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**President's Corner**

If you haven't made your plans to attend the 14th annual Digital Communications Conference in September in Arlington, Texas — get that calendar out right now and make a note, call the airlines, and make those hotel reservations! If you are an author, be sure to get that paper written and submitted by July 21st! This year's DCC looks like it is going to be an excellent one and the convenience of flying in and out of D/FW airport makes it easy for anyone to attend. The DCC this year is hosted by TAPR, Texas Packet Radio Society, and the ARRL. So, as the TPRS has announced, come on down and enjoy some Texas hospitality. Full details are printed at the back of the PSR and you can find information at

<http://www.tapr.org/tapr/html/dccconf.html> or  
<ftp.tapr.org>

If you have Web access, you should check out the work that Howie, N2WX, and I have been doing over the last few weeks:

<http://www.tapr.org/tapr>

will get you there. Lots of good information. The DCC/CNC abstracts have been added as well as information and pictures of TAPR history and items. Thanks goes to Heather Johnson, N7DZU, for the loan of her TAPR

**Look for TAPR at these Upcoming Events**

Sept. 1-3, 1995 HamCon '95, ARRL Southwestern Division Convention  
aboard the Queen Mary in Long Beach, California

Sept. 8-10, 1995 ARRL Digital Communications Conference, Arlington, Texas

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scrapbook. The TAPR.ORG site has been residing on another system for the past year and will be moving to its own computer in July. The system has been getting good access. I have written up an analysis of system usage since January for this issue. We have offered space on the TAPR web server to the various digital manufacturers and wait to hear back for further commitments. Initial contacts were positive, so we hope to be able to provide this space to help support information dispersal.

219 is a reality. The question is — what and how can we get equipment operational on it? TAPR would like to request articles and information on how groups or individuals are planning or implementing 219 systems. How we get equipment operational will determine the future of 219. Without equipment (either modified or built), the band will be hard to populate. In addition, there are issues regarding frequency allocations and usage, so this is another area of interest for articles and comments.

The 1995 new membership drive has been progressing. Our goal is to recruit another 1000 new members this year. As of the first of June we have 500+, so this puts us ahead of schedule. If you need TAPR materials for a club meeting or conference, let Dorothy at the office know. I would like to personally thank Gwyn Reedy, W1BEL, for his support in inserting TAPR information into various PacComm product orders.

We are sending out a membership survey over the next few months. When you get it, take a few minutes to answer it and then send it back to the office. It has some similar points to the one that was done in 1986, so we hope to do a little tracking based on that one to see how the membership opinions have changed.

### On the projects list

We are continuing to talk with the ARRL on possible ties between TAPR and the ARRL DCC. The two workshops held at the TAPR Annual meeting in March were video taped and someone has volunteered to do a little editing on the tapes to splice in the overheads and improve the audio quality. Another volunteer is working on treatments for a new TAPR video. The premise being there will be short segments (5 minutes or less) on different subjects for club usage. Looks interesting. Tom McDermott, N5EG, has about completed work regarding his book on RF Modem Design (no official title yet). From the proofs and the comments from the readers, this looks like it is going to be an excellent future TAPR publication. The 9600 baud land-mobile modifications book is still being worked on. One of the authors of that book has had a delay due to work. Part of it should be tested with real equipment by an outside tester later this summer to ensure accuracy.

Until next quarter - Greg, WD5IVD

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The Tucson Amateur Packet Radio Corporation is a non-profit scientific research and development corporation [Section 501(c)(3) of the U.S. tax code]. Contributions are deductible to the extent allowed by U.S. tax laws. TAPR is chartered in the State of Arizona for the purpose of designing and developing new systems for digital radio communication in the Amateur Radio Service, and for disseminating information required during, and obtained from, such research.

#### Article submission deadlines for upcoming issues:

Fall 1995	September 15, 1995
Winter 1996	December 15, 1995
Spring 1996	March 15, 1996
Summer 1996	June 15, 1996

#### Submission Guidelines:

TAPR is always interested in receiving information and articles for publication. If you have an idea for an article you would like to see, or you, or someone you know, is doing something that would interest digital communicators, please contact the editor so that your work can be shared with the Amateur community.

The preferred format for articles is plain ASCII text; the preferred graphic formats are HPGL or PCX. However, we can accept many popular word processor and graphic formats. All submissions on diskette should be formatted for MS-DOS.



## Upcoming TAPR Radio Modem Design/Theory book.

TAPR is very happy to announce that we are working with Tom McDermott, N5EG, to get closure on publishing his work covering radio modem design and theory. There are a few more things to get locked down before publication, but the word from the proof readers has been outstanding! As you might surmise from looking through the (as currently set) table of contents, this book is something to get excited about. No final title has been adopted (if you have a suggestion let me know - wd5jvd@tapr.org). Hope to see this on the TAPR publication shelf shortly!

1. Overview
  - Fundamental Data Capacity, Signal to Noise Ratio - Eb/No
  - Block Diagram of the Communication System
2. Additive White Gaussian Noise
  - Calculating the BER curve given AWGN
3. Antipodal, Orthogonal, and Non-Orthogonal signaling
4. Carrier Transmission
  - FSK, FFSK, mFSK, PSK, mPSK, OQPSK, ASK, MSK, OFDM, AFSK
5. Frequency and Impulse Response of optimum modem filters
  - Optimum filter criteria
  - Raised-cosine filter responses
  - Filter Response Partitioning
  - Filter Impulse Response
  - Filter Response to an Isolated Data Bit
  - Eye Pattern Generation
  - Equivalent Noise Bandwidth
  - Some Frequency Response Defects
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    - Theoretical Eb/No vs. Received Signal Level (RSL)
    - Pseudo-level error detection margin
    - Adjustment Aid - "Click" box
    - Bit Error Rate Test Statistics
- Appendix A - Some Useful Probability Distributions
- Appendix B - Pseudo-Random Bit Sequence (PRBS) Generators
- Appendix C - Discrete Fourier and Inverse Discrete Fourier Transforms and
- Appendix D - Correlation, Convolution, and Laplace Notation for Filters

## Apple Proposal for new Wireless Data Service

Dewayne Hendricks. WA8DZP

On May 24th, Apple Computer filed a petition for rulemaking with the FCC for a new unlicensed wireless data service called the NII Band (National Information Infrastructure). This action should be of interest to the Amateurs as part of the spectrum that Apple requests for this band is currently allocated to the Amateur Radio service.

A short summary of the Apple petition follows:

Apple, in their petition, calls for the creation of a new band of frequencies for high capacity, unlicensed wireless data, the "NII Band." Specifically, Apple proposes that the Commission allocate 300 MHz of spectrum in the 5 GHz range, comprised of the 5150-5300 MHz band (which has been allocated throughout most of Europe for "HIPERLAN" unlicensed wireless local area networks) and the 5725-5875 MHz band (which currently is used by unlicensed Part 15 technologies, industrial, scientific and medical (ISM) devices, and Amateur operators).

The essential characteristics of the NII Band are:

- Adequate bandwidth to support high-speed applications (up to 24 Mbps or more) and large numbers of users;
- "Part 16" operation in protected spectrum and in conformance with an overarching set of technical rules, developed by the information industry;
- Equal access to the spectrum for all compliant devices and all types of communications; and
- Longer distance communications (10-15 km or more), creating new possibilities for unlicensed community networks.

In case you haven't been keeping up on current events, the Amateur service allocation in this area of spectrum is 5650-5925 MHz. So it would appear that there is a conflict with this proposed new service and the Amateur radio service spectrum allocation.

The FCC has assigned this petition RM-8653. Comments were due on July 10th and reply comments were due by July 25th. If you are interested in reading the full text of this petition, you can find it at:

<http://www.warpspeed.com/>

or anonymous ftp at:

<ftp.warpspeed.com>

## Comments to the FCC on the Apple Wireless Data Service Proposal

In the Matter of Allocation of Spectrum in the 5 GHz Band To Establish a Wireless Component of the National Information Infrastructure (RM-8653)

In the Matter of Petition for Rulemaking to Allocate the 5.1 - 5.35 GHz Band and Adopt Service Rules for a Shared Unlicensed Personal Radio Network (RM-8648)

I wish to submit these comments to the petition for rulemaking filed by Apple Computer, Inc. ("NII Band Petition"), and by the Wireless Information Networks Forum ("WINForum Petition), in the above referenced matters. I am filing as an individual and a long time member of the amateur radio service (ARS). I strongly support the NII Band Petition and urge the Commission to take the necessary actions necessary to make this proposal a reality as soon as possible.

The ARS began with a few experimenters in the early 1900s and has grown to more than 700,000 licensed operators in the United States alone. Amateur Radio represents principles of radio communications that have endured and advanced since the days of the earliest radio pioneers. Part 97 of the Commission's rules sums it up the best by stating these principles [97.1 (a) (b)]:

Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.

Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.

For more than eighty years, hams have carried on a tradition of learning by doing, and since the beginning have remained at the forefront of technology. Through experimenting and building, hams have pioneered advances, such as techniques for single sideband (SSB) transmissions, and are currently engaged in state-of-the-art designs in packet radio and spread-spectrum technologies. Hams' practical experience has led to technical refinements and cost reductions beneficial to the commercial radio industry.

Over the years, it has been the Commission's obligation to see that the rules that regulate the ARS allow room for amateurs to move in new directions so they can live up to their potential for advancing technical and communications skills. The ARS is constantly changing to meet the new challenges brought forth by new technologies, and dynamic and flexible rules as embodied in Part 97 provide for this.

In my opinion, the NII Band petition represents a way for the general public to participate in this communications revolution that has been exclusive playing field of the ARS for so many years. It is now up to the Commission to craft and create a new service that

incorporates the principles and experience of the ARS, with the innovative guidelines proposed by Apple in its petition. Doing so would create a new service where communications and computing technologies will be available without regard to geography, income level, educational level, or organizational size to everyone in the United States. In particular, schools, colleges and universities must have access to advanced communications and computing technologies if they are to prepare our students to participate fully in, and contribute to, tomorrow's information-based economy. The recent recognition of the growth of the world-wide Internet has brought home to many that there is an increasing requirement for access to technologies that are broadband (capable of supporting, for example, videoconferencing and multimedia applications), flexible (capable of being used efficiently to maximize the benefits of limited resources), and affordable (capable of being installed and used on the budgets available to the average American).

If our society's communications needs are ever to be fulfilled, new options must be explored. One such option of note is the Part 15 unlicensed service. Since the rules for this service went into effect in 1985, the success of Part 15 unlicensed technologies has far exceeded the early expectations of many. Today, we see a market for these technologies that is comprised of millions of devices, hundreds of applications, scores of different technologies, and an untold number of dollars in investment. The experience that we all have seen with this service should serve as a useful platform to use for building the new NII Band.

As Apple notes in its petition there are problems with the Part 15 service as it is now. The unlicensed technologies are subject to certain constraints that will inhibit them from satisfying the growing need for wireless communications services. Under the Commission's rules, these devices must not cause interference to other non-Part 15 users of the spectrum that they share and they are not themselves protected from interference. As a result, many advanced applications, and those requiring extremely high reliability, have so far remained tethered to wireline services. As these technologies become more sophisticated and ubiquitous, this lack of interference protection will become more critical. This condition calls all the more for the creation of the NII Band which I feel will address most of the problems of today's Part 15 unlicensed service and provide a workable solution.

As I have said, the rules governing the operation of the NII Band should be broad enough to encompass a wide variety of wireless devices. While very high

speed devices may be necessary for the implementation of certain technologies and communications methods, their use in the NII Band should not be required so as to foreclose the band to other technologies. For this reason, I feel that the petition filed by Apple is far superior to that of WINForum. It appears to me that the WINForum petition favors rules that will restrict the technologies used in the NII Band towards the European HIPERLAN standards. In my opinion, the Apple petition proposes an allocation and usage approach that while accommodating the requirements of HIPERLAN, would also foster the development of new and more innovative technologies. Further, the rules proposed by Apple would assure that all devices retain an equitable right to access and share the spectrum resources. Such equitable access is necessary for at least two reasons. First, service rules that favor certain configurations or technologies will bias future development efforts towards those configurations and technologies and will therefore limit the scope of innovations possible in this band. If any one type of transmission method is given priority in the band, then many of the advantages of this new service will be lost. Experience in the Part 15 bands clearly demonstrates that technology will adapt to the spectrum environment as it finds it. As long as the service rules provide for an even "playing field", a multitude of different services using this band will thrive and any artificial regulatory "slights of hand" by the Commission will be unnecessary.

In conclusion, it is my feeling that the NII Band petition provides the basis for a great public experiment which if successful will provide one of the cornerstones for the proposed National Information Infrastructure (NII). The important principles embodied in the Apple petition should guide the Commission in creating an NII Band, particularly if it is to employ spectrum at 5725-5875 MHz in which both Part 15 and ARS technologies are currently being developed and deployed. The combination of adequate spectrum and efficient pragmatic spectrum sharing rules should create an environment in which this new service with its innovative technologies could thrive.

For the reasons stated herein, I wish to support the petition for rulemaking filed by Apple Computer, Inc.

Respectfully submitted,  
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July 7, 1995

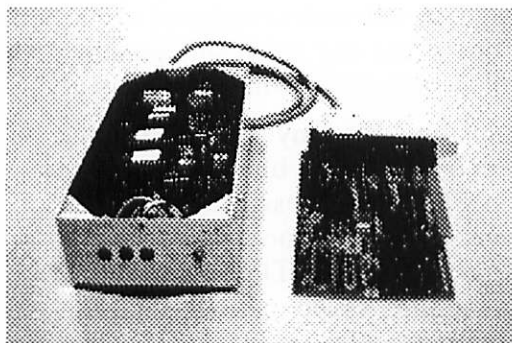
## Interfacing the TAPR 9600 bps Modem with the Ottawa PI2 Packet Interface Card

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### Introduction

This article describes the interfacing of a TAPR 9600 bps modem with the Ottawa PI2 Packet Interface card. There are several choices you can make in interfacing the two. Throughout this article I will introduce those choices and focus on the optional RS-422 interface of the Ottawa PI2 card with the TAPR 9600 bps modem.

The TAPR 9600 bps modem was designed to be interfaced with a host TNC via the TNC's modem disconnect header. The host TNC then supplies the necessary signals, power, and housing for the TAPR modem. However, there is no provision for installing a high speed modem on the Ottawa PI2 card, aside from the optional 1200 bps AFSK modem. Therefore, the TAPR 9600 bps modem must be installed external to the PI2 card. This will require a wire interface and the TAPR modem will require its own power and enclosure.



Interfacing the PI2 card with an external modem is done via one of two ports. The A port is the high speed port capable of interfacing with high speed modems such as the GRAPES WA4DSY 56 kbps, Kantronics D4-10 (19.2 or 9.6 kbps), or the TAPR 9600 bps modem. Connection with the external modem can be done using TTL or RS-422 signal levels. The B port is a low speed port capable of upto 9600 bps using a reasonably fast computer. Signal levels coming from the B port are TTL only. The B port can also be interfaced directly to a radio when the optional 1200 bps AFSK modem is installed on-board the PI2 card. Consult The PI2 Packet Interface Users Guide for more information.

In this article I will describe the interfacing of the A port with the TAPR 9600 bps modem. Signal levels coming from the A port are by default TTL, and the maximum recommended distance between TTL devices is 18 inches. However, many people have been successful with longer distances. You can experiment and see if

interfacing an external modem via TTL levels will work for your particular situation. Choosing TTL signal levels at a considerably long distance could be fraught with erratic performance, especially if there is excessive Radio Frequency Interference (RFI) from computers and transmitters in the area.

Interfacing the PI2 card with an external modem via the TTL signal levels is the easiest option, though not the most optimal. The short distance of TTL limits the choices of where to place the modem in a typical installation and TTL is prone to interference. The solution is to install the optional RS-422 interface onto the Ottawa PI2 card. This will extend the distance an external modem can be placed and provide for a high speed interface that is more resistant to interference than TTL. However, the TAPR 9600 bps modem does not have a RS-422 interface option. It was designed for TTL levels from the modem disconnect header of the host TNC. Therefore, a daughter board needs to be constructed for the TAPR modem to interface the TTL signals with RS-422 signals coming from the Ottawa PI2 card.

### Installing the Optional RS-422 Interface to the Ottawa PI2 card

Appendix D in the *PI2 Packet Interface User's Guide* that is provided with the PI2 card explains how to install the RS-422 option on the card. To summarize from the manual, to install the RS-422 interface, do the following:

- Install a 16-pin DIP socket at U14
- Install a 16-pin DIP socket at U17
- Install a 26LS31 line driver chip in the socket at U14
- Install a 26LS33 (or 26LS32) line receiver chip in the socket at U17
- Install 120 ohm resistors at R41, R42, R43, and R44
- Remove the TTLRS jumper (J2)
- Move the RTSAA jumper (J4) to the TTL position (lower two pins)

### Housing the TAPR 9600 bps modem

Construct the TAPR 9600 bps modem according to the instructions provided with the kit. Follow the directions for TNC 2 Internal Installation on page 8 of the manual. It is recommended that the clock option be installed on the modem. It is an inexpensive option and it simplifies interfacing the PI2 card with the TAPR modem.

Note: Throughout the discussion below, always refer to the TAPR 9600 bps modem manual for guidance. Make sure you understand why the changes listed below are being made. Blindly following directions without understanding why can lead to disaster! Double check all connections against the schematics supplied with the TAPR modem and the PI2 card.

The TAPR 9600 bps modem was originally designed to plug into the modem disconnect header of a host TNC.

The TNC supplies the necessary TTL signals, power, and a housing for the modem. Since the TAPR modem is not being installed inside a TNC, these items need to be supplied.

**Housing** - An aluminum project box 8" x 4" x 2" (LMB No. 842) is an ideal size. There is plenty of room for the modem with a 1/2 inch clearance around it. This will allow for three LEDs (DCD, PTT, and PWR), power switch, fuse, 15-pin female D connector, 5-pin female DIN connector, and a power connector to be mounted on the box. Install the modem in the box using three 3/4 inch stand-offs. This will allow sufficient clearance for the RS-422 interface daughter board explained later.

**Power** - Install U23, the LM7805 voltage regulator on the TAPR modem. The modem draws approximately 50 mA. A power cube of the appropriate current rating at 12 vdc will supply the necessary power to the modem. It is recommended that a power on/off switch and a 1/2 Amp fast blow fuse be installed on the project box for safety. Apply positive 12 vdc power to the modem via header pins 24 and 26 of P3. You may find that the LM7805 will require a heat sink when powering the RS-422 interface chips on the daughter board explained later.

**Signals** - The TAPR modem expects TTL level signals at the modem disconnect header (P3). To convert these signals into RS-422 requires the construction of a daughter board that will plug into P3 of the TAPR modem. P3 is a 20-pin female header that is soldered to the underside of the modem.

### Constructing a RS-422 daughter board for the TAPR 9600 bps Modem

The daughter board will contain a RS-422 driver chip (26LS31), receiver chip (26LS33 or 26LS32), 20-pin male header, two resistors, and two bypass capacitors (0.1 uF). The PC board is a Radio Shack mini PC project board (276-148). Solder the components to the project board according to the placement diagram and schematic below. When finished, the 20-pin male header of the daughter board will plug into the bottom of the TAPR modem's 20-pin female header. Connect the daughter board to the 15-pin female D-connector on the project box using a ribbon cable. This will lead to the PI2 card.

Power for the two chips on the daughter board can be taken from the TAPR modem. There are three blank chip positions on the TAPR modem that are reserved for the bit regenerative option. Tap into pin 16 of U3 for 5 vdc.

As mentioned earlier, you may find that the RS-422 interface chips will add an extra load on the TAPR modems LM7805 voltage regulator. This may require adding a heat sink to the LM7805.

### Interfacing the TAPR 9600 bps modem with the Ottawa PI2 card

Now construct an interface cable. A 36 inch long (approximately 1 meter) cable will do fine for most installations. The cable requires at least 9 conductors and it is preferred that it be shielded to help reduce interference.

It was chosen to install a 15-pin female D-connector on the aluminum box that houses the TAPR modem. This was to match the 15-pin female D-connector on the PI2 card. This way two 15-pin male D-connectors can be installed on both ends of the interface cable. Provided the connectors are wired pin-for-pin, you do not have to worry about which connector goes where. Below is the wiring diagram for the interface cable.

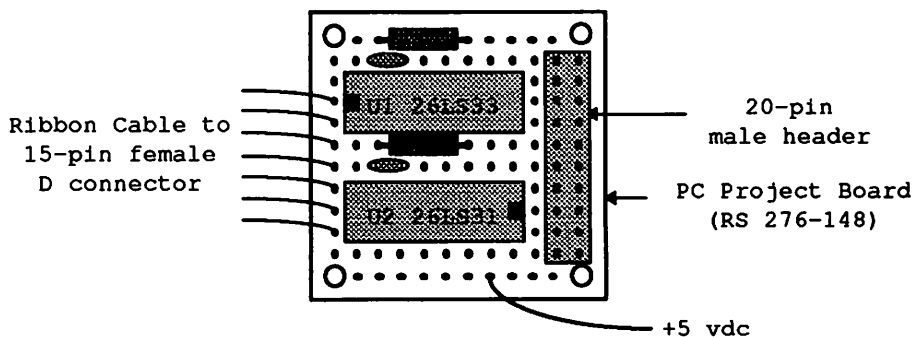
### Interface Cable Wiring Diagram

PI2 card	Description	TAPR modem
P1-6	TXD(+)	P1-6
P1-14	TXD(-)	P1-14
P1-7	RTS(+)	P1-7 (*)
P1-15	RTS(-)	P1-15 (*)
P1-3	RXD(+)	P1-3
P1-11	RXD(-)	P1-11
P1-5	DCD(+)	P1-5
P1-13	DCD(-)	P1-13
P1-9	Ground	P1-9

(\*) Note: See text for optional open collector configuration

### Interfacing the TAPR Modem to the Radio

A 5-pin DIN female jack was installed on the project box for the TAPR modem to Radio interface. This is the standard TNC-2 type radio port connection. This allows connectors already made up for other radio/tnc pairs to be used in this project. Below is the pin layout for the radio port.



RS-422 Interface Daughter Board for TAPR 9600 bps Modem (drawing is not to scale)

## Radio Port Wiring Diagram

TAPR Modem P1	Description	5-Pin DIN Jack
1	RXA	4
2	TXA	1
3	GND	2
4	GND	2
5	PTT	3

### Optional RTS Open Collector Interface

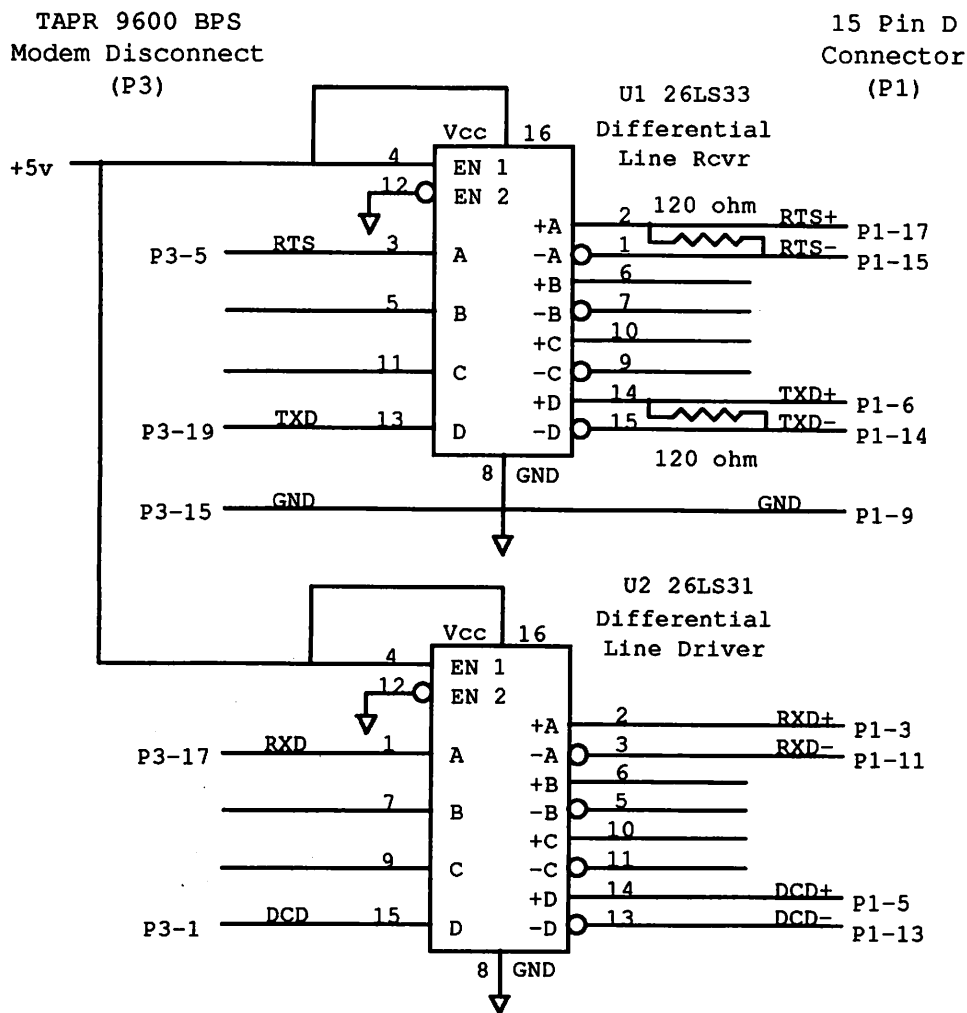
The Request To Send (RTS) signal commands the TAPR modem to transmit. The interface described above uses a RS-422 signal level for RTS. There is one drawback to this design. The modem needs to be powered off before the computer, otherwise the modem will go into constant transmit until the modem's watch dog timer times out.

To remedy this situation you can change RTS to an open collector signal level. The RTSAA jumper (J4) on the PI2 card allows for RS-422 or an open collector signal for RTS. To change the RTSAA signal to open collector, move the jumper on J4 to the upper two pins. This changes the RTS signal coming from the PI2 card (P1-7) to open

collector signal level. At the TAPR modem, the RTS signal should be passed directly to the modem disconnect header P3 pin 5. Now the problem of constantly transmitting when the computer is turned off will be solved.

### Summary

Together, the TAPR 9600 bps modem and the Ottawa PI2 Packet Interface card make a great price/performance combination. The PI2 card provides the high speed DMA driven port interface, and the TAPR modem the low cost high speed modem. The TAPR modem was designed to be interfaced with a host TNC via a modem disconnect header. The high speed port A of the PI2 card can only be interfaced to an external modem. This article describes how the two can be interfaced to provide the hardware component of a packet radio system. This hardware coupled with KA9Q NOS or the Linux Operation System completes the system and provides the user with a highly capable network node in the Amateur packet radio network.



Schematic Diagram for TAPR 9600 bps Modem Daughter Board



## What is a PI2 Card?

The Ottawa PI2 (Packet Interface 2) card is a PC-compatible synchronous interface card for high-speed packet radio using TCP/IP. The PI2 is the successor to the original Ottawa PI card, first introduced in late 1990 and now widely used in packet radio networking applications in a variety of PCs ranging from XTs to 486s. The PI2 is a two-port interface card which offers a superior alternative to Terminal Node Controllers, since it eliminates the delays associated with serial interfaces, and it will not become obsolete when you want to move up to speeds well beyond 9600 bits per second. The high-speed port of the PI2 is designed for operation at speeds up to at least 250 kilobits per second. A 1200 bps modem for the low-speed port can be installed on the card, allowing packet operation by simply adding a radio. In short, this card offers the packet radio experimenter high performance at a reasonable cost.

The PI2 card is produced by the Packet Working Group of the Ottawa Amateur Radio Club, Inc., a nonprofit, volunteer organization. All proceeds from the sale of the cards are used for the development of Amateur packet networking facilities.

### Technical Specifications

- 85C30 CMOS SCC chip (7.3 MHz clock) with two half-duplex ports: the 'A' port is High-speed DMA port, while the 'B' port is a Low to medium-speed interrupt-driven port.

#### High-speed port interface options:

- Buffered TTL (standard) for direct connection to external modems. e.g., GRAPES 56 kb/s modem, G3RUH-type modem, or Kantronics D4-10
- RS-422 (user-installed option)

#### Low-speed port interface options:

- On-board TCM3105 1200 bps modem (available as optional kit)
- Buffered TTL for direct connection to external modems
- On-board modem has state machine DCD for 'open squelch' operation
- Both ports have provision for 16X or 32X bitrate clock output for G3RUH-type modems, and also have RX Data qualified by DCD to reduce the interrupt load on the host CPU
- On-board timer chip for reliable CPU-independent timing
- Driver software, including source code, for KA9Q NOS included (backwards compatible with the original PI card)
- Linux driver available (from ftp sites)
- Compatible with PC, PC/XT, and PC/AT type systems
- Small size (6.25" length) and low power consumption
- Pre-configured software and detailed documentation included

The PI2 card and its predecessor have been extensively tested with the GRAPES 56 kb/s modem and KA9Q NOS, on various XT- and AT-class systems. Bench tests indicate that the high-speed port can support speeds of more than 460 kb/s. Performance of the "low-speed" port is more dependent on your machine's CPU, but we believe it will work at 9600 bps on most 386/486 class machines (actual performance will depend on what other interfaces are attached, and many other variables, so it is difficult to be definitive here).

The package includes KA9Q NOS (JNOS version) configured for the PI2 card, driver source, and installation documentation with schematic. In addition to the built-in driver for NOS, a packet driver (AX.25 class) compliant with the FTP Software Inc. specification is included in the package. The original PI card has been supported in NOS for several years now, and new releases of the drivers will be readily available from several Internet ftp sites (e.g., ftp.ucsd.edu, pc.usl.edu, and hydra.carleton.ca). The PI/PI2 driver for Linux can be found at hydra.carleton.ca and (probably) sunacm.swan.ac.uk.

The low-speed modem kit contains a complete set of parts (including modem chip, crystal, and state machine ROM) and detailed installation instructions. Assembly and tuneup should take about an hour. The PI2 documentation also includes instructions on installing the RS-422 line drivers and receivers, and details on interfacing the card to various types of external modems.

Support is available via Internet.

### Ordering Details

The PI2 card is available only fully assembled and tested (modem not included), for US\$125, or CDN\$160, plus shipping. A complete parts kit for the on-board modem is available for US\$30 or CDN\$40 (documentation on the modem is included with every PI2 card, so you can acquire your own parts if you wish).

Shipping: flat \$10 per order. For orders from North America, shipping is by air parcel post. For destinations outside North America, shipping is by surface mail. For air delivery outside North America, please add \$5 for each card ordered (e.g., for 4 cards, shipping by air would be \$30). Delivery by courier is more expensive - please enquire before ordering.

To order a PI2 Card, please print the order form from the Web page (<http://hydra.carleton.ca/info/pi2b.html>) and mail the completed form, along with payment to:

OARC Packet Working Group  
Lincoln Heights Postal Outlet  
P.O. Box 32032  
1386 Richmond Road  
Ottawa, ON K2B 8B0  
CANADA

## Linux & Ottawa PI/PI2 Card mini-HowTo

Barry McLarnon VE3JF,  
bm@hydra.carleton.ca

This document aims to explain how to get the Ottawa Packet Interface (PI or PI2) card working under Linux with the kernel AX.25 support by Alan Cox, GW4PTS. It does not cover installation of the AX.25 support itself, or the use of the associated utilities. It also does not cover modem interfacing (except for some clocking issues) or other subjects which are included in the card's user manual.

Thanks to Dave Perry, VA3DP, and Steve Bible, N7HPR, for their insights and helpful suggestions on improving this document.

For more info on the PI2 card:

Email: pi-info@hydra.carleton.ca

WWW: <http://hydra.carleton.ca/info/pi2b.html>

Before you begin, you should arm yourself with appropriate documentation. Start with "The PI Packet Interface User's Guide" of course. There are several Linux HOWTO guides that you should consult too, including:

HAM HOWTO

NET-2 HOWTO

Kernel HOWTO

All are available from:

<ftp://sunsite.unc.edu/pub/Linux/docs/HOWTO>.

Now, here are the steps needed to get your card up and running with Linux:

### (1) Set up the PI[2] card hardware

We won't get into the details here, but check the card's jumper settings and external cable connections carefully to make sure they are appropriate for your modem/radio setup (see the notes on clocking at the end of this document). If it's convenient for you to do so, you might want check the setup initially with JNOS under DOS... but you probably want to forge ahead with Linux, right?

### (2) Install the kernel AX.25 support

The details of installing the kernel AX.25 support and associated utilities are covered in the Linux HAM HOWTO, by Terry Dawson, VK2KTJ. Note that you do not need to use 'axattach', unless you are installing a KISS interface in addition to the PI interface. Make sure you use the latest version of the AX.25 support, which at the time of writing was v2.8 (filename for the distribution is `krnl028.tgz` - note that the PI driver contained in this distribution is *not* the latest). You should use a kernel in the 1.2.X or 1.3.X series. The AX.25 support is included in the 1.3.X kernel distribution, but there may be slightly more risk in using this series, since it is beta code and close to the "bleeding edge."

### (3) Install the PI2 card driver

The latest version of the driver (0.8alpha as of this writing) can be found on [hydra.carleton.ca](http://hydra.carleton.ca/pub/hamradio/packet/tcpip/linux), in `pub/hamradio/packet/tcpip/linux`. The file to look for is `pi2-0.8ALPHA.tgz`.

Unzip/untar the archive in a convenient place, and check out the README. Copy the `pi2.c`, `pi2.h` and `z8530.h` files to `/usr/src/linux/drivers/net`.

Since the autoprobe and the piconfig program have some limitations, it is a good idea to edit `pi2.c` and change the defaults to what you'll be using.

Before installing the card, you should check the existing cards in your PC for their usage of I/O addresses, IRQ levels and DMA channels (you DO already have a list of these, don't you?). Pay particular attention to cards such as sound cards and SCSI controllers, which are likely to use DMA channels and/or interrupts.

The card normally comes set for DMA channel 1. If you leave it at that setting, make sure you change it from 3 to 1 in `pi2.c`. Look for the line:

```
#define PI_DMA 3
```

This is the important one to get right. While you're at it, you might as well set the other parameters you need. In the latest driver version, you will find `#define` statements for them near the one for the DMA channel. In earlier versions, you have to look farther in the file (search on the string 'Param'); however, we encourage you to get the latest driver from [hydra.carleton.ca](http://hydra.carleton.ca).

Now edit the `/usr/src/linux/arch/i386/config.in` file. In the networking section, it should contain the line:

```
bool 'Amateur Radio AX.25 Level 2' CONFIG_AX25 y
```

if you have already installed the kernel AX.25 support. If you haven't, there will be a leading '#' that you should remove to 'uncomment' the line. If there is a 'n' at the end, you can change it to 'y', making it the default choice when you run 'make config'. Now add the line:

```
bool 'PI2 synchronous adaptor support' CONFIG_PI y
```

for the PI/PI2 card support (note that the README file in earlier driver distributions has it incorrectly as 'CONFIG\_PI2'). Although the driver source is in a file called `pi2.c`, it does also work with the PI card.

### (4) Build the new kernel

Follow the usual steps:

```
cd /usr/src/linux
```

```
make mrproper
```

```
make config
```

```
make dep
```

```
make zImage
```

Take it slow when you 'make config,' and make sure you answer 'y' to the questions about AX.25 and PI2 support. For more information on building a kernel, check the Kernel and NET-2 HOWTOs.

Save a copy of your old kernel, and copy the new one from `/usr/src/linux/arch/i386/zImage`. Don't forget to run `lilo`!

### (5) Reboot and check the messages

When you reboot, if the autoprobe for the card is successful, it should give a message similar to this:

```
PI: V0.8 ALPHA April 23 1995 David Perry (dp@hydra.carleton.ca)
```

```
PI: Probing for card at address 0x380
```

```
PI: Found a PI2 card at address 0x380
```

```
PI: Autodetected IRQ 5, assuming DMA 3.
```

If you miss the message during the boot sequence, you can play it back later, using the `/sbin/dmesg` command.

### (6) Configure the interface(s)

Assuming the card has been recognized correctly, you're ready to configure the interface with `ifconfig` and `piconfig`. The `piconfig` program is part of the PI driver distribution, whereas `ifconfig` is a standard Linux networking tool. The problem is that the `ifconfig` which came with your Linux distribution probably does not have the AX.25 support compiled in, in which case it will not work for configuring the PI interface. You'll need to get a recent net-tools distribution and compile a new one. The net-tools package is available from <ftp://sunacm.swan.ac.uk/pub/misc/Linux/Networking/PROGRAMS/NetTools>, or from [hydra.carleton.ca](http://hydra.carleton.ca) (same directory as Linux PI driver). The version to look for is net-tools-1.1.95. Consult the NET-2 HOWTO for more information on net-tools.

In addition to `ifconfig`, other important tools, such as `route` and `netstat` are included in this package; you might as well build and install them all, in case your existing ones are outdated. As root, dump the archive in a build directory somewhere and do a `'make all'`. You will be asked some configuration questions, similar to when you build a new kernel - make sure you answer `'y'` to the questions concerning AX.25, and for any other types of network interfaces you have. Assuming the compile goes ok, you can then do `'make install'`. Your old versions of the net-tools will be saved as `ame.old`, so you can always back out if the new ones don't work.

If you run into problems compiling your own `ifconfig` with AX.25 support, you can ftp a binary from [hydra.carleton.ca](http://hydra.carleton.ca). It can be found in the same location as the PI driver.

The things you need to set with `ifconfig` are the link encapsulation type (AX.25), hardware address (callsign), ip address, broadcast address, netmask, ARP, and MTU. Here's an example (for the Ottawa network) which sets up the PI2 A port:

```
ifconfig pi0a 44.135.96.8 hw ax25 ve3jf-2
ifconfig pi0a broadcast 44.135.96.255
ifconfig pi0a netmask 255.255.255.0
ifconfig pi0a arp mtu 2088 up
```

Now you should be able to enter `'ifconfig pi0a'` and get a report that looks something like this:

```
pi0a Link encap AMPR AX.25 HWaddr VE3JF-2
inet addr 44.135.96.8 Bcast 44.135.96.255 Mask 255.255.255.0
UP BROADCAST RUNNING MTU 2088 Metric 1
RX packets 0 errors 0 dropped 0 overruns 0
TX packets 9 errors 0 dropped 0 overruns 0
Interrupt 5 Base address 0x382 DMA chan 3
```

Now set up the `pi0b` interface with some appropriate `'ifconfig pi0b...'` commands. If you are not currently using the B port, there is no need to set all of the parameters, but you should at least set the interface type and enable it, e.g.:

```
ifconfig pi0b 44.135.96.8 hw ax25 ve3jf-2
```

The next step is to use `piconfig` to set the baud rate and other timing parameters on each pi-interface. If you have set all of these in the driver source before building the kernel, then this step is redundant. Running `piconfig` with no arguments should show the current settings. Don't try to use `piconfig` to change the DMA channel or IRQ. It should work for the other parameters, but there may still be some bugs. Here's an example which applies to a 56 kbps GRAPES modem on the A port (as with `ifconfig`, a single invocation of `piconfig` can be used to set multiple parameters, but we show them separately here for clarity):

```
piconfig pi0a speed 0
piconfig pi0a clockmode 0
piconfig pi0a txdelay 10
piconfig pi0a persist 64
piconfig pi0a slot 10
piconfig pi0a squelch 1 {aka "txtail"}
```

Now set up the B port if you are planning to use it.

Finally, you need to set up some routes. Here's a simple example, again drawn from the Ottawa network:

```
route add -host 44.135.96.35 dev pi0a
route add default gw 44.135.96.35
```

The `'dev pi0a'` in the first statement is not really needed, since the netmask set by `ifconfig` on the `pi0a` interface has already established an implicit route for 44.135.96.0... but you may need it in other circumstances. There are many other possibilities, but this isn't a tutorial on ip routing. :-) If you're familiar with NOS, the concepts in setting up the routing table are quite similar here, but the syntax of the commands differs slightly. Check `'man route'` for details, and for more background on routing and other networking topics, the "Linux Network Administrator's Guide" by Olaf Kirch in the Linux Documentation Project ([sunsite.unc.edu/pub/Linux/docs/LDP/](http://sunsite.unc.edu/pub/Linux/docs/LDP/)) is a good source.

Your setup should now be functional. The details of further testing are left as an exercise for the reader. :-) Once you get it the way you want it, you can put all the setup commands in your `/etc/rc.d/rc.local` file (or, if you prefer, in `/etc/rc.d/rc.inet1` with the other networking stuff).

## (7) And finally...

If you have questions, you can contact me by email. You can also tap the collective wisdom and experience of other PI/PI2 users by joining the pi-users mailing list. To join, send a message to

listproc@hydra.carleton.ca

Put this in the first line of text (**not** the subject):

subscribe pi-users YourName YourCallsign

You can also sign up via WWW. Point your Web browser at:

<http://hydra.carleton.ca/cgi-bin/lwgate/PI-USERS/>

## Appendix: Notes on PI/PI2 clock modes:

This is perhaps the most confusing part of setting up the PI(2) card radio interfaces and associated driver software, since different modems have different requirements. The card has two basic clock modes, 'internal' and 'external'. These designations refer to the card, not the modem, so 'internal clocking' means that the card generates the necessary data clocks internally, whereas 'external clocking' means that the card will expect to get both receive and transmit clocks from the modem. To complicate things a bit, however, there is also a special internal clocking mode available, in which the transmit clock generated by the card is at a multiple of the bit rate. This mode was added to accommodate the G3RUH-type modems. The three cases are described below:

**Case 1:** The modem provides both receive and transmit clocks, so the card is set up for external clocking (e.g., GRAPES modem):

```
speed = 0
```

```
clockmode = 0
```

This combination is likely to be used only on the A port. The TXCK jumper (J3) must be in place to allow the external transmit clock to reach the SCC (via the TXC input).

**Case 2:** The modem does not provide either receive or transmit clocks, nor does it require the card to provide any clock signals. The card must generate a receive clock for bit timing recovery, so it is set up for internal clocking. Examples where this case applies are the onboard 1200 bps modem (if installed), the Kantronics D4-10, and the TAPR 9600 bps modem with the 'clock option' installed:

```
speed = XXXX {modem bit rate}
```

```
clockmode = 0
```

The position of the TXCK jumper doesn't matter in this case.

**Case 3:** The modem does not provide either clock, but it requires a transmit clock at 16X or 32X the bit rate, so the card is set up for internal clocking, but with a special clock mode for transmit. This case covers the G3RUH 9600 bps modem, and the TAPR modem with no 'clock option' installed:

```
speed = XXXX {modem bit rate}
```

```
clockmode = 1
```

If this combination is used on the A port, it is essential that the TXCK jumper be REMOVED, so that the transmit clock can reach the modem via the 32CK output.

One final complication: clockmode = 1 configures the SCC to output a 32X baud rate transmit clock. Some modems can only use a 16X clock. The latest version of the PI2 (rev B) includes dividers so that the default transmit clock rate (for clockmode = 1) is 16X. With older PI2 and all PI cards, you will have to provide a divide-by-two circuit in the clock line if your modem requires a 16X clock. The TAPR modem (without clock option) can use either a 16X or 32X clock (jumper selectable), so this is not a problem with that modem.

---

## \*\*\* Connect Request

### Wanted: PK-232 Elmers

TAPR is in search of PK-232 owners who have enhanced their TNC with one or more TAPR products (i.e. DCD state machine, disconnect header, or 9600 modem) who would be willing to answer occasional questions about installing and operating TAPR products in the PK-232. Please help out your fellow Amateur by calling the TAPR office and adding your name to the elmer list.

### Query: TNC-2 Version 1.1.9

I'm writing to ask your assistance. I have a working TNC-2 that I'm trying to upgrade to firmware version 1.1.9. The TNC comes up under the old EPROM (release 1.1.3) with the message:

```
AX25 Level 2.0 Ver 2.0
```

```
Rel 1.1.3 03/30/86 16K
```

```
Check Sum $56
```

This version works and seems to indicate that the overall hardware is sound. When I install the version 1.1.9a EPROM the STA & CON LEDs light and stay on, and I do not get a sign-on message. Is there a hardware modification I missed? Any other things I can check? I'll appreciate any help you can provide.

Dan McMillin, W4DGE

### Response:

Yes, you forgot to upgrade to a 32K RAM. You need to replace U25 and switch jumper J12. Have fun.

Howie, N2WX

---

## APRS Version 7.0

Robert Bruninga

Well, APRS Version 7 made it out the door! Here is a summary of the changes. Two changes that are NOT backward compatible:

1) To accomodate NWS watch boxes up to 400 miles long, the APRS OBJS-AREAS-LINES shapes are now 4 times bigger. All stations in a network using these symbols must upgrade to 7.0.

2) MAPFIX1.bas now has an optional compression feature. If maps are compressed (60% size and 33% speed) then only 7.0 can use them. Save all original maps as xxxx.ORG so that you can always go back to the original for such commands as the IMPORT and OVERLAY. Since they are already somewhat compressed, there is NO advantage in compressing them before zipping them for distribution. The main advantage of compressing a map is on a slow 8088 laptop running from a floppy. I suggest that all maps should remain uncompressed except by an individual for his own use.

Other changes:

- New 32 mile maps from 2,000,000 CD ROM is EASY using MAKEMAPS1.bas/exe! If you have the CD, start cranking them out.
- With this new speed of making 32 mile maps, I am further splitting distribution versions to EAST, SEAST, WEST, CENTRAL, MIDWEST. See MAPS.txt or use MAPS-ALT command on the USA map to see the regions
- Eliminated NC-SC-GA.map which is all included in USASEAST
- Moved many 64 mile maps from standard distro into regional distro
- Improvement to MAKEMAP1.bas/exe to use a more optimum scale to help reduce the grainyness of 30 mile maps from the 1:2,000,000 CD ROM.
- New MAPFIX1.bas/exe has OVERLAY command to temporarily overlay or compare maps. Also has new compression technique. Useful for laptops.
- Have defined color 2 (light green) to represent ADMIN Boundaries (Parks)
- New MAKEMAP1.bas/exe now reduces the number of points generated in Boundaries, Streams, and railroads compared to Roads.

Then after 27 hours over the weekend of digitizing the Netherlands (wife was gone on a trip), I added several FX function hotkeys into MAPFIX11 so that you can begin each new line with a single key stroke. This MAPFIX11 is NOT in 7.0 but is in the file MAPTOOLS.zip. This zip file also includes the EXE version of the two programs since there is not room for distributing the EXE files in the APRS distribution.

---

## SMACK - Protocol Description

Jan Schiefer, DL5UE and Dieter Deyke, DK5SG/N0PRA

Translation by G0KIU

### 1. Introduction

The end of 1990 was the first time that the Stuttgart Packet Radio Amateurs thought about the factual certainty of data integrity between the TNC and a WAMPES-Node Computer. WAMPES stands for the Wrttemberg Amateurradio Multi-Protocol Experimental Software; this is a software package under UNIX, that implements multiple protocols including AX.25, TCP/IP, and NET/ROM, and will be installed mainly in the Stuttgart area, as net nodes. See reference 4.

We had already observed data loss in other TNC-Node systems and had considered whether a KISS-compatible protocol with a checksum could be used, and how it would be possible. From the result of this consideration came the name SMACK — Stuttgart Modified Amateur Radio CRC-KISS. This article explains the differences between SMACK and KISS and may make possible its implementation in other systems.

### 2. What is KISS?

KISS had been recommended by Phil Karn KA9Q [1] because his TCP/IP software needed a protocol that enabled a simple entry to packet radio below the AX.25 protocol level. KISS offers a layer 2A entry. In KISS mode, the purpose of the TNC is only for access control of the frequency (channel busy recognition, P-persistence action, etc.) and the conversion of the synchronous HDLC data on the radio channel into the asynchronous format of the serial port.

The KISS protocol separates individual packets with delimiters and defines a simple command structure for the setting of TNC parameters. Also, it is able to support TNCs with multiple packet channels.

### 3. Modification of the KISS Protocol

The host computer communicates with KISS in the form of packets. The beginning of each packet is recognized with the FEND character (0xC0), which is then followed by the command byte. The command byte denotes whether the message is a data or a command packet and which command is to be executed. With one exception (reset command = 255), all commands bytes use only the lower 4 bits of the command byte. The upper 4 bits are reserved for use with multi-channel (up to 16) TNCs to specify which channel the command is intended for.

Because we do not know of any 8- or 16-channel TNCs, we have used these upper 4 bits for a purpose other than originally intended. The topmost bit of this command

byte, if set, indicates that this is a data packet that includes CRC check bytes; only data messages have check bytes, never command messages.

With such packets, the CRC will be attached at the end of the frame, with the lower byte first. The following illustrations show the layout of a data frame before and after addition of the check bytes:

**KISS-Frame without CRC:**

FEND	0x00	DATA	DATA	...	DATA	FEND
------	------	------	------	-----	------	------

**SMACK-Frame with CRC:**

FEND	0x80	DATA	DATA	...	DATA	CRC	CRC	FEND
						LOW	HIGH	

It should be emphasized that only data frames will be CRC-secured. This will prevent a command from being misinterpreted if the TNC and host are not both in agreement as to whether the CRC is enabled or not.

**4. Switching from KISS into SMACK**

A SMACK-TNC operates in standard KISS mode after power up (and therefore generates no check bytes). As soon as the first frame is received with a CRC, it switches into SMACK mode and also generates frames with the CRC. Once in SMACK mode, the TNC will stay in this mode until a reset. The host operates similarly except that the first data frame it sends contains the CRC fields. If a standard KISS TNC is connected instead, the CRC frame from the host will be ignored because of the illegal command byte.

This method has the advantage that either KISS or SMACK TNCs can be alternately connected to a host without reconfiguration. Let's illustrate each case:

**Case 1: KISS TNC**

- Host: Sends one frame with CRC, then switches its sender back to normal KISS again.
- TNC: Receives a frame with an unknown command byte (0x80) and abandons it.
- Host: Dispatches KISS data without CRC.
- TNC: Dispatches KISS data without CRC.

**Case 2: SMACK TNC**

- Host: Sends one frame with CRC, then switches its sender back to normal KISS again.
- TNC: Receives a frame with CRC. Recognizes this alternate data frame type and switches its sender to also generate CRCs.
- Host: Dispatches KISS data without CRC.
- TNC: TNC sends the first frame with CRC.
- Host: Receives a frame with CRC. Recognizes this alternate data frame type and switches its sender to also generate CRCs.
- Host: Dispatches SMACK data with CRC.
- TNC: Dispatches SMACK data with CRC.

Independent of the mode (KISS or SMACK), the received frames will always be handled as follows:

**Received Frame**

- No CRC
- With CRC, Correct Checksum
- With CRC, Bad Checksum

**Action**

- Frame processed further
- Frame processed further
- Frame abandoned

This protocol assumes that a KISS implementation abandons frames with unknown command bytes.

**4. CRC Calculation and Implementation Tips**

This is not the place to explain the theory of the cyclic redundancy check (CRC). Reference should be made to the work of Michael Rhner, DC4OX [2]. This article explains only important details needed for an implementation. For this application, a CRC-16 polynomial will be used. This has the form:

$$X^{16} + X^{15} + X^2 + 1$$

The calculation of the CRC is performed over all data bytes inclusive of the command byte. Different algorithms for the CRC generator are described in reference 2. The listing shows the "C" code which calculates the CRC of a buffer with length 'n.'

**5. Implementation**

This protocol has been implemented in the WAMPES systems using SMACK, Version 1.3. This Software has been developed further by Jan Schiefer, DL5UE, from the TNC-2 KISS implementation written by K3MC.

It is installed in the TNCs of the WAMPES nodes DB0ID (Digipeater Stuttgart) and DB0SAO (Mailbox Stuttgart), where it also contains individual WAMPES-specific adaptations.

**7. Outlook**

A more desirable implementation of this protocol would be one which meets the requirements of a "packet driver" as described in a "Packet driver specification" [3]. With this packet driver, it would be possible for all existing NET and NOS versions to use the SMACK protocol without alteration of the source code.

This protocol description is preliminary, and the authors (dl5ue@db0sao, dk5sg@db0sao) would like to receive any suggestions for improvement or other comments.

**Literature:**

- [1] Karn, Phil, KA9Q; Proposed "Raw" TNC Functional Spec, 6.8.1986; published in the USENET-News;
- [2] Rhner, Michael, DC4OX; Was ist CRC?; distributed in the Packet-Radio Mailbox-Net, May 1988
- [3] FTP Software, Inc.; PC/TCP Version 1.09 Packet Driver Specification; Wakefield, MA 1989
- [4] Schiefer, Jan, DL5UE; WAMPES - Weiterentwicklung; Vortrags-Skriptum des 5. berregionalen Packet-Radio-Treffens; Frankfurt 1989;

```

static int calc_crc(char *buf, int n)
/* Calculate CRC of n bytes in buf */
{
    static int crc_table[] =
    {
        0x0000, 0xc0c1, 0xc181, 0x0140, 0xc301, 0x03c0, 0x0280, 0xc241,
        0xc601, 0x06c0, 0x0780, 0xc741, 0x0500, 0xc5c1, 0xc481, 0x0440,
        0xcc01, 0x0cc0, 0x0d80, 0xcd41, 0x0f00, 0xcf01, 0xce81, 0x0e40,
        0x0a00, 0xcac1, 0xcb81, 0x0b40, 0xc901, 0x09c0, 0x0880, 0xc841,
        0xd801, 0x18c0, 0x1980, 0xd941, 0x1b00, 0xdb01, 0xda81, 0x1a40,
        0x1e00, 0xdec1, 0xdf81, 0x1f40, 0xdd01, 0xdc01, 0x1c80, 0xdc41,
        0x1400, 0xd4c1, 0xd581, 0x1540, 0xd701, 0x17c0, 0x1680, 0xd641,
        0xd201, 0x12c0, 0x1380, 0xd341, 0x1100, 0xd101, 0xd081, 0x1040,
        0xf001, 0x30c0, 0x3180, 0xf141, 0x3300, 0xf301, 0xf281, 0x3240,
        0x3600, 0xf6c1, 0xf781, 0x3740, 0xf501, 0x35c0, 0x3480, 0xf441,
        0x3c00, 0xfc01, 0xfd81, 0x3d40, 0xff01, 0x3fc0, 0x3e80, 0xfe41,
        0xfa01, 0x3ac0, 0x3b80, 0xfb41, 0x3900, 0xf901, 0xf881, 0x3840,
        0x2800, 0xe8c1, 0xe981, 0x2940, 0xeb01, 0x2bc0, 0x2a80, 0xea41,
        0xee01, 0x2ec0, 0x2f80, 0xef41, 0x2d00, 0xed01, 0xec81, 0x2c40,
        0xe401, 0x24c0, 0x2580, 0xe541, 0x2700, 0xe7c1, 0xe681, 0x2640,
        0x2200, 0xe2c1, 0xe381, 0x2340, 0xe101, 0xe1c0, 0x2080, 0xe041,
        0xa001, 0x60c0, 0x6180, 0xa141, 0x6300, 0xa301, 0xa281, 0x6240,
        0x6600, 0xa6c1, 0xa781, 0x6740, 0xa501, 0x65c0, 0x6480, 0xa441,
        0x6c00, 0xacc1, 0xad81, 0x6d40, 0xaf01, 0x6fc0, 0x6e80, 0xae41,
        0xaa01, 0x6ac0, 0x6b80, 0xab41, 0x6900, 0xa901, 0xa881, 0x6840,
        0x7800, 0xb8c1, 0xb981, 0x7940, 0xbb01, 0x7bc0, 0x7a80, 0xba41,
        0xbe01, 0x7ec0, 0x7f80, 0xbf41, 0x7d00, 0xbd01, 0xbc81, 0x7c40,
        0xb401, 0x74c0, 0x7580, 0xb541, 0x7700, 0xb7c1, 0xb681, 0x7640,
        0x7200, 0xb2c1, 0xb381, 0x7340, 0xb101, 0x71c0, 0x7080, 0xb041,
        0x5000, 0x90c1, 0x9181, 0x5140, 0x9301, 0x93c0, 0x9280, 0x9241,
        0x9601, 0x96c0, 0x9780, 0x9741, 0x9500, 0x95c1, 0x9481, 0x9440,
        0x9c01, 0x9cc0, 0x9d80, 0x9d41, 0x9f00, 0x9fc1, 0x9e81, 0x9e40,
        0x9a00, 0x9ac1, 0x9b81, 0x9b40, 0x9901, 0x99c0, 0x9880, 0x9841,
        0x8801, 0x48c0, 0x4980, 0x8941, 0x4b00, 0x8bc1, 0x8a81, 0x4a40,
        0x4e00, 0x8ec1, 0x8f81, 0x4f40, 0x8d01, 0x4dc0, 0x4c80, 0x8c41,
        0x4400, 0x84c1, 0x8581, 0x4540, 0x8701, 0x47c0, 0x4680, 0x8641,
        0x8201, 0x42c0, 0x4380, 0x8341, 0x4100, 0x81c1, 0x8081, 0x4040
    };
    int crc;
    crc = 0;
    while (--n >= 0)
        crc = ((crc > 8) & 0xff) ^ crc_table[(crc ^ *buf++) & 0xff];
    return crc;
}

```

Storage for the lookup table requires 512 bytes. If the EPROM in the TNC should be too full for the saving of this table, the table can be calculated and stored in RAM as follows:

```

-----*/
unsigned short Table[256];
const int Rest[8] =
    { 0xc0c1, 0xc181, 0xc301, 0xc601, 0xcc01, 0xd801, 0xf001, 0xa001 };
main()
{
    int i, j;
    unsigned short value;
    for (i = 0; i < 256; i++)
    {
        value = 0;
        for (j = 0; j < 8; j++)
            if (i & (1 < j))
                value ^= Rest[j];
        Table[i] = value;
    }
}

```

## Packet Radio in Education

Greg Jones, WD5IVD

*This is the first of several articles that will appear in the PSR concerning Amateur/packet radio and its potential in K-12 educational applications. These papers were assembled over several summers of teaching a graduate level course at the University of North Texas. Many thanks to the Texas Center for Educational Technology for allowing TAPR to reprint this information.*

*As part of TAPR's goal in education, we hope that these articles published over the next few issues will be disseminated to a larger group that can take the concepts and ideas to the next step of application/implementation. If you have a teacher or educator as a friend, please pass these articles along.*

*Reprinted from: Jones, Greg (ed). *Infusing Radio-Based Communications Tools into the Curriculum*. Texas Center for Educational Technology. 1995. 136 pages.*

### Overview

For the past few years, technology educators at the University of North Texas in conjunction with the Texas Center for Educational Technology (TCET) have initiated activities designed to increase K-12 educators' awareness of the potential for using low cost radio and satellite technology to enhance traditional education. Initiatives are focused on three areas:

1. evaluation of existing low cost communication technologies,
2. research and development of integrated curricular-radio/satellite technology models to demonstrate feasible scenarios for use by teachers and learners to enhance education, and
3. dissemination and training activities intended to convey the lessons learned to technology coordinators and classroom teachers.

Research has shown that students learn better when motivated by an interest in their subjects. It is generally agreed by teachers who use radio/satellite technology in the classroom that this curricular enhancement can provide students with a fun and practical way to learn traditional content. Radio/satellite technology can be used in many curricular areas, such as General Science, Algebra, Geometry, Physics, Industrial Technology, Language Arts, Computer Literacy, and many others.

The upcoming articles are a continuing effort to disseminate the concepts of using radio/satellite technology in education. The articles to follow were first done during a summer institute covering Educational Radio/Satellite Communications taught by Gerald Knezek, KB5EWV, Greg Jones, WD5IVD, and Mike

Maner, WI5H, at the University of North Texas. Following institutes have resulted in prospective and practicing teachers leaving campus with radio-enhanced lesson plans in hand and having passed their technician Amateur radio exam. Many of the educators are currently working on integrating their summer projects into their school's activities.

The articles are built upon the following general model of using radio/satellite technology in the classroom. The three modes of the general model are:

#### 1. Monitor Mode (Receive Only)

The teacher and students receive only. Examples: Satellite Telemetry, Weather Imaging, Short Wave Listening, etc.

#### 2. Teacher Licensed

The teacher acts as the facilitator for access. Participation in real-time using the radio. Example: ATS-3.

#### 3. Teacher and Student Licensed

The teacher and students are licensed for communications. Examples: Packet Radio connections back to school. Amateur TV.

Each mode builds on the previous in knowledge and expertise. The monitor mode encompasses the largest group of the model, since any educator can receive without a license. Any teacher with minimal support and technology can introduce a wide variety of radio/satellite technology in the monitor mode. Educators sometimes do not realize that their classroom and schools are bombarded by millions of information sources daily. The secret is knowing which are useful for education. With a receiver and some way of decoding and displaying the information, these sources can be used directly in the classroom. Examples on the monitor mode might include: Voice of America broadcasts for language arts, reception of NOAA for physical sciences, or the reception of the low-earth satellites for data information that can be used in math and physics courses. In K-12 education, radio/satellite technology is beginning to spread with the reception of weather satellite images. There are now over twenty Amateur radio satellites and a score of weather satellites readily available to educators with low cost radio equipment to use their transmitted information in their classrooms.

The second mode (Teacher Licensed) assumes that the teacher or some facilitator is licensed, which allows the class to transmit. The major attraction of Amateur radio for classroom educators is that the use of the airwaves is free as compared to more traditional telephone communications. Although no license is required to listen, transmission access is controlled by a strict licensing procedure, which means communications inappropriate for an educational classroom (i.e. those



often found on CB radio) are unlikely to occur. In the classroom, the Amateur radio license is usually perceived as a motivational goal, rather than an insurmountable barrier, by teachers and students. Categories of licenses have been carefully arranged into Novice, Technician, General, Advanced, and Extra, so that each step provides interesting new privileges for the "graduate," but also leaves an incentive to advance to the next level. Another factor certain to increase the attractiveness of Amateur radio for educators is the "no Morse code" license. This new class of Amateur license allows educators to pass a written exam to gain limited transmission privileges, including voice and packet radio in the Amateur radio frequencies. For example, all 63 members of a middle school Amateur radio class in Bardstown, Indiana, recently succeeded in passing their Novice examination, which allowed them to "be on the air" even after this first level of mastery. Persons as young as 7 have succeeded in obtaining a license.

In addition to Amateur radio, there are other types of communications requiring alternate forms of licensing. The ATS-3 (Application Technology Satellite 3) satellite requires no test, but requires an experimental license from NASA and the FCC. A number of schools has been using this satellite to hold exchanges with the South Pole and many islands in the Pacific. ATS-3 is an FM transponder at 136 Mhz receive and 149 Mhz transmit. This is just one example outside the traditional Amateur radio usage.

With radio/satellite technology, an opportunity exists to add a new, highly motivational, thematic tool to the educator's repertoire that can grow with a student throughout his/her educational career. Radio/Satellite technology offers a low-cost method for integrating many curriculum areas. Its incorporation into existing secondary curricula could motivate students to become future scientists and engineers. The future looks bright for having more and more teachers use radio/satellite technology in the classroom.

Thanks to Larry Lucas, N5XRZ, for all his help and efforts at TCET to continue the work started, ongoing, and done concerning low cost radio/satellite technology in education. Thanks to Gerald Knezek, KB5EWV, for making low cost radio/satellite technology research a reality and setting a direction for the future.

## PSR Deadlines

Check page two for upcoming *PSR* deadlines. The deadline for issue #60, Fall 95, is September 15th, 1995. If you have something for publication, please contact Bob Hansen, *PSR* editor at [psr@tapr.org](mailto:psr@tapr.org). TAPR is looking for technical articles on the following subjects: information on general digital communications, applications using digital communications, equipment hints or modifications, future directions and standards, tutorials, and any regional packet news or information.

## Access Point

A compendium of recent books, articles, and on-line information of interest to digital communicators. Send your suggestions to [psr@tapr.org](mailto:psr@tapr.org). Among the contributors this issue are Dave Reeves, KF6PJ, Jon Bloom, KE3Z, and Sigi Kluger, DK4NB.

### Articles:

Build a Simple HF Packet Tuning Indicator:

*Popular Electronics*, July 1994, p.68, by Brian Pliker, KF0WD.

A description of how Error Detection and Correction (EDAC) memory (used on Amateur satellites) works:

*Oscar News*, No. 108, August 1994, p.16, by James Miller. G3RUH

### Internet Resources:

Information about Amateur Spread Spectrum:

<http://www.sp.nps.navy.mil/ss>

Brevard County, Florida, Ham radio clubs and repeaters; this page also has a link to LISATS (Launch Information Service & Amateur Television System):

<http://www.digital.net:80/HamRadio/>

Baycom server:

<http://www.baycom.de>

Information about the GRAPES 56kbps modem:

<http://www.mindspring.com/~bobm/grapes/grapes.html>

Forward Error Correction Demonstration:

<http://www.qualcomm.com/people/pkarn/fecdemo/index.html>

Government agencies:

<http://www.fcc.gov>

<http://www.itu.ch>

Sister station to CompuServe's HamNet Forum:

[http://www.webcom.com/~sjl/HamNet\\_Companion/](http://www.webcom.com/~sjl/HamNet_Companion/)

For information on using Linux in Amateur radio:

<http://www.rahul.net/perens/LinuxForHams>

Several interesting weather-related sites:

WeatherNet:

<http://cirrus.sprl.umich.edu/wxnet/>

WX Images and Info:

<http://typhoon.rdg.ac.uk/weather/weather.html>

Penn State WX Pages:

<http://www.ems.psu.edu/wx/index.html>

WX Image Menu:

<http://asp1.sbs.ohio-state.edu/wximage.html>

## More On Commercial Radios For Amateur Packet Applications

Keith Justice, KF7TP  
Internet: kf7tp@kf7tp.stat.com  
Amprnet: kf7tp@wb7tpy.az.usa.noam

In the last *PSR* I provided an annotated list of Motorola communication radios that have proved useful for packet radio applications. In this issue I give some hints and suggestions for hams about to undertake for the first time converting a commercial radio to the Amateur bands. If you have an Elmer with a "Service Monitor," this article is just for initial orientation. On the other hand, if you are on your own, maybe this will help get you started on the learning curve.

### Documentation

If your new at this, don't attempt a conversion without reasonable documentation. You should try to get documentation from the same source from which you get the radio(s). Get schematics and alignment sheets at a minimum, full service manuals if possible. Sometimes a local 2-way service center will have extra copies of manuals for obsolete radios. Lacking that or an Elmer you can copy from, Motorola sells manuals for recently obsolete equipment at reasonable prices. Contact your Motorola parts distributor.

### Crystals

The frequency control for these radios is derived from "channel elements." These are small plug-ins containing a crystal and, at a minimum, temperature compensation and frequency adjusting ("warping") elements. The channel element may also include the transistor for the oscillator, and even a buffer amplifier. To change the frequency, one can either send the channel elements (one each for receive and transmit) in to a crystal company to have new crystals installed and temperature-compensated, or one can order the bare crystal and install it ones self. The cost from Sentry Manufacturing Co, per send/receive pair, will range from about \$23.00 for the bare crystals to \$54.00 for crystals installed in your channel elements. (JAN and International Crystals will run a little more.) If you are comfortable with a soldering iron, and plan to use the radio in a temperature controlled environment such as a home shack, you can save some money by doing it yourself. If your only soldering iron draws a hundred watts, and/or your plan to put the radio on a mountain top, by all means get the crystal company to do it for you. If you order the bare crystals, be prepared to inform the order desk the model name of the radio and the part numbers on the channel elements. If you send

in the channel elements, check them in the radios first to make sure both the channel elements and radios are working at the original frequencies.

### Connectors

All of the trunk-mount radios have a connector which accomodates power lines and a cable to the control head for microphone, speaker, volume, squelch, and channel selection. The seller will frequently throw this in on the deal. Ask for it if he or she does not offer it. You will want to use at least the connector, and you may want to keep the control head itself in service. The connector for the Motrac, Mocom-70, and Mitrek are all the same, although different control heads were furnished with each model. Connectors for the Micor and Syntors are the same. The Mocom-35 is not trunk-mount, so only a power connector is used. It can easily be wired without the factory connector.

If you cannot get a connector, don't dismay. You can solder the power leads directly into the radio, and install your own connector for TX and RX audio, and PTT. If there is not room for a chassis connector, you can always use an in-line DIN connector. Squelch and audio contols can be installed in the radio, if needed at all.

### Retuning the Receiver

Tuning is facilitated by test points brought out to a metering socket. Your documentation will give you the pin-outs. Motorola made test-sets to plug into these, but you can use any meter with a sensitivity down to 50 microamperes. I prefer to use a VTVM or FET meter which can be switched to high sensitivity for difficult cases.

To retune the receiver you will need a signal source, and preferably an oscilloscope. The ideal signal source is an FM signal generator, but an HT with a dummy load will work in a pinch, especially if you have a friend who can take it down the street a ways when you need to reduce the signal level even more.

Assumig the IF stages and discriminator are already aligned, moving a receiver to a ham band consists of retuning only the local oscillator and following buffer/multiplier stages of the "injection string," and retuning the "pre-selectors," the tuned RF circuits ahead of the mixer.

If you cannot get a meter indication for the local oscillator following Motorola's procedures, put a scope probe on the output of the first tuned circuit and peak the RF. Or tune your HF rig to the local oscillator frequency and peak the signal. That should get you enough output to show on the meter as you move down the string.

The pre-selectors can be tough, especially if you do not have a well-behaved signal source, i.e. one which can be controlled over a wide amplitude range. Since the standard test point is not very sensitive to a weak signal, I prefer to look with a scope at the output of the discriminator, or some other point on the audio output string prior to the squelch gate. Key your signal source, and adjust the frequency of it, or the channel element, until you can see some quieting. You may have to feed some signal into the circuit beyond the pre-selectors to confirm that you have the radio and signal source on the same frequency. Now move the signal source back to the antenna connector and eliminate as much stray radiation as possible. Assuming you are tuning the radio down in frequency, start running the slugs down (in) on the preselectors. Hopefully, you will start seeing some quieting. As you do, keep reducing the level of the test signal. Eventually, you should be able to get good quieting under 1 microvolt signal level.

The main thing to remember is that in order to properly tune the preselectors, almost all of the energy has to be coming in to the mixer from the antenna terminal through the pre-selectors. If you are looking at a lot of stray radiation flying around the shack, you cannot tune them properly. If you are seeing quieting on the scope, but you cannot get any peaking effect from the pre-selector slugs, you are almost certainly seeing only stray radiation. Reduce the strength of the signal source and couple it directly to the antenna terminal.

If you have a weak signal source, and still cannot find the resonant point, you can sneak up on it one stage at a time this way: remove the slug from the next to the last stage and inject some signal in with an insulated probe. Tune the last stage. Replace that slug, and remove the the second from the last slug. Inject some signal, and tune the next stage, and retune the last stage. Repeat until you have all stages tuned.

After you think you have everything aligned, you should confirm the sensitivity. If you have a signal generator with a calibrated attenuator, you should get good quieting down to the 0.5 microvolts range. If you do not have a calibrated source, put the receiver on an antenna and look at a weak signal. Compare its performance with that of your synthesized ham rig. The commercial radio probably won't be quiet as good, because of all those pre-selectors, but it should be close.

### **Retuning the Transmitter**

Tuning the transmitter is generally straight forward. Just follow the instructions in moving from

coil to coil and test point to test point. Remember that if you are moving down in frequency you will be moving the slug towards middle of the coil, usually towards the pc board. However, there will usually be two resonance points, and one may give more output than the other. If you cannot get a meter reading, try using your HT with a dummy load as a field strength meter. Final amplifier tuning is done with a dummy load and wattmeter. Finals tune very broadly and trimmer capacitors may bottom out. If you are satisfied with the power you are getting, fine, but keep in mind that the final may be running at less than optimum efficiency if it is not in full resonance. This means that the final is producing more waste heat than it should be. That may be ok for the low duty cycle of packet, but if something goes wrong, the final locks on, and the time-out timer cannot shut it down, then you may fry the final amps.

### **Conclusion**

This has been just a brief introduction to the subject of retuning commercial radios. There is a lot I haven't said about getting by without expensive test equipment, solving unexpected problems, and dealing with specific models. Learning to cope with those challenges is part of the fun of doing this kind of ham radio. I hope you have as much fun as I have had, and wind up with some great packet radios!

---

## **League Offers Kit For 219 to 220 MHz Requests**

On April 26, 1995, US Amateurs gained secondary status access to 219 to 220 MHz. Amateur operation is limited to forwarding stations in point-to-point fixed digital message forwarding systems — including intercity packet backbone networks — only.

All amateur stations are required to notify ARRL (in its FCC-designated role as contact point) at least 30 days before operating in this band, and amateur stations within 80 km of an Automated Maritime Telecommunications Systems (AMTS) coast station must obtain written permission from the AMTS licensee before operating.

Amateur stations between 80 and 640 km of an AMTS coast station must notify the AMTS licensee.

A Form 219A kit, available from ARRL Headquarters, includes a cover letter of explanation, a Form 219A for the required notification to ARRL (one is required for each transmitter planned), and a copy of the 219 to 220 MHz band plan.

May 1993 QST (page 9) and May 1995 QST (pages 9 and 93) have more information.

## DSP-93 Software Updates

Ron W5RKN

The second shipment of the DSP-93 went out in June. We have a few units left to sell from this batch, so call the office and get your DSP-93 without the wait. Lots of software has been released and more continues to be developed. The goal of the DSP-93 was to generate a platform for Amateur DSP development and learning. Thus far, the results have been great! We still need more interested Amateurs developing code or porting existing implementations over to the system, so if you think you can help, let us know and we can put you in touch with someone on the DSP-93 development team. TAPR has been discussing licensing the technology from the project and progress is being made in this area. The DSP-93 list group on Internet has been a great source of comments and operational knowledge. The list is a good place to get started. Source and information on current DSP-93 software is available at <ftp://ftp.tapr.org/tapr/dsp93>. This area also contains the message archive from the DSP-93 mailing list.

You can get copies of all past messages distributed on the dsp-93@tapr.org list by sending mail to 'listserv@tapr.org', subject of 'list', message of 'index dsp-93'. This message will request a listing of all files in the dsp-93 mail archive. To then request a specific month, send mail again to 'listserv@tapr.org', Subject of 'request', message of 'request dsp-93 filename', where filename is the name of the file in the dsp-93 area you want to request (i.e. nov.94).

### The following software is available:

#### 9600 bps Modems:

FSK93U1/2 Half or full duplex operation, active DCD  
FSK93U1/2B Weak signal optimized  
FSK93K1/2 ISI comp. for KO-23/25, active DCD  
TPRS931/2 TPRS with NRZI in/out, active DCD

#### 1200 bps Modems:

PKT931/2 Standard AFSK, active DCD  
PSK93R1/2J Satellite PSK, active DCD, SmartTune  
PSK93R1/2Y Sat. PSK, active DCD, SmartTune, YAESU

#### HF Modems:

HOT\_HF93 RTTY modem, Viterbi soft detection  
HF\_93HT1/2 300 bps FSK, active DCD, adpt. threshold  
HF\_93U1/2 AMTOR using TOR.EXE, adpt. threshold

#### Sat. Pic/Telem:

APT\_93HX1/2 Carrier-sync. pixels eliminate doppler bow  
P3C93T1/2 AO-13 400 bps telemetry, P3C.EXE comp.

#### Noise Processing:

W9GR\_93 Adpt. carrier null, channel enh., BP filters,  
CW93\_D CW filter

#### Instrumentation:

D93WE series Loader, audio o'scope and spectrum analyz'r

#### Diagnostics:

Monitor Basic DSP-93 Monitor and SW utilities  
DSP-93 tests Check-out of all DSP-93 functions

## Documentation Update - June 29th, 1995

The June 1995 DSP-93 distribution ships with Version 2.17 of the EPROM. For Version 2.17 of the EPROMs, several documents on the distribution diskettes have been updated and their content included in a new document "Programming Guide for the DSP-93." The documents: MONITOR.DOC, MEM-93.DOC, and MONMEM.DOC should no longer be used. Also the comment in MONITOR.INC about the SIN/COS table is an anachronism and should be ignored for Monitor Version 2.17.

The new document "Programming Guide for the DSP-93" is available at <ftp.tapr.org> in the [tapr/dsp93/manuals](ftp://ftp.tapr.org/tapr/dsp93/manuals) directory with the name ProgGuide.word. The file is in Microsoft Word format. There are also several other documents in the same directory:

DSP93\_Interface\_Win\_Man.pdf - The D93WE PSR article  
DSP93\_Interface\_Mac\_Man.pdf - The Macintosh Interface article  
DSP93\_Assm\_Man.pdf - The current Assembly Manual  
DSP93\_Ops\_Manual.pdf - The new DSP-93 Operations Manual

DSP93\_Assm\_Man.pdf and DSP93\_Ops\_Manual.pdf, have been reprocessed and no longer issue the "Bad BBox warning."

"pdf" documents are in the Adobe portable document format. Freeware reader installers for this document format are available at:

<ftp.tapr.org> the file is /tapr/utlils/ACROREAD.EXE for Windows.  
<ftp.tapr.org> the file is /tapr/utlils/Acrobat\_Reader\_installer.hqx for MacOS.  
<ftp.adobe.com> the file is /pub/adobe/Acrobat/Windows/acroread.exe for PCs.  
<ftp.adobe.com> the file is /pub/adobe/Acrobat/Macintosh/2.0.1/AcroRead.mac.sit or /pub/adobe/Acrobat/Macintosh/2.0r2/AcroRead.sea.bin for MacOS depending on which version you want.

## New Items:

### New 2.17 EPROM Set

Images are available on <ftp://ftp.tapr.org/tapr/dsp93/eproms> and on many of the satellites. EPROM sets also can be purchased from the TAPR office for \$15.00 plus \$2.00 s/h within the US.

### New DSP-93 Operations Guide (see below)

### New DSP-93 Developers Guide (see below)

Documents are available on <ftp://ftp.tapr.org/tapr/dsp93/manuals> and <http://www.tapr.org/tapr>. A set of the new guides can be purchased from the TAPR office for \$5.00 plus \$2.00 s/h within the US.

## Update on DSP-93 HotHF modem.

Dave, W3HCF

My RTTY/SITOR HF FSK modem has been through another design review and overhaul. The major objectives this haul are (1) a much improved RTTY signal gate and autostart function, and (2) a much improved SITOR modem with performance demonstrably better than existing analog designs, which in my case is the AEA PK-232. While the PK-232 performance with weak signal SITOR is commendable, my objective was to see how much better an optimized linear receiver could do under suitably ugly band conditions.

I am happy to report the latest digital modem really and truly does achieve good copy on signals the analog modem completely misses and, for those signals that both modems can copy, the erasure rate with the digital modem is considerably lower than with the analog one. I verified these claims in tests with both modems connected to the same computer-tuned SSB radio and SITOR signals transmitted by AT&T radiotelex stations near New York, Miami and San Francisco, and signals transmitted by the profligated WLO radiotelex station near Miami (heard on zillions of frequencies in the NBDP coast station bands).

The computer tunes to one of these radiotelex stations twice an hour throughout the day and to W1AW four times per day and records the decoded text for both modems. On many occasions, SITOR signals were so faint or so covered up in QRM that they could not be detected by ear with the radio speaker, yet the digital modem copied them 100% and the analog modem with varying degrees of garble. A typical example given in the readme.txt file shows the digital modem produced an erasure rate only one-fourth that of the analog modem when faced with a challenging signal. These observations are of course very unscientific (we say "anecdotal") evidence; true evidence requires controlled conditions, measured error rates and comparisons with analytical models. Maybe I'll do that sometime.

I learned a few things on the overhaul, mainly to avoid absolute thresholds, where the amplitude of a signal (like the various distance functions) is compared to a manually adjustable threshold. This means, as the signal fades to the noise floor, the threshold cannot adapt, even though the signal/noise ratio might be just fine. I changed the distance function to be the ratio of the old distance to the RMS signal measured over the bits of each character as it is decoded. The improvement, especially with weak signals, is dramatic. In particular, the LED tuning indicators work right down to the noise floor.

I also changed the character sync scheme to use all five repetitions of the CCIR retrain signal - some 70 bits in all. The resulting processing gain is so much that it is no longer necessary to calculate the carrier/noise ratio or fiddle with signal gates, modulation gates and related claptrap. The LED tuning display continues to work, but

the signal gate (LED 3) is not used. Turns out the PK-232 does not use the threshold control in AMTOR either.

I then overhauled the RTTY decoder with what I learned in the SITOR overhaul. The improvement in error rate is not as dramatic as with the SITOR decoder, but certainly noticeable under weak signal conditions. The major improvement comes from an overhaul of the carrier distance code that operates the carrier gate. This resulted in a significant increase in reliably distinguishing between a legitimate carrier and noise. The implementation draws on technology developed in the area of pattern analysis and classification, a weakness to which I succumbed some years ago.

Responding to suggestions from current users, I added an unshift-on-space function (u{0-3} command) and a suppress-erasure function (q command). I happened to notice the radiotelex stations use the unshift-on-space function on information broadcasts, but not on at least some weather broadcasts. In fact, their weather broadcasts, apparently relayed from U.S. Weather Bureau feeds, contain many phrases and sentences separated by "...". An experienced RTTY operator would certainly advise against that! Like the PK-232, the modem now prints an erasure character "\_" if a received character quality (distance) is below the erasure threshold. I find this useful when adjusting the thresholds, but it can be disabled with the q command toggle.

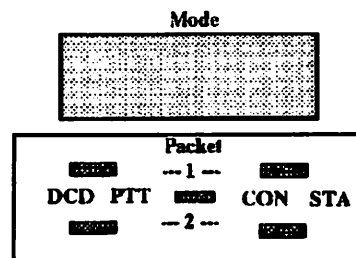
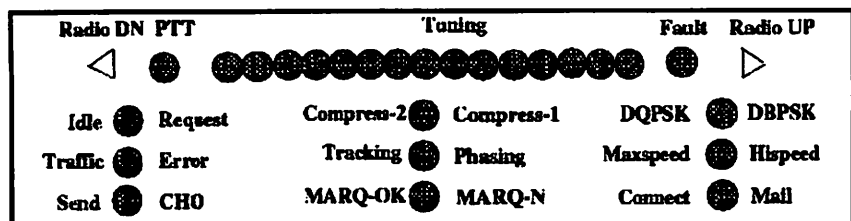
To conform with most radiotelex broadcasts, I switched the Baudot/ASCII translation to use the CCIR keyboard, rather than the U.S. keyboard. This conforms to W1AW broadcasts and AT&T broadcasts; but, on at least some WLO broadcasts, a butchered U.S. keyboard is used, where the "#" character apparently is replaced by """. Ask not for whom the BEL tolls.

There are other additions to the command suite, including the v{+-} and g{0-7} commands. The v{+-} command adjusts the erasure threshold, which affects the "\_" erasure as described above. The g{0-7} command adjusts the analog gain of the DSP-93, which can be useful when connecting to the recorder output on some radios. The a1 command is gone (replaced by the a2 command), since the new carrier distance code is so good that it is no longer necessary. As a side note, I don't presently plan to implement more exotic operator features, such as command completion, command confirmation or detailed status reports. Many of these functions can be implemented in terminal program scripts or Unix shell scripts. I do see a need to extract some performance data, such as error/erasure rates, signal and noise density histograms, etc.

Meanwhile, for what it's worth, the distribution, including updated readme.txt and relnotes.txt files, as well as new file info.txt containing useful RTTY and SITOR broadcast frequencies and times, is on louie.udel.edu in the pub/ntp directory as the files modem.zip and modem.tar.Z. I'll upload the stuff to the TAPR site when I catch my breath.



# PacComm PTC-II Multimode DSP Communication Controller



Artist's Depiction of PacComm PTC-II Five Color Lexan Panel

You've been hearing about it for several years.... Now it is available. PACTOR-II.

The PTC-II is a new multi-mode controller and "communications platform" which contains very powerful and flexible hardware and firmware.

It is being built in the United States by PacComm under license from S.C.S., the group that developed both the original PACTOR and PACTOR-II.

The PTC-II offers the most robust HF digital protocol available to radio amateurs, but it should not be overlooked that the PTC-II is configurable as a triple-port multimode controller supporting packet data rates of 1200 and 9600 bps and numerous other modes.

## What is PACTOR-II?

Like PACTOR-I, PACTOR-II is a communication system. There is a unique protocol, carefully designed and optimized for excellent HF performance, new and powerful modems realized via Digital Signal Processing, and a hardware platform to allow the firmware to realize its full operating potential.

PACTOR-II is the name of the new protocol including modulation specifications. PTC-II is the name of this specific hardware realization of the PACTOR-II architecture.

PACTOR-II offers all the following advantages:

- A step-synchronous ARQ protocol.
- Full support of memory ARQ.
- Independent of sideband; no mark/space convention.
- Center frequency adjustable between 400 and 2600 Hz to exactly match your radio's filters.
- Long-path capability for worldwide connectivity.
- Full compatibility with PACTOR-I (the original PACTOR system), AMTOR, and RTTY.
- All-mode mailbox with up to 32 megabytes of storage.

- Automatic switching between Level-1 (PACTOR-I) and Level-2 (PACTOR-II) at contact initiation.
- Occupies a bandwidth of under 500 Hz - use your 500 Hz CW filters.
- Constant bandwidth irrespective of actual transmission speed.
- Differential Phase Shift Keying with two continuously transmitted carriers. 100 symbols per second.
- DBPSK modulation yields 200 bps (uncompressed). DQPSK modulation yields 400 bps (uncompressed). 8-DPSK modulation yields 600 bps (uncompressed). 16-DPSK modulation yields 800 bps (uncompressed).
- Powerful Forward Error Correction (FEC):
  - » High performance convolutional coding. Constraint length of 9.
  - » Viterbi decoding using soft decision point. Coding rate varies between 1/2 and 7/8.
- Intelligent data compression monitors compression ratio and self-bypasses if not being effective.
  - » Huffman compression for English or German text.
  - » Markov (2 level Huffman) compression.
  - » Run-Length encoding for repeated sequences.
- 10 character MODE display, numerous multi-colored LED tuning and status displays.
- Watchdog timer on HF PTT port.
- Specialized communication program provided
- Firmware contained in Flash memory. Easy upgrade.
- Limited availability beginning late August 1995. Packet modems will be available somewhat later.
- \$995. Packet modems are optional at extra cost.

**PacComm Packet Radio Systems, Inc.**  
**4413 N. Hesperides Street, Tampa, FL 33614-7618 USA**  
**Telephone: +813-874-2980      Facsimile: +813-872-8696**  
**Internet: ptc@paccomm.com      BBS: +813-874-3078 (V.34)**  
**Orders/Catalog Requests: 800-486-7388 (24 hr. voice mail)**

## DSP-93 Kit SIG

Bob Stricklin, N5BRG

Hamcom 95 was a success for the DSP-93.

We had a 30-minute presentation scheduled this afternoon at 1:00. Unfortunately there was a little mix-up on the start time. Apparently some of the Hamcom literature had the session scheduled for 1:30. Well it worked out anyway. We had about 40 to 60 people come through the area during the presentation. The highlight was a video tape put together by Frank Perkins, WB5IPM. Frank had taped his station equipment working just about every possible digital mode known to Amateur radio using the DSP-93. The tape included footage illustrating Dave Mills' HF program copying RTTY. The RTTY signal faded completely into the noise but the digital data kept coming in on the monitor error free, impressive.

While we have an impressive suite of programs for the DSP-93. I still think we have not seen all of its capability.

It was an opportunity to talk to many people that have the kit. Unfortunately, things were a little hectic so we did not get to discuss as much as I would like. The listserver will be a better place for that anyway so you can be included in the conversation.

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## Introducing the TAPR-TNC SIG

Howie Goldstein, N2WX

To subscribe, send e-mail to:  
listproc@tapr.org  
with a blank subject. In the body of your message, write

subscribe tapr-tnc first\_name last\_name

This SIG is intended to be a low volume, high s/n place to discuss issues related to use of the TAPR

(and clone) TNCs. It is not moderated at this time; list subscribers are requested to remain on topic and use discretion to help keep up the s/n ratio.

The following subjects with respect to TNC-1 and TNC-2 are "on topic:"

- Hardware bugs, problems, mods
- Firmware bugs, problems, patches
- TAPR documentation
- Interface issues
- Announcements of the above
- Suggestions for enhancements
- and anything else reasonably resembling the above

Although packet radio novices are invited to join, this is probably the wrong place to post new user questions. More rapid and complete replies to new user questions are more likely to be found in one of the many newsgroups in the rec.radio.Amateur.\* hierarchy.

This is also the wrong place to debate the merits of various manufacturer's offerings or to elicit suggestions about "Which TNC should I purchase?" Please try the newsgroups.

At times, you may find your post is relevant to one of the other fine TAPR SIGs as well as this one. Initial cross-posting is not necessarily a bad idea. Use your judgment.

Spirited, lively discussion is invited, but flames will be promptly extinguished. The moderator reserves the right to deal with flames and off-topic posts from a stance somewhere between complete arbitrariness and Solomonesque. Hopefully more of the latter than the former.

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## NetSIG

John Ackermann, AG9V

NetSIG has been a yoyo lately. In May and June, it was virtually dead,

with only a little discussion quietly continuing. But things changed — not necessarily for the better — in July.

The bad news is that a flamfest on the propriety of using non-Amateur links as part of the Amateur network moved from the BBSSIG to NetSIG. The issue is an emotional one for some people, and the signal to noise ratio rapidly dropped to near zero, while personal attacks started to appear.

This points out a dilemma that TAPR, and especially the SIG chairs, face. We don't want to stifle discussion, and for both philosophical and practical reasons want to stay away from moderating the TAPR SIGs, but we've found time and again that both BBSSIG and NetSIG become charcoal barbecues hot enough to drive folks away. I'm afraid that sooner or later moderation is going to be the only answer, and that the time may be near.

So, to make a long story short, if you see an announcement that NetSIG has gone to moderation, don't be surprised. Don't blame TAPR; blame the folks who can't seem to understand that there are human beings at the other end of the mailing list.

Moving on to better news, buried amidst the noise on NetSIG have been a couple of really interesting topics. A few folks have been talking about meteor scatter as a propagation medium for packet radio (there's a similar discussion going on in the APRS SIG, by the way). There's been some fairly rational talk about the characteristics of TCP/IP, NetROM, and ROSE as networking protocols, and a few of the postings in those threads have been really instructive. Out of this may come some consensus values for NetROM configuration, and that would be a Good Thing.

That's about it from the email front. I'm planning to be at the ARRL DCC in Dallas; hope to see you there!

## **Dayton '95**

Dayton was unusual this year — no bad weather! Besides that slight drawback, everything was great. TAPR had another good year at the Dayton TAPR booth, at various activities, and in making lots of personal contacts. This was the first year in a long while that Bob Neban, K9BL, was not able to take an active part in the convention. Luckily, Dave Wolf, W05H, was able to step in and help organize and moderate the TAPR Digital Forum. The following people participated in presentations:

- Intro. to Digital Communications - Greg Jones WD5IVD
- TAPR Update - John Ackerman AG9V
- Layer 1 and Radio Conversions - Mel Whitten K0PFX
- TAPR/AMSAT DSP-93 Project Update - Bill Reed W0ETZ
- TCP/IP Issues and Trends - Barry McLarnon VE3JF
- BBS Issues and Trends - Barry Buelow WA0RJT
- G-TOR and Other HF Modes - an Update - Phil Anderson W0XI
- APRS - Bob Bruninga WB4APR
- TAPR APRS SIG - Keith Sproul WU2Z

Friday evening saw the first ever PacketBash, hosted by TAPR and the Miami Valley FM Association (MVFMA). This was hosted at TJ's Restaurant and worked really well as any first year event goes. This was a replacement to the MacNasty event held in the past. Dinner was good and was a real winner for long-time TAPR dinner participants. After dinner, Dewayne Hendricks, WA8DZP, made a presentation on wireless communications and its potential impact. Bob Bruninga, WB4APR, spoke on his world-used APRS software. Bob had some cool playtoys he was demonstrating and there was a lot of interest. The NET SIG group had a short meeting afterwards, but was cut short as the

restaurant needed to close for the night.

Saturday night was a meeting of the BBS SIG at the Radisson. For next year, we will work on getting the Saturday evening activity better organized. This should be easier, since we made our major changes on Friday this year. Dayton will continue to be an important yearly event for TAPR and we will continue to work on making the digital activities better.

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## **1995 ARRL Digital Communications Conference**

Mark your calendar and start making plans to attend the year's premier event in Amateur radio digital communications. The 14th Annual ARRL Digital Communications Conference will be held September 8-10, 1995, in Arlington, Texas — just minutes from D/FW Airport. Co-hosts for the conference are TAPR, and the Texas Packet Radio Society.

The hotel/conference center are extremely well-suited and well-sited for this event. They regularly host other ham events, and staff members are very familiar with the sight of satellite dishes temporarily erected on the lawn! They, and we, are looking forward to a tremendous conference.

The digital communication conference is for everybody, beginning to advanced digital experimenter or operator. A beginning/intermediate track will be held Saturday morning to help those wanting to transition to more advanced topics and terminology.

TAPR hopes YOU can be part of it!

## **TAPR BBS Available !**

Would you like to keep up with the various TAPR Internet lists, and don't have Internet access — but you do have a modem. TAPR is making available for a trial period, access to a read-only BBS system which has the TAPR lists and various files from the software library available. A Graphic User Interface is available for download for both Windows and Macintosh users. These can be found in the utils directory. The phone number is: (512) 475-6145. Login in as tapr, no password required.

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## **HamCon — Long Beach**

TAPR is making plans to attend the HamCon '95, ARRL Southwestern Division Convention, September 1-3, 1995, aboard the Queen Mary in Long Beach, California. Please come by and see us at our booth!

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## **Kit Updates**

### **AN-93**

Brian Straup, NQ9Q, picked up the project in May and has helped to take the work done to date to conclusion. The kit went to the board shop the middle of June and with luck the unit will be shipping and available for sale by the end of July. Thanks, Brian, for help when things looked worse. Everyone who has been on the AN-93 kit list has been patient in waiting this long for the kit.

The AN-93 kit (designed by Johan Forrer, KC7WW) provides any PC user with the capability for operating RTTY, AMTOR, and PCTOR with this simple modem-only design. AN-93 is the equivalent of a BayCom, BayPac, or PMP setup, but for HF digital operations. This very simple kit should be for many that have wanted to play on HF, but didn't want to pay the money for an expensive multi-mode controller.



With the AN-93, only three components are required for HF digital communications: a PC-compatible computer, the AN-93 modem, and software that performs the encoding and decoding. The AN-93 comes with a tuning indicator to allow visual tuning and the unit also provides audio output for oscilloscope display.

The TAPR AN-93 allows for both FSK and AFSK output, allowing operations on all HF radios. Instead of two separate boards as shown in the *QEX* article, the TAPR AN-93 is a single board. The AN-93 operates off 12 volts DC. The kit allows for self-tuning and calibration. A Digital VOM and a working PC is needed in order to calibrate and test the modem. Connections to the RS-232 serial and parallel ports are made through DB-9 and DB-25 connectors. Interfacing to the radio is through a DB-9 connector. The kit will be shipped with the A/D converter providing full-memory ARQ capability for PCTOR.

For a full description of the AN-93 modem and its specification, refer to the May, 1994 issue of *QEX* and *PSR* issue #55.

### TUC-52

Dave Dennis, N5BCA, has completed the PCB layout and a prototype should either be at the board shop or under testing as of this printing. The personality boards for the PCON and METCON-II have

been designed and should be laid out during the TUC-52 prototype testing. Jack Davis, WA4EJR and Seuo Asato, JA6FTL, have shown interest into looking at the possibility of generating a personality board that would perform TrakBox operations. Daniel Karmann has got a modified version of BASIC ready to port to the prototype when operational. From the comments being posted in the development group, it looks very good and will give the TUC-52 real programmability that the METCON-I didn't offer. Intel has announced a new processor which could be used with the TUC-52 design, called the MCS-251. It looks very powerful and could give some additional applications in the future.

### TNC-95

The layout person in St. Louis has been unable to work with the schematic capture and due to other time pressures at work has dropped out of the project. This has set back the prototype to, maybe three months. We have found another board layout person and the layout is progressing now. As soon as it is laid out, it will go to the board shop.

## Online Conference Abstracts

TAPR is proud to announce the creation of ARRL Amateur Radio Computer Networking Conferences and Digital Communications Conferences Index and Abstracts (Web Pages).

Abstracts from all thirteen ARRL CNC/DCC proceedings can be viewed from either the Packet Radio Page, Virtual Library or via the TAPR Page, Products, Publications area. The direct link is:

<http://www.tapr.org/tapr/html/cnindex.html>

This page has links to all 13 proceedings with abstracts from all the articles. Search capability is also available at:

<http://www.tapr.org/tapr/html/cnsearch.html>

If you have proceeding articles available on the Internet, please contact TAPR about generating a link from the abstract pages to your pages.

## Accessing TAPR via the Internet

There are several ways TAPR can be reached via the Internet.

### Information Server

The Automated Information Server that TAPR provides allows anyone to request information on TAPR, products, newsletters, and lots of other files. To find out more about this service, send an e-mail message to [listserv@tapr.org](mailto:listserv@tapr.org) with the subject line "Request" and one or more of the following text lines in the body of the message:

help (for a brief set of instructions)  
index -all (for a list of all files by topic area)  
list (for a list of TAPR Mail Groups)  
get tapr taprinfo.txt (for info on TAPR)

### Internet E-Mail

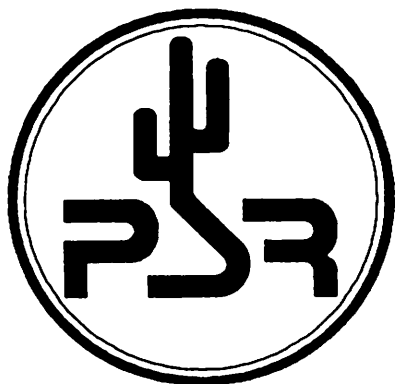
TAPR can be reached by sending mail addressed to [tapr@tapr.org](mailto:tapr@tapr.org)

### World Wide Web

<http://www.tapr.org/tapr>  
<http://www.tapr.org/tapr/html/pkthome.html>

### FTP

The TAPR Software Library is available at 'ftp.tapr.org' in the directory /tapr/software\_lib. Login in as 'anonymous', with a password of 'your\_account@internet\_address'.



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# ***1995 ARRL Digital Communications Conference***

***September 8-10, 1995  
Arlington, Texas, U.S.A.***

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## **DCC 1995**

Mark your calendar and start making plans to enjoy a little Texas hospitality and attend the year's premier event in digital communications. The 14th Annual American Radio Relay League (ARRL) Digital Communications Conference will be held September 8-10, 1995, in Arlington, Texas — just minutes from the Dallas/Ft. Worth Airport. Co-hosts for the Conference are TAPR and the Texas Packet Radio Society (TPRS).

The ARRL Digital Communications Conference is an international forum for radio amateurs and experts in digital communications, networking, and related technologies to meet, publish their work, and present new ideas and techniques for

## **Conference & Hotel**

Conference presentations, meetings, and workshops, will be held at the La Quinta Inn and Conference Center, 825 N Watson Road, Arlington, Tx, (800) 531-5900, (817) 640-4142, Fax (817) 649-7864, intersection of I-30 and Texas 360. Rooms rates are \$53/single, \$58/double, \$63/triple, and \$85+ for suites. When making reservations with the hotel, be sure to indicate you are attending the conference. Six Flags (larger than Disney Land), the Texas Rangers, and several other attractions are within a few miles of the hotel. If you are planning to stay at the hotel, it is highly recommended that you book your room prior to **August 25th, 1995** — a block of 100 rooms is reserved for Friday and Saturday. The hotel provides transportation to and from D/FW International Airport. You should contact the hotel to arrange airport transportation.

discussion. Presenters and attendees will have the opportunity to exchange ideas and learn about recent hardware and software advances, theories, experimental results, and practical applications. If you are doing HF, VHF, UHF, or SHF digital communications, then the 1995 Digital Communications Conference is the place to be in September. Two workshops will be held during the conference: An APRS workshop by Keith Sproul, WU2Z, will be held Friday afternoon and on Sunday, Dewayne Hendricks, WA8DZP, will present a workshop on Survey of Personal Communications Systems (PCS) Technologies and their application and use in the Amateur Radio Service (as of 5/1/95).

## **Call for Papers**

Anyone interested in digital communications is invited to submit a paper for publication in the Conference Proceedings. Presentation at the Conference is not required for publication. Papers are due by **July 21, 1995**, and should be submitted to Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111 U.S.A. or via Internet at [lweinberg@arrl.org](mailto:lweinberg@arrl.org). Please contact Maty for detailed format requirements.

## **For more Information**

**Tucson Amateur Packet Radio**  
8987-309 E. Tanque Verde Rd #337  
Tucson, Arizona • 85749-9399  
Office: (817) 383-0000 • Fax: (817) 566-2544  
Non-Profit Research and Development Corporation

# Registration

Contact the TAPR office by Phone, Fax, or e-mail (Internet: [tapr@tapr.org](mailto:tapr@tapr.org)) to pre-register or for additional meeting information. MasterCard and VISA accepted.

## Digital Communications Conference

- Pre-Registration (before August 21st) \$30.00 † \_\_\_\_\_
- Late Registration or at door \$35.00 † \_\_\_\_\_
  - † — Conference Registration includes:  
Conference Proceedings, Sessions, Meetings, and Lunch.
- Saturday Evening Dinner \$17.00 †† \_\_\_\_\_
  - †† — Dinner, Speaker, Prize Drawing (Limited Space)

## Workshops

**APRS Workshop, Friday, 4pm - 7pm.** Conducted by Keith Sproul, WU2Z

- Pre-Registration (before August 21st) \$10.00 \_\_\_\_\_
- Late Registration or at door \$15.00 \_\_\_\_\_

**PCS Workshop, Sunday, 9:00am - 1:00pm.** Dewayne Hendricks, WA8DZP

Survey of Personal Communications Systems (PCS) Technologies and their application and use in the Amateur Radio Service

- Pre-Registration (before August 21st) \$10.00 \_\_\_\_\_
- Late Registration or at door \$15.00 \_\_\_\_\_

**TOTAL Registration** \_\_\_\_\_

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## Schedule

### Friday, September, 8th

Registration  
Hospitality Suite  
**Special Friday Workshop — APRS.**  
conducted by Keith Sproul, WU2Z  
Special Interest Meetings  
ARRL Committee Meetings

### Saturday, September, 9th

Conference Registration  
Presentations  
Lunch  
Presentations / Breakout Sessions  
Dinner, Speaker  
Special Interest Meetings

### Sunday, September, 10th

**Special Sunday Workshop — PSC Technologies**  
conducted by Dewayne Hendricks, WA8DZP.

*Detailed conference information and schedule will be mailed to all pre-registered participants.*

## Sponsored by



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# Order Form

**July 1995**

All prices subject to change without notice and are payable in U.S. funds. Members receive 10% off on Kits and Publications.  
 Please allow six to eight weeks for your order to be shipped. For specific information on kits, see Product Description flyer.

Office Hours: Tue-Fri 9am-12pm, 3pm-5pm CST

## Kits / Firmware / Publications

Qty	Item	Unit Price	Total Price	Kit Code	Information
_____	DSP-93 w/ wall transformer (US) .....	\$ 430.00	_____	16	check with office on ship date, <u>no discount</u>
_____	DSP-93 w/o wall transformer .....	\$ 420.00	_____	16	for international orders only, <u>no discount</u>
_____	AN-93 HF Modem .....	\$ 90.00	_____	3	limited kits available.
_____	TAPR 9600 bps Modem .....	\$ 80.00	_____	6	
_____	Bit Regenerator .....	\$ 10.00	_____	1	used for regenerative repeater operation
_____	Clock Option .....	\$ 5.00	_____	1	used for regenerative repeater operation
_____	PK-232 Modem Disconnect .....	\$ 20.00	_____	2	simplifies connection of external modems
_____	PK232MBX Installation Kit .....	\$ 20.00	_____	2	for installation of 9600 modem in PK-232MBX
_____	XR2211 DCD Mod. ....	\$ 20.00	_____	2	
_____	State Machine DCD Mod. ....	\$ 20.00	_____	2	
_____	State Machine DCD w/Int Clock .....	\$ 25.00	_____	2	For KPC2 or other TNC w/o 16X or 32X int cloc
_____	METCON-1 Telemetry/Control .....	\$ 85.00	_____	6	includes 8 input, 4 outputs. limited kits available
_____	4 additional output ports .....	\$ 15.00	_____	1	
_____	Voltage-to-Frequency module .....	\$ 30.00	_____	3	
_____	Temperature-to-Freq module .....	\$ 40.00	_____	3	
_____	A-D Converter .....	\$ 45.00	_____	3	
_____	Elapsed Time Pulsar .....	\$ 35.00	_____	3	
_____	32K RAM w/ TNC2 update docs .....	\$ 20.00	_____	2	
_____	<b>TNC-2 1.1.9 w/KISS EPROM</b> .....	\$ 15.00	_____	4	includes 1.1.9 Commands booklet (below)
_____	1.1.9 Commands Booklet (only) .....	\$ 8.00	_____	2	full TNC-2 command set for 1.1.9
_____	TNC-2 WA8DED EPROM .....	\$ 12.00	_____	2	8 connect version for ARES/Data standard
_____	TNC-1 WA8DED EPROM .....	\$ 12.00	_____	2	
_____	TNC-2 KISS EPROM .....	\$ 12.00	_____	2	
_____	TNC-1 KISS EPROM .....	\$ 12.00	_____	2	
_____	PK-87 WA8DED EPROM .....	\$ 12.00	_____	2	
_____	<b>Packet Radio: What? Why? How?</b> .....	\$ 9.00	_____	2	130 pages. TAPR's Packet Radio book.
_____	<b>BBS Sysop Guide</b> .....	\$ 7.00	_____	2	60 pages. by: Barry Buelow, WA0RJT
_____	TAPR's 94 Annual Proceedings .....	\$ 7.00	_____	2	Papers from the Annual Meeting (Tucson)
_____	TAPR's 95 Annual Proceedings .....	\$ 7.00	_____	2	Papers from the Annual Meeting (St Louis)
_____	PSR Set Vol 1 (#1 - #17 '82 - '85) .....	\$ 20.00	_____	5	
_____	PSR Set Vol 2 (#18 - #36 '86 - '89) .....	\$ 20.00	_____	7	
_____	PSR Set Vol 3 (#37 - #52 '90 - '93) .....	\$ 20.00	_____	7	
_____	NOSIntro, Intro to KA9Q NOS .....	\$ 23.00	_____	5	Ian Wade, G3NRW, TCP/IP over Packet Radio
_____	ARRL CNC Proceedings 1st - 11th .....	\$ call	_____	.	Individual Proceedings, call for prices
_____	Entire Set ARRL CNC 1st - 11th .....	\$ 80.00	_____	36	9 Proceedings from 1981 to 1993
_____	TAPR Badge .....	\$ 10.00	_____	0	include Name and Call for badge
_____	3 1/2" Disk from TAPR Library .....	\$ 3.00	_____	0	\$3 per disk. See TAPR Software Library List

**Sub-Total Kits/Firmware/Publications/Disks:** \_\_\_\_\_

**:Added Total of Kit Codes**

(Example: 9600modem w/ BitRegen: 6 + 1 = 7)

**Members 10% Discount (Kits & Publications):** \_\_\_\_\_

**:Member # (Place New, if joining)**

(Except were noted)

**Total Sales (Sub-Total minus Discount)**

**Texas Residents add 7.75% tax**

**Membership (New or Renewal)**

**For Total Kit Codes between:**

<b>1-3</b>	<b>4-7</b>	<b>8-15</b>	<b>16-27</b>	<b>28-55</b>
Add \$2	Add \$3 <sup>50</sup>	Add \$4	Add \$5	Add \$6

Kit Codes above 55 or INTERNATIONAL orders  
 Please call TAPR for Shipping & Handling Amount

**TOTAL Order Amount** \_\_\_\_\_

**Credit Card #** \_\_\_\_\_  
 (Visa/Mastercard Only)

**Expires:** \_\_\_\_\_ **Signature:** \_\_\_\_\_

**Name:** \_\_\_\_\_ **Callsign:** \_\_\_\_\_ **City, State:** \_\_\_\_\_

**Address:** \_\_\_\_\_ **Zip, Country:** \_\_\_\_\_