

Packet Status Register

Jan-Feb 1987 #25



Tucson Amateur Packet Radio Corporation

PRESIDENT'S CORNER

Lyle Johnson, WA7GXD

It is now the first of February and the TAPR Annual Meeting is less than three weeks away! If you are on the fence about coming, come! This year we will have more speakers and more time to meet than ever before. The Board meeting will occur before the general meeting, so you won't have to wait for the March issue of PSR to find out what's going on in that regard. You will be able to provide some immediate feedback to the Board's actions and decision for TAPR's future.

In addition to the normal pizza bash and racing tournament, we are planning on some real western entertainment Saturday night at the Triple C Chuckwagon Ranch.

There are bound to be some surprises, so make your reservations now!

A special mailing was sent out the first week of February to all TAPR members with details on the meeting and, even more importantly, the Board of Directors election. If you haven't sent in your ballot, do so today!

In this issue Eric, N7CL and Dan, KV7B, report on some very interesting findings regarding HF packet modem performance. While their station setup may be different than yours, the results are very, very interesting. If you have access to the gear, or your local club or group does, it would be very informative if you conducted similar tests with other radios and/or IF bandwidths to compare results.

Meanwhile, looks like we have effectively opened 40 meters for a number of new packet channels without causing any other Amateur operations any problems at all!

On other technical fronts, the PSK modem project is barreling along and prototype units will be shown at the Annual Meeting. We hope to be able to take orders at that time as well, with "complete kits" (less cabinets, switches and cabling) selling for about \$70 to \$80. The final price has yet to be determined.

Stay tuned!

- PRM -

Interfacing the Kenwood TR2600
Eric Gustafson, N7CL

This article describes the radio-to-TNC interface required to put a Kenwood TR-2600 into service for packet radio. It is written for interface to a TNC-2, but the hookup and audio levels will work for a TNC-1 as well.

The 2600 has four interesting characteristics which make the hookup less straightforward than it should be!

First, the PTT signal is generated by connecting the shield lead of the microphone plug to the shield lead of the external speaker jack.

Second, the 2600 will not tolerate any dc coupling of the microphone signal lead to ground.

Third, the microphone audio signal goes in on the ring circuit of the microphone plug, NOT on the tip as one might assume.

Fourth, the squelch circuit in this radio is extremely slow to open. I have been unable to operate successfully when the squelch is used. I run mine open all the time. This may not be a problem with all TR-2600s. I have seen some later models that seem to work fine even with the squelch on.

The audio output circuit of the TNC provides far too much audio for most microphone input circuits. This requires the level pot to be set at or near the very bottom end of its range to obtain the proper drive for the radio.

Operation of the TNC with the level pot set in this fashion causes two problems.

First, the level of the audio provided by the 2206 AFSK modulator chip is reduced to a level comparable to the level of the power supply noise that is always present at the output of this chip. The result is almost as much modulation due to the power supply noise as from the desired tones.

Second, there is a region of adjustment near the bottom end of the level control pot (R76 on a TNC-2) where there is an abrupt change in audio level. It goes from almost no audio (when the wiper is on the conductor at the end of the resistance element) to too much for most radio microphone inputs (when the wiper moves onto the resistance element) in a small fraction of a turn of the adjustment screw. This turns the level adjustment into a hit or miss proposition. In order to get the level right it is

necessary to set the pot so that the wiper is just barely touching the ground contact at the bottom end of the adjustment range. This is a very critical adjustment at best and is likely to change due to temperature cycling, shock or vibration etc.

In order to avoid the above problems, install a 22k resistor in series with the microphone audio lead. This resistor can, and probably should, be located inside the microphone plug. With this resistor installed it will be necessary to increase the audio output from the TNC. This will put the pot wiper up onto the resistance element in a region of smooth adjustment. It will also set the audio output level from the 2206 chip at a level that is far above the power supply noise.

There are a couple of secondary benefits to the series resistor as well. I use it on all of my TNC-to-radio hookups. The relatively high series resistance in the audio line greatly attenuates RF feedback or stray RF from another transmitter. If you live near an AM broadcast transmitter, as some of the packeteers in this area do, this will remove the music and news from your packet transmissions!

Also, by selecting the exact value of this resistor for each radio I use, I can leave the audio level on the TNC set to one value and plug it into any of my radios without having to reset the level each time. It is also possible to use the audio loop-back in the TNC without increasing the TNC audio output beyond the level necessary to drive the radio properly (this may not be as noticeable on a Rev 2 TNC 2 as it is on a pre-Rev 2 board).

As is the case with most commercially available NBFM trancievers, the TR-2600 does not properly preemphasize modulation frequencies on the high end of the voice band (1500 Hz and up). To compensate for this, a capacitor with a value of 0.002 microfarads in series with the already mentioned 22k resistor in the microphone audio lead will provide D.C. isolation as well as add the needed preemphasis to the transmitted AFSK tones.

To properly interface a TNC-2 to a TR-2600:

1. Make sure that the radio is properly adjusted for voice operation.
2. Make the interface cables as shown:

TNC	RADIO
XMIT audio - 22k - 0.002 uF-	Mic plug "ring"
PTT (key) - - - - -	Mic plug "sleeve"
RCVE audio - - - - -	Earphone plug "tip"
Ground - - - - -	Earphone plug "sleeve"

(Note!!!! The TR-2600 microphone plug is a miniature 3 - circuit stereo type plug. Only the "ring" and "sleeve" circuits are actually used. The "tip" circuit of this plug is UNUSED !!!)

3. Set R76 in the TNC-2 so that an audio level of approximately 200 millivolts peak-to-peak appears at the audio output pin of the TNC-2.
4. Transmit a high tone in calibrate mode and make a small final adjustment to R76 so that the deviation on the high tone is 3.0 kHz. If you are unable to measure deviation, the 200 millivolt setting will be very close to the correct value for a properly adjusted radio.
5. Get on packet and have fun.

This same procedure can be used for other radios as well. If you have access to deviation measuring equipment and use this method for setting up other models of radio for properly preemphasized AFSK packet operation, please send the information on the final values of the series resistor and capacitor to me or have them published in PSR. In this way we can eventually get a compilation to publish for the popular radios. The newcomer's task will be greatly simplified if this is done. My address is:

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- PRM -

A MODEST PROPOSAL
Dan Morrison, KV7B

Do you think that HF packet radio on 40 meters is frustrating? Do you think that 7093 kHz is a little overutilized? Would you like to strike out for greener pastures on HF packet? Then read on!

On an number of occasions during the months of December and January, Eric Gustafson, N7CL, and I have been running tests of packet transmission in the vicinity of foreign broadcast stations on 40 meters. The high degree of success we experienced stimulated the proposal in this article. (I believe that the tests between N7CL and KV7B are the first two-way packet QSOs on these frequencies. Any challengers?)

As you must know all too well, these broadcast stations are permitted by international agreement to occupy 7100 to 7300 kHz in ITU Regions 1 and 3. Within Region 2 Amateur radio is the primary service, without however, any protection from the Region 1 and 3 broadcast stations. There are a number of "less well regulated" broadcast stations operating outside these limits. (Listen most any evening in the vicinity of 7030 kHz, for instance). Ostensibly all these stations are "intended for use within Region 1 and Region 3" (excerpted from note 3508D of IRR table, as quoted in ARRL publication.) Nevertheless, a casual trip through 40 meters will quickly convince you that, however their transmissions are intended, they manage to produce great wastelands in the Amateur allocation on 40 meters. Wastelands as far as those of us on SSB are concerned. Does it have to be true in general?

Well, not quite. It turns out that the signals broadcast by these stations are not particularly uniform. In fact, there are well defined holes in their signals. To convince yourself of this, dial up any one of these interlopers and switch in your 500 Hz CW filter. First stick the carrier in the middle of the filter passband (typically at about 800 Hz audio frequency) and look at your S meter. Reads 40 over 9, does it? Next, shift the carrier by 200 or 300 Hz away from center in either direction, so the carrier is significantly reduced. You should see a substantial drop in average reading, particularly if the program material is speech (BBC at 7105 or 7160 kHz is a good place to listen, on the hour). If you slowly dial further out, you will see your S meter begin to pick up again, then fall as you get out beyond the main speech frequencies. It turns out there's generally a hole in the spectrum between the carrier and either sideband out to about 300 to 500 Hz that can be utilized by a packet station. (HF packet occupies about 500 Hz of spectrum.) During times of music this may not be so true, but even then it seems there are long intervals when those bass notes aren't really very strong.

Eric and I decided to see if we could utilize these spectral regions in and near BC signals. The 300 to 500 Hz hole between the carrier and the lowest sideband frequencies seemed relatively difficult to use, although we were able to operate reliably after some critical tuning. Our greatest success, however, has been while operating about 2125 Hz away from the carrier. This is very simply achieved by anyone owning a TNC with 2025/2225 Hz modem tones: Simply zero-beat the station's carrier and transmit. For everyone else, I recommend you tune up to transmit at the same frequency offset. The reason for this is that those TNCs using 2025/2225 Hz modem tones are invariably using the AM7910 modem chip. This chip has no provision for a tuning indicator, and these TNCs are the least capable of being tuned up on other signals.

For packeteers using 1600/1800 Hz modem tones, simply off-tune 425 Hz after zero-beating the carrier--in the right direction, of course! If you are transmitting LSB, you will be moving your dial down 520 Hz, and the reverse if you are using USB. For packeteers using 2120/2320 Hz modems move 95 Hz in the other direction. Of course, it does not matter which sideband you use for HF packet, due to the NRZI data format. So far, Eric and I have had no difficulty in sustaining high quality QSOs with California and Texas stations, literally for hours, using the latter mode of operation. We've connected on 7093, moved to 7095 or 7097 so we could actually communicate, and then all moved over to the broadcast frequency. After that we enjoyed nearly 100 percent copy with no QRM whatsoever.

It turns out that the typical spectral power in the broadcast signal this far from the carrier is usually sufficiently weak to permit reliable packet activity. On the other hand, most wide band Amateur modes, especially SSB, tend to stay further away from the BC station than this, so the packet QSO is not generally interfering with Region 2 Amateurs.

What are the requirements? There are three major ones. First, there's a legal one: If you consult FCC Part 97.61, you will see that F1 is permitted from 7000 to 7150 kHz. At this time I don't know whether or not this means packet operation above 7150 is unauthorized. If it isn't authorized, it should be, along with RTTY and AMTOR, for reasons I'll go into later. In the mean time, please get a suitably responsible ruling on this issue before plunging ahead above 7150. Incidentally, LSB right at 7150 (Radio Moscow, I believe) adheres to this frequency allocation.

The two remaining requirements are technical in nature, not political. First of all, you must have a 500 Hz filter which you can center on your modem receive frequency. Don't even consider this type of operation without such a filter. It turns out that everyone on HF packet should be using such a filter anyway, since it seems that all present TNCs have limiters early in their audio processing, so this is a good time to go get a narrow filter if you don't already have one!

The final major technical requirement is that your TNC's DCD control signal should be derived from a phase-coherence detector rather than an envelope detector. Unfortunately, this leaves out a fair number of TNC owners--all TNCs using the AM7910 modem chip derive their DCD output from an envelope detector rather than from a phase detector. This means that they cannot operate properly in an interference environment. This is a real shame, as the AM7910 otherwise seems to perform quite acceptably as a demodulator. The AEA PM-1 and PK-232 also have an envelope detector for this function. (See Eric's article(s) on the extensive modem comparison tests he recently performed.) All modems using PLLs (primarily represented by the EXAR 2211 based demodulators), which have phase-detector derived DCD, can be used in this mode quite easily, particularly if the DCD filter is modified, to increase the time-constant by a considerable and adjustable amount. For an example of such a modification, see the schematic of the reference modem Eric used in his tests.

Other users could use favorite broadcast stations as congregation points, much as 7093 kHz is being (over)used today. "See you at Radio Moscow" might be a rallying cry in the future. Quite seriously, we're talking about increasing the available channels from 3 or so presently (more often than not, only one channel is used) to somewhere between 10 or 20, depending on how the packet/F1 frequency allocation issue comes out. As a side effect, the greater the packet occupancy near broadcast stations, the less desirable 40 meters will become to the broadcasters, at least in Region 2, and perhaps we will have taken a step toward eliminating this substantial incursion into Region 2 Amateur activity.

One minor issue remains for operation near to BC stations. In fact it's an issue for operation anywhere, but is particularly important within an interference environment. I'm talking about tuning accuracy. The single greatest cause of missed packets (after of over-occupancy of the packet channels) is miss-tuning on the part of one or more parties in a packet QSO.

The single best cure for this problem is an accurate tuning indicator on your modem, such as the TAPR unit for 2211 demodulators. With a good tuning indicator you don't need laboratory-grade frequency synthesizers to get on frequency. For example, the TAPR tuning indicator, which is an LED bargraph type indicator with a single lit element which indicates PLL loop stress, will resolve tuning errors to 10 Hz, far more accurately than is required for a properly set up demodulator.

A proper method for getting on frequency is for everyone to agree on a frequency offset from the BC station's carrier. If it's 2125 Hz and everyone is on LSB (the usual case), and one person has a TNC with modem tones at the desired offset, that person should carefully zero-beat the BC carrier and transmit a dithered calibration tone (available on TNC2 clones, for example) or alternate between high and low tones for a several seconds. Everyone else should adjust their frequency so that their transmission frequency ends up at the same place they hear the calibration tones. After this, everyone should restrict all tuning operations to their receive frequency. If all participants in the QSO have 1700 Hz center frequency modems one person should agree to be the reference and offset his or her transmission by the appropriate amount from the carrier. Tuning by the other participants then proceeds as above.

Why do I advocate allowing all types of F1 operation throughout the entire HF Amateur allocation? Simply, because it will permit modes such as the one described in this article to really make use of all the available "wasteland" now carved out of 40 meters. I don't have a pipeline into the FCC, but I presume their restriction on F1 was based on a non-interference principle: If F1 were permitted everywhere, it would be everywhere. Well, that just isn't so. As a counterexample, slow-scan TV (which can be considered an example of wide-shift F1) is permitted in SSB allocations, and is rather closely confined by informal agreement in those bands where SSTV activity is highest. In fact, it is the SSTV operators who feel interference first, rather than the SSB operators.

As a practical matter, all the digital modes are more "fragile" than SSB voice, and simply don't compete well enough with SSB voice to be a nuisance threat. Present demodulators, be they for packet radio, RTTY, or AMTOR, simply can't tolerate significant amounts of interference. In fact, this a major reason most packet activity on 40 meters is confined to a single channel at 7093 kHz: Most other frequencies between 7090 and 7100 kHz are typically occupied by South American SSB signals. On the other hand, by permitting F1 throughout the whole of 40 meters, a very substantial increase in digital communications could take place, with no additional interference to other Amateur transmissions. I hope the present wording of 97.61 permits packet radio operation throughout the whole of 40 meters. If it doesn't, I hope steps are taken to rectify this situation.

In view of the rapid acceptance of HF packet radio as a predominant long haul traffic handling mode, it behooves all of us to seek greater utilization of

our precious spectral allocations. I encourage all HF packeteers to try my proposal, and look forward to comments on any of the subjects I've discussed.

[Editor's note: This is a fine article dealing with a new method of improving the utilization of the 40 meter band. The following notes are intended only to add perspective to some of the technical comments, and are not meant to detract from the central message of the article in any way. The reader is referred to the modem performance articles in this issue and the previous issue for further technical discussions.

This article makes some generalizations about carrier detection, and lumps all TNCs into two broad categories, carrier detection by phase detection or envelope detection. The reader may choose to investigate the methods used in various TNC designs. In addition, the conclusions expressed in this article are for a special mode of operation purposely using a channel shared with voice. For usage on a dedicated packet frequency, or on a multiple use frequency where transmission on top of an existing voice user is undesirable, the user may wish to consider whether detecting only other packet signals is the most appropriate method of operation.

TNCs may use 2025/2225, or similar tone pairs higher than the 'TAPR standard' 1600/1800 tones for a variety of reasons unrelated to the modem chip being used. Two significant reasons are to allow the use of modem filters designed for RTTY operation, and because the EXAR 2211 demodulator may perform better with more signal transitions per data bit and a smaller frequency shift. Secondly, the statement about the 7910 having no provision for a tuning indicator is only applicable to support of a 'TAPR style' tuning indicator based on PLL error signals.]

- PRM -

The Hidden Terminal
Lyle Johnson, WA7GXD

"Hidden Terminal Syndrome" simply refers to the case where station A and C can't hear each other, but station B can. If A and B are having a QSO, C can cause a lot of interference even though he politely waits for B to end his transmissions.

An excellent example is a wide-area digipeater. If you use long digi chains in your area, or have a wide area one, you know what I mean. Retry city! I spoke to one individual who has a busy tone on his digi at the 600 kHz split. His throughput is dramatically better, because now other stations hold off whenever the digi detects a transmission on its input/output frequency. Of course, now the digi needs cavities and all the rest of the hoopla that is necessary for a standard full-duplex repeater (probably should have 'em if it is on a mountaintop, or an rf-intense area, anyway).

What we have done here in Southern Arizona is install a dedicated packet full duplex audio repeater. Now we have 1200 bps throughput (not 600 as you would get with a single digi), everyone can hear everyone else so there are few if any hidden terminals, and it works like gangbusters. Of course, we carefully balanced the audio, deviation, and etc.

- PRM -

Last time I talked about doing some modem comparisons. Now it is time to examine the choice of reference demodulator and report the results of the comparisons.

There is an error in the circuit diagram of the reference demodulator as presented in the December PSR. One corollary to Murphy's laws is that no schematic diagram can be published error free. Two component values have been switched. The 0.0047 uF cap shown on pin 8 of the 2211 should be marked 0.01 uF. The 0.01 uF cap shown on pin 11 of the 2211 should be marked 0.0047 uF. I have no idea how this could have happened. I can only suppose that Murphy got into Gwyn's photo copier and distorted the lens in such a way that those values were transposed when he copied the hand drawn schematic I sent him. (I believe that this is the first error generated by this mechanism in an article related to packet radio. Any challengers?)

There are a number of good reasons for choosing the XR-2211 as the reference demodulator. It is a cheap and easily duplicated circuit. The demodulation technique is matched to the baud rate / shift combination being used for HF packet. It is very easily retuned to various center frequencies used by other less easily shifted modems. And, I had all the fixin's for one already in place in my TNC-2 clone. In fact, any TNC-1 or TNC-2 demodulator can be easily converted to the circuit of the reference demodulator. MFJ informs me that they will be using this circuit as the demodulator in their new model 1274 HF/VHF switchable TAPR TNC-2 clone.

HF FILTERS

Those of you who are paying attention will have noticed that other than the very broad passive input coupling circuit there is no audio bandpass filter included ahead of the demodulator. The reasons for this are twofold. First, dispensing with an active relatively high Q audio filter keeps the demodulator circuit very simple and easy to retune. Second, and most important, is the fact that a narrow filter at this point in the system is closing the barn after the horse is out!

While running these modem tests it became very clear to me that the system noise bandwidth has to be established ahead of the system AGC detector. This means in the I.F. strip of the receiver. All of the demodulators I have tested are sensitive to audio input level variations. While some are much less sensitive to this than others, all will suffer degraded performance when a signal other than the desired one is operating the receiver AGC system. If an undesired signal reduces receiver gain so that little or no audio is recovered for the desired signal, modem performance suffers. Most TNCs have a limiter of some flavor or other as the first stage of the demodulator. Since these limiters are ahead of any filtering, it is important to limit the system bandwidth before this point to avoid interference from in-band intermodulation products generated by the limiter.

The optimum bandwidth filter to use for 300 baud NRZI FSK data is somewhere in the neighborhood of 400 to 500 Hz. It is a fortunate happenstance that most transceiver manufacturers offer CW filters of approximately this bandwidth. All testing I have done for comparison of different types of modems has been done with a 500 Hz bandwidth I.F. filter in the radio. I used the I.F. shift feature of my particular radio to center the filter passband over the modem center frequency being used. Once the noise bandwidth of the system is established in the I.F. strip, there is no need to do additional filtering at audio frequencies unless your receiver has some very disgusting characteristics in the product detector and audio stages. [Ed. Note: Most CW filters are extra-cost options and therefore may not be installed in many transceivers if the owner is not interested in optimum CW performance. Properly adjusting (or modifying) the radio to center the filter over the packet signal requires skill that new packet operators may not possess. Therefore audio filtering on the TNC device may be the best approach for commercially produced TNCs.]

TEST METHODOLOGY

There are a few caveats to be aware of if you intend to duplicate this type of test. So that you don't have to spend as much time as I did in discovering this for yourself, I'll describe the test methodology used for these tests in a step by step fashion.

1. As I mentioned last time, the audio fed to each modem is from a single receiver. This gives both demodulators exactly the same signal to work with. Comparisons done using two different signals at different times are simply invalid for use as performance comparison data.

2. Some time must be spent finding out the optimum audio level for the demodulator being tested. The audio level is then adjusted to the optimum value for the modem under test. The reference demodulator is very tolerant of input level variations and so far it has been happy with whatever level was required by the demodulator being tested. If this is not the case, it will be necessary to take steps to assure that both demodulators are happy with the audio signal level.

3. Determine whether there are any software idiosyncrasies which may affect the results. This refers both to the TNC software and the terminal software of the host computers. For example, I wished to test the demodulator in the single chip AMD7910 modem. Since I was too lazy to build a breadboard version to test, I used a Kantronics KPC-2400 TNC. The only fly in the ointment was that the KPC software had a slightly different format for displaying monitored packets. The files had to be filtered to remove a few extra characters from each line which were different from the lines reported by the TNC-2 clone which was running version 1.1.3 software. The differences in terminal programs were resolvable by finding compatible parameter settings (like auto linefeed handling etc.).

4. Align the reference demodulator center frequency to the center frequency of the demodulator under test and center the receiver I.F. filter pass-band over the demodulator center frequency.

5. Tune to the center of a busy channel like 14.109 MHz on 20 meters or 7.093 MHz on 40 meters. If the modem under test had a tuning indicator, I used it for this determination. Otherwise I used the TAPR tuning indicator on the reference demodulator. The TAPR tuning indicator also turned out to be very useful for centering the receiver I.F. filter response over the demodulator center frequency.

6. Capture and store 2 buffers simultaneously. The buffer being fed by the reference demodulator should have at least 10K characters in it for the test to be very meaningful. I tried to get 18K to 22K when I ran the tests. This number is necessary since there is typically only a small difference in performance between the various modems.

If you are smart you will give the disk files meaningful names (not TEST1, TEST2...etc.) and include a header in the file with information as to which demodulator generated the file, date, time, etc. so that you will be able to correlate them later. The headers can be stripped off before counting characters.

7. Correlate which file is to be compared to which other file. Edit the files to compensate for any software differences. Then strip off any header information.

8. Count the characters in the files.

9. Divide the number of characters captured by the demodulator under test by the number captured by the reference demodulator. The result of this division will be a number greater than 1 if the demodulator under test is superior to the reference demodulator. This number is the "figure of merit" for the demodulator under test.

10. Repeat steps 5 through 9 above at least 4 times to make sure the results you are getting are consistent. If they are, then average the figure of merit numbers to get a final value to use.

TEST SETUP

Now for the good part: The results of the testing done at my QTH so far. All of the testing I have done has been with a TS430S as the receiver. The 500 Hz CW filter was used at all times. The antenna was a random wire about 100 feet long and fed from an "L" network tuner. Tests were run on both 40 and 20 meters and the results reported here are averages of the tests on both bands. Significant differences were noted between bands for all modems tested. The R.F. gain was run at maximum and the audio level was set to produce optimum performance of the demodulator under test. This included the operation of the data carrier detector. That is, nobody cares how well a modem receives if, in order for it to receive, it has to be adjusted so that you never get to transmit. Therefore, on modems with no separate DCD threshold control, the audio level was adjusted to give useful DCD operation.

AEA PM-1

The first demodulator I tested was a filter/slicer type. It was an AEA PM-1. This was available due to the generosity and curiosity of its owner, Jim Reynolds, W7FPX. I used this unit for a few weeks before starting the tests to be sure that I was operating it properly. After hearing how much better the PM-1 was supposed to be than the built in 2211 demodulator, I was expecting the PM-1 to slightly outperform the reference demodulator. I found this to be the case only if the 500 Hz filter was not used in the radio and then only when there was no strong adjacent channel interference capable of capturing the receiver AGC from the desired signal. The figure of merit for this demodulator when running the 500 Hz filter in the radio was 0.9158 (4 decimal places are probably not significant but you can round the numbers wherever you feel comfortable). This was the lowest figure of merit for any of the tested demodulators. [See editor's note above. Operating all demodulators in a standard fashion for uniform test reporting may not reflect the manufacturers intended mode of operation for which the unit is optimized.]

KPC-2400

The next demodulator to be tested used the AMD7910 single chip modem. I was not expecting this demodulator to perform well in a radio environment as this chip had been specifically designed for use on nice quiet land lines. Needless to say I was shocked when this unit turned in the best demodulation performance of all the modems tested so far! The figure of merit I obtained for this modem using the above test method was 0.9988. This is, for any practical purpose, as good as the reference demodulator. I would have needed to capture huge 100K buffers to make this difference from 1.000 significant.

This would be an excellent modem to use for packet except for 1 major drawback. The carrier sense system uses an envelope amplitude based detector. This is fine on a nice quiet phone line or on a VHF FM channel which is so lightly loaded that it can tolerate the extra delay of squelch circuits but it is unusable on a busy, noisy HF radio channel. The DCD in this chip will falsely detect noise as a carrier and also fail to catch the weak station who is actually putting a carrier on the channel. Thus it will prevent you from transmitting at times when it would be perfectly all right to do so and also let you transmit over a weak station even though that station is perfectly readable. All of the modems which base DCD on an amplitude decision suffer this fault. A good "phase coherence level" type of data carrier detector will hold you off a signal which is so weak as to be completely unreadable and yet it will ignore an uncorrelated noise level of arbitrary amplitude. [editor's note: This discussion of 7910 carrier detection may not apply to all TNCs which use the 7910 modem, since some of them do not make use of the 7910's built-in carrier detect function.]

The last demodulator tested was the one in the PK-232 from AEA. AEA graciously provided TAPR a unit for use in this test. They bill the demodulator as a filter discriminator type rather than a filter slicer type although I'm not sure what the basis for distinction is. At any rate, AEA assured me that the demodulator in the PK-232 would outperform the one in the PM-1 which I had already tested. This turned out to be quite true in fact. The figure of merit generated for this demodulator was 0.9524. This places it just about midrange for the commercially available packet modems tested up to this point.

GENERAL OBSERVATIONS

During the course of this testing I have had a chance (been forced) to spend a lot of time observing HF packet communications under various band conditions. It was very instructive to have two demodulators of different types which used different demodulation techniques copying a channel simultaneously. This made it possible to note the conditions which caused both systems to fail to copy.

COLLISIONS

The single biggest observable reason for failure to copy a particular packet was by far collision with another packet. I would guess (this is a very well educated guess) this accounts for 70% of the failures to copy on 20 meters and fully 50% of them on 40 meters. While a large number of these collisions are due to the effects of HF propagation preventing everyone on the channel from being able to hear everyone else on the channel, a significant fraction are due to the use by many stations of amplitude based data carrier detectors with characteristics as mentioned above.

MULTIPATH

Running a distant second to collisions is time dependent channel distortion due to multipath. When a multipath null drifts through the channel such that the actual null occurs between the opening and closing flags of the packet, none of the demodulators is capable of recovering all the data error free. This is a much more frequent occurrence on 40 meters than on 20 meters. In general, the closer you are to the MUF the less of a problem this will be. Even during the worst times on 40 meters if multipath is the only hindrance to copying, the channel will be quite usable. There will be a significant number of retries but the channel will handle a useful amount of data. It will certainly handle enough to support a very enjoyable QSO!

QRM

Running a close third to multipath is non-packet QRM. This is also much more prevalent on 40 than on 20 meters accounting for approximately 20% of the hits on 40 and 5% on 20 meters. On 40 meters (at my location) this is usually foreign SSB stations who are miffed that the U.S. amateurs are using their phone bands for packet. The RTTY jammers finally

seem to have given up as they have discovered that a TNC with RETRY set to 0 is more patient than any jammer. As soon as they would let up to see if they were being effective, the TNC would slide the data past 'em (this is another reason it is important for DCD to be working properly). Since the channel sounded the same before and after the jamming session, they couldn't tell if they had been effective. Since most of them couldn't copy the epithets being sent about them on packet, the jamming was no fun and they quit. There is a lesson here for other modes as well...

WEAK SIGNAL

Weak signal conditions account for only a small fraction of the misses at this location on these bands. They were responsible for only about 10% of the hits on 20 meters and 5% on 40. These usually were in the form of retries on the last packet or 2 to make it when the band was on the way out. Similarly, when the band was coming in, there would be a brief period of more than average number of retries on the first few packets to be heard. When the 10 and 15 meter bands are working the weak signal performance of the demodulators is of much more importance. I did happen to catch 1 opening of 15 meters where there was some packet activity on 21.093 and 21.097 MHz. I didn't get a chance to run an actual direct comparison test as I was having too much fun operating in the QSO mode but I quickly determined to my own satisfaction that the reference demodulator is superior to all the other tested units in weak signal conditions. Only the AMD7910 coped as well and it required the audio level to be set to a point where the background noise kept the DCD on 100% of the time. Since I also wished to transmit, I ended up using the TNC with the reference demodulator in it.

Finally, there were about 5% of the misses that I was unable to definitely identify a reason for. I suspect that they are related to multipath but were not associated with a definite "audio suckout" type null as the others that I have ascribed to multipath were. This is only a suspicion on my part as there was no observable difference between these packets and others that printed fine.

It should be noted that these measurements were done during October, November, and December. This is a time when there is almost no lightning static noise at all in this area. If there had been, all the percentages reported above would have been modified considerably to make room for a new and significantly large category.

I was surprised to find that automobile ignition type impulse noise could be suppressed with the noise blanker in the TS430S without any apparent degradation to even weak signals. I had thought that the blanker would put discontinuities in the signal which would foul up the demodulators. I could not have been more mistaken in this assumption as none of the demodulators had any trouble copying through the blanker. At the time I made this discovery, I was on 15 meters monitoring weak signals. None of the signals were readable without the blanker in operation.

CONCLUSIONS

There are only small differences in the ability of the demodulators to copy packets. The worst one will only capture about 8% fewer characters than will the best one when monitoring a busy real world packet channel. In fact the relative performance difference between one type of demodulator versus another is rarely if ever actually the limiting factor in the ability to copy any particular packet. The differences would be more significant if we were working with weak, predominantly single path signals in the absence of collisions from other packet stations and QRM. However this is currently not the case for the vast majority of HF packet operation. When the sunspot cycle is more favorable and the 10 and 15 meter bands are open more frequently it will be possible to make some measurements under conditions which will accentuate the performance differences between demodulator types.

The data carrier detector characteristics of packet demodulators are far more important than the attention given them by the various manufacturers would indicate. Since the channel belongs equally to all the users, it is extremely important that the DCD circuit perform as well as possible. This is probably a more important characteristic for a packet demodulator than absolute demodulation performance. One mediocre data carrier detector on the channel reduces the performance of all the demodulators on the channel. This causes the offered load to increase very rapidly due to unnecessary retries resulting from collisions.

Aside from DCD considerations, the vagaries of HF propagation make CSMA less than ideal as the traffic cop that AX.25 expects it to be. It is clear that we are going to have to quit hanging on to the 1 channel security blanket and spread out some. There is plenty of spectrum available for this and as time wears on packet will be operated on a non channelized basis as CW and SSB are now. I have literally spent hours calling CQ less than 2 kHz above 7093 without ever hearing a peep in response. But let me accidentally hit a carriage return in converse mode on 7093 and I will get 3 to 5 connect requests. We should establish a calling frequency (I thought we had done this on 7097) which is different from the BBS forwarding frequency. Once contact is established on the calling frequency, we should MOVE OFF TO A CLEAR FREQUENCY and do our QSO or file transfer or whatever there. Dan Morrison and I have been doing some work on spectrum sharing with the broadcasters on 40 meters. At the 1 hop distance packet stations with a narrow I.F. filter and a "phase coherence" type of DCD can use the sideband areas of the broadcasters quite effectively. See Dan's article elsewhere in this issue for more poop on this technique. These sidebands are little pieces of spectrum that shouldn't produce any hard feelings in the rest of the amateur community when we start to use them.

Finally, as Steve Hall said in his excellent talk on HF packet at the San Diego convention, "If you are going to operate HF packet, get a tuning indicator." To this I would like to add get a 500 Hz wide I.F. filter in your radio. If you don't do

these two things you are going to find HF packet far more difficult and less reliable than it should be.

That is about all I have to report at this time. I sincerely hope that others will take the time to do some similar demodulator testing. If you do indeed do this please report the results so the rest of us can benefit from your labors.

NEXT TIME

Next time I will present a complete packet demodulator circuit based on the reference demodulator circuit. In this design I will try to optimize the operation of the data carrier detector for HF work. I will try to make the changes "easily kludgeable" into existing TNC-1s and TNC-2s.

I will continue to test demodulators as I have done for this article and will be reporting the results in this publication. Currently on the list and available for me to test are the Kantronics all mode unit, the original unmodified TNC-1 modem, the original unmodified TNC-2 modem, and the improved versions of both TAPR modems. It will be interesting to see if we really have improved the performance measurably from the original designs.

- PRM -

TAPR MEMBERSHIP APPLICATION

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I hereby apply for (select one) full / associate membership in Tucson Amateur Packet Radio Corp. I enclose \$15.00 (full) / \$5.00 (associate) for one year's membership dues. I understand that \$10.00 of my dues (full members) are for subscription to the PACKET RADIO MAGAZINE (PRM). Associate members do not receive any publication. The entire amount of the associate membership dues and \$5.00 of the full membership dues go to support TAPR's research and development activities in packet radio. My signature indicates that I desire to become a TAPR member, and subscribe to PRM (full members only).

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