
PSK31 The Easy Way

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SYNOPSIS:

This paper outlines the concept of PSK31, proposed by Peter Martinez, G3PLX, and suggests an easy approach to constructing a simple interface between an Amateur Radio transceiver and the average home computer. A general overview of PSK software is covered from installation and operation of this new mode of communicating on the HF bands.

The future of PSK is also discussed, and conclusions suggest that new innovations in transceiver design, together with the possibility of multi-tone dedicated PSK modems being introduced into the Amateur Radio marketplace early in the New Millennium.

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1. The Introduction

The average home computer is now well established in the Amateur Radio (AR) fraternity where assertive operators have devised easier ways of operating their equipment. Packet radio, RTTY, Logging and Control software now offer innovative ideas to keep track of information, and even turn the big beam antenna to coincide with the bearing of an entered callsign. DX tracking via Wormhole clusters, packet BBS nodes, and a massive increase in the use of the Internet has provided AR resources and research information, each uniquely leading to an explosion of information interchange enhancing the enjoyment of AR worldwide.

It has been many years since any “new modes” have been introduced. The more traditional CW, SSB, RTTY and specialised error detecting data modes, like Amtor (G3PLX), Pactor and Clover, have each added to the myriad of unusual “chirping” signals now heard on the international short wave AR bands.

However, with an increasing demand on the HF spectrum, and considering that most of the current modes of AR operation with the exception of CW are “spectrum hungry”, the need for a new AR communications system that is more efficient in spectrum occupancy has become vital for the continued expansion of the AR service.

Based on an idea by SP9VRC and developed by Peter Martinez, G3PLX (1) a new Amateur Mode called PSK31 is emerging. Instead of keying using Frequency Shift, FSK, this mode uses Phase Shift Keying, PSK. It uses an alphabet similar to Morse, which gives a text speed of about 50-wpm. Our experience to date shows that even without an error-correcting algorithm, copy is as good as any and better than most at low signal levels. It is a particularly attractive mode since it requires no lock condition or handshaking with a second radio station, and roundtable QSO's with more than two stations can be enjoyed (6).

Early experiments involved the use of a specialised PSK modem (4). Later, assertive AR operators wrote dedicated PSK computer programs (1) that exploited the digital sound conversion (DSP-CODEC) qualities of the average 16-bit computer sound card instead of acquiring an expensive and customised PSK modem. This concept, together with “freeware” PSK computer programs (7) has lead to a rapid worldwide expansion of PSK operation on the AR HF bands.

Already, the ARRL have approved claims for the first “All PSK” DXCC, and the British Amateur Radio Teledata Group (BARTG) have issued their first certificates to PSK operators, with 40 confirmed countries worked (4), in commemoration the 40th Anniversary of the BARTG. Even WAC using PSK is easily achievable in just one weekend of operation!

Today, 14Mhz is brisk with PSK traffic from all parts of the globe. Operators keyboard chat to each other in a similar manner to the more traditional RTTY contacts but with a considerably reduced bandwidth and enhanced signal to noise ratio. In fact, the bandwidth of PSK is narrower than keyed CW (1) and up to 60 PSK stations can operate within the usual spectrum occupied by a single SSB station. With all this in mind, PSK is well worth a look at by AR operators with a computer in their shack, and about one evening's work constructing a tiny interface from “junk box parts” connected between the transceiver and the computer.

2. Some Basic Theory

Peter Martinez, G3PLX (1) scanned normal text and compared the character usage with ASCII code for frequently used letters. A new binary code was then developed based upon his findings. From just 10 bits of binary code, all 128 ASCII characters were represented. Later, Peter extended this new code to include other accented characters for potential users in other countries. Naming the new code – **Varicode**, Peter established that with English text, Varicode had an average code length, including the ‘00’-letter gap, of 6.5 bits per character. By simulating random bit errors and counting the number of corrupted characters, Peter found that Varicode is 50% better than start-stop code (Eg. RTTY) and verified that its self-synchronising properties worked very well.

When idle, Varicode sends a continuous string of zeros, just like the “diddle” used in RTTY message gaps, and using a reasonable typing speed of 50 words per minute, requires a bit rate of 32 per second. 31.25 was chosen because it is easily derived from the 8kHz sample rate used by many DSP systems. To make things easier, the bit rate was rounded off to 31 and the new mode became known as PSK31. It works by using phase shift keying, but instead of keying the carrier on and off which is wasteful, Peter shifts the phase of the carrier by 180 degrees. The polarity of the carrier is changed, and when “shifted” in this way the resulting Varicode becomes BPSK or Binary Phase Shift Keying. Demodulation of BPSK starts with a narrow bandpass filter of 62.5 Hz at the 50dB-down points. When at idle, the 31.25 BPSK signal offers receive synchronisation making the process reliable at normal text rate (1).

The new PSK31 signal now comprises a very narrow, PSK signal at 31.25 bauds, about 50 words per minute and slightly slower than the more common RTTY signal running at 50 bauds or 66 words per minute. The “self synchronising” properties of PSK31, and its ability to occupy only a small bandwidth means that the receiving station can considerably reduce the receiver bandwidth hence improve the receive path signal to noise ratio (SNR). All this means lower transmit power, less interference to other users, more stations can be accommodated in the narrow allocations to the AR service, and better chances of working long haul DX in a busy part of the band. And lastly, the addition of a very exciting new mode of communications for Radio Amateurs around the world.

3. The System Requirements

The Internet now offers a large number of “freeware” PSK31 computer programs (9) including DOS based programs suitable for the older Intel 286 systems, through to higher level Window 95/98/00 32 bit operating systems running on faster Pentium III class machines.

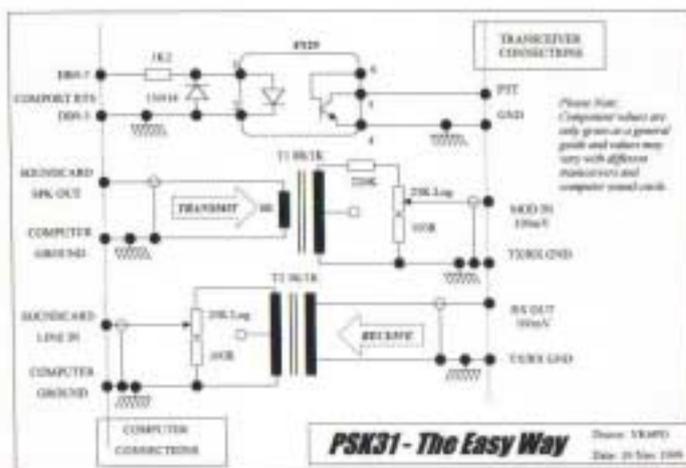
Assuming you have a just humble, recycled Intel 486-DX2, 50MHz computer (just like the writer!), with a minimum of 16 megabytes of RAM, a floppy disk drive, a good quality 16 bit sound card such as a SoundBlaster 16, and a spare communications (RS232) port – then you are in business. Windows 95, update 3 will work well on these machines provided you have a “clean system” with plenty of hard drive space available to experiment with different PSK and logging software when running your station.

4. Building the Interface Box

Linking the computer to your transceiver is the easy part, and an opportunity for you to do a little “home brew” in the process. For readers that just want to “try before you buy”, just connect the loudspeaker output from your transceiver to the line input of your sound card. Run your installed Windows sound mixer and select “Line In”. Run the software described in part 5 below and tune around 14.070 listening for a “warbling” sound. Vary the tuning to give an audible output of about 1kHz and you should see words appearing in the middle of the PSK software window. That’s it!

So, once you have listened, and watched the PSK31 QSO’s “warbling” around the world, and you’ve decided that you’d like to have a go, then turn to the back page of this paper for a detailed circuit diagram of how to build the interface box.

The interface box uses two transformers for DC isolation between your computer and the transceiver.



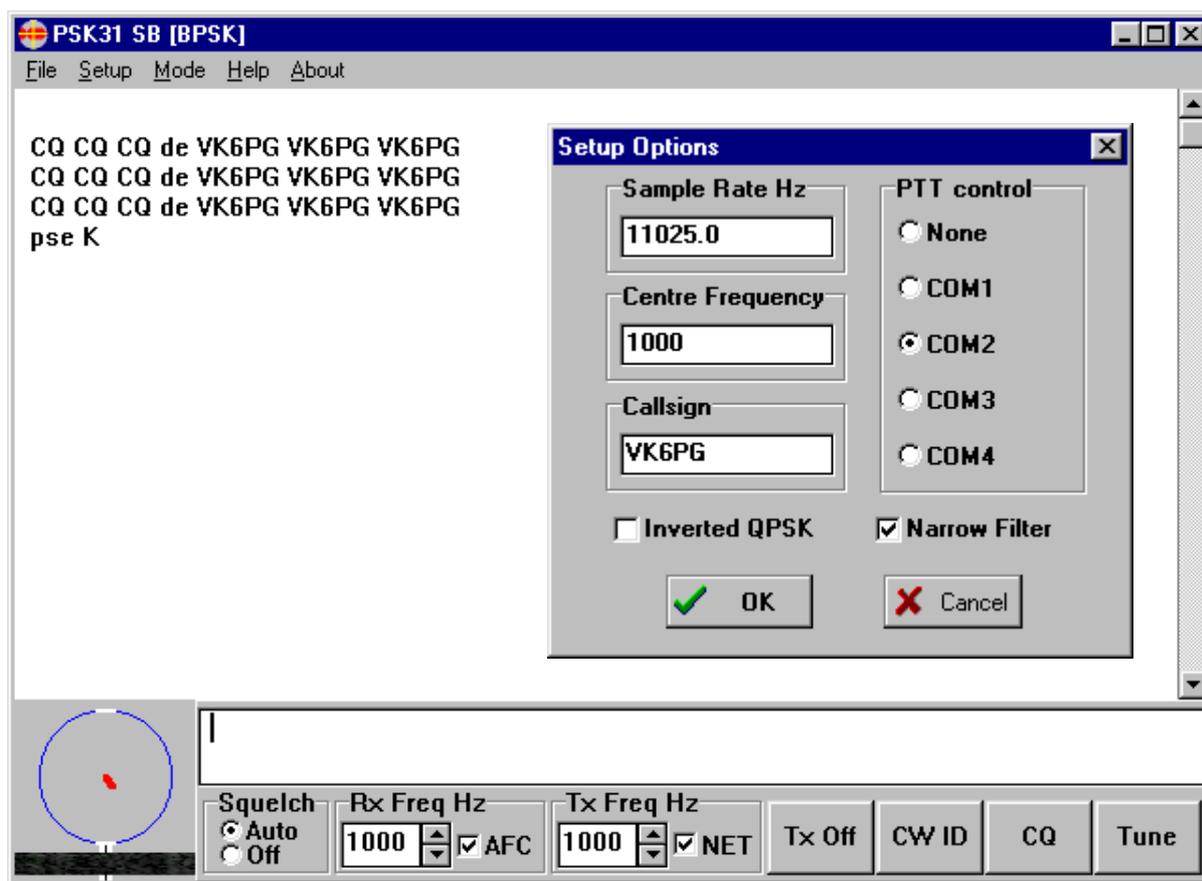
Two potentiometers allow optimisation adjustments of transmit and receive levels. Fixed resistors “pad” the circuitry to prevent transmit overdrive and receive soundcard distortion. The PTT circuit comes from WM2U, and offers excellent snappy PTT control with the advantage of total opto-isolation between the computer communications port and your transceiver. These techniques give you satisfaction that if any “funny business” happens between the computer and transceiver, then nothing will be damaged.

Do be prepared to make changes to the circuit to allow for the equipment variations used in your own shack. Perhaps you are lacking a line input and line output socket on your transceiver. In these circumstances the microphone-input socket might have to be used instead. In this case the input to the microphone socket must have an attenuator with a 100:1 gain reduction to avoid overdrive on transmit. If one of the pots seems to only work when stuck on one end of the rotation, then add/remove/change the values to give the correct levels in the center of the potentiometer. Once this is done, no further adjustments are needed.

The writer used a normal “plastic style” box, and carried the screened cables through into the box. Remember to use log pots, which can be pre-sets or panel mounted with shiny knobs for later twiddling and fine-tuning. On the rear of the box, the writer fixed a recessed DB9 connector, that can be connected to the computer comport with a standard DB9/DB25 data cable. A small 3.5mm jack socket was used for the sound in, and the sound out used an “RCA” phono socket to avoid accidental cable interchange when “grubbing” around the rear panels of the equipment. The writer has not experienced any problems with RF breakthrough interference, but should this happen in your case, try a few ferrite beads on all input and output leads. Rest easy in the knowledge that you don’t have to build power supplies for this little box! The opto-isolator is powered from the computer RTS line at the comport output.

5. The “Freeware” Software

Peter Martinez, G3PLX (2) designed a very simple PSK31 software package (shown below) that provides all the features needed in an operational AR station. To further promote experimentation of PSK31, Peter has offered the software free-of-charge (“Freeware”) to licensed AR operators’. Windows 95/98/00 compatible software is freely available on the Internet (9), in compressed format, with the filename – **p31sbw108.zip (179k)**. Simply install this file in a new folder called PSK, Unzip the file using WinZip and place all the files together in the one PSK folder. Place a PSK shortcut pointing to the file – **psk31sbw.exe** on your desktop and you are ready to open the program and run the setup.



From the screen view shown above, select the Setup menu to open the Setup Options dialogue box. Enter the sample rate at 11025.0 Hz, Centre Frequency at 1000, your own callsign, and the comport number for PTT access. Check the Narrow Filter radio button and close the box by “clicking” OK.

If you have a 16 bit sound card correctly installed on the computer and taken the mute off your loudspeakers then try “clicking” the CQ button. Your customised CQ will be heard in the speakers, the Phase Scope will display a green vertical line, and you should hear the characteristic “warble” of BPSK keying in the computer speakers. The large upper window will display each character when keyed by the software shown above. On completion, PSKSBW zero idles then automatically sends your callsign as a CW ident to complete your first “test transmission”.

Selecting Tune will place the software into idle with a PSK31 signal ready to feed into your transceiver. TX Off simply drops the keyed tone and signals the comport to release your PTT line dropping your transceiver to receive mode. If your tests have been successful thus far, you are now ready to connect the transceiver audio output to the soundcard line input to receive live PSK31 signals off air.

Remember that PSK31 is experimental, and most authors have their own opinions to setting up individual stations. The following extract by WM2U reviews some overall tips and hints:

The simplest and quickest computer to radio interface is to connect the Line Output from the Sound Card to the transceiver audio input with a 100:1 voltage divider to reduce the voltage output, and the Sound Card Line Input to the audio output of the radio. You can use the VOX to switch from Receive to Transmit. To setup this arrangement, adjust the sound card output level using the computer 'mixer' control until maximum transmit power is reached, and the ALC is just starting to read. Then tune to a strong carrier and adjust the soundcard-input gain until the red line goes away as observed on the spectrum display. (Waterfall indicator) This procedure is covered in great detail in the PSK31 Help files under "setting up the sound card" (6.)

WM2U's Hints List:

1. Set sound card sampling rate to 8000Hz
This must be at least a 16 bit sound card.
2. No Signal observed? Check WAVE slider is not zero.
3. Set Rx and Tx frequencies to 1000Hz.
NOTE: This value will get you up and running but if you plan on using a filter change it to the center frequency.
4. If using LSB check the "Inverted QPSK" .
5. Too much noise! Use a narrow CW filter.
6. Using a Word Processor, write your buffered messages and save them as .txt files, placing em! in a folder called 'buffers' created in the main PSK31 folder.
NOTE: This is NOT a form of type ahead buffer. It is simply a method to pre write 'Standard' messages hence saving you keyboarding time.
7. **READ THE HELP FILES.**
8. Your sound card output must NOT overdrive your Mic Input.
9. Do not overdrive the sound card input from the Radio.
10. Get used to the Waterfall/Phase indicators for tuning.
11. Do not use your Speech Processor.
12. Be patient. This is a new mode. You will not find all the features you are used to yet!

6. On the Air with PSK31

With the interface connected, and your transceiver connected to a dummy load, select the Tune button to activate the PTT line and send the PSK31 tone to your transceiver input. Turn down the transceiver microphone gain or disconnect the microphone altogether to avoid acoustic interference to the PSK31 signal. With audio compression switched off, adjust the power output to well below the ALC threshold and measure the output power of the transceiver. A good setting will be say 80 watts output from a 100 watt rated transmitter. This setting will ensure you are not overdriving the transmitter to a point where the transmit intermodulation products (IMD) are poor. This will give you a linear output with IMD figures in excess of 25dB or better.

Check that received PSK31 signals are clearly readable, and that the phase tuning indicator changes to yellow on received signals. When the tuning is "rocked" from side to side, PSK signals can be seen to move horizontally inside the Waterfall display below the phase scope loop. Signals will show up as pairs of white dots crawling slowly down the Waterfall, and fine-tuning allows centring the white dots on the graticule below the loop in the middle of the

Waterfall. It takes a little practice but your time will be well spent if you learn how to receive PSK31 signals **BEFORE** you start transmitting them. If your received level is too high into the sound card, horizontal red lines with suddenly appear in the waterfall. If this happens reduce the receive level pot at your interface to avoid overload.

Note that on a received signal, the software automatically “Nets” with the incoming signal and the RX Freq Hz display may change to say 885 Hz. Leave the RX Freq Hz AFC box ticked, and the TX Freq Hz at Net to allow the software to “track” and “net” with stations that you wish to communicate with. Next, try re-entering 1000 Hz to both boxes, move the tuning so that a PSK31 signal is heard and within the Waterfall but clear of the graticule. Move the mouse onto the white PSK spots in the waterfall and “click” the mouse. The software will “autotrack” the wanted signal in phase, in the graticule, and will display the receive text in the large upper window.

The waterfall displays about 250 Hz high and low from the optimised 1000 Hz setting, this gives a visual display of channel activity, interference problems, tuning accuracy and a time display that slowly ripples down the window. A very useful device once you get used to its unusual characteristics.

Lastly, try typing on your computer keyboard. The first character automatically switches the transceiver to transmit, sends a preamble of “00’s” and starts the transmission process. To return back to receive, just “click” the TX Off button. Once all this works to your satisfaction, signals can be simply resolved, and your transmissions are “clean and tidy”. Now comes your chance to find some DX and have fun with PSK31.

To streamline some of your own activities, try opening the Windows Notepad text editor and type in your own customised CQ file. Save the file as say **cq_psk.txt** and place the file in your PSK folder. Try another file for your “Rig Info”, another for your “Personal Info” and another for ... “Thanks for the contact. My QSL is fine via the Buro. 73’s de (Callsign) SK” with one hard return at the end of the message. When you try selecting File, Send File, the dialogue box opens your PSK folder and lists all the saved **.txt** files ready for selection. “Double click” your choice and PSKSBW automatically sends the file for you. To abort at any time just “click” the Abort button and resume your chatting on the keyboard.

Once a file is being transmitted, you can “click” on the CW ID button at any time. Once the file has been completed, PSKSBW will send your CW ID and drop back to receive automatically. This is a nice feature for contests and snappy DX operating on the HF bands.

The main International-calling frequencies suggested by the RSGB (6) are:

3780.150 7035.150 14.070.150 21080.150 and 28080.150

Other WARC band allocations are currently being negotiated with other mode users. However, the following frequencies should be also tried:

**3595.150 7037,150 10142.150 14.072.150 18102.150
21082.150 24082.150 and 28120.150**

Good luck and fine DXing.

Once you have enjoyed your first PSK31 experiences, the time will soon come when you feel the need to improve your receive capabilities by adding audio DSP filters to minimise white noise and include additional narrow transceiver receive filters. Just like any other mode, PSK31 is still vulnerable to adjacent channel interference. Tuning has to be very precise, and within a few Hertz to capture signal acquisition successfully.

The writer uses an Icom IC756 transceiver with a Timewave DSP9 to minimise noise and gain some degree of digital filtering. The IF bandwidth on the IC756 is reduced by operating the radio passband controls to prevent adjacent channel QRM from desensitising the receiver when trying to read PSK signals. It's rather like visualising the channel, and making adjustments according to band conditions at the time.

One writer (8) suggests that all these techniques are valid, including fitting a narrow CW filter and programming the receiver to "think" that it has an SSB filter in the IF chain. To do this, the PSK tone has to be shifted to 1200 Hz placing further demands on other devices like the audio DSP device. These are all techniques currently being explored to enhance the already exceptional qualities of PSK31.

The future of PSK looks very bright indeed ...

7. The Future of PSK

New developments in PSK (4 & 5) operations include digital, multi-channel telephony with 60 simultaneous PSK signals all within the spectral occupancy of existing SSB transmissions. Military users have been well practiced in the use of PSK for a number of years now, and the mode is well equipped with encryption technology for national security and commercial confidentiality. Specialised PSK development kits (2. Motorola DSP56002EVM by G3PLX) can be used in AR communications, and in digital telephone and satellite applications. Even the principles of the forthcoming digital television systems rely on PSK for minimising spectrum occupancy.

However, the simple concept of BPSK suggested in this paper is just the dawning of developments to come. Being a part of this euphoria is exciting and fun, yet economic to the average Radio Amateur who just likes to "fiddle" with new things or just aims for a DXCC on PSK31! AR commercial equipment designers and developers have yet to include PSK options with their equipment. But if they start thinking harder on how the digital programming options can be expanded to include these new mode configurations, then we are all in for an interesting New Millennium.

8. The Summary

This paper has been compiled because the writer would like to "give back" a little something to a hobby that has been much loved for almost half a century. This was earlier done with RTTY in the 70's, but with PSK the time is right to try conserve valuable spectrum space and to improve the resolution ability of communications for the benefit of all Radio Amateurs.

Why don't you give it a try?

The writer would like to commend the contributors listed in the reference section of this paper. They not only have demonstrated their own skills and prepared to share them with other AR operators, but also taken the time to write about their findings that we can all learn from their experiences.

9. Attachment

1. Circuit diagram of a simple PSK interface box

10. References

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