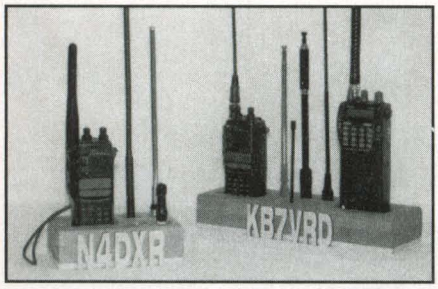
from the button and attach it the backside of your item. Then slide your belt through your clip with the spring and hole facing out. Next, push to click and push the clip slide off. Cost is $9.95 plus $3.95 S/H from Quick Draw Clip Systems, Inc., 4869 McGrath St., Ventura, CA 93003-7767; Phone: (805) 6440-6888; Fax: (805) 644-7320.

Circle 104 on reader service card

Shack Attack License Plaques

Shack Attack offers callsign license plaques that meet FCC license display requirements. The plaques are handcrafted and hand-finished from dark alder wood, finished with a polyurethane gloss, and measure 7 1/4 x 12 inches with 2-inch callsign letters inset. They also include a 5 x 7-inch clear Plexiglas cover and mounting hardware. The Callsign License Plaque is $21.95 plus $4.00 S/H. Plaque upgrade packs (with letters for your new call) are $3.00 and may be ordered by calling (801) 225-3340.

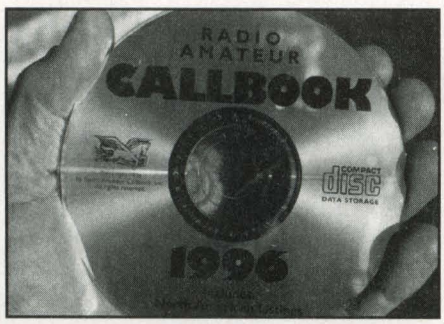


Shack Attack also offers the "Handie Station" storage system for handheld radios ($19.95), and the Desktop Callsign ($9.00). For information, contact Shack Attack, 51 W. Center St., Box 325, Orem, UT 84057-5903; e-mail <kb7vrd@aol.com> or <WWW.VCNET.COM/ SA>.

Circle 105 on reader service card

Radio Amateur Callbook CD-ROM, Version 2

Version 2 of the Radio Amateur Callbook CD-ROM is now available. An improved print program allows for multiple entries to customize a mailing label or logging format, giving contesters double-duty operation in recording callsigns and automatically printing customized fields for labels or QSL addressing. Birth dates are now available, and countries are an active part of the foreign program. Version 2 also contains a QSL manager database along with the existing bureau list.



Version 2 of the Radio Amateur Callbook on CD-ROM sells at the same price as Version 1 (suggested retail, $49.95). You can order through your local ham radio dealer, or for more information, contact Radio Amateur Callbook, Inc., 1695 Oak Street, Lakewood, NJ 08701; Phone: (908) 363-5679; Fax: (908) 363-0338; orders only: (800) 278-8477.

Circle 106 on reader service card

Ham Radio Paging: Putting "POCSAG" on Packet

Why pay monthly fees for non-business paging services when your TNC can do the job for you?

By Phil Anderson, WØXI*

The weather is bad and you know your emergency group may be called up at any time, but you can't keep your HT turned on while you're at work. Or you're the repeater trustee "on call" in case anything goes wrong, but your job takes you from place to place.

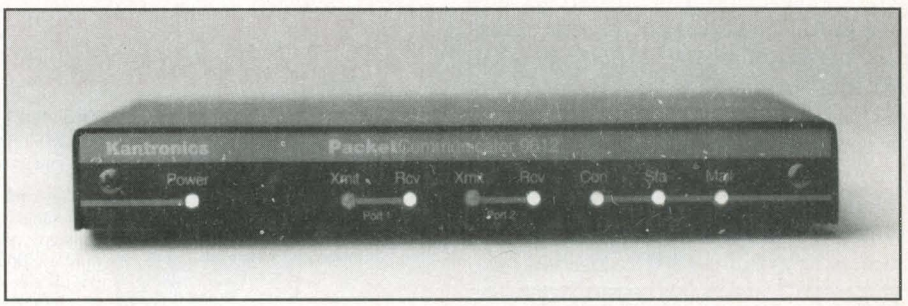
In both of these scenarios, a pager would be just the thing to help you keep in touch. But a paging service is expensive, especially if you want to equip a whole group with them. Unless, of course, you do your own paging...via ham radio.

While attending the "Wireless World" conference last December in San Francisco, I managed to take in the sessions on paging. I was curious about two-way paging and the future of paging, both of which were advertised session topics.

Once the discussions got under way, I couldn't help thinking about the similarities between paging and 9,600-baud packet. Both use frequency shift keying (FSK) modulation and a synchronous data format with check bits for error detection.

Once home, I obtained a copy of the International Radio Consultative Committee's (CCIR) Radiopaging Code No. 1 Recommendation (R-584-1), more commonly known as the Post Office Code Standardization Advisory Group (POCSAG) code. I examined that standard, thought about how to implement it in hardware, and outlined some experiments to try POCSAG paging on the 2 meter band.

After checking appropriate sections of Part 97 and running the experiments, Michael Huslig, KBØNYK, Karl Medcalf, WK5M, and I succeeded in porting the POCSAG code into our Kantronics KPC-9612™ packet TNC. After some debugging, we had proof of concept: paging from bench to bench using a laptop computer, the TNC as POCSAG encoder, a Kenwood TM-251A with a dummy load, and Motorola Bravo Plus™ pagers recrystalled to 2 meters.



The KPC-9612 TNC is the centerpiece of Kantronics' packet paging system, with the latest release of the 9612 firmware supporting the mode. A personal computer may also be used to encode pager messages.

With the prototype system working, two exciting amateur paging applications came to mind: paging in emergency situations and paging coupled with our packet radio system. Two unplanned benefits also emerged: the TNC as a paging encoder to test/recrystal pagers and the realization that inexpensive pager receivers can be converted for other uses. We hoped, too, that paging technology would add some more excitement to our hobby, and would get a few folks back into tinkering with their signal generators and oscilloscopes to "put those used pagers on frequency."

Commercial Paging Systems

I'm assuming you're familiar with pagers but not with how complete paging systems work. So, let's examine how a typical commercial system is structured and then we can compare that with our prototype system and imagine how amateur systems might be constructed.

A typical commercial paging system consists of the public telephone system, a local control system (paging terminal), several radio transmitters, and many individual pagers. The control systems and transmitter sites are strategically placed

Table 1. Frequency Bands Used by Pagers

Paging Band	Frequency Range
VHF low band	33-50 MHz
VHF high band	138-175 MHz
UHF	406-422 MHz
UHF high	435-512 MHz
'900' band	929-932 MHz

Note that pager frequencies are interspersed among other services, including our own 2-meter and 70-centimeter bands.

* *Phil Anderson, WØXI, is the President of Kantronics Co., Inc. He currently lives in Lawrence, Kansas.*

Table 2. POCSAG Signal Format

Preamble	Batch 1 Codewords	Batch 2 Codewords	Batch 3...
1010101010.....	SC+16 codewords	SC+16 codewords	and so on....

The format of the POCSAG paging code is similar to AX.25 packet. See text for explanation of what it all means.

so that the system's operating area is "covered" with an RF signal strong enough to reach each pager.

When you purchase a pager from a paging provider, they'll make sure your pager's receiver is set for their paging transmitter's frequency and they'll assign an ID (called a *capcode*) and phone number to the pager. Then, when a page phone number is dialed, the page control system matches the phone number with the ID, prompts the caller for a message (which the caller enters using a Touch-Tone® phone), and sends the page message to the transmitter.

Pagers: Four Types, Five Bands

Pagers developed since 1978 are one of four types: tone, numeric, alphanumeric, or voice. The vast majority sold today are numeric. Most are also crystal-controlled. While synthesized pagers have been developed in recent years, crystal-based pagers remain the favorite, perhaps because of price and battery life. Pagers are readily available for the VHF Low, VHF High, UHF, UHF High and 900-MHz bands and have been produced in the millions (see Table 1).

The transmission format of the POCSAG signal is similar to that of 9,600-baud packet radio: frequency shift keying (FSK) modulation at 4.5-kHz deviation. That fact led us to realize that paging could be adapted for use with our KPC-9612 and "data ready" radio equipment already at hand.

The packet-like format of the digital paging code is a preamble of 576 bits—alternating 1s and 0s—followed by one or more batches of *message codewords* (see Table 2). Each batch consists of a 32-bit *synchronization codeword* (SC) followed by eight frames of 64 bits each, each frame consisting of two codewords. Codewords are defined as *synchronization, idle, address, and data*. The format for the data codeword differs slightly from the rest, but all contain 10 check bits for error detection and correction. A full description of the POCSAG code can be found in CCIR Recommendation R-584-1 or in the *Pager Handbook for the Radio Amateur* (see References).

The transmission rate for POCSAG is either 512, 1,200 or 2,400 baud. These rates and the defined format of the code determine the shortest durations possible for a page transmission at a given baud rate. Examples for various baud rates appear in Table 3.

Amateur Paging Systems

Like the commercial systems, an amateur system must consist of a paging signal encoder, a transmitter, and pagers. Encoding, of course, can be carried out by a PC or a TNC, and we chose to port our code into the KPC-9612. We did this for several reasons: 1) because the TNC is easily located remotely; 2) because a packet connection (for paging) can be easily accommodated; and 3) because, unlike typical AFSK 1,200-baud or 9,600-baud G3RUH-type packet modems, the integrated circuit modem in the KPC-9612's port 2 can accommodate the POCSAG signalling format.

To make it as easy as possible for amateurs to experiment with packet paging, our firmware upgrade version 7.0 for the KPC-9612 includes the functions of digital paging transmission and monitoring of 512-, 1,200-, 2,400-baud numeric and alphanumeric messages based on the POCSAG standard. Pages are sent by entering an ID (capcode) and message for a pager, using the PAGE command. For example, assume my pager's capcode number is 0111222 and your call-back number is 555-1212, you'd enter (at the **cmd:** prompt) **PAGE 0111222 555-1212**. Note that the paging message doesn't have to be a phone number. It can be any string of numbers, such as a repeater frequency, so you could type **PAGE 011222 147060** if you wanted me to contact you on 147.060 MHz.

Our firmware upgrade also includes a paging server (PS), similar to a packet mailbox, enabling paging to "callsigns" with an entry in a page directory via a

Finding Pagers for Your Club

You have three choices for obtaining pagers: 1) buy one already crystalled for amateur use by an amateur company (see below); 2) buy a new commercial pager (without service) from a reputable dealer; or 3) buy a used pager—either from a dealer or at a hamfest—and convert it.

Buying a commercial pager, either new or used, is a real option. Select one that's already crystalled for 148.6–152 or 152–159 MHz for 2-meter use, or 450–465 MHz for 70-centimeter operation, and recrystal it. Be cautious, though; not all pagers will take a retune.

For the convenience of hams who don't want to go the recrystalling route, Kantronics will be selling refurbished Motorola pagers already set up on one of several amateur frequencies. Motorola Bravo Plus, Bravo Classic, and Lifestyle Plus pagers will be available through Kantronics, crystalled for any one of the following frequencies: 145.070, 145.090, 145.630, 145.670, 145.730, 145.770, 149.895 (CAP), 441.000, 441.075, and 446.150 MHz. Crystals for these frequencies will also be available separately, and other frequencies may be added if there is demand for them.

Table 3. POCSAG Transmission Rates

Baud Rate	Preamble (sec)	One Message Batch	Total Duration
512	1.125	1.0625	2.1875
1,200	0.480	0.4530	0.9330
2,400	0.240	0.2270	0.4670

Table 4. Bravo Plus Receiver Boards for VHF Operation

Frequency Range (MHz)	Motorola Model #
138-143	AARD4050A
138-143	NRD7211A,B
143-148.6	AARD4051A
143-148.6	NRD7212A,B
148.6-152	AARD4052A
148.6-152	NRD7213A,B
152-159	AARD4053A

Motorola Bravo Plus pagers use different receiver boards for different band segments, even within a particular band (VHF High, in this case). One of their 143–148.6-MHz boards is ideal for recrystalling to a 2-meter ham frequency. UHF high-band boards may be recrystalled for use on 435–450 MHz.

packet connect to MYPAGE at either 1,200 or 9,600 baud.

Transmitting

As noted above, the POCSAG standard calls for a paging transmission with 4.5-kHz FSK at 512-, 1,200-, or 2,400-baud. To accomplish this, a transmitter capable of handling audio with a frequency content as low as 20 to 50 Hz is required. Some of the "9,600 data ready" radios meet this specification.

Why is the frequency content so low? The reason is two-fold: the FSK modulation and the absence of any bit-stuffing or data-scrambling defined for the POCSAG code. If a string of 1s is called for in the data, the carrier is shifted up by 4.5 kHz and held there. In addition, if a numeric page is sent that contains a large number of 0s (in a phone number such as 842-1000, for example), then 15 "0" bits will be sent in a row. The transmitter simply must be able to handle these strings. (*See the "Digital Data Link" column in the March and April, 1996, issues of* CQ VHF *for discussion of 9,600-baud data radios.—ed.)*

Receiving

You have two choices for receiving pages: use the TNC in monitor mode or recrystal a pager for your club's chosen paging frequency. Most pagers can be recrystalled to another frequency, assuming they were manufactured for the band segment in which you wish to operate. A listing of Bravo Plus receiver boards for VHF operation (Table 4) is typical. The 143–148.6-MHz boards are suitable for a crystal change to a frequency within the 2-meter band. We've also converted some from the higher band segments, such as 152–159 MHz.

Putting Packet Paging to Work

Our club paging system consists of a Kenwood TM-251, a KPC-9612 with version 7.0 firmware, a batch of Bravo Plus pagers recrystalled for our local frequen-

But Is It Legal?

A careful reading of Part 97 of the FCC rules makes it clear that paging is lawful for amateur radio operators—even useful. See Part 97 sections 97.3(a)(10), 97.111(b)(2), 97.305(c) and 97.307(f)(5).

Don't confuse one-way transmissions with "broadcasting"—meaning commercial broadcasting. One-way transmissions are made every day by amateurs to establish communication with other amateurs, often using one mode to establish contact in another mode.

The rules also state that unspecified protocols/codes may be used for communications on 50 MHz and above, as long as they are not transmitted for the purpose of obscuring the meaning of any communication.

Station identification remains a requirement; therefore, we recommend that a CW ID at 15 wpm be sent following each page or set of pages transmitted.

cy, and a dual-band Diamond antenna on the roof at 30 feet. The system is housed in the center of a 20,000-square-foot metal building. With a transmission power of 5 watts, we can activate pagers stored in a metal cabinet in the middle of the building. Plus, we can beep other amateurs living five miles away. Our local commercial provider, located five miles from us, uses a 100-watt transmitter with an antenna at 100 feet. Their signal easily penetrates our metal structure—even to the center of the building—and has no trouble activating my commercial pager.

So there you have it, a new mode to experiment with. If you're interested in emergency communications or remote control of equipment, then digital paging just might be for you. We can picture paging messages reaching emergency workers via one, two, or even three nodes when the commercial phone and (hence) paging systems are down.

The challenge now, it seems to us, is to take this technology and make use of it alongside existing systems, particularly packet radio. ■

To Learn More

For more information on paging and paging standards, we recommend the following:

"Digital Paging and the Paging Server," KPC-9612 Manual Addendum, version 7.0, Kantronics Inc., March 27, 1996

"Radiopaging Code No. 1 (POCSAG)," CCIR Recommendation R-584-1

Pager Handbook for the Radio Amateur, Anderson, Phil, WØXI, Lawrence, KS 66046, 1996

"150 MHz Receivers," Ludvigson, David, *Mobile Radio Technology* (MRT), September, 1994

"406-512 MHz Receivers," Ludvigson, David, MRT, August 1994

"Four Technologies Compete to Meet Pager Specifications," Sharpe, A.K., MRT, September, 1988

"Why RPC1 (POCSAG) Is the International Standard," Tridgell, R.H., MRT, January, 1988

Resources

Crystals may be ordered from any of several sources, including:

Crystronics, 2400 E. Commercial Blvd., Suite 360, Ft. Lauderdale, FL 33308; Fax: (305) 776-0109

Pagecorp Industries, 366 San Miguel Dr., Suite 211, Newport Beach, CA 92660; Fax: (714) 721-1030

KPC-9612 TNC: Kantronics, 1202 E. 23rd St., Lawrence, KS 66059; Phone: (913) 842-7745; Fax: (913) 842-2031; Internet: <http://www.kantronics.com>

Pagers (see "Finding Pagers for Your Club")

Predicting Sporadic-E Openings on 6 Meters

E-skip may be sporadic, but WB2AMU says that doesn't mean it occurs at random. Ken shares his latest research with us here.

By Ken Neubeck, WB2AMU*

For a number of years, Sporadic-E propagation has been viewed by some hams as a mysterious, randomly-occurring phenomenon. While most users of 10 and 6 meters know that Sporadic-E, sometimes known as "short skip" or "Es," occurs a lot during the summer months and occasionally during the rest of the year, it's only in recent years that information has been collected on its basic annual pattern.

Sporadic-E takes place in the E region of the ionosphere and is essentially caused by a cloud of metallic particles of sufficient density to reflect radio signals. Scientists believe that the metallic particles are of meteoric origin, although other sources, such as the sun, cannot be ruled out. While its exact nature is still enigmatic, it's not really the random phenomenon that many hams think it is! Through the collection of scientific ionosonde data and amateur radio observations, we can see a basic pattern that repeats itself from year to year with minimal variation. (An *ionosonde* is a radio station used by scientists to study Sporadic-E. See "Hams and Research," below, for an explanation of how it works.)

What is particularly amazing about the Sporadic-E phenomenon is that it follows a unique yearly pattern for many locations in the mid-latitude ranges of the Earth where the temperate zones are.

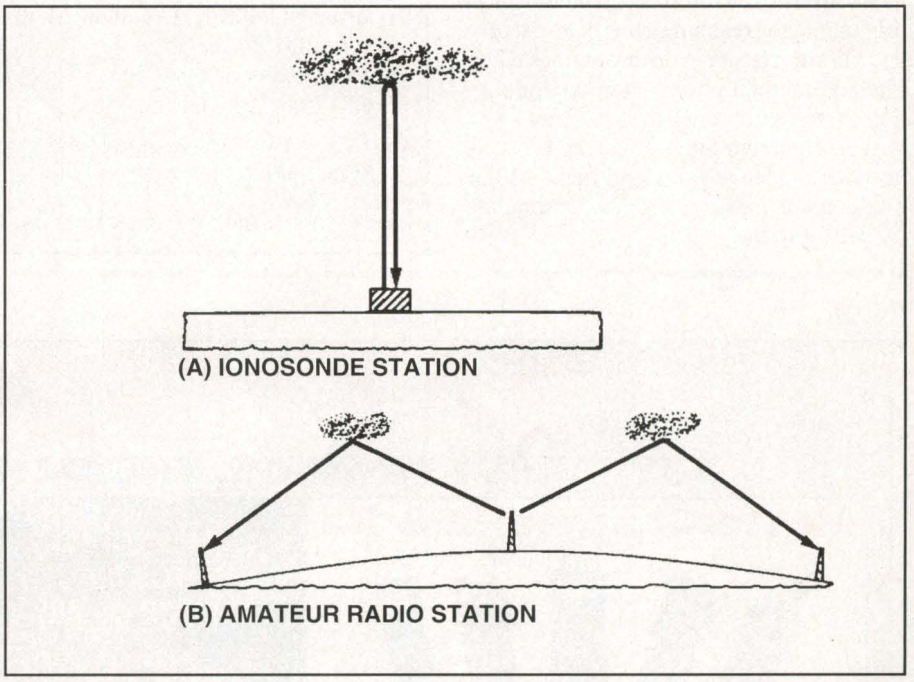


Figure 1. The difference between how an ionosonde station and an amateur radio station detect Sporadic-E propagation. See text for explanation.

A Basic Pattern

Hams who live in the northern temperate zone, which includes all of the United States, Mexico, and the lower half of Canada, have observed the following basic yearly pattern for Sporadic-E on the 6- and 10-meter bands:

1) Major activity occurs during the summer months from May through early August, with the peak occurring around the time of the June solstice.

2) There's a minor season of winter activity, from November through January, with the peak occurring around the time of the December solstice.

3) A minor valley exists during the fall equinox, when there may be some very scattered activity on 10 and 6 during early September and late October.

4) A major valley occurs during the spring equinox, when there is very little activity on 10 and none on 6 meters. In fact, March is the worst month for Sporadic-E activity on 6 meters for hams in North America, whereas September is the

"...it's helpful to draw on both the experiences of radio amateurs and actual scientific data...."

* *Ken Neubeck, WB2AMU, is a regular contributor to* CQ VHF *and author of* Six Meters: A Guide to the Magic Band.