# Packet Status Register

NOV. 1983
Number 8

## Tucson Amateur Packet Radio Corporation

Fire up the 10 Meter rig with your TNC as the St. Louis group led by Scott Kuether plan to have an Apple BBS system running on 28.310 MHZ upper side for the approaching holiday season. The system will be active every day from 9 AM till 6 PM November 19 thru November 27. And again on the same schedule December 23 till January 2. It will beacon every 20 seconds for help in tuning. The other parameters are an HBAUD of 300 and PACLEN of 50. The station will use Scotts' call, KA9AKM. The BBS program is the one written by Lynn Taylor, WB6UUT. It has some nice mods in it that allow the beacon to let everyone know if the board has any mail for you. Let's use this as an opportunity to try some "low band" operation with the TNCs.

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TAPR has attracted many new members of late who are asking a lot of questions. In order to meet these members needs, as well as refresh some of you old timers, we hope to begin an (ir)regular series in PSR somewhat akin to the ones we ran a year ago in the AMRAD Newsletter, but updated to present standards. Such topics as TNCs, AX.25, gateways, interfacing and the like will be covered if all goes well.

Those of you who know, write! We need to spread the burden (and joys) of writing PSR with more members. **Many of you have much to contribute.**

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A video-tape lecture entitled "**INTRODUCTION TO PACKET RADIO**" featuring Pete Eaton, WB9FLW, is now ready for distribution. This discussion, taped during Pete's presentation to the **CENTRAL IOWA TECHNICAL SOCIETY** on July 23, 1983, covers digital packet concepts, packet radio local area network (LAN) operations and the Tuscon Amateur Packet Radio (TAPR) terminal node controller (TNC).

Pete's long term experience with the TAPR TNC project and as President and founder of the St. Louis Amateur Packet Radio organization provides a solid foundation for this lecture. Groups interested in packet radio who have not had the advantage of such a presentation will find this time and money well spent.

Commercial equipment and methods were used for production of this video tape. It is one-hour long and available in either VHS or BETA format.

Please send $25, which covers the cost of the tape and first-class postage, to:

**CENTRAL IOWA TECHNICAL SOCIETY**
c/o Ralph Wallio, W0RPK - President
Rural Route Four
Indianola, Iowa 50125
515-961-6406

Proceeds will be used to partially cover expenses associated with the development of METEOR SCATTER digital communications for packet radio inter-LAN trunking.

The PACSAT Project Final Design and Review Meeting for the feasiblilty phase of PACSAT was held in Boston the weekend of July 29-31, 1983. Many decisions were made which led to a document presented to VITA on August 2nd.

What is PACSAT? PACSAT is a PACket radio SATellite that will contain up to 2 megabytes of memory for access by the world's radio amateurs and is "scheduled" for a 1986 launch. Harold Price, NK6K, TAPR Director and PACSAT Program Manager will be covering many of the details of this project in his new Satellite column which debuts in this PSR. VITA, Volunteers in Technical Assistance, is a third world development agency based in the United States and is a non-governmental group. They are the folks who want to see PACSAT fly badly enough to arrange to have someone else pay for it!

The primary PACSAT experimental package will be designed in the United States and Canada with a spaceframe built by the University of Surrey in England. The various major subsystems are being built by various groups and many TAPR members are playing significant roles in this project.

The three days of meetings resulted in a fairly extensive design overview, parsing of tasks to team members and resolution of many problems.

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Tom Clark, W3IWI, had a phone call about 6PM tonite from Gordon Hardman, ZS1FE/KE3D who was calling from Durban, the site of the 1983 SA-AMSAT (South Africa' AMSAT) annual meeting. He passed on to all the greetings of the SA-AMSAT membership as well as his and Molly's personal regards. Tom asked him to convey our greetings to the collected members of SA-AMSAT.

He reported that the new President of SA-AMSAT is Hans, ZS6AKV who replaces Greg, ZS1BI. Greg has for some time asked to be relieved 'cuz he is tired (sound familiar?), but has agreed to serve on their board of directors for another year.

Gordon also reported that he had been demonstrating TAPR TNC's and Packet Radio at the meeting and found great interest. Boards for use in ZS are desired ASAP and they will be writing TAPR to make arrangements. Gordon described PACSAT to the meeting, and found considerable support for an SA-AMSAT initiative to join in on the project working on user ground terminals. He asked Tom to "bless" this decision which he did wholeheartedly.

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Be sure to see the slate of candidates on page 8 for the Board of Directors election coming up in February. Ballots will be distributed in the next PSR, in the event you do not attend the annual meeting in February.

# Presidents Corner

by Lyle Johnson, WA7GXD

There is a tremendous level of excitement in TAPR at this time. Not only in Tucson, but in selected Beta sites across the nation people are talking about the new TNC kits. As this is being written, there are another 127 kits with parts bagged waiting for the manual to come off the presses so they can be sent on the way to their new owners!

On October 12, 19 test kits were sent by a second day air service to a number of carefully screened Beta sites for assembly and feedback. The kits arrived (with three exceptions) at their destinations on the 14th, and most were on the air by the 16th! Reports were then sent to Tucson by the test participants. They were asked to carefully scrutinize the TNC and the accompanying breliminary documentation, then rush the reports back to us to be in our hands in Tucson by the 21st.

A tall order? Indeed! Did the testers come through? In almost every case, yes!

What did they say? The overall tone of every report was very positive. There were some points that needed clarifying in the assembly instructions, a few corrections to some technical explanations and a couple of holes were tight on the pc board. However, all boards were brought to life with minimal problems (a case of switched voltage regulator ICs was the most serious) and every new TNC owner that responded was delighted with his purchase.

Who were these testers? Some were old hands at the packet art, some were brand new. Some were very competent technically, some were less technically inclined. Some had their hands held by their Beta coordinator, some did it alone. In other words, they were just like you and me -- hams with an interest in packet radio.

How difficult was it to build the kit? No one completed the kit in less than about 6 1/2 hours, while some took as long as 10. The assembly appendix in the TNC manual is over 50 pages, with plenty of illustrations. A great deal of effort went into its writing and those who worked on it are justifiably proud of the results of their efforts. This is not to say that the kit is a piece of cake to assemble: it requires patience and care. The results of the test indicate, however, that if you are willing to follow detailed instructions exactly, take your time and exercise good workmanship you will have a working TNC in a day or two after you receive your kit.

The manual contains about 220 pages which include information on virtually every facet of packet radio and particularly the TNC. This is not to imply that you must be familiar with all 220 pages: like the older Beta manual, you need only read a small fraction of the manual to get on the air. However, if you have any questions about the operation, protocols or hardware of your new TNC, the answer will most likely be found in this comprehensive work. And the real beauty of the new manual is, of course, the - ah, but I don't want to spoil the surprise! Just look in the bottom of the box that your kit comes in.

How fast are the kits coming? We have deposits on 400 TNCs now. They will all be shipped before the end of the year if our suppliers keep their commitments to us on parts deliveries. We are scheduled to have parts for 200 TNCs by the end of November, another 200 during December and another 300 by February 1st! TAPR is determined to satisfy every request for the the TNC, thus helping to define and support the growth and acceptance of this new mode of reliable communications within Amateur radio.

## Cabinets

There have been rumors that a cabinet is being developed for the TNC. Depending on the rumor you have heard, it may be true! In fact, a prototype cabinet is now in Tucson and a kit is being developed. This cabinet will be punched, painted and silk-screened. It will include a three-wire line cord, strain relief, fuseholder with fuse, siwthces, front panel LEDs, etc. It will be of all-metal construction, with all surfaces (top, bottom, front, rear and sides) removable with a screwdriver. In short, a first class, top-quality cabinet to complement your TNC and your (there's that surprise again!).

Expected price class is \$60-\$70. Silicon is cheap, but aluminum is expensive. If you are interested, please contact TAPR at the PO Box so we can decide how many to order. Color? That's a surprise, too!

## EPROM Programmer

The TAPR EPROM programmer is in testing now and should be available in the very near future, depending on parts flow. There will probably be a pre-release test to selected Beta sites, so rattle your Beta Coordinator's cage to get on the test list! Price is to be determined, but will likely be in the \$50 to \$70 class. This unit clones EPROMs of the 2764 and 27128 variety. More details will be forthcoming. Stay tuned!

## Unsung Heroes

There are a number of folks who work very hard but receive little recognition. Mel Whitten, K0PFX, is one such person. Vice President of the SLAPR group, Mel is also a very active RTTYer and is now on AMTOR as well. I want to mention Mel this month, because he is the person who is responsible for the TAPR TNC cabinet design and did a lot of thoughtful rework of the original TAPR EPROM programmer design, then did the artwork for the pc board for the programmer and even supplied us with a couple boards and hard-to-find parts to get the project rolling!

If you don't like the (surprise!) color scheme Mel chose for the TNC cabinet, just remember: Mel did the work!

I look forward to reading YOUR comments as you receive, build and operate your new TNC.

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Linkoping University S-581 83 Linkoping, Sweden
Phone: Nat. 013-28 10 00 Int. + 46 13 28 10 00

# BBS Connection

by Lynn Taylor, WB6UUT

One afternoon in February, not long after the long-awaited arrival of the Beta TNC's, we were discussing how wonderful they were, and wouldn't it be nice to do something with them besides chatting back and forth. One idea advanced was the idea of Mailbox/Bulletin Board system. As the discussion continued, it became clear that the hardware was available, and since I had written a mailbox before, I began the task of developing a new mailbox for packet. This is the story of that mailbox, and the one that replaced it. It is also the story of how you can get a mailbox for your Local Area Network.

The first mailbox followed quickly. It drew from my previous experience with a mailbox for RTTY, and was almost, but not quite exactly exactly what a packet mailbox shouldn't be. This brought up the question of how a packet mailbox whould be designed, what features, and most importantly, how secure should it be.

The RTTY mailbox did not encourage 'browsing' other people's mail because you can tie a channel up pretty good when you are talking about 45 baud, and no channel sharing. This idea of secure mail, good at 45 baud, was carried into the packet mailbox release 1. The result was that the users would check in, see no mail for themselves, log off and go away. A second problem with the original mailbox was that it stored mail in order from newest to oldest, which was sometimes a bit confusing.

A little thought brought up these design goals: A packet mailbox should primarily accept messages from the users and deliver them to those they are addressed to. It should disseminate information to the user community. It should encourage users to get on the air, and give them something to talk to. To achieve this goal, the new mailbox was designed for easy access to all messages, vs. the high security of the original.

"Great, what does this thing look like", you ask. Let's connect and find out! Connecting to the mailbox is just like connecting to any other packet station, including the use of the familiar "converse" mode. When the connect is completed, we get a message asking us to stand by. The mailbox is now checking the call it just received from the TNC against it's known users. If it knows the call, we are greeted by name, if not, the mailbox asks for a first name, and adds that call to it's list. Then comes the latest "news headline", the time, a notice if we have mail and the command prompt:

Cmd: H)elp, N)ews, L)ist users, S)end, R)ead, B)rowse, C)all:

Now typing a single letter will execute one of these commands, and, like the TNC, all responces may be in upper or lower case. For example, typing H<return> will give detailed instructions on how to use the mailbox, or N will display the news. L gives a list of the users and nets (non-callsign mailbox addresses that mail may be sent to), sorted alphabetically by call suffix, then call prefix.

Send asks for a list of callsigns and/or nets, a 30 character subject, and 1 to 50 lines of text. The mailbox prompts for each line of text, so most of the 'smart terminal' programs can use the prompt to keep from getting too far ahead. Typing '***end' stores the message. Every message has a 4 digit serial number, and a 'time stamp' giving the date and time the message was sent. The mailbox will only accept messages for known stations and nets, preventing typos from sending mail to the wrong station, or to someone who does not check into the mailbox.

Each message has a header and a body. Typing R will display all messages sent to you since you last read your mail. After you read a message, it will be kept in the mailbox (but not displayed again unless you ask for it) until it's disk space is needed for new messages.

The Browse command is a generalized form of the read command. It allows the user to display the headers, or headers and text of every message in the mailbox, either selectively (all messages to or from a given call) or all the headers, starting with those entered since you last browsed the mail, from a specific serial number, or every message in the mailbox. If you choose to display only the headers, you may type the serial number of any message, either while the headers are being displayed, or when promped at the end of the list, and read the text of any single message.

The Call command simply rings a bell at the computer running the mailbox. If the system operator is present, he can enter a 'chat' mode after you complete your next command.

Now we have read our messages, sent replies, caught up on the latest news about OSCAR by using the Browse command, and are ready to log off the mailbox. All we have to do is disconnect, and the mailbox will update it's records to show what we have read, what messages to start with next time we browse and what time we logged off.

In addition to the above functions, which are available over the air or on the system itself, the system operator has several additional features. As part of the mailbox program itself, he may select a 'log' display, showing who logged on and when, or to monitor everything sent to and from the mailbox, either on the screen or on a printer. Seperate programs repair possible damage to the files caused by disk errors or power faliures, allow the editing of the user list, including nets, and automatically reboot the mailbox in the event of a power faliure. The system operator can also use the system's utility programs to edit and maintian the news and help command text files.

The mailbox is written in UCSD Pascal, and is available now for the Apple (][, ][ plus, or //e) with dual disks, either a Mountain Computer CPS card or a California Computer Systems 7710 serial card and a Thunderware ThunderClock (I recommend the CCS card/ThunderClock) and a TAPR TNC. A printer is supported, but optional, and you should have the Apple Pascal 1.1 disks. Other systems and configurations will be available in the future.

To get a copy of the mailbox, send a complete description of your system's configuration, three disks (with the Pascal system on them) and return postage to:


Lynn W. Tylor, WB6UUT<br>
463 Myrtle Street<br>
Laguna Beach, California 92651


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Be sure to take note of the <u>director nominations</u> found on page 8. Please read these outlines carefully and be ready to vote. Ballots will be provided in the next issue of PSR. Or come to the annual meeting to be held in Tucson on Feburary 4th. Whatever the case, **VOTE**.

Thanks.........

# Satellite Space

by Harold Price, NK6K

Amateur packet radio and the amateur satellite program have been intertwined for some time now. The protocol running on the TAPR TNC was made standard at a meeting sponsored by AMSAT (Amateur Satellite Corporation) in October 1982. The most sophisticated satellite yet to be designed by AMSAT will be devoted entirely to packet radio.

Although there is no official connection between TAPR and AMSAT the hierarchies of both organizations share some of the same individuals. The past president of TAPR, Den Connors, KD2S is an assistant vice president for engineering for AMSAT. The current president of AMSAT, Tom Clark, W3IWI is on the board of directors of TAPR. Several members of the TAPR board of directors are heavily involved in ASMSAT's PACSAT project.

Two of the journals of the amateur space program, ORBIT and the Amateur Satellite Report have devoted space to packet radio to get the non-packet space enthusiast informed about packet radio. With this issue of PSR, we begin to do the same for the non-space packet enthusiast. In the past few weeks there have been two events in the satellite world of interest to packeteers, a PACSAT meeting and AMSAT-OSCAR 10.

A meeting was held recently in Boston to finalize the initial design of PACSAT, the Packet Radio Satellite. Put in simplest terms, PACSAT will be an orbiting mailbox system offering two million characters of data storage accessible via packet radio at 9600 baud with omni-directional antennas. A more complete description of PACSAT will appear in future articles. Several members of TAPR hold key roles in the PACSAT project, they are mentioned below as sources of additional information and contact points should you wish to volunteer your services.

Harold Price, NK6K. Project Manager. Responsible for the overall project.

Den Conners, KD2S. Program Manager. Liaison to industry and funding agencies.

Lyle Johnson, WA7GXD. Head of microprocessor design for PACSAT. There will be six CMOS Z80 CPUs on board.

Bill Reed, WD0ETZ. Head of Ground Station design.

Pete Eaton, WB9FLW. Integration Coordinator and expediter.

Phil Karn, KA9Q. Modem design. 9600 baud PSK offers a new challenge.

The meeting in Boston got everything off to a good start for an expected launch in the late 1985-early 1986 time frame.

Other space news of a more immediate nature was the launch and successful activation of AMSAT OSCAR 10. AO-10 currently offers 150 KHz of spectrum to users in an entire hemisphere for several hours each day. Roundtables have been held between packeteers in Maryland, New York, New Jersey, Los Angeles, and New Zealand with sufficient signal quality to exchange packets. Since experiments have shown that a signal with 22db of quieting on FM is required for the Beta TNC to maintain a low error rate, this should show that AO-10 provides true "armchair copy" on the somewhat noisier SSB mode used on satellites.

AMSAT has even set aside a special frequency for use by packet radio, the downlink frequency 145.830. During the current period of not much data but a lot of voice coordination, voice packet roundtables are held on 145.83, but eventually this channel will be exclusively digital.

While it has been shown that only 10 watts of uplink power on 435 MHz into an 11db gain antenna will produce a usable downlink signal, not every amateur will have the time, space, or $ to get into the satellite. It is envisioned that small groups of packeteers will band together to support a gateway station, much as local repeater or remote base groups do for terrestrial communications. Gateways can be digial or voice, broadband or channelized. A local amateur without satellite gear has already participated in a satellite roundtable by as simple a scheme as an uplink microphone being held next to an HT.

AO-10 is currently running in "Mode B", the user transmits around 435.100 and receives around 145.900. The satellite will be placed in "Mode L" for several hours each week starting in September. Mode L uses an uplink centered on 1269.45 and a downlink centered on 436.55. A total of 800 KHz is available in this mode, equal to the 20 meter and the 15 meter HF bands put together.

Packets have been exchanged on AO-10 on an almost daily basis. Data files have been moved at 1200 baud coast to coast, and W3IWI's computer has been remotely controlled from both the West Coast and New Zealand. New modems based on KA9Q's PACSAT work will be available in the months to come, hopefully moving the bit error rate down to the point where the packet retry rate nears zero.

Amateur satellites offer another means for packeteers to get active. Watch this Space!

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There is a small bug in the Version 2.1 software which shows up when you try to operate on a noisy channel full duplex. This bug surfaced when people began sending packets on Oscar 10, and the symptom is flags sent indefinitely at the beginning of a packet. Changing 19 bytes between E80E and E829 will fix the problem. If you have access to a commercial prom programmer, copy your E-rom into the programmer memory, change the bytes marked with asterisks below them, and program a blank prom. If you can not program proms in this fashion, and if you consider your case to be urgent, please contact me to arrange to get this bug fixed.

This bug will be fixed in Version 3.0 software which will be available with Beta upgrade kits and new TNCs.

Old version (2.1 or 2*)

```
E800 4F 5F DD 57 97 59 97 5B  DC FB 85 08 27 1B C5 40
E810 26 18 0D E6 27 13 17 FE  A6 D7 E6 5C D7 E5 0D 51
E820 26 07 0D 55 2E 03 5C D7  4F 3B CC 01 FF 97 E6 D7
```

New version

```
E800 4F 5F DD 57 97 59 97 5B  DC FB 85 08 27 1B C4 40
                                                 *
E810 26 18 0D E6 27 13 D7 E6  5C D7 E5 0D 51 26 0A 0D
                       *  *   *     *  *  *  *  *  *
E820 55 2E 06 5C D7 4F 17 FE  96 3B CC 01 FF 97 E6 D7
      *  *  *  *  *  *  *  *   *
```

# JAMSAT

"JAS-ONE" to be launched in early 1986, by NASDA's H-1 two-staged launcher from Tanegashima Space Flight Center !

JAS-1 Mission Objectives:

1. JAS-1 will be an amateur radio communications satellite carrying two transponders. One will be a linear transponder and the other will be a digital "store-and-forward" type transponder utilizing packet-technology.

2. JAS-1 will enable radio amateurs to study tracking and command techniques.

3. JAS-1 will offer an in-space "proving ground" for radio amateur developed and built, transponders and sub-system etc.

4. JAS-1 will provide NASDA an opportunity to carry out a "multi-payload" launch using their new "H-1" launcher. (NASDA has never engaged in a multi-payload launch, thus the JAS-1 project will offer NASDA an excellent opportunity by providing them with an actual payload having its own telemetry-beacon and transponder for ranging and etc.)

5. JAS-1 will be a joint venture between JAMSAT, JARL and NASDA.

The JAS-1 satellite

1. Form and general dimensions: The spacecraft will take the form of a 26 faced polyhedron, which will measure 40 c.m. X 40 c.m. X 50 c.m., and will weigh 50 kilograms.

2. Orbit: It will be launched into a circular low-earth orbit, which will be non-sun synchronous, non-Polar.
   Estimated inclination: 50 degrees
   Estimated altitude : 1500 k.m.
   Estimated period : 120 minutes.

3. Estimated window per orbit: 20 minutes/orbit
   Estimated passes per day : 8 passes/day

4. Designed life: estimated at a life of 3 years

5. Special Features of JAS-1: JAS-1 will carry two separate mode J transponders. One will be a linear transponder, and the other a digital "store-and-forward" transponder mainly for non-real-time communication between stations located in different time zones.

A conventional 2-meter FM transmitter can be utilized for access to the digital transpoder.

The reasons for selecting mode J for this first Japanese amateur radio communications satellite are:

a) Due to the fact that it is becoming increasingly difficult to use 145-MHz for a satellite downlink band because of man-made electrical noise and other interferences.

b) The planners of JAS-1 wanted to provide a successor to AMSAT OSCAR-8's mode J, which was originally developed by JAMSAT's engineering team back in 1976.

c) 435-MHz is much more quieter than 145-MHz as a downlink band, it is comparatively free from man-made noise and sky-temperature effects.

The digital transponder will provide "error-free" information exchange.

6. Transponders:

   a) The linear transponder:

   Band-width of passband will be 100-kHz, and the transponder will have an output of 2-watts p.e.p. And, will require an uplink power of 100-watts e.i.r.p. for access from ground stations. Sidebands will be reversed i.e. uplink : LSB, downlink : USB. There will be a 100-mW c.w. beacon switchable to PSK when needed.

   b) The digital transponder:

   There will be four 145-MHz band input channels using PSK/FM for uplink. For access from ground stations 100-watts e.i.r.p. will be required. There will be one downlink channel using the 435-MHz band using PSK, and the output will be 1-watt RMS.

   Code used will be NRZ-I.

   Protocol will be amateur radio standard called AX-25, based on ISO's X-25.

   Any codes that belong to an 8 X n bit system will be accepted.

   For TNC (Terminal Node Controller) we are thinking of using either the TAPR system or the VADG system, or an equivalent system.

   The on-board memory will have 1MBs. 256k-bit N-MOS chip and D-RAMs will be used, and to counter soft- error and error-correction circuit will be incorporated.

   The microprocessor used will be an NSC-800 run by a 1.3-MHz clock.

   It will also act as JAS-1's IHU (Integrated Housekeeping Unit).

7. Telemetry: A 28-channel (or more) telemetry system is being planned.

8. Tele-command: At least 3-channel tele-command system will be incorporated, e.g. transponder "ON"/"OFF", digital transponder "ON"/"OFF" and independent "ON"/"OFF" of the A-0 beacon. However, maximum capacity of 40 channels will be available mainly for controlling the digital transponder.

9. Outline of project schedule:

   Freezing of conceptual/preliminary design: November 1982

   General Design: November 1982 - June 1983

   Detailed Design: July 1983 - March 1984

   Engineering Model: To be finished by March 1984

   Proto-Flight Model: To be finished and tested by August 1984

   System Integration: Same as above

   System Approval of Proto-Flight Model: To be ended by March 1985

   Delivery of satellite to NASDA: by January 1986

   Launch of Satellite by H-1: February 1986

# PACSAT Modem Project

by Phil Karn

This is a combination tutorial on data transmission and progress report on the PACSAT modem design project.

I have been fortunate to recruit a fellow Bell Labs employee, Ed Shrum, W2IKI, to assist with this project. Ed works at the Holmdel lab about an hour south of here and we keep in touch mainly by electronic mail and an occasional eyeball when he comes here (Murray Hill) for other business. Ed plans on attending the AMSAT general meeting and also the Oscar-10 ground command station meeting assuming schedules permit. He is very interested in becoming an AMSAT "hard core" contributor and is beginning to do quite a bit of work.

So far he has constructed a prototype BPSK modem using switched capacitor loop filters (the MF-10), essentially combining my ideas for selectable speed with W1HDX's GOES BPSK Costas Loop design. He is about to start testing on this unit once he finishes a test PSK transmitter and gathers the appropriate equipment (like a bit error rate analyzer.)

As far as turning this effort into usable modems, I do not anticipate any major changes to the design once the usual testing and fine tuning is completed. At that point it could be turned into a PC layout (if someone is willing to volunteer for this job) and mass produced. It will be usable for the AO-10 GB, the UoSAT-B beacon, and as a terrestrial packet radio modem. In summary, to build a complete BPSK modem for either PACSAT, AMICON or terrestrial use, you will need three boards:

1. A Costas loop BPSK demod (the board we're designing.) This board will also contain the necessary baseband filtering hardware for the PSK transmitter.

2. A front end capable of turning whatever RF you are using into IF. The ONLY frequency determining component on the entire demodulator is the VCO coil; by winding a different number of turns you could accommodate any IF in the HF range (e.g., 3.395, 10.7, etc.) For our purposes we are using Hamtronics 70cm/10m converters and changing the crystals for 10.7 mhz output (Hamtronics doesn't make a 70cm/10.7 mhz converter any more.) I have bought and assembled two at $49.95 each.

3. A linear transmitting converter on the appropriate band with a wideband input mixer. This seems to be the rule rather than the exception. I have bought and assembled two Hamtronics 10m/70cm 1 watt transmitting converters for this purpose. This particular converter is fairly conventional in design: an oscillator chain generates an injection signal 28 mhz below the intended RF frequency and feeds it to one port of a SBL-1 wideband balanced mixer. The 10 m drive signal is fed via a resistive attenuator to the IF port of the mixer. The RF signal appears at the third port of the mixer and is fed through a linear amplifer chain to the output.

It struck me very early while working with these modules that it would be very easy to simplify the transmitter design as follows. Retune the oscillator chain to produce a signal ON the output frequency (rather than 28 mhz below.) Remove the resistive attenuator designed to pad down a 10m SSB transmitter. Now drive the converter with lowpass filtered data from your TNC or whatever and voila! out comes BPSK. Very little extra hardware, no images to worry about.

In contrast to Ed, who has been doing all the actual soldering, I have been spending most of my time recently boning up on all the signal and filtering theory that I either should have learned in school (when there wasn't any real incentive to learn it) or learned once and forgot.

My goal here is to design the optimal filters for both the transmitter and the demodulator arms to minimize the RF bandwidth and maximize the bit error rate performance of the system. I have been assuming that the DPLLs in the HDLC chips will do receive clock recovery (as they do now) so in addition the zero crossings of the received data stream should be reasonably jitter free.

At this point I go into tutorial mode, so you can skip the rest if you don't care about all the gory details of signal theory and filter design, etc.

Transmit Bandwidth Limitation

The FCC rules on digital communications (assuming we don't want to deal with STAs) define occupied bandwidth as "the width of the frequency band, outside of which the mean power of any emission is attenuated by at least 26 decibels below the mean power of the total emission; a 3 khz sampling bandwidth being used by the FCC in making this determination." (97.69 (3) (c) (2)) On 2 meters, this bandwidth has to be less than 20 khz.

If we assume that they mean the power contained in ALL frequencies outside the passband should add to less than 26 db down from the in-band signal components, this means that we have to have less than 0.25% of the total transmitter power outside of the bandwidth limits. To be polite to our amateur neighbors (particularly for a terrestrial link where the signal levels might be quite strong) we should do better than this if we can, particularly for components well removed from the main signal.

The ideal spectral shape for a signal such as ours would be rectangular in shape, i.e., be entirely contained within a specified bandwidth. The Fourier Transform of a square pulse is a sinc (sin(x)/x) waveform; conversely, the Fourier transform of a sinc waveform is a square pulse. Unfortunately, the sinc function extends off to infinity in both directions. If we run the output of a TAPR board directly into our PSK modulator, the resulting power spectrum will have this sin(x)/x shape (actually a sin-squared(x)/(x^2) shape) and extend over quite a bandwidth. I simulated this on a computer using randomly-generated data; the resulting spectrum has sharp nulls at 1x, 2x, 3x, etc., the bit rate on each side of the carrier and spectral peaks between each pair of nulls. The peak of the lobe between 1x and 2x the bit rate was only about 9db below the main lobe; all the way out at lobe #16 it was only down to about 25 db. Hence the case for filtering.

One way to get a good cutoff would be to signal with sinc pulses instead of square pulses. In the ideal case the spectrum would fall off to nothing instantaneously, but the time-domain pulses would have to extend off to infinity in both directions! In fact, if you were to signal with impulses (rather than square pulses) and use an "ideal" low pass filter, this is what you would get.

Ignoring for the moment how you generate the signal over all time, it is alright to send sequential bits consisting of summed, shifted sinc (continued on page 7)

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pulses and still be able to separate them at the receiver SO LONG AS the bandwidth represented by the Fourier transform of the sinc pulses is no less than 1/2 the bit rate. E.g., if you're sending 10 kilobits/sec, the required baseband bandwidth would be at least 5 khz. Since this applies only for the baseband signal, you have to double this for BPSK since it is essentially double-sideband AM, complete with two mirror-image sidebands. I.e., the minimum RF bandwidth would then be 10 khz, or a "spectral efficiency" of 1 bit per second per hertz.

This is just the Nyquist sampling theorem in reverse. This is the one that says that in order to digitally record and reproduce an audio signal you have to sample at a minimum of twice the highest frequency component. For example, to reproduce 20 khz you have to sample at at least 40 khz. Here, however, the 2:1 rate/bandwidth ratio is in our favor.

A problem comes here when you want to recover the data clock. The preceding analysis assumed that you already had perfect knowledge of when to sample the demodulated data stream at the receiver; the sinc waves (due to bandwidth limiting) add and cancel in all kinds of funny ways between each bit, but assuming that the bandwidth is wide enough for the bit rate there will be an instant in the middle of the bit interval at which the sinc pulse components from the adjacent bits (the "intersymbol interference") all go to zero and allow us to accurately sample the current bit.

You can see this with an "eye pattern" on a scope which monitors the recovered baseband data at the demodulator output. Sync the scope to trigger at some submultiple of the bit rate and run random data through the system. On the scope you will see all of the various bit sequences overlapped, but there will be empty space in the middle of each bit interval (the "eye opening".) The point at which this opening is the widest vertically is the point at which you sample the signal and decide whether a 1 or a 0 was received.

Since we can't exactly use atomic clocks at each of our decoders to determine this magic sampling instant, we will have to recover clock from the data stream itself and this will require some more bandwidth. One way is to transmit a bit framing sequence at the beginning of each packet and phase lock a bit clock which will then "free-run" through the rest of the frame, generating sample pulses for the demodulator. I haven't investigated this approach fully, but it has the disadvantage of extra complexity and requires that we toss the "free" DPLL in the HDLC chips.

In order to do things the "easy" way (i.e. let the HDLC chip do all the bit timing), it is necessary that not only do the bit centers come through without inter-symbol interference, but also the transitions between each bit. This is equivalent to "sampling" the data stream twice as fast and therefore requires twice as much bandwidth. Now we're up to 20 khz for our 10 kbps signal. Interestingly enough, this corresponds to the first spectral null in the unfiltered BPSK signal. All we have to do is lop off the extra redundant side lobes and we're done.

There are several ways to do this filtering. Clearly, whatever method is used will be easier to do as lowpass filtering on the baseband signal before BPSK modulation than as bandpass filtering on the modulator output; this allows the use of audio (including active op-amp and switched capacitor) filters instead of requiring passive RF (e.g., crystal) filters.

Whenever a pulse signal is filtered, we would like that all of the frequency components of the signal that do make it past the filter do so with an equal propagation delay. The term for this is "constant group delay". Since group delay is the derivative of the phase response (the shape of the phase shift vs frequency curve) another term for this characteristic is "linear phase."

Unfortunately, the analog filters that have the fastest amplitude rolloff in the frequency domain (desirable to get rid of the extra side-lobes) are also the ones that have the worst group delay response. The effect is to smear the pulses in time such that the eye opening closes, reducing the system's tolerance to noise. If the eye opening closes completely, you get errors even in the absence of noise. Since the group delay distortion is greatest near cutoff, you can minimize its effect by making the filter wider than it has to be, but this obviously offsets the only advantage of the filter which was its faster rolloff.

Digital filtering is one way to construct sharp cutoff filters that also have good group delay response. In particular, the FIR (finite impulse response) filter can always be constructed in such a way as to GUARANTEE linear phase (and flat group delay). The FIR filter has been around for a long time, before digital filtering, under a different name: transversal equalizer. The basic idea is simple: you run your signal down a delay line. At regular intervals along this line, taps sample the signal as it propagates. Each tap feeds an amplifier with a proscribed gain (the "tap coefficient") and the outputs of all the amplifiers are summed. This becomes the output of the filter.

For an ideal low pass response, the delay line would have to be infinitely long and the tap gains would follow a sinc (sin(x)/x) pattern. It turns out, however, that linear programming methods very similar in principle to the algorithms I used for least-squares fitting of orbital elements to ranging data on Oscar-10 can be used to determine the optimum (you get to define "optimum") tap gains to be used in a real (i.e., finite length delay line) filter. The finite length of this delay line is what gives the filter its name.

For example, with a 32-tap delay line, you can get low pass filters which fall reasonably fast to zero response outside the passband and then have stopband response ripples with a maximum amplitude of -50 db, obviously sufficient for our purposes. If you want faster cutoff at the expense of somewhat higher ripple in the stopband, you can get this too. Faster response AND lower ripples require more taps.

Unfortunately, delay line implementations of FIR filters are impractical for our needs, and software implementations on conventional microprocessors are much too slow. There are a number of digital signal processor chips around (e.g., the Intel 2920.) While it is most likely unsuitable for spacecraft use (NMOS and EPROM!), it might conceivably be useful on the ground; unfortunately even it may not be fast enough for our use. The Bell Labs DSP chip is considerably faster than the 2920 but it is both very expensive and not yet available outside the company. The whole idea of using DSPs in our modems is promising, but it needs further study and is probably not practical in the short term.

Since the use of an FIR filter for transmit signal filtering is actually a rather degenerate case, it might be possible to synthesize the response of such a system through the use of a ROM look-up table and D/A converter. This approach also needs further study to evaluate the complexity tradeoffs. One particular case I have looked at is putting a sine wave into the ROM, driving a D/A converter with the ROM and addressing the ROM with a counter that is ramped up and down between its limits for each bit. This method works quite well; the peak sidelobe amplitude outside the main one is down perhaps 30+ db.

Which brings us back to the topic of analog (i.e., simple) filtering. Actually, there is a
(continued on page 10)

# AO-10 Packets

by Tom Clark, W3IWI

Tonite was a remarkable nite -- multiple two-way packet radio tests were run by W3IWI, NK6K, ZL1AOX along with KA9Q and WA2LQQ as spectators. We used 1200 baud (and tried 600 baud) PSK on the AMICON (L1) channel around 145.830-835 downlink.

First, I set up the following beacon:

W3IWI>BEACON: W3IWI Packet Radio Test -- anybody Copy? The quick brown fox jumped over the lazy dog's back 0123456789.

Then I repeatedly called CQ:

```
W3IWI>CQ:cq de w3iwi
W3IWI>CQ:is anybody there??
W3IWI>CQ:hello packets de w3iwi
W3IWI>CQ:w3iwi packet radio test
W3IWI>CQ:via amsat oscar-10
```

Nobody was around, so I worked myself, going up to the satellite, back to myself, up to the satellite again, and then back down:

```
cmd:c w3iwi via w3iwi
cmd:*** CONNECTED to W3IWI
*** CONNECTED to W3IWI
test
test
now is the time for all good men to have aparty
now is the time for all good men to have a party
cmd:d
cmd:***disconnected
```

Then, after a long time of sending to myself with KA9Q spectating, ZL1AOX showed up (he used CAP's, I used lower case):

```
cmd:c zl1aox
cmd:*** CONNECTED to ZL1AOX
hi ian -- how copy
OK I HAVE A CONNECT MSG TOM
ONLY OCCASIONALLY
ok, well I seem to copy u fb
DID U RX MY ACK?
yep
hi harold                    (NK6K called in on freq)
OK
RGR TOM IT'S NOT AS WELL AS IT SHOULD DOWN HERE
cmd:d
c nk6k
cmd:*** CONNECTED to NK6K
hi harold
Hello tom
seems pretty gud copy
Loks great
welcome to the wonderful world of racket radio !!!
Yep. am surprised,
1200 baud too
mebee we should tryy 600
Hot stuff!
```

Then we tried a real first. I connected with myself, thru AO-10 to NK6K, who digipeated my packets back to me:

```
C W3IWI VIA NK6K
cmd:*** CONNECTED to W3IWI
TALK ABT DUMB THING TO DO
TALK ABT DUMB THING TO DO
cmd:D
cmd:***disconnected
C NK6K
cmd:*** CONNECTED to NK6K
DID U SEE WHAT I DID??
Copied 100%!!
```

The only question remaining -- where are all the other packeteers -- the AO-10 AMICON channel is now officially christened and operating well. Who will be the next to join us?

# Board Elections

by Lyle Johnson, WA7GXD

As a member of TAPR, it is your privilege to exercise your vote in the election to the Board of Directors. There are 15 Directors, five elected every year for a three year term. In turn, the Board of Directors annually elects the Officers of TAPR at the BoD meeting held after the annual meeting every February.

We have 7 excellent candidates for election this time. The actual election takes place in February at the annual meeting, so if you can't come (it will be in Tucson on February 4, 1984), please mail in your ballot from a forthcoming PSR with your 5 selections clearly marked. Your vote counts!

Tom Clark, W3IWI

Tom is an incumbent Director of TAPR and has been very active both in promoting packet radio and in its use. He was the first US station to work New Zealand on packet on 10 meters, and one of the first to use it on AMSAT-OSCAR 10. As President of AMSAT, he brings tremendous experience to the Board.

John DuBois, W1HDX

John is an incumbent Director of TAPR and one of the early packet users in the greater Boston area. He is the AMSAT-OSCAR 10 command station chief and in this role has had considerable experience in digital communications via radio in support of the AMSAT Phase III project.

Peter Eaton, WB9FLW

Pete, an incumbent Director, is founder and President of of the St Louis packet group (SLAPR). He is one of the most energetic and enthusiastic supporters of TAPR and packet radio and has donated literally months of his time in Tucson to help get the TNCs out.

Margaret Morrison, KV7D

Margaret is an incumbent Director. She is co-developer of the MF10 audio filter on the TNC amd wrote the low-level software routines for the AX.25 protocol effort. She is also active in membership services support and is publisher of PSR.

Harold Price, NK6K

Harold, an incumbent Director, is responsible for writing the command parser used on the TAPR TNC. An active supporter of TAPR in the LA area, he is now full time project director for the PACSAT (packet satellite) project for AMSAT/VITA. NK6K was one of the first packet stations on AMSAT-OSCAR 10.

Pat Snyder, WA0TTW

Pat heads the Minnesota group (MAPR) and is the editor of PSR. He has been an active supporter of TAPR and packet radio in the Twin Cities and is the Beta Coordinator for that area. Pat wants to become even more involved in the development and implementation of packet radio.

Lynn Taylor, WB6UUT

Lynn is an active packeteer in the San Diego area. He is especially interested in linking and level three protocol concepts. Elsewhere in this PSR is a description of his packet bulletin board system for the Apple computer.

# REV. 2 Review

by Paul Barnett, N0CRN

Being fortunate enough to be among the group that made the final evaluation of Revision 2 of the TAPR TNC kit, I thought that those of you that are awaiting arrival of your kit would like an early glimpse of what to expect.

I should explain that I rank somewhere between beginner and novice in electronics assembly. However, this proved to be little handicap, thanks to the excellent instructions supplied with the kit. What question or difficulties I had were quickly resolved by Pat, WA0TTW, who was kind enough to loan me his expertise, workbench, and tools for the weekend.

I assembled the TNC in two days, spending about eight hours per day, with no major problems except that I occasionally would put a component in the wrong place, and then would realize my mistake when I tried to insert the proper part in an already occupied spot. My luck ran out when I switched two IC regulators, but that became apparent during the power-up test before the IC's were installed.

Installation of the IC's went smoothly, and after calibration, the TNC worked the first time! Fortunately, KD0BY had his station up (even at one in the morning!), and we did some digipeating before giving up for the night. Since then, I have had very few problems, except for the apparent inability of the NOVRAM to retain data. I suspect that it either suffers from crib death (since it worked fine until I left the TNC on overnight), or an accidental static discharge during handling wiped it out.

The assembly manual very clearly indicates the need for a fine tip temperature controlled soldering iron, and I emphatically agree. I would also suggest trying to obtain a static ground strap (which attaches to your wrist and the preferably conductive work surface) for use while handling the IC's. I borrowed one from my employer for this purpose, but the manual offers sufficient alternatives to protect these devices.

I cannot provide a very good comparison of the new TNC to the Beta TNC, since this is my first one, and I only had a borrowed Beta board for a short time. However, I will say that I had no trouble using the interface I had installed in my radio (an ICOM 290A) previously.

Overall, I am very pleased. I now anxiously await Version 3 of the software and the final update to the manual, and I plan to install my TNC in the "official" TAPR cabinet as soon as it is available.

# Packet BIB

We have had numerous requests for recommended reading by new comers to the packet fold. Most want introductory, easy-to-read material as compared to precise technical works which tend to be dry, boring and not exactly aimed at the Amateur.

TAB books publishes "Packet Radio" by Hodgson and Rouleau, a couple of Canadian amateurs who were among the first packeteers. While their system and protocol aren't "standard," the concepts are applicable. You may feel free to skip the chapters on binary arithmetic and what a microprocessor is if you already know...

Major articles have appeared in the Amateur press. Among the more noteworthy are:

QST :

> "The Making of an Amateur Packet-Radio Network", October, 1981, pp 28-30, by W4RI and K8MMO.

73 :

> "The Packet Radio Revolution", December, 1978, pp192-193, by VE2PY.
>
> "Join the Packet-Radio Revolution", September, 1983, pp 19-24, by WA7GXD.

Ham Radio :

> "An Introduction to Packet radio", June, 1979, pp 64-67, by VE2BEN.
>
> "Amateur Packet Radio: Part 1", July, 1983, pp 14-18, by KV7B and KV7D.
>
> "Amateur Packet Radio: Part 2", August, 1983, pp 18-29, by KV7B, KV7D and WA7GXD.

Watch PSR for announcements of other major packet articles!

**From the editors.**

The task of putting out each issue of PSR has been quit an experiance for us. We have enjoyed it and hope we are getting the hang of the job. It would be very helpful if the material we received came in the format we are using, Word Star for IBM PC or PC alike systems. If this cannot be, please send it unformated. It takes quite a bit of time to reformat. Material that arrives on paper takes longer to see print. We have to enter it, this uses more time than editing and layout.

**MEMBERSHIP APPLICATION**

Tucson Amateur Packet Radio Corporation
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I hereby apply for membership in TAPR. I enclose $12.00 dues for one year.

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Which Beta Test site (if any) is closest to you?

______________________________

(continued from page 7)
filter which has quite good group delay characteristics: the "Bessel" filter. Unfortunately, it also has terrible amplitude roll-off response.

There are other filters with varying degrees of tradeoff; to quantitatively evaluate each type, I spent quite some time writing programs to simulate sending a random data sequence through each type. One program produced an eye pattern; another simulated the whole PSK system, complete with random white noise being added to the "channel" and the bit error rate performance recorded. (It's great having all this spare CPU capacity at night!) In my next installment I will summarize the results of these models and determine what kind of filter we can use and what the likely performance will be as compared to ideal BPSK.

The Tucson Amateur Packet Radio Corporation is a nonprofit scientific research and development corporation. The Corporation is licensed in the State of Arizona for the purpose of designing and developing new systems for packet radio communication in the Amateur Radio Service, and for freely disseminating information acquired during and obtained from such research.

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