EASY POCSAG SIGNAL DECODER

Learn how alpha-numeric pagers receive messages with this simple interface and computer software.

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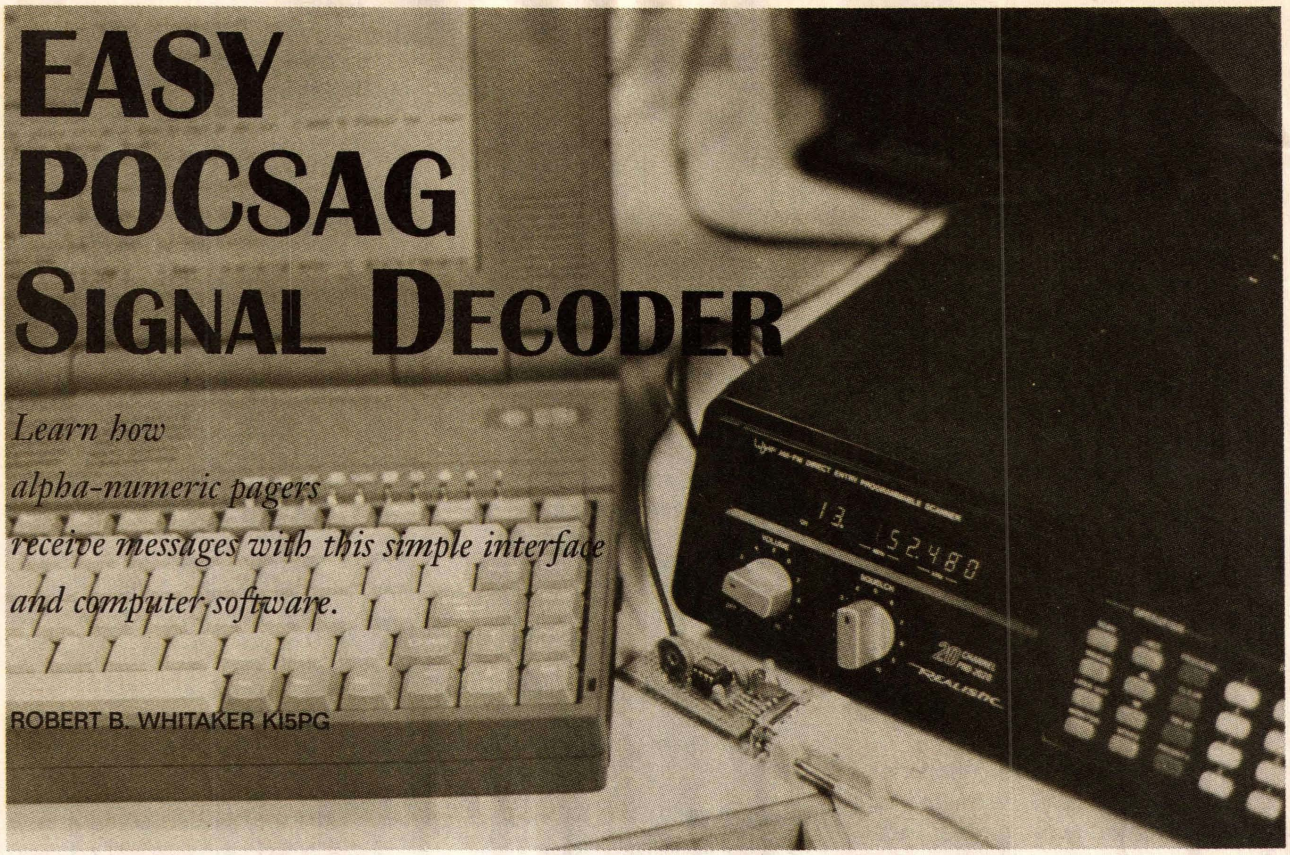

Have you ever thought about how those alpha-numeric pagers work? Have you heard erratic buzzing and beeping digital signals while scanning across the VHF or UHF bands? Message services for small, portable pagers have become as widespread as cellular telephones.

But is it possible to decode the pager messages flying around the airwaves? It is easy to do from a technical point of view, but the information contained in the radio signals is a completely different matter from a legal point of view. The willful intercepting a non-broadcast-type signal meant for private communication other than a tone-only signal is a violation of law and carries the same penalty and criminal status as intercepting cellular-telephone calls.

That said, a scanner, a simple interface circuit, a personal computer, and a shareware program available through the Internet are all you need to set up your own pager-signal monitor. The monitor described here will decode 512-, 1200-, and 2400-baud data streams. An additional feature of the software is that it can be configured to only decode signals sent to your own pager or a pager for which you have permission from the owner to receive. If the monitor is used solely on ham bands for monitoring ham pagers, any legal limitation might not apply. To be safe, always check with a legal advisor before using the decoder in your area.

What is POCSAG? POCSAG stands for Post Office Code Standardization Advisory Group. That advisory group has established the standard signal code and transmission protocols now in use by the vast majority of pager services. POCSAG is sent by frequency-shift keying (FSK) an FM-carrier wave at ± 4.5 kHz. A list of commonly-used frequencies for POCSAG signals are shown in Table 1. Check with your pager service to find the actual frequency they use.

The decoder will work with regular speaker audio from an external speaker jack or headphone jack, but will work much more reliably with raw de-emphasized audio taken directly from the discriminator of the receiver or scanner. Scanners or radios that are 9600-packet ready should be useable without any further modifications. Other scanners or radios that don't have an audio or discriminator out-

WARNING!

Please note that unauthorized electronic communications interception is illegal under Federal and State Law. In addition Federal law renders illegal the intentional manufacturing, assembling, possessing or selling of any electronic, mechanical or other device, knowing or having reason to know that the design of such device renders it primarily useful for the purpose of surreptitious interception of oral or electronic communications. Federal law imposes both civil and criminal penalties for violations of the applicable statutes. Thus, the use of the POCSAG Signal Decoder described in this article is intended for and should be restricted to educational, scientific and/or informational purposes. This is not intended to constitute legal advice and readers are advised to obtain independent advice as to the propriety of their use thereof based upon their individual circumstances and jurisdictions.

Mod Box as a battery-powered floor unit, using a push-on push-off switch to enable and disable the effect. Bass players will no doubt want to boost the low-end response and probably won't need the balanced output connector. Keyboardists and studio musicians might prefer a rack-mounted version with all of the bells and whistles tossed in.

Once you've decided upon a configuration, gather together the required parts. None of these should be hard to find or expensive. While a hand-wired perfboard approach might be possible, a printed-circuit board will give the neatest and most stable results. You can etch a board yourself using the supplied pattern. The parts-placement guide in Fig. 2 is based on the printed-circuit pattern. An etched, drilled and tinned circuit board as well as a kit of parts are available from the source given in the Parts List.

The Mod Box is a straightforward circuit to build, but it is essential that it be built as neatly as possible. Since there are some high gains involved, sloppy workmanship could spoil its operation with spurious oscillation, hiss, and hum. As a general rule of thumb, keep the inputs away from the outputs, and if any wire from the circuit board to the front panel is longer than 6 inches, use shielded cable. To avoid ground loops, which can lead to serious hum problems, be certain the shield is grounded on one end only.

Some obvious tips when building the Mod Box include being careful to observe the orientations of the polarized devices like the diodes, IC, and electrolytic capacitors. Remember that some of the component locations on the board might be left empty depending on the modifications you decide to use. Note that C4, C6, and C11 mount behind potentiometers R21, R23, and R22 respectively—not on the printed-circuit board.

What sort of enclosure will you need? If you plan on using the Mod Box on stage, then a sloped-face floor box made of $^1/_{16}$-inch steel is perhaps best. A floor unit should have the DPDT push-push switch mounted in a central location. That lets the guitarist or bassist punch in the effect with a stomp of the foot. That is why effects boxes geared toward stage performance are sometimes referred to as "stomp" boxes. With that type of enclosure, the PC board is mounted on the bottom of the box with some small nuts and screws. A thin piece of insulating foam underneath keeps the board from shorting out against the metal cabinet.

Another possibility is a rack mounted version. The front panel can be made of $^1/_8$-inch aluminum stock, with the industry standard dimensions of 1-$^3/_4$ × 19 inches. After cutting and drilling the panel, it can be given a coat of colorful epoxy paint and labels applied to the controls. One method for creating labels is a laser printer or copy machine and either self-stick labels or clear label material with a peel-off backing.

Once the Mod Box has been built and power applied, patch an instrument into J1 and connect the desired output (J2, J3, or J4) to an audio amplifier. To avoid any ear-splitting surprises, keep the volume low initially.

Making Music With The Mod Box. This description assumes that a guitar is being used, although the following comments apply similarly to other instruments. Set S1 to the Clean position, set the Low, Mid and High controls to their center positions, and the Volume control low. The Drive control has no effect when the

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PARTS LIST FOR THE MOD BOX

SEMICONDUCTORS

IC1—TL074 quad op-amp, integrated circuit
D1, D2—1N4001 silicon diode
D3-D5—1N34A or 1N60 germanium diode

RESISTORS

(All resistors are $^1/_8$-watt, 5% units, unless otherwise noted.)
R1—100-ohm
R2, R3—470-ohm
R4—1,000-ohm
R5, R6—1,800-ohm
R7—2,200-ohm
R8, R9—3,300-ohm
R10-R13—10,000-ohm
R14—10,000-ohm potentiometer, audio taper
R15-R17—12,000-ohm
R18, R19—22,000-ohm
R20—100,000-ohm
R21—100,000-ohm potentiometer, audio taper
R22, R23—100,000-ohm potentiometer, linear taper
R24—500,000-ohn potentiometer, linear taper

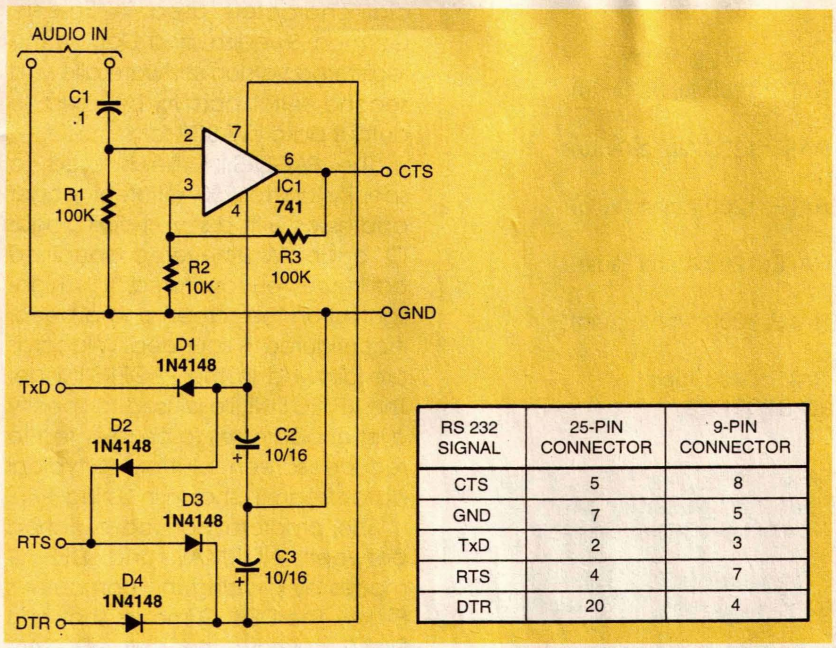
CAPACITORS

C1-C3—10 pF, ceramic disc
C4, C5—0.001 µF, Mylar
C6, C7—0.0047 µF, Mylar
C8, C9—0.01 µF, ceramic disc
C10—0.022 µF, Mylar
C11—0.047 µF, Mylar
C12—0.1 µF, Mylar
C13-C17—1 µF, 16-WVDC, electrolytic
C18, C19—10 µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

J1-J3—¼-inch phone jack
J4—XLR connector
S1—SPDT switch
IC socket, battery holders, battery clips, printed-circuit board or perfboard, enclosure, knobs, wire, solder, etc.

Note: The following items are available from: Midwest Analog Products, P.O. Box 2101, North Mankato, MN 56003. Etched and drilled printed circuit board, $15.00. Kit of parts including etched and drilled circuit board, resistors, capacitors, semiconductors, socket, SPDT switch, potentiometers, ¼-inch stereo phone jacks, 9V battery clips and holders (does not include enclosure, knobs, XLR connector, DPDT stomp switch, wire or solder), $39.95. Heavy-duty DPDT push-push stomp switch, $8.00. U.S. and Canadian orders add $2.00 S/H for the printed circuit board alone, $4.00 S/H for the printed circuit board and kit of parts, or $1.00 S/H for the stomp switch. Write for shipping information to other countries. Prices shown in US dollars. Remit U.S. funds only. MN residents add 6% sales tax. Money orders and checks only. Prices and terms subject to change without notice. For up-to-the-minute circuit modifications and suggested settings, be sure to check out Midwest Analog Products on the Internet World Wide Web Homepage: http://prairie.lakes.com/~map. E-mail: map@prairie.lakes.com



RS 232 SIGNAL	25-PIN CONNECTOR	9-PIN CONNECTOR
CTS	5	8
GND	7	5
TxD	2	3
RTS	4	7
DTR	20	4

Fig. 1. The interface circuit for the POCSAG decoder is simply a comparator that takes the demodulated audio from a scanner or radio receiver and changes it to digital pulses that can be read by the software. Power for the circuit is derived from the unused pins on the serial port.

put might need to be modified in order to pick up the signal directly from the discriminator output. If you do not know where the discriminator output is on your radio, and a schematic diagram of your radio is not available, a good place to test as a pick-up point is the high-side lead on the squelch-control knob.

The Hardware. The primary component in the interface circuit of Fig. 1 is a 741 op-amp available at Radio Shack and just about all other major electronics parts vendors. Power for the op-amp can be supplied separately, or could be easily supplied from the unused TxD, RTS, and DTR pins from the computer's RS-232 serial port. Diodes D1 to D4 act as a type of bridge rectifier, making sure the supply pins of IC1 are only connected to the proper voltages from the RS-232 pins.

In this circuit the 741 op-amp is used as a comparator, converting the signal from the receiver into the ±10-volt signal necessary to drive the RS-232 CTS (or DSR) input. That comparator has a positive feedback network, giving hysteresis that helps to recover the data from a receiver's audio output. The level of hysteresis, set by the R2 and R3, can be adjusted for best reception. A 100,000-ohm potentiometer could be substituted for the hysteresis network, allowing the circuit to be fine tuned. If a direct discriminator output is available from the receiver no hysteresis might be necessary; in that case, R2 could be omitted.

Construction. The circuit is simple enough to be built on a perfboard in a few minutes. An alternative is to purchase either a complete kit or an assembled and tested interface from L0pht Heavy Industries (see Parts List), a small group of Boston-area experimenters with a deep interest in electronic hardware. Note that the group has a "zero" in their name and not a capital letter "O".

If you opt for the kit, it includes a high-quality, silk-screened, double-sided PC board with plated-through holes measuring about one-inch square. Although the construction is not difficult, that circuit board (not shown here), which is designed to fit inside the hood of a DB-25 pin connector, is rather small and there is little margin for excess solder. The kit includes all documentation for the project, as well as a shareware version of the software to decode the POCSAG signals on a single 3-½ inch PC disk. The interface kit includes some assembly instructions in the README.1ST file, although the kit designers assume that the builder has some experience in soldering and electronics experience. The same information is available through the Internet by visiting the POCSAG Web page at http://www.l0pht.com/~kingpin/pocsag.html.

Incidentally, that Web page is quite interesting. It features a high quality image of the front and back of the interface board. If you look closely, you will notice that the background wallpaper is actually a schematic diagram of the decoder interface shown here.

Whether the interface is breadboarded or built from the available interface kit, a fine tip, well tinned, soldering iron is essential. A fine touch and soldering experience are also beneficial. Poor soldering will undoubtedly contribute to poor results.

PARTS LIST FOR THE POCSAG SIGNAL DECODER

IC1—LM741 op-amp, integrated circuit
D1–D4—1N4148 silicon diode
R1, R3—100,000-ohm, ¼-watt, 5% carbon resistor
R2—10,000-ohm, ¼-watt, 5% carbon resistor
C1—0.1-µF, ceramic-disc capacitor
C2, C3—10-µF, 16-WVDC, electrolytic capacitor
Socket for IC1, PC board, DB-25 or DE-9 female connector, hardware, wire, solder, etc.

Note: The following items are available from: L0pht Heavy Industries, POCSAG Project Division, P.O. Box 990857, Boston, MA 02199-0857; Complete kit with registered software, $59.95; Assembled and tested unit with registered software, $89.95; Complete kit with unregistered software, $19.95. Please add $5.05 for shipping and handling for each unit ordered. All payments are to be in US funds. Accepted forms of payment are cash, check, or money order only. Please make all checks payable to L0pht Heavy Industries. No COD orders will be accepted. Shipment is via first-class US mail to anywhere in the world. Massachusetts residents please add 5% sales tax. Allow four to six weeks for delivery.

LISTING 1

```
20:13:03 04/18/96 ******* LOGGING STARTED *******
20:13:17 RIC: 0546426 FUNC: 0 RATE: 1200 Alpha (auto):
;;TEST POCSAG PROTOCOL
20:13:18 RIC: 0546426 FUNC: 0 RATE: 1200 Alpha (auto):
THIS IS AN EXAMPLE=OF L0PHT
20:13:18 RIC: 0546426 FUNC: 0 RATE: 1200 Alpha (auto):
HEAVY INDUSTRIES POCSAG
20:13:18 RIC: 0546426 FUNC: 3 RATE: 1200 Alpha (auto):
PAGING DECODER.==;
20:13:20 RIC: 0546426 FUNC: 0 RATE: 1200 Alpha (auto):
u0+D90f
20:13:20 RIC: 0546426 FUNC: 2 RATE: 2400 Tone
20:13:46 04/18/96 ******* LOGGING STOPPED *******
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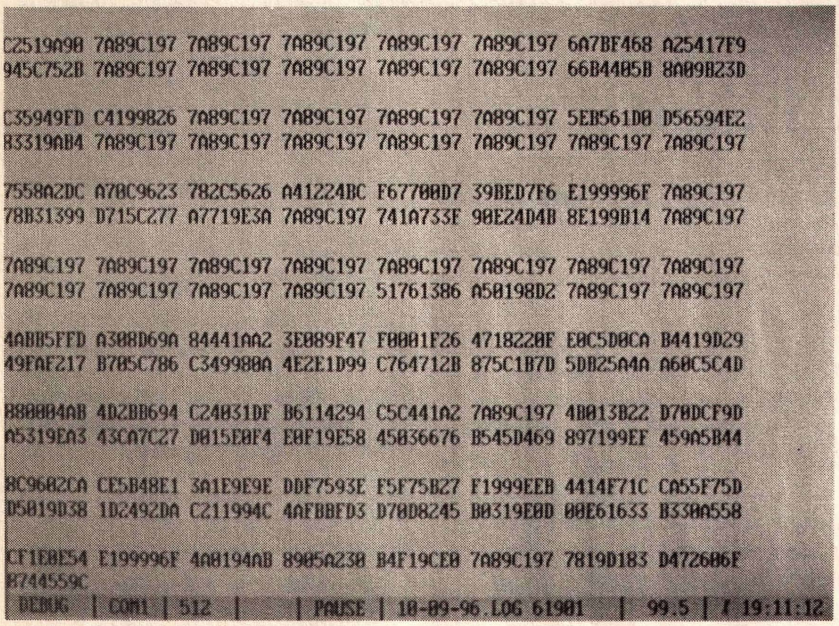
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D5019D38 1D2492DA C211994C 4AFBBFD3 D70D8245 B0319E0D 00E61633 B330A558
CF1E0E54 E199996F 4A0194AB 8905A230 B4F19CE0 7A89C197 7819D183 D472606F
87445590
DEBUG | COM1 | 512 | | PAUSE | 10-09-96.LOG 61901 | 99.5 | T 19:11:12
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*Fig. 2. The software can display the raw codes coming off the airwaves in this special debug mode. Seeing the raw codes helps adjust the interface circuit if you're having difficulty reading the signal with the particular radio you're using.*

**The Software.** The PC-compatible software, PD-203.zip, is relatively small at only 90 kilobytes, and can be downloaded directly from the POCSAG Web page. It must be dearchived using PKUNZIP or similar decompression software.

The main program file, PD.EXE, is only 79 kilobytes in size. Written by Peter Baston, GW0PJA and AA2DZ in England, it is distributed as shareware. The trial version will time out after about fifteen minutes of use. At that time, storing the decoded pager data to disk is disabled. The registered version of the software can be ordered from L0ght Heavy Industries (see their POCSAG Web page), or the author.

The decoding software is designed to run under MS-DOS. Because the software does all of the decoding, running it in a DOS box under Windows is not recommended because of the overhead Windows produces. The program is configured by editing the PD.INI file. Serial ports 1, 2, 3, or 4 can be used for message input. The bit rate can be selected manually or be set automatically as messages are received, which will decode all bit rates. Display colors for the background, foreground, and status line can be changed to any combination desired. The program is designed for international use and output can be optimized with special characters used in English, German, Swedish, and Danish. The registered version software allows a second serial port to be used to output data in ASCII form.

The PAGERS.INI file is used to specify up to 250 different pager addresses with a seven-digit pager ID code. Whenever a specified address is encountered, it is highlighted on the screen and a beep, if configured, is sounded. Wildcards are allowed in the PAGERS.INI file. The REJECT.INI file is used to specify a list of addresses to be rejected to reduce screen clutter. A typical data stream is shown in Listing 1.

The program can be switched between NORMAL and DEBUG modes by pressing the computer's F1 key. The DEBUG mode, shown in Fig. 2, displays the raw POCSAG codes in hexadecimal format. That is particularly useful for setting up the hardware interface as it gives a visual indication of the number of processing errors in real time. A very helpful status line is shown across the bottom of the screen. That line displays the serial port being used, the current POCSAG bit rate, a PAUSE/RUN indicator, an indication of relative receiving efficiency, a rotating signal indicator, and the current time (taken from the computer's clock). The relative receiving efficiency is expressed in percent. An indication of 100% indicates that all received codes contain no errors. The rotating signal indicator appears to spin when data is being received on the correct pin at the serial port.

The entire project is quite educational. Included with the shareware is a file called POCSAG.TXT written by Brett Miller, N7OLQ, which gives an excellent explanation of the technical aspects of POCSAG signaling and pager operation. It is quite well written, and is perfect for those who are interested in the technical end of pager operations.

**In Case Of Difficulty.** Many unsuccessful electronics projects can be traced to power supply problems. The first place to check for wiring

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only $35. There are other combinations of elements and fees for the other elements.

Preparing For An Exam. The best way to prepare for any of these exams is to study the available background subject material. ISCET offers excellent, inexpensive study materials that will help all candidates prepare for each of its exams. If you are at the entry level, the Study Guide for the Associate CET Test will give you an excellent review for this first test. The 96-page booklet is priced at $10. The Software Study Guide and Practice Test with 300 sample questions is price at $39.95 plus $2 shipping. In addition, ISCET offers practice tests for most of the Journeyman options as well as excellent review texts on each of those options.

The FCC examinations are assembled from questions in a published question pool. By making the complete question pool available, the FCC has defined the limits of the basic knowledge that it expects each successful candidate to have. The availability of the pool also assures all persons taking the test that there will be no nasty surprises. A study guide and compete question pools for Elements 1, 3, and 8 is available for $29.95 plus $3 for shipping and handling costs. In addition, self-test computer software packages are available. Not surprisingly, being well prepared for all examinations can make the difference between passing and failing!

If, after reading this, you decide that you would like to take the CET CAT, or any of the FCC exams, contact one of ISCET's volunteer test administrators listed elsewhere in this article for details. As stated earlier, the exams are scheduled for the week of April 20 through April 26. For additional information, or to obtain an order form listing all of the available guidance and help materials, contact ISCET directly at 2708 West Berry St., Fort Worth, TX 76109; Tel: 817-921-9101, Fax; 817-921-3741.

See you at Testing Week 97, and on Electronics Technicians Day! Ω

MOD BOX

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Mod Box is in the Clean mode.

Adjust the Volume control to a comfortable sound level. Strum a few chords and notice that the sound is more or less unaltered. Now crank up the Low control and listen for the full rich boom of the bass notes. Turn it in the opposite direction, and observe how the low end is attenuated. Test the Mid and High controls in a similar manner. By the way, a boosted Mid is great for imitating the cheesy guitars of the early 1960s, while bumping the High gives a great edge to country-western solos.

Switch S1 to distorted, but be sure to watch the Volume control to keep from blowing out your loudspeakers! Dial up the Drive to see how the sound becomes increasingly more ragged. Low settings are perfect for rhythm guitar work, since the sound is quite similar to the creamy distortion of a tube amplifier. For piercing rock solos, spin the Drive control up to its highest setting and notice not only the increase in distortion but the long lasting sustain. And of course, you can further alter the effect by working over the Low, Mid and High controls.

In learning to play any musical instrument, practice is the name of the game. Even though the Mod Box only has 5 potentiometers and 1 switch, there are countless subtle (and not so subtle) effects possible. Experiment with the Mod Box and note the various settings you feel are most useful. After a while, you will probably find the Mod Box to be an indispensable part of your rig. It really can be a natural extension to just about any musical instrument. So what are you waiting for? Build the Mod Box today and see for yourself! Ω

POCSAG DECODER

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errors is with the op-amp power taken from the RS-232 serial port TxD pin and DTR pin. Pin 7 on the 741 op-amp should read about +10 volts. Pin 4 on the op-amp should read about -10 volts. If either voltage reading is incorrect, check the polarity of D1-D4, C2, and C3.

An easy way to get a visual indication of the operation of the decoder board is with a RS-232 mini-tester, which uses red and green LEDs to indicate voltage polarity. The TxD LED should glow red (for -12 volts), the DTR LED should glow green (for +12 volts), and the CTS (or DSR) pin should flicker red and green to indicate a proper signal output to the computer. Also, as mentioned above, the software signal indicator will spin when data is being received on the proper serial port and pin. If a discriminator tap is being used, and everything else appears normal, but the program does not function or many errors are indicated by a low percentage of copy, try either removing R2 from the circuit, or replacing R2 with a jumper. Finally, make sure the software is correctly configured for the proper serial port and the proper data input pin (*i.e.* either CTS or DSR pin).

TABLE 1—COMMONLY USED POCSAG FREQUENCIES

152.03 - 152.24
152.51 - 152.84
158.10
158.70
454.025 - 454.650
931.0125 - 931.0875
931.8875, 931.9125, and 931.9375 are the national channels

Whether you buy the kit or build your own on perfboard, the interface is easy and inexpensive to build. The software is both well written and documented. The project provides an excellent hands-on education with POCSAG signals. But the best reason to try out this project is that it is just plain fun. Ω