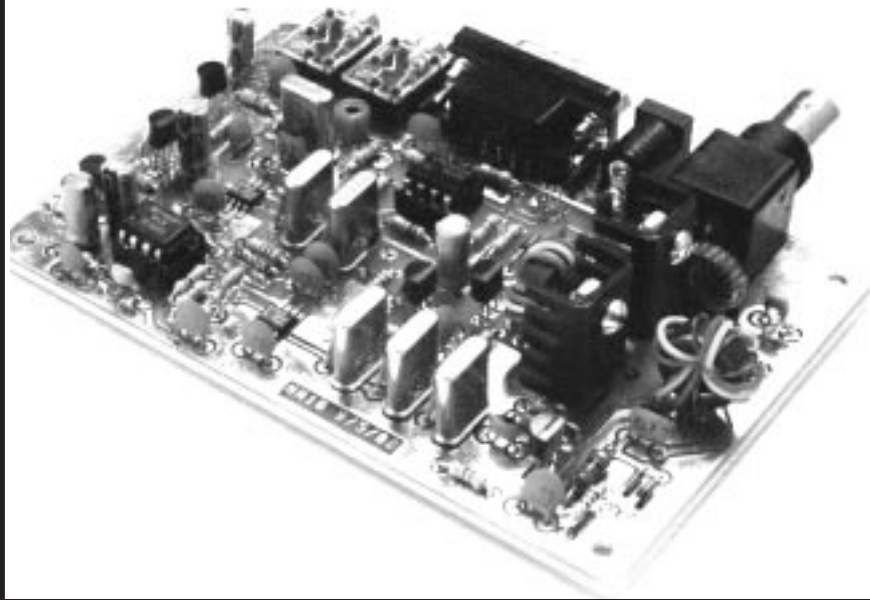QRP

New Jersey

The PSK-80 "Warbler"

A Simple PSK31 Transceiver for 80m

Technical Manual - rev B

Brought to you by the New Jersey QRP Club

PSK-80 "Warbler"

A Simple PSK31 Transceiver for 80m

Technical Manual

Here's a little brother to the popular PSK-20 PSK31 transceiver designed by **Dave Benson, NN1G** in 1999. This time, Dave simplified his design and took advantage of inexpensive crystals for a popular 80m frequency to create the "PSK-80". Wishing to proliferate an easy and inexpensive way for hams to get on 80m with PSK, NN1G shared the design with the NJQRP Club who is kitting and selling the project worldwide. They named the design "The Warbler" for PSK's characteristic two-tone sound through the speaker, as well as for the club's state bird (the mosquito!). As it turns out, 80m is a great band for local (200 mile radius) communications, and the PSK-80 Warbler is the perfect, narrow band, low power rig for club round table QSOs and regular fireside skeds with your friends.

Last winter, while preparing my PSK31 talk for Atlanticon, I was casting about for a simple means of putting a PSK31 signal on the air on HF. It struck me that the standard PSK31 'watering hole' on 80 meters is at 3580.15 Khz. This brought a wave of nostalgia for the New England QRP Club's old 'colorburst' evenings, wherein a half-dozen or so of us would be camped right around 3580 Khz. The rigs for this affair were a simple 3-transistor VXO transmitter. It was always a thrill hearing multiple QSOs within the space of just a couple KHz!

I can't promise to keep the project to three transistors, but the concept is an intriguing one- a standard 80M frequency and simple transceiver used as a club 'intercom' over a fairly wide geographical area. The hardware design started with an evaluation of simple filters using colorburst crystals . **Figure 1** below shows an example of a 3-crystal filter and its passband response.

The asymmetric skirt response is typical of a Cohn filter- the upper-frequency slope is steeper. We take advantage of this by setting the carrier/BFO on the high
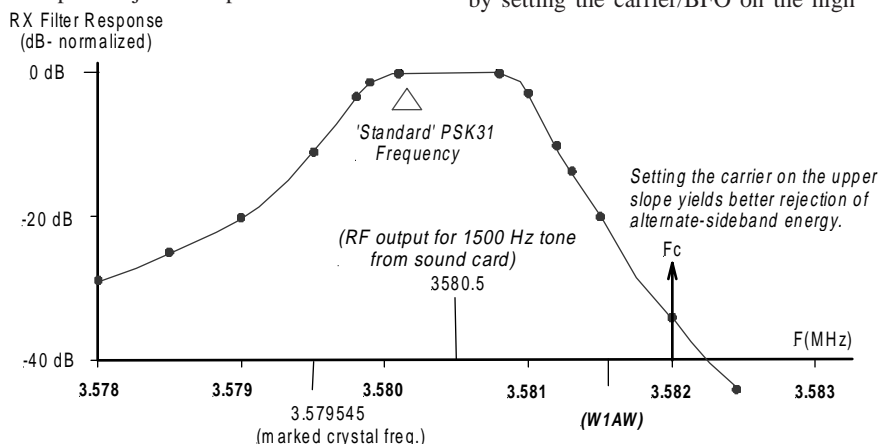

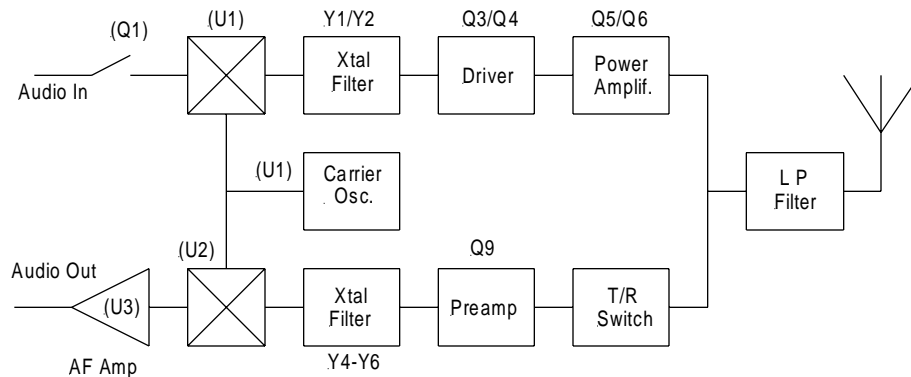**Figure 1: Receiver passband response**

Figure 2: Warbler block diagram

side of the passband. This yields better rejection of W1AW and results in lower-sideband (LSB) operation. Because the filter uses series-resonant type crystals, the passband is actually above the marked crystal frequency. The BFO is pulled to the high side of the passband using a small value of capacitance in series with the BFO crystal.

So what do we do with a filter which operates right at the RF? For starters, consider a 'Neophyte' DC receiver- it's nothing but a product detector and AF amp. By tacking a crystal filter right on the front end, it's still a DC receiver, but its selectivity and its resistance to out-of-passband IMD are considerably improved! On the transmit side, adding such a filter to the output of a balanced modulator creates an SSB signal right at the RF frequency. Take a look at the block diagram in **Figure 2** ... Pretty simple, eh? Naturally, reducing this simplicity to practice always seems to involve adding a few components.

The complete schematic of this transceiver design is shown on the full-page insert to the center of this manual. Please refer to it for the following discussion.

Let's start with the transmitter. Audio from a computer's soundcard output

(LINE OUT) is connected to J2. Q1 is 'closed' during transmit and passes audio- and DC bias- to Q2. Several hundred mV p-p of audio are applied to mixer U1 to generate DSB energy at a (suppressed) carrier frequency of 3582 KHz. Crystals Y1 and Y2 and C6-C8 provide a measure of filtering to eliminate the bulk of the unwanted sideband energy. The remaining SSB signal is amplified by Q3 and Q4. The output of Q4 includes an L-network (collector choke L1 and C10) which matches the driver impedance to that of the PA stage.

Things begin to look a little different around the PA stage! The push-pull configuration used here was done for two reasons: to improve available output power and for better spectral purity. To the extent that the two halves of the amplifier show equal gains on their respective half-cycles of conduction, this balance pays off in rejection of second-harmonic energy. Input trifilar transformer T1 splits the drive signal into two out-of-phase drives to Q5 and Q6. Another multifilar winding (T2) combines the collector outputs. The third winding on T2 is wound separately and has a different turns count. It's set for a collector impedance of 12 ohms- in theory, up to 6W should be available from this stage. In

practice, though, IR drop through R13/13A and saturation effects on Q5 and Q6 limit this to something a bit less.

As a result of the balance provided by the push-pull configuration and the improvement in 2nd harmonic performance, the output harmonic filtering can be considerably simpler. In this design, it's a single section! Thanks to the 15-20 dB of 2nd harmonic suppression inherent the push-pull configuration, the minimum harmonic rejection for this design is 33 dB-compliant with current FCC regulations.

Components C13,D3-D4, and L3 are a T-R switch and provide a measure of front end selectivity for the receiver. Q9 is a preamplifier stage, providing 10 dB of gain. Aside from the gain feature, its other purpose is as a 'flat' 1.5K ohm source for the crystal filter. The initial design lacked this stage and the filter passband was poorly-behaved. Y4-Y6 and associated capacitors provide the passband selectivity charted earlier. Mixer U2 converts the filter output to audio, where it's low-pass filtered and amplified by U3. R23-24 and Q7 provide a muting function to prevent feedback problems during transmit- this is described in more detail in the June 2000 issue of *QST*.

Comparator U4 and related components provide T-R sequencing. This logic turns PNP switch Q8 on to provide transmitter bias.
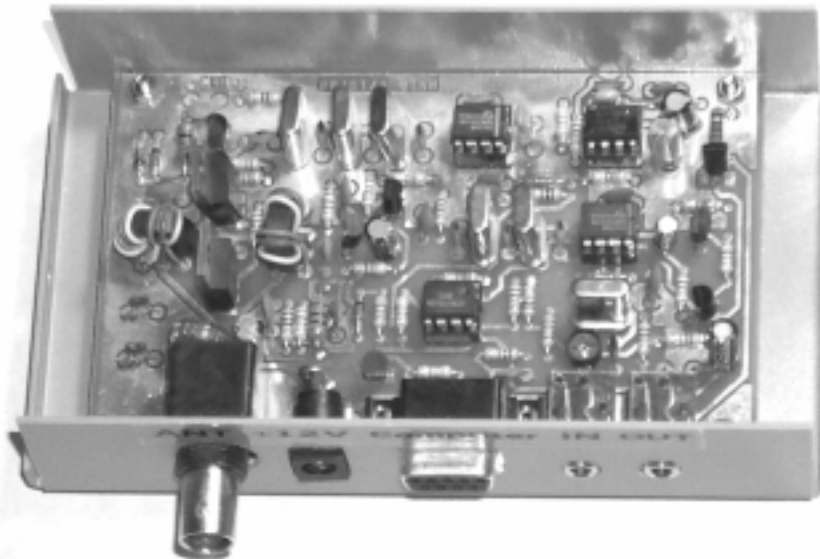
A prototype Warblers mounted in an LMB-139 enclosure ... perfect fit!

Kit Assembly

Refer to the full-page Board Layout diagram provided on the sheet the the center of this manual. Components are installed on the silkscreened side of the board.

TOOLS

You'll need te following tools:
- soldering iron ... ~25W
- 60/40 solder, small dia
- Diagonal cutters
- Needle-nose pliers
- Small slot screwdriver
- Wire-strippers (recommended)
- Tweezers (recommended)

TEST EQUIPMENT

- Multimeter

LET'S BEGIN!

Install only 3-4 components at a time before soldering. Doing so makes it easier to check progress as you go, and reduces the chances of leaving some component connections unsoldered.

1) Open the main component bag supplied with the kit and verify its contents against the Parts List on the next page. Ensure that you have all parts by putting a check mark next to each line once verified. Let us know if you are missing anything. Components are described by their reference designators (C1, R3, Y1, etc., as shown on the Board Layout diagram and Schematic), their values, and whenever possibleby some distinguishing characteristic like size, color, physical marking. There may some discrepancies in these descriptions due to alternate parts supplied by the vendors, but they should be generally okay and useful in identification.

2) There are two surface mount ICs for this project. When installing, be sure to match the orientation of the device to that shown on the pictorial drawing. When the lettering on the IC reads "upright", the chip is in the same orientation as shown in the Board Layout diagram. Then, pin 1 is in the lower left corner of the device. This part may be held gently in place with a pair of tweezers and tacked down by one lead. Once in place, remaining leads may be soldered. A sparing hand with the solder is recommended, but solder bridges may still be difficult to avoid because of the close pin spacings. If this occurs, use solder-wick to clear any solder bridges between adjacent IC pins.

3) Q1and Q7 (2N7000) are static-sensitive. Handle this part as little as possible, and if possible, ground yourself when installing this device.

4) Diode D6 (near J4) is bent for "upright" installation on the board. Installation polarity is as shown below. Be sure to note the orientation of the silkscreened circle on the board and install the diode body over this hole. The cathode (banded) end of the diode is oriented at the top. The remaining diodes are installed 'lying down'- match the banded end to that shown on the silkscreen.

Component Silkscreen

banded end is cathode

Diode-Schematic

Installation- Pictorial
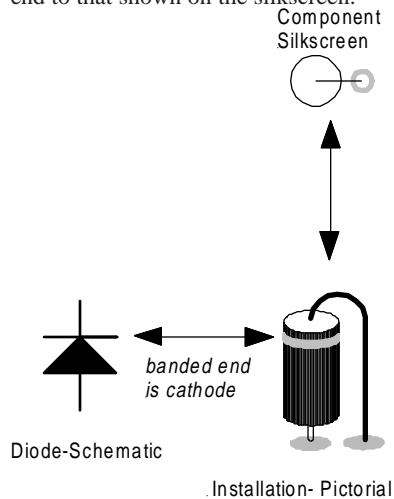
PSK-20 "NJ Warbler" PARTS LIST

C3 .... 4-20 pF .... trim cap - round, red insert
C6-8,C15-18 .... 33 pF .... disk cap - "33"
C4 .... 47 pF .... disk cap - "47"
C5 .... 68 pF .... disk cap - "68"
C13 .... 100 pF .... disk cap - "101J"
C22 .... 150 pF .... disk cap - "151"
C10 .... 220 pF .... disk cap - "221"
C11,C12 .... 1000 pF .... mono cap - "102J", blue or yellow
C9,C14,C19,C101-106,
   C108-C110,C112 .... .01 uF .... disk cap - "103"
C20 .... .022 uF .... mono.cap - "223" yellow
C21,C107 .... .1 uF .... mono. Cap - "104" yellow
C1,C2,C23.C24 .... 1 uF .... Elec. Cap - blue
C111,C113 .... 47 uF .... Elec. Cap - blue
D1,D2 .... 7.5V .... zener diode
D3-D5...................................... 1N4148 .... diode
D6 .... 1N4001 .... diode
J1,J2 .... audio jack...... 3.5mm
J3 .... RS-232 conn . 9 pin D-style
J4 .... coaxial pwr ... 2.1mm connector
J5 .... BNC .... antenna jack
L1 .... 10 uH .... molded RF Choke: brn-blk-blk-gld
L2 .... T37-2 .... 23 turns #26 on the red core
L3 .... 22uH .... molded RF Choke: red-red-blk-gld
Q2,Q3,Q4,Q9 .... 2N4401 .... NPN transistor
Q5,Q6 .... 2SC2166C .... NPN power transistor (or 2SC2078)
Q1,Q7 .... 2N7000 .... MOSFET transistor
Q8 .... 2N3906 .... PNP transistor
R13,R13A .... 1 ohm .... resistor: brown-black-gold
R21 .... 10 ohm .... resistor: brown-black-black
R14 .... 51 ohm .... resistor: green-brown-black
R4 .... 100 ohm .... resistor: brown-black-brown
R8,R12 .... 150 ohm .... resistor: brown-green-brown
R3,R10 .... 220 ohm .... resistor: red-red-brown
R5,R17 .... 470 ohm .... resistor: yellow-violet-brown
R18 .... 1K.................. resistor: brown-black-red
R6,R15 .... 1.5K .... resistor: brown-green-red
R2,R11,R23 .... 2.2K .... resistor: red-red-red
R9,R19,R30,R32 .... 4.7K .... resistor: yellow-violet-red
R1,R22,R24,R25,
   R27,R29............................... 10K............... resistor: brown-black-orange
R26,R28 .... 22K............... resistor: red-red-orange
R7,R31 .... 47K............... resistor: yellow-violet-orange
R16,R20 .... 330K............. resistor: orange-orange-yellow
S1, S2 .... DIP socket 8-pin
T1,T2 .... FT-50-43 .... black toroid cores (see text)
U1,U2 .... SA612AD ...... SMT mixer
U3 .... MC1458 .... dual amp, DIP
U4 .... LM393 .... comparator, DIP
W1 .... 12" .... telephone wire
W2.. 12" .... power cord (and mating coaxial plug)
W3.. 14" .... #26 magnet wire
Y1-Y6 .... 3.579 MHz .... crystal, series-resonant
HS1,HS2 .... heatsinks ...... incl. 4-40 nut + screw
PCB.. Printed-circuit board

5) When installing the crystals on the board, space these components slight (~0.5 mm) above the board to preclude shorts between the crystal cases and board traces. This is best accomplished by soldering the crystals in place and then re-heating individual connections and pulling the crystal gently to pull it slightly away from the board.

6) The monolithic capacitors used at C11 and C12 are somewhat fragile. Use caution when adjusting the lead spacing to match the hole locations on the PC board. Hold each capacitor body firmly between thumb and forefinger when spreading the leads apart.

7) T1 is wound using three 4" lengths of wire (leave insulation on) removed from the 4-conductor cable supplied. **Four (4) turns** of these three wires are wound 'flat' on a dark grey core, with no wire crossing over its neighbors.

Example: Assuming red, yellow and green wires are used, if 'red' leads in the direction you're winding the core, 'red' will lead all the way around the core. Once these windings are prepared, trim the excess lead length to 1/2" (1.2 cm) maximum and remove the insulation from the protuding leads. (It may be helpful to cut the lead lengths at an angle to ease installation, since only one lead-pair at a time then needs to be inserted into the board.)

Install T1 as shown on the pictorial.

8) T2 has a primary winding and separate secondary winding. The secondary should first be wound using **8 turns** of magnet wire distributed uniformly around the circumference of a dark grey core. *Important: each time the wire goes through the toroid center hole it counts as a turn. Be sure that the turns do not cross over one another.*.

The primary is wound next using two 4" lengths of distinctly-colored wire from the 4-conductor cable. The two wires are "bifilar wound", or wound together for **4 turns** over the magnet wire secondary already on the core. When complete, strip the leads and install T2 as shown on the pictorial drawing. *Note: It's important to ensure that the magnet wire leads are thoroughly stripped- these wire ends should be scraped gently using a hobby knife or other sharp blade. Unless adequately stripped, this magnet wire will not accept solder properly, and a cold solder joint will result.* The magnet wire winding connects to the ouput harmonic filter and should be installed in the rightmost pair of T2 holes.

9) Before installing Q5 and Q6, mount the two heat sinks to them using the supplied 4-40 screws and nuts. Install the transistors into the recess in the heat sink so that the heatsink fins 'cradle' the transistor.

C2028
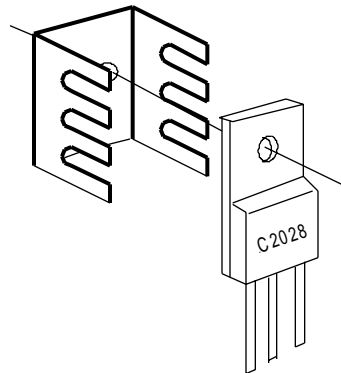
10) Install final amplifier transistors Q5 and Q6 last. Observe the installation orientation as shown on the pictorial drawing. *These parts are quite large and if installed early, will make it more difficult to install nearby components. The transistor leads also prone to fatigue if bent too many times during construction.*
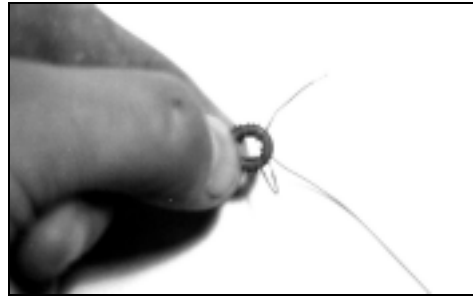
11) Make output filter inductor L2 by winding 23 turns of the #26 magnet wire around the red T37-2 toroid core. Use the illustrations on the next page for guidance. Clip excess length from the ends, strip the enamel from the ends with a sharp hobby knife, and solder in place on the board.
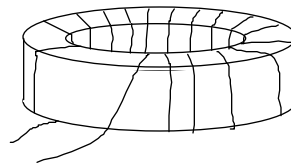
12) A length of power cord is supplied in the kit, along with a coaxial plug to mate with the power connector on the board. Noting polarity (center pin is positive), wire this cable and plug to connect with your favorite 12-15V power source. 15V is preferred for maximum power output.

12) You can easily mount the small PSK-80 board in any convenient enclosure. Shown below is the Warbler mounted in an LMB-139 enclosure that perfectly fits the front-to-back dimensions. Note that careful cutouts for the board-mounted controlsmake for a neat-looking project!

Hookup and Alignment

This transceiver connects to your computer's rear panel using the following connectors:

J1: to Soundcard "Microphone" / 3.5mm stereo

J2: to Soundcard "Line Out" / 3.5mm stereo

J3: to Serial port (9-pin D) / 9-pin male/female

Setup

Download DigiPan if you don't already have it. This free software is best accessed through <http://psk31.com> and by following the links to 'software'. After opening the application, initialize the frequency display to '3582000', and select 'LSB', which places 3582 khz on the right edge of the display. Connect an antenna and DC power (12-15V) to J5 and J4. Adjust the Soundcard microphone sensitivity control (you'll need to look under 'Options' after double-clicking on your Windows Task Bar speaker icon.). Set

the level with this control to yield blue-to-yellow 'speckles' on the screen. This should yield a band covering about one-third of the screen width when properly adjusted.

Adjustment

There's only one adjustment on the transceiver board itself- trimmer cap C3! The ARRL was kind enough to furnish us a calibration marker to adjust these rigs. Between the hours of 4-6 and 7-9 PM Eastern (local time), W1AW is transmitting on 3581.5 Khz. You should have little trouble spotting their CW transmissions on-screen, and C3 is simply adjusted with a jeweler's screwdriver (Radio Shack- $1.99) until W1AW is lined up under the 3581.5 tickmark on the DigiPan frequency display.

Note: If you're close enough to W1AW that their signal causes spurious traces on the display, and reducing the microphone sensitivity to cure this effect causes PSK31 signals to disappear into the mud,

Figure x: W1AW provides convenient calibration!

a different approach is needed. In this case, set the DigiPan start frequency to '3581500' and adjust C3 so that W1AW is zero-beat at the right extreme of the display. This takes advantage of the low-frequency rolloff characteristics of the receiver to knock their signal down to manageable levels. I live about 2 miles from W1AW and they're <u>very</u> strong here. Once this adjustment is performed, though, I can copy PSK31 signals without interference

Transmit adjustment:

Click on 'Tune' on the DigiPan menu- this sets the transceive into transmit mode at 100% duty cycle. Click on the speaker icon and advance the volume slider until output power (viewed on a watt meter) no longer increases. Back it off slightly until power output begins to decrease- this setting assures linear operation. (If you don't have a watt meter, a 50-ohm resistive load and peak detector circuit will accomplish the same job effectively.)

Operation:

Clicking your computer's mouse cursor over the typical "railroad track" PSK31 should cause text to begin appearing in DigiPan's upper text window. Clicking on 'TX' in the DigiPan menu puts you in 'transmit' mode, and your typed text in the lower window is streamed out on the air.

Results:

Success with 80M PSK31 is considerably influenced by antenna performance. NN1G's present 80M antenna is a hastily-erected dipole up only 12-13 feet at the center, and he's routinely able to work DigiPan's creator Skip, KH6TY/4. He's in a condo in SC and his antenna is up only 25' maximum -- one side of it runs through the attic, the other end slopes down to the ground at the far end. Another SC station reports a considerably better copy with a better antenna setup. For QSOs over shorter paths the situation improves considerably. A ragchew with a VE2 about 250-300 miles away yielded 95% or better copy at both ends.

FURTHER INFORMATION

If you have any questions concerning your PSK-80 Warbler Kit, please check the NJQRP website page maintained for the Warbler. It's located at http://www.njqrp.org/warbler/

You may also contact:
George Heron, N2APB
2419 Feather Mae Court
Forest Hill, MD 21050
email: n2apb@amsat.org

The NJQRP wishes to thank Dave Benson, NN1G, for his gracious supply of the PSK-80 Warbler design to the NJQRP. With it we're able to proliferate this simple-yet-effective means of getting onto PSK throughout a wide Amateur Radio community. Simultaneously, the NJQRP is able to leverage the small profits from its kitting efforts back into QRP by hosting its annual QRP forum called Atlanticon.

NN1G may be contacted at:
Dave Benson, NN1G
Small Wonder Labs
80 East Robbins Ave
Newington, CT 06111
email: dave@smallwonderlabs.com
http://www.smallwonderlabs.com

PSK31 & DigiPan ...
A Short Primer

Dave Benson, NN1G
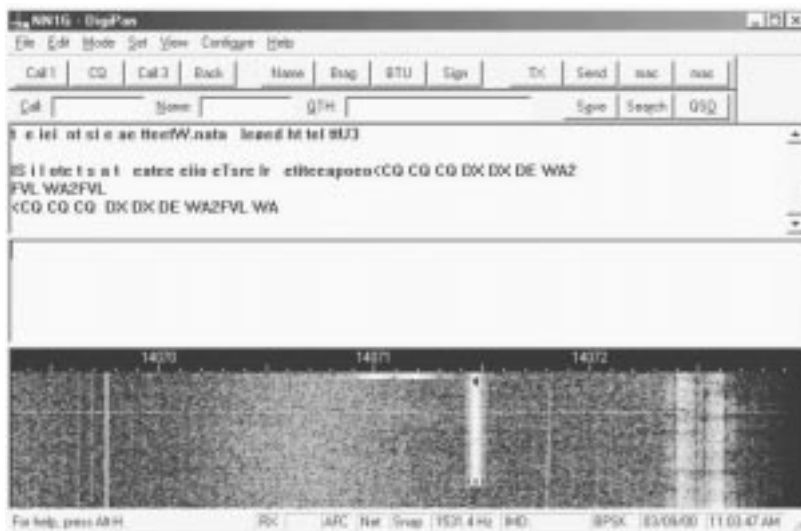*(as excerpted from the Atlanticon 2000 Proceedings)*

One of the most exciting new developments to come down the road in amateur radio recently has been the explosion in growth with the newer digital modes. Of these, the best known to the QRP community is the PSK31 mode.

What is PSK31?

It's a narrow band digital communications mode. It takes advantage of the considerable processing power available in your home computer, and uses Digital Signal Processing (DSP) techniques and some other sophisticated filtering. As a result, it does a good job of recovering weak signals from the noise, and that attribute is what makes it attractive to our community. The 'price of admission' is a computer with sound card and a stable SSB transceiver. During the course of this discussion, I'll be referring to the Digipan software, this is *free* software available for downloading from the Internet[1].

PSK31 was developed by Peter Martinez, G3PLX, and originally published in *RadCom* in Great Britain as a 2-part series in 1995/6. It was subsequently reprinted in *QEX*[2]. As originally implemented, the PSK31 signal used a fixed tone-pair frequency and the accompanying receiver software featured a narrowband tuning indicator. This put a premium on tuning a receiver quite carefully to put the tone-pair within the range of the tuning indicator software. The most recent entry into this mode has been the DigiPan software, and within about a month of its release has proven to dominate the mode. The reasons why will become obvious in a moment as we review the screen-captured image from the computer.

The most dramatic feature in this image [at least in the color rendition] is the 'wa-

terfall' display at the bottom of the image. This display is a panoramic slice of spectrum 4 KHz wide in the 20 meter band. New signals appear at the top of the waterfall just below the frequency tick marks and proceed downward as they get older.

In this image, there are 4 distinct amateur signals- this snapshot was taken early in the day under poor conditions. The broad trace on the right side of the waterfall is a Pactor station present through the entire time history onscreen. A second Pactor station may also be seen starting up (top center of waterfall.) The faint line on the left of the waterfall is a steady carrier, and although not evident in the reproduction copy, is accompanied by a number of fainter 60 Hz artifacts from unintentional modulation from that station's power supply. The signal we're interested in, though, is the distinct trace to the right of screen center; this is a PSK31 station calling CQ.   The uppermost dialog window on the display shows the decoded text from this station's transmission- it appears onscreen as it's being decoded.

You'll note a small black diamond centered over this signal's waterfall trace. This symbol is placed by 'pointing and clicking' with the computer mouse. If you tire of reading the mail with one signal, click on the next one and 'you're there'. There's no need to touch any tuning adjustments, as the frequency selection is done in the software. This point-and-click feature obviously represents a significant advantage over narrow-band tuning indicators, and is now being used for other narrowband digital modes as well[3].

As you can see from the upper dialog window, the early copy for this session is 'gibberish' resulting from the software's best efforts to make sense of the noise it's receiving. Peter Martinez

touched on the rationale for (and largely against) the use of active error-correction schemes for this live QSO 'keyboard-to-keyboard' mode. Since there's no such correction applied, the software provides an output whenever it decodes a 'valid' character in the noise . As soon as the PSK31 station came on the air, I clicked on its trace and the text in the upper window immediately changed to 100% copy for this fairly strong signal.

The middle window (blank in this instance) is used to type in messages being transmitted. These can be either typed ahead and then streamed out by clicking the 'TX' button, or once you're transmitting, the software sends the contents of this window as you type. If you're as skilled a typist as I am <g> , only the plentiful use of backspaces and corrections keeps me ahead of the outgoing data. As you transmit, your own typing is shown the upper window- for better or worse.

 The buttons across the top provide access to a number of menus used to set display options and also to access various Windows functions such as "Save", " Edit" and so on.   The "Call" and "Name" boxes are used to store personal information on the station you're talking to, and when you click on the "BTU" ('Back to you' button, it incorporates that information into your transmission as you turn it over.

How does the mode work?
Transmitted signals use a pair of tones which are separated by 31.25 Hz. Because of the modulation method and requirements for the hardware, nearly all of the energy in a PSK31 transmission is in only these two tones. As a result, this mode is very spectrum-efficient.   In theory, anyway, you could fit about 80 PSK31 QSOs into the space occupied by a single SSB voice transmission! A spectrum display for this mode is shown below, this is a "clean" signal.   In actual
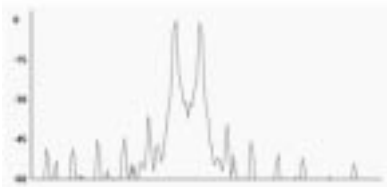
practice, non-linearities in the transmitter chain will degrade this signal quality somewhat.

In the time domain, the signals closely resemble the classic two-tone SSB test waveforms, as you might expect from the spectrum plot above,
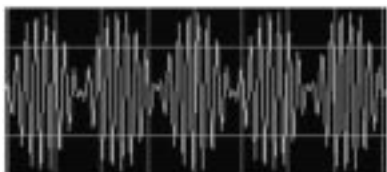
The above picture shows a stream of logic 'zeroes'. If you'll observe closely, each waveform envelope has an opposite 'sense'- starting positive or negative-going in polarity. A logic '0' is defined by a phase-change at the bit period.

The figure below shows a logic '1'. This is mechanized by the absence of a phase change, and as you see from the figure, the envelope is briefly a steady carrier for an extra bit period.
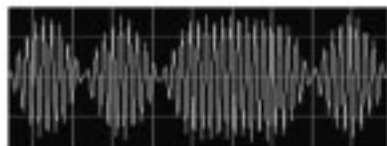
The character set devised by Peter Martinez is called Varicode, and like Morse code, uses shorter code sequences for the most commonly-used letters. The space between characters is formed by two or more sequential zeroes. When there's no data being sent but the transmitter is on, it's sending zeros continuously so the waveforms resemble that of the first picture above.   Each character in the alphabet contains primarily 'ones'- never is a 'zero' seen for more than one bit time within a character. The character set encompasses all 128 ASCII characters- alphanumerics, punctuation and control codes- that last one a crucial advantage for the average typist. I've grown to love my 'backspace' key!

Receiving PSK31 Signals

The recovery software employs a rather clever scheme to ensure good freedom from data corruption by noise, and this is one of the features of PSK31 which makes it attractive to our QRP community.   In addition to the narrowband DSP filtering which is centered over the tone-frequency pair, there's a special-purpose algorithm at work as well. This is a so-called Viterbi decoder, and it consists of 32 parallel functions. Each of these functions is examining the DSP output over the last 5 bit times and 'scoring' the correlation between its own code (00000 through 11111). In a sliding-window fashion - at each bit time- the sixteen codes with the best correlation scores are kept and the next 32 parallel functions will include the 16 'winners' plus the two 'children', i.e., a '1' or a '0' at the newest bit time.   This processing means that there's a 5 bit-time delay or 'pipeline' before received data starts trickling out of the decoder.

 This correlation process may be extended in time up to the point where the evaluation delay becomes objectionable to the user- somewhere around one second or so.

This sounds like a fair amount of processing is involved, and indeed it is.   There's nothing to prevent the homebrewer from tackling this rather interesting topic at a
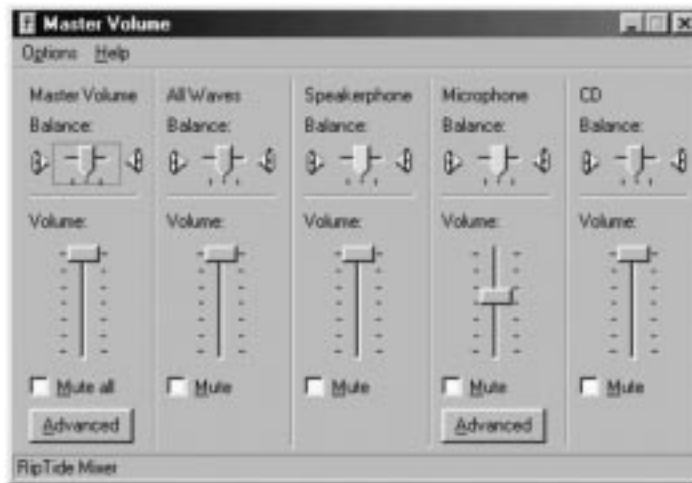
variety of levels of sophistication. Some of the more recent mult-mode controllers include PSK31 modem functions in DSP, and this is a 'Cadillac' approach. At the other end of the spectrum, I know there's at least one gentleman using a PIC to demodulate PSK31 data. Without knowing how robust his algorithm is, that is, how sophisticated the correlation process is, it'd be tough to predict how well this approach would work for all but the strongest incoming signals.

Operating adjustments: *"Look, ma-no hands"*

At present and for the foreseeable near-future, PSK31 activity is clustered within a narrow band of frequencies on each band. This means that aside from dialing in a particular transceiver frequency, there's nothing to be done with the transceiver hardware after that. All operating adjustments from there on out are handled by the computer sound card interface. The figure below illustrates the Windows sound card dialog box used to set Microphone Gain. This actually refers to the Microphone input to the sound card, so it's functionally the transceiver's receiver gain control. The sound card's master

volume slider (in the Windows lower tray) sets the output level to adjust transmit output power.

Needless to say, with no adjustments on the transceiver itself, this lends itself to some pretty neat 'remote' applications like telephone or cross band HT control. There are now a number of Internet-accessible amateur transceivers- if they're not doing anything else at the moment you can steer them to the PSK 'watering holes' and monitor the goings-on from anywhere. Just the thing for those business trips with a laptop but no rig!

Hardware requirements

Computer: The requirements for the computer portion of the system are pretty simply stated: Windows 95, 75 MHz Pentium (or equivalent) or faster, sound card and Serial port.

Transceiver: This is worthy of a little more attention, since many of us will be interested in the homebrewing or kit-compatibility aspects of this mode. PSK31 uses SSB rather than the simpler (Class-C) designs used for CW for the transmitter design.

First and foremost, if you have a synthe-

sized SSB rig - a 'Yaecomwood' , high-end Ten-Tec, Index Labs QRP+, etc., you're all set. The phase-locked commercial rigs provide sufficient frequency stability for PSK31. In the kit domain, the K2 offered by Elecraft (Wayne Burdick and Eric Swartz), with its SSB adapter, fits the bill nicely. I'll also touch on my work in this area later in this discussion.

Technical Considerations:

Frequency stability:

As a narrowband mode, PSK31 is pretty intolerant of drift. With the 'AFC' feature in PSK31 decoding software engaged, it'll retain good copy on strong signals for drifts of up to 0.5 Hz/ second. This means, though, that for successful QRP operation you want good stability. This requirement may be filled either by a synthesized rig or by the use of crystal control. The full band -coverage analog-VFO rigs are likely problematic in this regard.

I had considered the 'Huff-and-Puff' frequency-stabilization as an adjunct to my 'stock' White Mountain SSB series. Although this type of scheme is capable of the necessary long-term frequency stability for PSK31, there's a catch- the 'Huff-n-Puff' schemes are prone to 'limit-cycle' (frequency cycling) behavor as they dither between several pseudo-lock points. Although this behavior may sound fine to the ear for SSB and even CW applications, it exceeds the drift-rate limit I mentioned earlier. It's possible to filter the error voltage very heavily (in effect making the loop response as sluggish as cold molasses) but that in turn affects cold-start lock time. This approach is not for the faint-of-heart homebrewer. The Ten-Tec Scout uses this scheme, and although I know it's being used to receive PSK31, I haven't heard yet how it stacks up with the more demanding 'transmit' application.

Linearity:

It's possible to transmit- and decode- signals which have been amplified and distorted to the point of being 100% duty-cycle transmissions. Besides being tougher on your finals, it's not in accordance with good amateur practice. In this special case, the signal becomes FSK and sprouts considerable extra sideband content. One of the very nice features of the panoramic display environment is that all transmitted signals are on-screen for all to see. Set your SSB drive level too high and you may rest assured that you'll hear about it!- overmodulation is easily seen on the waterfall display. As a rule of thumb, the 3rd-order intermod products should be down at least 27 dB, this is roughly comparable to a decent SSB signal's distortion figure.

If you're building a rig for PSK31 from scratch, several other considerations come into play-

At least in the software implementations I've seen, the sound card settings are not accessible and re-configurable between the 'transmit' and 'receive' intervals. This means that the receiver output, for instance, is always being applied as a sound card input (along with the desired two-tone output) during transmit. This raises the specter of unwanted feedback paths, and indeed, without the proper care taken, the transmitted waveform ends up distorted by the unwanted receiver-wrap-around path. Similarly, unless the transmitter chain is effectively disabled during receive, the unwanted modulation will be clearly audible in the receiver, giving rise to the same sort of distortions. In both cases, effective muting of the transmitter and receiver paths eliminates these feedback paths.

Transmit-Receive Switching

A means of switching a rig between transmit and receive is needed, and several

approaches are practical. For an approach with the minimum number of cables between the rig and computer, a VOX (audio-derived) switching scheme seems attractive. On the 'plus' side, the outgoing audio to the transmitter is pretty well defined in terms of its wave shape. Several practical considerations soon intrude, however. Due to the wraparound / feedback situation mentioned earlier, the audio out of the sound card is never really shut off. Further, with some of the Windows functions liable to make noises when the operator performs a mouse-click, there's a potential for triggering the transmitter at unintended times. Users of several different PSK31 software packages have reported this behavior and have largely shelved the VOX approach. There's one other factor in this discussion- remember the 'CD volume" adjustment? The computer soundcard probably finds use for other applications. Remembering to turn off the rig power before exiting the software application is necessary in this case. This ensures that you're not treating other band users to your favorite music or video game sound effects!

A more secure method in involves the use of one of the RS-232 signals present on your computer's Serial port connector. While this increases the number of connections between rig and computer, it adds some 'piece of mind'. The currently available software packages use either DTR (Data Terminal Ready) or RTS (Request to Send) to signal the transceiver to do the T/R switching. When connected to the PTT line of most transceivers, these signals require modest extra circuitry to convert the (bipolar) RS-232 signal to a PTT-compatible level.

In search of the simple PSK31 rig
I was approached by KH6TY regarding modifying my existing WM-20 transceiver for PSK31 use. With a sample in hand, Howard came up with modifica-

tions to that design to put it on the 20M PSK31 frequencies using crystal control for high stability. Best of all, the crystals are all standard microprocessor types!

When this became a 'real project', as opposed to a marathon e-mail correspondence, I re-laid out the WM-series with a number of changes, largely for reasons of improved ease of construction. This also provided the opportunity to incorporate the necessary I/O connectors onto the PC board itself. These connectors mate with standard computer interface cables (3.5mm stereo and serial port/DB-9), available through electronics retail outlets. Interested readers may request copies of that project's schematic from me (business-sized SASE for mail inquiries, please).

"Onward and, er, Upward*"- A still-simpler PSK31 rig*

Last year, I had some remarks about the 'rock-bottom' approach to getting on the air, in that case with some relatively simple ideas for 50 MHz. I'd like to continue in that vein, and in the case of PSK31, there appears to be a very straightforward way to put a low-parts count transceiver on the air successfully.

The result of this simplified PSK31 transceiver is my design of the PSK-80 transceiver ... or the "Warbler" as the NJQRP guys like to call it!

As I hope you can sense from the tone of this material, I've really enjoyed getting into PSK31. I hope also that some of my enthusiasm is contagious! The PSK31 mode really combines the best aspects of amateur radio and computer technology, and it's a natural for our QRP specialty.

Further Reading:
For more information on PSK31, check out the following sites:

http://psk31.com

and http://aintel.bi.ehu.es/psk31.html