Amateur Radio HF Digital Communications

A Primer on How to Setup and Operate the Digital Modes on the HF Bands

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I. HF Digital Communications – A Brief History

Digital Communications have been available to amateur radio operators for many years, and can be divided into 3 separate eras:

1. **The Early Years (mid 1940s to early 1980s)**

2. **The Age of Innovation (early 1980s to late 1990s)**

3. **The Modern Era (late 1990s to present)**

1. The Early Years

- Began after World War 2, when surplus mechanical print machines become readily available for amateur use. Prior to then, there was some experimentation with Hellschreiber, but this and radioteletype were both mainly confined to military and commercial use prior to the 1940s. Communications were "live," requiring both the receiving and transmitting station to actively interact with each other over the airwaves.

- **Modes of Operation –** Radioteletype (RTTY).

- **Equipment Required –** Transceiver, teletype printer, oscilloscope, homemade interface to actuate teletype printer, lots and lots of yellow paper and oil.
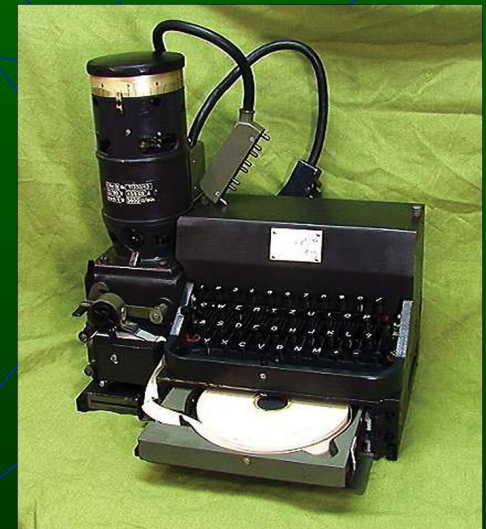
2. The Age of Innovation

- Began in the early 1980s with the rise of the personal computer. Key differences w/1ˢᵗ era: error-free or error correction transmissions now available, and automatic operations (e.g. electronic mailboxes, etc.) could be set up without requiring "live" participation by the licensee.

- **Modes of Operation –** Started with AMTOR, then grew with the popularity of Packet. Pactor, Pactor II, Clover, and G-Tor also appeared during this period.

- **Equipment Required –** A stable transceiver, PC (Commodore 64 on up to 286 or 386), multimode processor (TNCs) used as the interface, software needed to interpret signals.

3. The Modern Era

- Began in the late 1990s with the rise of the Internet. Key differences w/2nd era: return to emphasis on "live" communications. Easier, more affordable set up costs led to broader acceptance of digital communications by hams in the U.S. and overseas.

- **Modes of Operation** – Predominately PSK31, followed by MFSK, Hellschreiber, MT-63, and PSK63.

- **Equipment Required –** A stable transceiver that can tune in 1 Hz steps, modern PC (Pentium 133 Mhz on up, w/ sound card), sound card interface, and software needed to interpret signal.
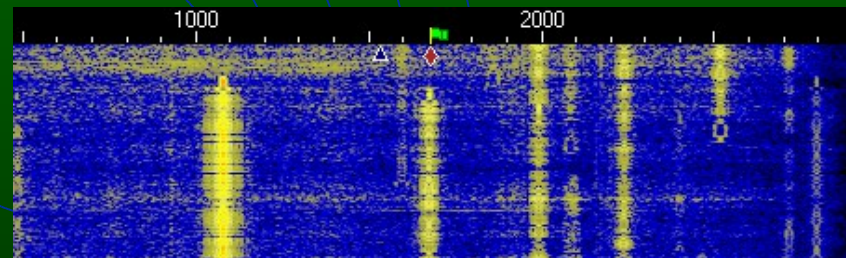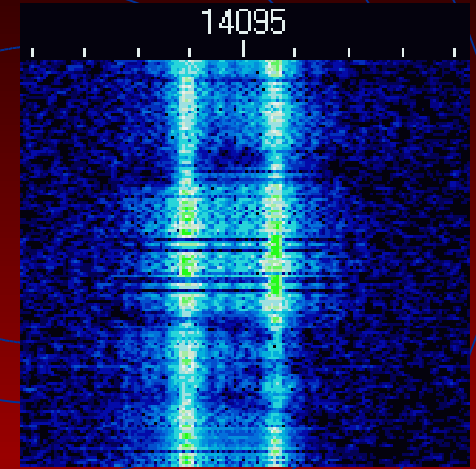
II. Overview of Various HF Digital Modes

1. RTTY
2. AMTOR
3. Packet
4. PACTOR I, II, III
5. Clover/G-TOR
6. Hellschreiber
7. MFSK
8. PSK31
9. MT63
10. Olivia

1. RTTY (Radioteletype)

- RTTY is the "old fart" of digital communications. Basically works using a 5 bit code for characters and numbers. Transmits 2 tones: a 2125 hz *mark* (or "1") tone, and a 2295 hz *space* (or "0") tone.

- **Bandwidth** – 170hz – 200 hz

- **Sounds Like** – A very fast *blee-blee-blee-blee…*

RTTY Trace

- **Advantages** – Any radio can be used, it's still the *modus operandi* for DX and digital contests. Has very fast transmission speed, can be used at maximum power without affecting signal quality, and is fairly reliable for HF communications, even w/poor band conditions.

- **Disadvantages** – Print is all UPPER CASE. No error correction, can't backspace what you transmit. Has rapidly been replaced by PSK31 for daily use.
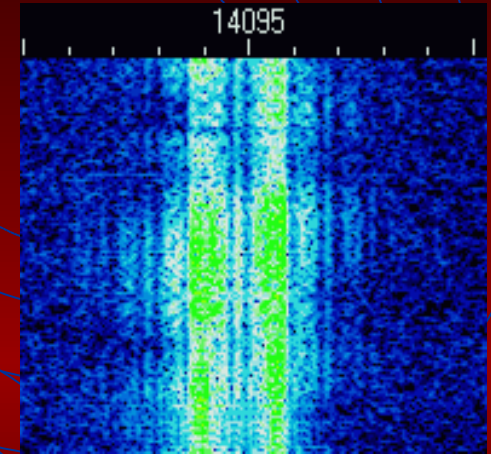
2. AMTOR (Amateur Teleprinting Over Radio)

- AMTOR is the 1st error-free/automatic digital mode. Although it's still available w/most digital sound card and TNC software, it's been out of use since the early 1990s and was surpassed by PACTOR.

- **Bandwidth** – 170hz – 200 hz

AMTOR Trace

- **Sounds Like –** Much like RTTY, but w/ a scratchy *chirp chirp* added…

- **Advantages –** None, other than it's free

- **Disadvantages –** No one uses it

3. Packet

- Packet is the next error-free/automatic digital mode, with data being sent in short bursts . Very popular in the 1980s on the VHF/UHF bands, was 1st mode to be able to send binary data. Still in use for DX spotting and APRS.

- **Bandwidth** –200 hz - 2 Khz

- **Sounds Like** – a loud *beee chirrrrrrp*

- **Advantages** – Fairly common mode on VHF/UHF, provides for a wide variety of live and automatic uses. Lots of Packet equipment can be had on the cheap.

- **Disadvantages –** Very susceptible to static, noise, and fading signals, making it not very good for HF. Ubiquitous functionality has rapidly been replaced by the internet.
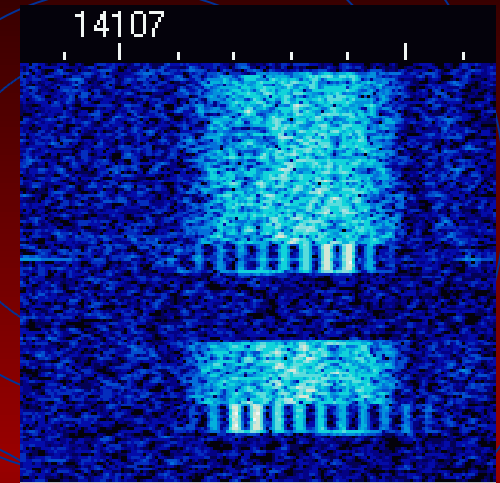
HF Packet Trace

4. PACTOR/ PACTOR II & III

14068

PACTOR Trace

- PACTOR, PACTOR II, and PACTOR III are hybrids of Packet w/the HF functionality of AMTOR. It memorizes error-free data and fills in the gaps missing from interference or QRM w/subsequent correction blasts, making it faster and easier to use than Packet or AMTOR on HF

- **Bandwidth** – 200 hz – 500 hz

- **Sounds Like** – similar to Packet sound, typically makes repetitive *chirping* noises on HF.

- **Advantages** – It's the most common error-free data mode on HF, mostly used for automatic operations such as having internet access or email from remote locations. PACTOR II is backward compatible w/ regular PACTOR. Often used nowadays for WinLink 2000

- **Disadvantages –** Normally requires TNC, or PCKTERM 3.0 software for soundcard use ($100.00). PACTOR II used to cost a lot of money, required specific type of TNC. Not suited for daily "live" communications.
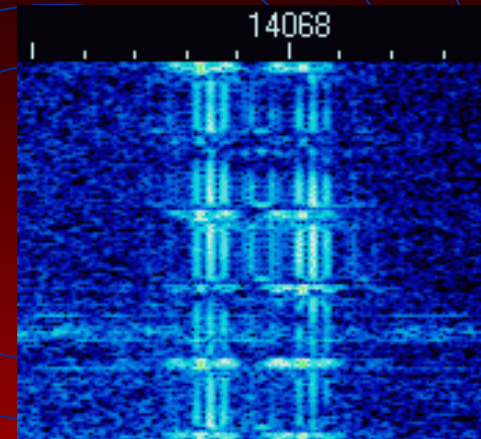
5. Clover / G-TOR

- Clover is a 4 tone, error-correcting digital mode, a proprietary creation originally designed to compete w/ PACTOR. G-TOR is very similar, but uses 2 phase-continuous tones instead.

- **Bandwidth** – 500 hz (Clover) / 300 hz – 500 hz (G-TOR)

- **Sounds Like** – a staccato *brrrrrrrr* (Clover) / similar *chirp* sound as w/PACTOR (G-TOR).

- **Advantages** – Much better error-correcting ability, can handle large volumes of data, both perform very well under bad HF conditions.

- **Disadvantages –** Requires multimode processors, cannot be used w/ soundcards. Clover requires controller hardware to be installed into your PC. Both are proprietary digital modes and cost a lot of money. Almost never heard on the HF bands, functionality is superceded by the internet.

6. Hellschreiber

- Hellschreiber is a visual or "image text" digital mode, very similar to fascimile. Characters appear to scan across your viewing screen as you receive or transmit text. Mode was pioneered back in the 1920s and 1930s, used extensively by German Army in World War II.

- **Bandwidth** –1 hz - 245 hz

- **Sounds Like** – a light, fast *tic tic tic brrrrrp brrrp… brrrrrp brrrp*

- **Advantages** – Prints text twice to reduce the effects of phase shifts and timing errors due to QRM. Moderately fast digital mode for it's extremely narrow bandwidth.

- **Disadvantages –** Not very common on the HF bands.
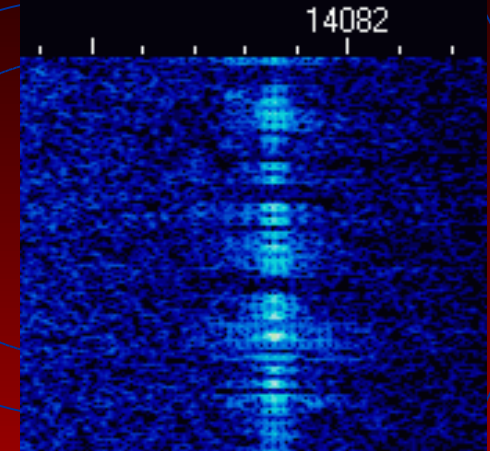
Hellschreiber Trace

"HOGAN!!"--

Colonel Klink

7. MFSK

- MFSK is essentially a super-RTTY mode, using 16 to 32 different tones instead of just 2. Developed in the heyday of commercial teleprinter HF communications, for use when RTTY was no longer receivable.

- **Bandwidth** – 300 hz

- **Sounds Like** – Think of an insane picolo solo, playing completely random notes.
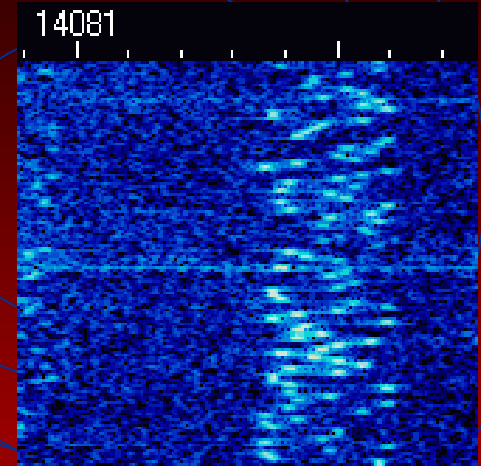
MFSK Trace

- **Advantages** – Perfect mode for DX long-path and polar operations, good for QRP ops. It's very resistant to noise and QRM, making it ideal for low band operations. Print is moderately fast (40 WPM).

- **Disadvantages –** Can be hard to sync up w/on your software. Although it does have some error-correction capabilities, it is strictly a live operation mode.

8. PSK31

PSK31 Trace

- PSK31 stands for Phase Shift Keying. The 31 stands for the bit rate, but this number is also the typical bandwidth for PSK ops. Mode was pioneered by AMTOR creator Peter Martinez, G3PLX, as a live communications alternative to RTTY for weak signal use. Gained popularity in 1999, when a Windows-based software platform was made available. BPSK is the standard binary mode, while QPSK is an error-correcting version.
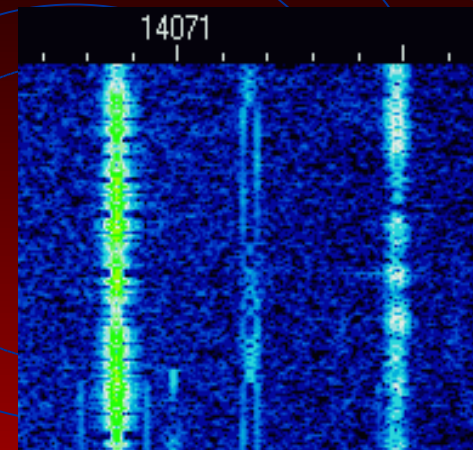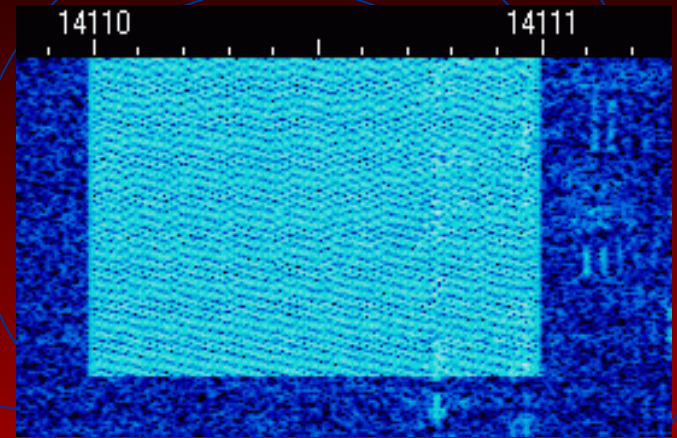
- **Bandwidth –** 31 hz

- **Sounds Like –** A continuous tone with slight warbles in pitch.

- **Advantages –** Most common digital mode on HF. Narrow bandwidth allows for dozens of signals in a given Khz. range. Extremely well suited for poor band conditions, QRP ops.

- **Disadvantages –** Has the 2nd slowest print rate of all digital modes. Not as efficient as RTTY in contests.

9. MT63

- MT63 uses 64 different modulated tones to transmit large amounts of data, offering superb impulse noise rejection and robust forward error correction capabilities.

- **Bandwidth** – 1-2 khz

- **Sounds Like –** Low pitch, hoarse *wrrau-wrau-wrau-wrau*

MT63 Trace

- **Advantages** – Offers incredibly fast data transmission speeds on HF bands, very hard for intermittent or static noise to affect data sent, easy to sync up once signal is found, often found packaged with multi-mode digital software

- **Disadvantages –** Seldom found on the bands, takes up a lot of bandwidth and tends to blanket other digital modes (causing much irritation to other hams), typically used only as a live operation mode

10. Olivia

- Olivia is technically another MFSK mode, but it uses 32 different tones over a larger bandwidth. This mode is much more robust, and therefore can be sent and received when band conditions are very poor, even being received when not audible to the human ear.

- **Bandwidth –** 250 hz, 500 hz, or 1 Khz

- **Sounds Like –** Yes, much like MFSK, this mode sounds like an insane flute solo, playing completely random notes, but more muffled.

- **Advantages –** Another great mode for DX and QRP operations. It combines the best strengths of MFSK with the weak signal capabilities of PSK31.

- **Disadvantages –** Fairly new mode (2005), not widely used yet. Wideband capabilities tend to infringe on other neighboring digital modes.

III. Station Setup and Operations

1. Equipment Required
2. Station Setup
3. Getting Started
4. Where to Find the Action

1. Equipment Required

a) **Computer** – Windows-compatible PC, Pentium 133 Mhz or faster (120 Mhz is okay for some PSK software), Windows 95 OS or greater, with soundcard, at least 1 serial or USB port (COM1), 1 audio line out, 1 audio line in (or microphone line). Will need internet access to download free software if none is available from the interface you purchase.
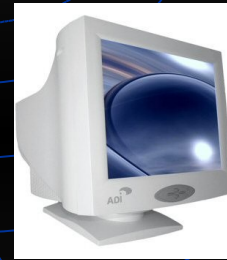
b) **Monitor** – (duh)

c) **HF Transceiver** – Any HF rig w/a digital read-out that goes down to the 1 hz range, OR any rig that is very stable. Most modern rigs have auxiliary jacks in the back. If not, you will at least need an audio output (external speaker) line and a microphone input line.

d) **Antenna** - (duh again)

1. Required Equipment (cont.)

e) **Soundcard Interface –** This can be homebrewed, but beginners should order a new interface from RIGblaster, MFJ, Rascal, etc. to start with. All interfaces use either a round or modular 8-pin hook-up to serve as the audio input and TX/RX keyer. Many interfaces have internal jumpers to allow you to properly wire up your interface to any modern HF rig. Also, most manufactured interfaces come with popular demo or free software for you to test. Cost for manufactured interfaces ranges from $30 to $150. If you only have USB ports, make sure to get a compatible interface that has USB connectors. Using serial-to-USB adapters have been known not to work.

f) **Software –** Many different software programs are available, but the most common ones are: MixW, DigiPan, and WinPSK. Some software are specific to one digital mode, while others offer multiple modes.
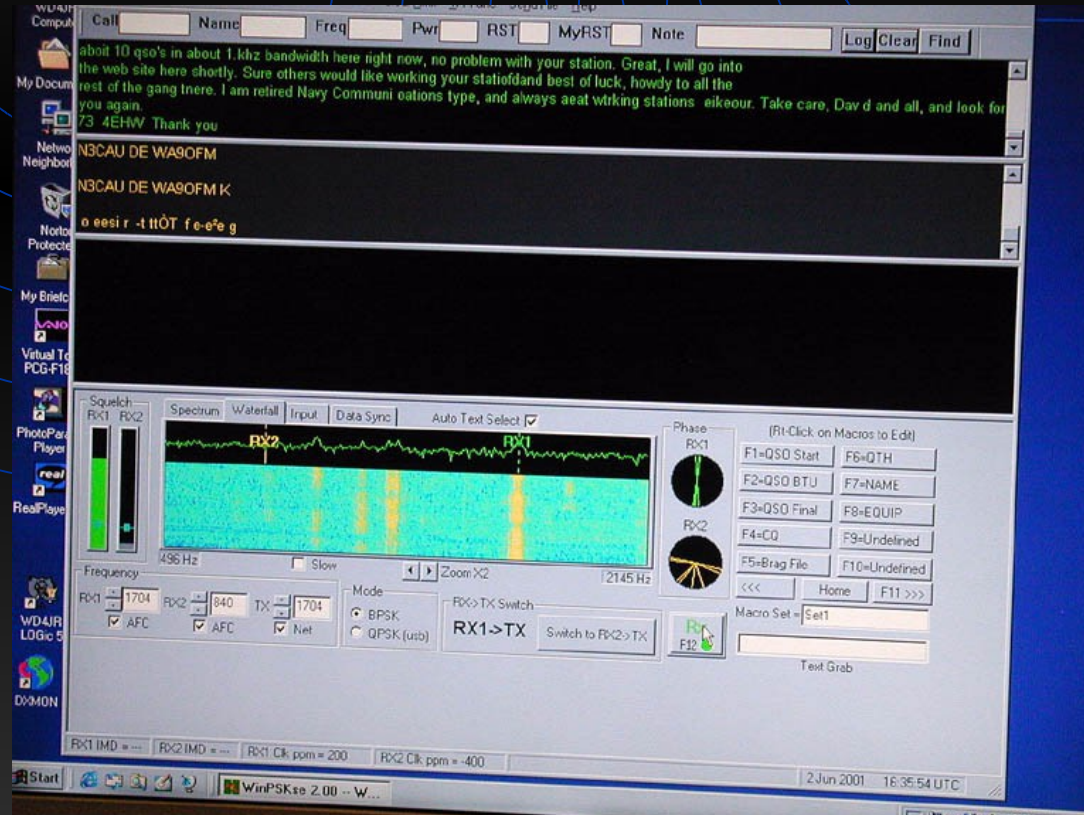
2. Station Setup

Trying to set up your HF digital station can be like hooking up your DVD or VCR to your entertainment system. Here are some basics to remember:

- **Computer Audio Line Out (or speaker output)** - Using a 1/8th inch jack line, hook this up from your PC Audio Out to your interface where it says "From Soundcard Audio Out." This is where your audio output from your PC runs thru the soundcard into your radio.

- **Computer Audio Line In (or microphone input)** - Using a 1/8th inch jack line, hook this up from your PC mic/audio input to your interface where it says "To Soundcard Audio In." This is the line where your audio output from your RADIO will go to your PC (thru the soundcard), thus allowing your software to interpret the signals received. OR, you can run this direct from the radio to your computer, but this is not recommended.

2. Station Setup (cont.)

- **Interface Audio Line Out** - Using a 1/8th inch jack line, hook this up from the interface to your radio, so that your radio audio will get back to the PC for the software to interpret the signal.

- **Interface Speaker Output Line** - This line will allow you to hook up an external speaker to monitor signals while in receive mode. Some will also allow you to monitor your audio output when transmitting.

- **Interface Ground** - Some interfaces allow you to ground the unit along w/all of your other equipment. But doing this may cause a ground loop when you transmit, so you should try operating without grounding the interface first.

2. Station Setup (cont.)

- **Interface Serial/USB Port Line** - This pre-wired line connects directly from your interface to your primary serial or USB port (or COM1) on your PC. The sole purpose of this line is to key up your radio to transmit/receive thru the interface when using your digital program software

- **Interface Microphone Line** - This pre-wired line connects directly to your radio via a round or modular 8-pin connector thru your microphone input. This is ultimately where your audio output from your computer goes through to reach the radio, and it is also the final step where your radio gets keyed up by the interface.
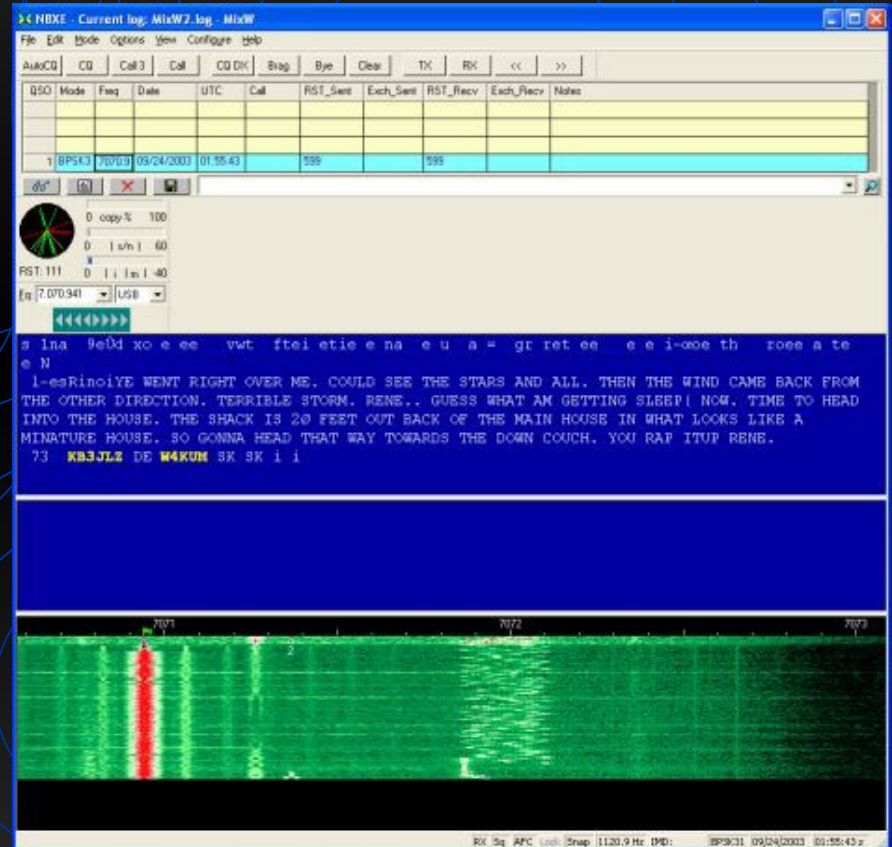
3. Getting Started

Once you have setup your equipment and have installed/configured your software, you can begin to operate on the air. Having a conversation in digital modes is very much like having a CW conversation.

Start by typing CQ CQ CQ de (YOUR CALLSIGN) a few times, then hit or click on the TX button on your software. When someone answers your call, reply back to them w/your name, QTH, and a basic signal report. Most software have RST signal readouts for you, but you can make your best guess this first time around. Make sure before you sign back over to the other station that you ask them to please evaluate your signal.

3. Getting Started (cont.)

A good PSK31 signal should appear on your screen as a very thin bluish-green line (or redish-yellow line) on your software "waterfall." If you see ghost images on either side of the signal, then that station is over-modulating. This is what the other station will be looking for when you ask them to evaluate your signal.

If you are over-modulating, then you need to either 1) cut back your power output, 2) reduce your mic gain, or 3) adjust your soundcard audio output on your PC. Your power output should always be 50% or less of your maximum output (anywhere from 20 to 40 watts).

3. Getting Started (cont.)
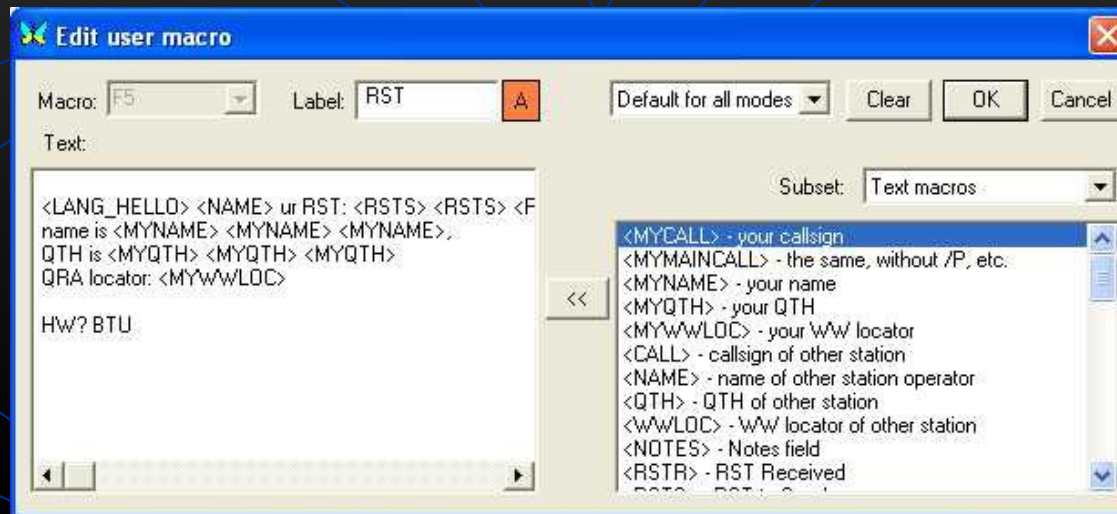
After you finish your 1st QSO, log your information (in your logging program or your paper log). Then, take a look at your **macro** buttons at the topic of your digital program. Macros allow you to pre-can standard QSO information (your CQ call, RST, name/QTH, a station "brag" file, etc.) so that all you have to do is click the macro and begin transmitting.

This is a tremendously useful feature, particularly for contest operations. But once the "formalities" are over, it's generally considered poor taste to use nothing but macros in your QSO. PSK31 is a live mode operation, so you should interact with your contact as you would any normal conversation.

4. **Where to Find the Action**

Here's where you will find most PSK31 activity on the HF bands:

- 10 Meters - 28.120 Mhz
- 15 Meters - 21.070 Mhz
- 20 Meters - 14.070 Mhz
- 40 Meters - 7.073 Mhz
- 80 Meters - 3.583 Mhz

4. Where to Find the Action (cont.)

Here are your typical frequency ranges to find all other digital communications on the HF bands:

- 10 Meters - 28.070 - 28.130 Mhz
- 12 Meters - 24.920 - 24.930 Mhz
- 15 Meters - 21.060 - 21.099 Mhz
- 17 Meters - 18.100 - 18.110 Mhz
- 20 Meters - 14.060 - 14.099 Mhz
- 30 Meters - 10.120 - 10.150 Mhz
- 40 Meters - 7.060 - 7.099 Mhz
- 80 Meters - 3.580 - 3.600 Mhz
- 160 Meters - 1.850 - 1.900 Mhz (???)

4. Where to Find the Action (cont.)

- 20 Meters (14.070) is where 95% of all digital activity takes place at any given time during daylight hours. Of that, most digital operations are using PSK31, but you will find MFSK and occasional Pactor a few kHz up or down from 14.070…just enough to be heard by other PSK31 operators looking to change modes. During the summer months, PSK31 signals can be heard after 12 midnight. RTTY activity is normally centered around 14.080.

- 40 Meters (7.073) is where most nighttime digital activity takes place. Again, it's mostly PSK31, but you will hear more MFSK signals here. This band typically opens around 5 PM and will stay open until about 2 hours after sundown. However, during the winter months, signals can linger after 12 midnight. During DX contests, RTTY will be very active from 7.040 to 7.070.

4. Where to Find the Action (cont.)

- 80 Meters is very much a winter-time band, normally opening up around sundown. PSK31 activity is very sparse on this band, but you can always expect 1 or 2 QSOs on any given night during Dec./Jan./Feb. Look for activity here particularly during digital contests.

- 15 Meters will occasionally have signals on the air around noon time. DX is surprisingly common on this band, mostly into the Caribbean and South America. Look 10 kHz up to catch some RTTY action as well, around 21.080.

- 10 Meters will seldom have digital activity, even when the band is open. Expect to use this band only during DX or digital contests

4. Where to Find the Action (cont.)

- PSK31 contests normally stay around the typical operating frequencies. So many signals can fit into 1 kHz that there normally is no need to go beyond the main freqs. However, RTTY contests will take place all over the entire standard sub-band.

- DX digital signals are normally found on 20 Meters, with the occasional operator on 15 Meters. PSK31 has supplanted RTTY for day-to-day DX operations. Fortunately, South American, Caribbean, and European stations have eagerly embraced PSK31, so finding them won't be hard. Russia has also quickly adopted this mode as well. The unspoken secret of PSK31 is that working DX is like shooting fish in a barrel…there's not much competition, and several countries are well represented by hams active on PSK31. The highest amount of "natural" DX will be available during the summer months on 20m.

IV. Hands-on Demonstration

Okay…enough talk.

Let's begin the demo.