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A 4800-BAUD MODEM DAUGHTER BOARD FOR PACKET TNC

Introducing the HAPN-T, developed by the Hamilton and Area Packet Network

Packet radio has become incredibly popular since its introduction in 1979. So popular, in fact, that many local-area networks are rendered nearly useless as a result of peak-period congestion. There are two solutions to this problem – use more channels, and increase the baud rate.

The Hamilton and Area Packet Network (HAPN) has a daughter board 4800-baud modem that plugs into many of today's TNCs, but still uses the same radio equipment and channel bandwidth as 1200 baud.

Background

The HAPN-T 4800-baud modem is the third in a series of high-speed modems developed by HAPN. The modem was originally conceived by Ken Smith, VE3HWB, and Glenn Simpson, VE3DSP.[1] Glen Leinweber, VE3DNL, and John Vanden Berg, VE3DVV, built a practical modem based on their design.

The first version of the 4800-baud modem was designed for external stand-alone use with TNCs like the VADCG TNC+. The modem proved to be a great success and a second version, which could be constructed on the prototype area of the HAPN-1 packet-radio adapter, was developed.[2]

Finally, the HAPN-T modem was introduced. This modem takes advantage of the accessory modem headers on many TNC circuit boards, into which a daughter board modem can be plugged.

Why 4800 baud?

The transmission of packets at 4800 baud (or more correctly, 4800 bits per second) rather than 1200 baud has certain advantages. Most importantly, a given amount of data can be sent in a quarter of the time.* The HAPN-T has a very fast built-in squelch circuit, which substantially reduces the carrier-detect and turnaround times. Although the dynamics of channel use can be quite complex, much more data can be passed over a channel at 4800 baud than at 1200 baud. If the modem is inexpensive and requires no special RF equipment, this can be an attractive way to accommodate many more users on the packet channels.

HAPN-T features

The HAPN-T modem (shown in **Photo A**) consists of a small printed circuit board that plugs into the 20-pin header on many of

*Actually, because of the various overheads associated with packet radio, the difference is a bit less than four times.

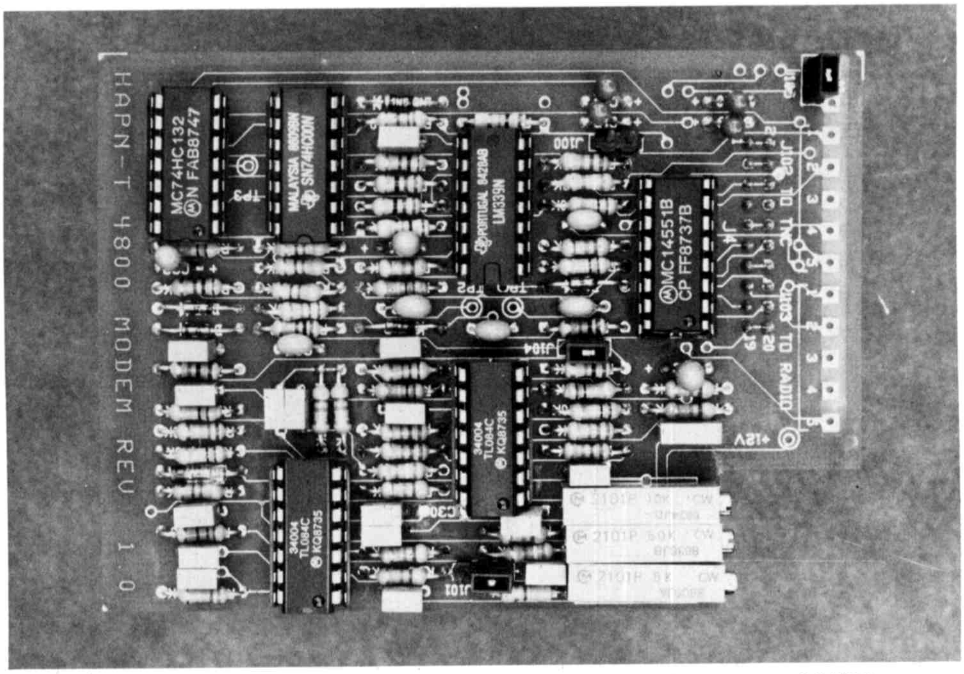

Photo A. The HAPN-T modem plugs into the 20-pin header on many of the commercial TNCs.

commercial TNCs. The board is 3.7 × 2.7 inches and fits inside the TNC case. You can add a switch to control the multiplexer on the 4800-baud modem; this lets you alternate between 4800 and 1200 baud. Connections are required inside the radio for transmit (TX) and receive (RX) audio, because TX audio must be applied directly to the frequency/phase modulator and RX audio must be extracted at the discriminator—ahead of the de-emphasis network.

To use this modem, you must have a TNC with a 20-pin header on its circuit board, or a place where a 20-pin header (modem connector) can be installed. You must also be prepared to access the appropriate TX and RX points in your transceiver. This article tells you how to build the HAPN-T modem, install it in your TNC, and connect it to your transceiver. Printed circuit boards and parts kits are available from HAPN. The address is listed at the end of the article.

Circuit description

The HAPN-T block diagram is shown in **Figure 1**; the circuit diagram is shown in **Figure 2**. The modem consists of three main sections: receive data (top), carrier detect (center), and transmit data (bottom). There's no PTT section because the existing circuit, including the watchdog in the TNC, is used by the HAPN-T modem.

Receive section

The upper left-hand portion of **Figure 1** shows the level-adjust op amp (U3B). U3B converts the signal from the radio's discriminator to a fixed level suitable for decoding. The maximum possible signal from the radio has a fixed level that can be observed with no signal present when the radio is turned on; only noise is received. The gain of the radio will be at maximum, and the signal amplitude will be at its highest. (You can hear this when you open the squelch on your receiver with the volume control wide open.)

U3B is followed by low-pass filter U3A. During the adjustment procedure, the level is set so the four-pole low-pass filter isn't overdriven. If you use a scope when making your adjustments, you'll see the first signs of overdriving on TP4. (However, you don't need a scope to properly set up the modem.) The low-pass filter removes the noise from the audio, as shown on the waveshapes diagram at U3C/8 in **Figure 3**.

The low-pass filter output is followed by positive and negative-peak detectors (U3C). The positive-peak detector signal appears at TP1 in **Figures 1** and **2**. The signal at TP2 is similar, but the polarity is inverted. All signals are referenced to +6 volts—half the 12-volt power-supply voltage. The RC timing of the peak detectors is very important and has been optimized to follow the received signal quickly.

The signal from the peak detectors is sent to their respective data comparators. When 68 percent (100 × R15/(R15+R16)) of the positive-peak (TP1) voltage falls below the low-pass filter output (U3C/8), the comparator output at U2/2 will go low (**Figure 3,**

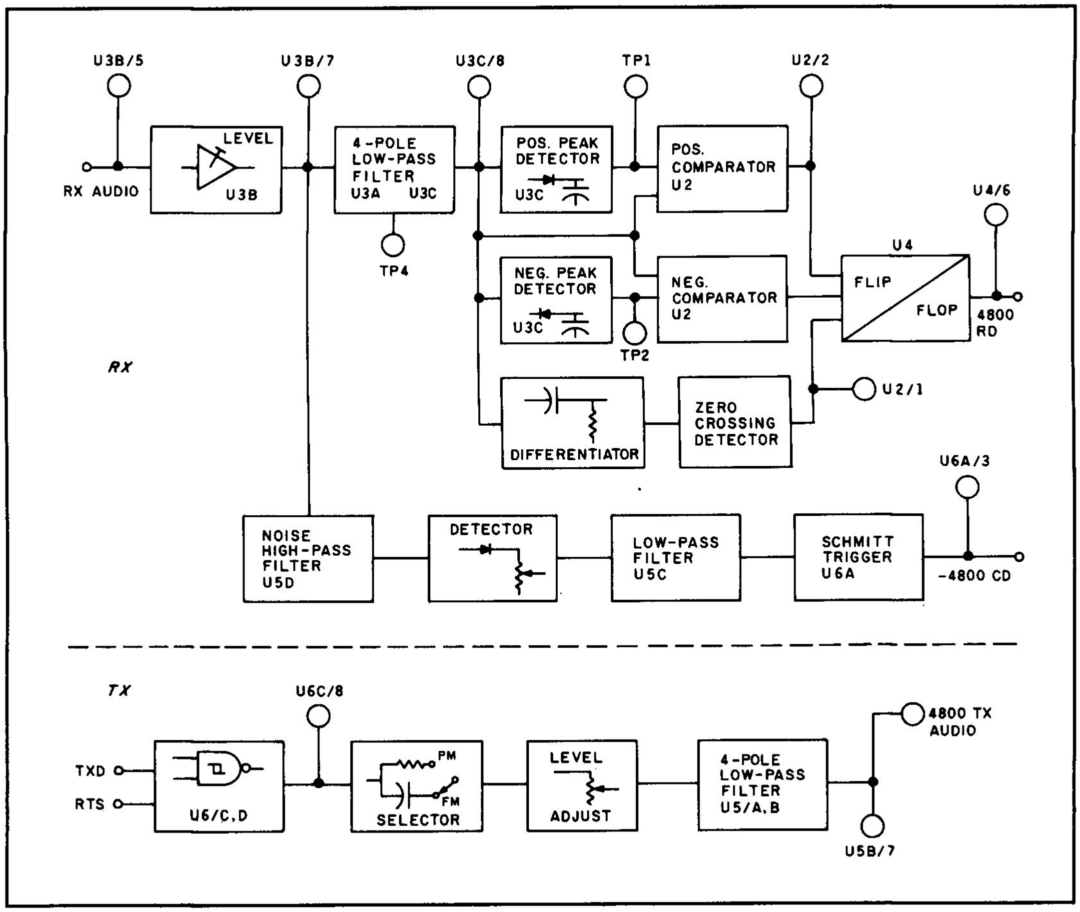

Figure 1. Block diagram of HAPN-T 4800-baud modem.

U2/2). When 68 percent of the signal at TP4 exceeds the low-pass filter output, the comparator level will go high again. A similar process occurs for the negative comparator (**Figure** 3, U2/13).

The zero-crossing detector generates pulses when the low-pass filter output changes direction. The input to the detector is derived by differentiating the low-pass filter output (C10 and R34). This signal is compared with a threshold at the junction of R31/R32 and R33/R35 to generate a pulse on the output. Both sections of the comparators are dot ORed together (**Figure** 3, U2/1) to produce positive pulses.

The output of the zero-crossing detector gates the output of the data comparators into flip-flop U4. The output at U4/6 (**Figure 3**) now contains the recovered digital data. Note that a simple cross-wired 74HC00 is used as a flip-flop. Since the modem is decoding continuously, you'd normally see the flip-flop change state due to noise decoding.

The output is ANDed with a carrier detect signal so data is only valid when a radio transmission is received. This reduces unnecessary decoding attempts by the synchronous controller in the TNC.

Carrier-detect section

The TNC needs a signal to indicate if the channel is busy. This signal prevents the TNC from transmitting when another station is using the channel. Many modern TNCs using modem chips like the AMD7910 or 3505 aren't able to detect a carrier from the data properly, so they usually rely on the radio for audio squelching.

This reliance on the radio presents performance problems. VHF-radio squelches are optimized for voice use and are slow to produce a signal. This is fine for voice, since it prevents marginal signals, like those received by mobiles (mobile flutter), from disturbing you. However, it leads to difficulties in a packet-radio application, because you want short transmissions without unnecessary delay. One popular radio takes about 500 ms to open its squelch. Consequently, short packets, like "acknowledges," may be missed completely. The sender has to com-

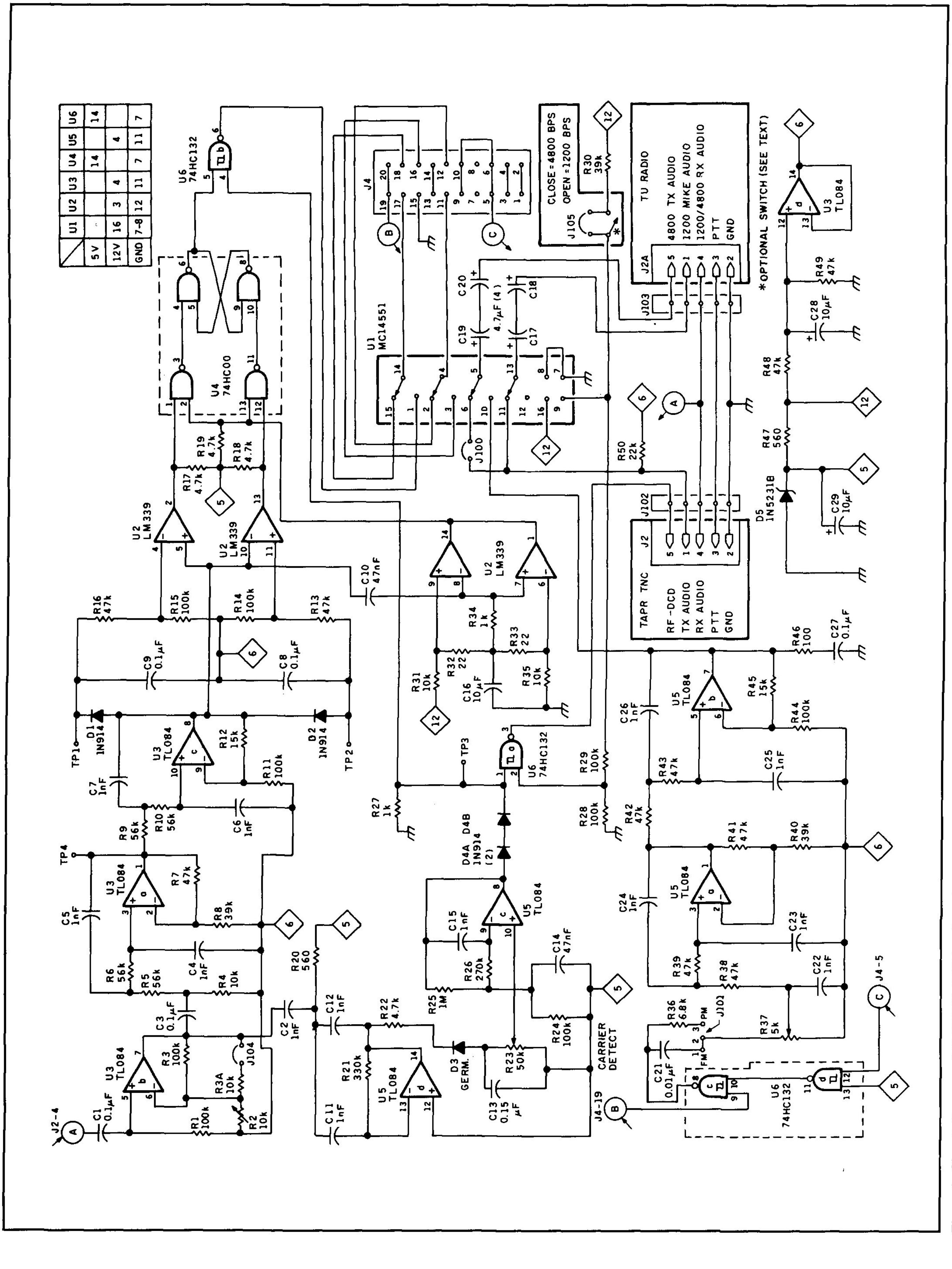

Figure 2. Circuit diagram of HAPN-T 4800-baud modem.

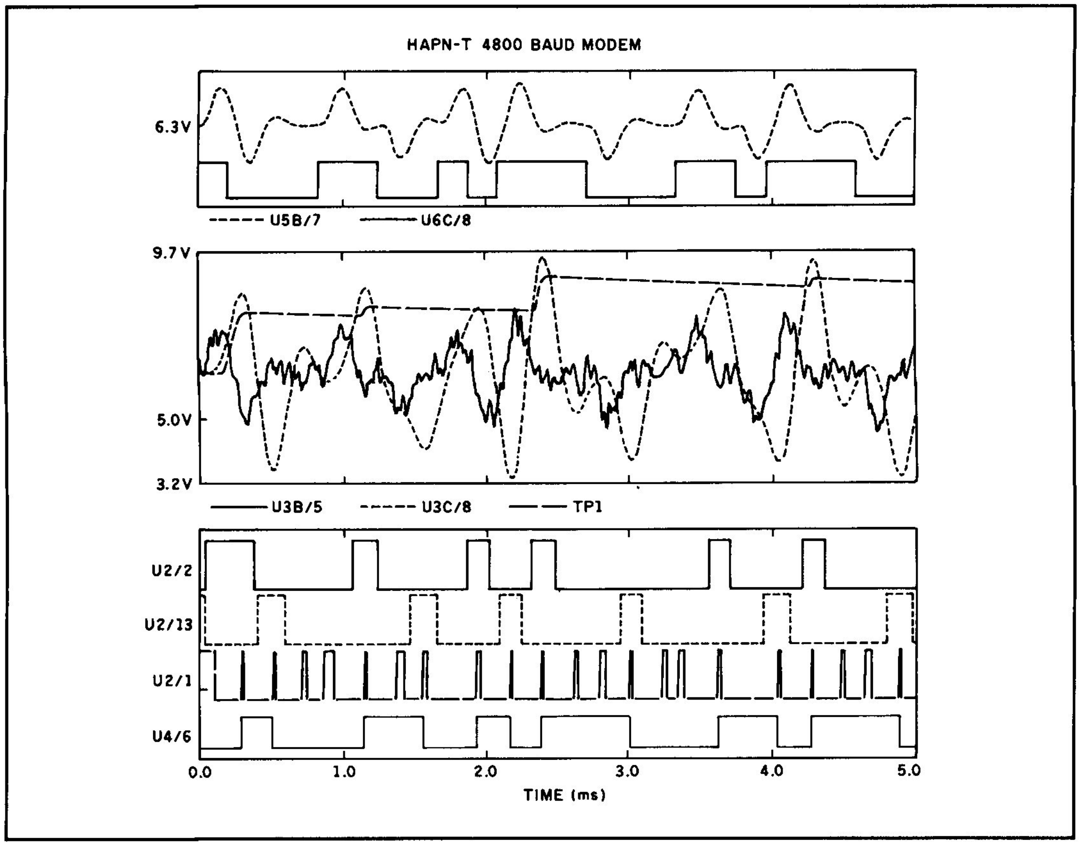

Figure 3. HAPN-T modem waveshapes.

pensate for this by extending the TX delay to 600 ms or more, creating a lot of wasted channel time. The 4800-baud modem described here contains a carrier detect (CD) circuit optimized for packet. It switches in 10 to 15 ms to indicate a busy channel, enabling the TX delay to be kept short as well.

The first part of the carrier-detect circuit is a high-pass filter, U5D, that allows for the separation of the high-frequency noise (around 11 kHz). One stage of a TL084 is used for this circuit.

The noise is rectified by a 1N34 germanium diode. We chose a germanium diode because it has a lower voltage drop than a silicon diode. The level is adjustable by 50-k trim potentiometer R23. The level must be set after the receive data level adjustment has been made. Normally, it is not changed after installation.

Rectified noise is amplified by low-pass filter op amp U5C. The output at U5C/8 will be +5 volts when no noise is received (radio disconnected), because the op amp is biased to +5 volts. When noise is received, the signal will go low toward zero volts. The drop in signal voltage depends on the amount of noise being received.

The analog output of the noise low-pass filter is converted to a digital signal by carrier-detect squelch gate U6A. The voltage drop across two 1N914 silicon diodes, in conjunction with the 1-k pull-down resistor (R27), shifts the level to the range suitable for the 74HC132 Schmitt trigger input (TP3, **Figure 2**). The typical 0.9-volt hysteresis of the chip avoids false triggering. The output signal at U6A/3 is logical zero when the radio is disconnected or a carrier is received (in 4800-baud mode).

Transmit section

The digital-transmit data from the TNC is gated with the RTS line to prevent unnecessary audio from getting into the modulator when in receive mode (**Figure 3**, U6C/8).

Jumper J101 selects either the more common frequency modulation (FM) or less common phase modulation (PM). It's important to match the jumper with the type of modulator in your transmitter. In PM mode, the digital data is sent directly to the low-pass filter; in FM mode the data is first differentiated by C21 and R37. The resulting transmitted signal will then be the same.

Trimpot R37 sets the audio deviation being transmitted. Avoid setting the level too high. This will cause overdeviation and result in an uncopyable signal, because receiver IF will distort it. A level which is too low results in a poor signal-to-noise ratio. This is similar to what happens when you hear someone with low voice modulation. The optimum deviation is around 3.5 kHz. The adjustments section tells how to determine the proper setting when you don't have access to a deviation meter.

The TX low-pass filter is a four-pole device that removes the higher harmonics from the digital data. It's important to maintain the wave shape shown at U5B/7 in **Figure 3**. Feeding the data through the mike input won't work. The mike audio amplifier and emphasis network normally introduce too many phase and amplitude changes. The output should go directly to the FM or PM modulator.

Multiplexer section

Figure 4 shows the multiplexer block diagram. The multiplexer allows for convenient switching between 1200 and 4800 baud. The radio interface consists of three signals: PTT, RX audio, and TX audio. The TNC requires demodulated data (1200RD or 4800RD), CD (carrier detect), and a clock signal (1200CLK or 4800CLK) for decoding the digital modem data. The TNC outputs the TXD (Transmit Data) and the RTS (Request To Send) lines.

The multiplexer (U1, MC14551) consists of a four-pole two-position CMOS switch (**Figure 4**) capable of switching analog and digital signals. Section S1 switches the TNC clock between 1200 and 4800. S2 selects the proper receive digital data. S3 sends audio from the 1200-baud modem to the mike input if required. This normally results in an emphasis of the high audio tone (2200 Hz) because of the radio's internal emphasis network.

Some Amateurs prefer a flat response on 1200 baud. You can obtain this by using the 4800-baud modulator input point on 1200 baud, instead of the mike input. In this case, you'd install J100. Switch section S4 feeds TX audio to the modulator.

The CD is derived from the 1200-baud modem as DCD (data carrier detect) and from the 4800-baud modem's internal squelch detect. Both the 1200 and 4800 CD signals are ORed together. Either CD will light the CD LED on the TNC's front panel.

RX audio from the radio is sent to both modems, and each one will try to decode the data. As we mentioned earlier, the proper digital data is selected by S2 of the multiplexer. Since the PTT and watchdog function is the same for both modems, the existing TNC circuit is used for both the 1200 and 4800 mode.

To make selection convenient, you may wish to add a small single-pole two-position switch to the front panel of the MFJ TNC-2 (**Photo B**). The TNC-1 uses the existing

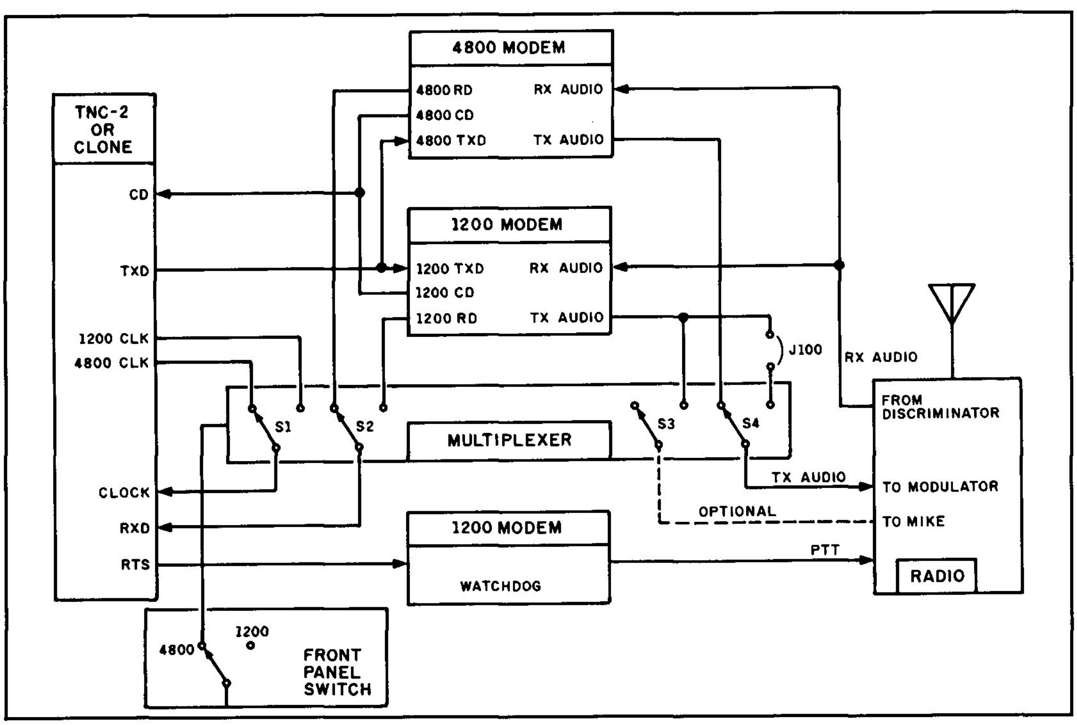

Figure 4. Multiplexer block diagram.

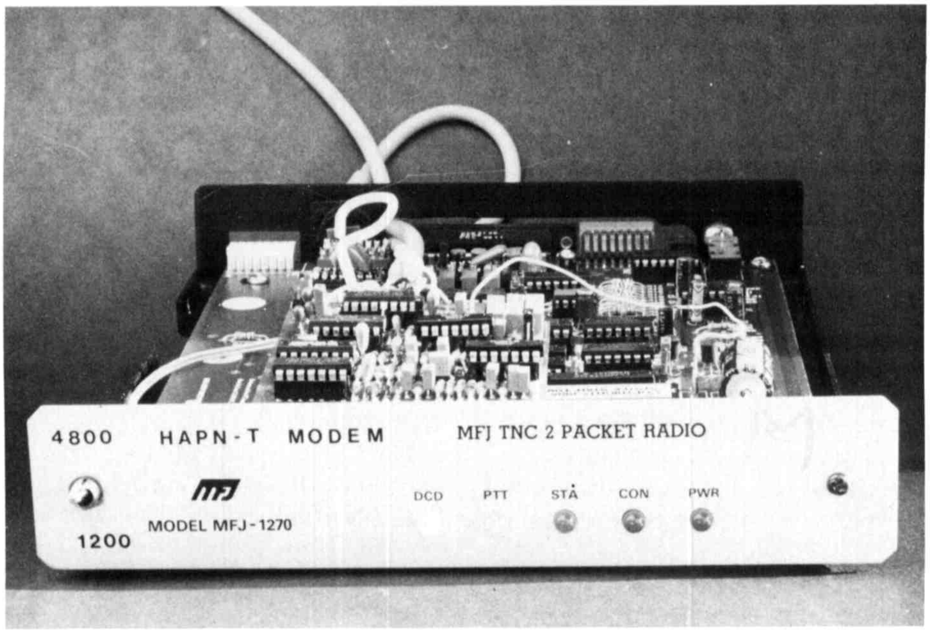

Photo B. A single-pole, 2-position switch on the MFJ TNC-2 is used to switch 1200 and 4800 baud.

bank switch on the front panel to do the switching. The spare LED will light in the 4800 mode.

Circuit modeling

We used a circuit modeling program to plot modem waveforms similar to those seen on an oscilloscope. Modeling programs (like SPICE) are very useful tools and can now be run on personal computers. Most circuits of interest to Amateurs, like audio amplifiers, power supplies, RF-tuned amplifiers, power stages, mixers, and filters (both crystal and LC) can be investigated with good accuracy. We chose SPICE to fine-tune component values and obtain a good transmit waveshape.

Figure 3 shows the digital transmit data of a random sequence of ones and zeros, along with the resulting modem output waveshapes. There are a number of waveshapes from the receiver part of the modem, including the input waveform (with noise added), both before and after the four-pole Butterworth filter. The positive peak-detector (TP1) waveshape is also shown. The four digital waveforms from the receiver are from the positive-peak slicer, negative-peak slicer, zero-crossing detector, and received digital output.

HAPN-T circuit-board assembly

Before assembling the circuit board, make sure all parts are on hand, and inspect the circuit board under a bright light or magnifying glass to make sure there are no flaws. Bend the leads of the resistors and diodes to 0.4 inch (10.4 mm) lead space.

Mount the resistors, following the silkscreen and component mounting diagram. Solder and trim the leads. Mount the diodes, watching the polarity; the band is the cathode. Solder and trim the leads. Mount the IC sockets, watching the direction. The notch side is near pin 1. Mount the tantalum capacitors. Be careful bending leads, and watch the polarity! Mount the remainder of the capacitors. Trim the leads. Mount the trimpots. Mount female connector J4 on the bottom side of the modem board. Cut at length and mount posts J100 (2 pin), J101 (3 pin), J104 (2 pin) and J105 (2 pin). Using an analog ohmmeter, check pin J4/15 (gnd) and the +12 volt lead for about 16-k ohms.

Now install the HAPN-T in your TNC.

Installation

You can use the HAPN-T in both TAPR TNC-1 and TNC-2 TNCs. The following instructions apply to the MFJ TNC-2. Instructions are also available from HAPN for the TNC-1, Tiny-2, and PK232. TNC-1 and TNC-2 instructions are included with HAPN-T orders. Tiny-2 and PK232 instructions are available upon request.

Preparing the TNC-2

Install external modem connector J4 (if not already present), and add one wire to feed 4800-baud clock pulses to vacant pin 16 of connector J4. Remember, these instructions apply to the MFJ TNC-2; other TNCs may vary to some degree.

Remove the covers from the TNC (on MFJs, you'll also remove the front plate). Remove four screws and the mother board. On the back of the board, cut the trace between the modem interface connector J4 pins 11 and 12 (clock pulses) and the trace between J4 pins 17 and 18 (receive data). Solder in male connector J4. Solder a small-gauge wire from U1 pin 7 to J4 pin 16 (4800-baud clock). You may wish to add a miniature switch for easy switching between 1200 and 4800 baud. A good place for mounting this switch is the left screw hole of the front panel, as shown in **Photo B**. Make sure that J10 on the TNC isn't so high as to interfere with the bottom of the modem board. If it is too high, trim the height of J10 with a pair of side cutters. Reinstall the board in the cabinet.

Test the modifications by temporarily installing jumpers at J4 pins 11-12 and pins 17-18. This restores the original traces and lets you verify that the TNC is still functional before continuing with the modem board installation.

Installing the modem board in the TNC-2

Solder a wire from the 12-volt pad on the modem board (near corner cut) and connect it to a 12-volt source on the TNC (like the cathode of CR7). Plug the modem board into the TNC male header. Make sure the board is plugged in properly by looking at it from the side. Using an ohmmeter, check for zero ohms between square pad J102 pin 2 on the modem board and ground on the TNC (such as RS232 pin 7). This step verifies proper mating of the J4 connector (*very* important).

For the next step, you'll need four-conductor shielded audio cable and a male DIN plug(s). Use Radio Shack cable part no. 42-2151, cut in half. Refer to the circuit diagram and connect the TNC interface wires to J102 using the cable and DIN plug. The shield goes to J102 pin 2. The 5-pin DIN plug is plugged into TNC radio-connector J2. Refer to **Figure 1**. Connect J103 to the radio using the shielded cable again. The shield goes to J103 pin 2. Test the 1200-baud operation using your old radio interface points, like speaker at J103-4 and audio at J103-1.

Your modem is now installed in the TNC-2. The next section lists modifications you need to make to the radio for the 4800-baud tie points.

Connecting the HAPN-T to your rig

It's very important to select the proper interface points inside the radio. If you choose the wrong points, the modem will perform poorly, or not at all. The radio modification doesn't interfere with normal voice operation. However, in normal packet use, you *should have the mike unplugged* when in packet mode to prevent any room noise from being modulated along with the packets. If the mike switch is connected so the audio input to the radio is grounded when the PTT on the microphone isn't activated, you can leave the mike connected. In transmit mode, the modem's output impedance will likely pull the audio level down, so it's advisable to unplug the modem cable when using the radio for voice.

RX audio

The RX audio can't be taken from the speaker output because of: (1) phase distortion of the de-emphasis network in the receiver, and (2) the characteristics of the audio amplifier. The proper take-off point for the receiver is at the discriminator—before the de-emphasis network. This is often the point in the radio where the noise is taken off for the radio's squelch circuit. The HAPN-T modem needs this noise to operate its carrier-detect (squelch) circuit. This CD circuit has been optimized for packet operation and switches in at about 10 to 15 ms.

Some older radios may have a discriminator test point which could be used for take-off. If the discriminator test point has a large bypass capacitor to ground (larger than 1000 pF), the HF-noise component (around 11 kHz) is attenuated along with the IF. In this case, replace the bypass capacitor with 1000 pF to allow the audio noise to pass through.

Many newer radios use ICs in the IF and demodulator sections—almost always the Motorola MC3357 (14-pin dip) or the MC3359 (16 pin). Both chips are similar and lend themselves very well to interfacing. The low output impedance (around 300 ohms) on the audio-out line (pin 9 for MC3357 or pin 10 for MC3359) allows longer shielded cables for the modem, so the radio can be placed further away from the TNC.

You need to be able to place the radio further away from the TNC because the shielded-cable parallel capacitance, which is added to the take-off point capacitance, might attenuate the audio noise component needed for the modem squelch. It has much less effect on the low 300-ohm output impedance of this chip, than it does on those on older type modulators which have a high output impedance. For example, if you use a 20-foot run of Belden 8723 cable with a cable capacitance of 62 pF/foot, 1240 pF (20 × 62 pF) is added to the take-off point. The reactance at 11 kHz (audio noise component) would be around 110-k ohms ($1/(6.28 \times 11000 \times 0.00000000124)$). This value has no effect on the 300-ohm output impedance of the demodulator chips, but could load down a high-impedance demodulator. Usually the audio cable to the radio is 10 feet or less, and you'll encounter no side effects in either case. As a precaution, you can use a 10-k series resistor at the take-off point to prevent accidental shorting of the demodulator. This normally won't present a problem, but may give you an added sense of security.

TX audio

Because of the nonlinear characteristics of the audio amplifier (limiter and emphasis network), interfacing through the mike doesn't work. You must go directly to the modulator. The modem output impedance is around 200 ohms and is suitable to drive almost any FM or PM modulator. To find the interface point, look at the radio schematic for the deviation control. You'll usually find it after the limiter/filter. The deviation trimpot output normally goes through a resistor (and often a capacitor, as well) to the modulation varicap diode. The diode capacitance is changed by varying the voltage across the diode (since the diode is reverse biased). The varicap is often mounted in a shielded compartment. Do not connect directly to the diode, but to the resistor that carries the signal to the diode. This is often the same point as the deviation-control wiper.

Determining modulation type

There are two types of modulators, FM and PM. It's important to know which type your rig uses so you can install modulation-selection jumper J101 correctly. If J101 is in the wrong position, the modem won't generate the proper waveshapes for the transmitter, and nobody will be able to copy your signal. The radio manual's specification section should tell you what type of modulation the transmitter uses. However, don't take their word for granted. One HAPN-T user was convinced that his modulator was phase modulated, and set J101 accordingly. The modem didn't work very well. Interestingly enough, he did receive a short packet on occasion. However, he spent many hours looking for faults until he set J101 for frequency modulation.

An FM modulator changes the oscillator frequency directly, usually by means of a small varicap diode in the tuned section. On the other hand, PM modulators change the phase of the signal in a stage following the oscillator. Most radios use an FM modulator; it's always a good bet to try that first when in doubt.

Examples of receiver interface points

The RX4800 audio must be taken from the discriminator ahead of the audio de-emphasis network. Often, this point is also used for squelch takeoff. It's *important* to use shielded cable.

Yaesu FT480R. Figure 5A shows connections to the Yaesu FT480R. Note that the demodulator is a conventional FM discriminator using one-half of the IF transformer; divider R45 and R46, instead of a center tap; two diodes, D10 and D11, for rectification; and C51 to filter the IF AC voltage. The squelch noise is taken from series filter L05 and C53. The audio is taken from de-emphasis network R47 and C52. The take-off point at D10, D11, and C51 is located in the same place where the receive signal is taken for the modem. Use a 10-k series resistor for isolation.

Kenwood TR-7400A. Figure 5B shows another conventional FM modulator. The RX audio take-off point is similar to that of the FT480R. A 10-k series resistor is added from the modulator output (R44, R46, C48) where it meets the squelch take off (C49) and the audio take off (C65, R62). This is located just before the de-emphasis network R62 and C64.

Kenwood TR-7730. Figure 5C shows another Kenwood. The take-off point is from a 10-k resistor at the junction of the discriminator output (R51, C58), the squelch take-off (C57), and the audio take off (R114).

Santec ST-144μp. Figure 5D shows the handheld interface. It uses the MC3357 FM chip. We could have chosen pin 9 for the take-off point, but since this pin is difficult to access in the handheld, we used CT5 (demodulated AF output test point). Note that this take-off point is still before the de-emphasis network (R105 and C146).

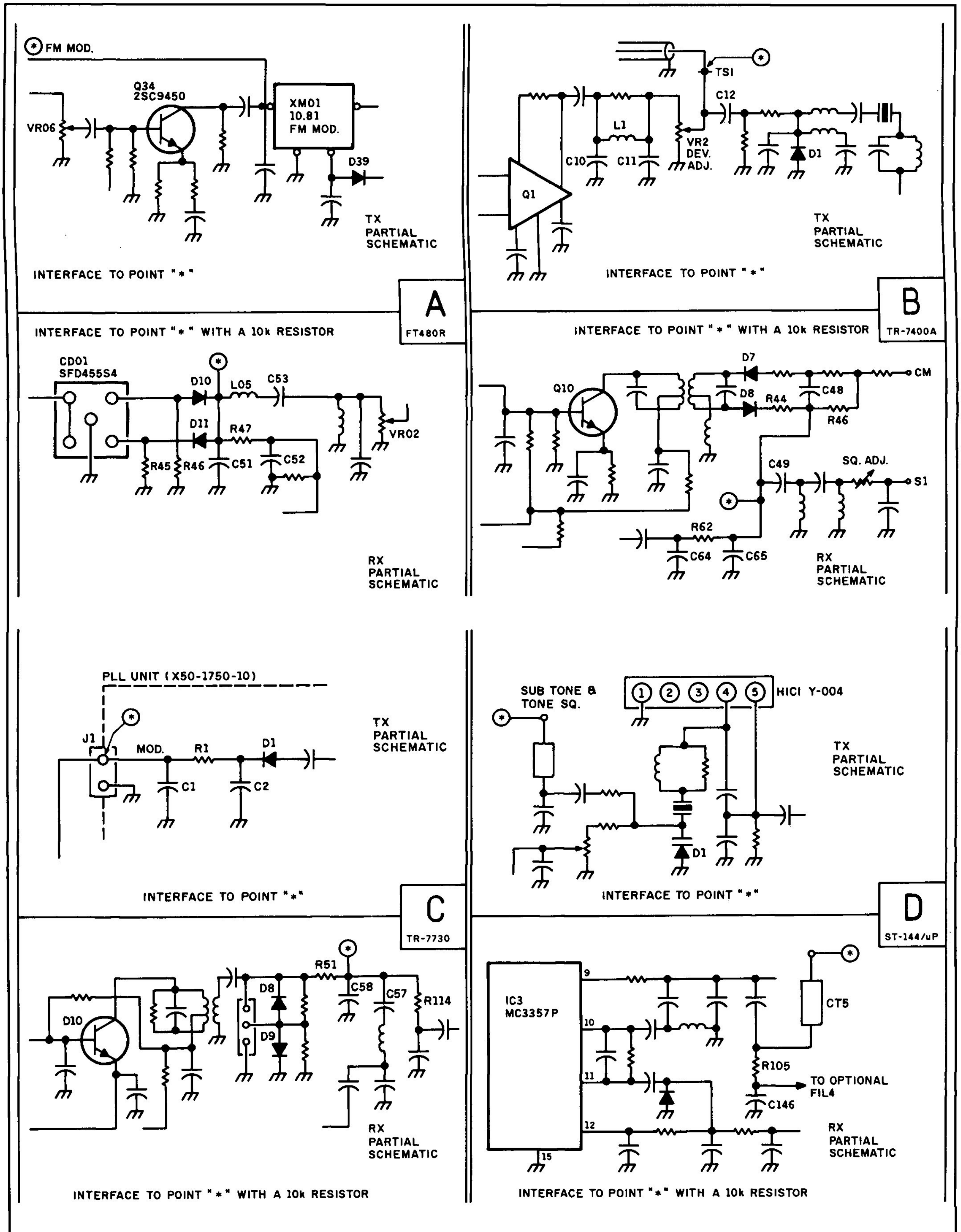

Figure 5. Interface diagrams for four radios.

Examples of transmitter interface points

The 4800TX audio must go directly to the FM or PM modulator to avoid distortion. As we have said, it is *very* important to ascertain the modulator type and set jumper J101 accordingly. Use good shielded cable from the modem to the radio. RF pickup in the TX audio cable will cause distortion in the modulator.

Yaesu FT480R. The TX audio should be tapped into the FM modulator line, as shown in **Figure 5A**.

Kenwood TR-7400A. The connection is shown in **Figure 5B**. The modulating component is D1, a varicap diode, which changes the 10.7-MHz crystal oscillator frequency. Backing up, you see VR2 and the 5-k deviation adjustment pot. Limiter filter C10, C11, and L1 is just ahead of this. You can conveniently interface the 4800TX audio to point TSI going to the wiper of VR2 and coupling capacitor C12.

Kenwood TR-7730. The TX audio can be tapped easily at connector J1, at the point where the modulation enters the PLL board (see **Figure 5C**). The audio goes to a varicap diode, D1, which modulates the PLL-oscillator frequency.

Santec ST-144μp hand-held. The TX audio can be connected to the SUB-AUDIO TONE IN entry point (**Figure 5D**). This audio is applied to D1, the frequency modulation varicap diode. We used a 1-k resistor as a limiting resistor, but it's not really required.

Adjusting the HAPN-T

Install the modulation selection jumper on J101 posts (refer to radio manual for modulator type):

- FM modulators (most radios): position the jumper on the side closest to R37 pot (pins 1 and 2).
- PM modulators: position the jumper away from pot R37 (pins 2 and 3).

Adjust the modem potentiometers. Make sure the radio is connected and turned on.

1. **Level adjustment, R2:** Put an analog voltmeter at TP1 and adjust for about 9 volts DC when receiving noise (no antenna). If you have a scope, use U3A/1 (TP4) and adjust until the noise signal is just clipping. If you find that turning R2 doesn't decrease the signal sufficiently, install jumper J104 to decrease the op-amp gain.
2. **Squelch (carrier-detect) adjustment, R23:** Turn until the DCD light on the modem is on when the radio is turned off, and comes on when the radio is turned on and receiving noise (coarse adjustment). Attach the antenna and connect a voltmeter to TP3. Monitor an active packet channel (1200 or 4800). Turn the pot until you measure about 2.5 volts or higher with carrier and 0.5 volt or lower with no carrier.
3. **Transmit level adjustment, R37:** Make sure jumper J101 is installed, as mentioned earlier. Put the modem in 1200-baud mode by opening the switch on the TNC-2 (J105 removed) or the TNC-1 (select BANK 0 and actuate RESET). Connect an AC voltmeter or scope to J103 pin 5. Key up long 1200-baud packets (or use the CALIBRA command) while observing the meter. Write down this value; it's your 1200-baud operating level.

Temporarily increase the level to maximum by turning the 1200-level pot on the TNC board. If you're like most packeteers, feeding audio through the mike might not cause a further increase because the signal hits the limiters in the radio. Write down this value; it's your limiting value (usually about 5 kHz deviation). Take 70 percent of this value and write it down; it's your preferred transmit level (about 3 to 3.5 kHz deviation). Turn the level pot on the TNC back to the first value you recorded. Now switch to 4800 baud by installing the jumper at J105 (TNC-1 select BANK 1 and actuate reset). Key up the TNC again. This time packets are at 4800 baud. Observe the level. Adjust R37 until you read the third value you recorded.

You've now completed all the adjustments and are ready to try on-the-air tests. If you encounter poor results, make sure your radio is on frequency—both for transmit and receive. Also double-check to make sure that the J101 (FM/PM select) setting is correct for your rig. Finally, cut down on your TXdelay. (You may also have to cut down other delays.) You can make the TXdelay shorter because of the fast-acting modem squelch, which switches in at about 15 milliseconds. This will result in better use of the available radio channel.

If everything is working at this point, and you wish to experiment some more, you can try the 4800-tap points on 1200 baud. This often results in better performance for 1200-baud reception and eliminates the additional interface wires. As an added benefit, you don't have to watch your radio's volume and squelch controls anymore, as they will have been bypassed. For more information on this subject, see the sections on service aids.

There's an additional modification which may improve your 1200-baud reception (it really has nothing to do with the 4800-baud modem). Try bypassing the MF10 filter in the TNC. Some of the newer TNCs, like the MFJ1270B and MFJ1274, have eliminated this filter altogether.

If you still encounter problems at this point, check *all* previous steps, and then check the sections which follow.

Modem service aids

First, look for poor or missing solder joints. Next, verify that the ICs are plugged in properly and check for bent pins. Finally, check the op amps. With no signal (radio turned off and not transmitting), the outputs of op amps U3B, U3A, U3C, U5A, and U5B should be 6 volts (same level as U3D/14). The outputs of U5D and U5C should be 5 volts (same as zener D5 voltage).

If you're not getting enough high-frequency noise from the receiver for the squelch to operate properly (about 2-volts swing at squelch gate U6A/1 is needed), a bypass capacitor on the line from the RX-audio tap point might be the culprit. Remove or replace the capacitor with a smaller value. If this isn't the case, you can pick up more noise (HF, about 11 kHz) by increasing C2 (try 1500 pF).

Radio service aids

Signals at TP1 and TP2 referenced to U3D/14 should be about equal to the noise amplitude. If not, check to see if you're picking up a weak received signal, like computer noise. If your computer is causing interference, turn it off or change frequency. Disconnect the antenna and check again. If the reading persists, and it's severe, your RX discriminator may not be working properly.

If 4800-baud packet signal levels at TP1 and TP2 vary a lot, but the above noise test is okay, consider the possibility that your receiver (or the sender) is off frequency.

If you're not sure of the correct tie points for the TX audio and/or RX audio for your rig, send us a copy of your circuit diagram and we'll suggest the best connection points.

TNC-2 service aids

To eliminate the "1200-MIC-AUDIO" line and use the "4800-TX-AUDIO" for 1200 baud, try the following: Disconnect the wire at J103 pin 1 (1200-MIC-AUDIO) and install a jumper at J100. Now, readjust the 1200-baud audio level control (R76 on MFJ1270B) on the main board. If the level is too low, short out series-output resistor R56 and/or increase the coupling capacitor value.

To bypass the MF10 filter in the MFJ1270 (the MFJ1270B and MFJ1274 don't use the MF10), unplug U18 and replace network U17 with a DIP header. Connect pins 1 and 8 on the header. This will result in a flat audio response where the high and low tones (2200 and 1200) should have more equal amplitude. (The XR2206 chip has trouble decoding when the tones are too dissimilar.)

If you'd like to use the 4800-carrier detect for 1200 baud as well, ground the XR2211 DCD line (U20 pin 6 on the TNC-2). Then connect U6 pin 2 to pin 14 (+5 volts) on the modem board. This enables the 4800 CD unconditionally. Next, install jumper J105 and move one of the wires of the baud-rate switch to GND. This should make U1 pin 9 about 10 volts at 4800 baud or 0 volts at 1200 baud.

Available from HAPN

The HAPN-T 4800-baud modem circuit board is available for $15. You can also purchase the circuit board and a parts kit for $48. Prices are in United States dollars. To cover shipping costs, please add $5 for United States and $8 for overseas orders. Amateurs who are interested in packet radio, and who own an IBM PC or compatible, might also be interested in the HAPN-1 adapter—a complete integrated packet radio system. Write for details. HAPN's address is Hamilton and Area Packet Network, P.O. Box 4466, Hamilton, Ontario, Canada L8V 4S7.

Conclusion

We invite your comments and suggestions on the HAPN-T modem. We can be reached by mail at the address listed above, on Compuserve at 73327,176 (VE3LNY), or by packet radio to John, VE3DVV, at VE3HPL. We're interested in your feedback. We would like to thank VE3LU, VE3NAV, and VE3MCF for their assistance with the HAPN-T project. ■

REFERENCES

1. Ken Smith, VE3HWB, and Glen Simpson, VE3DSP, "Packet Radio with the 1802," *Ipso Facto newsletter of the Association of Computer Experimenters*, April 1979.
2. Glen Leinweber, VE3DNL, Max Pizzolato, VE3DNM, John Vanden Berg, VE3DVV and Jack Botner, VE3LNY, "A 4800-Baud Modem for VHF/UHF Packet Radio," *Ham Radio*, August 1988.