An Introduction to PSK31

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What is PSK31?

- PSK31 is a digital mode ideally suited for use in the HF bands.
- The “PSK” means **P**hase **S**hift **K**eying.
- “31” means **31**.5 baud.
- PSK31 rivals the weak-signal performance of CW, and is a *vast* improvement over RTTY. The bandwidth of a proper PSK31 signal is only 31 Hz – narrower than the average CW signal!!!

Overview of the Presentation

- The origins of PSK31
- What you need to use PSK31
- How to setup a PSK31 station
- Operating a PSK31 station
- The technical side of PSK31
- Where to get more information
- Demonstration

The Origins of PSK31

- PSK31 was developed by Peter Martinez, G3PLX, who also created AMTOR.
- He wanted a robust weak-signal mode that used very little bandwidth.
- Originally (in the mid-’90s) PSK31 required DSP (**D**igital **S**ignal **P**rocessing) development hardware, but now it only requires a typical PC sound card.

What's Needed for a PSK31 Station?

- [1] Almost any SSB HF transceiver; high power isn't required!
- [2] A PC with at least a 16-bit sound card
- [3] Appropriate PC to transceiver cables or interfaces
- [4] Appropriate software

[1] SSB HF Transceiver

- Almost any HF transceiver will be suitable for use with PSK31.
- High power output isn't required; 5 to 50 watts will usually work well.
- What is important is frequency stability.
- Connections:
  - [a] Audio output
  - [b] Audio (microphone) input
  - [c] Push to talk (optional, but very convenient)

HF Transceiver: Audio Output

- Ideally the rig will have an audio “line out” jack (usually an RCA phono jack) that supplied audio with a constant level (that is independent of the AF gain control).
- If no “line out” is available, then speaker output or headphone output can be used (with isolation and/or attenuation).

HF Transceiver: Audio Input

- In most cases, the PC's sound card output (e.g. "line out" or "speaker out") is connected to the microphone input of the transceiver.
- In most cases, some attenuation and/or isolation is be required.

HF Transceiver: Push To Talk

- A push-to-talk input is almost universal on HF transceivers, but its use isn't required to PSK31 – although it's certainly convenient.
- The transceiver's VOX control can also be used, but this isn't the best scheme.
- If you don't configure the push-to-talk connection to your PC or use VOX, then you'll need to manually control transmit/receive switching on the PC and the transceiver; switch to transmit on the transceiver before switching the PC software to transmit.

[2] PC with 16-bit Sound Card

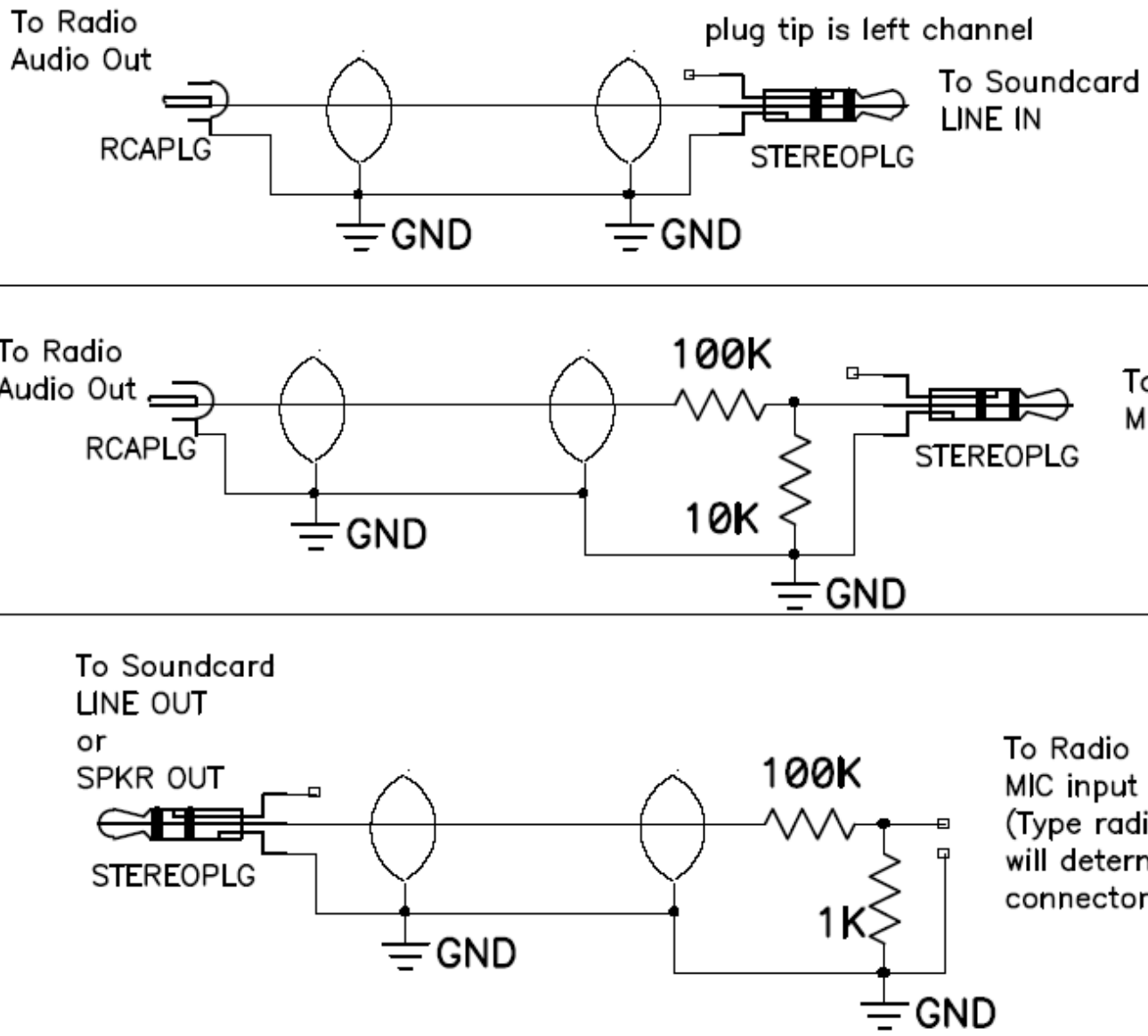
- In general, the faster the PC, the better – some of the PSK31 applications do lots of work.
- Almost all of the available software is designed for Intel x86 (IA32) processors, although source code for some software is available and can be (easily?) ported to other processors.
- Sometime the simpler (cheaper) sound cards are better for PSK31 than the “higher-priced spread.”

[3] Appropriate Cables/Interfaces

- Obviously, the particular connectors used for the cables depend on your transceiver.
- The PC sound card cables almost always use 3.5 mm stereo plugs.
- Transceiver “line out” and PTT jacks frequently accept RCA phono plugs.

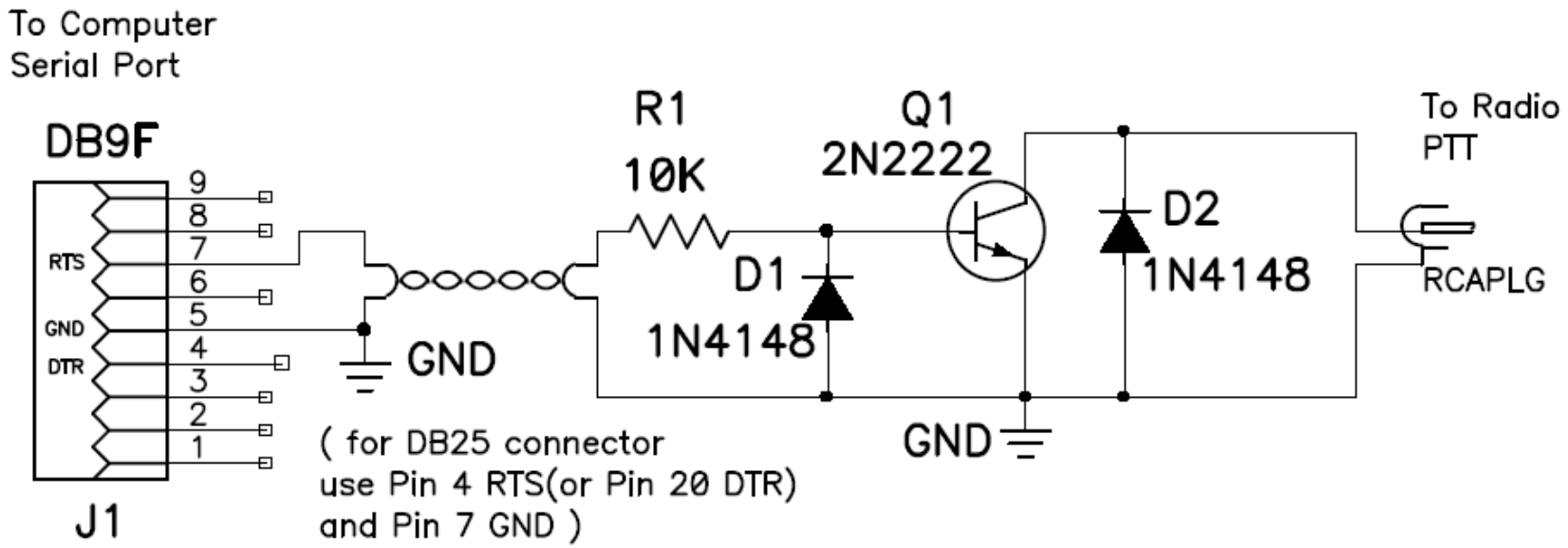
Attenuation and Isolation

- Attenuation can be used, for example, to drop a high-level (e.g. speaker) output to the level required for a sound-card microphone input. A pair of fixed resistors, or a fixed resistor and a potentiometer can be used for this purpose.
- Isolation is easily accomplished with a 1:1 audio transformer for sound card line out to mic in, or a 8 Ω to 1K Ω transformer for speaker out to line in. This helps prevent hum and ground loops.


To Radio
Audio Out
RCAPLG
GND
plug tip is left channel
To Soundcard
LINE IN
STEREOPLG
GND
To Radio
Audio Out
RCAPLG
GND
100K
10K
GND
To Soundcard
MIC IN
STEREOPLG
To Soundcard
LINE OUT
or
SPKR OUT
STEREOPLG
GND
100K
1K
GND
To Radio
MIC input
(Type radio
will determine
connector)

The Push-To-Talk Interface

- Most PSK31 software will use the RTS (or DTR) signal of a PC's serial port to control transmit/receive switching. Unfortunately, that signal is RS232-compatible (that is, ±12 volts), and the PTT input of a transceiver expects a TTL signal (0v/5v).
- The following circuit (and others) can be used to connect the RTS (or DTR) signal to the PTT signal.


To Computer
Serial Port
DB9F
9
8
7
6
5
4
3
2
1
RTS
GND
DTR
J1
GND
(for DB25 connector
use Pin 4 RTS(or Pin 20 DTR)
and Pin 7 GND)
R1
10K
D1
1N4148
Q1
2N2222
GND
D2
1N4148
To Radio
PTT
RCAPLG

[4] Appropriate Software

- A variety of software is available, but two popular programs are DigiPan and WinPSK.
- DigiPan is the first program to introduce the “waterfall” display which is almost indispensable for tuning (demo later).
- Software is available for Windows and Linux.

Setting Up Your Station

- Set up your HF transceiver
- Set up your PC
- Set up the PC to transceiver cables
- Configure the software
- Adjust signal levels as appropriate

PC to Transceiver Signal Level

- If the audio signal to the transceiver is too large, overmodulation will result, and the signal's bandwidth will be (perhaps much) larger than 31 Hz – operators using adjacent frequencies will not be happy!
- Unless you've got an ALC indicator (to show when audio limiting is taking place), or can monitor your RF signal on an oscilloscope, you must ask someone to evaluate your on-the-air signal.
- (Even ALC monitoring may not be fail-safe, since some transceivers will not activate ALC even if the signal is splattering.)

Transceiver to PC Signal Level

- It is much easier to verify an appropriate level for the signal from the transceiver to the PC.
- In WinPSK, click on the “Input” tab to view the actual input signal.
  - If you see only a flat line, the signal is too low (or not present).
  - If the signal is too high, it will be shown in red (it’s normally displayed in green).
- In DigiPan, adjust the input level so the waterfall appears with a speckled blue background.

Operating a PSK31 Station - 1

- The first steps in using PSK31 (or any new mode) are listen, listen, and then listen!
- Realizing PSK31 isn't error free, you'll probably want to send important information several times (such as your name or call).
- Most software expects you to configure certain personal information, like your call, name, QTH, and so forth. These are placed in "macros" that can be sent by pressing a key.

Operating a PSK31 Station - 2

- Remember that tuning is critical, but not extremely difficult with current software. Left click the mouse on what looks like a signal, or using the scanning features of the software to seek out a likely signal.
- To call a station, just switch to transmit mode (T/R or F9 on DigiPan, or F12 on WinPSK) and type. Don’t forget to switch back to receive mode after sending!

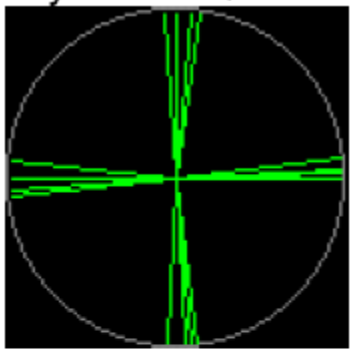
Operating a PSK31 Station - 3

- Both WinPSK and DigiPan have a “mini-vector” display to aid in identifying signals and tuning.
- A perfectly-tuned BPSK signal is almost vertical.
- A perfectly-tuned QPSK signal looks like a “+” sign.

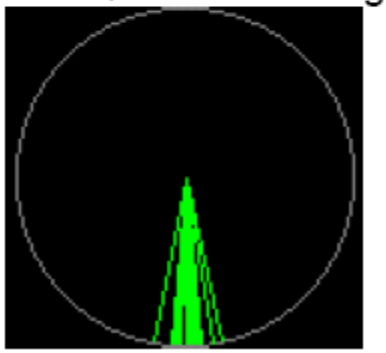
Mini-Vector Display Examples

Properly tuned BPSK Signal.

Properly Tuned QPSK Signal



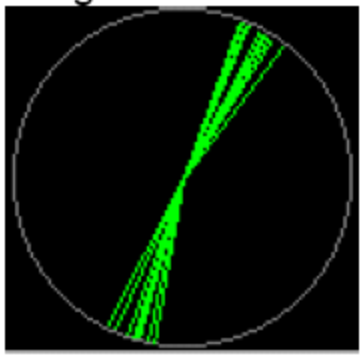
BPSK or QPSK "idle" Signal.



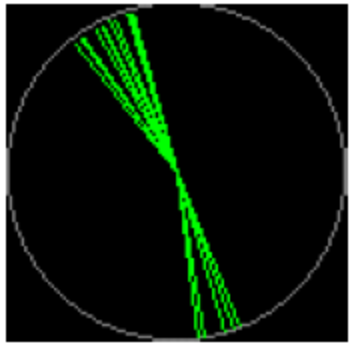
Un-modulated carrier

Mini-Vector Display Examples

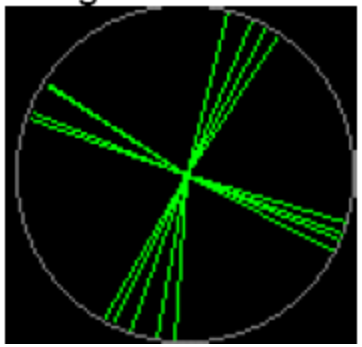
BPSK Signal too low in frequency.



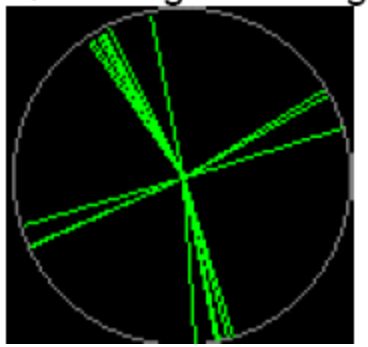
BPSK Signal too high in frequency.



QPSK Signal too low in frequency.



QPSK Signal too high in frequency.



What Does PSK31 Actually Send?

- If you're familiar with RTTY or with typical encoding of characters for computer use, you know that each character has a fixed length, or number of bits.
- For example, in RTTY, an "A" is sent as 00011, and a "B" is sent as 11001; every character occupies exactly 5 bits.

PSK31 Coding (called “Varicode”)

- PSK31’s designer knew about variable-length codes (like Huffman codes), and assigned shorter bit sequences to more frequently-used characters.
- For example, “a” has the code 1011, and “b” has the code 1011111; “b” takes 75% longer to send than “a”. Heavily-used “e” has the code 11.

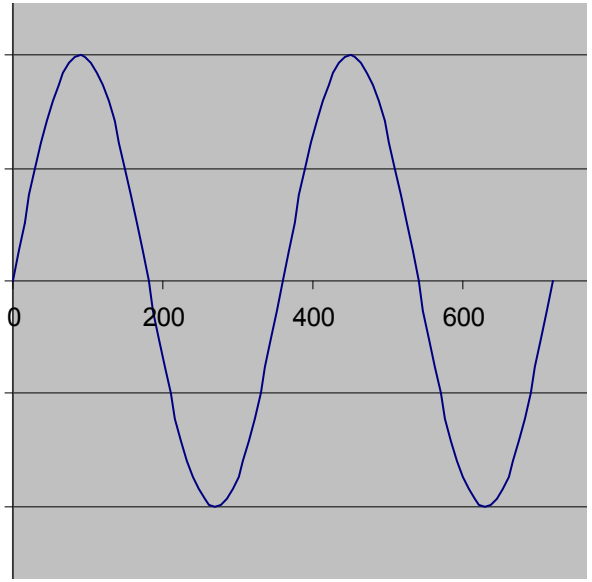
Where Does One Character End and the Next One Begin?

- Obviously there's got to be something "between" characters to separate them.
- In Morse code, for example, we leave extra space between letters so a "U" doesn't sound like "IT". RTTY uses start and stop pulses.
- In PSK31, each character is followed by two 0 bits. The code is constructed so two consecutive 0 bits never appear in a letter.

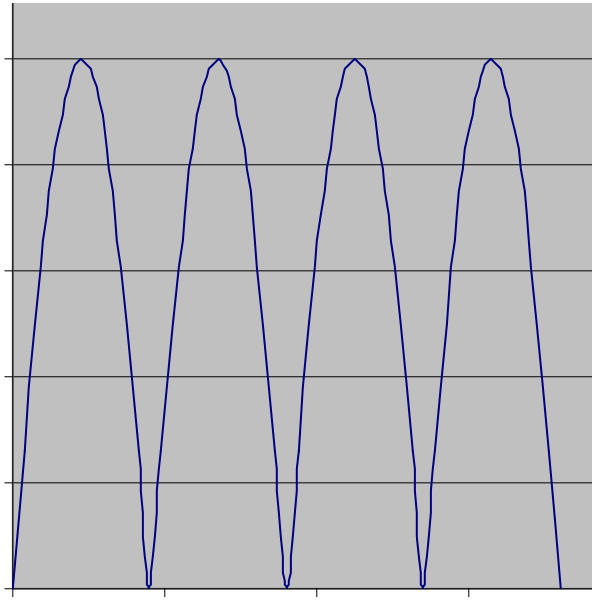
So What About PHASE SHIFT?

- RTTY actually uses two tones for 1 and 0 bits (2125 and 2295 HZ for a 170 HZ shift, or 2125 and 2325 HZ for a 200 HZ shift.
- PSK uses only a single tone (frequency), but varies the phase of that tone by 180 degrees for a 0 bit, and not at all for a 1 bit.

Three Ones…



Three Zeroes…



What is QPSK?

- Original PSK31 is actually “BPSK”, for **B**inary **P**hase **S**hift **K**eying, because there are only two possible signal states.
- QPSK is **Q**uaternary **P**hase **S**hift **K**eying, which has a second carrier 90 degrees out of phase with the first, giving a 3-dB signal to noise penalty.
- QPSK normally gives 100% copy, but tuning is twice as critical (~ 4 Hz accuracy!)

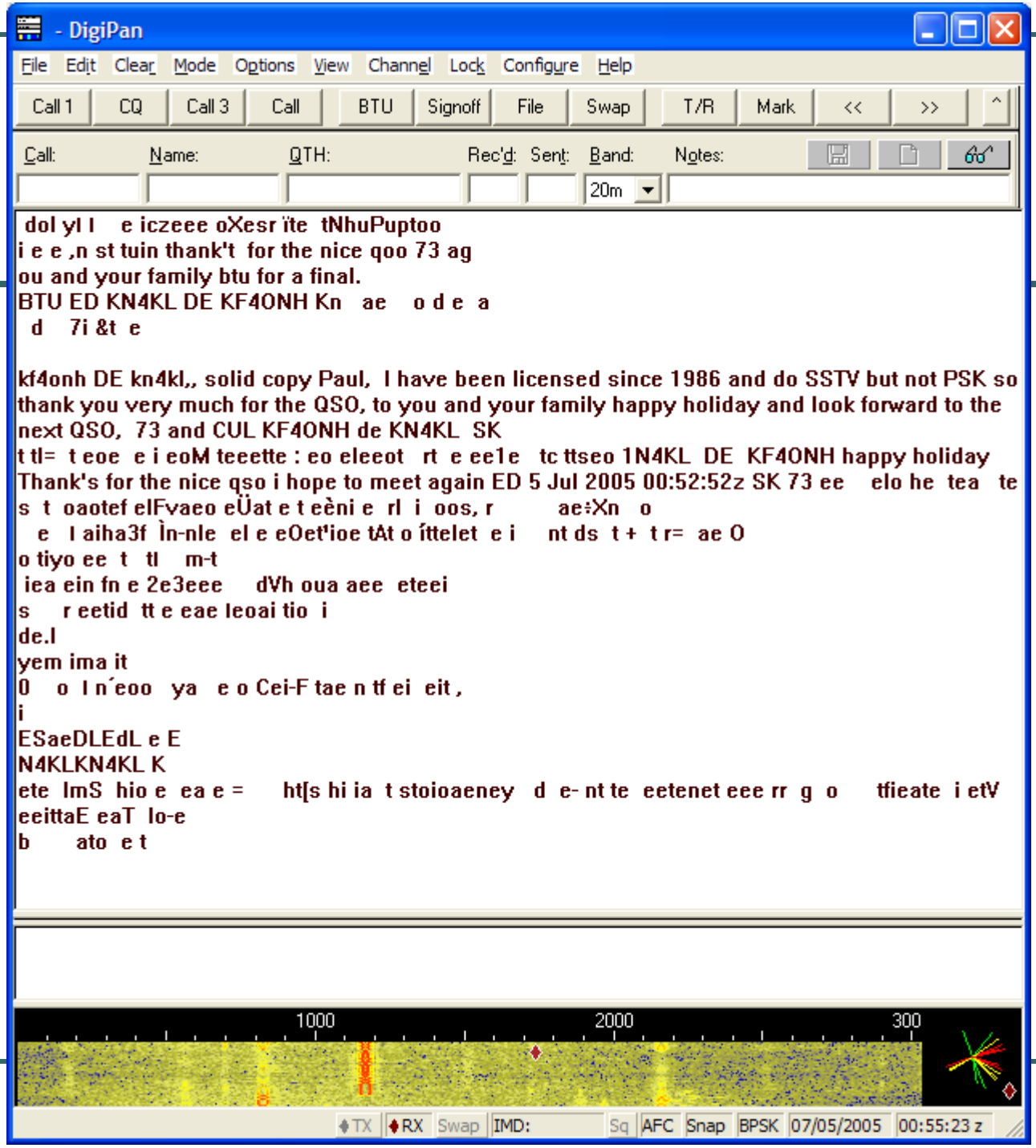
Popular HF Digital Frequencies

Band	Frequencies (MHz)
10 meters	28.070—28.130
12 meters	24.920—24.930
15 meters	21.060—21.099
17 meters	18.100—18.110
20 meters	14.060—14.099
30 meters	10.120—10.150
40 meters	7.060—7.099
80 meters	3.580—3.640

References

- Steve Ford, ARRL HF Digital Handbook, © 2001, American Radio Relay League
- packetradio.com – contrary to its name, this site has good information on PSK31, including more details on transceiver-sound card interfacing.
- psk31.com
- smallwonderlabs.com
- aintel.bi.ehu.es/psk31.html

DigiPan Examples


- DigiPan
File Edit Clear Mode Options View Channel Lock Configure Help
Call 1 CQ Call 3 Call BTU Signoff File Swap T/R Mark << >>
Call: Name: QTH: Rec'd: Sent: Band: Notes:
20m
dol yl l e iczeee oXesr ïte tNhuPuptoo
i e e ,n st tuin thank't for the nice qoo 73 ag
ou and your family btu for a final.
BTU ED KN4KL DE KF4ONH Kn ae o d e a
d 7i &t e
kf4onh DE kn4kl,, solid copy Paul, I have been licensed since 1986 and do SSTV but not PSK so thank you very much for the QSO, to you and your family happy holiday and look forward to the next QSO, 73 and CUL KF4ONH de KN4KL SK
t tl= t eoe e i eoM teeette : eo eleeot rt e ee1e tc ttseo 1N4KL DE KF4ONH happy holiday
Thank's for the nice qso i hope to meet again ED 5 Jul 2005 00:52:52z SK 73 ee elo he tea te
s t oaotef elFvaeo eÜat e t eèni e rl i oos, r ae÷Xn o
e l aiha3f Ìn-nle el e eOet'ioe tAt o íttelet e i nt ds t + t r= ae O
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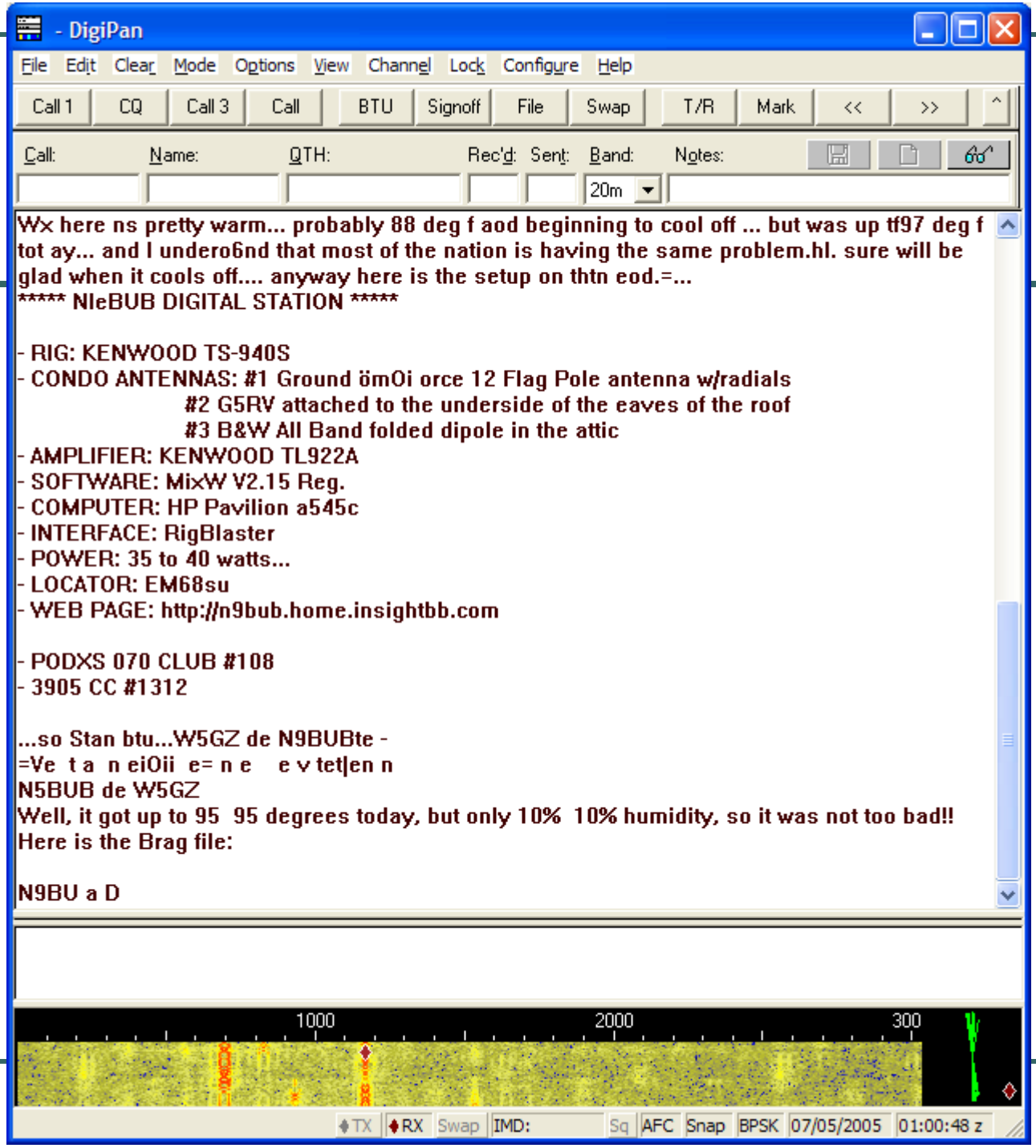
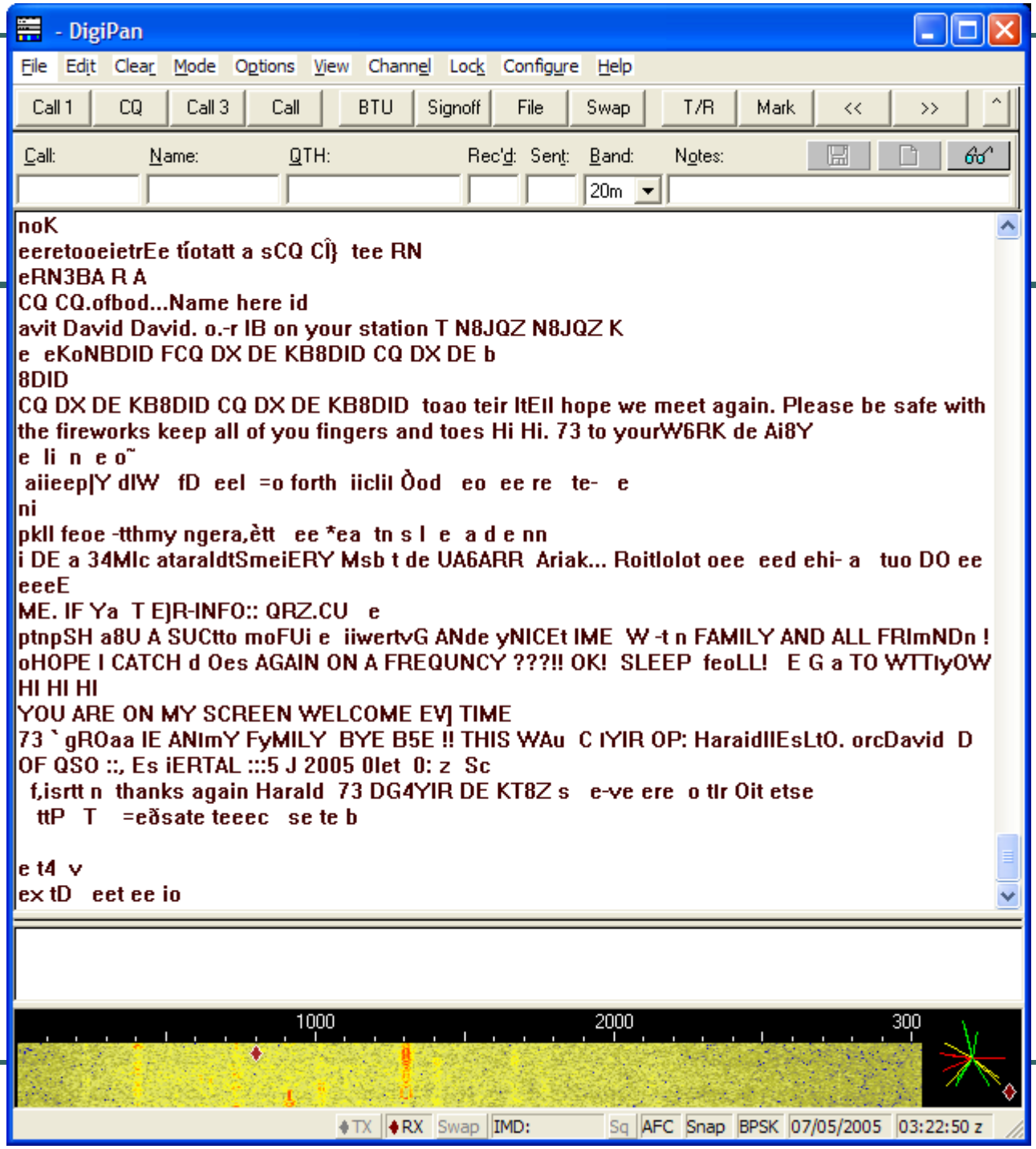
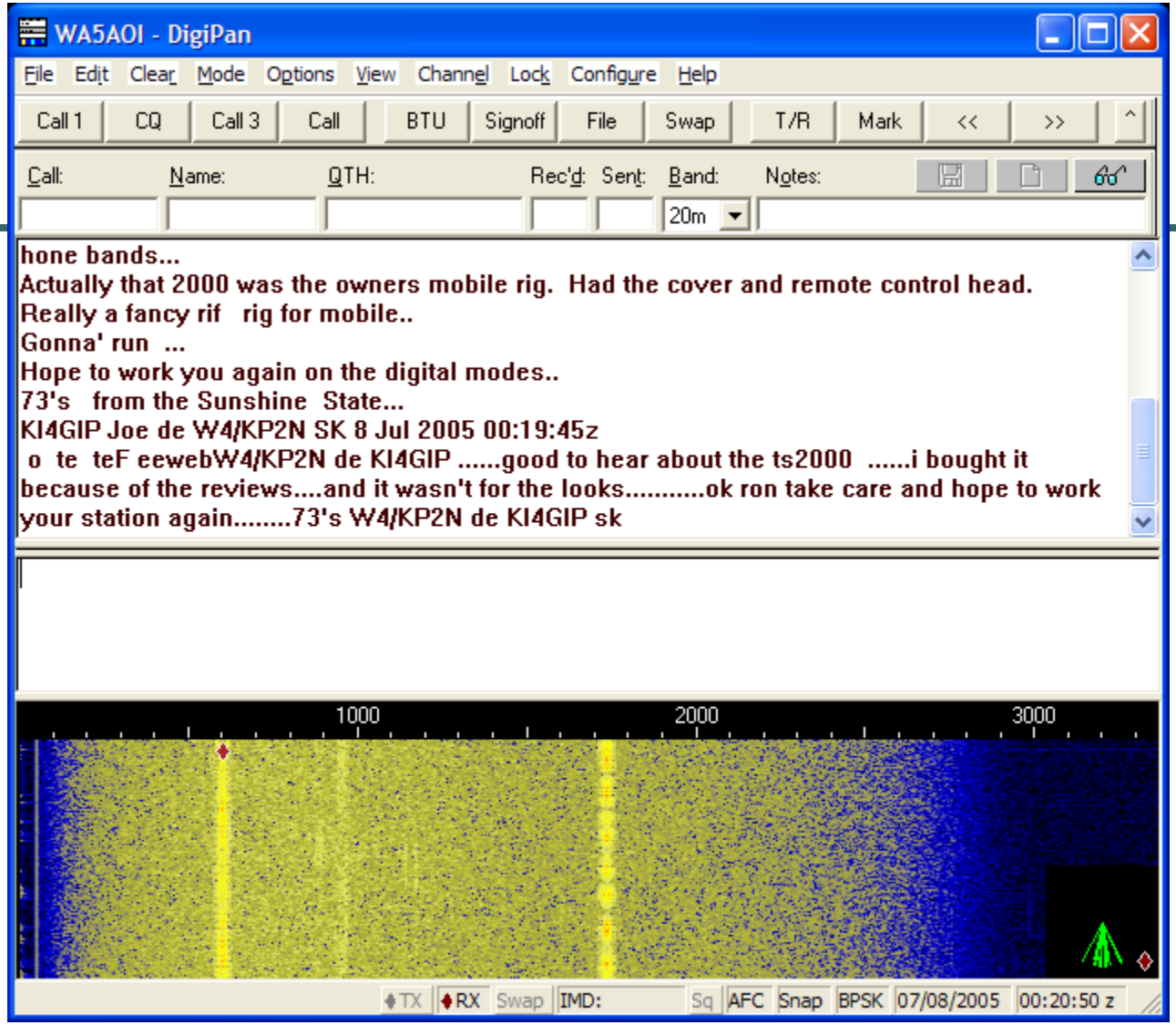
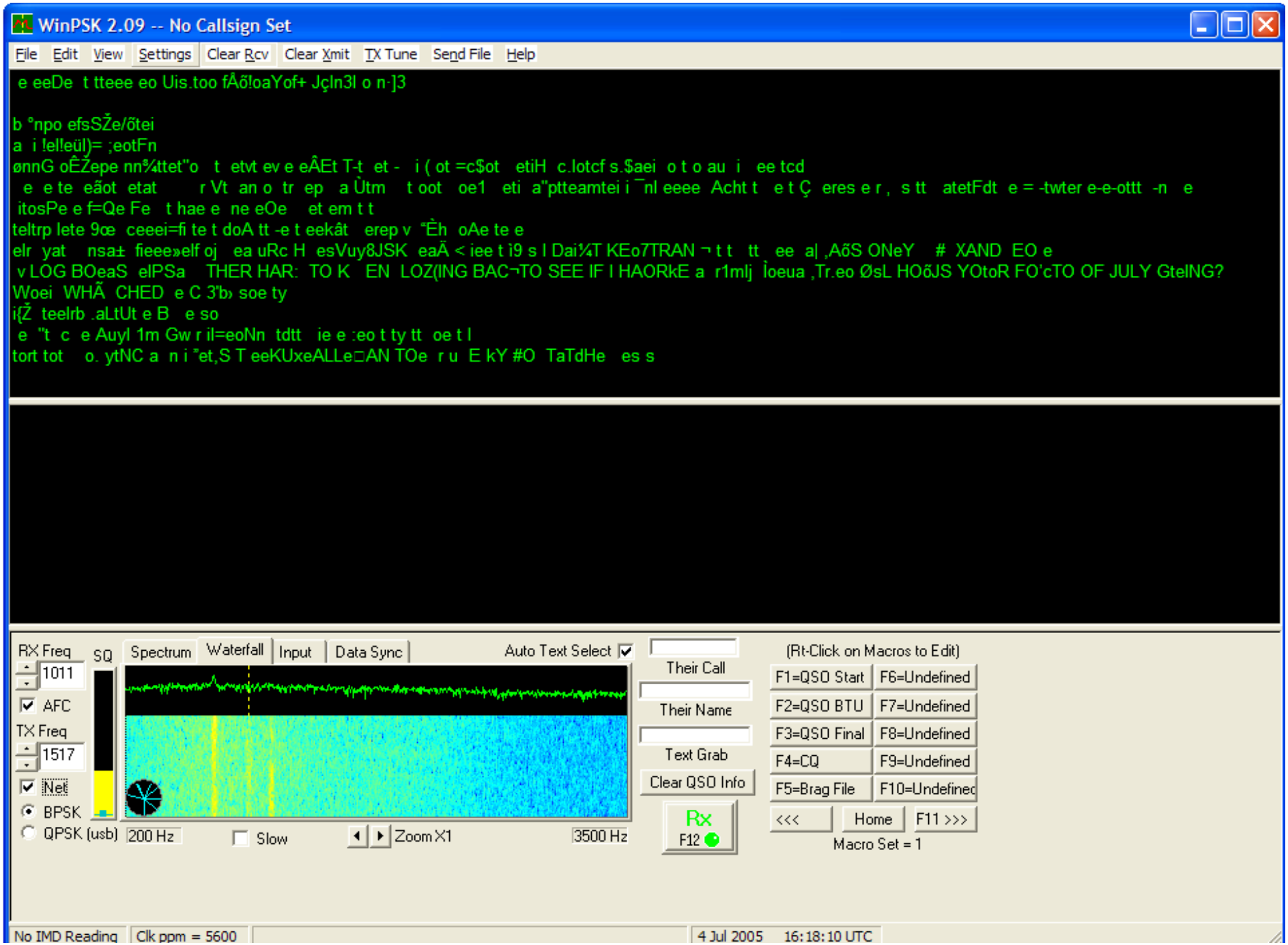
ESaeDLEdL e E
N4KLKN4KL K
ete lmS hio e ea e = ht[s hi ia t stoioaeney d e- nt te eetenet eee rr g o tfieate i etV
eeittaE eaT lo-e
b ato e t
1000
2000
300
TX RX Swap IMD: Sq AFC Snap BPSK 07/05/2005 00:55:23 z

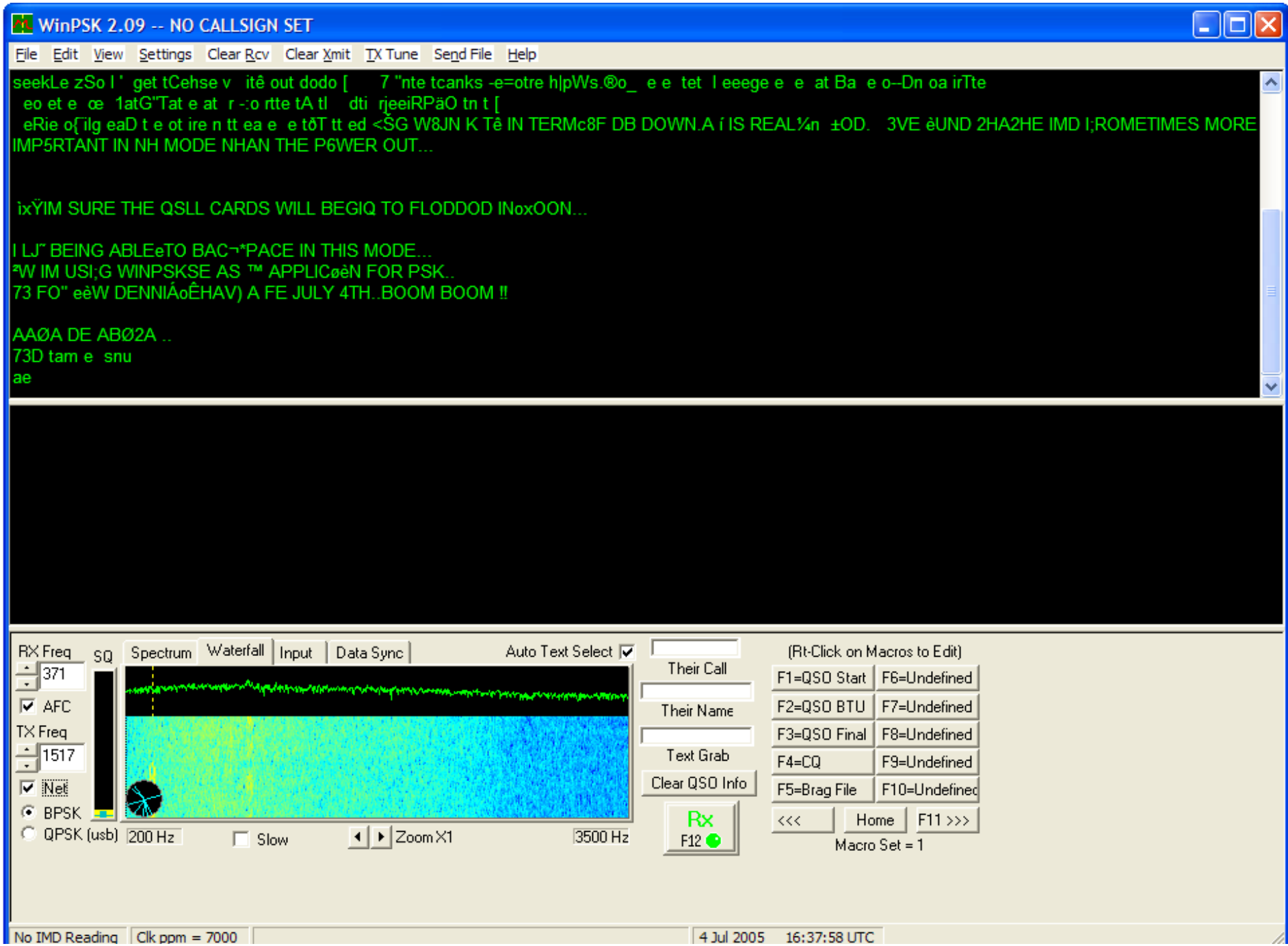

- DigiPan
File Edit Clear Mode Options View Channel Lock Configure Help
Call 1 CQ Call 3 Call BTU Signoff File Swap T/R Mark << >>
Call: Name: QTH: Rec'd: Sent: Band: Notes:
20m
Wx here ns pretty warm... probably 88 deg f aod beginning to cool off ... but was up tf97 deg f tot ay... and I undero6nd that most of the nation is having the same problem.hl. sure will be glad when it cools off.... anyway here is the setup on thtn eod.=...
***** NIeBUB DIGITAL STATION *****
- RIG: KENWOOD TS-940S
- CONDO ANTENNAS: #1 Ground ömOi orce 12 Flag Pole antenna w/radials
#2 G5RV attached to the underside of the eaves of the roof
#3 B&W All Band folded dipole in the attic
- AMPLIFIER: KENWOOD TL922A
- SOFTWARE: MixW V2.15 Reg.
- COMPUTER: HP Pavilion a545c
- INTERFACE: RigBlaster
- POWER: 35 to 40 watts...
- LOCATOR: EM68su
- WEB PAGE: http://n9bub.home.insightbb.com
- PODXS 070 CLUB #108
- 3905 CC #1312
...so Stan btu...W5GZ de N9BUBte -
=Ve t a n eiOii e= n e e v tet|en n
N5BUB de W5GZ
Well, it got up to 95 95 degrees today, but only 10% 10% humidity, so it was not too bad!!
Here is the Brag file:
N9BU a D
1000
2000
300
TX RX Swap IMD: Sq AFC Snap BPSK 07/05/2005 01:00:48 z


- DigiPan
File Edit Clear Mode Options View Channel Lock Configure Help
Call 1 CQ Call 3 Call BTU Signoff File Swap T/R Mark << >>
Call: Name: QTH: Rec'd: Sent: Band: Notes:
20m
noK
eeretooeietrEe tíotatt a sCQ CÎ} tee RN
eRN3BA R A
CQ CQ.ofbod...Name here id
avit David David. o.-r IB on your station T N8JQZ N8JQZ K
e eKoNBDID FCQ DX DE KB8DID CQ DX DE b
8DID
CQ DX DE KB8DID CQ DX DE KB8DID toao teir ltEll hope we meet again. Please be safe with the fireworks keep all of you fingers and toes Hi Hi. 73 to yourW6RK de Ai8Y
e li n e o˜
aiieep|Y dlW fD eel =o forth iiclil Òod eo ee re te- e
ni
pkll feoe -tthmy ngera,ètt ee *ea tn s l e a d e nn
i DE a 34Mlc ataraldtSmeiERY Msb t de UA6ARR Ariak... Roitlolot oee eed ehi- a tuo DO ee eeeE
ME. IF Ya T E]R-INFO:: QRZ.CU e
ptnpSH a8U A SUCtto moFUi e iiwertvG ANde yNICEt IME W -t n FAMILY AND ALL FRImNDn !
oHOPE I CATCH d Oes AGAIN ON A FREQUNCY ???!! OK! SLEEP feoLL! E G a TO WTTlyOW
HI HI HI
YOU ARE ON MY SCREEN WELCOME EV] TIME
73 ` gROaa IE ANImY FyMILY BYE B5E !! THIS WAu C lYIR OP: HaraidllEsLtO. orcDavid D
OF QSO ::, Es iERTAL :::5 J 2005 0let 0: z Sc
f,isrtt n thanks again Harald 73 DG4YIR DE KT8Z s e-ve ere o tlr Oit etse
ttP T =eðsate teeec se te b
e t4 v
ex tD eet ee io
1000
2000
300
TX RX Swap IMD: Sq AFC Snap BPSK 07/05/2005 03:22:50 z


WA5AOI - DigiPan
File Edit Clear Mode Options View Channel Lock Configure Help
Call 1 CQ Call 3 Call BTU Signoff File Swap T/R Mark << >>
Call: Name: QTH: Rec'd: Sent: Band: Notes:
20m
hone bands...
Actually that 2000 was the owners mobile rig. Had the cover and remote control head.
Really a fancy rif rig for mobile..
Gonna' run ...
Hope to work you again on the digital modes..
73's from the Sunshine State...
KI4GIP Joe de W4/KP2N SK 8 Jul 2005 00:19:45z
o te teF eewebW4/KP2N de KI4GIP .....good to hear about the ts2000 .....i bought it
because of the reviews....and it wasn't for the looks.....ok ron take care and hope to work
your station again.....73's W4/KP2N de KI4GIP sk
1000
2000
3000
TX RX Swap IMD: Sq AFC Snap BPSK 07/08/2005 00:20:50 z

WinPSK 2.09 Examples


WinPSK 2.09 -- No Callsign Set
File Edit View Settings Clear Rcv Clear Xmit TX Tune Send File Help
RX Freq
1011
AFC
TX Freq
1517
Net
BPSK
QPSK (usb)
SQ
Spectrum Waterfall Input Data Sync
Auto Text Select
200 Hz
Slow
Zoom X1
3500 Hz
Their Call
Their Name
Text Grab
Clear QSO Info
Rx
F12
(Rt-Click on Macros to Edit)
F1=QSO Start
F2=QSO BTU
F3=QSO Final
F4=CQ
F5=Brag File
F6=Undefined
F7=Undefined
F8=Undefined
F9=Undefined
F10=Undefined
<<<
Home
F11 >>>
Macro Set = 1
No IMD Reading
Clk ppm = 5600
4 Jul 2005
16:18:10 UTC


WinPSK 2.09 -- NO CALLSIGN SET
File Edit View Settings Clear Rcv Clear Xmit TX Tune Send File Help
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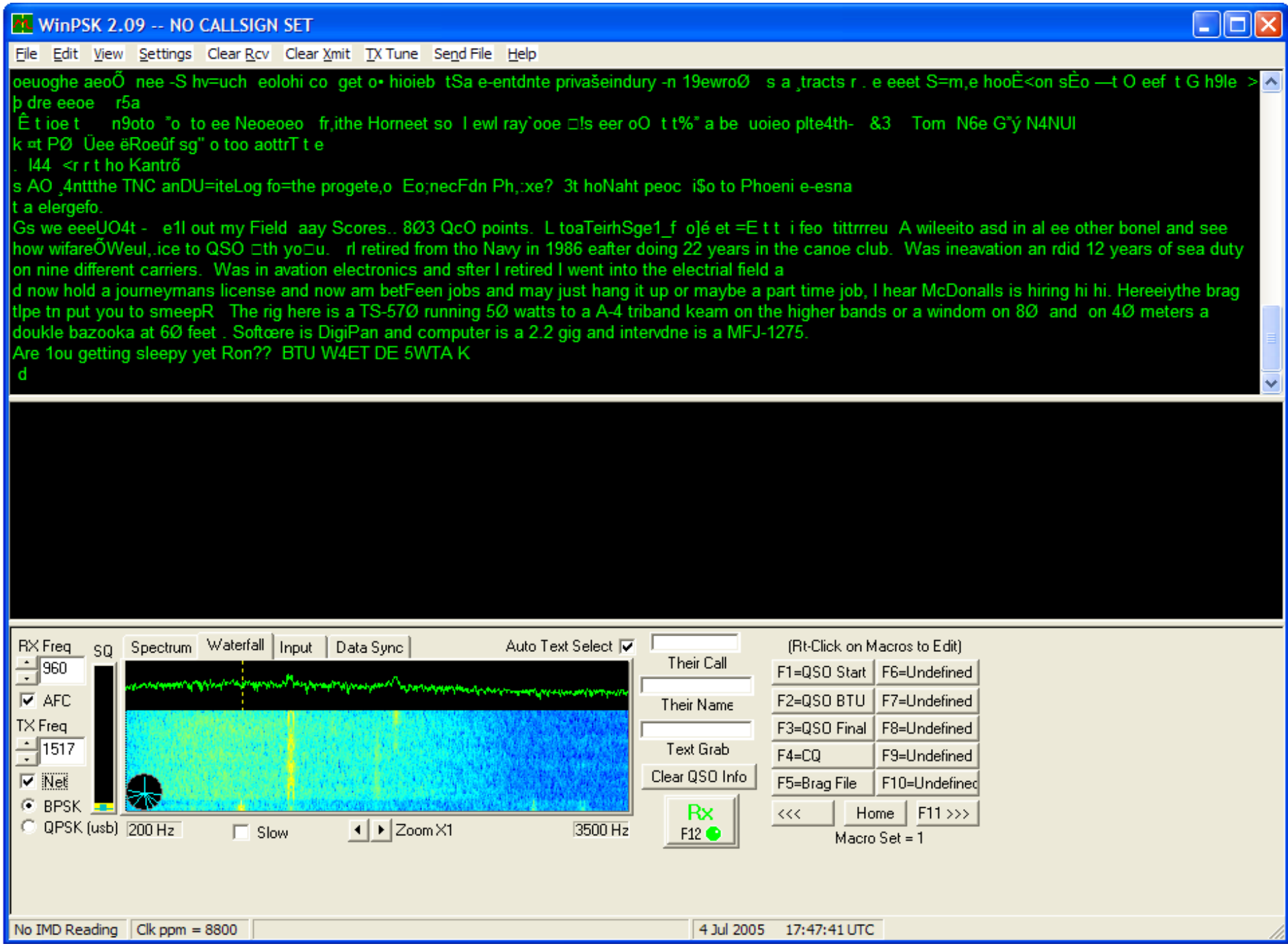
ixŸIM SURE THE QSLL CARDS WILL BEGIQ TO FLODDOD INoxOON...
I LJ" BEING ABLEeTO BAC¬*PACE IN THIS MODE...
²W IM USI;G WINPSKSE AS ™ APPLICøèN FOR PSK..
73 FO" eèW DENNIÁoÊHAV) A FE JULY 4TH..BOOM BOOM !!
AAØA DE ABØ2A ..
73D tam e snu
ae
RX Freq
371
AFC
TX Freq
1517
Net
BPSK
QPSK (usb)
SQ
Spectrum
Waterfall
Input
Data Sync
Auto Text Select
200 Hz
Slow
Zoom X1
3500 Hz
Their Call
Their Name
Text Grab
Clear QSO Info
Rx
F12
(Rt-Click on Macros to Edit)
F1=QSO Start
F2=QSO BTU
F3=QSO Final
F4=CQ
F5=Brag File
F6=Undefined
F7=Undefined
F8=Undefined
F9=Undefined
F10=Undefined
<<<
Home
F11 >>>
Macro Set = 1
No IMD Reading
Clk ppm = 7000
4 Jul 2005
16:37:58 UTC


WinPSK 2.09 -- NO CALLSIGN SET
File Edit View Settings Clear Rcv Clear Xmit TX Tune Send File Help
oeuoghe aeoÕ nee -S hv=uch eolohi co get o• hioieb tSa e-entdnte privašeindury -n 19ewroØ s a ¸tracts r . e eeet S=m,e hooÈ<on sÈo —t O eef t G h9le >
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d now hold a journeymans license and now am betFeen jobs and may just hang it up or maybe a part time job, I hear McDonalls is hiring hi hi. Hereeiythe brag tlpe tn put you to smeepR The rig here is a TS-57Ø running 5Ø watts to a A-4 triband keam on the higher bands or a windom on 8Ø and on 4Ø meters a doukle bazooka at 6Ø feet . Softœre is DigiPan and computer is a 2.2 gig and intervdne is a MFJ-1275.
Are 1ou getting sleepy yet Ron?? BTU W4ET DE 5WTA K
d
RX Freq
960
AFC
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BPSK
QPSK (usb)
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Data Sync
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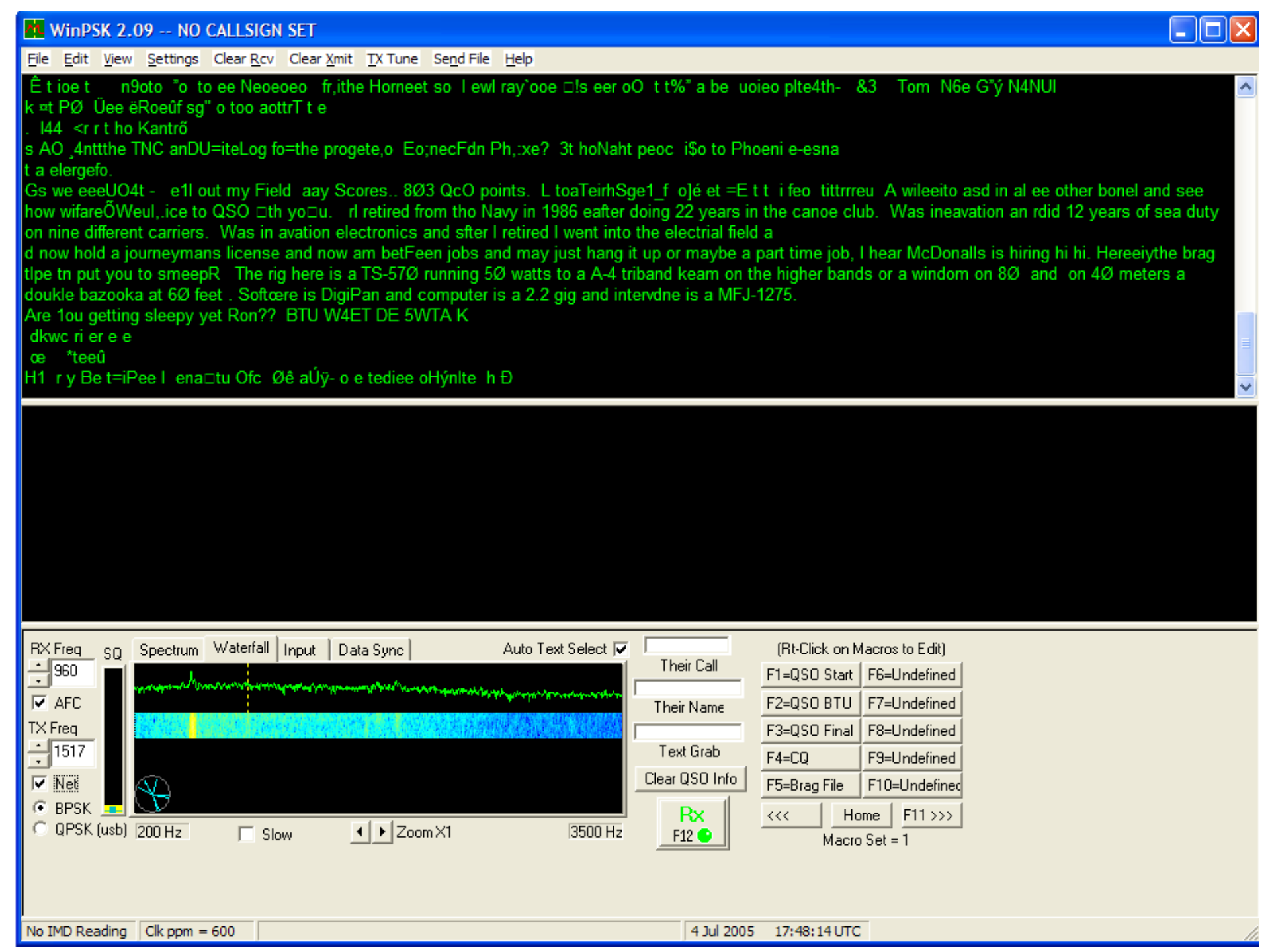
Zoom X1
3500 Hz
Their Call
Their Name
Text Grab
Clear QSO Info
Rx
F12
(Rt-Click on Macros to Edit)
F1=QSO Start
F2=QSO BTU
F3=QSO Final
F4=CQ
F5=Brag File
F6=Undefined
F7=Undefined
F8=Undefined
F9=Undefined
F10=Undefined
<<<
Home
F11 >>>
Macro Set = 1
No IMD Reading
Clk ppm = 8800
4 Jul 2005 17:47:41 UTC


WinPSK 2.09 -- NO CALLSIGN SET
File Edit View Settings Clear Rcv Clear Xmit TX Tune Send File Help
Ê t ioe t n9oto "o to ee Neoeoeo fr,ithe Horneet so I ewl ray`ooe □!s eer oO t t%" a be uoieo plte4th- &3 Tom N6e G"ý N4NUI
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tlpe tn put you to smeepR The rig here is a TS-57Ø running 5Ø watts to a A-4 triband keam on the higher bands or a windom on 8Ø and on 4Ø meters a
doukle bazooka at 6Ø feet . Softœre is DigiPan and computer is a 2.2 gig and intervdne is a MFJ-1275.
Are 1ou getting sleepy yet Ron?? BTU W4ET DE 5WTA K
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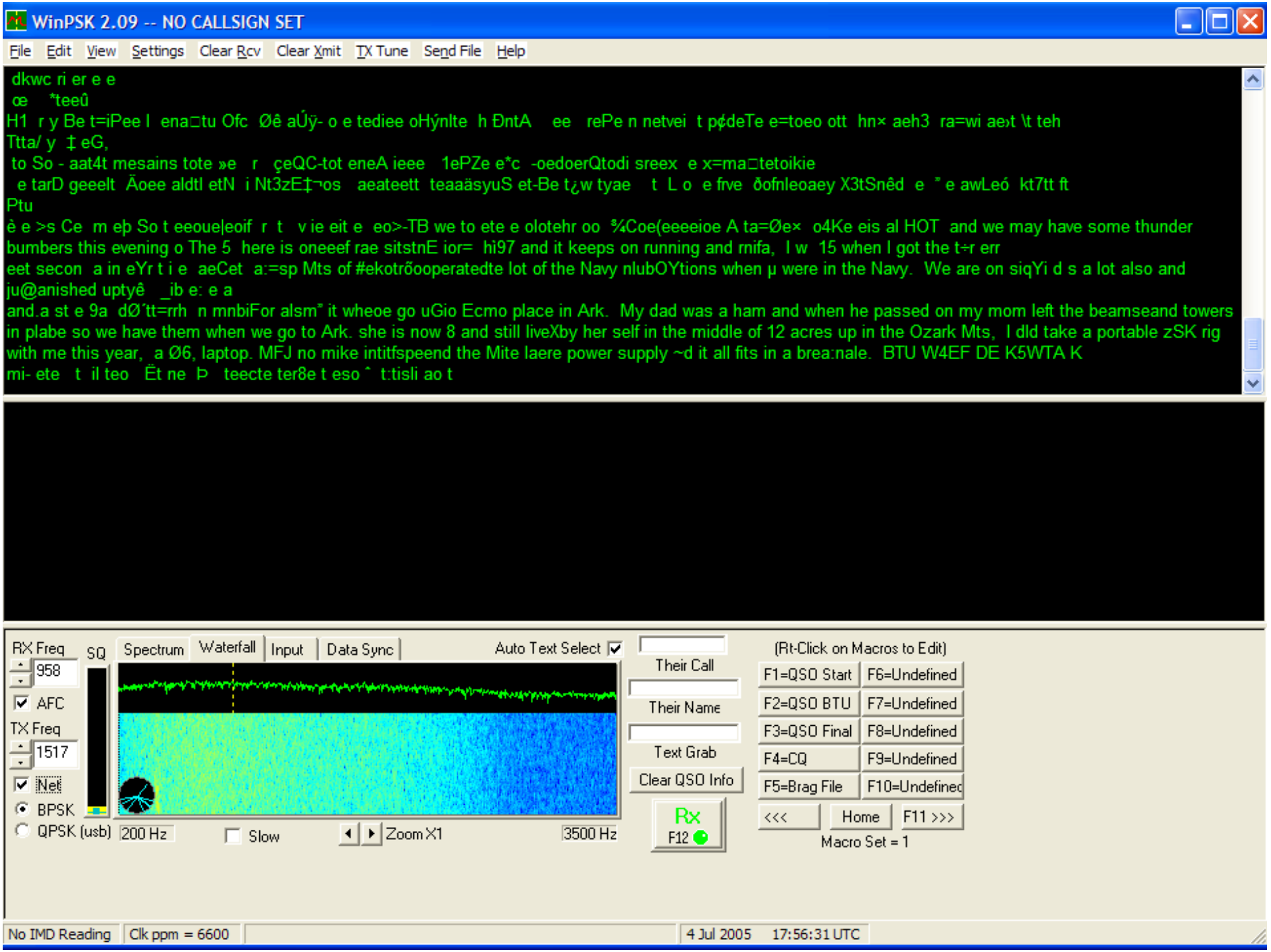
Auto Text Select
200 Hz
Slow
Zoom X1
3500 Hz
Their Call
Their Name
Text Grab
Clear QSO Info
Rx
F12
(Rt-Click on Macros to Edit)
F1=QSO Start
F6=Undefined
F2=QSO BTU
F7=Undefined
F3=QSO Final
F8=Undefined
F4=CQ
F9=Undefined
F5=Brag File
F10=Undefined
<<<
Home
F11 >>>
Macro Set = 1
No IMD Reading
Clk ppm = 600
4 Jul 2005 17:48:14 UTC


WinPSK 2.09 -- NO CALLSIGN SET
File Edit View Settings Clear Rcv Clear Xmit TX Tune Send File Help
dkwc ri er e e
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eet secon a in eYr t i e aeCet a:=sp Mts of #ekotrõooperatedte lot of the Navy nlubOYtions when µ were in the Navy. We are on siqYi d s a lot also and
ju@anished uptyê _ib e: e a
and.a st e 9a dØ´tt=rrh n mnbiFor alsm" it wheoe go uGio Ecmo place in Ark. My dad was a ham and when he passed on my mom left the beamseand towers
in plabe so we have them when we go to Ark. she is now 8 and still liveXby her self in the middle of 12 acres up in the Ozark Mts, I dld take a portable zSK rig
with me this year, a Ø6, laptop. MFJ no mike intitfspeend the Mite laere power supply ~d it all fits in a brea:nale. BTU W4EF DE K5WTA K
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200 Hz
Slow
Zoom X1
3500 Hz
Their Call
Their Name
Text Grab
Clear QSO Info
Rx
F12
(Rt-Click on Macros to Edit)
F1=QSO Start
F6=Undefined
F2=QSO BTU
F7=Undefined
F3=QSO Final
F8=Undefined
F4=CQ
F9=Undefined
F5=Brag File
F10=Undefined
<<<
Home
F11 >>>
Macro Set = 1
No IMD Reading
Clk ppm = 6600
4 Jul 2005 17:56:31 UTC