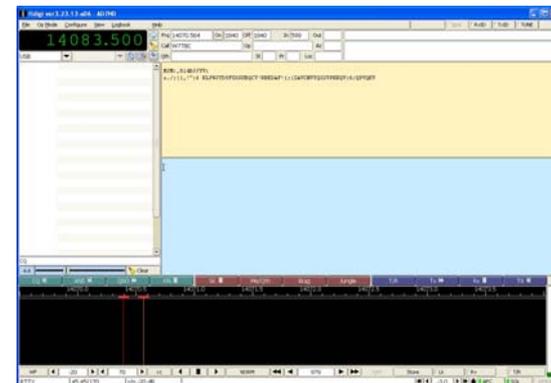
Joe Taylor K1JT

What is a Digital Mode?

- **For the purpose of this presentation, a digital mode is any mode that:**
  - **Requires the use of an encoding/decoding system**
  - **It is <u>not</u> analog voice (SSB, FM or AM)**

- **Examples of digital modes include:**
  - **PSK**, QPSK, **RTTY**, MFSK, HELL, PACTOR, THROB, **OLIVIA**, **JT65, JT9**, SSTV, DominoEX, THOR, WSPR, OPERA, etc.

Reasons to Operate Digital Modes

- **Reasons to use digital modes include:**

  1. More punch than (analog) voice
  2. Better signal to noise ratio (S/N)
  3. Forward Error Correction (FEC) - not all digi modes
  4. Bandwidth efficiency (better usage of spectrum)
  5. Better performance relative to analog SSB/AM
  6. Entire QSO can be recorded (and played back)
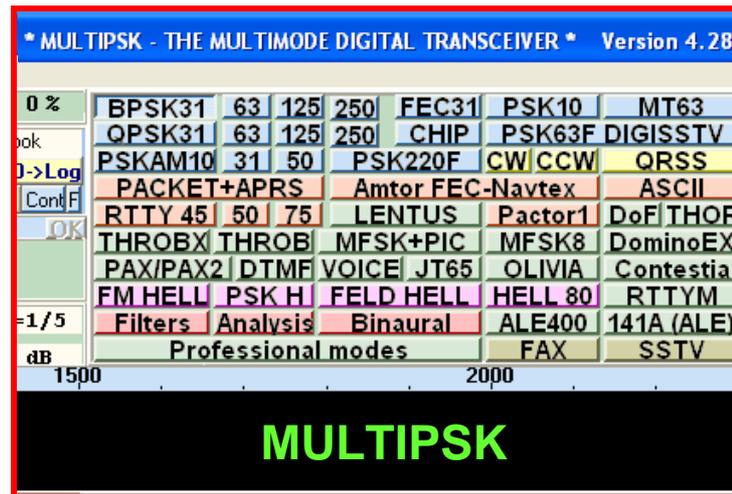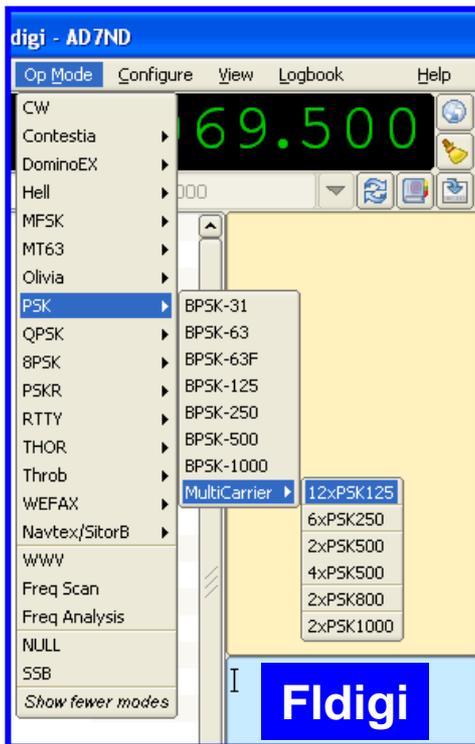
Reasons to Operate Digital Modes

Mode	SNR (dB)	Performance	
JT65	+24	JT65 Outperforms CW	**Best**
OLIVIA	+13	OLIVIA Outperforms CW	
PSK31	+8	PSK Outperforms CW	
CW	0	Reference	
RTTY	-5	CW Outperforms RTTY	
FM	-10	CW Outperforms FM	
SSB	-17	CW Outperforms SSB	
AM	-29	CW Outperforms AM	**Poor**

Source: Data from QST Dec 2013 How Much "Punch"Can You Get from Different Modes? by Kai Siwiak, KE4PT and Bruce Pontius, N0ADL.

How Many Digital Modes Are There?

- **Probably 30+ modes and over 200 submodes**
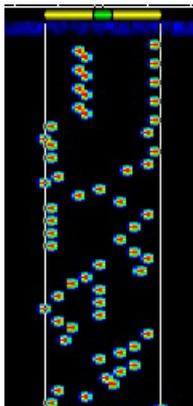- **New modes are constantly being added**

Fldigi

MULTIPSK

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PSK31
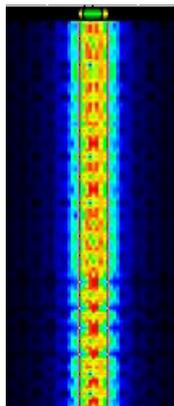
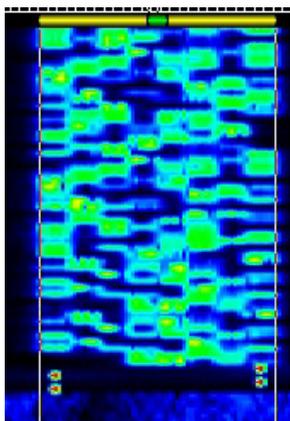**DominoEX**
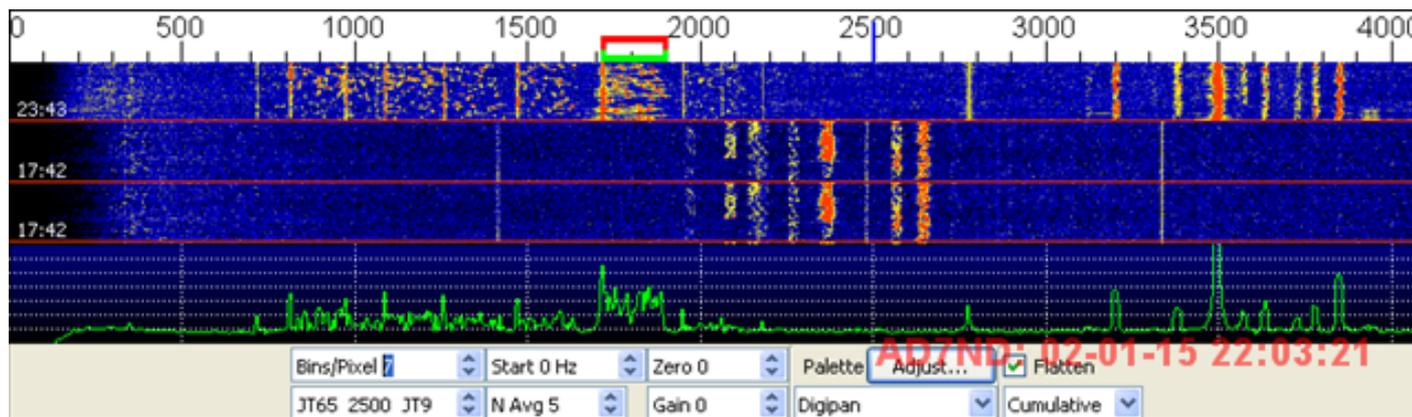
Throb4
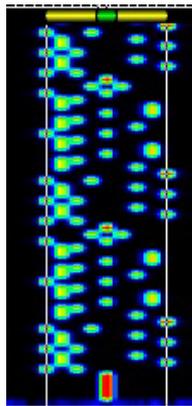
$MFSK_{16}$
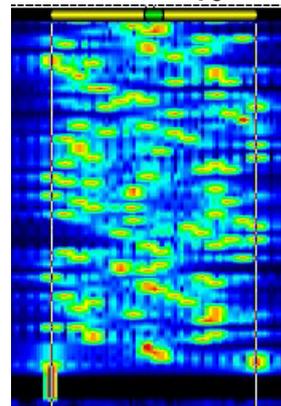
RTTY
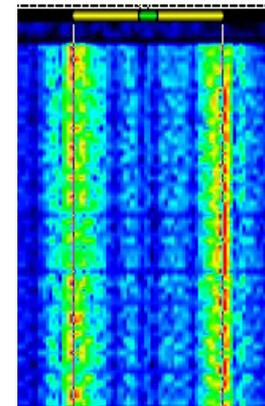
$OLIVIA_{250/8}$

JT65

JT9

Digital Modes Comparison

Mid-Latitude Disturbed NVIS Ionospheric Simulation using AE4JY 'Pathsim' simulator for 0dB S/N in a 2.4kHz band

Performance	Parameters	Best	Poorest
Propagation	Error Rate vs Mode Speed (WPM)	MT63 MFSK16	PSK RTTY
Bandwidth	Bandwidth	JT9	Olivia
Coding	Coding Gain (WPM/Symbol Rate)	Throb MT63	Feld-Hell
Signal/Noise	(S+N)/N	JT9/JT65 Opera	RTTY

Digital Mode Modulations

AFSK (Audio Freq-Shift Keying)	**RTTY, AMTOR, PACTOR, CLOVER**
MFSK (Multi Freq-Shift Keying)	**JT65/JT9, FSK441, OLIVIA, DominoEX, THROB, WSPR**
PSK (Phase-Shift Keying)	**PSK31, PSK63, MT63, Q15X25**
Other	**CW, HELL, ON-OFF KEYING (OOK)**

http://wb8nut.com/digital/

Digital Mode Basic Setup

Interface

Transceiver
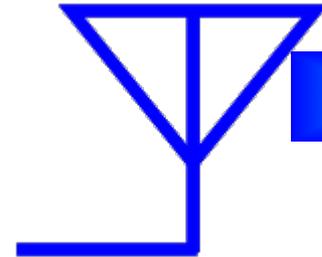
Ant

This setup works for most digital modes

Radios like TS-590 and IC-7300 do not require an interface

PC+Application

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What is Needed to Get Started?

- **At a minimum:**
  1. **PC running Windows XP or better**
  2. **SSB HF or VHF transceiver**
  3. **Means to connect PC to Radio (e.g. Signalink, Rigblaster)**
  4. **Connecting Cables**
  5. **Software Applications (e.g. FLDIGI, WSJT-X, etc.)**

> **Some digi mode applications are supported by Linux and Apple.**

Digital Communication System

PC +
Sound Card
+ Sw App

Audio/Control
Interface

Radio
Transceiver
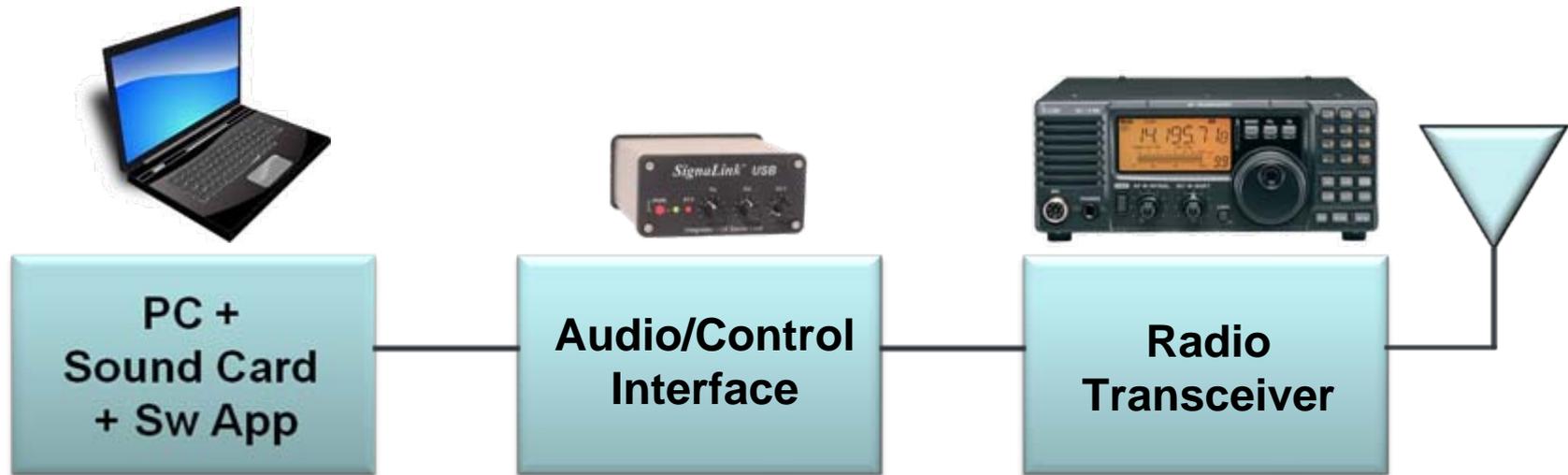
- **Most digital modes have 100% duty cycle**
- **Operating rig at full power may result in overheating and damage to the rig**
- **Choose appropriate power level for the mode and the capabilities of the rig.**

Audio modulation level and ALC adjustment are very import as transmitter must maintain linear operation to avoid distortion of the digital signal.

Basic Steps

1. Download Applications
2. Install Applications
3. Connect PC, Interface and Radio
4. Configure Audio & CAT
5. Configure Applications with Station Information
6. Turn off any speech processor or compression
7. Adjust Signal Levels, ALC, Power, etc.
8. Check reception and signal decoding
9. Transmit into a dummy load for testing
10. Ask another ham to monitor and report your first transmissions

Downloading Applications

- ## FLDIGI
  - **David Freeze's webpage: http://www.w1hkj.com/**
  - **Download FLDIGI from here:**
    https://sourceforge.net/projects/fldigi/files/
  - **FLDIGI Wiki is here:**
    https://fedorahosted.org/fldigi/wiki

- ## WSJT-X
  - **Home Page: http://physics.princeton.edu/pulsar/k1jt/**
  - **Download WSJT-X software and documentation from here:**
    http://physics.princeton.edu/pulsar/k1jt/wsjtx.html

- ## JTAlert
  - **http://hamapps.com/**

- ## Dimension-4
  - **http://www.thinkman.com/dimension4/**

Downloading FLDIGI and WSJT-X

Downloads

Be sure to refer to the online **WSJT-X User Guide** for Version 1.6.

Windows

- Latest full release, Version 1.6: wsjtx-1.6.0-win32.exe.

Linux

Installation instructions for Linux can be found here in the User Guide. Download system, from the lilst below. (Versions installable ... package maintainers create the packages.)

- Latest full release, Version 1.6
    - Debian, Ubuntu, ... (32-bit): wsjtx_1
    - Debian, Ubuntu, ... (64-bit): wsjtx_1
    - Fedora, RedHat, ... (32-bit): wsjtx-1
    - Fedora, RedHat, ... (64-bit): wsjtx-1

fldigi
Ham Radio Digital Modem Application

Brought to you by: dave-w1hkj, sb42

| Summary | Files | Reviews | Support | Mailing Lists | Git ▾ |

Looking for the latest version? **Download fldigi-3.23.13-alpha01_setup.exe (5.3 MB)**

Home

Name ⬍	Modified ⬍	Size ⬍	Downloads / Week ⬍
📁 alpha_tests	< 16 hours ago		1,692
📁 pets	2016-06-29		38
📁 flrig	2016-06-25		920
📁 fllog	2016-06-24		975
📁 flmsg	2016-06-22		608
📁 fldigi	2016-06-22		3,218

Recommendation is to download the latest stable version

Do not forget to download the manuals

Downloading FLDIGI and WSJT-X

Opening fldigi-3.23.12_setup.exe

You have chosen to open

📁 **fldigi-3.23.12_setup.exe**
    which is a: Application (5.0 MB)
    from: http://jaist.dl.sourceforge.net

Would you like to save this file?

[Save File] [Cancel]
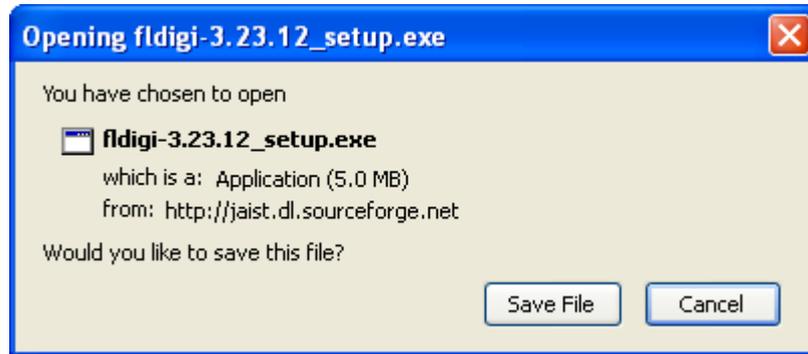
Save these files to your computer then install them…

Opening wsjtx-1.6.0-win32.exe

You have chosen to open

📁 **wsjtx-1.6.0-win32.exe**
    which is a: Application (18.6 MB)
    from: http://physics.princeton.edu

Would you like to save this file?

[Save File] [Cancel]
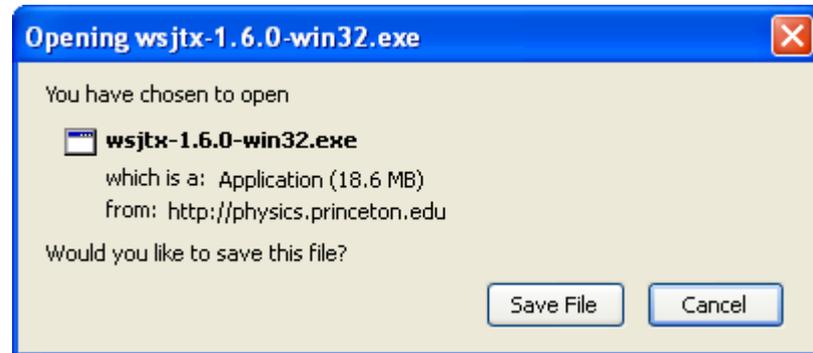
Installing Applications

Installation instructions are available in the FLDIG and WSJT-X User Guides

- **Install FLDIGI**

- **Install WSJT-X**

- **Install Dimension-4 or other NTP$^{(*)}$ like Meinberg**

(*) NTP (Network Time Protocol) application is needed to synchronize the computer's clock

Connecting PC-Interface-Radio

- **There are many types of interfaces, the link below provides step-by-step instructions to connect a Tigertronics SignaLink™ USB, which is a popular interface used by many hams operating digital modes:**

    http://www.tigertronics.com/sl_suprt.htm

    Adobe Acrobat
    Document

- **Rigblaster, Unified Microsystems, kits available in the internet and even homebrew can be used**
    http://www.qsl.net/wm2u/interface.html

Remember… some modern rigs __don't need__ an external interface. Check before you buy hardware that you may not need.

Configuring Audio

- **Audio card should be set in Windows and digital mode applications (e.g. WSJT-X and FLDIGI)**

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Configuring Audio

**Recommendation to rename the interface/rig audio CODEC,
e.g. change "microphone" to "IC706 RX"
and change "speaker" to "IC706TX".
Always ensure that the interface/rig is NOT the default sound device!**

Windows

WSJT-X
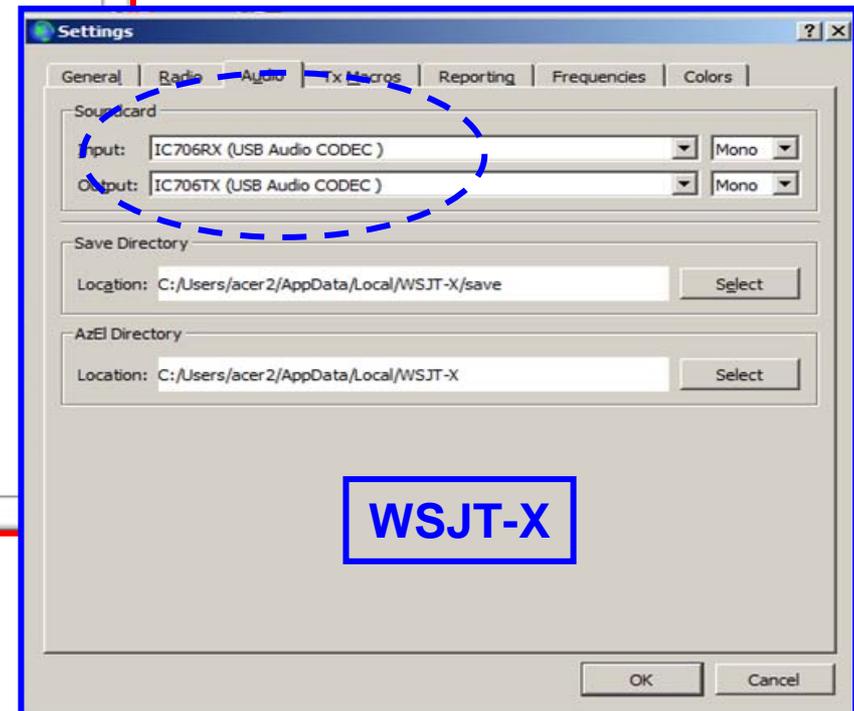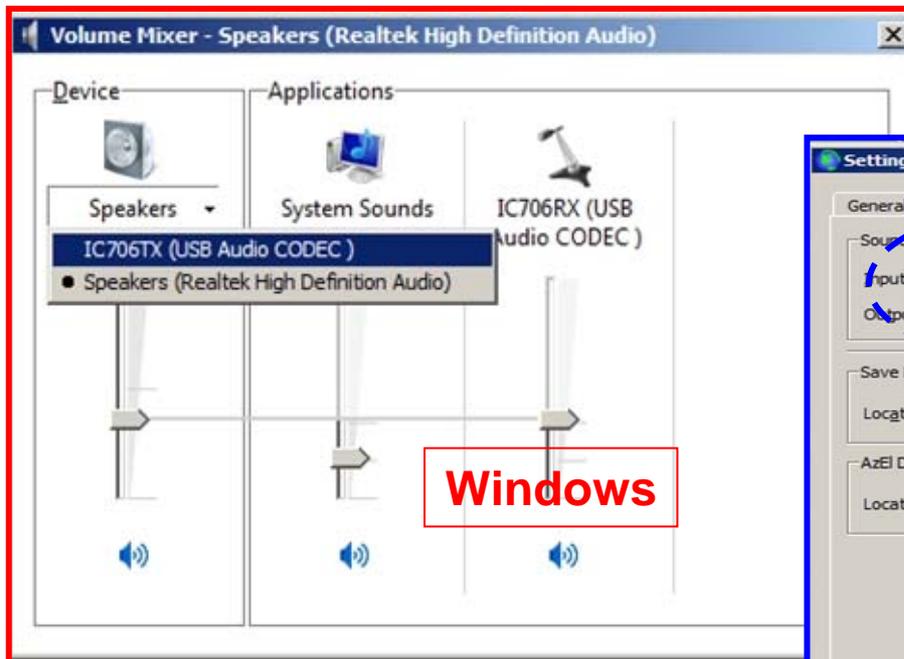
Configuring CAT

- **Most Radios require a Serial/USB cable interface to connect to the computer**
- **Serial/USB cable adapter usually requires a driver installation**
- **Port, Baud Rate, Stop Bits, Data Bits, Parity and Handshake information is usually required**
- **Radio's baud rate must match the serial port information**
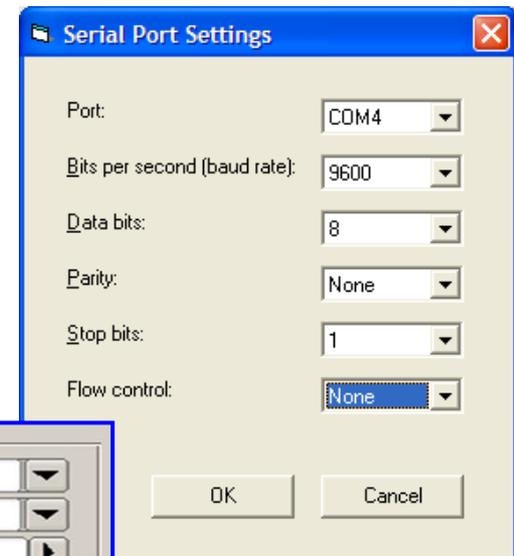
Why Adjusting Signal Levels?

Excerpt from Digital Modes – Sight & Sound: http://www.w1hkj.com/FldigiHelp-3.21/Modes/

Below are examples of what **not** to do on the ham bands. In both cases the audio drive to the transmitter was set **too high**, either **by mistake or because the operator thought that more power is better**. When the audio stages of the transmitter are over driven with clipping then you might possibly see 3rd. harmonic audio images of the PSK signal.

Be careful when evaluating a received signal. The **receiver might also be overdriven and result in similarly distorted waterfall signatures**. You can always check your local signal path by inserting 20 dB of attenuation at the antenna. If things get better then the distortion is in the receiver and not in the transmitter.

You **cannot** achieve better communications **by overdriving the audio** on any of the digital modes that require linearity. These include all of the modes that have an amplitude modulation component. Some like PSK and THROB have both an amplitude and frequency or phase modulation component.

An overdriven signal can produce more decoder errors than a properly driven signal of lesser power. This is particularly true for all variants of PSK.
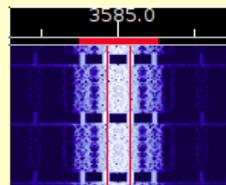
BPSK-31, imd = -18 db, about 6 dB of ALC
Sound
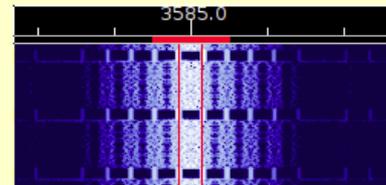
BPSK-31, imd = -14 db, about 12 dB of ALC
Sound

Adjusting ALC

ALC = Automatic Level Control

- ALC is a transmitter closed loop control function that is intended to keep the transmitter operating in the linear region, and at set power, when the input signal (drive) varies in amplitude.

- ALC will only work correctly within the design range of audio signal drive levels

- Below the design operating range ALC will not maintain power

- Above the design operating range ALC may introduce significant distortion in the transmitted signal

- Know how ALC operates in your transmitter and understand how the acceptable ALC operating region is displayed

Adjusting Power

Two approaches to adjusting power:

1. Set required power level on rig and then adjust audio input for correct ALC indication

2. Set rig power setting to maximum and control power by adjusting audio input level (for low power settings ALC will be outside the design range and there will be no ALC meter reading)

There are typically several places that the **audio drive level** can be adjusted:

- In the digital mode application
- Using the Windows "Playback Device" level slider
- Using a control on the digital mode interface
- Level control internal to the transmitter

Sometimes the digital app controls the Windows slider, sometimes it's an independent adjustment.

Balance the gain distribution so a high output of one stage does not drive next stage non-linear.

Adjusting Power

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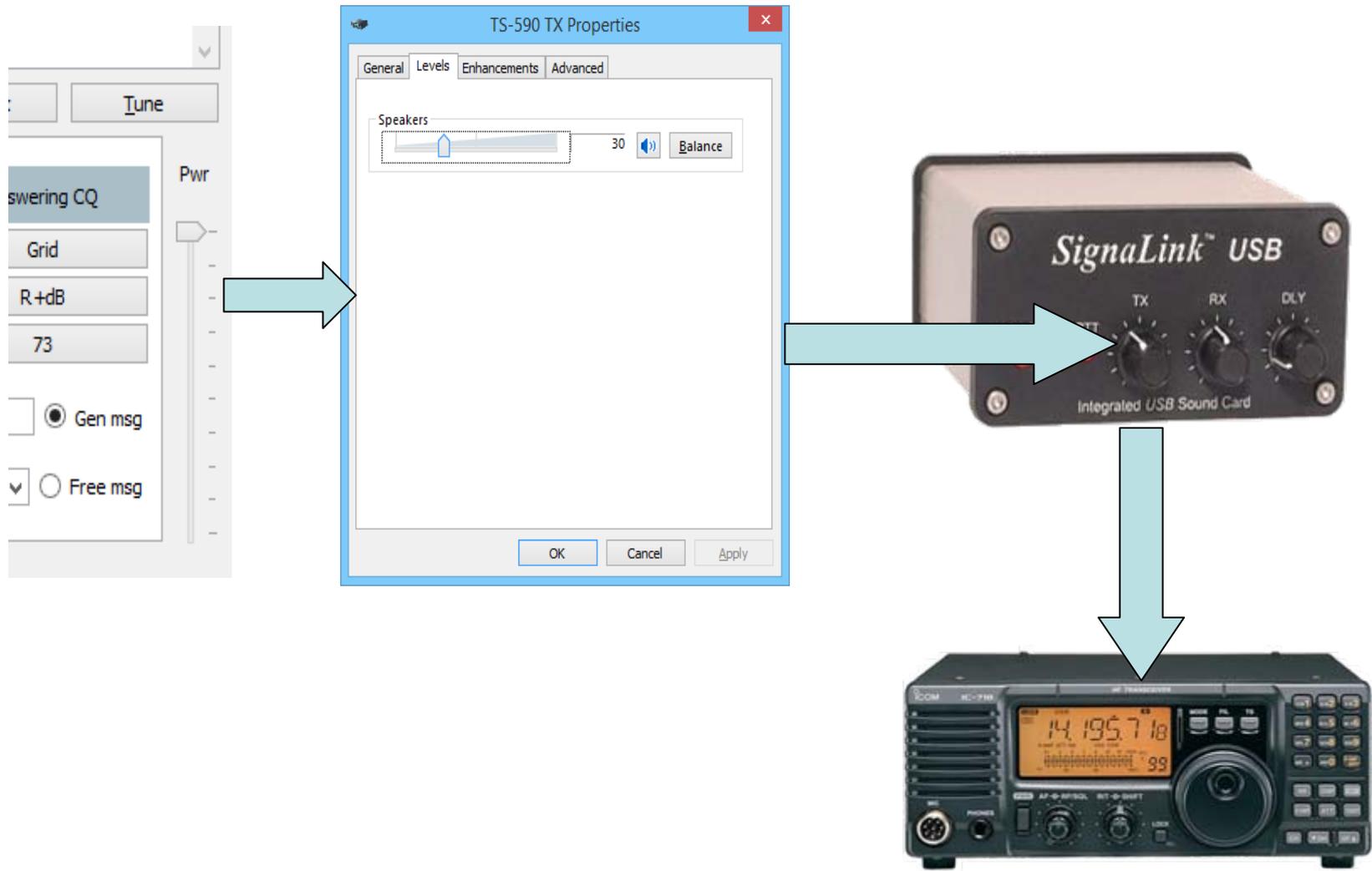
Monitoring Digital Mode

- It is very **easy to transmit a bad signal** with most, if not all, modes (not just digital)

- The Choices

  - Don't monitor because you know your signal is perfect
    Congratulations…

  - Ask someone else to check your signal quality
    Can be a good choice for those new to a mode

  - Check you signal yourself
    Some methods are described

Self Monitoring of Transmissions

1. **Use a separate receiver and PC with digital mode software to listen to, visually inspect, and decode your signal**

2. **Use the transmit monitor function of your transceiver to take a sample of your signal and listen, visually inspect, and decode it**

3. **Some digital mode programs provide a TX monitor function others require an independent monitor such as Spectrum Lab.**

4. **Note that TX monitors are not all the same. Some sample the actual RF signal, others sample the modulation audio.**

5. **Use a specialized analyzer such as PSKMeter**

6. **Monitors used for phone/CW modes may also show problems with digital modes (oscilloscope, spectrum analyzer etc)**
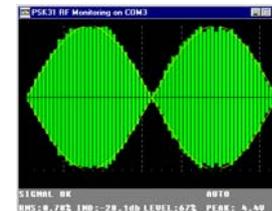
Typical Problems

- **Over modulation – especially true for PSK modes**

- **Audio harmonics**

- **Spurious modulation by 60 Hz and its harmonics**

- **Spurious modulation by unintended PC audio**

- **Spurious modulation from microphone pickup**

- **Mark/space reversal (RTTY only)**

Examples

- **JT65 second, third, and fourth audio harmonics**
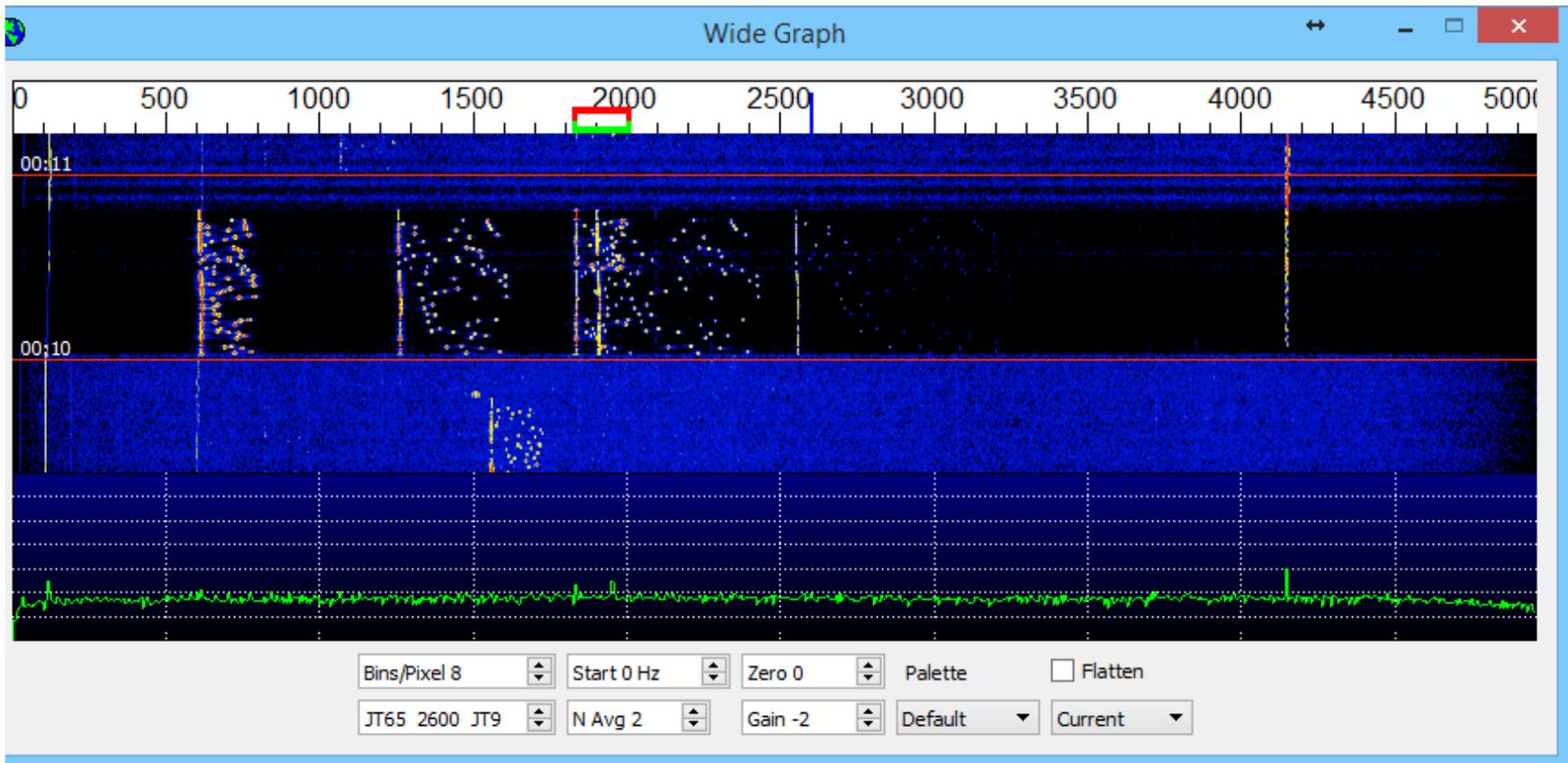
Fundamental sync tone 620Hz, 2nd at 1240Hz, 3rd at 1860Hz, 4th at 2480Hz
Note 2nd harmonic signal is twice as wide as fundamental, 3rd is 3 times, etc.

Examples

- **JT65 weak 2nd harmonic with stronger 3rd harmonic**
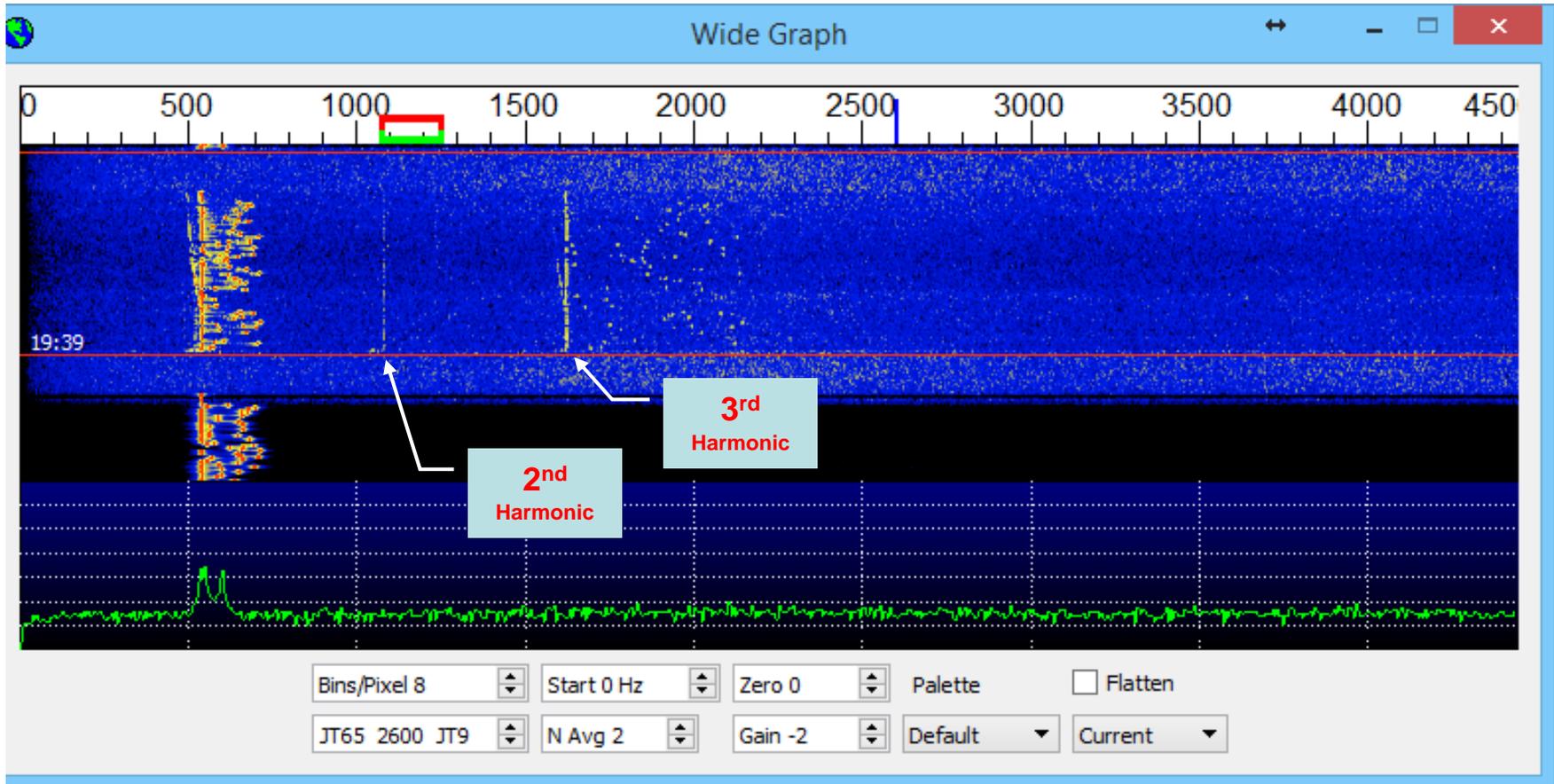
Digital Mode Frequencies

- ## JT65 & JT9

Adobe Acrobat Document

- ## Band Plan Recommendations
  ### http://www.bandplans.com/?band=All

BAND	OLIVIA 500 Center Frequency	OLIVIA 500 CQ: 500/16 DIAL Frequency USB kHz	OLIVIA 500 Audio Centre Marker
20 meters	**14075.4** 14078.4 14074.4	**14074.65** 14077.65 14073.65	750Hz 750Hz 750Hz

Common PSK, RTTY Exchanges

- **Sending a CQ call**
- **Answering a CQ call**
- **Starting a QSO (<his/her-call> de <your-call>)**
- **Your station details (Name/Location/Grid Reference/Radio/Antenna etc…)**
- **Ending a QSO (SK)**

JT65 QSO

W7TBC Working N8CDY in JT65 Mode Using WSJT-X, 20m

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JT65 QSO

AD7ND Working KG5HTH in JT65 Mode Using WSJT-X, 6m

JT9 QSO

AD7ND Working K7YCH in JT9 Mode Using WSJT-X in 20m

JT9 QSO
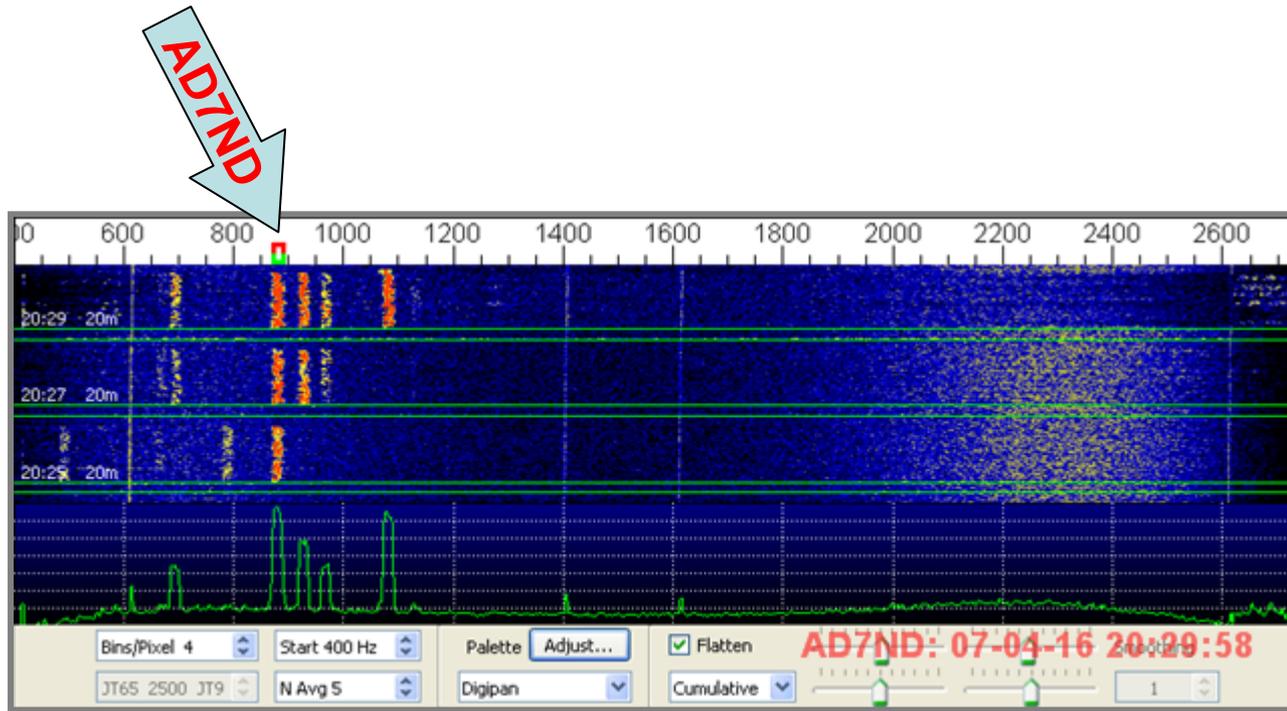
AD7ND Working K7YCH in JT9 Mode Using WSJT-X in 20m

PSK Calling CQ

Calling CQ: PSK Mode Using FLDIGI

RTTY Calling CQ

Calling CQ: RTTY Mode Using FLDIGI

Olivia Calling CQ

Calling CQ: Olivia 8-250 Mode Using FLDIGI

MFSK Calling CQ
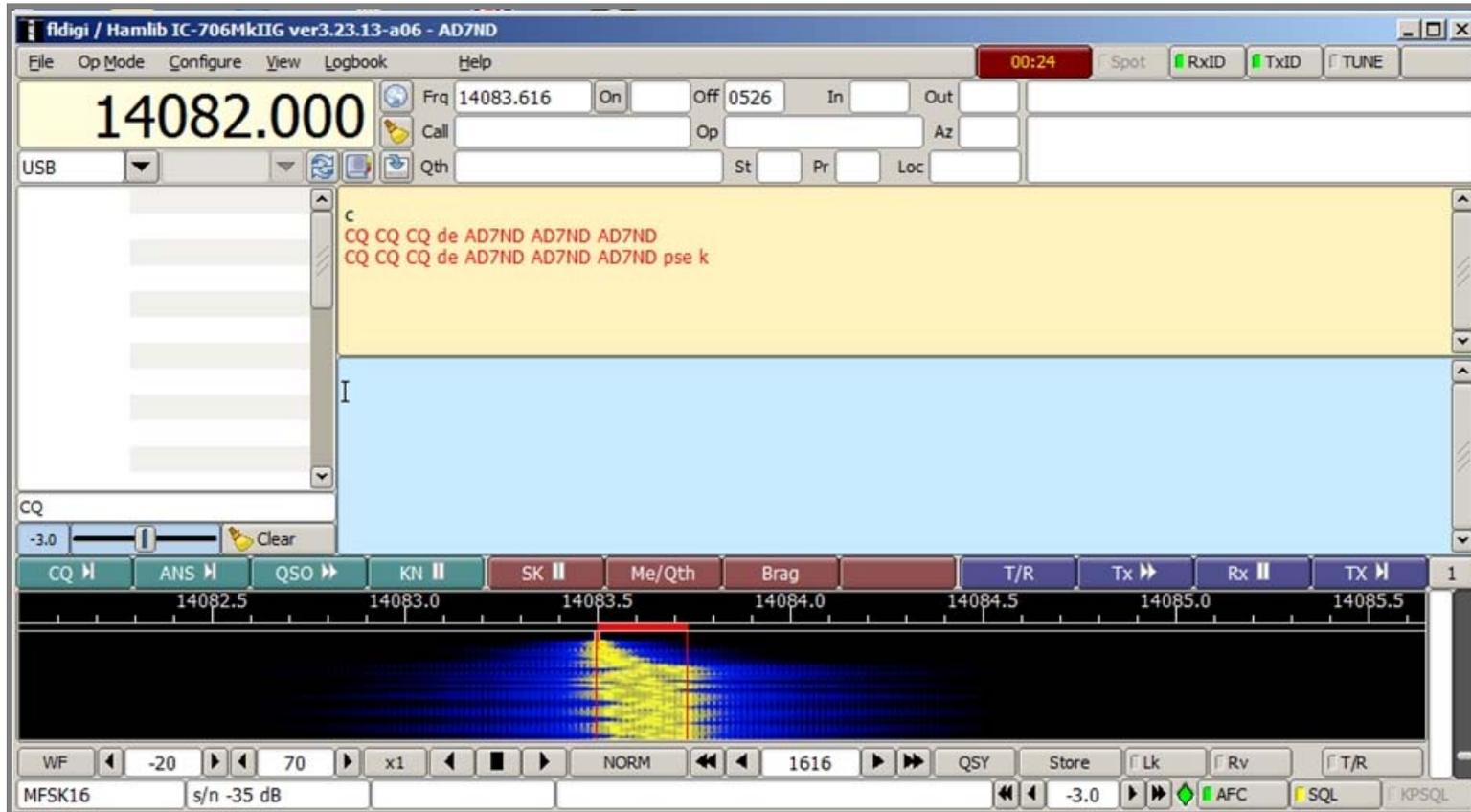
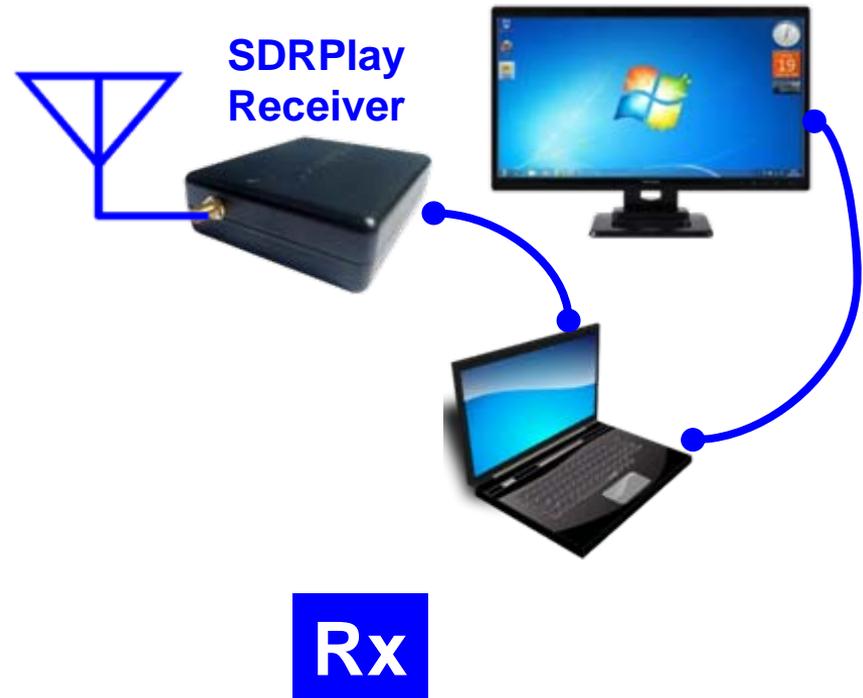**Calling CQ: MFSK-16 Mode Using FLDIGI**

PSK Calling CQ

Example of Calling CQ in PSK Mode Using FLDIGI

Demonstration

SDRPlay Receiver

HF Transceiver

Tx

Rx

Simple Way to Decode PSK, RTTY…
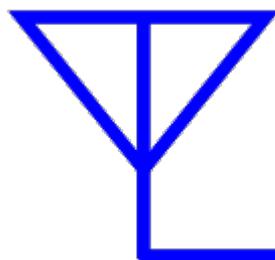
Microphone

Most laptops have built in microphones

HF Rcvr

Ant

No excuses, you can try PSK today…

PC+Digipan

Link References

- Digi Modes – Sight & Sound: http://www.w1hkj.com/FldigiHelp-3.21/Modes/
- Digital Modes Information Page WB8NUT: http://wb8nut.com/digital/
- ARRL Digital Mode Page: http://www.arrl.org/digital-modes
- Wireless Society of Southern Maind: http://www.qsl.net/ws1sm/digital.html
- Jim Brown K9YC: http://k9yc.com/publish.htm
- HF Path Simulation Project: http://www.moetronix.com/ae4jy/pathsim.htm
- WM2U Soundcard Interfacing: http://www.qsl.net/wm2u/interface.html
- K7AGE PSK: http://www.hamblog.co.uk/top-10-psk31-tips-for-beginners/
- Guide to RTTY Operation: http://www.plicht.de/ekki/rtty/dxguide.html
- Ham Radio Glossary: http://noji.com/hamradio/glossary.php

Q&A

Q&A