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In This Issue...

President's Corner

by Bob Nielsen, W6SWE

There is quite a bit to report to you this issue, unfortunately not all of it positive. The TAPR Board of Directors has reluctantly voted to shelve the packetRADIO project, due mainly to a lack of the necessary human resources to complete the job. The DSP is still an active project, but there is no new progress to report at this time. We had hoped to complete both of these efforts by now, but it just hasn't happened.

In the October issue of *PSR*, there was a call for nominations for five vacancies on the Board of Directors. To be frank, the response has been underwhelming. There were no nominations for these openings, as of the December 1st deadline. It's hard to have an election without candidates. At the Board meeting prior to the 1991 Annual Meeting, there was quite a bit of discussion on reducing the size of the Board. We have 15 members, but not all of them have been very active. The incumbents whose terms are expiring have, for personal reasons, chosen not to run for re-election.

Additionally, Andy Freeborn, N0CCZ, has decided, for personal reasons to resign from the Board of Directors and Executive Committee. His leadership and continuing contributions will be sorely missed, as will those of the other retiring Board members. However, we did receive a last minute candidate, Jack Davis, WA4EJR. Although there is no ballot, for the reasons given above, Jack has been appointed to the Board to fill the remainder of Andy's term.

When the lack of candidates became known to the Board, the subject of reducing the Board size naturally came up again. Since we have not completed any official action at this time, the issue is still open, but if there is any formal change in the size of the Board, it will be announced at the Annual Meeting on March 7, 1992.

On a more positive note, the Deviation Meter is proceeding nicely. The TAPR board has also approved work on two other new projects, a new 9600 baud modem kit, and an antenna tracker box which has been designed by SM0TER, JA6FTL and others. TAPR will be making this available as a kit. Hopefully all three of these new items will be available soon. See Lyle Johnson's articles in this issue for details.

We are busy getting ready for the upcoming Annual Meeting. We hope that, since it celebrates the 10th anniversary of TAPR, that it will be well attended. Hopefully we will have some new kits to introduce at this time and we are also planning to issue a Proceedings which will contain a printed copy of the technical papers which are presented at the meeting. There may even be a surprise or two. Further details can be found elsewhere in this issue of PSR.

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Tucson Amateur Packet Radio

1992 Tenth Anniversary

Annual Meeting

March 7-8, 1992

The tenth anniversary Annual Meeting of Tucson Amateur Packet Radio will be held on the weekend of March 7th and 8th, 1992 at the Best Western Inn at the Airport, 7060 S. Tucson Blvd, Tucson, Arizona, adjacent to Tucson International Airport. In addition to the usual presentations of the latest and greatest developments in packet radio, we plan to have some special features in commemoration of TAPR's tenth birthday.

We are expecting to have the usual "pizza bash" and other informal activities on Friday night, March 6, with the meeting all day Saturday and an open discussion forum on Sunday morning. Registration is $15.00, including a buffet luncheon. The buffet dinner on Saturday is also $15.00. TAPR will have a hospitality suite where you can gather informally, join TAPR or purchase kits and software.

A block of rooms has been reserved at the special rate of $55.00 per night, single or double occupancy, including full American breakfast and happy hour reception. For reservations, call the Inn at the Airport at 1-800-772-3847, or in Arizona at 602-746- 0271, FAX 602-889-7391 no later than February 20 (mention TAPR to get this rate).

If you are planning to attend and have a project you would like to present at the meeting, please call or write the TAPR office and let us know. To have your paper included in the printed proceedings of the meeting, camera-ready copy should be submitted to TAPR no later than February 25, 1992. For further information, contact:

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Deviation Meter Project Progress

By Lyle Johnson, WA7GXD

The Deviation Meter (DevMtr -- don't you just love acronyms?) project is rolling along and gaining momentum! As reported in the last issue of *PSR*, prototype PC boards had been delivered and construction had commenced.

For those of you not familiar with this device, it is a station accessory that is designed to allow you to easily and accurately measure your FM transmitter's deviation. Deviation is one of the most important parameters you must set to get optimum performance from your packet station. It is easy to adjust (merely set the TX Audio output level from your TNC), but generally so difficult to measure that most folks don't do it.

The downside of incorrect deviation is poor station performance. For example, running 5 kHz peak deviation with a normal TNC will seriously degrade the ability of other stations to copy your packets. This leads to excessive retries and less channel time for everyone. Under deviation is less of a problem, but most folks just plug in their TNC to their radio and operate.

In the case of a 9600 bps direct FSK system, excessive deviation means you won't fit in the receiver's filters very well, again leading to excessive retries or just plain poor performance. Under deviation in this case will rapidly lead to "intersymbol distortion," which is just a techno-phrase meaning the other station will have a hard time copying your signal.

From this, I think you can see that proper deviation of your transmitter is fairly critical to decent packet performance.

The DevMtr is designed to enable you to quickly and inexpensively measure your transmitter deviation with enough accuracy to allow your packet station to operate at peak efficiency. It is also designed to include within itself all necessary calibration circuitry. All you'll need to make this unit operate is a soldering iron and, initially, a terminal or computer to talk to its serial port. With a little luck (luck meaning I am able to cram all the needed routines in the tiny EPROM space of the DevMtr's controller), you won't even need the terminal...

The DevMtr consists of a power supply, 2-meter receiver, synthesizer, signal conditioning circuitry, calibration oscillator, 4-channel A/D converter, microcontroller, serial port, switches and 4-digit LED display. And, yes, all of this fits on a 3" by 5" PC board!

I am writing this on January 1, 1992 (what did you get to do on your holiday?) and I am happy to report the following status (statuses? stati?):

Power Supply

The unit runs internally on +5 volts DC. A simple LM7805-style regulator is included on the PC board to allow operation from a +8 to +16 volt DC source. This circuit has been built and tested on the prototype and runs just fine.

2-meter Receiver

The receiver is based on the Motorola MC3362 receiver chip. It has a first IF of 10.7 MHz and a second IF that is presently set to 455 kHz. The second IF will probably change to a different frequency as testing progresses. Nonetheless, the 2-meter receiver is now functioning. Input from a signal generator at 2-meters has been successfully detected and the modulating audio recovered. So far, so good!

Synthesizer

The first LO in the receiver runs at about 135 MHz. So far it has been free-running. The synthesizer chip, a Motorola MC145170, has not yet been fired up on the prototype board. So, no progress to report here yet.

Signal Conditioning Circuitry

The signal conditioning circuitry has been checked out. The deviation measuring portion is working quite nicely. The signal-strength measuring portion needs to have a resistor value changed and I haven't yet tweaked this value. Nonetheless, the circuit itself is functional.

Calibration Oscillator

This is one of the keys to the DevMtr design. This oscillator runs at the 1st IF of 10.7 MHz. It is enabled by a control line from the microcontroller that also kills the receiver 1st LO, so the only signal the receiver will hear in its IF is the output from the calibration oscillator when selected.

The synthesizer chip will control this oscillator during calibration, generating precise frequencies whose DC level can be measured by the deviation circuitry and stored in a table in the microcontroller to be compared against the real signal to be measured. In this manner, the DevMtr can be recalibrated at will, in a completely automated fashion, in just a second or two.

The calibration oscillator has been built and is functional. It is presently on the wrong frequency, but that just means tweaking a capacitor value or two, or perhaps swapping out the inductor.

4-channel A/D Converter

This is a serial-interface chip, a National ADC0833 with LM335-2.5 voltage reference. This circuit has been built and interfaced to the processor. It works just fine.

Microcontroller

The microcontroller used is a Microchip PIC16C5X. The prototype is using a 16C56 for memory size, but I am hoping the final software will fit in a 16C54. In any event, this is an 18-pin, self-contained computer with clock, RAM, EPROM and CPU. This is a CMOS part that draws only a few mA of current, and executes its (rather limited set of) instructions very quickly. It has a weird instruction set and is a somewhat bizarre part, but it works and is now controlling the display and A/D sections of the board.

If you use a mouse with your computer, there is a high probability that it contains this chip to track the ball movement and send the resulting information to your computer's serial port.

Serial Port

This is a pseudo-RS232 port (uses +5 and 0 volts so will work with almost anything out there, but undoubtedly not everything). The bits have been wiggled but I haven't yet programmed any code to make it do anything.

Yes, this is a bit-banger serial port for those of you who remember such...

Switches and 4-Digit Display

There are a pair of push buttons that can be read by the microcontroller to allow local control of the DevMtr without resorting to the use of a serial port. They have been read, so this works, too.

Finally, there is a 4-digit 7-segment LED display on the board. These are continuously being strobed and refreshed by the microcontroller chip. This section of the circuit is working fine, as is the software that drives them.

Remaining Tasks

The synthesizer has to be programmed and then must lock the 2-meter receiver 1st LO to a programmed channel. Then, the signal conditioning circuitry has to be tweaked for signal strength readings. Third, the calibration oscillator has to be put on the correct frequency and control by the synthesizer verified. Next, the serial port has to wake up and say something!

At that point, the PC board layout can be committed to production artwork.

Finally, the software will have to be written and debugged to make the DevMtr useful.

I plan to demonstrate the DevMtr at the Annual Meeting in March. With luck, TAPR will also have kits to sell at that time.

Stay tuned!

Renew Your Membership!

TAPR doesn't send out constant reminders when your membership has expired. Our only way of communicating your expiration date to you, is the date on the address label for this issue. Please check it and renew if required. Your membership is very important.

The TrakBox Project

By Lyle Johnson, WA7GXD

Have you ever tried to operate an OSCAR or RS satellite in low earth orbit (this is every OSCAR except AO-10 and AO-13)? If so, you have probably wished for three or maybe even four arms.

You have to point your directional antennas at the satellites which are rapidly moving across the sky. This means updating both azimuth and elevation every minute or so.

You have to constantly retune your radio so your uplink and downlink stay where they belong.

And you have to fiddle with your microphone or keyer, and maybe switch antenna circularity.

You can do it manually (I have!), but it isn't too much fun.

Now, if you have a PC or clone, and if it has available slots, you can always buy a Kansas City Tracker and let it handle the antennas, and possibly the radios as well. If you have no slots, or aren't using a PC, your choices are more limited. You have to use the armstrong method.

Well, Bruce, SM0TER, decided this was no fun and came up with a program that runs on a MicroMint Basic 8052 controller. It is based on W3IWI's orbit tracking programs made popular in the early '80s.

This was a step forward -- it didn't require a PC -- but it was still expensive and a bit slow.

Last year, Sueo, JA6FTL and some others in JAMSAT, started corresponding with Bruce via UO-14. They collaborated and came up with a PC board that was much cheaper than the MicroMint controller and included everything necessary for computing satellite orbits and pointing antennas automatically. They wrote software for the board in 'C' and sped it up considerably.

Jack, WA4EJR (your new TAPR director), got involved with Bruce and Sueo and became a Beta tester of the new tracker. As time went on, more and more folks became interested in this device. I became involved in the project in late November.

To shorten the story, new PC boards were made in December and a number of us built them and helped issue bug reports, write documentation and so forth. The efforts by the JAs were underwritten by JAMSAT, and TAPR was asked to provide a distribution channel in the U.S. for anyone interested in this device.

The TAPR Board decided this project made sense. TAPR's experience in bringing useful kits to Packeteers and Satellite types was a good match, so TAPR is now bringing this project to you!

The unit is a sort-of super MetCon, with lots of digital I/O as well as an 8-channel 10-bit A/D converter. Configured as a satellite tracker, it can be as simple as the board, a source of 12 volts DC to run it, and a connection to your rotator control box(es) and serial port of your computer and let it run.

Alternately, you can add a couple switches to it, a potentiometer and a 2-line 16-character LCD display and have a totally self-contained unit that needs no computer at all! (Well, you need a computer or terminal to initially set the real-time clock and load the satellite elements, but after that it is standalone!)

The present software (late December 1991) can control a Kenwood TS-790 satellite rig for doppler correction, but later firmware should also support ICOM and Yaesu radios as well.

You will be able to see a prototype unit or two at the Annual Meeting and buy kits at that time as well, if all goes according to schedule. Shucks, you may be able to buy kits before the Annual Meeting!

See you in March in Tucson!

TAPR Board Shelves PacketRADIO Project

At the 1989 Dayton HamVention, a demonstration was made of the prototype TAPR packetRADIO. It performed well and we had great hopes. The digital circuitry and modems performed excellently. However serious problems in the R.F. circuitry arose.

Over the past two years, there have been several layout changes and an almost complete turnover of the personnel involved in the effort. Recently, the TAPR Board of Directors voted to shelve the project because of a lack of the necessary human resources to complete the job.

All of the TAPR developmental efforts are the results of dedicated **volunteers**. Unfortunately, it is not always possible to keep these volunteer efforts on track as we all have other obligations to fulfill.

This has been a disappointment for many of us involved with TAPR, as well as those who would have been potential users.

Since this action was taken, there have been expressions of interest by individuals in possibly bringing the packetRADIO to completion. This is being studied, and it may indeed happen, but we wanted to inform the membership of the current situation.

DSP, A Status Review

The AMSAT and TAPR organizations jointly started work on a digital signal processing project in 1988. It was originally a standalone box which would use the Texas Instruments TMS320C15 DSP chip. The same individuals who were originally working on this project subsequently became heavily involved in the design and construction of the MicroSats and the project lie dormant for a while. In 1990 it was revived, this time as a plug-in card for an IBM-compatible computer and using the TMS320C25 chip.

Features this board will have include:

- will operate with either an 8 or 16 bit ISA slot. If in a 16 bit slot, it will configure itself to do 16 bit data transfers to/from the PC.
- 6K words of default memory, expandable to 128K words.
- clock speed of 32 MHz (8 MIPS).
- phase-adjustable sample clock in the I/O section.
- 8-bit analog I/O. This will provide about 44 dB of dynamic range. Provision for I/O expansion is provided.
- 8530-based serial I/O.
- contains 68 ICs and 9 programmable logic devices on a six-layer board.

We expect to be able to sell a wired and tested board for a price that will be substantially less than currently available DSP hardware. We also hope to be able to license commercial manufacturers to build this board, as was done with the TNC-1 and TNC-2.

The hardware has been essentially complete for several months. As are all our projects, this is entirely a VOLUNTEER effort and we have 'beta' boards in the hands of about 10 persons who are working on various pieces of software, such as 1200 and 9600 baud FSK modems, a 1200 baud PSK modem and the other bits necessary to have the DSP board perform as a TNC. There is a waiting list of several others who have volunteered to help. At this point, we do not yet have any operable software, but this will hopefully change soon. When we have a chance to put the board through its paces with the software and determine any final circuit changes, a decision will be made by TAPR and AMSAT regarding production and pricing. At that time an official announcement will be made by both organizations as to availability of the TAPR/AMSAT DSP board.

Disabling Pre/De-Emphasis to Increase Link Range

Richard Place, WB2JLR

[From the NEDA Quarterly, Vol. 2, #1, Winter '91, published by the North East Digital Association.]

Using 1200 baud modems and FM radios, there is a theoretical advantage of not using the radio's audio pre-emphasis and de-emphasis circuits. Tests show the advantage to be in the neighborhood of 2 dB.

Knowing this, and wanting the user port on my node to work its very best, I disabled the pre-emphasis and de-emphasis on the user port radio. Big Mistake!

In order to get the 2dB advantage, you must disable the emphasis at both ends of the link. Defeating it at one end, but not the other, results in delay distortion of the data, which can be disastrous. Depending upon the modem chip used, the radios will either work marginally, or not at all. Since most users connect to their TNCs via the microphone and speaker jacks, they are using the pre- and de-emphasis circuits, so the user port radio in the node needs it too.

On the other hand, if you have a long haul backbone link, and think that another 2dB will make a difference, this would be an easy way to get it. Just be sure that both ends of the link get the changes.

A New 9600 BPS Modem

By Lyle Johnson, WA7GXD

Background

9600 bps direct FSK packet operation is getting more popular all the time. Pioneered by K9NG, the K9NG 9600 bps modem kit has been available from TAPR for a number of years. A couple years back, G3RUH made a compatible modem with a number of improvements and this has helped spur 9600 bps interest. Finally, the UO-14 and UO-22 satellites, along with availability from Kantronics of radios easily interfaced to 9600 bps modems, have made 9600 bps operation commonplace.

The K9NG design, and the TAPR kit, are half-duplex, fairly simple and with some keying circuitry tailored to a no-longer-available Hamtronics FM-5 transceiver. The main advantage of the K9NG modem is price: a complete kit is only $35 from TAPR. A variation of the K9NG design has been offered as a kit from the TexNet folks for about $50.

The G3RUH design is full-duplex and offers a number of features in the transmit and receive sections of the modem that offer improved performance. The G3RUH design is available in the U.S. assembled and tested from a number of sources for $100-$120.

There is now a third design becoming available.

Last year, Eric Gustafson, N7CL, and myself had the opportunity to work on a project that required 9600 bps operation in a manner compatible with the K9NG system. We leveraged development work that had been done on the now-defunct packetRADIO project and came up with an improved design. This design has now been accepted by the TAPR Board as a standalone project.

What?

The TAPR 9600 bps modem design offers improved 9600 bps operating performance and includes the following areas of enhancement:

1) full duplex operation (for loopback, satellite, backbone and other purposes);
2) improved transmit spectrum using a raised-cosine table-lookup modulator (which can be compensated for your particular transmitter);
3) receiver phase compensation circuitry (based on work done by the TexNet folks) with an improved tracking slicer;
4) an improved clock recovery state machine with an optimized sampling window;
5) DCD that works (!);
6) transmit watchdog timer;
7) BER test output suitable for driving a small speaker;
8) an optional bit regenerator with a FIFO buffer for optimum performance in full-duplex 9600 bps packet repeater applications;
9) an optional self-contained clock source for standalone bit-regeneration applications, or for use with TNCs which don't provide a 16x or 32x clock (this also enables the unit to be easily set to a "nonstandard" data rate to discourage casual users from jumping into a backbone channel, for example);
10) direct connection to TNC-1 and TNC-2 modem disconnect headers.

Why?

The K9NG is currently the only 9600 bps modem available in the U.S. as a kit. It is very cheap and works well in its intended application.

The G3RUH design is fairly expensive and has no receiver compensation circuitry. Rather, this design attempts to pre-distort a transmitter's output to match the distant receiver. This has two drawbacks:

1) the transmit bandwidth becomes wider than necessary as a result of the nonlinearities in the overall transmit transfer function that may have been introduced to compensate for the distant receiver;
2) you have to know all about the distant receiver beforehand. In a point-to-point link this is do-able, but in general it is not possible to know and thus the compensation is not achievable.

In a multi-user network environment, things need to be consistent at the "interfaces." Thus, we have RS232 voltage and signalling standards, AX.25 protocols and so forth. In an RF network, the "big interface" is the radio channel. Things should be standardized here.

The new design places compensation where we think it belongs from this system viewpoint — you compensate your transmitter for minimum bandwidth to output a true raised-cosine waveform, and you compensate your receiver's filter group delay characteristics to properly demodulate a correctly transmitted signal.

This encourages all transmitters to be "good neighbors" and allows everyone in the network to optimize their performance, knowing they will then be optimized for everyone else in the network.

Finally, the existing modems have DCD circuits that seem to be somewhat unreliable. They are based on recovered clock information, but may "stick" under certain conditions (e.g., if the incoming signal totally disappears). The new modem has an improved DCD that takes into account both the presence of a signal and its recovered-clock stability.

A Closer Look

Let's examine the points under WHAT? one at a time.

Full Duplex Operation

This means that the modem can receive and transmit at the same time. This is necessary for satellite work and for bit regenerating repeaters. It also helps during modem alignment, allowing you to set the receiver compensation circuits to a reasonable starting point, and verifying the operation of the modem as a unit.

Improved Transmit Spectrum

The transmit waveform is generated by use of a lookup table in EPROM. Unlike the G3RUH, which examines multiple bits at a time and is thus capable of correcting severe distortion, this is a simple raised-cosine generator which looks at the current and previous bits only.

Every transmitter we have examined has a fairly linear modulating characteristic, so extreme compensation is not necessary. The lookup table values used in this modem will be included in the manual so if you have a poor transmitter in this regard, it will be a simple matter for you to compensate the lookup table for your transmitter's nonlinearity, resulting in clean, narrow output spectra.

Receiver Phase Compensation

The incoming signal from your receiver's demodulator is passed through a buffer and thence to a two-stage adjustable compensator. One stage is used to correct for low-frequency distortion, the other is used for compensating group delay anomalies which show up as high frequency distortion. The output of these filters is then fed into a tracking slicer for excellent bit recovery.

This compensation circuitry can handle small to moderate distortion in the receive channel. If your radio is beyond the level which can be compensated by these circuits, it probably needs to have its IF filter replaced (or re-aligned if it is alignable).

Improved Clock Recovery State Machine

Eric has analyzed the original TNC-2 State Machine and improved it for the purpose of bit sampling and DCD stability. The State Machine implements a digital phase-locked-loop which is used to recover a clock signal from the data stream, and an analyzer which checks the recovered clock for stability. The result is improved weak-signal performance without sacrificing lock-up time.

DCD that works!

The improved State Machine code is coupled with a signal-present detector to prevent false DCD indications from a "stuck" state machine. Hang-time is included to prevent momentary dropouts, which result in the TNC grabbing the channel while the distant station is still transmitting.

Transmit Watchdog Timer

A transmit watchdog timer is included independent from the one that may already exist on the associated TNC. Since the TNC's internal modem will likely be connected to a different radio, and since the needed watchdog timeout is much shorter at 9600 bps, it makes sense that the transmit watchdog should be included on the modem.

BER Test Output

A Bit Error Rate (BER) test output is provided that can be connected to a counter for a quantitative measurement, or coupled to a small speaker or amplified speaker for a qualitative indication.

You simply listen to the BER output while tuning in a weak station which is sending a "stuck level" before the data scrambler (such as putting the remote TNC in CAL mode and sending a single "tone"), then adjust your modem and radio for minimum "popping" for maximum performance.

This method is also useable if you lack an oscilloscope to monitor the eye pattern from the modem while tuning or aligning it. The oscilloscope is better, but this makes the modem useable for those without access to a 'scope.

Optional Bit Regenerator with FIFO

For full duplex repeater use (still the best way to set up a local area channel in this author's opinion), a bit regenerator is needed for good performance. 9600 bps signals can't be converted to audio and then used to modulate a repeater transmitter for the same reasons that you can't inject the 9600 bps transmit audio into your radio's microphone connector.

A bit regenerator uses the data output from a modem which decodes the incoming signal, then uses the data stream to drive the transmit portion of a modem which drives the transmitter in the repeater.

A problem that may occur, especially with weak input signals, is recovered clock jitter. A second problem is that all 9600 bps data streams may not really be 9600 bps; they may be somewhat slower or faster.

A first-in first-out (FIFO) buffer can easily solve both these problems. The recovered signal is clocked into the FIFO, say eight bits worth. A crystal-controlled, jitter-free transmit clock is then used to clock the data out from the FIFO. In this manner, the two modems may be out of sync up to eight bit-times worth and still not lose the packet, and the resulting output from the repeater is clean and stable.

For a packet consisting of seven frames with all digipeater fields full and each data portion having 256 bytes of data, and further assuming all the data is "ones" so lots of zero insertions are needed by the NRZI packet format (in other words, a worst case scenario), the repeater will hear 24,192 bits. The FIFO will allow each modem to be off the 9600 bps target by 0.03%. This doesn't sound like much, but most crystal oscillators in TNCs are accurate to about this level. Thus, the FIFO is large enough and necessary. The performance "penalty" for this electronic scrubbing of the incoming signal to be repeated is 833 microseconds of additional system delay.

The bit regenerator circuit in this modem is an option, and consists of only three ICs — a programmable logic device, a FIFO chip, and a hex inverter used to create a short delay. Along with the self-contained clock option, described below, this modem is all you need to turn any full-duplex audio-type repeater into a 9600 bps repeater!

Optional Self-Contained Clock

The optional clock serves two purposes. The first is for standalone bit-regenerating repeaters, described above.

The second is to provide a simple way to connect up a standard TNC at an "unusual" baud rate to discourage local access to a backbone channel. This helps to encourage users to follow the local band plan for local access to the packet network. This is accomplished by using a crystal of a frequency different than that normally used.

For example, using a 5.608 MHz crystal instead of the normal 4.9152 MHz will result in a channel data rate of 10,953 bps. Using a 4.194 MHz crystal will result in a data rate of 8192 bps. Neither of these rates would be decodable by most TNCs without knowing what was happening and then copying the frequency in use.

Direct Connection to TNC Headers

This allows simple selection of TNC-1 or TNC-2 compatible modem disconnects without cutting traces or other little nasties. In addition, a bypass circuit is included so grounding a single point will remove the 9600 bps modem from the TNC and restore the original modem.

When?

We expect to have units available at the Annual Meeting for sale as kits, as well as provide a demonstration of their operation. We'll provide details of the modem's operation at the meeting as well, so come on out!

Notes from the Office

by Heather Johnson, N7DZU

We hope that you have had a great holiday season, and that this new year will bring you a lot of joy and fulfillment.

First, let's get old business squared away: I still have a broken 5 1/4" disk copying machine... The repair shop can identify the problem, but not the fix... So until I can get my machine functional, I am sending only 3 1/2" disks out.

If you purchased a MetCon-1 unit, but did not get the errata sheet (Version 9109 07-1.02), let me know and I'll send you a copy. If you have an Alpha MetCon-1 (identified by the 87C51 computer chip having a window under the sticker) and did not already send in your IC to be updated, I'll include the sheet and the new manual with your reprogrammed part when you send it in for updating. Be sure to include $5 for reprogramming.

I've always complained that our 9600 baud kit had inadequate documentation. Well, no longer! Gary Hauge took our old stuff and gave it new life. Further, Mike Curtis has done a tremendous job of documenting information on the 9600 baud modem! Thank you so much Gary and Mike.

There are several things that I'm excited about.

Our wonderful volunteers are in the process of making some new things for you, as you're reading about in these pages, plus we're closing out other things that you're used to seeing on our lists. The TNC-1 Upgrade kit is to receive the eraser. I have 8 of these kits left in stock. The PSK modem is a possible eraser candidate. I have 50 of these left. Of course the Tuning Indicator is gone except for 20 bare circuit boards that come with documentation. The boards are available at the special price of 2 for $15.

I would like to draw your attention to Paul Newland, AD7I. Paul has been a faithful, behind-the-scenes volunteer. He designed the TNC-2 hardware back in 1984/5, and more recently the MetCon hardware and firmware. He provided the TNC-2 Monitor program as well (disk #33 in our software library). TAPR would not be the organization that it is without his steady, and very much appreciated, efforts. Thank you Paul.

TAPR is in a time of transition, from the old guard to the new. The names that you have seen since day one are being replaced by new names. The Grandpas of the organization are stepping back and watching the next generation. And they will not be disappointed. Many of you that are new to TAPR have that same selfless spirit, drive and devotion to the hobby. A very large WELCOME to all of you. You also will MAKE THE DIFFERENCE. The lights are on YOU.

We're looking forward to seeing you at our tenth Annual Meeting, March 7^{th} and 8^{th}.

For TAPR,

Heather Johnson, N7DZU

9600 Baud Packet Handbook

by Mike Curtis, WD6EHR

Why 9600 Baud Packet ?

"My TNC works fine at 1200 baud. Why bother with 9600? I can only type with 2 fingers." This is true, if we assume the following:

1. You're the only one typing with 2 fingers on "your" channel,
2. Typing with 2 fingers is the ultimate goal of packet,
3. What We're presently doing is all we ever want to do, and
4. Packet in fact IS working perfectly.

However, the present packet system needs improvement. Packet is capable of much more than what we see today.

Defining Packet Radio's Shortcomings

Let's analyze the situation:

1. Short hop simplex works well, but only if the hop is a clean, line of sight path, and the channel is not very busy. If you live in L.A., you're already rolling on the floor with hysterical laughter.
2. NETROM/TheNET/ROSE, and other networking protocols work poorly with multi-hop 1200 baud trunking.
3. Mail requires days/weeks to reach its destination, IF it every gets there!
4. Ruling out HF packet (which isn't such a bad idea anyway :-), we're limited to NETROM over radio paths of a few hundred miles or so.
5. Other areas, like Europe, have far more sophisticated and efficient packet trunking systems and user access channels that work.

The Cure

Now, let's dream a bit:

NEWS FLASH! WD6EHR's fairy godmother grants Mike several wishes. After the obvious wishes have been carried out, a slip of the tongue grants us a super-duper packet system. (HEY!! I wanted a new pair of socks instead! My old ones are gettin' kinda gamey!)

When I wake up in the afternoon, I work FR0CK in France, TR0PIC in Gabon, L0RRY (Moe) and CU2LY (Joe) (and SH3MP breaks into our round table too), doing all of this via our high-speed packet multi-megabit world-wide trunking system.

I receive packet mail at my station within seconds of its being posted. We have conferences with 50 to 100 packeteers on a single 2-meter frequency. Wow, are my eyes buggin' out! A lot of us are involuntarily learning to speed read!

Large files are being transferred between local stations, and are coming in via the high-speed trunk. I decide to get a copy of the newest public domain version of "Super Italian Brothers," which was just finished 30 minutes ago in Japan. So, I connect to our LOCAL file server (he got it automagically off the master trunk) and download a copy of this 400K file. This takes me all of 10 minutes on our 9600 baud end-user channel, while I chat with a few of the locals (W1MPY in Baastin, Mass., and K0OKY in Dayton, OH) on the conference bridge. While in QSO, I open another session and look up these guys in the central name server data base, and find that W1MPY used to be a shipmate of Popeye Doyle, went to school with Dan Quayle, and was originally licensed in the 60's as H1PPY.

Packet has capabilities far beyond simple text applications, such as file transfer, remote execution (allowing you to use my computer to run software, and send the results back to yours), name servers (Callbook on a CD is an example of this), remote printing, and even linking several smaller computers to undertake a much larger task than any one of these would be capable of alone.

What would make all of this possible? Higher speed packet. A 10 megabit world-wide trunking system would tie all the metropolitan areas together, and these would be served by metropolitan area networks, with efficient 2-meter 9600 baud local access channels (and higher speed, i.e.: 56K baud on higher bands).

Am I dreaming? Too many brewskis? Not at all -- this is all done using **existing, inexpensive** technology! We don't need any magic -- just a small fire under certain easy chairs -- **yours**! And do you know who I'm talking about? All of you who think I'm talking about someone else! Yes, with **popular** support, this isn't just possible, it's easily accomplished!

2-meters is the most logical place for end users. The band is amateur-only, and is one of our most consistent and predictable bands. 9600 baud packet is a "natural." It is "top speed" on 2-meters. It's a lot more efficient than 1200 baud, and therefore a much better use of our precious radio spectrum. Being FSK, it actually requires slightly LESS bandwidth than 1200 AFSK packet, or voice.

We're going to have 9600 baud elsewhere, of course, but many feel that two-meters should be the primary thrust for end-user 9600 baud packet.

What Does It Require?

All right Mike, I'm sold! What do I need?

Modem

9600 baud packet requires a modem. The two most common varieties are the K9NG and G3RUH modems, but DSP modems will also do 9600 baud. Due to the high cost of DSP modems, we will limit our discussion here to G3RUH and K9NG modems.

There are two flavors of 9600 baud modems: K9NG and G3RUH. Both are compatible with each other, and will work with the same TNCs.

The G3RUH is a very nice 9600 baud modem. It works with all radios we've tried so far. It's full-duplex capable, and has a lot of test points.

The K9NG is a low-cost means of getting into 9600 baud. It works with a lot of radios, but is a little less forgiving of group delay, a form of phase distortion inherent in filters when approaching passband edges. Voice tolerates phase delays, data does not. If necessary, this can be minimized by widening the receive filter. This can be accomplished by reducing C13 (4000 pf) and C16 (2000 pf) to half their original values (2000 pf and 1000 pf respectively).

The Kantronics D-410 radio has a data slicer, and has been tested successfully with raw data. However, this configuration is not compatible with any other formats, such as K9NG/G3RUH, but could certainly be used in a point-to-point application, such as trunking.

TNC

Most TNCs are capable of 9600 baud. Notable exceptions are the Kantronics KAM/KPC line. If your TNC has a "9600 baud RADIO" option, or setting (as opposed to a 9600 baud RS-232 setting), it will very likely work with K9NG/G3RUH modems.

Radio

You can NOT use the radio's microphone and speaker jacks for 9600 baud packet. Period, so don't ask!

Why, you ask? (wise guy) Well, the normal receiver signal path is designed for voice. Data doesn't make it through. The transmitted and received audio signals are pre-emphasized and de-emphasized; this boosts, and cuts higher frequencies, and helps with voice and music. However, like all filters, it also SHIFTS the phase, which is verboten with data.

Besides, both of these 9600 baud modems use FSK (shifts between two RF frequencies; for a nominal operating frequency of 145.01 the frequencies used would be 145.00985 and 145.010150 MHz), whereas Bell 202 1200 baud AFSK modems (the ones currently used), use 1200 and 2200 Hz AUDIO tones FM'd onto a carrier.

Translated into simple English, this means that you need direct connection to the FM modulator varactor and FM detector.

A few radios, such as the TEKK KS-900 or Kantronics D-410, will do 9600 baud right out of the box.

How 9600 Baud Packet is Done

Modem

The PacComm NB96 G3RUH modem board plugs right inside many TNCs, such as the TNC-2 clones. There is a special modem available for the MFJ 1278T, from MFJ. It takes the place of the 2400 baud modem.

The K9NG modem kit is cheaper than the G3RUH modem, but is a little fussier about receivers. If the radio you want to use has a pretty broad receiver passband, then the K9NG will work almost as well as the G3RUH. If the receiver passband is tight, the K9NG will be noticeably poorer.

If you need to externally mount your modem and use a ribbon cable, mount the modem header on the opposite side of the PCB. Why? Ribbon cables "flop" the pins, i.e., odds pins are now even and even ones odd!

Normally, you'll want to use the TNC's keying circuit. With the G3RUH, you have no choice.

TNC

PacComm, Kantronics, and MFJ all have TNCs with 9600 baud G3RUH modems built-in. Many of us will take the route of installing our own modems. These may often be installed internally. Sometimes it may be necessary, or desirable, to install these externally.

As with all RF environment installations, shielding is important. If an external box is used, it should be a metal one. Shielded cable to the radio is mandatory -- it will not work without it. Some kind of RFI-proofing of the modem disconnect cable is needed as well. This should be kept as short and unexposed as possible.

The G3RUH modem requires you to use the TNC's keying circuitry, and this is recommended for the K9NG as well. If you do this, don't cut the PTT line on the modem disconnect.

Radio

Many modern rigs are true FM, and it's very simple to add a 9600 baud port. You need only a couple of internal connections and decoupling components to bring out the "raw" transceiver: the direct detector output, and the direct FM modulator input.

Most modern rigs use receiver chips, such as TA7761F/P, LA5006M, LC7532M, TK10420, TK10424, MC3357P, and others. Note: ALL of the chips mentioned here use pin 9 for the detector output. Others may or may not, so check first!

Transmit audio is injected through a 5-10 uF non-polarized capacitor through a 5K resistor into the modulator. This is typically a varactor diode in a transmit oscillator stage, and is pretty simple to find by simply tracing forward from the microphone. If this is "over your head," see my free offer at the end of this article.

Crystal Controlled Phase Modulated Radios

I've found that synthesized, true FM multi-mode rigs using varactor modulation in a crystal oscillator stage tend to work best. They tend to have a tad wider IF filter (i.e. CFW455E) and pass data with less distortion. Most synthesized rigs can be made to work, most with extremely simple modifications.

If your rig is crystal controlled, it can also be made to work. If it's a true FM rig, it's simply a matter of connecting directly to the FM modulator. This will always be in a crystal oscillator stage.

Modifications

There are some 9600 baud-ready radios, like the TEKK KS-900, Kantronics DVR 2-2 (not recommended), and the D410, but most of us will be using our existing radios for 9600 baud packet. Here are some specific mods. and tips.

Radio

I'm almost embarrassed to call these "mods." We're only bringing out terminations of existing signals. These modifications are non-destructive, unless you QSLF (solder with your left foot :-), your rig will still do what it did before.

Note: Be sure to use a 10K resistor at the TXA (TX Audio) attach point in the radio. This keeps the varactor from significant detuning.

Icom IC290H/V

RXA (RX Audio) may be obtained at IC12, pin 9, on the main board; TXA may be injected at D3 cathode on the main board. (This one is my personal 2-meter 9600 baud rig, and it performs fantastic!)

Icom IC28A/E/H

RXA may be obtained at IC1, pin 9, on the RF unit; TXA may be injected at R45, at the end NOT connected to the trimpot R100.

Icom IC3200A/E

RXA may be obtained at IC1, pin 9, on the main board. This is a common receiver chip for both bands; TXA may be injected at D3 cathode (VHF) and D1 cathode (UHF).

Kenwood TM221, TM321A, TM421

RXA may be obtained at IC1, pin 9, on the IF board. TXA may be injected at connection #7 on the VCO assembly on the TX/RX unit.

Kenwood TR751

RXA may be obtained at IC2, pin9, on the RX unit. TXA may be injected at D21 cathode on the RX unit.

Use the circuit in Figure 1 to couple the modem to the radio.

If you want to leave your 9600 baud modem connected and use the rig for other stuff, use the relay circuit shown in Figure 2.

This removes the modem's transmit audio line from the radio's modulator when you're not keying from the 9600 baud TNC. If you're using the same

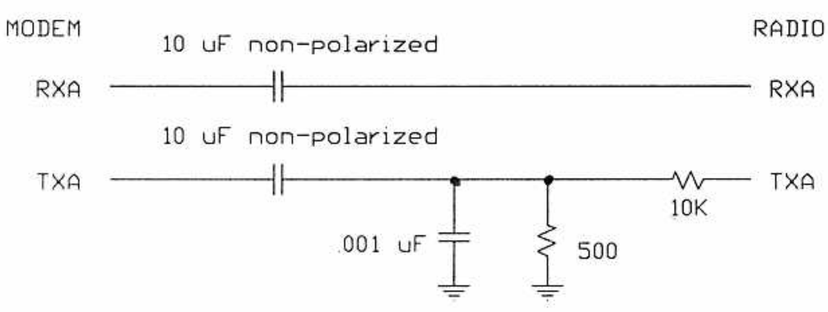


Fig. 1

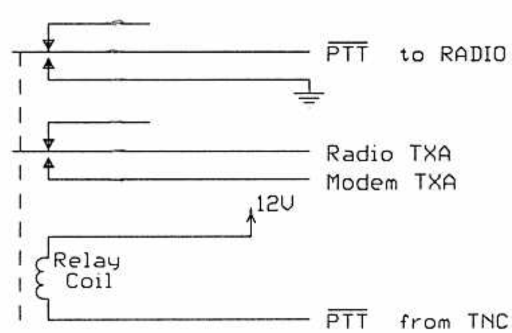


Fig. 2

TNC for 1200 and 9600 baud, make sure you remove the PTT signal from the relay! Otherwise, you'll pick up a nice 4800 Hz tone from the 9600 baud modem.

[Modifications for the FT736 were published in PSR #43 and for the IC22A in PSR #42.]

Crystal Controlled Radio Modifications

If your crystal-controlled rig is true FM (varactor modulator in an oscillator stage), inject TXA through a 5 uF capacitor into the varactor cathode. However, a lot of crystal controlled rigs are phase modulated and need a varactor modulator added to the transmit crystal oscillator.

Use an abrupt junction type, such as the MV2105 (available from Kantronics), and adjust the capacitance in the crystal circuit to compensate for the additional capacitance of the varactor. If there are fixed capacitors, remove or pad them. If not, change the trimmer to one of a lower minimum value.

You'll need to bias the varactor. I've used the transmit oscillator Vcc and a 20K trimpot to ground, feeding bias through 2 10-47K fixed resistors, feeding the modem TXA through a 5-10 uF capacitor to the center junction of these, and feeding the free end to the cathode of the varactor. The bias needs to be adjusted for best received eye pattern on a service monitor or receiver.

Remove the old transmit trimcap (15-30 pF) and substitute the with the circuit in Figure 3.

TNC Modifications

Your TNC will work better at 9600 baud if you speed it up. For TNC-2 clones, change the Z80 and Z80-SIO to 10 MHz types, and change the clock speed by changing the jumper on JP1. Older ones use the 2 OUTER pins, and newer ones use the center and (other) outer pin. Trace your schematic and PCB to be sure.

Modem Modifications

Most rigs require a lot less TXA than the modem generates, so a resistive swamping network may be needed. For example, the TEKK KS900 want 50 mVolts. On the TEKK KS900/PacComm NB96 combo, I use 500 ohms in series, and 50 ohms across the TEKK's input terminal to ground.

K9NG Modifications

The K9NG modem's keying circuit can be omitted if you use the TNCs existing PTT circuit. If you do this, remember to leave the PTT connections uncut on the TNC modem disconnect.

The K9NG modem's DCD circuit is terrible, and can be vastly improved by shorting R31 and changing C18 to .1 uF.

You may find it helpful to widen the K9NG's receive filter. Change C13 to 2000 pF and C16 to 1000 pF (half their original values). This will widen the passband, but in the process will minimize group delay; Bob, WB9MJN says this works great.

Use the PTT from the TNC. This makes things a lot simpler. Cut only these traces between pads on your TNC-2's modem disconnect J4:

1/2 DCD
11/12 transmit clock
13/14 receive clock
17/18 receive data

The TNC-2 manual tells you to cut other traces, but by doing it this way, you'll be able to use the TNC's PTT circuit. The N9NG's keying circuit, which doesn't work all that well without modifications (it's designed for the Hamtronics FM-5), may now be omitted from the PCB, if you like. This is most of the stuff on the lower edge of the PCB.

The G3RUH modem from PacComm already does this.

G3RUH Modifications

The PacComm NB96 G3RUH modem has a jumper selectable defeat function. When a jumper is in JPS, the modem disconnect is normalled through.

I've installed a DPDT slide switch on the front of my MFJ 1274 to make radio baud rate changes simple. The first pole is used to make the connection to JPS. The second pole is used to change the radio baud rate, normally done by the rear apron DIP switch.

A quick and dirty DCD LED can be easily added to PacComm's NB96 modem board. Pin 13 on U10 supplies a DCD signal. Connect a 680 ohm resistor and LED between this and +5 volts, obtainable on pin 24 of S1 or S1a (both 26-pin connectors). Only one is used. Solder your +5 volt wire into the unused hole of the other. Tack the other lead to U10 pin 13, or, on the "garbage" mod. below, to pins 8 and 9 of the 74HC00.

You may also use the DCD LED in your TNC by lifting the cathode of the LED, inserting a diode in series, tacking a second diode to the LED cathode, and running the cathode of this to modem U13, pin 10.

G3RUH "Garbage" Modification

[This mod. is from Steve King, KD7RO]

This modification gets rid of random garbage calls in the MHeard list.

1. Remove socket for U11 (74HC14).
2. Insert the 74HC14 directly into the PC board.
3. Lift all the pins of a 74HC00 except 7, 12, and 14.

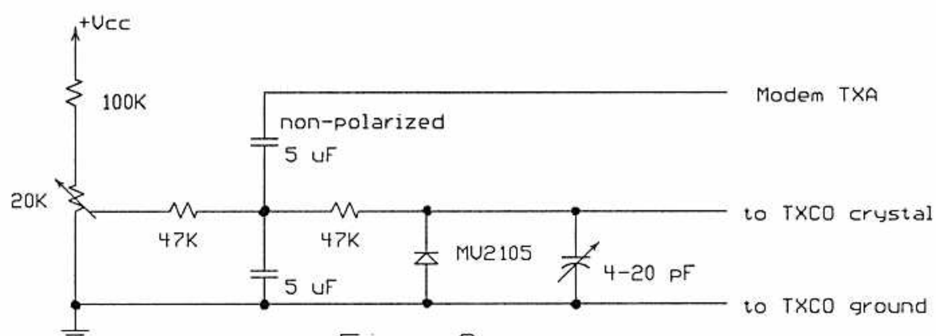


Fig. 3

4. Bend pins so they are pointing straight out.
5. Cut back the bent pins so the 74HC00 can be piggybacked on the 74HC14. Without removing the socket on U11, I would not have been able to slide the modem and Tiny-2 back into the box (you may not have this problem).
6. Cut the trace from U11, pin 12 to U20 (74HC157), pin 13.
7. Solder the 74HC00 on top of U11 (soldering pins 7, 12, and 14).
8. Wire U10, pin 13 (LM339) to the 74HC00 pins 9 and 10.
9. Wire 74HC00 pin 8 to pin 13.
10. Connect pin 11 of the 74HC00 to pins 1 and 2 of the 74HC00.
11. Connect pin 3 of the 74HC00 to pin 13 of U20 (74HC157).
12. Put a piece of tape over the top of the 74HC00 to insulate it from the case.

The DCD signal coming from U10 is low true, so I invert it using one of the NAND gates (pins 8, 9, and 10) of the 74HC00. This is used to qualify the RXD signal from the 74HC14 (pin 12). Pin 11 of the 74HC00 is the RXD signal (low true) qualified by the DCD signal, which is Lock Detect. One more inversion of this signal (74HC00 pins 1, 2, and 3) and I have the qualified RX Data signal which is connected to U20 (74HC157) pin 13.

RX Data is always zero until the PLL is locked to the data. Then RX Data will be true data coming from the unscrambler, or zeros if we are not locked.

9600 Baud Parameters

As you'd expect, the parameters we all know and love at 1200 baud don't work very well at 9600 baud. These are what we've found work well at 9600, see the figure.

How to get additional help

If you have a radio you'd like to use for 9600 baud, but don't know where to find the "magic points," send me 2 copies of the schematic -- one for me, one for you -- (block diagrams are nice but not absolutely required), and a Stamped Self-Addressed Return Envelope. I'll get out my red pen and mark the points where you'll find the raw RXA and TXA.

Some of these modifications are tested, and some aren't, but should work fine. These are non-destructive (you can still use it for whatever it was used for previously), and are generally a simple matter of tacking 2 capacitors to spots on the PC board, adding 2 resistors, attaching 2 pieces of mini-shielded cable, and bringing these 2 connections out.

Mike Curtis
Packet:
WD6EHR@N6YN.#SOCA.CA.USA
Internet:
wd6ehr.ampr.org!wd6ehr@
puffin.UUCP
CompuServe: 73240,3523
U.S. Mail: 7921 Wilkinson Ave., North
Hollywood, CA. USA 91605-2210

9600 Baud Parameters

AX.25 Parameters

TXDelay	8-15, set for best throughput
RESPtime	100ms seems to have better results than 0
FRack	8 seconds on a busy channel, but never less than 5
PERSIST	256/users; if it's a clean channel, 4 is nice; if it's busy, estimate the average number of users and divide 128 by this number (i.e. 8 users = 256/8 = 32)
SLOTTIME	20
MAXFrame	if the channel is great, 7; average, 3; rough, 1
RETry	15
CHeck	300 seconds (5 minutes)

TCP/IP Parameters

My 9600 baud interface is called "96." Here are params from my files:

```
par 96 1 8
par 96 2 64
par 96 3 20
par 4 2
ax25 maxframe 3
ax25 paclen 256
ax25 pthresh 64
ax25 retry 15
ax25 t1 8000
ax25 t2 100
ax25 t3 300000
ax25 t4 900000
mode 96 datagram
ax25 persist 96 256 5 128 15 60
```

Some of these are specific to PE1CHL NET, so don't get an ulcer if your version barfs on them.

Notes about 9600 bps and G3RUH Modems

Bill Slack, NX2P

[Reprinted from the Summer 1991 NEDA Quarterly (Volume 2, #3), published by the North East Digital Association.]

You may or may not have known that voltage variations on the 12 volt line affect the modulation level out of the NB96 (G3RUH) modem. This has caused some problems in some of the stuff I have done. A voltage change from 12 to 13.8 volts can easily change the transmit deviation (when fully interfaced to radio) from 3KHz to 5KHz. This is something to be aware of when setting up the 9600 bps modems.

I heard a report about a fix, which has made a big difference for some UoSAT operators, but with no cause. I looked into it, and I can see why. Here it goes:

On the NB96 card (internal or external), a reference voltage is derived off the 12 volt power supply by a resistor divider. This divider consists of two 100K resistors with a .1uF capacitor from the junction of the resistors to ground. The resistors in question are RS1-3 and RS1-4. This provides a 6 volt reference. This network gives a time constant of .005 seconds, which filters out high frequency noise (above 200 Hz) which may be present on the 12 volt line. The 200 Hz rate is significantly below the modulation rate, that is good, but it is too high to provide isolation from 60 or 120 Hz ripple from a poorly regulated power supply, and it provides no isolation from the low frequency voltage changes which occur when the transmitter keys-up. I have noted that I have had to set TXDELAY much longer than I would have expected in some installations; this power supply problem could be the root cause of that.

That resistor divider is buffered through an op-amp follower to convert it to a low impedance suitable for use by the remainder of the circuitry. This is good, or it would be much worse, but still, any fluctuations in the reference on the high impedance side of the op-amp will be faithfully duplicated on the low impedance side. That reference is used by all the analog circuitry, and noise there degrades the overall system performance.

The fix to this problem is to replace RS1-3 with a 6.2 volt zener diode (anode goes to ground). I would recommend replacing RS1-4 with a lower value resistor to increase the idling current of the zener, minimizing voltage swings. Something between 1K and 5.1K should do nicely. Also adding a larger capacitor in parallel with C24 would be a good idea. A 5 uF capacitor would maintain the same time constant if a 1K resister were used instead of a 100K. 25 uF would provide some immunity to 60 and 120 cycle stuff, but that starts getting big. The zener works well on the lower frequency stuff, so the time constant between the resistors and capacitor is much less important; it is not worth getting too hung up on the capacitor. C24 should be left in the circuit as a .1 uF. That provides isolation from the high frequency stuff which the zener is not good on. RS1-3 and RS1-4 are parts of a resistor SIP (Single In-line Package) network, so it is not simple to just remove these without affecting the other resistors. Since the impedance of the reference circuit is being dropped so low with the above changes, these resistors can be left in place with little effect.

Note: the above modification not only applies to the PacComm units, but probably to all the G3RUH-based modems since the above problem is in the original design.

The YU3 38,400 bps Packet Radio Network

by Matjaz Vidmar, YT3MV

[Reprinted from the June 1991 issue of QEX, published by the ARRL. The article originally appeared in Connect International.]

Introduction

At the very beginning of packet radio in our area, we noticed the severe limitations of a single channel, 1200 bps CSMA network. The terrain requires many repeaters to serve all the Amateur population, and our network has to handle traffic from Austria, Italy, Hungary, and other parts of Yugoslavia, as well.

The solution we found is to build a network of nodes with user-access channels in the 2-meter and 70-cm bands at low speeds (1200 bps and soon 2400 bps), interconnected via 38,400 bps links operating in the 23-cm band. At this time, the network has three such high-speed links connecting four main nodes: 4N3K, 4N3L, 4N3H, and 4N3P. The network is operating well, and several other nodes are under construction.

The 1.2 GHz network in Slovenia is the result of a collective effort of more than ten enthusiasts, whose work was coordinated by Iztok, YU3FK. Within this group, I was in charge of developing the hardware. In the following discussion, I will describe the technical aspects of our network.

Selecting the Transmission Standards

It was immediately clear that we could not use standard narrow-band Amateur transceivers and low-speed modems for our network interlinks. New hardware had to be developed. Furthermore, we could not use the 70-cm band without overriding the IARU band plan since the band only extends from 432 to 438 MHz in Yugoslavia. Besides, finding a clear wide-band channel in this frequency range is a challenge, so it was decided to use the 23-cm band.

The modulation standard had to be selected considering the constraints of both modem and transceiver design. Coherent modulation techniques (like PSK) provide the best spectrum efficiency and longest communications range. Unfortunately, they require good frequency stability for both transmitters and receivers. The lock-in time of the demodulator may require long synchronization headers (long TXDELAY). The transceivers have to be designed for this particular transmission standard; alignment and testing may be very difficult for Amateurs without much test equipment.

Considering the above constraints, we decided to build wide-band FM transceivers equipped with 200-KHz wide ceramic filters (like FM broadcast receivers). Such transceivers, together with suitable modems, can support digital communications up to about 64 kbps. The penalty for using an FM discriminator in place of a coherent demodulator is around 5 dB in terms of receiver sensitivity, or communications range, with well-designed modems.

The FM transceiver could be modulated with the NRZI data. Unfortunately, NRZI data has a noticeable DC component, which requires a dc-restoration network in the receiver, even with data randomization (scrambling). Therefore, Manchester coding was selected. Although it requires twice the bandwidth, a Manchester-coded signal has no DC or low-frequency component. Manchester modems can be built as simple digital state machines (no alignment) with fast and reliable digital carrier-detect logic.

To remain 100% compatible with the existing network, TNC-2 clones with NETROM software is used. This software can operate up to about 40 kbps with a 10 MHz Z80 clock, therefore, a standard speed of 38.4 kbps was selected for the network. Initial problems with TNC-2 clones operating at 10 MHz were solved by carefully selecting the components used, and by designing new logic with less-critical timing.

From the beginning, we agreed to use simplex transceivers and CSMA. A network with full-duplex transceivers could provide slightly higher capacity. However, it would have significantly higher costs, and each node would require two or three transceivers with bulky duplex filters and dedicated TNCs. The selection of multiple operating frequencies would cause problems too. This complicated (full-duplex) solution was considered out of reach for our limited resources.

Transceiver Design

The wideband transceiver is a simple single-channel crystal-controlled FM transceiver. Except for the RX/TX antenna and supply switches, the receiver and transmitter circuits are completely independent.

The receiver is a double-conversion receiver. The first (variable) IF is in the 65 MHz range, and the second IF is 10.7 MHz. A single crystal oscillator, operating between 26.5 and 27 MHz, is used for both conversions. The oscillator output is multiplied by 45 (5x3x3) for the first conversion, and by 2 for the second conversion. The receiver has two RF amplifier stages at 1.2 GHz (BFQ69 and BFR91), a mixer at 1.2G/65M (BFR34A), another mixer stage at 65M/10.7M (BF981), and a standard 10.7 MHz FM IF (CA3089). The receiver achieves a noise figure of about 4 dB.

The transmitter includes a varactor-modulated crystal oscillator in the 9.8 to 10 MHz range, followed by seven frequency doubler stages, (for a total multiplication factor of 128), and a power amplifier. High-speed switching transistors (BSX39) are used up to 300 MHz. The last two multiplier stages use a BFR91 and a BFR96. Finally, the four-stage power amplifier uses a BFR91, two BFR96s, and a BFQ68, supplying between 1.5 and 2 watts at 1.2 GHz.

The RX/TX switching is fully electronic. The RF switch uses four BA379 PIN diodes. To speed up the switch-over, the receiver is powered-on all the time, except for the two front end RF amplifier stages. The transceiver is able to work reliably with a TXDELAY of only 5 msec., but for reliability reasons the TXDELAY parameter was finally set to 20 msec.

Modem Design

Two different modems were developed. Both modems include a state machine that operates with a clock that is 64 times the bit-rate frequency. The same state machine is used during transmission and reception to synchronize a 50% duty-cycle square wave with the incoming signal.

Both demodulators include a limiter followed by an exclusive-OR gate and an integrator. Limiting the incoming signal degrades the demodulator sensitivity by 2-3 dB. This is the price paid for such a simple circuit. A few dB are lost in the integrator, too, which is a simple RC low-pass filter followed by a voltage comparator in place of a synchronized integrate-and-dump.

The first modem has an EPROM-based state machine with a 74HC374 8-bit D-latch. Most of the analog functions are performed with an LM339 quad comparator. A 16-bit shift register (two 74HC164s) generates a 1/4 bit delay for the data carrier detection, since this modem was developed to work with standard TNC-2 clones. The modem can have its own clock oscillator, but for 38,400 bps, the required 2.4576 MHz clock can be derived directly from the TNC.

The second modem uses 74LS logic only, thus eliminating the need for a relatively slow EPROM that needs to be programmed. The state machine is built with just four TTL ICs: a 74LS86 XOR, a 74LS153 multiplexer, a 74LS163 counter, and a 74LS175 D-latch chip. LM311 comparators are used for the analog functions. Since this modem is intended to work with the new TNC-2 clone (to be described later) and the latter already has a very reliable Data Carrier Detect (DCD) circuit, no DCD circuit was included in the modem itself.

The Manchester modems were also tested with standard Amateur narrow-band FM transceivers. By connecting the modem to the mike and speaker connectors, very reliable operation was possible at 2400 bps. Higher speeds (up to 4800 bps) require a direct connection to the varactor and discriminator. We believe that 2400 bps Manchester is a valid and cheaper alternative for user links to the now widely used Bell-202 1200 bps. Unfortunately, 2400 bps Manchester is not compatible to the Kantronics 2400 bps QPSK standard, but in our area, very few Amateurs have commercially built TNCs anyway.

Revised TNC-2

The first experiments were made with off-the-shelf TNC-2 clones. These have a number of drawbacks that are summarized as follows:

1. Most clones have a very unreliable reset circuit/nonvolatile RAM protection logic. This leads to undesirable "latch-ups," especially if the TNC is installed in a remote location.
2. Although the original TNC-2 had EPROM-based state machine RX synchronization, most clone makers replaced it with a 74LS393 counter with a rough reset logic. The performance of this circuit is very poor with weak signals.
3. Most clones have a poorly designed address decoder. MREQ is gated with A15 to select the 27256 EPROM. This circuit requires a

very fast 150 nsec. EPROM for 10 MHz Z80 clock operation. Gating MREQ with RD releases the EPROM access time requirements by at least 50 nsec.

4. TNC-2 clones usually do not have digital carrier detect logic. This is not a problem for Manchester modems where a reliable DCD can be built easily. It is a problem with AFSK modems (Bell 202). The transceiver squelch has to be adjusted critically and an unnecessarily long TXDELAY is required.
5. The RS-232 drivers and related negative supply are a source of trouble. In a multiple NETROM node, it is much simpler to interconnect the TNCs at TTL levels.
6. Many TNC-2 clones have other design mistakes that cause unreliable operation. These vary from one TNC to another.

To avoid these problems, we developed a revised TNC-2 clone. It includes a very reliable reset logic and an improved address decoder. The RX synchronizer is a state machine operating with a clock that is 32 times the bit rate frequency. The state machine includes DCD logic that looks where the transitions occur. If they occur at the beginning or the end of the bit time, the signal is good. If they occur in the middle of a bit, the input is considered noise.

The remaining circuits are similar to other TNCs. In spite of all the additions and improvements, the revised TNC-2 has fewer chips than some clones.

Experimental Results

The most important information from early tests is the capacity of the link, which was experimentally measured as 8700 bps of useful data (not including headers, address info., and acknowledgements) between two stations on an otherwise clear channel.

The theoretical range between two transceivers in free space is around 1000 km with medium gain antennas (10 dBd). This is about 10 dB less than a link with ideal coherent modems could do. The range was confirmed by a practical experiment. The link, 4N3K-12 to 4N3L-12, is 9 km apart, and it operated reliably with an additional 20 dB attenuator in the antenna cable.

The single-channel CSMA network allows us to do something we did not even think about. We can now monitor the propagation conditions on 1.2 GHz. With good conditions, we noticed connections between nodes that do not have a common visibility, nor antennas oriented in the right direction. Although these effects are a nuisance for a packet radio network, they can easily be made harmless by correct setting of the network node parameters.

Additional Comments on 38,400 bps.

by John Papson, WB2CIK @ N1DCS

[The following letter appeared in the September 1991 issue of QEX, published by the ARRL.]

I read with great interest the article about the YU3 high-speed packet radio transceiver project. In the past, I too have thought about using FM broadcast 10.7 MHz IF filters for higher speeds than is possible with a standard FM voice communication bandwidth. I would like to add the following thoughts on the subject.

The long multiplier chains are a great concern because they can be a constant source of spurs and unwanted crystal multiples. These spurs can be very temperature dependent, thus compounding the problem at unheated mountaintop sites. A better approach is to utilize a phase-locked loop (PLL) as a fixed ratio multiplier and share the loop between transmit and receive functions.

I am not referring to a full synthesizer as in a design that can generate individual channel increments. What is needed is a (X 128) or (X 256) fixed ratio multiplication loop. Thereby, a pair of crystal oscillators, one for the receiver and the second for the transmitter, would be multiplied by the PLL to either the receiver LO frequency, or the transmit frequency. Selection of either the receive or transmit frequency would be accomplished by switching between the outputs of the respective crystal oscillator. With a reasonable amount of shielding, both oscillators could be continuously powered, thus eliminating the frequency chirp of the transmitter upon key-up.

The crystal oscillators in the 4-10 MHz range, generate the reference frequency for the phase detector, while the feedback signal to the phase detector is counted down from L band via a divide-by-128 or divide-by-256 fixed ratio, prescaler IC for TV synthesizers. The high reference frequency of the PLL (the crystal frequency) enables the use of a wide loop bandwidth, thus allowing the loop to follow both the FSK modulation of the transmit crystal oscillator and the rapid transmit/receive switching. An HC 4046 IC could function as the phase detector, while the VCO could be printed on the PCB using microstrip techniques.

The VCO in the PLL can supply enough power to directly drive a hybrid PA module, which would constitute the rest of the transmitter. The 10 or 20 watts of power that currently available amplifier modules generate will help compensate for the losses in the demodulator.

A single conversion receiver is probably good enough for the current band utilization, as the image frequency most likely will be unused, if chosen to fall within the Amateur radio band.

When the transceiver is to be used for a dedicated point-to-point link, a single crystal oscillator can supply both the receiver LO and transmit signal by split frequency operation. Alternatively, when using a pair of rocks, the receive and transmit crystals may be swapped, to move from an interfering signal.

For the near future, the market for these high-speed data transceivers will be limited to node operators. By limiting the amount of RF and microwave circuitry, and the alignment thereof, the chance of success of an Amateur assembling the unit is greatly improved.

Finally, a common PCB design could support both a 902-928 MHz and a 1240-1300 MHz design.

What is TCP/IP ?

by Tadd Torborg, KA2DEW

[Reprinted from the NEDA Quarterly, Vol. 2 #2, Spring '91, published by the North East Digital Association.]

Transmission Control Protocol / Internet Protocol. TCP/IP defines a protocol suite. TCP/IP is a system of messages sent between computers, via radio (or telephone, or wire) that enable the computers to exchange data meaningfully. Where AX.25 is a protocol that defines how two TNCs can communicate, either directly or via digipeaters, TCP/IP is a protocol suite that defines how two computers can communicate over wire line, telephone with modems, or two or more TNCs. TCP/IP is called a suite of protocols because it actually includes hundreds of different message types and response procedures for dozens of different purposes.

Defined in TCP/IP as commands (and as separate protocols) are TELNET, FTP, SMTP, FINGER, PING, and others that are of direct use to the user. TELNET establishes a real-time two-way interactive connection between a user at his own computer, and a remote computer. This lets the user command the remote machine as if he were sitting at the keyboard of the remote machine. This is similar in effect to how an AX.25 user perceives BBS operation.

FTP, or File Transfer Protocol, is a customized command set for getting, or putting files on a remote computer. Files may contain non-text information. This is a key feature of TCP/IP for Amateur packet radio.

SMTP, or Simple Mail Transfer Protocol, is a system for automatically routing multi-line messages from one computer to another over any number of intermediate computers. Unlike FTP and TELNET, which require that an end-to-end path must be established in real-time, SMTP allows messages to traverse the computers that are available, and then wait for computers that are unavailable, and then proceed when they come on-line.

FINGER is a command to send a packet to a remote computer to find out if it is connected to the network, and if so, how long it takes to get a packet there and back.

There are many other useful protocols built into TCP/IP that allow such things as data sharing between programs running on two different computers, identifying what hosts are available, finding out the time at a remote machine, authenticating passwords, and even passing silly quotes.

Message routing with TCP/IP is based on a 32-bit address and aliasing. Each host computer is given it's own specific 32-bit network address and a text alias. The text alias for Amateur TCP/IP is usually callsign.ampr.org. The "ampr.org" is used to differentiate the Amateur network from the commercial networks in cases where there are tie-ins between the two.

The 32-bit address is of the form 255.255.255.255 where each of the numbers is called an octet (it uses 8 bits). Each of the four octets from left to right decreases in priority. The first octet is used to determine whether the destination address is ham, military, commercial, educational, etc. The second octet might indicate which state the destination machine is in. The third, depending on how the ham TCP/IP addressing committee decide to run things, might determine a network node output, a county, or a city. The last octet determines which individual machine that the message goes to.

So, given that the network extends across the country, it should be possible to address from any TCP computer to any other. The addressing system also allows for more than one user at each machine. Thus I can be ka2dew@k1tr.ampr.org which is different than k1tr@k1tr.ampr.org.

The process in the TCP program which sends messages from the host and waits for acknowledgement from the destination station is more sophisticated than TheNET. With TheNET, up to four messages are sent out of the originating node, and then when acknowledgments come back for those messages, new messages can be sent out again. Up to four messages may be outstanding at any given time. If an acknowledgment doesn't come back within 5 minutes, the originating node will regenerate the message. With TCP/IP, this time is automatically adjusted depending on previous performance of the link. TCP/IP is loaded with these kind of intelligent networking features.

TCP/IP using the KA9Q software package is very easy to modify. NET.EXE, which is the original package, has been enhanced by dozens of other Amateurs. NOS, Network Operating System, is updated and customized by many hams for many purposes, and is entirely public domain.

TCP/IP is a mature protocol system due to the vast number of people working with it. TCP software is available for most computers. It can be run over a huge number of different kinds of data links. It is extremely powerful. It is in use on many, if not most, commercial workstation systems in the world. Sun Microsystems, Apollo, HP, Xerox, DEC, Apple, NeXT, Wang, and others use TCP/IP.

Why Aren't All Packeteers Using It?

The first reason is that it won't run in a simple TNC; you need a computer somewhat more powerful than a TNC to run the software. There are things that can be done with TCP/IP that we can't do with a standard TNC, and some things we are doing that could be done better with TCP/IP, but these advantages do not yet outweigh the cost of needing another computer, for most hams.

The other reason is that certain networks are incompatible with the linking method used by TCP/IP. Operating parameters used by a network are tuned for best performance depending on the number of nodes, path quality, etc. The network then provides a port for an AX.25 user at the "connection" level of protocol; that is, the user connects to the network port using AX.25, then, from that point on, the network protocol dictates the settings of the parameters used. The problem with TCP/IP is that it operates at a lower level than AX.25; it connects with the ultimate destination node, rather than the first intermediate node. In order to do this, it must control the communication parameters over the entire link, this is where the conflict with some existing network systems exists.

Solutions to this problem are gateways, and node software capable of multiple protocols. NOS (Network Operating System) is a program that supports both TCP/IP and NETROM. One or more ports on the NOS node would then be available for TCP/IP access to a NETROM network. An intriguing capability of NOS is the ability for a TNC-only user to connect into the NOS node and then use it's TCP/IP features.

Modifying the Kantronics DE-1200 for Full-Duplex Repeater Operation

by Bdale Garbee, N3EUA

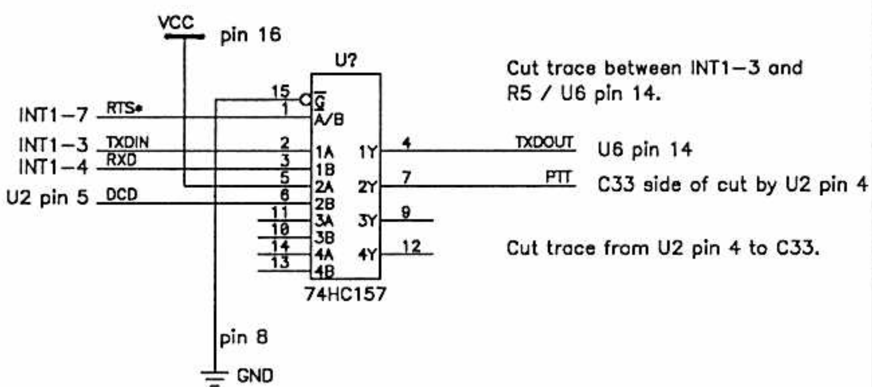
Several articles have appeared in the past on building full duplex, bit regenerative repeaters for packet radio use. Those that I have studied all involved modifications to TAPR standard TNC-2 designs. Because we intend to use a Gracilis PackeTen switch at our voice and data repeater site here in Colorado Springs, and because the Gracilis switch makes use of the Kantronics modem daughter cards, I was motivated to develop a suitable modification to the Kantronics 1200-baud modem, the DE-1200. This modification should work in either the Gracilis PackeTen switch, or in a Kantronics Data Engine.

There are pros and cons to performing the repeater function at the RF level, at the analog level, or at the digital level. For a variety of reasons, not the least of which being a desire to have the repeater be a source of "reference tones" and deviation for users to calibrate against, I chose to perform the repeater function at the digital level, which turns out to be easy to do on the DE-1200. I suggest you have a copy of the schematic for the DE-1200 in hand, along with the attached schematic of new circuitry when making the changes.

There's only one component needed for the modification, a 74HCT157 mux chip. This chip is basically a 4PDT switch with TTL inputs and outputs. I suspect that any variant of a 74157 would work fine here, I happened to have this CMOS variant in hand because it's used in the Gracilis processor board. Depending on the requirements of your transmitter's PTT circuit, you may also want a VN10KM or equivalent FET to replace the 2N2222 transistor used in the PTT circuit. I pulled one from a dead TNC-2 board.

I started by piggy-backing the 74HCT157 on the 74HC153 already on the board at U7. To do this, I bent

Repeater Modification for Kantronics DE-1200 Modem
Bdale Garbee, N3EUA



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all of the pins on the 74HCT157 except pins 8 and 6 180 degrees, so they pointed up in the air. I then tack-soldered pins 8 and 16 to pins 8 and 16 of the 74HC153, to get power and ground connections. Next, I cut two traces on the bottom side of the modem board. One is the RTS line, the other is the transmit data line. The RTS line is easiest to cut adjacent to pin 4 of U2, which is a 74HC04. The transmit data line is easiest to cut between pin 3 of connector INT1 and one end of R5.

With the IC on the board, and the traces cut, there are 8 wires to add. I used 30-gauge wire-wrap wire, stripping a small bit of insulation on ends that I tack-soldered to existing holes in the board, and using a hand-held wire-wrap tool to wrap bare wire on the now-vertical pins of the 74HCT157. Since the pins of the IC are not guaranteed to make gas-tight connections with the wire-wrap wire, I soldered the pins after wrapping them.

The wires are all documented on the attached schematic. Pin 1 of the '157 goes to pin 7 of the connector INT1. Pin 2 of the '157 goes to pin 3 of the connector INT1. Pin 3 of the '157 goes to pin 4 of connector INT1. Pin 4 of the '157 goes to the end of R5 that was once hooked to pin 3 of connector INT1, and is still connected to pin 14 of U6 (the 3105 modem chip). Pin 5 of the '157 goes to pin 16 of the '157 (5V). Pin 6 of the '157 goes to U2 pin 5. Pin 7 of the '157 goes to the C33 side of the trace cut made next to U2 pin 4.

If the 2N2222 transistor used by Kantronics doesn't pull the PTT line to ground hard enough to key your repeater's transmitter (a common problem with older commercial rig-based repeaters), pull it out and stick in a VN10KM FET in the same holes. The transistor in question is Q3. And while you're at it, Q4 adds absolutely no value in repeater operation, so I pulled it out. It's a 2N7000 FET between the transmit audio line and ground, I suppose it was intended to squelch the transmit audio during receive.

If your repeater uses a relay to switch the transmitter on and off, I cannot suggest strongly enough that you replace it with a FET circuit. The Maggiore repeater I've been working with used a relay to switch 12VDC into one pin on the exciter. After about a day of pinging every 5 seconds, the relay welded itself in the "on" position. If it isn't obvious how to do this, find a friendly local "transistor jock" to give you a hand. It's well worth the effort. Relays are evil!

That's all there is to it. This circuit, as designed, gives precedence to the packet switch at the repeater site, by switching the mode of operation from repeater to transceiver using the RTS line from the switch. When the switch wants to transmit, it can. When the switch isn't transmitting, anything heard by the receiver will be sent out the transmitter as well. Since the switch has the port which is connected to the repeater configured for half duplex, it won't transmit when a valid packet is being received, so this works out great.

I hope this modification is useful to others, the Gracilis switch with Kantronics modems is an easy and powerful way to build a multi-port digital site. With this modification, attaching a digital repeater is easy. A similar modification can be made to the DE-9600 modem, I'll write that up too if there is sufficient interest.

Forward any comments or suggestions to me at bdale@col.hp.com on the Internet, or look me up in a current callbook...

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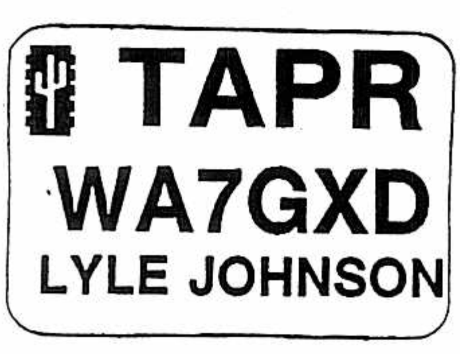

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Eaton, Pete WB9FLW,	1993	72727,2641
Garbee, Bdale N3EUA,	1992	76430,3323
Goode, Steve K9NG,	1992	70525,364
Gustafson, Eric N7CL,	1992	71750,2133
Johnson, Lyle WA7GXD, *	1992	76246,565
Jones, Greg WD5IVD,	1994	72047,3455
Lemley, Don N4PCR,	1993	73230,310
Morrison, Dan KV7B,	1994	70541,2374
Nielsen, Bob W6SWE, *	1994	71540,2364
Price, Harold NK6K, *	1993	71635,1174
Toth, Dave VE3GYQ,	1993	72255,152

Date is expiration of term on Board of Directors.
Asterisk indicates member of Executive Committee.

The TAPR Board of Director members "attend" a meeting, which is continuously in session, in a reserved area on the CompuServe information network. The Board encourages input from all interested members. If you have an issue you want addressed, or an idea for a project you would like TAPR to sponsor, contact any Board member, or drop a note to the TAPR office.

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