

Introduction to ...

DIGITAL DATA MODES



George Heron, N2APB



30th Digital Communications Conference

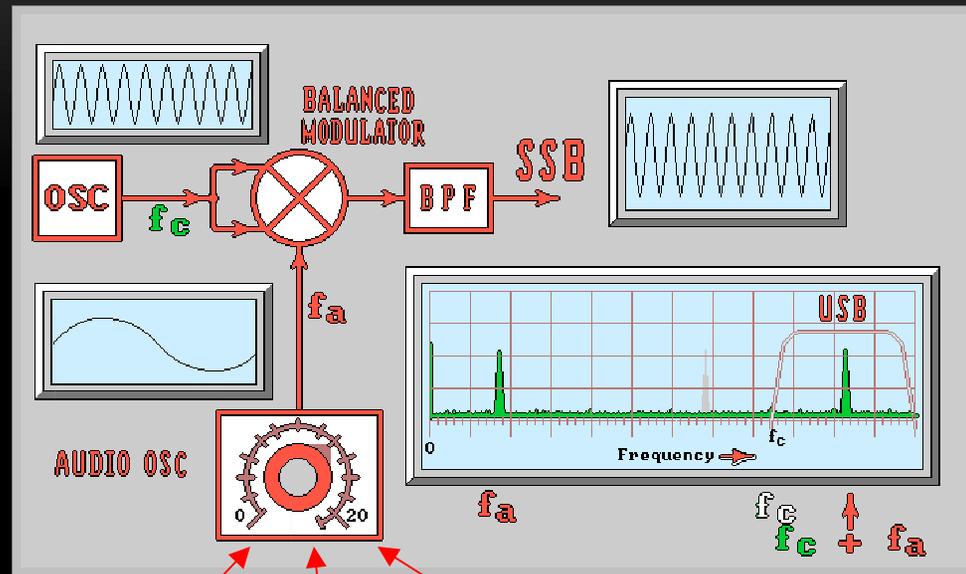
Sept 15, 2011

Baltimore, Maryland

WHAT WE'LL COVER

- So just what is “Digital Mode Communication?” ... *Modulation, Demodulation, then Tribulation!*
- Survey of some popular digital modes ... “What the heck are all those weird-sounding stations I hear as I tune around the bands?”
- Setting up your station for using the Digital Modes ... *SSB rig + Sound Card + PC + Software = A Brave New World*
- An alternative to that darned PC ... *Hardware-based, embedded digital modem!*
- So what's holding you back?!

WHAT IS DIGITAL COMMUNICATION?



Voice

Yada
Yada
Yada



CW

Tone ON
Tone OFF

Tones

1, 0, 1, 1, 1, 0, ...



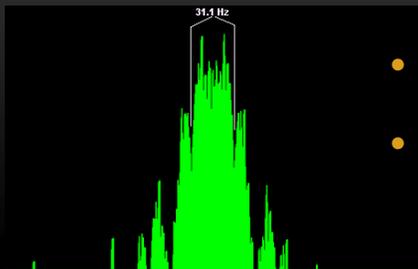
Digital

SO MANY MODES, SO LITTLE TIME



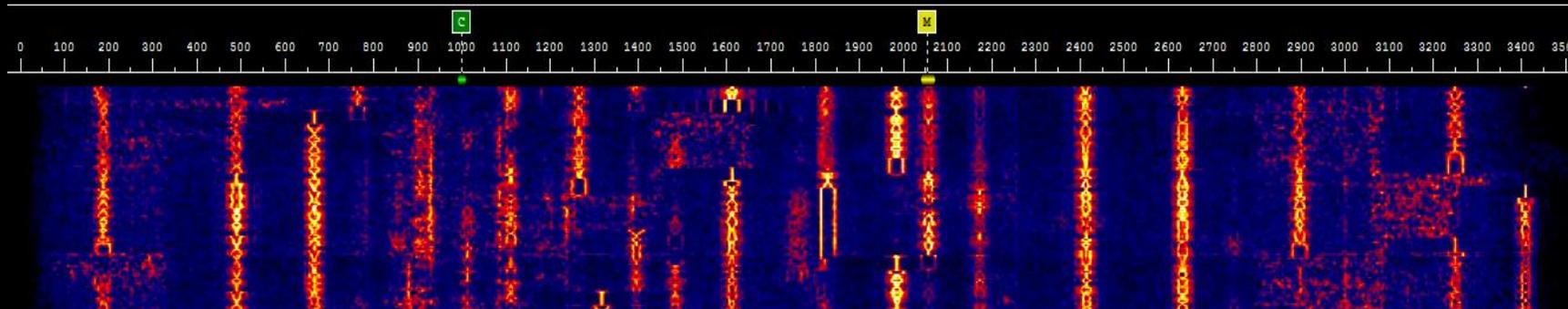
PSK31, PSK63, SSTV, HD SSTV, RTTY,
MFSK16, MFSK32, MT63, Hellschreiber,
Olivia, Packet, PACTOR, Throb,
Contestia, JT6M, Ham DRM, Domino,
DominoEX, DominoF, WSPR, ROS,
SITOR, SITOR-A, SITOR-B, Swedish
ARQ, Clover, CHIP, ALE, PAX, PAX-2,
STANAG, HFDL, NAVTEX, SYNOP,
COQUELET, AOR, WinDRM

PSK31



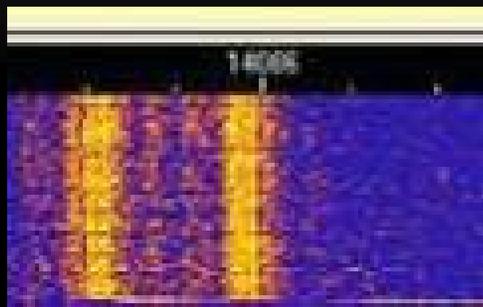
The Undisputed King!

- Debuted in 1999
- Most popular HF digital mode
- Heard near: 3.580, 7.070, 14.070, 21.070 MHz

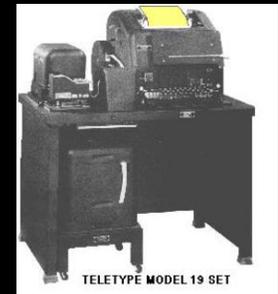


- “Phase Shift Keying” is the the most popular of the newer digital modes.
- Wealth of information on the web regarding BPSK (Binary PSK) and QPSK (Quadrature PSK)
- Because bandwidth only 31Hz, many signals can fit into the same bandwidth occupied by an SSB signal (2.4kHz approx.).
- Quite common to see 15 or more signals on a 2.5kHz waterfall display.

RTTY

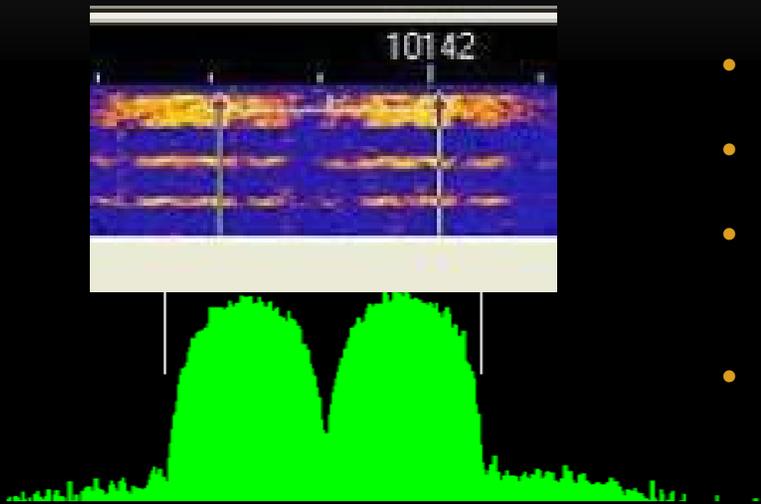


- One of the oldest HF digital modes—Hams began using it immediately after WW II.
- Most popular contest and DX mode.
- Heard near: 7.040, 14.090, 21.090 MHz



- Been around for many, many years and is still just as popular.
- Years ago the only way to get on RTTY was to use a mechanical terminal unit such as the Creed 7 series, which were big, noisy and messy.
- Today virtually all RTTY is done by the computer/soundcard combination.
- Hams use 45 baud (the speed) with 170Hz shift (between mark and space).
- Commercial stations use 50 or 100 baud with shifts of 425 or even 850Hz.
- Most software caters for differing speeds and shifts.
- Unlike most digital modes, RTTY is transmitted on LSB.

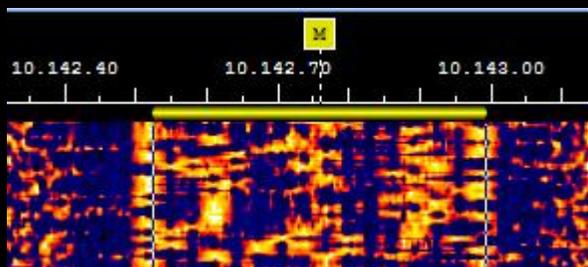
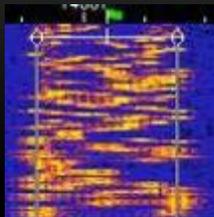
PACTOR



- Developed in 1991
- Three versions: 1, 2 and 3
- PACTOR 2 and 3 are the most popular today
- Error-free burst mode
- Used primarily to exchange data, such as in the Winlink 2000 system.
- 400 Hz bandwidth ... ~ 2x 100 baud PSK

- HF mailboxes use PACTOR to forward messages to users.
- Lots of bad press recently, mainly due to the actions of a few inconsiderate operators who are apparently causing interference deliberately to existing users of the digital sub bands.
- Because it uses error correction, it can take quite a time to send a message particularly over a less than perfect path—but the transmitting station will keep trying until the message is received perfectly.

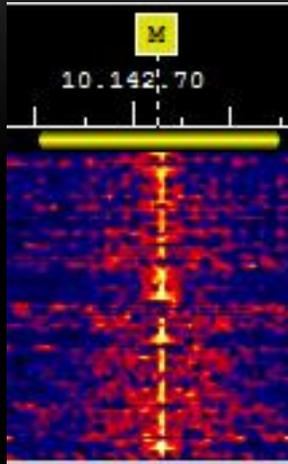
MFSK16



- Introduced in 2000 by IZ8BLY
- Uses 16 tones
- Good performance in poor signal conditions
- Heard near 14.080 MHz

- Usual variant is MFSK 16, but other types such as MFSK 8.
- MFSK is sideband dependent ... must have receiver set to the correct sideband in order to decode it properly.
- Tuning is quite critical, although AFC helps somewhat.
- Top image is of an MFSK16 signal and the lower image is of an MFSK32 signal (which is nearly 500Hz wide, twice as wide as an MFSK16 signal).

HELLSCHREIBER

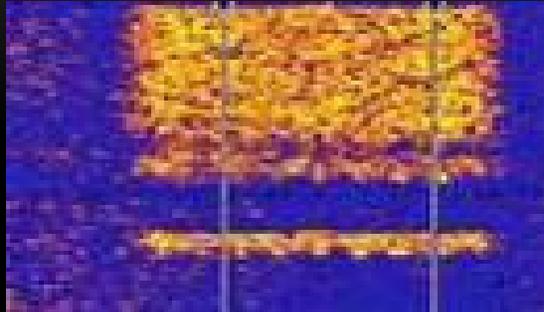


- Oldest digital mode; created in 1929
- Fax-type mode where text is “painted” on the screen for direct reading—not decoded by software.
- Heard between 14.075 and 14.080 MHz

```
CALL UR RST 579 579 QSB NAME  
CALL UR RST 579 579 QSB NAME  
R HAMBURG QRA JD53AR JD53AR  
R HAMBURG QRA JD53AR JD53AR
```

- Your eyes do the filtering!
- Decoded text displayed on a ‘ticker tape’ display.
- Very distinctive ‘grating’ sound and is a narrow band mode.
- Even weak signals can be decoded as your eye/brain combination can ‘fill in the blanks’ where the signal fades.

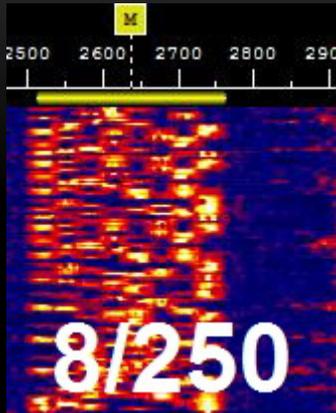
PACKET



- Declining popularity, but still heard
- Used for message forwarding, APRS and some “live” keyboard-to-keyboard QSOs.
- HF forwarding heard near 14.095 MHz
- APRS near 10.150 MHz
- Live QSOs at 14.105 MHz

- HF mailboxes etc. use packet to forward messages to users.
- Usual data rate on HF is 300 baud, with 1200 and 9600 baud being common place at VHF and UHF.
- Picture shows a mailbox/BBS in Turkey negotiating with a BBS in the UK.
- Short burst at the bottom of the picture is header and call sign information.
- Longer burst is the actual data.
- Packet BBS/mailboxes can be heard chirping around 14.1MHz.

OLIVIA



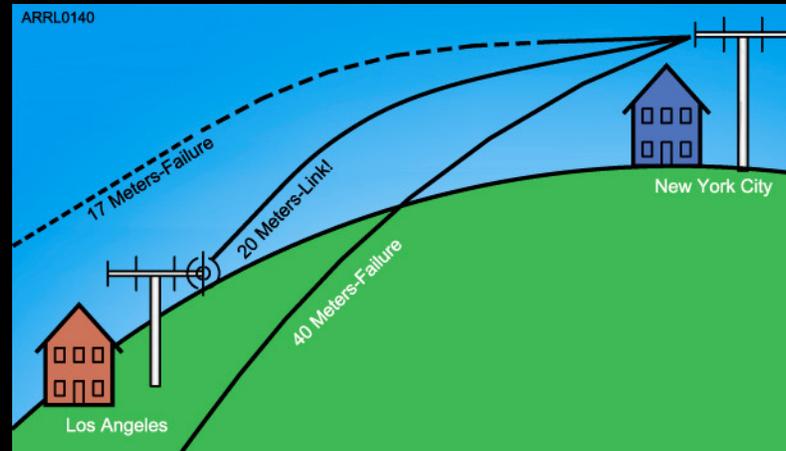
- New HF digital mode introduced in 2005
- Selectable bandwidth
- Heard between 14.105 and 14.109 MHz

8 tones over a 250Hz bandwidth

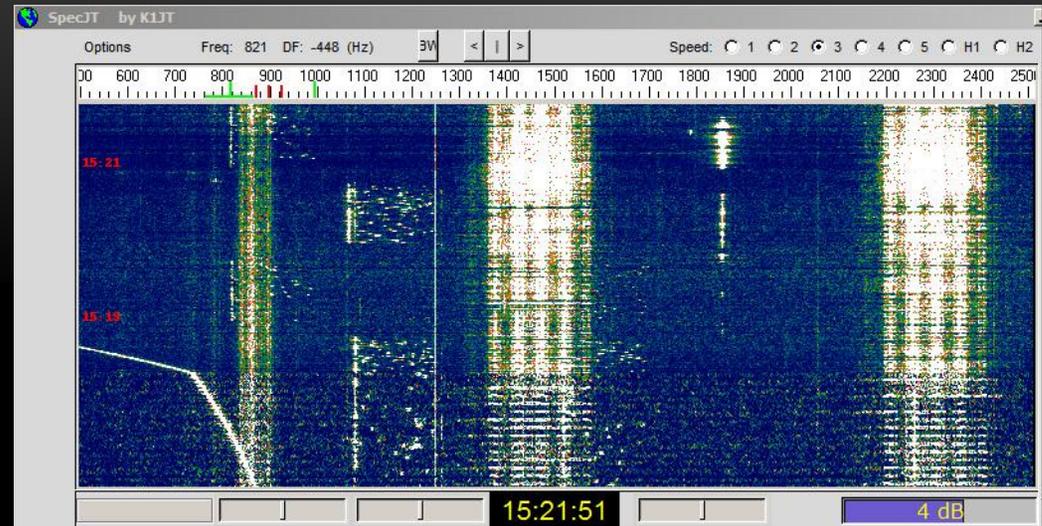
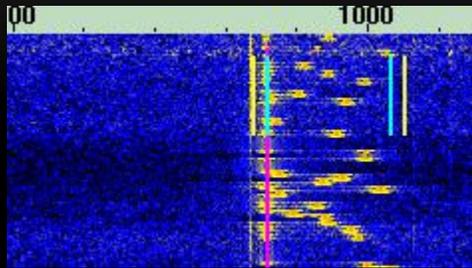
- Extremely resistant to fading and QRM.
- Can get full copy on stations that are barely audible ... even ones that fade down to almost zero seem to still print well.
- Has different variants each having a different bandwidth (from 500Hz to 2kHz) and different number of tones.
- Can be very slow (2-3 characters per second) but a slow contact is better than none at all!
- To avoid interference to other stations is it usual to start an Olivia transmission on a full kHz (i.e. 14.108.0 rather than 14.108.3 for instance).

ALE

- Automatic Link Establishment
 - Automatically determines the best band for communication between two stations.
 - Will alert operators when path is determined
-
- Now finding more use in amateur circles, thanks to the efforts of the writers of some of the multimode decoders, such as MultiPSK.
 - When running correctly, can initiate and establish connections between two stations without human intervention (hence the 'Automatic' part.)



JT65



- Developed originally as part of the WSJT weak signal modes software package by Joe K1JT.
- Can also be decoded by other packages, such as MultiPSK.
- Has found a use on HF and can be found around 14.076MHz and 21.076MHz amongst others.
- Signals that are virtually inaudible can give perfect copy so its performance is excellent on the noisy HF bands.
- Transfer rate is slow, as are most modes that excel in low signal decoding.

DESIGNING AN HF DIGITAL STATION

- With the exception of PACTOR and AOR digital voice, all other amateur HF digital modes are sound-card based.
- The sound card advantage: Once you've wired your station for one HF mode, you can work another by just selecting a different mode in the software.



SSB transceiver



A (good) Sound Card
(An external USB sound card is most flexible)



Software:
- FLDIGI, ...

A (fast) PC

THE COMPUTER

- For *Windows XP*, should be at least a 500 MHz Pentium. Ditto for *Linux*. For *Windows Vista*, invest in a 1 GHz machine
- For Macs, a modern iMac
- Of course, faster is always better!
- Don't rely on the built-in sound card ... use an external USB sound card *



* If you use a desktop workstation, an internal high-performance sound card PCB may easily be used (M-Audio, etc.).

THE SOUND CARD

- The heart of your HF digital station
- Converts received audio to data
- Converts data to transmit audio
- Stereo, if you wish to do SDR with I & Q channels
- Connects to PC over USB
- Higher sampling rates are better (e.g., 24-bit, 96 kHz or better)

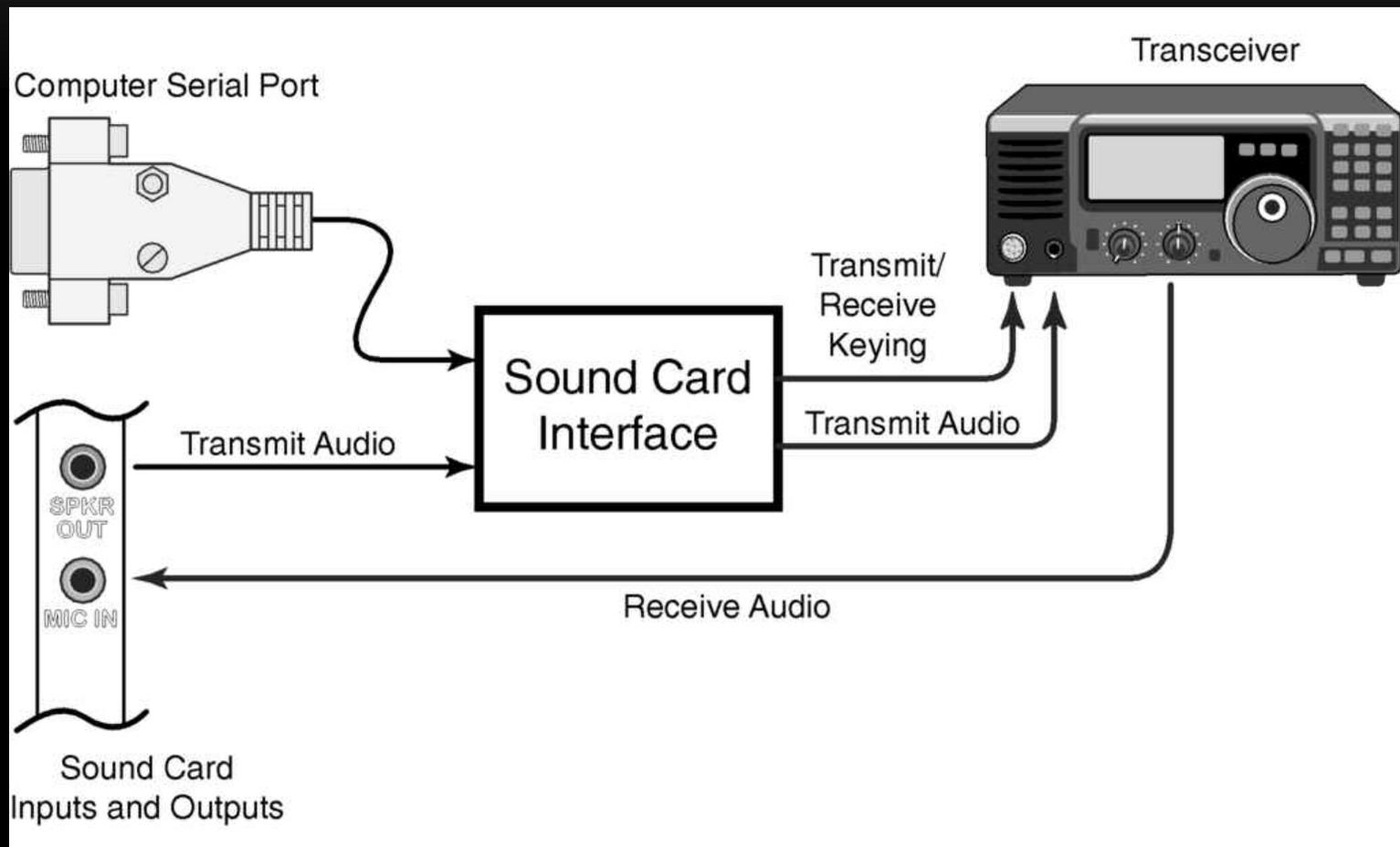


<http://us.store.creative.com/Creative-Sound-Blaster-XFi-Surround-5.1/M/B0044DEDCA.htm>

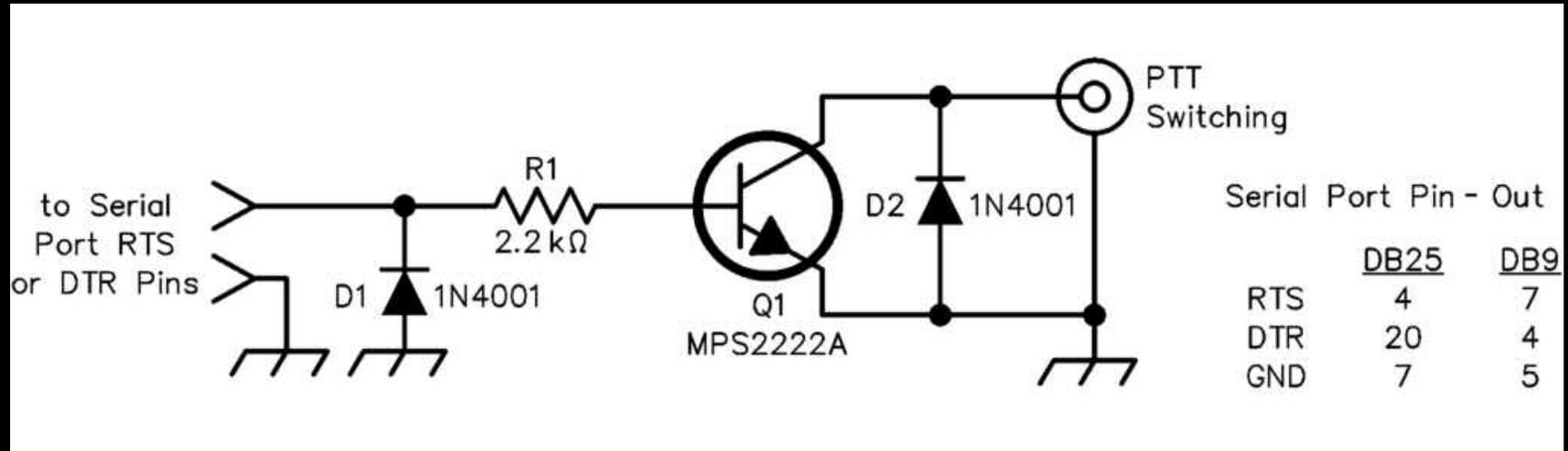
EXTERNAL SOUND CARDS & INTERFCES MADE BY MFJ, TIGERTRONICS, WEST MOUNTAIN RADIO AND OTHERS



MEET THE SOUND CARD INTERFACE



YOU CAN ALSO MAKE YOUR OWN INTERFACE



FLDIGI

Logbook - logbook.adi

Date / Time	On	Off	Call	Name	Freq.	Mode	In	Out
20081208	1109	1139	WA4KBD	Bill	3.581536	PSK31		
Qth		St	Pr	Country	Loc	Tx Power	QSL-rcvd	
OALS, AL, USA		Loc EM						
Comment		IOTA		QSL-sent				
Request sent to		DXCC		Call Search				
qrz.com...				WA4KBD				
Ser# out	Ser# in	Xchg #1	Xchg #2	Xchg #3				
Recs	1413	New	Update	Delete				
Date	Time	Callsign	Name	Frequency	Mode			
20081231	0303	N0NB	Nate	3.584000	OLIVIA			
20081229	1421	N2PSH	Dave	7.070882	PSK31			
20081228	2152	K1EPT	George	7.071785	PSK31			
20081227	0346	W6JVE	Jim	3.583250	MFSK16			
20081227	0338	N0NB	Nate	3.583245	MFSK16			
20081227	0108	N5MNX	JJ	7.070748	PSK125			
20081227	0102	KD8BIN	John	7.071602	PSK31			
20081226	2152	N9FDF	Toby	7.072727	MFSK16			

Event log

Log sources: Warning

0: main: fldigi 3.1preC log started on Thu Jan 15 05:41:20 2009

Scope

fldigi - W1HKJ

Rig Control - FT-450

3580.000

QSO Freq On Off Call Name In Out Comment

3581.492 1142 1146 WA4KBD WILLIAM

DATA QTH MUSCLE SHOALS St AL Pr Cnty USA Loc EM64et Az 264

I do hospital administration here as a second full-time career...the change has been good for me...no more intense night and weekend call....did h internae med thing here for 30 years....went this new roste in 2004...even made it to Daaton the past two years in a row...better life overall.

BTU Rick - VE3FMC de WA4KBD K WA4KBD de VE3FMC
Well maybe Obama can straighten out this weather hi hi
He is sure going to have his hands full once he takes over. I hope he succeeds in his mission.
Yes you are right about DX on PSK.
Much like years ago when RTTY DX was fun and easy to work
I have also tried Olivia, which seems to work even better in nosiy conditions.

Myself, I am retired.

3580.5 3581.0 3581.5 3582.0 3582.5

WF 0 60 x1 NORM 1492 QSY Store Lk Rv T/R

BPSK31 s/h 17 dB imd -30 dB AFC SQL

DIGIPAN

WM2U - DigiPan

File Edit Clear Mode Options View Channel Lock Configure Help

CQ 2 de 1 Ernie BTU CQ DX QRZ loc:10x Brag T/R Clear 070 Club internet ^

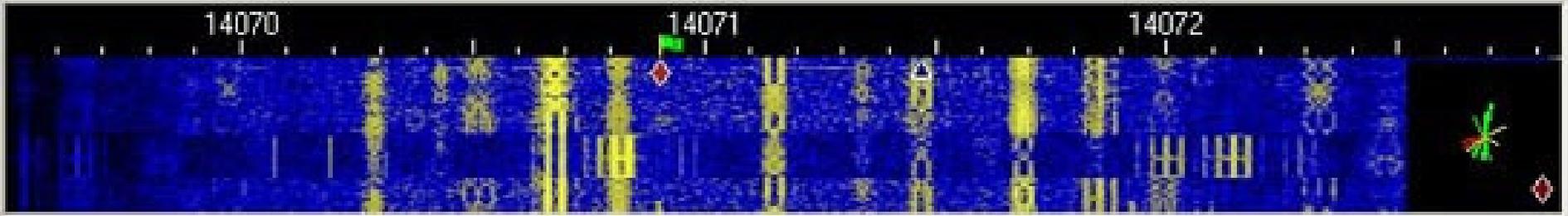
Call	Name	QTH	Rec'd	Sent	Band	Notes
DJ8RP	Harald	Germany	599	599	20m	

NAME is Harald Harald and
my QTH is Moenchweiler JN48FC Moenchweiler JN48FC
south west DL, near the boe der to FRANCE and SWISS.
BTU Ernie, WM2U DE DJ8RP pse K Ke o ee

KK5LQ DE KA5FJA Ke oeeelca tael leat yol with the beaest seAe. You are pretty wide on the signabut I
thought it was the distance that was tte cause. BTU KA5FJA DE KK5LQ loes, eOK...I'mt tunning

DJ8RP de WM2U hello name here is Ernie Ernie. QTH is Ballston Lake, NY. Saratoga County. loc: FN32cv.
10x 54583. □so btu DJ8RP DE WM2U@

DJ8RP de WM2U hello Harald good to cu in new York today. ur 599 599 and sigs look excellent.



* DJ8RP (Harald) TX RX: 1402.6 Hz Swap IMD: Sq AFC Snap BPSK 02/24/2001 18:14:42 z

BUT YOU DON'T NECESSARILY NEED A COMPUTER, SOUND CARD OR SOFTWARE!

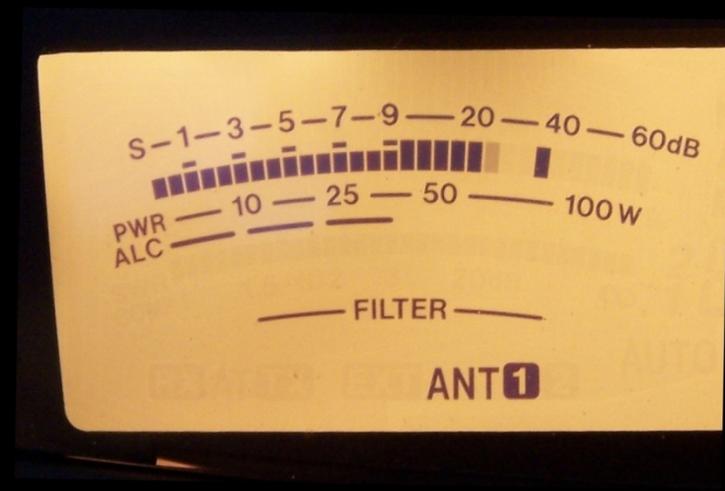
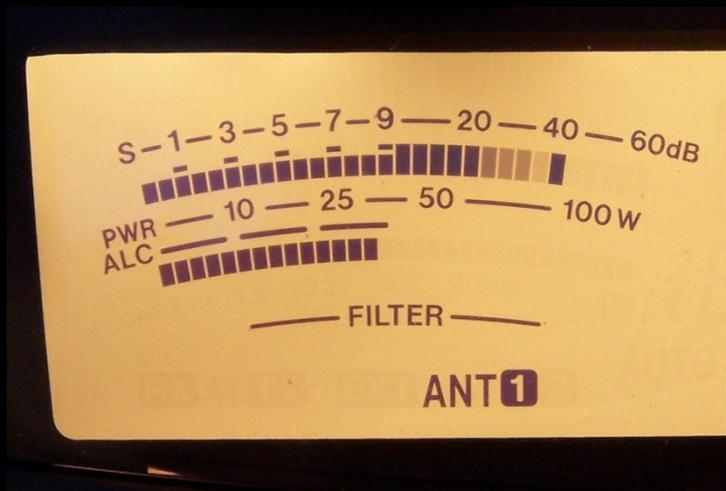
- NUE-PSK combines everything into a single battery operated device.
- PSK31, RTTY and CW now ... more modes late



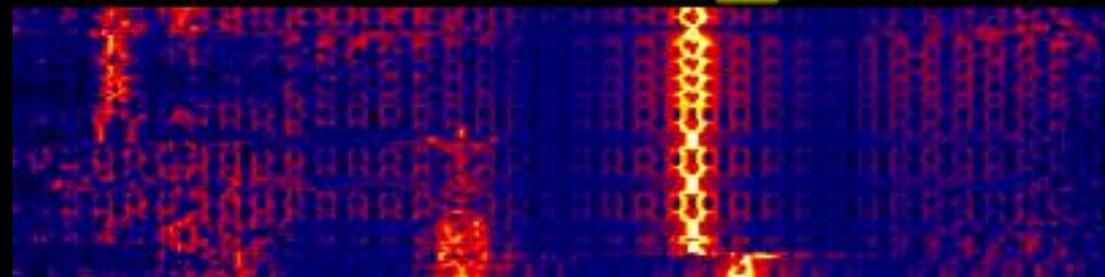
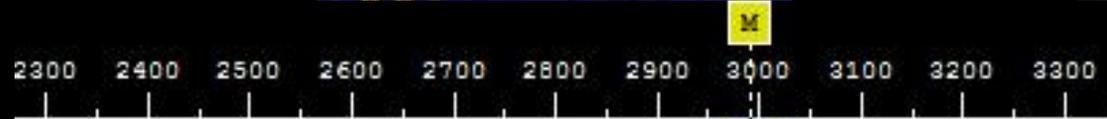
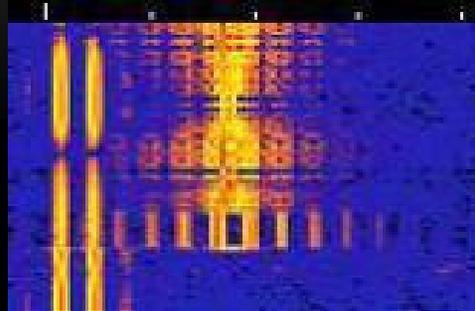
*“We don’t need
no stinkin’ PC!”*

BE CAREFUL WITH AUDIO LEVELS

- Too much transmit audio will distort your signal, especially with PSK31.
- Increase the sound output from your computer or interface until you see ALC activity, then reduce ALC to zero.



THE WORST PSK31 SIGNALS ... *EVER!*

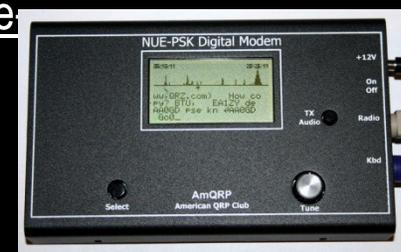
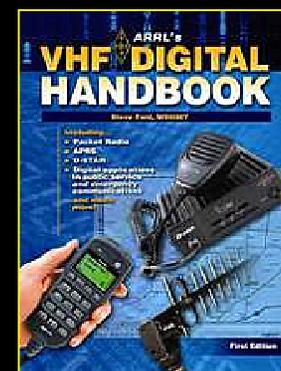
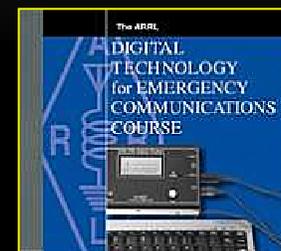
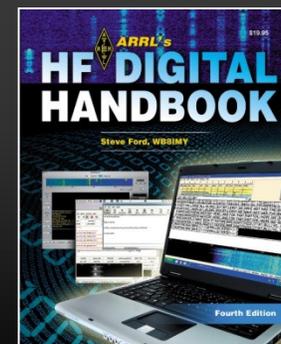


SO WHAT'S STOPPING YOU?!

- Join the thousands of hams using digital modes daily
- Another way to provide help in emergency communication situations
- Expand your own horizons with new opportunities: Digital contests, awards, ragchewing, swap nets, EmComm,
- Help to push the technology envelope by using one of the emerging modes
- More fun than sitting all night doing email, Facebook or Internet surfing

REFERENCES

- **ARRL HF Digital Handbook, 4th Edition** ... Available on-line at ... <http://www.arrl.org/shop/ARRL-s-HF-Digital-Handbook/>
- **Digital Technology For Emergency Communications Course** ... <http://www.arrl.org/shop/ARRL-Digital-Technology-for-Emergency-Communications-Course/>
- **VHF Digital Handbook** ... <http://www.arrl.org/shop/ARRL-s-VHF-Digital-Handbook/>
- **G4UCJ website** ... http://www.hfradio.org.uk/html/digital_modes.html
- **Steve Ford, WB8IMY** ... Inspiration, championing and contributions to this presentation
- **NUE-PSK Digital Modem** ... *"We don't need no stinkin' PC!"* ... <http://www.nuepsk.com> (W8NUE, N2APB, AD7JT)
- **FLDIGI** ... <http://www.w1hkj.com/download.html>



THANKS, AND HAVE FUN!



George Heron, N2APB
2419 Feather Mae Ct
Forest Hill, MD 21050

[n2apb@MidnightDesignSolutions.co](mailto:n2apb@MidnightDesignSolutions.com)

[m](mailto:n2apb@MidnightDesignSolutions.com)