

NUE-PSK Digital Modem

Operator's Manual



*The **NUE-PSK Digital Modem** is a standalone, battery-operated digital modem using Microchip dsPIC technology. Weighing about 12 ounces and requiring only 60ma at 12V DC, the modem is easily taken to the field. For easy visibility in high or low ambient light, the NUE-PSK modem's backlit graphic LCD displays transmit and receive text data, as well as band spectrum and tuning indicator. When coupled with a standard PS2 or USB keyboard and an SSB-capable transceiver, you can have an effective portable PSK31 station.*

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Caution:

Shortly after going to production status and starting to ship the modems, we discovered a couple of errors in the "power supply" area of the pc board. The unusual arrangement we use with two internal 9V batteries (yielding 18V) was conflicting with an external power supply when connected to the J1 power connector. Current would flow from the batteries back to the nominally lower voltage external supply, causing the batteries to heat up and fail in pretty short order.

One solution to this condition is to remove the batteries whenever an external power supply is being used.

A better solution is to make a few simple modifications on the pc board, as described and illustrated on the NUE-PSK website at www.amqrp.org/kits/nue-psk31/batt_mod

1) Introduction

PSK31 is one of the latest communications modes to capture the interest of hams worldwide. Its inherent ability to dig out weak, nearly-inaudible signals is ideally suited for low power QRP enthusiasts. The PSK31 digital modem engine, however, requires intense DSP processing that is only commonly available in PC sound card. Thus the PSK operator desiring portability for field operation is locked into using a laptop computer as a controller, which results in a cumbersome station. But there's hope!

The NUE-PSK Digital Modem offers a unique way for hams to get on the air using the digital modes. No PC is required, thus enabling one to communicate using PSK31. This self-contained, hand-held modem connects to your SSB transceiver and allows you send and receive text data using the PSK31 digital mode.

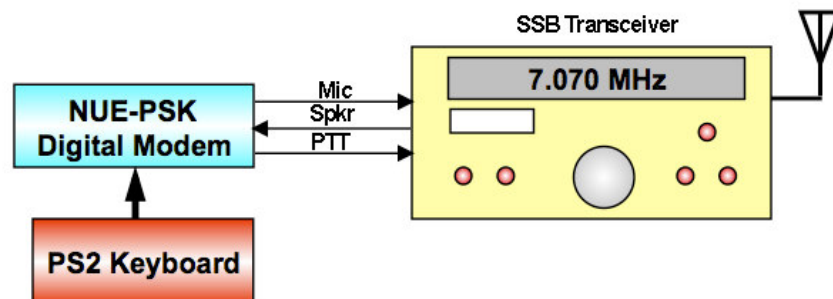
PSK31 is actually one-of-many modulation techniques within the “phase shift keying” family of communication. PSK31 operates at 31.25 bits/second, while other speeds may be achieved using variations to the software algorithm. PSK is perhaps more accurately termed BPSK, for bi-phase shift keying, whereby two distinct phase states separated by 180 degrees 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!

2) Connections

Ideally, you just need to connect up two cables:

- Connect the modem's “Radio” cable to the “data” jack on the back of your SSB transceiver. Most radio manufacturers today provide this way for getting audio modulated tones to/from the rig.
- Connect a standard PS2 keyboard, or a PS2/USB combination keyboard, to the “Kbd” jack on the modem.



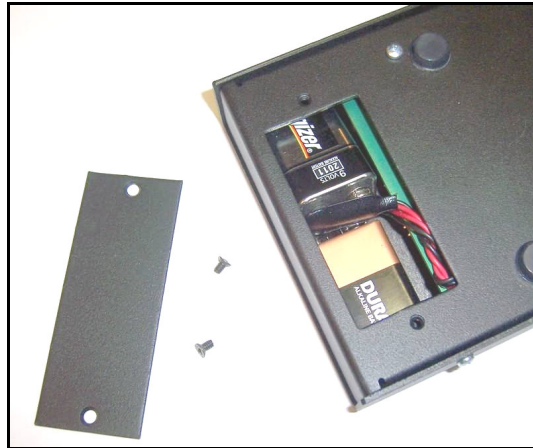
You are now ready to rock & roll using PSK31 ... read on and enjoy!

3) Specifications

- > Standalone, half-duplex modulator/demodulator for amateur radio digital mode communications
- > Handheld unit ... no PC required
- > Menus select operating modes, Squelch Thresh, PGA Gain, CW ID
- > 128 x 64 pixel graphic LCD displays audio signal spectrum 500 Hz to 2.5 kHz (with backlight)
- > Tx and Rx buffers and menuing system displayed in lower half of LCD using four 20-character lines of text
- > Tune controls modem position along audio spectrum
- > Modes currently supported: BPSK31, QPSK, QPSK reversed
- > External keyboard jack: 6-pin mini-DIN, PS2-compatible
- > Standard PS2-style or dual-mode USB/PS2 keyboard (user-supplied) provides text input for Tx entry, command/mode selection and modem frequency adjustment
- > Connection to SSB transceiver: 8-pin mini-DIN (audio in, audio out, PTT, power)
- > Powered by two internal 9V batteries (not included) or an externally-applied supply via 2.1mm coaxial jack
- > Power requirements: 9-18V DC. Current at 12V is 60 ma without backlight, 80mA with backlight. The current decreases as input voltage is increased.
- > Field reprogrammability of internal microcontroller to allow software updating in the field by the owner
- > Aluminum enclosure provides for rugged portable use while shielding transceiver from digital EMI
- > Enclosure dimensions: 7" x 4" x 1"
- > Single 3.75" x 5.25" pc board contains all components and connectors
- > Lightweight: < 1 lb with batteries.
- > Control for precise audio level control to transceiver
- > Cable assembly provided (plug and shielded cable) for connection to the SSB transceiver

4) Power

Install two standard 9V alkaline batteries in the battery compartment, or connect a 9 to 18 volt supply to the coaxial power connector (2.1mm) on the right end of the modem. The two 9V alkaline batteries nestle tightly against the pc board in the compartment. One battery lies flat and over to one side in the compartment, with the other battery sitting up at an angle with its connector overlapped with that of the first. The screw-on cover holds them firmly in place.



5) Signal Connections

Install a connector, or connectors, to the end of the cable which has an 8-pin mini-DIN connector. Most modern HF rigs have a mini-DIN Data or AUX connector which provides for PTT, fixed level audio from the receiver (independent of the volume control on the rig), and a line-level (approx 100mv rms) audio input to the transmitter. On the Yaesu FT-817/857/897 this connector is a 6-pin mini-DIN. On many Kenwood HF rigs there are 6-pin and 13 pin mini-DIN connectors that may be used. See Appendix A for wiring details.

6) Keyboard

The modem requires an AT/PS2 style keyboard for character entry. The keyboard also provides for entry and playback of macros. Use the 6-pin mini-DIN connector on the end of the modem to connect to the keyboard. A USB keyboard may be used if it has built-in PS2 support. Most USB keyboards that are *sold with a USB to PS2 adapter* will work, using the adapter.

7) Operation

Once you have the cable between the modem and the rig connected, keyboard attached, and power available, you are ready to operate PSK. But first, some additional setup may also be desired, as described next.

Turn on the modem. If the cabling between the rig and modem is wired correctly, you should see evidence of signals and/or noise on the top half of the display (the spectrum area). Tune your rig to one of the PSK sub-bands. These are typically 70 to 74 kHz above the lower band edge on 40 and 20 meters. If there is PSK activity on the band, you should see peaks on the graphic display. The horizontal location of the peaks corresponds to the audio frequency of each signal relative to the tuned frequency of the rig. For example, if the rig is tuned to 14070kHz, the display shows audio frequencies from 500Hz to 2500Hz, or actual RF frequencies from 14070.5 to 14072.5 kHz.

Now for the fun ... **tuning!** Turn the encoder clockwise, or counterclockwise, to move the cursor to a higher, or lower frequency. (The cursor is the small triangular icon just below the spectrum display.) The audio frequency is displayed when turning the encoder. Try to align the cursor with one of the peaks on the display. Don't worry if it is not exactly aligned. Once close to the peak, stop turning the encoder. The modem now attempts to "lock" onto the signal and fine-tune the frequency if needed. If the modem is able to lock onto a PSK signal, it will very shortly begin decoding the signal, and then display characters on the screen. The time it takes for decoded characters to appear depends on the ability of the modem to estimate the center frequency of the incoming signal, and the signal to noise ratio. Tuning can also be done with the arrow keys on the keyboard. The right and left arrow keys provide finer tuning, while the up and down arrow keys provide faster tuning. The tuning rate of the encoder on the modem can also be selected from a menu setting. Note: When tuning in receive mode, the spectral display is frozen - this is intentional.

Now on to **setup for transmission.** If you have a dummy load for your rig, connect it now.

Since PSK signals generated by the modem contain simultaneous multiple frequencies (over a very narrow bandwidth), it is imperative that the audio output from the modem not overdrive the input to the rig, or very poor signal quality will result. To facilitate setting the audio drive to the rig, a potentiometer on the modem may be used to adjust the level. In addition, the modem includes provision for "measuring" the position of the potentiometer, so that it can be easily reset to the same setting in the future. More on this later.

We have found that the best way to set up for PSK operation is to initially set up the transceiver for normal SSB operation, including whatever power setting you usually employ. For example, if you have a 100 watt PEP rig, set it up for 100 watts on SSB.

Switch to Digital mode (if your rig provides that option, otherwise retain the SSB mode).

Then press F8 on the keyboard. This places the modem in the TUNE state, which is denoted by "TUNE" at the top left of the display. The modem is now generating a continuous tone, which is fed to the audio input of the rig. The PTT signal from the

modem should also cause the transceiver to switch to Transmit. At this point, the potentiometer on the modem (just to the right of the display) can be adjusted to set the power level of the transceiver. A transmit power of 15 to 40 per cent of the rig's rated power is recommended. (i.e. 15 to 40 watts with a 100 watt rig). Keeping the power at this level does two things. First, it minimizes distortion due to clipping. Second, it avoids excessive heating in the rig finals, since PSK is a 100% duty cycle mode. A power meter is very handy for making this setting. Once the potentiometer has been set, press F8 again to return to receive mode.

You should now be ready for transmitting PSK.

Pressing F12 will place the modem in transmit mode, but with a PSK idle tone being generated (unlike the CW tone in TUNE). If you are ready to give it a try, Press F12. At this point, anything that you type on the keyboard, will be converted into Varicode characters and transmitted using PSK modulation. Pressing F12 again, will toggle back to receive. When in TX mode, "TX" will appear at the top left of the display.

8) Macros

If you want to set up macros (pre-recorded strings of characters for subsequent playback) before proceeding, now is a good time to do it.

For those already familiar with PSK operations, macro setup is very similar to many of the popular PSK programs. There are a few differences though. Some of the typing will be "blind"—not all of the input characters will be echoed to the display.

Macro recording is initiated by pressing Ctrl plus the function key that you want to be associated with your macro. For example to use F1 for calling CQ, press Ctrl + F1. Then begin typing "cq cq cq de ". Now enter Alt+M, press the space bar, enter Alt+M again, press the space bar again, enter Alt+M again, press the space bar, enter "K" and finally enter Ctrl+Q. (Omit the quotes during the typing). Now press F9 to store the macro. When this macro is played during transmission, by pressing function key F1, it will call CQ three times followed by your callsign 3 times, followed by "K", and then the modem will revert to receive. In the above, entering Alt+M, informs the modem that you want to insert your call sign into the transmit buffer. Entering Ctrl+Q, inserts a special character, that the modem recognizes as "quit transmitting and revert to receive". Each macro can contain up to 255 characters.

In order for the above macro to be able to insert your call sign, you must first record your call sign in the modem's EEPROM. This is done, while in receive mode, by typing your call sign and then pressing Ctrl+M.

You can also record the "other station's" call sign in RAM (not in nonvolatile EEPROM) by pressing Ctrl+T after first typing their call sign on the keyboard. To insert the other station's call sign into a macro, simply use Alt+T in the macro. Then, when you play the macro, the other station's call sign will be inserted into the macro. This way, whenever you enter a new call sign using Ctrl+T, you do not need to re-record the macro to use the new call sign.

9) Menus

Configuration of the modem is done through a menu system. For example, you can select between PSK, QPSK, and QPSK reversed. You can also change the software squelch setting, the gain of the programmable gain amplifier (PGA), turn CW Identification on or off, Turn the display backlight on or off, change the tuning “increment”, monitor battery voltage, or monitor the setting of the TX audio potentiometer. Other items may be added to the menu at a later time.

The menu system has two means of access. If you wish to access the menus using the keyboard, simply press F10 on the keyboard. Next enter a number on the keyboard corresponding to the submenu that you wish to access. Once this selection is made, choices for the submenu will be displayed. Another numeric entry will denote your selection. With the keyboard menu system, entering the submenu choice on the keyboard will cause an exit from the configuration menu.

The second method of menu access is through the “Select” button on the menu and the rotary encoder. Pressing and holding the Select button for more than ½ second will activate the menu system. When initially activated, the display will show “Configure” on one line, followed by “Exit” on the line below. If you wish to abort configuration, simply tap the Select button at this time. If, on the other hand, you wish to configure one of the modem settings, simply rotate the encoder clockwise, or counter clockwise, to cycle through the top level menu selection. Once you see an item that you wish to change, tap the Select button again. This will then allow you to cycle through a list of choices (again by rotating the encoder). When the choice you wish to make appears on the display, tap the Select button again. This will record your choice, and the menu will revert to the top level, showing “Exit” as the default choice. You can now make additional changes, or tap the Select button again to exit the Configuration menu.

See a useful list of available menus and hot key assignments on the next page.

Hot Keys

A number of “Hot Keys” have been defined for use with the modem:

F1 to F7 Play Macros

Ctrl-Fn Record Macros-- Enter keystrokes. When finished, Press F9.

Alt-Fn Delete Macro associated with Fn.

F8 Toggle TUNE mode. May be accessed only in RX or TX (Not in Setup, or Macro Recording.)

F11 Display the first few bytes stored in EEPROM.

F12 Toggle between RX and TX (again, not in Setup, or Macro Recording)

F10 Display the main Setup Screen. (Accessible only in RX mode)

A numeric selection from the Main Menu, selects a submenu, which is then displayed. Another numeric selection activates your selected parameter.

Ctrl-M Save keyboard entries into a fixed location in EEPROM (for recording “my callsign”, for use in Macros).

Ctrl-T Save keyboard entries into a RAM location (for recording “their callsign”—also for use in Macros).

Alt-M Insert “my callsign” into a Macro.

Alt-T Insert “their callsign” into a Macro.

Ctrl-F Save the current frequency into EEPROM so that it can be restored at the next power-up.

Alt-F Retrieve the saved frequency and makes it the current frequency.

Ctrl-Tab Displays the current frequency (audio)

Ctrl-A Enable AFC

Alt-A Disable AFC

PgUp Increase PGA gain

PgDn Decrease PGA gain

Ctrl-L Clears the text area of the LCD

Ctrl-K Clears the keyboard buffer. (While receiving, keystrokes are not displayed—this allows clearing the buffer, so that callsigns may be entered, or re-entered in case you think that you have entered the wrong callsign)

Ctrl-B Clears the internal buffers

Ctrl-Q Inserts a TX-OFF control character in the TX buffer, or Macro. (Toggles back to Rx mode when encountered in the string being transmitted.)

Ctrl-O Toggles the display backlight on and off.

Here is a useful combination of macros that you could construct:

F1 CQ

F2 Call “them” twice w/ toggle

F3 Call “them” once w/o toggle

F4 BTU

F5 73

F6 Brag File

F7 Test message

For your personal macros, choose whatever you want. You can create ones for contesting, or just for casual rag-chewing.

10) Updating Modem Software

Increasingly today, microcontrolled projects have an ability to be “field updated” with new features and software updates made available by the designers. So, instead of needing to send your instrument back for re-programming to get these new capabilities and bug fixes, you can simply download the latest-and-greatest software from the Internet and send it to the target hardware and the device automatically updates its internal memory with the new program. What a great way to keep your project completely up to date with the latest features!

We have incorporated this field updating capability into the NUE-PSK Digital Modem. You just need to connect your PC serial port to the modem using a simple adapter, and send it the new software obtained from the NUE-PSK website whenever new capabilities are made available.

We designed a TTL serial port into the modem, accessible via a 4-pin connector P4 located inside the battery compartment. Just connect your computer’s USB port to an inexpensive USB-to-TTL adapter such as the CP2102 from SparkFun⁹, plug it into P4 and run the Modem Loader program on the PC. Then pressing the Select button when turning the modem on will initiate the bootload sequence to “burn” the new software into the modem’s controller. Once you power-cycle the modem, you’ll be running the latest software release containing, for example, a new digital mode, some new I/O capabilities, and so on. This is really quite a convenient and powerful capability for the project.



Photo 10: CP2102 USB-to-TTL interface from SparkFun

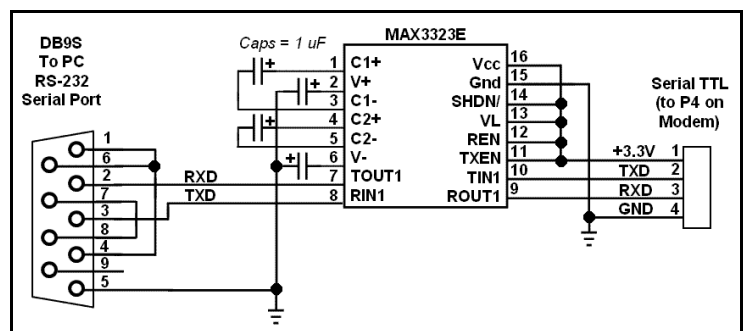


Figure 5: Schematic of an easy RS-232 interface to the NUE-PSK Digital Modem

To load new code into your modem, you will need to download the latest hex file from the NUE-PSK website (www.amqrp.org/kits/nue-psk).

A simplified procedure is as follows:

- 1) Connect the serial interface between the NUE-PSK modem programming port and the PC.
- 2) Open a Command Window on the PC.
- 3) From the command line, type the command to run PROG (the PC based bootloader software), but do not yet press <Enter>. The name of the hex file to be loaded will be included as part of the command, as shown by example here:

```
PROG -i com/x/ nuepsk_v5.hex
```

where x is the COM port on your PC, and **nuepsk_v5.hex** is the new program you downloaded from the web page.

- 4) Hold down the "Select" button on the Modem, while turning on the power switch.
- 5) Press the "Enter" key on the PC to execute the command.
- 6) Wait for the display on the PC to stop issuing progress indicators. The modem should now be reprogrammed and immediately start executing the new code.

A more detailed description is available on the AMQRP website, as is the PROG bootloader program for the PC.

11) Tips & Techniques, and “Things to Watch Out For”

Here is a real useful section that will undoubtedly grow in length over time. Please be sure to often check the NUE-PSK website for the latest online information.

- a) **Signal Level** – Setting the right drive level to your SSB rig is essential to success when operating the PSK31 mode. Please be sure to read the corresponding section on the NUE-PSK website containing lots of tips on this topic.
- b) **Inserting Plugs to the Modem** – You will want to be sure that you fully insert the Radio and Keyboard plugs into the connectors on the modem. Failure to do so could well result in unusual, intermittent or “noisy signal” symptoms during usage. When inserting, be sure to press firmly in the direction of insertion – do not “wiggle the plug while inserting. Same for unplugging – just pull it back firmly. (Care in this area will save the life of the connectors on the modem.)
- c) **Tune Control Sensitivity** – You will likely notice that the Tune dial seems a bit sensitive, and you might have some difficulty in dialing up some of the options in the Config menu of the modem. Rest assured that you can indeed dial up all the available options, but it might take a few retries to find the desired menu. (We will fix this in the next software release.)
- d) **Tap-Hold to Select Config** – As described elsewhere in this manual, you can get into the Configuration menu in order to make various settings in your modem. Config is entered by a press-and-hold of the Select pushbutton ... just press the pushbutton for about one second (say “one one thousand”) and release it to see the options that you can further select by rotating the Tune control. You can select any other operation or menu selection merely with a quick tap of Select.

- e) **Tx Audio Level Setting** – This menu selection in Config will show you the relative position of the mini-pot used for the control on the top of the modem. The control currently ranges from 0%-to-26%, or -60%, -125% or even -160%, etc. Don't worry about the specific number at this time, and we will make the readings more consistent from unit-to-unit in the next software release.
- f) **Spectrum Artifacts** – When viewing a moderately-strong signal at the midscale point on the modem's LCD spectrum (which corresponds to 1500 Hz), "noise" will also be seen on the far right and far left ends of the spectrum display. This is common and is an artifact of the DSP process of the signal, and it will occur even when viewing received signals a bit below or above the spectrum midpoint.
- g) **How We Tested the Modem (in part)** – Some might find this info helpful in testing their own modems. We had direct audio connections to a laptop running Digipan, with the audio in/out cables connected to the soundcard headphone/mic connectors, respectively. We then commanded the modem to transmit at 1500 Hz and viewed the classic two-tone "railroad track" signal on the Digipan waterfall display. Ensuring that the Digipan frequency (i.e., the red diamond) was centered on the tracks to ensure we were tuned to the modem's signal, we adjusted the Tx Audio level control fully counterclockwise to generate no signal, then increased it slowly in a clockwise direction while viewing the IMD reading on the Digipan window. We stopped turning the control when the IMD reading got to a -54 dB level, after which turning it further has no more effect. We found this level to be an ideal setting of the Tx Audio level delivered by the modem. Characters typed on the modem keyboard could then be seen on the Digipan receive window. We then turned the channel around (i.e., set Digipan to Tx and the modem to Rx), and saw on the modem display the characters typed into Digipan. [Note, you should follow the adjustment procedure elsewhere in this manual when connected to a radio.]

12) Technical Support

In case of questions or problems, feel free to send an email with your comments to the AmQRP Club at **nue-psk@amqrp.org**.

Be sure to also check the NUE-PSK website at **www.amqrp.org/kits/nue-psk** for the latest information, software availability and tips & techniques to make your digital mode operating experience enjoyable. This printed manual will be updated frequently with corrections and new capabilities presented in the current software, so be sure to always check out the website.

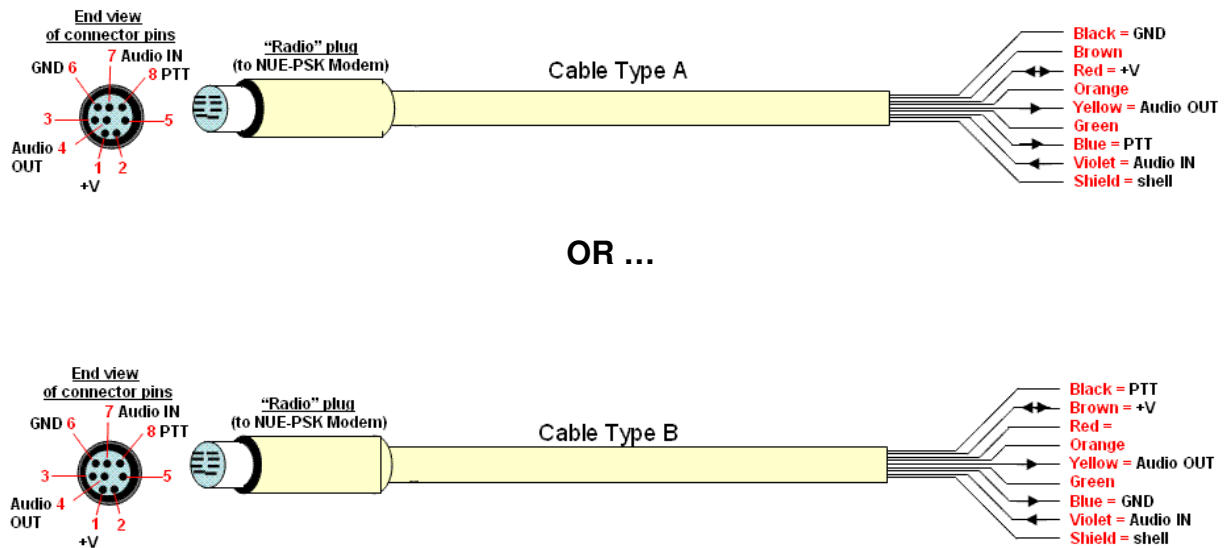
Another great source of information and camaraderie with fellow owners of the digital modem is the **NUE-PSK email reflector** on Yahoo Groups. If not already signed up for this great communication forum, go to www.yahogroups.com and search for the group called NUE-PSK. You can view all the messages posted there, and if you join (for free!), you will be able to post questions and comments yourself, as well as access the files in the group.

Appendix A: The Radio Cable

This diagram represents what is shipped with your NUE-PSK modem. Since the modem can interface with literally hundreds of different SSB transceivers, it will be necessary for you to connect the “unfinished end” of the Radio cable to properly interface with your specific radio. Once you have the proper connector in hand for your radio, the task is simple – just use the signal names and wire colors here as a guide to get the PTT signal and audio tones to your rig.

The cable supplied with the modem has color-coded wires on one end, either as shown in Figure A or in Figure B below. You will need to determine which type you have before attaching the connector required for the data connection to your specific radio.

You can easily determine which cable type you have by using a VOM to check for continuity from pin 8 on the molded Radio plug to the blue wire on the other end of the cable. If there is continuity, you have Cable Type A. Otherwise, with pin 8 continuity to the black wire, you have Cable Type B



To help owners get on the air as quickly as possible with their new modems, we have made certain custom cables available for purchase from the NUE-PSK website. If interested, see www.amqrp.org/kits/nue-psk for available options. We also have identified a resource you might call upon to help you make a custom cable for your radio, if desired.

Appendix B: Schematic

