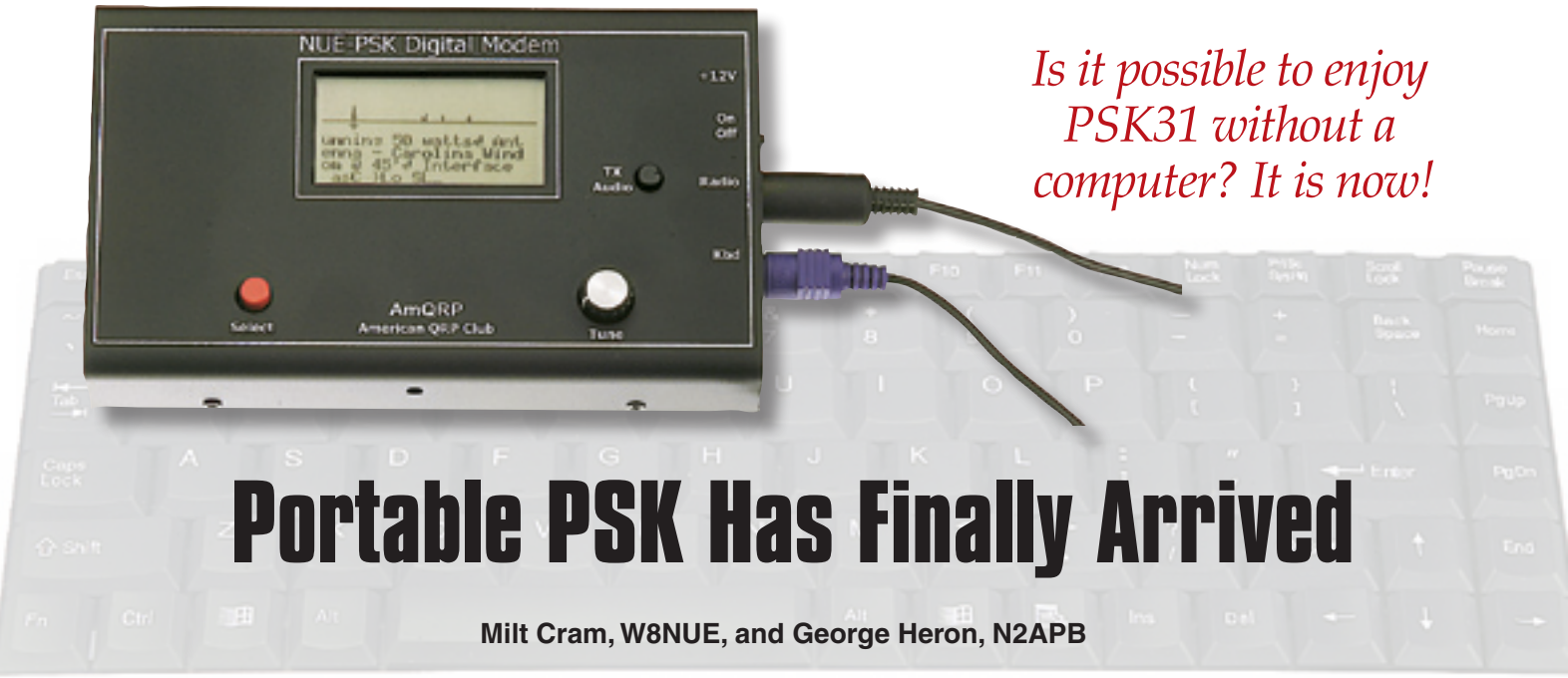


Is it possible to enjoy PSK31 without a computer? It is now!

Portable PSK Has Finally Arrived

Milt Cram, W8NUE, and George Heron, N2APB

You say you haven't even tried PSK31 yet? Of all the HF digital modes, this is one of the best, especially considering the mediocre band conditions we're experiencing today. With a few watts and a wire, you can enjoy PSK31 keyboard conversations with stations throughout the country. There is plenty of DX to be had as well.

If you've been putting off PSK31 because you lacked a computer, you've just run out of excuses. The NUE-PSK modem doesn't require a computer — just plug it into your SSB transceiver's mic and speaker jacks, plug in a standard PS2 keyboard, and you're on the air.

Many modern transceivers also provide fixed-level audio inputs and outputs using DATA or AUX connectors. These connectors often include AFSK Out, Audio In and PTT (Push To Talk) lines — just what the digital modem needs. If your radio features this convenient multipurpose port, you're in luck. It will greatly simplify the task of connecting the NUE-PSK.

The battery-operated NUE-PSK digital modem fits in the palm of your hand and can provide hours of digital communications enjoyment.

PSK31: The King of HF Digital

Unless you've been asleep for the past eight years, you probably know that PSK31 is one of the hottest digital modes on the airwaves. Much like instant messaging (IM) over the Internet and text messaging over cell phone networks, PSK31 provides hams the same type of peer connectivity over the HF bands — and it is still growing in popularity as technology marches on.

PSK31 first burst onto the Amateur Radio scene in 1998 with some intrepid experimenters providing complex hardware and software designs for this new digital mode. These early PSK experiments required digital signal processing development kits and other hardware. Not long afterward, however, technology improvements enabled some other smart hams, such as Peter Martinez, G3PLX, to find ways to use the common PC and sound card to provide the required computing power and convenient user terminal I/O. Steve Ford, WB8IMY, described the excitement in *QST* articles (1999 and 2000), extolling the virtues of this fun new mode. Design veteran Dave Benson, K1SWL (ex-NN1G), even designed a whole series of dedicated, single-board/single-band low-power (QRP) transceivers for PSK31.

But even with these clever hardware and software innovations, there was yet room for improvement. The computer and its sound card still form the core of all present-day PSK31 stations. The sound card functions as the modem and the computer runs the necessary PSK31 software. The problem with this arrangement is portability. Even if you resort to using a laptop computer to take your PSK31 to the field, you are limited to the operating time that the laptop battery provides. Standard-sized laptops are also bulky and their LCD screens are difficult to see in bright sunlight.

The NUE-PSK digital modem can currently support the digital modes of BPSK and QPSK, and will soon support MFSK and RTTY.

And portable operating aside, what about hams who do not own computers? Even today there is still a percentage of the amateur community that does not have access to computer hardware. These people are excluded from HF digital operating entirely.

With these challenges in mind, we decided that we wanted to invent a PSK system that did not require the use of a PC in any form. We wanted something that would be portable and compatible with both standard and QRP transceivers, providing many hours of operation from a battery (unlike the 2 or 3 hours you might squeeze out of a typical laptop).

Two Flavors of PSK

PSK31 is one of many modulation techniques within the "phase shift keying" family of communication. PSK31 operates at 31.25 bits/second, while other speeds may be achieved using variations to the software algorithm. PSK is perhaps more accurately termed *BPSK*, for bi-phase shift keying, whereby two distinct phase states separated by 180° are used to convey the information. Four states may also be encoded/decoded, as is done with *QPSK* (quad-phase shift keying), in order to provide higher speeds with greater error correction ability.

The NUE-PSK digital modem can currently support the digital modes of BPSK and QPSK, and will soon support MFSK and RTTY. In fact, the field updating capability — that is, the ability to download new/improved programs from the Internet and simply program them into the modem — will allow users to stay current with new features and modes for years to come!

Design Overview

At the heart of the NUE-PSK digital

From March 2008 QST © ARRL

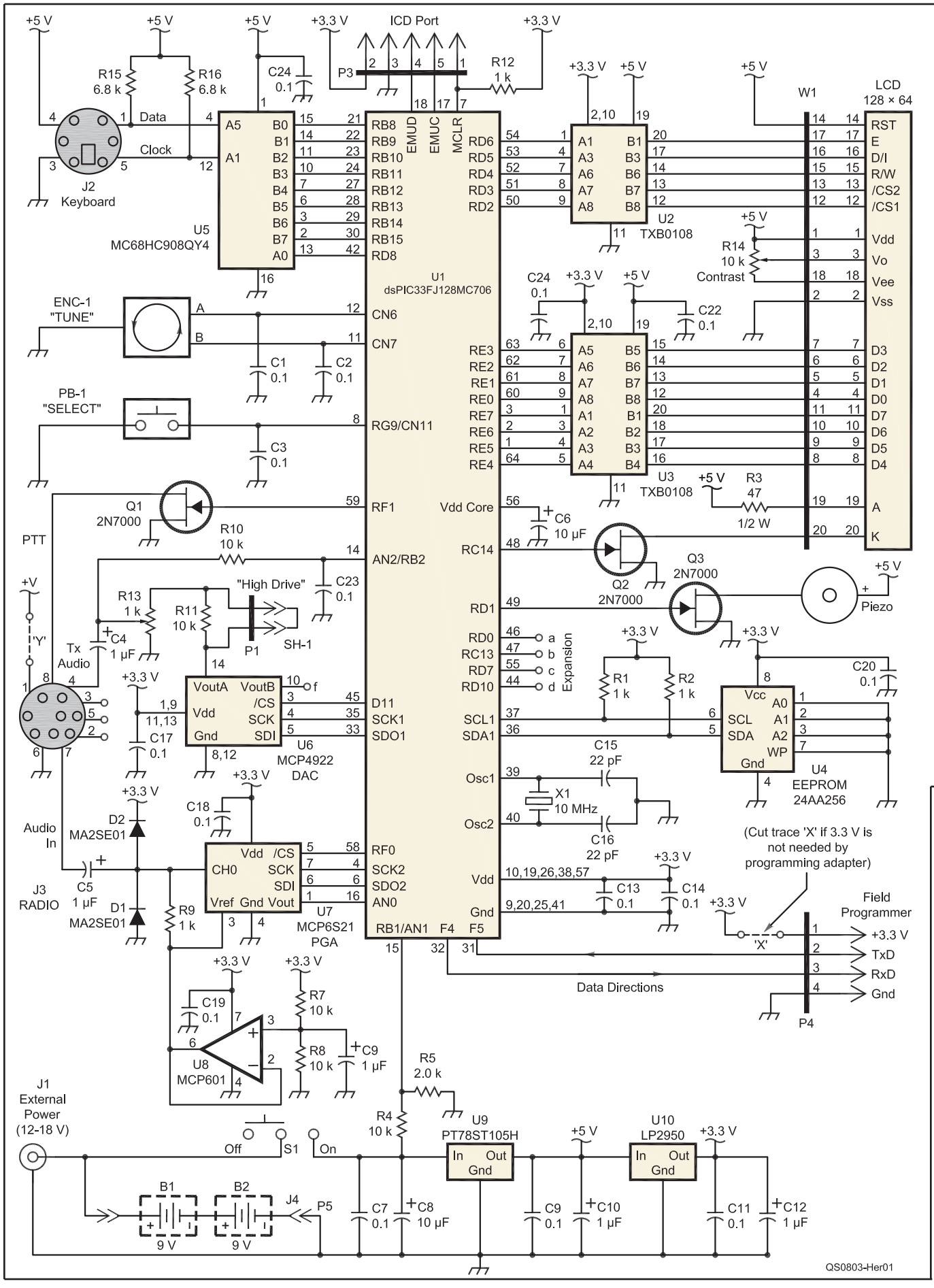

+5 V
+3.3 V
ICD Port
R15 6.8 k
R16 6.8 k
C24 0.1
P3
R12 1 k
J2 Keyboard
Data
Clock
U5 MC68HC908QY4
U1 dsPIC33FJ128MC706
U2 TXB0108
U3 TXB0108
W1
LCD 128 × 64
RST
E
D/I
R/W
/CS2
/CS1
Vdd
Vo
Vee
Vss
D3
D2
D1
D0
D7
D6
D5
D4
A
K
R14 10 k Contrast
C22 0.1
ENC-1 "TUNE"
C1 0.1
C2 0.1
PB-1 "SELECT"
C3 0.1
Q1 2N7000
R10 10 k
PTT
C6 10 µF
Q2 2N7000
Q3 2N7000
R3 47 1/2 W
Piezo
"High Drive"
R13 1 k
R11 10 k
P1
SH-1
C4 1 µF
Tx Audio
'Y'
C23 0.1
R1 1 k
R2 1 k
C20 0.1
U6 MCP4922 DAC
C17 0.1
U4 EEPROM 24AA256
C15 22 pF
X1 10 MHz
C16 22 pF
C18 0.1
D2 MA2SE01
D1 MA2SE01
Audio In
J3 RADIO
C5 1 µF
R9 1 k
U7 MCP6S21 PGA
(Cut trace 'X' if 3.3 V is not needed by programming adapter)
'X'
Field Programmer
TxD
RxD
Gnd
P4
Data Directions
C13 0.1
C14 0.1
C19 0.1
R7 10 k
R8 10 k
C9 1 µF
U8 MCP601
R5 2.0 k
R4 10 k
J1 External Power (12-18 V)
Off
S1
On
U9 PT78ST105H
U10 LP2950
B1
B2
9 V
J4
P5
C7 0.1
C8 10 µF
C10 1 µF
C11 0.1
C12 1 µF
QS0803-Her01

Figure 1—Schematic diagram of the NUE-PSK modem. Supplier part numbers are shown where applicable (Digi-Key Electronics: tel 800-344-4539, www.digikey.com; Mouser Electronics: tel 800-346-6873, www.mouser.com; Newark: tel 800-463-9275, www.newark.com; Crystalfontz America: tel 888-206-9720, www.crystalfront.com; Freescale Semiconductor: tel 800-521-6274, www.freescale.com).

B1, B2 — See text.
C1-C3, C7, C11, C13, C17-C19, C21-C25 — 0.1 µF ceramic capacitor, SMT, Digi-Key PCC1883CT-ND.
C4, C5, C9, C10, C12 — 1 µF electrolytic capacitor, 16 V, SMT, Digi-Key PCE3045CT-ND.
C6, C8 — 10 µF electrolytic capacitor, 25 V, radial, Mouser 140-XRL16V10-RC.
C15, C16 — 22 pF capacitor, SMT, Digi-Key 311-1153-1-ND.
D1, D2 — Schottky diode, MA2SE01, SMT, Digi-Key MA2SE0100LCT-ND.
ENC-1 — Rotary encoder, Digi-Key P10860.
J1 — DC power connector, coaxial, 21 mm, Mouser 163-5004-E.
J2 — 6-pin Mini-DIN, Mouser 161-2206.
J3 — 8-pin Mini-DIN, Mouser 161-2208.
J4 — 2-pin receptacle, pinheader, female, 1×2, Mouser 517-870-01-03.
J5 — 9 V battery clip.
LCD — CFAG12864, Graphics LCD, CFAG12864, 128×64, Crystalfontz CFAG12864BTFHV.
P1, P2 — Pinheader, 1×2, 0.1", Mouser 517-834-01-36.
P3 — Pinheader, 2×3, 0.1", Mouser 517-836-01-36.
P4 — Pinheader, 1×4, 90-deg, Mouser 517-835-01-16.
P5 — Pinheader, 1×2, 0.1", 90-deg, Mouser 517-835-01-16.
P6 — 8-pin Mini-DIN plug, Mouser 171-2608.
PB-1 — Push button, DPST, momentary, Newark 19C6398.
PB1-cap — Push button cap, Newark 18M6492.
Piezo — Piezo sounder, Digi-Key 433-1023-ND.
Q1-Q3 — 2N7000 transistor, NFET, Digi-Key 497-3110-ND.
R1, R2, R9, R12 — 1 kΩ resistors, SMT, Digi-Key RHM1.00KFCT-ND.
R3 — 47 Ω, ½ W, resistor, Mouser 293-47-RC.
R4 — 10 kΩ resistor, SMT, 1%, Mouser 71-CRCW1206-10K.
R5 — 2 kΩ resistor, SMT, 1%, Mouser 71-CRCW1206-2K.
R7, R8, R10, R11 — 10 kΩ resistors, SMT, Digi-Key 311-10KECT-ND.
R13 — 1 kΩ mini-potentiometer, Mouser 317-2080F-1K.
R14 — 10 kΩ trimpot, Mouser 652-3306W-1-103.
R15, R16 — 6.8 kΩ resistors, SMT, Digi-Key 311-6.8KECT-ND.
S1 — Slide switch, SPDT, PCB mount, 90-deg, Digi-Key EG1917-ND.
SH-1, SH-2 — pinheader, 1×2 shunt, Mouser 517-951-00.
U1 — dsPIC33FJ128MC706, Microchip DSC, 64-pin, Mouser 579-33FJ128MC706IPT.
U2, U3 — TXB0108, Octal Level Shifting Buffers, Mouser 595-TB0108PWR.
U4 — 24AA256, Microchip EEPROM, Digi-Key 24AA256-I/SN-ND.
U5 — MC68HC908QY4, Freescale Semiconductor microcontroller, MC68HC908QY4VPE-ND.
U6 — MCP4922, Dual-DAC, Digi-Key MCP4922-E/SL-ND.
U7 — MCP6S21, Programmable Gain Amplifier, Digi-Key MCP6S21-I/SN-ND.
U8 — MCP601, Op Amp, Digi-Key MCP601-I/SN-ND.
U9 — PT78ST105H, 5 V Switching Regulator, Digi-Key PT78ST105H-ND.
U10 — LP2950, 3.3 V regulator, Digi-Key LP2950CZ-3.3-ND.
X1 — Crystal, 10 MHz, 20 pF, Digi-Key 631-1101-ND.

The NUE-PSK modem sends and receives PSK-31, with more modes to come, without requiring a computer. Any PS/2 keyboard can be used. The NUE-PSK is shown here with the lightweight, portable Parallax Mini-Keyboard, which is available from retailers for $19.95 (or directly from Parallax at www.parallax.com).

modem sits a new and inexpensive 16-bit microcontroller from Microchip called the dsPIC33F. See Figure 1. This device combines a standard control processor together with a computational powerhouse digital signal processor. While the conventional control processor instructions handle the display and keyboard I/O, the DSP instructions are what actually perform the complex PSK31 demodulation, thus allowing the NUE-PSK modem to be the first economic solution for digital modem operation without the aid of a PC sound card.

Only a few other integrated circuits are required to handle everything in the digital modem. A digital-to-analog converter creates the analog audio tones sent to the radio, and the programmable gain amplifier receives the speaker tones from the rig for demodulation. A memory chip serves to hold your call sign and the macro commands used for efficient QSO exchanges, and several interface chips are used to buffer the LCD connections to the MPU. A second, smaller MCU serves as the keyboard interface, processing the many interrupts generated from the user keystrokes. The digital modem draws about 80 mA at 12 V, or as little as 45 mA when used with a supply up to 18 V (eg, two standard 9 V batteries in series).

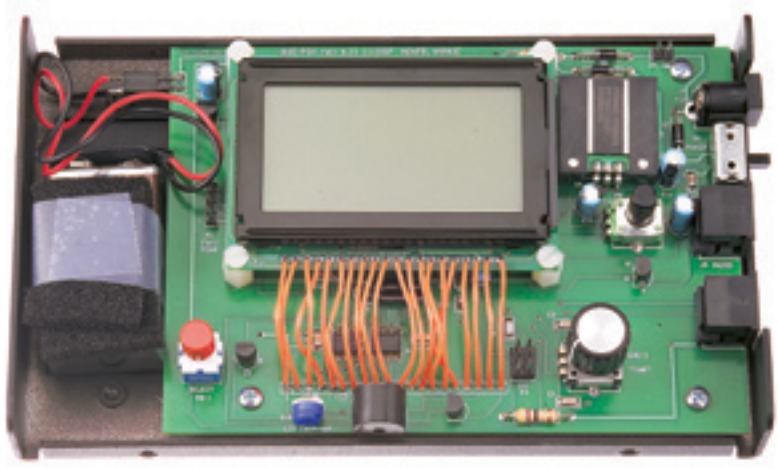
The audio input, audio output and PTT lines are connected to the radio by using a single cable instead of implementing the conventional rat's nest of wires. When the modem is used with a dedicated HF rig like a Yaesu FT-817 having a "digital control" jack, the rig-end of the cable may also be consolidated to a single multi-pin plug, thus providing a neat and elegant interconnect with the radio.

The entire NUE-PSK digital modem is contained on a single 3¾ × 5¼ inch printed circuit board that can be placed into your favorite homebrew enclosure. A custom-made aluminum enclosure was designed to house the PC board, with the graphic display and controls on the top surface, connections to the outside world on the right side panel, and a battery compartment on the bottom side.

The NUE-PSK software design implements a straightforward approach to I/O control, while employing the AE4JY *PSKcore* modem algorithm engine. Wheatley's documentation and *C++* source code was professionally done and graciously placed into the public domain for everyone to use.

The software is also open source under the GPL license, which allows others to freely implement the fruits of our labor in related projects. In this way we hope to be further enabling technology to evolve and produce even more advanced designs downstream.

A detailed technical discussion of the NUE-PSK is beyond the scope of this article. However, you can read a much more thorough treatment in the March/April issue of



An interior view of the NUE-PSK.

QEX magazine, *QST's* sister publication for experimenters. If you don't subscribe to *QEX*, the article is also available on the Web for free downloading at **www.arrl.org/qex/2008/3/Heron.pdf**.

Using the NUE-PSK

When the NUE-PSK is switched on, the LCD shows a graphical spectrum representation of signals in the band. A cursor in the signal portion of the display may be moved up or down the band by turning a rotary dial on the modem, or by using the arrow keys on the keyboard. This tuning method allows you to move to select the PSK signal you wish to monitor. As soon as the cursor approaches a PSK31 signal, the software automatically locks onto it and the decoded characters of the signal being received start displaying on the lower LCD.

Now, suppose you want to answer a station's CQ, or call him after his conversation ends. Just press the F12 key to go into transmit mode and begin typing! Your typed characters are shown in a new line of the display and the PSK31 audio tones are sent character-by-character over to your rig that has been automatically set to transmit mode. When you're done with your reply, pressing F12 again puts the rig back into receive and his typed reply will show character-by-character in your display…just as if you were instant messaging!

Just like the popular PC applications for PSK31, the software in the NUE-PSK digital modem provides numerous menu options, hot key short cuts, and time-saving buffers in memory to allow you to have an easy-and-effective QSO. For example, these features make it easy to record macros, and change various setup features like mode, AFC On/Off, CW ID, etc. Its internal memory is used for storage of setup information and macros so that they will be retained when power is removed from the modem.

Conclusion

We already have a long list of additional features planned, including extra digital modes (MFSK, RTTY), improved tuning and sensitivity, and a super-portable mode using a CW paddle to input data and Morse tones for output. The portable evolution keeps on coming!

The NUE-PSK digital modem is used regularly by both authors and has seen intense operation during QRP contests during the past year. It is a great pleasure to be able to operate PSK31 out in the field with such little reliance on a conventional PC or laptop. This portable PSK digital modem truly helps one enjoy the overall communications experience.

Some truly outstanding opportunities exist for using the NUE-PSK digital modem in the field of emergency communications. The modem's suitability for field portability — battery-operated, small, lightweight, integrated and no-PC design — is a fabulous component for state, local and ARES communications use during weather- and nature-related disaster communications. The PSK31 mode excels in establishing low-power communications, much more efficient than voice, and is able to be quickly and effectively used by any emergency personnel that can type at a keyboard.

We hope you enjoy the NUE-PSK digital modem. We are indebted to the pioneering efforts of others before us here in the field of PSK31, especially the avid experimenters of the Austin QRP Club. Let us know how it works out and we'll be looking for you on the air!

Milt Cram, W8NUE, was first licensed in 1953 as WN8NUE and has held several calls (minus the "N") with an Amateur Extra license. He is a long-time homebrewer and member of the Austin QRP Club, enjoying operating low power and the digital modes on HF. Milt holds BEE, MS and PhD degrees in electrical engineering from Georgia Tech and comes from a family of hams (dad, Ernie, W8JKX [SK], great uncle, Oz, W1JUJ [SK], and son, Marc KC5RWZ). You can reach him at 9807 Vista View Dr, Austin, TX 78750 or at **w8nue@arrl.net**.

George Heron, N2APB, has been a technology manager in the northeastern US for more than three decades. He is the chief scientist for McAfee, helping to develop new security products and technologies to protect users from all forms of computer malware. First licensed in 1968, George is an avid homebrewer in RF and digital circuits, with a special interest in DSP and microcontroller applications to QRP. He leads the New Jersey QRP and the American QRP clubs and can be reached at 2419 Feather Mae Ct, Forest Hill, MD 21050, or at **n2apb@amsat.org**. QST

Buying or Building Your Own NUE-PSK

Assembled and tested NUE-PSK modems can be purchased from the American QRP Club at **www.amqrp.org/kits/nue-psk31/**. The cost is $199 for US and Canadian shipment; $219 for overseas orders. Accessories are also available. You can order online, or send a check or money order payable to the American QRP Club c/o George Heron, 2419 Feather Mae Ct, Forest Hill, MD 21050. Full and partial kit versions will be available later this year. Check the American QRP Club Web page for the latest updates.

If you prefer to source your own parts and build from scratch, see Figure 1. The NUE-PSK software is available for free downloading on the NUE-PSK Web page.

Whether you decide to homebrew the modem, or perhaps get the partial kit and assemble it yourself, don't be afraid of soldering the surface mount ICs used in this project. Here's a technique that works great even for the 64-pin dsPIC chip. Using a magnifying lamp, position the IC on the pads and tack solder two corner leads to hold the package in place. Liberally solder all the leads to the pads without any concern for shorts between the leads. Next, use some desoldering braid (like SolderWick) to remove all excess solder along the rows of leads. Don't worry about overheating the IC package — it's tough. After all that excess solder is sucked up, you're left with the cleanest looking connections that could ever be achieved by hand soldering!