

Can We Continue To Ignore Level One?

by
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ABSTRACT

For some reason which I cannot fathom, there has been a great reluctance to specify or even to provide guidelines for the various level 1 issues in the amateur packet radio system. This reluctance traces back all the way to the very early days of packet radio development. I find this situation very strange indeed since if level 1 isn't working, all the other levels of the protocol which everyone seems eager to specify down to the last bit position are all irrelevant.

In this paper I will choose one of the most consistently botched and yet most easily corrected level 1 parameters, the modem's data carrier detector. I will show how the performance of our present packet systems can be improved by careful consideration of even just this single level 1 issue.

Data Carrier Detect (DCD) is one of the most important items to consider on any multiple access packet channel. This paper explains why, then describes how to improve the performance of the current generation of amateur packet terminal node controllers (TNC).

INTRODUCTION

It has been six years now since the birth of the AX25 level 2 standard in late 1982. I think that now it is appropriate to ask "What has the ostrich approach to setting level 1 standards gotten us so far?" Well, it has gotten us a number of things:

1. It has gotten us a user base that is almost completely ignorant that there is anything that needs to be considered at level 1. This is too bad since the user is the only one who has any control over what happens there.
2. It has gotten us manufacturers building TNCs with modems that have a number of characteristics which are detrimental to the performance of what was originally touted as a SHARED channel.
3. It has gotten us radio manufacturers who are under zero pressure to provide products which physically interface in

a standard manner or even use similar levels for the digital mode audio signals. Manufacturers who are still content for the most part to build radios which are from 3 to 10 (or even more) times as slow as necessary for good packet system performance (NO aspect of voice radio performance must be compromised in order to achieve adequate speed).

4. It has gotten us a protocol specification which so judiciously avoids any provision for any level 1 issue whatsoever that its performance is significantly degraded when used on a channel where the signal propagation is anything less than similar to a land line. This could probably be adequately fixed as an implementation issue but there is NO information available to the implementer warning him of the necessity.

Do I blame the manufacturer of radios or TNCs? No not at all. The manufacturers have no reason to gamble on trying to set up anything in a standard manner unless the standard pre-exists and there is some consumer pressure on all to bring about general conformance. With relatively short product lifetimes and low profit margins in the amateur market nobody could expect them to spend a lot of engineering time to optimize the modems, for example, before getting a product to market. This fact is what drove the formation of groups like TAPR to support the development of the mode in the first place.

However, my purpose here is not to enumerate EVERYTHING that is wrong, but rather to show how relatively easily ONE thing can be done right.

DCD is a "level one" issue, which means that there is no standard document for TNC manufacturers to use as reference for guidance in this aspect of a TNC design. Writers of software for TNCs and other level 2 devices also have no guidelines on what is reasonable to expect from the DCD circuit.

This is unfortunate* because proper DCD operation can make or break a packet channel. I have observed many thousands of unnecessary collisions and retries on VHF and HF packet channels (both amateur service and commercial as well) related to

substandard DCD performance. After helping a number of hams drastically improve the operation of their TNCs here in the Tucson LAN, I decided to write this paper and share the results of my work with the Amateur packet community at large.

WHAT DCD SHOULD DO

The purpose of the DCD function in the modem used in a packet radio TNC is to prevent transmission on an occupied channel. If two stations transmit at the same time, we say a collision has occurred. This almost invariably means that both stations will have to resend the corrupted data. This has the effect of increasing the total load on the channel and reducing throughput for everyone sharing the channel.

Ideally, no station would ever step on another's transmission, and all stations would clearly hear all other stations (or no other station except the other one involved in the collision). The world is not ideal, however, so the best we can do is tune the protocol to minimize its sensitivity to this fact. This means considering at least some level 1 issues in the protocol specification.

We can also define how a proper DCD circuit should act and then see what we can do to implement such a circuit.

There are four key features that a DCD circuit should possess:

First, the DCD circuit must be able to reliably distinguish a data carrier from noise or other non-packet signals. An open squelch circuit, for example, should not inhibit transmission of packet data. There is no point in not transmitting because of receiver noise in the absence of signals. A DCD circuit which requires the operation of the TNC with audio gated by the typical narrowband FM radio squelch circuit, directly contributes to increased collision frequency. It does this by increasing the "deaf time" of the packet radio system. The TNC has no way of determining that another station has keyed up if this happens to occur during the system "deaf time". The total system deaf time (neglecting the presence of a duplex repeater or regenerator for now) is the sum of:

1. The radio's transmitter keyup delay. That is, the time that elapses between assertion of push-to-talk (PTT) and the appearance of an on-frequency, full power, correctly modulated packet radio signal on the channel. Transmitters commonly used in amateur packet radio service exhibit delays ranging from approximately 60 to over 500

milliseconds for this parameter. Most commercially available synthesized radios are in the 150 to 200 millisecond range.

2. The radio's squelch circuit attack time. This is the time between the appearance of a signal just above the squelch threshold at the receiver input and the appearance of usable audio at the modem input. Radios commonly used in amateur packet radio service exhibit delays ranging from approximately 80 to over 750 milliseconds (no that is not a misprint!) for this parameter. Most commercially available VHF FM radios currently available fall in the 150 to 300 millisecond range.
3. The modem's DCD attack time. This is the time between the appearance at the minimum usable signal-to-noise ratio (SNR) of decodable packet audio at the input of the demodulator and the assertion of the DCD output. Typical values for this parameter range from approximately 8 to a little more than 30 milliseconds. These numbers are for 1200 baud modems. Phase information DCD circuits which use the recovered data stream to make the DCD determination will have delays which are proportional to the baud rate. Five character periods is typically long enough to produce a DCD circuit with a zero false detection rate when monitoring uncorrelated noise. This is a little over 30 milliseconds at 1200 baud.

As you can see, even the worst case DCD circuit is better than the best of the squelch circuits. If we take the middle of the typical times for the various delays we see that eliminating the squelch delay reduces the "deaf" time from approximately 420 milliseconds to approximately 195 milliseconds. Doesn't seem like much? Then consider that this will reduce the collision frequency by approximately 50 percent on a channel with no hidden terminals. Depending on the DWAIT, FRACK, and RESPTIME settings of the TNCs using the channel, and the amount of traffic on the channel, this can and usually does have a dramatic effect on the channel throughput.

Second, once a data carrier decision has been correctly made, it is important that the DCD indication remain valid through short fades, collisions, and periods when a signal too marginal to decode is on the channel. This prevents a TNC which is holding off its transmission from transmitting over a station which has a marginal signal, or beginning to transmit over a station which is still transmitting but whose signal received a short multipath hit during the packet. The DCD "hang" time also prevents the phase

information based DCD circuits from "piling on" collision between two other stations on the channel. The appropriate amount of "hang" time will depend on the propagation characteristics of the band being used and the exact type of modem (if other than straight two tone FSK or AFSK). I have been having good success at 300 baud on HF FSK and at 1200 baud on VHF FM AFSK with a hang time of approximately 8 character periods.

Third, it is important that the DCD system NOT be sensitive to audio amplitude variations. It should respond in exactly the same way for any signal that the modem is capable of decoding regardless of absolute input amplitude. This will prevent transmission over a relatively weak station who has keyed up immediately after a much stronger signal has terminated. For this to be fully effective the modem must have a large dynamic range.

Fourth, as can be seen in the above discussion, the modem should not take an unreasonably long time to assert the DCD output signal. An attack time of 5 character periods seems to me to be a reasonable MAXIMUM allowed DCD delay specification.

EXISTING IMPLEMENTATIONS

There are two primary methods of determining the presence of a data carrier in use in most TNCs today. These are phase information based DCD and amplitude information based DCD.

Phase information based DCD circuits look for coherent (phase related) information in the audio presented to the demodulator or in the data stream emerging from the demodulator. The TAPR TNCs use the in-phase carrier detector of the phase locked loop (PLL) in an XR2211 demodulator to look for phase information in the incoming audio. This type of detector directly detects the presence of the data carrier.

It is also possible to design a system which uses information derived from baud period phase relationships of the demodulated data stream to infer the presence of a data carrier. A good example of the use of this type of circuit is the KSNG 9600 bps modem. [1]

Either of these two phase information based methods are demonstrably superior for use in the radio environment than any of the amplitude information based methods with which I am familiar.

Amplitude information based circuits simply look for energy in the modem passband. Any signal is assumed to be a data signal. These circuits are appropriate only for telephone systems which are generally very quiet in the

absence of the desired signal. Telephone modems are typically not required to operate in a Carrier Sense Multiple Access (CSMA) environment so their DCD requirements are much less stringent than demanded by our radio environment. Popular single chip modems are usually of this type, including the AMD7910 and TI TCM3105 chips.

Apart from the MFJ-1278, which incorporates the XR2211 improvement shown later in this paper, I am not aware of any Amateur packet TNCs which have modems which are fully optimized for the amateur packet radio environment.

IMPROVING EXISTING DCD CIRCUITS

Much of the following material is either taken from or is based on information found in articles I have previously published in several low circulation newsletters. Some of it had been simply sent as messages in response to questions on the linked packet bulletin board system. Don't be surprised if some of this material looks familiar to you. This is the first time this has all appeared in one place. Some recently discovered errors are corrected in this version. [2],[3],[4],[5]

The information presented here will allow the owner of almost any existing TNC to upgrade the performance of the DCD circuit in his TNCs modem for proper operation on a packet radio CSMA channel. The vast majority of TNCs currently in service are covered. Only units which do not use the popular Exar PLL modem chip set or which don't have an appropriate baud clock signal available for use by an external synchronous modem are not addressed. These units are only a tiny minority of the TNCs currently in use.

It is not particularly difficult to make a DCD circuit which operates in accordance with the points mentioned above. And, making the changes in your station TNC(s) will make a noticeable improvement in operation. At least, it has in the Tucson LAN where many TNCs have been modified for proper DCD circuit operation!

I should mention that the Tucson area is using a duplex audio repeater to eliminate hidden terminals from the system. A duplex regenerator would have the same effect if properly implemented. I believe that eventually it will be seen by everyone involved that all user access to network nodes should be by way of either repeater or regenerator.

XR2211 IMPLEMENTATIONS

Units such as the TAPR TNC 1 and TNC 2 can be easily modified to have dramatically improved DCD performance. Figure 1 is a

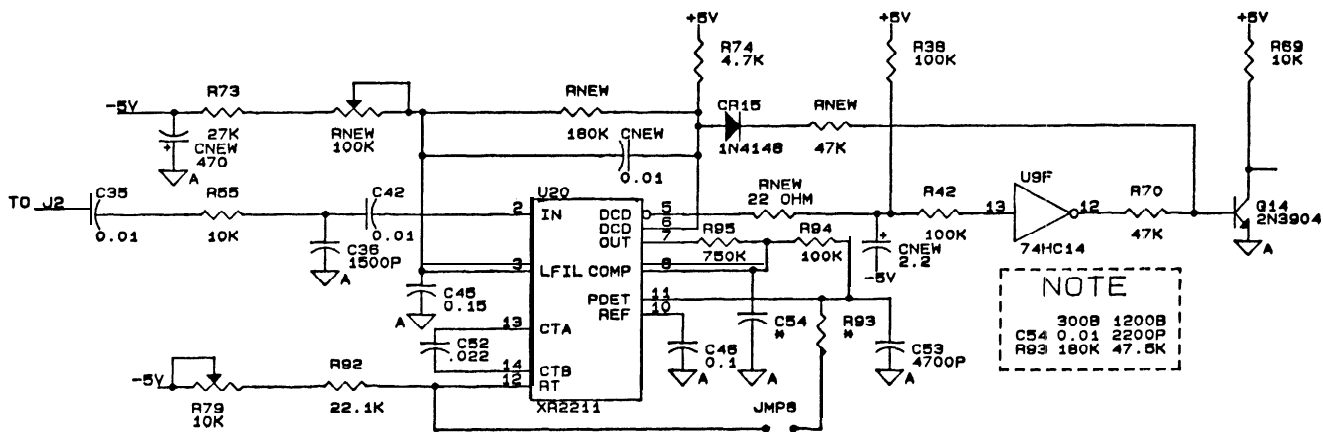


FIGURE 1 - TNC 2 DCD MODIFICATIONS

circuit diagram of a 2211-based demodulator which has the characteristics noted above.

Hysteresis is employed in the DCD decision threshold and "hang" time is added by the 74HC14 circuit following the modem chip.

I have incorporated this circuit in many TNCs and literally hundreds of commercial packet communications controllers. The improvement is very noticeable. Check the schematic diagram of your TNC. You will probably notice different values used in the various feedback resistors and capacitors used. That's because most TNC's 2211 demodulators are based on Exar Applications Notes or Data sheet information which assume that the chip is to be used to implement a land line modem. The changes presented here have been incorporated in some commercial packet systems designed from the ground up for radio application. The improvement in performance really is noticeable. Try it!

The following modification procedure gives a step by step process to follow for modification of the modem in the TNC-2. The same modifications can be performed on a TNC-1 or beta test TNC-1 board but the part numbers given in the procedure will not apply. Also, it will be necessary to patch a 74HC14 into the wire wrap area of the board to construct the "hang time" generator.

If the complete modification including the variable threshold control is done on a TNC-1 or Beta Board, extreme caution should be exercised to assure that the threshold control is not set to defeat the DCD entirely. Software available for these TNCs has no provision for detecting a DCD fault condition. For this reason it is recommended that if this modification is done to a TNC-1 or Beta Board, you should include hardware gating of the data output from the modem based on the DCD output signal. This will prevent reception when the DCD circuit is disabled and thereby warn the operator that something is wrong.

MODIFICATIONS TO TNC-2 DATA CARRIER DETECTOR (DCD) CIRCUIT

These modifications are to allow correct DCD operation in a TNC-2 modem. Variable DCD decision threshold, is included to allow compensation for various audio bandwidths presented to the demodulator when using appropriately narrow filters on HF.

NOTE! For 1200 baud HF linear mode FSK work on 10 meters, the normal 2.4 KHZ SSB filter constitutes a "narrow" filter for the demodulator.

There are three objectives to these modifications:

1. Provide threshold control for the DCD circuit. This allows the operator to adjust the demodulator to compensate for the DCD threshold shift which accompanies bandwidth limiting the audio fed to the demodulator when a narrow filter is used in the radio.
2. Add hysteresis to the Data Carrier Detector. This reduces the DCD's sensitivity to noise. It does this WITHOUT DEGRADING DCD ACQUISITION TIME for a valid data carrier.
3. Add DCD hang time on release.

The modifications presented in Appendix A will upgrade the modem in any TNC-2 or clone (including MFJ-1274) which has a 2211 demodulator to the level of DCD performance of the 1278 modem.

OTHER TNCs

Other TNCs may require somewhat more drastic measures. If you have a TNC which uses either the AMD7910 or the TCM3105 single chip modem, or a TNC which uses a modem based on audio filters like the PK-232, you can vastly improve the DCD performance of your modem for packet radio use. The circuit presented in Figure 2

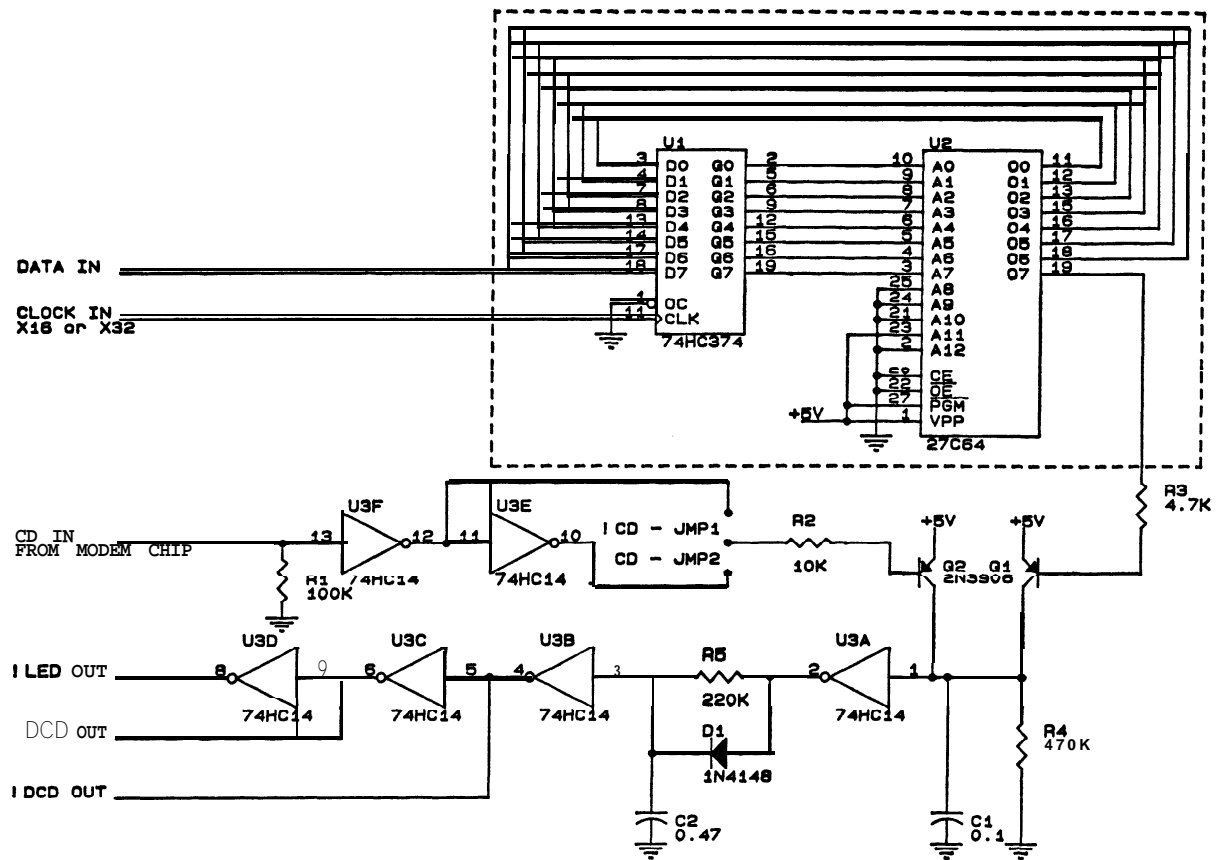


FIGURE 2 - IMPROVED DCD RETROFIT CIRCUIT

will provide a phase information based DCD for these TNCs which currently use amplitude information based DCD circuits.

If your TNC incorporates a TNC-2 style state machine (if it uses a 280 SIO chip, it may; if it uses an 8530 SCC, it probably doesn't), you can add a phase information based DCD by using the circuit shown in Figure 2 that is outside the dotted lines. If it doesn't incorporate such a state machine, you need the whole circuit as shown in Figure 2.

HOW IT WORKS

Please refer to Figure 2 for the following discussion.

The DCD circuit presented here is based on the update signals in a Digital Phase Locked Loop (DPLL) which recovers both baud clock and data from an NRZI packet data stream. Its output represents detection of baud clock phase coherence in the data stream.

The circuit consists of the state machine used in the TNC-2 and some delay elements used to make the DCD decision. The state machine is formed from the 74HC374 and the 27664 chips. The 74HC14 is used as a pair of retriggerable delay elements and for signal inversion and buffering.

The 27664 with the state machine code already burned into it can be obtained directly from TAPR. This same code is in the state machine ROM in any full TNC-2 clone which uses the 2211 demodulator and 280 SIO.

One of the state machine signals (which was not used in the TNC-2) appears on pin 19 of the 27664. This signal is the DPLL update pulse. As long as the DPLL is correctly locked to the incoming data, no pulses will appear on this pin. When the DPLL is not locked to an incoming data stream, there will be a continuous stream of pulses on this pin.

The DPLL update signal is used in this circuit to retrigger the first delay element so that it never times out so long as DPLL update pulses are present. If the pulses disappear, the delay element times out and generates the DCD signal.

The output from the first delay element keeps the second delay element triggered so long as DCD is true. When DCD goes false, the second delay element begins a time-out sequence which keeps the DCD output true until the time-out period expires. This is the source of the DCD "hang time".

While the circuit presented here is primarily intended for 1200 baud VHF FM

operation. it will also work well for 300 baud HF packet work. If this is your application, the time constants on the delay elements will have to be increased.

The time constant of the "hang" generator (0.47 uF cap) will have to be increased for 300 baud operation to about 2 uF.

The time constant which is optimum for the DCD generator (the 0.1 uF cap in fig. 2) will depend on a number of factors including the bandwidth of the radio used ahead of the modem (You should use a 500 Hz IF filter in ANY radio used on 300 baud HF packet regardless of the presence or absence of audio filtering in the modem!).

You should pick a value for the DCD generator delay capacitor so the DCD circuit produces approximately a 10 percent duty cycle of false DCD "ON" time while monitoring receiver noise on a channel which is ABSOLUTELY free of ANY signals which fall within the demodulator's passband. The DCD generator delay capacitor will probably need to be somewhere in the range of 2 to 4 times the 0.1 uF value used for 1200 baud.

Both negative true and positive true DCD outputs are provided so that you may use the polarity which is required by your TNC. Also, JMP1 and JMP2 allow the DCD circuit to be configured to operate correctly from either a positive or negative true CD output from whichever modem chip is found in your TNC.

TNC SIGNALS

Once you have constructed the DCD circuit, you will have to obtain some signals from your TNC for the new DCD circuit to use. You will also have to arrange for the output of this circuit to be substituted for the normal DCD signal used in the TNC.

The signals required for the DCD circuit operation are:

1. A sample of the data recovered by the demodulator in the modem.
2. A sample of a clock which has a frequency of either 16 or 32 times the baud rate (X16 or X32 baud clock).
3. The intercepted Carrier Detect (CD) signal from the modem. This is the CD generated by the modem based on amplitude of the input audio.
4. A source of + 5 volts. If you use all CMOS parts, the power supply current requirements are minimal. The 74HC14 MUST be a CMOS part for the circuit to work properly.
5. Ground

If your TNC has provision for a TAPR style modem disconnect header, these signals (including the X16 or X32 baud clock) will

be easily located and conveniently interfaced at this header. If it doesn't have this header, you will have to fish around in the circuit of your TNC on your own to locate them.

In any case, the DCD signal currently used in your TNC will have to be disconnected and rerouted through the new circuit.

STANDARD HEADER SIGNALS

The signal locations on the TAPR standard modem disconnect header are as follows:

1. Receive Data is obtained from header pin 18.
2. Carrier Detect is obtained from header pin 2.
3. Data Carrier Detect (DCD) is inserted at header pin 1. Jumper from header pin 1 to header pin 2 is removed.
4. The baud clock is obtained from header pin 12. The frequency of this clock will be either 32 times the baud rate or 16 times the baud rate depending on whether you have a TNC-1 or one of two types of TNC-2. No changes are necessary to make use of either clock speed.

AR7910 CONNECTIONS

The signals of interest on the AMD7910 modem chip are:

1. Receive Data output (RD)----> pin 24
2. Carrier Detect (CD)-----> pin 25
This signal is negative true for the 7910 chip.

TCM3105 CONNECTIONS

The signals of interest on the TCM3105 modem chip are:

1. Receive Data output (RXD)----> pin 8
2. Carrier Detect (CDT)-----> pin 3
This signal is positive true for the 3105 chip.
3. In TNCs which use the TCM3105 chip but do not provide another source of the baud clock, like the Kantronics KAM, you can use the signal at pin 2 of this chip. This signal is very close to 16 times the baud rate (19.11 KHz instead of 19.2 KHz for 1200 baud).

COMMERCIAL TNC SIGNAL LOCATIONS

The information you need to find the proper signals in several commercially available TNCs is presented in Appendix B. This is not intended to be a complete list by any means. It is simply a list of TNCs

which have been successfully modified to include this circuit.

CONCLUSION

This paper outlines desirable characteristics in a TNC's DCD circuit. Modification instructions have been presented to enable owners of existing TNCs to upgrade their units. Hopefully, TNC manufacturers will take time to investigate their TNC DCD implementations and make the minor changes necessary to reduce unneeded retransmissions on our crowded packet frequencies!

- [1] Goode, Steve, K9NG, "Modifying the Hamtronics FM-5 for 9600 bps Packet Operation? ARRL Amateur Radio Fourth Computer Networking Conference, pp.45-51.
- [2] Gustafson, Eric, N7CL, "HF Modem Performance? Packet Radio Magazine, DEC 1986, p.12.
- [3] Gustafson, Eric, N7CL, "HF Modem Performance Comparisons? Packet Radio Magazine, JAN-FEB 1987, pp.21024.
- [4] Gustafson, Eric, N7CL, "Letters To The Editor", Packet Radio Magazine, APR 1987, pp.8, 9, 19.
- [5] Gustafson, Eric, N7CL, "Improved Data Carrier Detector (DCD) for 2211". RMPRA>PACKET, AUG 1988, pp.29,30.

APPENDIX A

MODIFICATIONS TO TNC-2 DATA CARRIER DETECTOR (DCD) CIRCUIT

Part numbers referred to are for the original TNC-2 as produced (briefly) by TAPR. I have not reviewed schematics of clones produced by all manufacturers so I cannot be sure that these numbers will be correct in all cases. Since I have seen information on the MFJ series, I can say that the numbers are ok for the 1270, 1270B, and 1274. If you are in doubt about part number correspondence, obtain a schematic of the original TNC-2 as produced by TAPR. Comparison between the TAPR schematic and the schematic of your TNC should resolve any differences. The TNC I used to verify this modification was a 1274 which I use primarily on HF packet. Since the physical layout of the modem area of the 1274 is different than the layout of the original TNC-2 or "pure" unaltered clones, I have avoided giving specific physical location information in the modification procedure.

Any manufacturer of the TNC-2 can feel free to incorporate this change into their hardware if they wish without incurring any obligation to myself or TAPR. I am available to answer any questions in this area.

NOTE! Do NOT use TNC-2 firmware earlier than **version 1.6** with this modification.

Firmware prior to V1.6 has no facility for detection of a DCD fault condition and therefore cannot warn you when the threshold control has been improperly set.

STEP BY STEP MODIFICATION

1. If you have a TNC-2 or clone (except MFJ-1274), and have not already removed the MF-10 filter and associated header parts, do so at this time. The reason for removing the MF-10 is that the operation of this filter circuit in the TNC-2 is marginal. This marginal condition drastically reduces the modem dynamic range. Simply remove both the MF-10 and the header associated with the MF-10. Then, under the board, solder a jumper between pin 1 and 8 of the header socket. Removing the MF-10 also unloads the negative 5 volt supply, improving its regulation and reducing the noise generated by the charge pump circuit. There is ABSOLUTELY NO PERFORMANCE PENALTY for removing this filter. The same filter used in the TNC-1 is NOT marginal and there is NO reason to remove the MF-10 from a TNC-1 or beta board.
2. Replace C35 and C42 with 0.01 uF caps.
3. Remove the 470 K resistor at R73. Be careful not to damage the circuit board pads or traces as they will be needed later in the modification.
4. Remove CR13.
5. Replace R70 with a 47 K resistor.
6. Lift the cathode end of CR15 from the circuit board. Install a 47 K resistor in series with CR15. Solder one end of this resistor to the hole vacated by CR15's cathode end. Solder the other end of this resistor to the cathode end of CR15 above the circuit board.
7. Replace R74 with a 4.7 K resistor.
8. Form a parallel network consisting of a 180 K resistor and a 0.01 uF cap. Make this network as compact as possible as it will have to fit underneath the circuit board. Solder this network in place under the board. One end goes to pin 3 and the other to pin 6 of the 2211 socket (U20).
9. Replace R38 with a 100 K resistor.
10. Above the circuit board, using leads as short as possible, install a 470 uF, 10 volt rated electrolytic capacitor between the -5 volt pad on the tuning indicator connector header (J3, pin 1) and ground. Connect the

positive lead to ground. Remember that this cap will have to clear the cabinet so position it as near the board as possible.

11. Under the circuit board, solder a 2.2 uF, 16 volt rated electrolytic capacitor from the junction of R38 and R42 to the negative 5 volt supply. The negative end of this cap goes to the negative 5 volt supply.
12. Under the circuit board, solder one end of a 22 ohm resistor to the junction of R38 and R42. The other end goes to pin 5 of the 2211 (U20).
13. On the front panel, mount a miniature 100 K, linear taper potentiometer (yes, there really IS room for this). This will be the DCD threshold control. It will be used to set the DCD trigger point to the proper value.

If linear mode operation is not contemplated, you can eliminate the 100 K potentiometer and the 27 K fixed series resistor referred to in the next two steps. Instead, install a fixed 180K resistor in place of R73. This is possible because there is not very much difference in the audio bandwidth presented to the demodulator from the various makes of NBFM radios.

14. Solder a wire from the wiper of the 100 K pot to the pad vacated by R73 which connects to C45 and pin 3 of the 2211 (U20).
15. Solder one end of a 27 K resistor into the pad vacated by R73 which connects to the negative 5 volt supply. Solder a wire from the other end of this resistor to one of the 2 remaining leads from the 100 K pot. Use the lead that is set to zero resistance when the shaft of the potentiometer is turned fully CCW.

When operating a TNC with a DCD threshold control, set the control so that the DCD LED on the front panel flashes occasionally when there is no signal present. The "false DCD" duty cycle should be approximately 10 percent.

When operating VHF FM with the radio squelched, the DCD will not false. If you MUST operate with the radio squelched (thus incurring the penalty of the additional delay time of the squelch circuit), set the threshold fully clockwise as described below.

The audio bandwidth of some VHF FM radios is so wide that the DCD will not false regardless of the threshold control setting. This will almost always be true when the audio is obtained ahead of the radio's squelch controlled stage before de-emphasis. For these radios simply turn the control fully clockwise. This sets

the DCD to maximum sensitivity. DCD operation will not be impaired.

This completes the TNC-2 modem modification.

APPENDIX B

COMMERCIAL TNC SIGNAL LOCATIONS

AEA PK-87

It is relatively easy to interface this new DCD circuit to the PK-87 because there is no requirement to switch back to the internal DCD circuit once the modification is installed.

The Receive data signal is obtained from the center pin of JP4.

The Carrier Detect signal is obtained from the end of JP5 which connects to the modem chip.

The DCD output signal from the new circuit is inserted at the center pin of JP5. Use the NEGATIVE TRUE output. The jumper originally installed at JP5 is removed. The DCD indicator on the front panel will show the action of the new DCD circuit.

The X32 baud clock signal is obtained from pin 13 of U20 (a 74LS393 divider)- Don't be tempted to get this signal from the "clock" line on J4, the external modem connector9 as this is a X1 clock.

AEA PK-232

The PK-232 is also relatively easy to interface.

The Receive Data signal is obtained from the center pin of JP4.

The Carrier Detect signal is obtained from the end of JP6 which is NOT connected to pin 3 of the external modem connector.

The X32 baud clock signal is obtained from pin 13 of U8 (also a 74LS393 divider).

The DCD output from the new circuit is inserted at the center pin of JP6. Use the NEGATIVE TRUE output. The jumper originally installed at JP6 is removed.

To use the new DCD circuit with a PK-232 on VHF FM 1200 baud:

1. Set the audio level from the radio so that the tuning indicator "spreads" fully on the station with the lowest transmitted audio level on the channel.
2. The existing DCD threshold control should be set so that the existing DCD indicator LED on the front panel lights up whenever there is ANY signal or noiae input to the TNC from the radio.

Be sure that even the station with the lowest amount of audio on the channel lights this LED. This LED should extinguish when there is no audio input from the radio (dead carrier from repeater etc.).

If you wish to observe the action of the DCD signal generated by the new circuit, add a high efficiency LED and 1k series resistor between +5 volts and the LED output of the new DCD circuit. The anode end of the LED should go towards +5 volts.

Pat-Comm TINY-2

The Pat-Comm TINY-2 hooks up as follows:

The X16 baud clock signal is obtained from U10 pin 1.

Receive Data is obtained from J5 pin 17.

Negative true Carrier Detect (CDT) is obtained from 35 pin 2.

NOTE: This is an inverted version of the CD output from the TCM3105 chip itself. Since this is a negative true logic signal, JMP1 on the new DCD circuit will be used instead of JMP2 which would normally be used for a TCM3105.

Negative true DCD from the new circuit is applied to the TNC at J5 pin 1. Remove the connection between J5 pins 2 and 1. The existing DCD indicator LED will not show the action of the new circuit.

If you wish to observe the action of the DCD signal generated by the new circuit, add a high efficiency LED and 1k series resistor between +5 volts and the LED output of the new DCD circuit. The anode end of the LED should go towards +5 volts.

If you wish to observe the action of the new DCD circuit on the existing LED indicator, you will have to do the interface a bit differently. First, you will get the negative true CDT signal from pin 1 of JPD. Then insert the LED output signal from the new circuit at either pin 2 of JPD or pin 2 of J5. Remove the jumper currently installed at JPD on the TINY-2 circuit board. If the new circuit is interfaced in this manner, the "RFDCD" signal can no longer be used. (This is no great loss, however, as it will also no longer be necessary.)

Kantronics KAM

For 1200 baud operation the signal location points of interest in the KAM are as follows:

The Receive Data (RXD) signal is obtained from pin 8 of the TCM3105 modem chip.

The X16 baud clock signal is obtained from pin 2 of the TCM3105.

The POSITIVE TRUE Carrier Detect (CDT) signal from the modem is obtained from pin 3 of the TCM3105. This line from the modem to the CPU is labeled with two numbered pads (7 and 8). These numbered pads represent pin numbers on a 20 pin modem disconnect header which is physically similar but electrically dissimilar to the standard TAPR modem disconnect header. The connection between these 2 locations should be broken. JMP2 on the new DCD circuit will be used.

The DCD output from the new circuit is injected at pin 21 of the 63B03 CPU.

The front panel LED which normally indicates the CDT signal activity will show the action of the new DCD circuit.