TUCSON AMATEUR PACKET RADIO

Packet Radio

Terminal Node Controller

TNC 2, Rev 2

SYSTEM MANUAL

Including Command Reference for
Firmware Version 1.1.8

FOURTH EDITION

1992

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Tucson Amateur Packet Radio   TNC 2 System Manual

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ACKNOWLEDGMENTS

The Tucson Amateur Packet Radio Terminal Node Controller Model 2 project was made possible through the selfless dedication of many individuals. These people represent the highest ideals of volunteerism and public service, giving of themselves for the benefit of the Amateur Radio community worldwide. It is on this basis that TAPR exists, and it is on this basis that Amateur packet radio has flourished during the past few years.

It is not possible to document the specific contributions of every participant in TNC 2's development, nor even to list everyone who made a contribution. However, the following list includes those without whose efforts the project would not have been possible.

    Peter Eaton, WB9FLW   Circuit board layout
    Howard Goldstein, N2WX   Software design
    Steven Goode, K9NG   Modem
    Charles Green, N0ADI   Documentation
    Lyle Johnson, WA7GXD   Documentation
    Daniel Morrison, KV7B   Testing
    Margaret Morrison, KV7D   Documentation
    Paul Newland, AD7I   Hardware design
    Harold Price, NK6K   Protocol

To the above list must be added those who were involved in the Beta Test of the TNC 2 design: Paul Barnett, N0CRN; Jon Bloom, KE3Z; Mike Brock, WB6HHV; Tom Clark, W3IWI; John Conner, WB0FHG; Terry Fox, WB4JFI; Andy Freeborn, N0CCZ; Eric Gustafson, N7CL; Skip Hansen, WB6YMH; Phil Karn, KA9Q; Scott Loftessness, W3VS; Hank Magnuski, KA6M; Bill Reed, WD0ETZ; Gwyn Reedy, W1BEL; Russell Reiss, K1HOP; Jeff Ward, K8KA.

The TNC 2 project would never have taken place without the success of the TNC 1 project. In addition to many of those listed above, the following people contributed to making TNC 1 a recognized standard of Amateur packet radio: Mark Baker; Marc Chamberlin, WA7PXW; Den Connors, KD2S; David Henderson, KD4NL; Heather Johnson, N7DZU.

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Chapter 1 INTRODUCTION

Welcome to the exciting world of Amateur packet radio.   You will
soon be joining the ranks of the fastest growing mode in Amateur
Radio since 2-meter FM.

The purpose of the Tucson Amateur Packet Radio (TAPR) Terminal
Node Controller (TNC) is to act as an interface between your
ordinary voice radio, such as a 2-meter FM transceiver or HF SSB
transceiver, and your computer. The TNC will perform all of the
"magic" of establishing error-free communications between your
station and another packet-radio equipped station. You will be
able to have a "private channel" while sharing a frequency with
other packet stations, "read the mail" or other QSOs, operate
remote computer "bulletin board" or "mailbox" stations, handle
message traffic -- in short, be able to enjoy all the advantages
of digital communication techniques in your ham shack.

Your TAPR TNC 2 is the key to your packet station. It is based
on the original TAPR TNC and inherits many of the advanced
features of that design, coupled with the experience gained by
thousands of TAPR-equipped Amateur packet stations worldwide.

This manual will be your guide into the realm of Amateur packet
radio. The Assembly Manual will take you step by step through
the construction and testing of your TNC. You will then be ready
to start with Chapter 2, which explains how to connect your TNC
to your station computer.   Chapter 3 will instruct you on
interfacing the TNC to your radio and Chapters 4 and 5 will guide
you through packet radio operation.   Chapter 6 is a detailed
breakdown of the various commands the TNC will accept and
messages it may report. A description of the hardware design of
TNC 2 and troubleshooting hints follow in Chapters 7 and 8. The
manual concludes with Chapter 9,   an overview of packet radio
protocol. The Bibliography lists sources of further information
on packet radio.

What is TAPR?

Tucson Amateur Packet Radio is a non-profit research and
development group dedicated to the advancement of Amateur digital
communications.   Its technical "staff" consists solely of
volunteers who donate their time in pursuit of TAPR's goals. TNC
2 was designed by such volunteers. TAPR is a membership
organization with members spread around the globe. The quarterly
Packet Status Register carries technical and operational
information on packet radio,   Further, it is the means by which
TAPR provides support for your TNC 2.   We encourage you to join

TAPR and share with us in the development of this exciting mode.

Join the Packet Radio Revolution!

First Steps

Refer to the Assembly Manual included with your TNC 2 board and follow the directions given.   When you have completed construction, continue with Chapter 2, Computer Interfacing. Build your TNC 2 carefully and...

... happy packeting!

Chapter 2 COMPUTER INTERFACING

Before beginning this chapter, you should have assembled your TNC
2 and verified that the power supply is functioning and that
various of the LEDs function properly. You will now attach, or
interface, your TNC 2 to your station computer or terminal.
Throughout this manual we will use the term "computer" to refer
to the computer or terminal you use to communicate with your TNC.

TNC 2 communicates with your computer through a serial port using
signals corresponding to a standard called RS-232C. Why an
RS-232C interface? Nearly every computer in production today
either incorporates an RS-232C style serial port as a standard
feature, or has one available as an optional accessory, either
from the computer manufacturer or from a manufacturer of computer
accessories.

In order to use the TNC with your computer, the computer must
have an RS-232C serial port and a program to support the serial
port. The program will typically be called a modem, terminal
emulator, or communications program.

Since there are so many computers on the market today, it is
impractical for this chapter to provide detailed instructions for
each computer. Detailed information is given for some of the
popular models available in the United States. Also provided is
general computer interfacing information.

Serial Port Signals

The serial port connector on your TNC is on the rear panel and is
marked "SERIAL." There are several signals available at this
connector. You won't need all of them for standard packet
operation. For some special applications, such as binary file
transfer or some Bulletin Board operations, you may want to use
more of them. In that case, see TNC 2 Serial Port Pin Functions
at the end of this chapter.

The pins on the serial port connector of TNC 2 that must be
connected are shown in Table 2-1. Note that the TNC connects to
a computer exactly as if the TNC were a standard RS-232C modem.
If you have successfully used your computer with a telephone
modem, hook it up to TNC 2 in the same way. Use whatever program
you ordinarily use to communicate with the modem and proceed to
the section, Verifying Serial Port Operation.

Table 2-1. Serial port signals required by TNC 2.

Pin   Signal Name   Description

2   Transmit Data   Serial data from your computer
                      to the TNC.
3   Receive Data   Serial data from the TNC to
                      your computer.
7   Signal Ground   The common ground for both
                      data lines.

If your computer is listed in Table 2-2, refer to the specific
information in the following sections to connect your TNC to your
computer.

Table 2-2.   Computers with specific serial interfacing
          instructions.

    Manufacturer   Model

    Apple   Macintosh (tm)
    Commodore   VIC-20 (tm)
            64 (tm)
    IBM   PCjr (tm)
    Radio Shack   Color Computer (tm)
              Color Computer 2 (tm)
              Model 100
    NEC   8201

Many computers require a serial port adapter card.   These cards
incorporate the circuitry necessary to add an RS-232C port to the
computer. Some popular models in this category are the Apple II
series, the IBM Personal Computer, many Radio Shack computers,
and the Sanyo MBC-55X series. If you have one of these computers
with an "add-in" serial port, or if you have another computer we
haven't mentioned, you should skip to one of the sections on
"other computers." If your computer has a 25-pin RS-232C serial
port, refer to the section Other Computers with 25-pin RS-232C
Ports. Otherwise refer to the section Other Computers with
Nonstandard Serial Ports.

Some computers have no serial port and no adapter is commercially
available. Such computers are not suitable for use with TNC 2.

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Apple Macintosh

The Macintosh serial port is an RS-422 compatible port, but it will work fine with the RS-232C serial port on your TNC. You will need a cable wired as shown in Fig. 2-1.

```
          Macintosh (DE9P)    TNC 2 (DB-25P)

          1 ----------------- 1
          5 ---------------- 2
          9 ---------------- 3
          3 ---------------- 7
          7 ---------------- 8
          6 --------------- 20
```

Fig. 2-1. Serial port wiring for Apple Macintosh.

Note that pin 1 is not connected inside the Macintosh or the TNC. If you use a shielded serial cable, which we recommend, connect both pin 1s to the shield and connect pin 1 of the TNC 2 serial connector to digital ground on the TNC circuit board. A printed circuit board pad is provided for this purpose near pin 1 of the serial connector.

Commodore 64 or VIC-20

Commodore (as well as other manufacturers such as Jameco) sells a voltage converter device that installs in the User port connector on the rear of a VIC-20 or Commodore 64 computer. This adapter converts the internal TTL-level voltages of the computer to the proper RS-232C levels and polarities. Unless you are very familiar with the inner workings of your computer, you should purchase such an adapter rather than trying to "do it yourself."

IBM PCjr

The PCjr uses standard RS-232C voltage levels for its serial interface; however, the connector used is non-standard and not readily available from electronic supply dealers. Pinout information for this connector is given in the IBM PCjr Technical Reference Manual.

IBM dealers sell the "IBM PCjr Adapter Cable for Serial Devices" for converting the connector on PCjr to a standard RS-232C terminal connector. This cable attaches directly between the TNC and the PCjr. It is only about 3 inches long, however, so you

may want to obtain a male-to-female RS-232C extension cable, which should be readily available.

Radio Shack Color Computer

The Color Computer series (except for the Micro Color Computer) uses a 4-pin DIN-style connector for its serial interface. Wire a cable as shown in Fig. 2-2 to interface your TNC to a Color Computer. All necessary parts should be available from Radio Shack dealers.

        Color Computer   DB-25P

            4 ------------------ 2
            2 ------------------ 3
            3 ------------------ 7
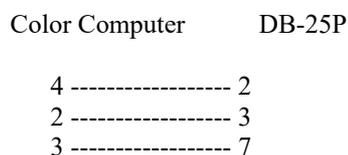
    Fig. 2-2. Serial port wiring for Radio Shack
            Color Computers.

Radio Shack Model 100 and NEC 8201

These computers have built-in standard RS-232C serial ports that are compatible with the TNC. You will need a standard male-to-male RS-232C extension cable to connect the computer to the TNC.

Other Computers with 25-pin RS-232C Ports

If your computer has a 25-pin RS-232C port, you should consult your computer manual or accessory manual to see which pins it uses to send and receive data on, as well as which pin is used for signal common. Follow the computer manufacturer's recommendations for connecting the serial port to a modem. You may also find the technical information in this section useful.

Your TNC is configured as Data Communications Equipment (DCE), the technical term for an RS-232C modem. Most computers are configured as Data Terminal Equipment (DTE). If this is the case for your computer, you will probably be able to simply wire pin 2 of the TNC connector to pin 2 of your computer's RS-232C port, pin 3 to pin 3 and pin 7 to pin 7. You can provide these connections with a standard 3- wire male-to-female or male-to-male RS-232C extension cable, depending on whether your computer has a DB25S or DB25P connector.

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If your computer is configured as DCE, you will have to wire pin 2 of your TNC to pin 3 of the computer connector, and pin 2 of the computer connector to pin 3 of your TNC. Pin 7 of the computer connector will still connect to pin 7 of your TNC serial port.

Some computers may require that pin 5 of the computer serial port connector be connected to an appropriate signal. Others may require connections for pin 8 and pin 20. You can use the computer's output signals on pins 4 and 6 as shown in Fig. 2-3.

```
        TNC 2        Computer

          2 ------------- 2
          3 ------------- 3
          7 ------------- 7
                 / ---- 4
                 \ ---- 5
               /--------- 6
               |--------- 8
               \--------- 20
```
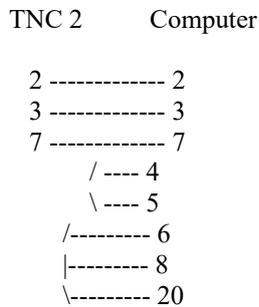
Fig. 2-3. Serial port wiring with jumpers for
          auxiliary signals.

Other Computers with Nonstandard Serial Ports

Computers with nonstandard serial ports must meet the following conditions.

First, the signal levels should be RS-232C compatible. The TNC requires that the voltage levels sent from the computer be greater than about +3 volts in one state and less than about +1 volt in the other state.

Second, the polarity of the signals must conform to the RS-232C standard. This means that the low voltage state must correspond to a logical "1" and the high voltage state to a logical "0".

Third, the computer must be able to correctly receive a signal which meets the RS-232C specification. The TNC supplies signals that meet this specification.

Make or buy a cable that provides the following connections. The computer serial port common pin must be tied to the TNC serial port connector pin 7. The data line that sends data from the computer must be tied to the TNC connector pin 2. The pin on which your computer receives data on must be tied to the TNC connector pin 3.

If your computer requires any other signals, you must arrange to
provide them. The documentation provided with your computer or
its accessory serial port should clarify any special requirements
of your port.

Software Requirements

Any software package that enables your computer to act as an
ASCII terminal with an ordinary telephone modem should work with
your TNC.   If you have a program that you have used successfully
with telephone a modem and that you are familiar with, use that
program to communicate with your TNC.

Apple Macintosh

Apple dealers sell a program called MacTerm for the Macintosh
that works with the TNC. Load this program and set the options
according to Table 2-3.   In addition, set the TNC for 1200 baud
as described in Verifying Serial Port Operation, below.

        Table 2-3. MacTerm option settings for operation
                    with TNC 2.

            Compatibility   Terminal

            1200 baud   VT100
            7 bits/character   ANSI
            even parity   UNDERLINE
            Handshake Xon/Xoff   US
            modem connection   80 Columns
            "telephone" port   ON LINE
                        AUTOREPEAT

Commodore 64 or VIC-20

A BASIC communications program is given in the Programmer's
Reference Guide published by Commodore. Use the program listing
for "true ASCII," as these computers use a modified ASCII format
internally. You will probably want to run your TNC at 300 baud
on the serial port with these computers. Setting the TNC serial
port baud rate is discussed in the next section, Verifying Serial
Port Operation.

IBM PCjr

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The IBM PCjr has a built-in terminal program in the BASIC cartridge. Start this program by typing TERM. Refer to your PCjr BASIC manual for details on this program. For best results with PCjr, do not run the TNC serial port faster than 1200 baud. Setting the TNC serial port baud rate is discussed in the next section, Verifying Serial Port Operation.

Radio Shack Color Computer

There are several terminal programs available for the Color Computer. You will probably want to use a commercial program (rather than writing your own) since the Color Computer has a "software UART" that is difficult to program in BASIC.

Radio Shack Model 100 and NEC 8201

These computers have built-in terminal programs in ROM. Consult your computer's documentation for instructions in their use.

Verifying Serial Port Operation

Turn off the power to your computer and to your TNC. Connect the computer and TNC with a properly configured serial cable. Set the DIP switch on the rear panel of the TNC to the desired baud rate as shown in Table 2-4. The power must be OFF when these switches are set.

NOTE: The serial port baud rate used between the TNC and the computer has no relationship to the baud rate used over the radio. The serial port baud rate you set on your TNC must match the baud rate used by your computer serial port.

Table 2-4. DIP switch settings for serial port
                baud rates.

Baud Rate	Switch 1	2	3	4	5
300	ON	OFF	OFF	OFF	OFF
1200	OFF	ON	OFF	OFF	OFF
2400	OFF	OFF	ON	OFF	OFF
4800	OFF	OFF	OFF	ON	OFF
9600	OFF	OFF	OFF	OFF	ON

CAUTION: Only one of these switches may be ON at any time.

Turn on your computer and start the terminal program. Follow the directions for the program you are using to match the computer's

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baud rate with that selected on the TNC, and to set other options. Set your computer's port options to 7 bits even parity and select either 1 or 2 stop bits.

Turn on your TNC. You should see a sign-on message, which should be a readable text message, printed on your computer screen. This demonstrates the ability of your computer to accept data from your TNC. If you see nothing, switch off your TNC for a few seconds, then on again. If you still see nothing, verify your wiring and restart your terminal program. If you see gibberish on your screen you should verify that you have set the same baud rate for the TNC and the computer.

When you have successfully read the sign-on message from your TNC, type

   DISPLAY

followed by a carriage return. You should see a lengthy list of items on your screen. This verifies the ability of your TNC to accept and respond to input from your computer.

Your serial interface is now working. If you are completing construction of your TNC, return to the assembly manual and continue from where you were directed to this manual.

TNC 2 Serial Port Pin Functions

This section describes the pins used on the TNC's RS-232C serial port connector. It is intended for packet operators with special applications requiring hardware handshaking. This information should not be needed by most users.

    Table 2-5. RS-232C Pin Designations

Pin	Mnemonic	Name
1	FG	Frame Ground
2	TXD	Transmit Data
3	RXD	Receive Data
5	CTS	Clear To Send
6	DSR	Data Set Ready
7	SG	Signal Ground
8	DCD	Data Carrier Detect
9	---	+ 12V unregulated reference
10	---	- 12V unregulated reference
20	DTR	Data Terminal Ready

Frame Ground is provided for attachment to the chassis of the TNC and the chassis of the attached device (computer or terminal). This pin is brought out to a feedthrough on the TNC 2 PC board near pin 1 of the serial connector. It is not electrically connected anywhere else on the TNC circuit board.

Transmit Data is an input line to the TNC on which the attached device sends data.

Receive Data is an output line from the TNC on which the attached device receives data.

Clear To Send is an output from the TNC signaling the attached device to send or refrain from sending data to the TNC. This line is used for hardware flow control.

Data Set Ready is an output from the TNC telling the attached device that the TNC is operational.

Signal Ground is the common, or return, path for all signals between the TNC and the attached device.

Data Carrier Detect is an output from the TNC. As normally configured, DCD reflects the status of the CON LED: It is true when an AX.25 connection exists between your TNC and another station; it is false when no connection exists. This configuration is useful when the TNC is used with a telephone style Bulletin Board system, since the AX.25 connection, analogous to a modem signal on the telephone, indicates the presence of a user. Shorting JMP1 on the TNC 2 PC board will cause this output to always be true.

Pins 9 and 10 provide access to the TNC's unregulated +/-12 volt supplies for use by an external device. These are not intended to power an accessory, and should not be used to source or sink more than a couple of milliamperes!

Chapter 3 RADIO INTERFACING

Computer interfacing, covered in the previous chapter, is only
half the interfacing task. The other half is connecting your TNC
to a radio.

Before you interface the TNC to your radio you should calibrate
your modem frequencies. If you have just assembled your TNC, you
should have done this as part of the assembly procedure.   The
complete modem calibration procedure is described in Chapter 5.

Interfacing the TNC to your radio involves connecting the
following signals at J2.

Pin 1 Microphone audio, from the TNC to your transmitter.

Pin 2 Ground, audio and PTT common.

Pin 3 Push-to-talk, to allow the TNC to key your transmitter.

Pin 4 Receive audio, from your receiver to the TNC.

Pin 5 Squelch input (optional) to allow the TNC to detect
activity on a shared-mode channel.

This chapter describes how to connect these signals between your
TNC and your radio and how to adjust the receive and transmit
audio levels appropriately.   The interconnection should be
planned so as to minimize pickup of stray audio and RF noise by
the lines. If possible, you should set up your packet station
with a monitor speaker and be able to operate on voice without
disconnecting the TNC.

This chapter assumes that you are using an FM radio. If you are
operating on another mode, such as SSB, most of the information
is still applicable.

Two interfacing methods are presented. You will have to use the
second method if you can't adjust the audio levels properly with
the first method.   They require no special test equipment for
adjusting the audio levels.   If FM test equipment is available,
however, it should be used as described. You will need a second
receiver in your shack that you can use to listen to your own
signal. Read the remainder of this chapter carefully before
starting to interface your TNC to your radio.

Method 1: Direct Connection to Microphone and Speaker

TNC 2 was designed to allow hookup and initial testing to be done without any modifications to the radio or any signal level balancing devices in the cables.

For Method 1, the TNC's audio will be fed directly into the microphone connector or similarly connected auxiliary jack, and the output of the TNC will be adjusted to give a proper modulation level. The receiver audio will be taken from an earphone plug or speaker jack and fed directly to the TNC.

This method is expedient but, unless you have an auxiliary speaker/mike jack, it doesn't allow you to monitor the channel or to conveniently use the rig on voice. The connection may also be susceptible to RFI from nearby Amateur and commercial trans-mitters. For these reasons you may want to use the second interface method for your permanent station interface, after the initial testing phase.

Connect your TNC to your radio. Turn on your TNC and computer and start your terminal program.   Connect the radio to a dummy load and listen to the transmission with another nearby radio.

 1. Enter the modem calibration procedure by typing

        CALIBRA

and a carriage return. Press the K key on your keyboard to key the transmitter, then tap the space bar until the higher of the two tones is heard.   Pressing the K key again will unkey the transmitter.   After the transmitter has been keyed for a few seconds, it will be shut off automatically by the transmit watch-dog circuit. As you perform the adjustments below, you will have to periodically unkey then re-key the transmitter by typing the K key.   If you wish to defeat the watch-dog timer, place JMP4.

 2. With the TNC keying the transmitter and transmitting the higher of the two tones, adjust the transmit audio level as follows.   With a small screwdriver, adjust trimpot R76 while you listen to the monitoring receiver. Turn the adjustment screw on R76 clockwise (CW) until no increase in output level is heard at the monitoring receiver.

 3.   Rotate the adjustment screw of R76 counterclockwise until the audio signal on the monitoring receiver is slightly, but noticeably, reduced from the maximum level.

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4. Press the K key to return to receive mode and type Q to exit
the calibration routine. Be sure to remove JMP4 if you placed it
to defeat the watch-dog timer. You have now set your transmitter
deviation to approximately the correct level.

5. With your radio in the receive mode, open the squelch con-
trol so that a steady hiss would be heard on a speaker. Set the
volume control so the DCD LED on your TNC flickers occasionally
with no received signal. This is approximately the proper level
for best receive performance from your TNC's modem.

If you notice a significant hum level in the monitored audio in
Step 3, take measures to remove it. This may require shielded
wire (recommended in any event) in your microphone audio circuit.
If your transmitter has an adjustable microphone gain control,
try reducing the sensitivity of the transmitter microphone
circuit and increasing the signal level from your TNC to minimize
hum or other noise problems.

Method 2: Accessory Jack or Interface Box Connection

If your radio has an accessory jack with PTT, transmit audio, and
receive audio signals, the interface can be done through this
jack with the addition of only a single resistor inside the
radio. This resistor should be placed in series with the TNC
audio output where it is connected to the microphone audio to
provide isolation. The method of determining the value required
will depend on the radio used, and is described below..

If your radio does not have an accessory jack and you don't wish
to add a connector to your radio, you should construct a separate
external interface box. This box will permit simultaneous
connection of your TNC and a microphone. Again, a series
resistor should be placed in series with the TNC audio output.
It will either have its own speaker or pass the speaker signal
through to a connector so that you can monitor the receive audio
while your TNC is hooked up.

Regardless of whether you use an accessory jack or an external
interface box, you should use shielded wire for all
signal-carrying leads. The connector types and pinouts will be
determined by the connector jacks on your radio.

When all required cables have been assembled and the TNC is
connected to the radio, you are ready to set the levels according
to the following procedure.

1. Remove the shunt attenuator element, R57 in the microphone
audio section of your TNC.

2. Temporarily solder a variable resistor in place of R(S) in Fig. 3-3 or Fig. 3-4. The maximum value of this resistor must be determined by experiment, but 500K should handle most cases.

3. Connect your TNC to the radio. Connect the microphone to the radio, or to the interface box if one is being used. Connect the radio to a dummy load.

4. Turn on your TNC and computer and start your terminal program. Enter the modem calibration procedure by typing

    CALIBRA

Press the K key to key the transmitter, then tap the space bar until the higher of the two tones is heard.   Pressing the K key again will unkey the transmitter. After the transmitter has been keyed for a few seconds, it will be shut off automatically by the transmit watch-dog circuit.   As you perform the adjustments below, you will have to periodically unkey then re-key the transmitter by typing the K key. If you wish to defeat the watch-dog timer, place JMP4.

5. With the TNC keying the transmitter and transmitting the higher of the two tones, adjust the transmit audio level as follows. With a small screwdriver, adjust trimpot R76 and set the output of your TNC to about 70% of its maximum undistorted value as observed on an oscilloscope monitoring the transmit audio at JMP7.   This level may be estimated without an oscilloscope by turning R76 clockwise to maximum (indicated by a clicking sound inside the trimmer) and then backing off 15 turns. At this point the signal amplitude at JMP7 should be about 2.5 volts peak-to-peak.

6. Adjust the variable resistor installed in step 2 for proper modulation level (typically between 3.0 and 4.5 kHz deviation for Amateur FM). If FM test equipment is not available, adjust R(S) as described in steps 2 and 3 of Method 1 above, using R(S) instead of R76.

7. Press the K key to return to receive mode and type Q to exit the calibration routine. You have now set your transmitter deviation to approximately the correct level. Remove JMP4 if you placed it in Step 4.

8. Carefully remove the variable resistor and measure its value. This is the proper value of R(S) for your particular radio.

9. Select the nearest standard value fixed resistor (1/4 watt
is fine) and permanently install this resistor as R(S) in the
interface circuit.

10. If you have access to FM test equipment, check to see that
the modulation level is still within the limits of 3 to 4.5 kHz
deviation.   If it is not, make a final adjustment with the TNC
transmit audio level control, R76.

11. Open the squelch control on your radio so that a steady hiss
is heard.   Set the volume control so the DCD LED on your TNC
flickers occasionally. This is approximately the proper level
for best receive performance from your TNC's modem.

Chapter 4 OPERATION I: GETTING STARTED

This chapter will guide you through the basics of packet radio
operation with TNC 2. Packet radio has a great deal of power and
flexibility, and this chapter only scratches the surface of your
packet station's capabilities. However, it contains the basic
information required to get you on the air with packet radio to
begin exploring this new mode.

First Steps

The serial port baud rate switches on the back of the TNC should
be set to the same baud rate as your computer.   These settings
are described in Chapter 2, Computer Interfacing. Set the
following switches, with the TNC OFF (be sure only one of these
switches is ON when the TNC is powered up):

Table 4-1. DIP switch settings for 1200 baud
         radio data rate.

Switch	Setting
6	OFF
7	ON
8	OFF

This sets a radio baud rate of 1200 baud. The radio baud rate is
not related to the computer baud rate.

Turn on your TNC. You should see something like the following
display.

Tucson Amateur Packet Radio TNC 2
AX.25 Level 2 Version 2.0
Release nn
Checksum $xx
cmd:

The first five lines are the sign-on message, which you will
normally see only when you power up the TNC.   (See the Software
Release Notes for values of nn and xx.) The Command Mode prompt
cmd: will appear when the TNC is in Command Mode and is ready to
accept your instructions.

You may see some anomalies in the appearance of the display,
which will be corrected as you proceed through the next section.
The sign-on message may appear double-spaced, or characters you
type may be displayed twice. You may even see incorrectly
displayed characters.

Entering Commands

In the examples in this chapter, text that you are supposed to
type will appear in boldface. Text typed by the TNC will appear
in normal type:

        cmd:RESET

This means that you are supposed to type the text, "RESET",
following the Command Mode prompt which the TNC typed. End the
line with a carriage return. All command entries will end with a
carriage return, abbreviated <CR>. The <CR> at the end of a
command normally won't be mentioned.

You should see the TNC's response to the RESET command:

        bbRAM loaded with defaults

        Tucson Amateur Packet Radio TNC 2
        AX.25 Level 2 Version 2.0
        Release nn
        Checksum $xx
        cmd:

The TNC has reloaded all user-settable parameters normally stored
in the battery backed-up RAM (bbRAM). All parameters are now set
to their default values. The TNC has also re-initialized itself
exactly as it would upon power-up, and typed a sign-on message.
You probably won't use this command often.   The TNC will
automatically reload the bbRAM at power up if it finds that the
data is bad.

If you make mistakes while entering commands to the TNC, you can
make corrections. To erase the last character you typed, enter a
<BACKSPACE> character.   The TNC will throw away the last
character you typed (unless you are at the beginning of a line)
and try to erase the character from your screen. Input editing
will be discussed in more detail in the section, "Special Input
Characters."

You are now ready to start setting up the parameters you will
use. You may be satisfied with most of the defaults for now, but
a few parameters will have to be changed!

```
        cmd:MYCALL WA7QST
        was    NOCALL
        cmd:
```

Type the text, "MYCALL WA7QST", following the command mode
prompt. Of course, you should substitute your own call sign for
WA7QST. Don't forget the <CR> at the end of the line. Your call
sign will be used by the TNC as its "address."   The TNC responds
by telling you the previous value of the MYCALL parameter, and
gives you a new Command Mode prompt.

Now try typing just the command by itself:

```
        cmd:MYCALL
        MYCALL   WA7QST
```

You can see the current value of most parameters by typing the
command that sets the parameter followed by just a <CR>.   This
verifies that the TNC accepted your call sign.

The next section describes the commands you will use to configure
the TNC for proper text display for your particular computer.
You may not use these commands again unless you change computers
or terminal programs.   The following sections, "Basic Operation"
and "Monitoring Channel Activity," describe the commands you will
use for your everyday packet operations. With these commands you
will be ready for the section, "Your First Packet QSO." The last
section of the chapter, "Special Input Characters" contains
information on input editing and other special characters used by
the TNC.

If you intend to use your packet station for "advanced"
applications, such as a computer Bulletin Board or binary file
transfers, you should continue with Chapter 5, Operation II:
Further Details. However, Chapter 4 contains all the information
that is needed for most packet operations.   For a full
description of all commands, refer to the appropriate entry in
Chapter 6, TAPR TNC 2 Commands.

Most commands can be abbreviated, and the minimum abbreviations
for each command are given in the listings in Chapter 6. For the
sake of clarity, only the full command names are used in this
chapter.

Serial Port Configuration

This section describes the commands you will use to set up your
TNC to work best with your computer.

Parity and Word Length

If messages from your TNC appear garbled, with incorrectly displayed characters, you may need to change the TNC's serial port parity and word length. (We assume that you have set the baud rate correctly. See Chapter 2 if the baud rate needs to be changed.) The most common parity and word length combinations are 7 bits, even parity (the TNC default), and 7 bits, space parity. The TNC default will probably be accepted even if your computer actually uses the latter setting. If your computer receives 8 bits as data, you may have to set space parity, since text may otherwise be interpreted as graphics or other special characters. To set 7 bits, space parity, use the following combination:

        AWLEN 8   (8-bit words)
        PARITY 0   (no parity bit)

To return to 7 bits, even parity, set

        AWLEN 7   (7-bit words)
        PARITY 3   (even parity)

One of these combinations will satisfy most computers. You are more likely to require a different setting if you have a terminal rather than a computer, or if you have configured your terminal port for some special application.

If your computer requires odd parity, set PARITY 1. If your computer detects framing errors, try setting

        AWLEN 7   (7-bit words)
        PARITY 0   (no parity bit)

for shorter characters. For longer characters, set:

        AWLEN 8   (8-bit words)
        PARITY 1 or PARITY 3

Echos

You may see two characters on your screen for every character you type, for example:

        cmd:RREESSEETT

Your computer is echoing the characters you type, and the TNC is also echoing them. In this case, set ECHO OFF to stop the TNC's echos. If you later use your TNC with a different computer, or

with a different terminal program, you may see nothing displayed
when you type. In that case, set ECHO ON.

New Lines and Line Wrapping

If everything displayed appears to be double-spaced, your
computer is adding an extra linefeed (<LF>) whenever it displays
a carriage return (<CR>). Set AUTOLF OFF to keep the TNC from
also adding an <LF>. If you change equipment you may have to set
AUTOLF ON to restore the TNC's automatic linefeeds.

The screen-width parameter is set by default to 80, the width of
many CRT displays. The TNC will send an extra <CR> (or <CR> <LF>
if AUTOLF is ON) when 80 characters have been displayed on a
line.   If your computer does not automatically break long lines,
you will need to set the screen width to the width of your
display. For example, for a computer using a TV set for a
display, you would set   SCREENLN 40. If your computer does
automatically break long lines, you should set SCREENLN 0 to
disable this feature on the TNC.   Otherwise, you will get two
<CR>s when the line wraps around.

A few computers will frequently lose the first characters of a
line when several lines are typed in rapid succession, for
example, in the sign-on message. You can give the computer more
time between lines by setting NUCR ON (delay after <CR>), or NULF
ON (delay after <LF>).   The delay is adjusted by NULLS, which
sets a number of character-times for the delay.

Basic Operation

You can learn quite a bit about your TNC's operation without
actually transmitting anything. For your first experiments, your
TNC will be "talking to itself," allowing you to become familiar
with it before you go on the air.

Disconnect your radio from your TNC and turn off the TNC.
Install the digital loopback jumper, JMP10. The analog loopback
jumper, JMP7, should not be installed. Connect your computer to
the TNC with your serial cable. Turn on the computer and start
your terminal program.

A Connecting and Disconnecting Exercise

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Packet radio QSOs are started by a connect process, which sets up
the "handshaking" between the two stations that insures
error-free communications. QSOs are terminated by a disconnect
process, which leaves both stations free to start new QSOs.
Packet QSOs can also make use of digipeaters, other packet
stations which can automatically relay packets from one station
to the other over a specified route.
To see how this works, you can have your TNC connect to itself.
Since you have set the TNC up for digital loop-back, it will
receive all packets that it sends. Try the following:

        cmd:CONNECT WA7QST
        *** CONNECTED to WA7QST

replacing WA7QST with your own call sign. The TNC generates
packets initiating and confirming the connection. The packets
aren't actually converted to audio signals and transmitted over
the radio, but they are otherwise just like packets you will be
transmitting later on.

The *** CONNECTED to message tells you that the connection was
successful. You should also notice that the CON LED has lit up
and that you do not see a new cmd: prompt on the next line. You
are now in Converse Mode, ready to start talking. Try it. Type
your message, ending the line with a <CR>.

        Hello, there.
        Hello, there.

The <CR> causes your message to be put into a packet, or
"packetized," and transmitted. (We explain in the next chapter
how you can use a different character to send packets.) The
underlined text is a message that the TNC received in a packet
and displayed. Whenever you are in Converse Mode anything you
type will be assembled into a packet addressed to the station you
are talking to and transmitted. If there isn't a QSO (con-
nection) in progress, the packet will be sent to the address CQ.

In the example above, your TNC entered Converse Mode automa-
tically after the connect took place. You can also command the
TNC to move back and forth between Command Mode and Converse
Mode.

To return to Command Mode, you must enter a special character,
Control-C (abbreviated <CTRL-C>), or else send a BREAK signal.
"Control" characters are usually entered by holding down a
special control key and then typing another key without releasing
the control key. If your keyboard doesn't have a key marked CTRL
or something similar, consult the documentation for your computer
or terminal program to see how to enter control characters. A

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BREAK signal is a special transmission (not an ASCII character)
which your computer may be able to produce.

   NOTE: If <CTRL-C> will cause your computer to do something
to interfere with packet operations, such as halting the terminal
program, and you can't send BREAK signals, you will have to
change the character that returns you to Command Mode.   See the
section on "Special Input Characters," below.

Now type a <CTRL-C>. The TNC doesn't echo the <CTRL-C>, but you
should immediately see a Command Mode prompt.   To return to
Converse Mode, enter the command CONVERS:

        <CTRL-C>
        cmd:CONVERS
        Whatever I type in Converse Mode is transmitted.
        Whatever I type in Converse Mode is transmitted.
        <CTRL-C>
        cmd:

To terminate the QSO, you must end the connect by giving the
DISCONNE command. The TNC will transmit packets terminating the
conversation and notify you when the disconnect is complete:

        cmd:DISCONNE
        *** DISCONNECTED

An actual QSO might be terminated by the other station, of
course. In that case, you would see the *** DISCONNECTED message
without having issued the command.

You have just performed the basic operations of any packet QSO.
You established a connection with the desired station to begin
the QSO, sent and received some messages, and disconnected from
the station at the end of the QSO.

Digipeating

You may wish to have a QSO with another packet station that is
beyond your direct radio range. If a third packet station is on
the air and both you and the station you want to talk to are in
range of this third station, that station can relay your packets.
You set up the packet routing when you initiate the connection.
Your TNC will then automatically include the routing information
in the packets it sends.

The diagram below shows an example situation in which digipeating
is useful.

```
              AD7I
             /  \
   N2WX _____/   _____ WA7QST
```

You are station WA7QST, and you want to have a packet QSO with
N2WX. There is a mountain in the way and you are not in simplex
range of each other.   However there is a station located on the
ridge, AD7I, which is in range of both you and N2WX.

You direct the TNC to set up a connection to N2WX using AD7I as
an intermediate digipeater as follows:

        cmd:CONNECT N2WX VIA AD7I

You can specify a routing list of up to eight intermediate
stations.   For example, consider a modification of the example
above:

```
              ____
             /  \
   N2WX _____/   _____ WA7QST
      .            .
         .      .
          KV7D . . . NK6K
```

AD7I has turned off his station, but you can contact N2WX by
going around the mountain through NK6K and KV7D.   This time you
issue the connect command like this:

        cmd:CONNECT N2WX VIA NK6K, KV7D

You specify the digipeaters in the order you would encounter them
going from your station to the station to which you wish to
connect.

Your station can also act as a digipeater for other stations.
This doesn't require any special actions on your part -- your TNC
will do everything automatically.   If your station is
digipeating, you may occasionally notice your transmitter keying
during lulls in your own conversations.

Unsuccessful Connections

Sometimes you will initiate a connect sequence that can't be
completed.   The station may not be on the air, or it may not be
within range of your station. You may have even mis-typed the
other call sign. If the TNC does not get a response to its first
connect packet, it will try again. You can control the number of
attempts the TNC will make with the command RETRY. The default

number of retry attempts is 10. If the TNC doesn't get an answer
after this number of transmissions, it will give up and display
the message

    *** retry count exceeded
    *** DISCONNECTED

The retry count is also used once the QSO has started. Each
transmission sent to the other station is "acknowledged," or
ACKed by the other station, and vice versa. The ACK means that
the packet was received and that the CRC checksum indicated that
it was received without errors.   This is the means by which
packet radio can ensure error-free communications.   Sometimes a
packet won't be received correctly by the other station, either
because of accidental interference from another packet station (a
collision), or because of other channel noise.   If your TNC
doesn't get an ACK soon enough, it retransmits the packet and
increments the retry count.   If the count set by RETRY is
exceeded, the TNC will automatically disconnect and display the
same message:

    *** retry count exceeded
    *** DISCONNECTED

The automatic disconnect feature keeps a TNC from indefinitely
retransmitting a packet and tying up the channel under hopeless
conditions. For example, an intermediate digipeater might have
been shut down, or the RF channel might have deteriorated to the
point of being unusable. The other operator might have even
turned off his station without disconnecting.   If you are
operating under special conditions, such as a marginal HF
channel, you can set RETRY 0 to disable all automatic disconnects
(the retry limit is never reached).

Monitoring Channel Activity

In addition to displaying messages from the station you are
connected to, your TNC can allow you to monitor other packet
activity on the channel. You can "read the mail," displaying
packets between other stations. Your TNC will also keep track of
stations heard during a session. This section will describe some
of the monitor functions.

Monitoring is enabled or disabled by the MONITOR command. You
can try this out in digital loop-back mode while disconnected.
Type:

    cmd:MONITOR ON

    cmd:CONVERS
    This is a test packet.
    WA7QST>CQ:This is a test packet.

Since you aren't connected to another station your packets are
sent to the address "CQ," i.e., anyone. The packet you sent was
"heard" by the TNC and displayed, along with the sending station
and the destination.

If you also want to see any intermediate digipeater stations
being used, you can set MRPT ON. This feature would be useful if
you later want to connect to one of the stations you are
monitoring and will need a digipeater route in order to reach it.
For example, you might see the following display:

    WB6YMH>WD0ETZ,KV7B:Hello, Bill!

This packet was sent from WB6YMH via KV7B to WD0ETZ.

If there are several digipeaters, or if the message lines are
long, the display may be difficult to read. You can put the
address header on a separate line from the text by setting
HEADERLN ON:

    WB6YMH>WD0ETZ,KV7B:
    Hello, Bill!

Ordinarily, your TNC will stop displaying monitored packets if
you connect to another station, permitting you to converse
without interruption. If you want to monitor activity while
connected to a packet station, set MCON ON.

To display a list of stations heard since the last time your TNC
was powered up, type

    cmd:MHEARD
    AD7I
    WA7GXD
    N2WX
    NK6K
    KV7B*

The last several stations whose packets were heard by your TNC
are displayed. The entry "KV7B*" means that KV7B was heard
digipeating a packet rather than sending one of his own. You can
clear the "heard log" with the command MHCLEAR.

You can see the settings of the monitor parameters described
above, as well as several others, by typing DISPLAY MONITOR.

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Your First Packet QSO

Although there are still a number of features you should be
familiar with for comfortable packet operation, you are probably
eager to get on the air and try out your TNC. Arrange to have
another packet operator get on the air to help you get started.
Make sure that your friend will be close enough to ensure solid
copy, with no FM "popcorn" noise. It's best if you can get an
experienced packet operator to help you get started. If you are
both beginners, try to have both stations in the same room and
operate on low power or into dummy loads.

Starting the QSO

You are ready to initiate a connect. For the sake of example, we
will continue to use WA7QST in place of your call sign, and we
will use WB0QRP for your friend's call. Make sure you are in
Command Mode, and type

        cmd:CONNECT WB0QRP

After a moment you should see the message

        *** CONNECTED to WB0QRP

and you will be in Converse Mode. Your friend will see the
message

        *** CONNECTED to WA7QST

and he will also be in Converse Mode. You have begun your first
QSO.

If you have trouble connecting, make sure your microphone drive
level is set properly, as described in Chapter 3.   It may be
helpful to have an experienced packet operator listen to your
transmissions and monitor with his TNC. You can also try the
following procedure. Both you and your friend should set MONITOR
ON, enter Converse Mode and send some packets. Each station
should display packets sent by the other. If only one station is
"hearing" properly, you can concentrate on the modulator and
transmitter of that station and the demodulator and receiver of
the other station. You can try experimenting with the TXDELAY
timing parameter for the sending TNC. Set TXDELAY 64 for a long
delay. If this solves the problem, you can back off to the
smallest value that works consistently.

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Exchange several messages to get a feel for this new mode. If you monitor the radio transmit indicators and listen to the speaker audio from the two rigs, you will have a better idea of what is happening. You radio will be inactive most of the time, even while you are actually typing. When you get to the end of a line and type a <CR>, your radio will be keyed briefly and your friend will hear a "brrrraaaap" on his speaker. As your message is displayed on his computer, his radio will be keyed for an even shorter time and you will hear a "brraap" on your speaker. This is the ACK, or packet acknowledgment coming back. Your TNC takes note that the packet was received correctly, but nothing is displayed on your screen.

Digipeating

Now that you are on the air, you and your friend can try out the TNC's digipeating capabilities. This is actually more interesting if you have at least three stations participating, but you can get the feel for it with two stations.

Return to Command Mode and disconnect from the other station:

        <CTRL-C>
        cmd:DISCONNE
        *** DISCONNECTED

Now issue the following command.

        cmd:CONNECT WA7QST VIA WB0QRP

As before, substitute your call for WA7QST and your friend's call for WB0QRP. You are requesting a connect to yourself, as you did before in digital loop-back mode, but this time you are using a sort of RF loop-back. You transmit packets to your friend's TNC, which relays them back to you. When the connection is established you will see

        *** CONNECTED to WA7QST VIA WB0QRP

and you will be in Converse Mode. Your friend won't see anything displayed on his computer and his TNC's state won't be affected at all by your QSO. In fact, your friend could issue this connect request,

        cmd:CONNECT WB0QRP VIA WA7QST

and you can carry on two separate conversations completely independently. Monitor the radio transmit indicators and listen

to the speaker audio. See if you can follow the packets and the
acknowledgments back and forth.

Monitoring on the Air

This is a good time to try out the TNC's monitor functions.
While you and your friend are separately connected, type

    <CTRL-C>
    cmd:MONITOR ON
    cmd:MCON ON
    cmd:CONVERS

You will be able to see both your "conversation" and your
friend's conversation. Also try HEADERLN ON and MHEARD.

Special Input Characters

The TNC can a number of special characters that can be used to
control its actions.   Many of these special characters can be
used to "edit" commands and packet text as they are entered.
These features can all be customized to suit you and your compu-
ter. Most of the special input characters we will describe are
active in both Command Mode and Converse Mode; the exceptions
will be noted.

The character used to return to Command Mode from Converse Mode
is by default a <CTRL-C>. (Sending a BREAK signal also works.)
This   character does nothing in Command   Mode, so if you
accidentally enter it twice you won't mess up the next command
line. You can change the Command Mode entry character with the
command COMMAND.   This is one of several commands that set
special character functions.   You can choose any character for
this function, by entering the ASCII character code for the key.
For example, you can use a <CTRL-E> to enter Command Mode by
setting

        cmd:COMMAND 5
        was $03

The TNC displays the previous value in hex, and you can also
enter character codes in hex if you prefer. All of the special
characters described below can be changed in the same way as
COMMAND.

We have already mentioned that you can erase mis-typed characters
by typing the <BACKSPACE> character.   You can change this
character with the command DELETE. If you set DELETE ON, you can
erase characters by typing the <DELETE> character; setting DELETE

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OFF returns to using <BACKSPACE>. You will probably want to use
the same key that your computer normally uses to rub out
characters.   <BACKSPACE> is more commonly used than <DELETE> by
personal computers. If you aren't sure whether your rubout key
produces <DELETE> or <BACKSPACE> characters, you can try both
settings of the DELETE command and see which works.

When you rub out a mis-typed character, the TNC will attempt to
correct the screen display. This will work for most computers as
well as display-type terminals.   It won't work for hardcopy-type
terminals or possibly with a few computers. If your display
doesn't look right after you rub out a character, try setting
BKONDEL OFF. The TNC will not try to correct the display but
will indicate the rubout with a "\" character (<BACKSLASH>). You
can restore display correction by setting BKONDEL ON.

If you make several mistakes in a line, or if you change your
mind, you may want to cancel the whole line rather than rubbing
out the characters one at a time.   You can cancel the line by
typing <CTRL-X>. The TNC will display a <BACKSLASH> followed by
<CR>. If you are in Command Mode, you will see a new prompt:

     cmd:Hi, John, how are you?<CTRL-X>\
   [You started typing text while in Command Mode.]
     cmd:CONVERSE
     Hi, John, how are you?

The cancel-line character can be changed to any ASCII character
by the command CANLINE.

If you have changed your input by rubbing out and retyping
characters, you may want to see a "fresh" copy of your input,
especially if you have set BKONDEL OFF. The TNC will retype the
line you are entering when you type <CTRL-R>:

     cmd:CONNECT KB7\\\WA7<CTRL-R>\
   [You mis-typed the call sign.]
     cmd:CONNECT WA7GXD

Here the user mis-typed the first three characters of the call
sign and rubbed them out.   The TNC displayed "\" for each
character rubbed out.   The user then retyped the characters
correctly and redisplayed the line. He finished typing the call
sign on the new line.   The redisplay-line character can be
changed to any ASCII character by the command REDISPLA.

If your TNC displays information faster than you can read it
before it scrolls off the screen, you can halt the display by
typing <CTRL-S>. To resume output from the TNC to your computer,

enter <CTRL-Q>. These characters can be changed to any ASCII
character by the commands STOP and START, respectively.

You may occasionally want to include one of the special input
characters in a packet. For example, to send several lines at
once in the same packet, you would have to include <CR> in the
packet at the end of each line, bypassing its "send-packet"
function except at the actual end of the packet. You can include
any character in a packet including all special characters by
prefixing it with the pass character, <CTRL-V>. For example,

        I wasn't at the meeting.<CTRL-V><CR>
        What happened?

Ordinarily, this message would be sent as two packets. By
prefixing the first <CR> with <CTRL-V>, the operator sends it all
at once, but maintains the <CR> in the text. The pass character
can be changed to any ASCII character by the command PASS.

QRA or help for My path's fallen, and it can't get up

    QRA ("Who are you") pinging is supported in release 1.1.8. A
QRA ping polls all of the TNCs within range. Each TNC hearing
the QRA ping will transmit its identification packet within 1 to
16. This technique provides the names of all reachable TNCs and
digipeaters to the new, roving, and emergency-use packeteer.
Also see "ANSWRQRA" command.

    Note that the QRA function will not work if there are any
digipeaters in the UNPROTO path. This somewhat, but not com-
pletely, helps limit a malevolent user's ability to seriously
harm the network.

    Sending QRA ping:

    1) Set the unprotocol callsign to QRA
       cmd: UNPROTO QRA<cr>

    2) Manually send an unconnected packet
       cmd: CONVERSE<cr>
       <cr>
       ^C
       cmd:

3) In 1-16 seconds, if MONITOR is ON you should be receiving packets empty identification packets from other connectable and compatible TNCs.

    WB9FLW>ID:
    AD7I>ID:
    W5DID>ID:

Chapter 5 OPERATION II: FURTHER DETAILS

This chapter describes some aspects of packet operation that you
don't need to be concerned with for everyday conversational
operation. You will want to consult this chapter if you are
using your station for special applications such as a computer
Bulletin Board, binary file transfers, or a "host" program. You
will also find some of this material useful if you intend to
operate on HF or OSCAR, or if your radio has special timing or
other requirements. Even if you don't have any of these applica-
tions, you may enjoy exploring the capabilities of your TNC.

We will use the term "computer" to refer to computers or
terminals.   In the command examples, the TNC's prompts and other
messages are shown in ordinary type, your responses are shown in
bold face, and received packets are shown underlined. Commands
and other special keywords are shown in upper case; other text
entered to the TNC is shown in upper and lower case.

Special Characters

The TNC recognizes a number of special characters for input
editing, flow control, and other control functions.   You can
change any of these special characters to customize your TNC to
suit your applications, your computer, or your whim. Most of the
characters are set by commands which specify the ASCII character
code for the desired character.   You can disable any special
character feature by setting the character value to 0.   Input
editing characters may be disabled with no serious effects. You
should use caution in disabling the flow-control or Command Mode
entry characters.   Also be careful not to set two special
characters to the same value.

Special characters are normally set to various control char-
acters. Control characters are entered by holding down a special
control key while typing another key. For example, control-C, or
<CTRL-C> is entered by holding down the control key while typing
C. If your computer doesn't have a special control key, you will
have to consult your computer's documentation to see how to enter
these characters. If you will have difficulty entering control
characters, you can change the special characters to, for
example, seldom-used punctuation.

The action of each special character is described in detail under
the entry in Chapter 6 for the command that sets that character.

You can enter the code for a character in either hex (base 16) or
decimal notation.   The TNC displays character codes in hex. A

number in hex notation is indicated by beginning the number with a $. The "digits" of a hex number represent multiples of powers of 16. The values 10 through 15 are represented by the letters A through F, which may be upper or lower case. For example,

$$\$1B = 1 \times 16 + 11 = 27.$$

Tables of ASCII character codes are available in most computer manuals. A table of ASCII codes for control characters follows.

Table 5-1. ASCII Codes for Control Characters.

Dec	Hex	Control	Mnemonic	Dec	Hex	Control	Mnemonic
0	$00	<CTRL-@>	NUL	16	$10	<CTRL-P>	DLE
1	$01	<CTRL-A>	SOH	17	$11	<CTRL-Q>	DC1
2	$02	<CTRL-B>	STX	18	$12	<CTRL-R>	DC2
3	$03	<CTRL-C>	ETX	19	$13	<CTRL-S>	DC3
4	$04	<CTRL-D>	EOT	20	$14	<CTRL-T>	DC4
5	$05	<CTRL-E>	ENQ	21	$15	<CTRL-U>	NAK
6	$06	<CTRL-F>	ACK	22	$16	<CTRL-V>	SYN
7	$07	<CTRL-G>	BEL	23	$17	<CTRL-W>	ETB
8	$08	<CTRL-H>	BS	24	$18	<CTRL-X>	CAN
9	$09	<CTRL-I>	HT	25	$19	<CTRL-Y>	EM
10	$0A	<CTRL-J>	LF	26	$1A	<CTRL-Z>	SUB
11	$0B	<CTRL-K>	VT	27	$1B	<CTRL-[>	ESC
12	$0C	<CTRL-L>	FF	28	$1C	<CTRL-\>	FS
13	$0D	<CTRL-M>	CR	29	$1D	<CTRL-]>	GS
14	$0E	<CTRL-N>	SO	30	$1E	<CTRL-^>	RS
15	$0F	<CTRL-O>	SI	31	$1F	<CTRL-_>	US
				127	$7F	<DELETE>	

Operating Modes

The TNC has three operating modes. We discussed two of these modes, Command Mode and Converse Mode, in Chapter 4. The third mode, Transparent Mode, is a data-transfer mode like Converse Mode but is intended primarily for computer data interchange rather than human conversation. We describe all three of these modes below. Additionally, the firmware supports the KISS (keep it simple, stupid) mode. Limited information is supplied here in the description of the KISS command. A description of this mode may be found in the proceedings of the Sixth ARRL Computer Networking Conference. Effective with firmware version 1.1.8, the TAPR firmware supports a host mode. At the time of this writing, this was still somewhat experimental and is not described herein. Contact TAPR for further information.

Command Mode

Command Mode is used to enter commands which alter the TNC's operating parameters. The other modes are entered from Command Mode. When the TNC is in Command Mode, the Command Mode prompt,

        cmd:

is printed at the beginning of each input line. Note, however, that if the TNC has received and displayed packets, the prompt may have scrolled off the screen.

The TNC will be in Command Mode after a reset or power-up. After a power-off, power-on sequence, all operating parameters of the TNC are re-initialized to the parameter stored in battery backed-up RAM (bbRAM) by the resident software. After the RESET command is issued all operating parameters are reset to the default values stored in EPROM. The values of most parameters are stored in a permanent but easily changed form in the bbRAM memory.

The following commands set special characters which are active in Command Mode. Refer to the discussions of these commands in Chapter 6 for details on the operation of the characters in Command Mode. Also see the section on special input characters in Chapter 4.

    CANLINE   Cancel current line
    CANPAC   Cancel output (Command Mode function only)
    DELETE   Character deletion
    PASS   Insert following special character
    REDISPLA   Re-display current line
    START, STOP   User's flow control characters (sent to TNC)
    XOFF, XON   TNC flow control characters (sent to terminal)

The following commands enable display features which are active in Command Mode. Refer to the discussions of these commands in Chapter 6 for details on the operation of these characters in Command Mode. Also see the section on terminal configuration in Chapter 4.

    AUTOLF   Add <LF> after <CR> in data sent to terminal

    BKONDEL   Echo after character deletion
    ECHO   Automatic echo of serial port input
    FLOW   Type-in flow control
    LCOK   Lower case translation
    NUCR   Nulls after <CR>
    NULF   Nulls after <LF>
    NULLS   Null count
    SCREENLN   Automatic <CR> insertion

Entering Data-Transfer Modes

There are several ways to enter a data-transfer mode from Command
Mode. You can type the command CONVERS to enter Converse Mode or
the command TRANS to enter Transparent Mode, and the TNC will
immediately enter the specified mode. The TNC will automatically
enter a data-transfer mode if you are in Command Mode when a
connection is completed. You can specify the data-transfer mode
for automatic entry with the command CONMODE:

        cmd:CONMODE TRANS

will specify Transparent Mode, and

        cmd:CONMODE CONVERS

will return to the default choice of Converse Mode.

The timing of the automatic entry into data-transfer mode depends
on whether you or the other station initiated the connection.
If you receive a connect request which your TNC accepts, you will
enter data-transfer mode when the TNC sends the connect
acknowledgment (ACK) and types the message *** CONNECTED TO
<callsign>.

If you initiate the connection with the CONNECT command, you can
control the timing of the mode change with the command NEWMODE.
If NEWMODE is OFF, the mode will change when the connect ACK is
received and the *** CONNECTED TO: <callsign> message is typed.
If NEWMODE is ON, you will enter data-transfer mode immediately,
without waiting for a successful connection. Any text sent to
the TNC at this point will be queued up in packets which will
wait for a successful connection before being sent. If the
connect attempt fails, you will be returned to Command Mode. You
will also be returned automatically to Command Mode when either
station disconnects and ends the QSO.

Converse Mode

The data mode used most often for ordinary QSOs is Converse Mode. In Converse Mode, the information you type is assembled by the TNC into packets and transmitted over the radio. The send-packet character causes the input to be packetized for transmission. If you type a full packet-length of characters without typing the send-packet character, your input will be   packetized and transmitted anyway.

The default send-packet character is <CR>, but you can specify any character with the command SENDPAC.   You may also choose to have the send-packet character transmitted in the packet or not. If the send-packet character is <CR> it is natural to include it in the packet as part of the text as well as interpreting it as a command. This is accomplished by setting CR ON. If you use some other character to force packet transmission, you may want to set CR OFF and inhibit transmission of the send-packet character. If you set the send-packet character to something other than <CR>, you can cancel packets of more than one line   with the cancel-packet character, which is set with the command CANPAC. Single-line packets can be canceled with either the cancel-line character or the cancel-packet character.

To return to Command Mode from Converse Mode you must type the Command Mode entry character, or send a BREAK signal over the serial port. A BREAK is not a regular ASCII character, but it can frequently be transmitted by typing a special key on the keyboard.

A BREAK signal is a continuous mark (or 1) signal on the serial port Transmit Data line lasting approximately 0.2 second.   In fact, the timing of the signal is not very important, and most serial ports will recognize a BREAK if the mark signal lasts significantly longer than the time required for a character transmission. Because of the simple nature of this signal, it is easily possible to generate a BREAK with circuitry external to the computer, thus guaranteeing entry to Command Mode in auto-matic station operation.

The following commands set special characters which are active in Converse Mode. Refer to the discussions of these commands for details on the operation of the characters in Converse Mode.

      CANLINE   cancel current line
      CANPAC   cancel current packet
      COMMAND   Command Mode entry
      DELETE   character deletion
      MFILTER   characters to be filtered in monitored
          packets
      PASS   insert following special character
      REDISPLA   re-display current line
      SENDPAC   send current packet
      START, STOP   user's flow control characters (sent to TNC)
      XOFF, XON   TNC flow control characters (sent to
terminal)

The following commands enable display features which are active
in Converse Mode. Refer to the discussions of these commands for
details on the operation of these characters in Converse Mode.

      8BITCONV   Retain high-order bit from serial port
              in converse mode
      AUTOLF   Add <LF> after <CR>
      BKONDEL   Echo after character deletion
      ECHO   Automatic echo of serial input
      ESCAPE   <ESCAPE> translation
      FLOW   Type-in flow control
      LCOK   Lower case translation
      NUCR   Null characters after <CR>
      NULF   Null characters after <LF>
      NULLS   Null count
      SCREENLN   Automatic <CR> insertion

Transparent Mode

Packet radio is very well suited to transfer of data between
computers. In some cases Converse Mode will work well for
computer data transfer. However, files such as a .CMD file on a
CP/M system, a BASIC program, or even a word-processor text file,
may contain characters which conflict with special characters in
Converse Mode. Some of these files may utilize all eight bits of
each byte rather than the seven bits required by ASCII codes. If
you transfer such files you will have to use Transparent Mode.

Transparent Mode is a data-transfer mode like Converse Mode. In
this mode there are no special characters -- everything you type
(or everything your computer sends to the TNC) is sent over the
radio exactly as it was received by the TNC. There are no input
editing features and there is no send-packet character. Packets
are sent at regular time intervals or when a full packet of
information is ready. The time interval at which data is
packetized is set by the PACTIME command.

The display characteristics of the TNC are also modified in Transparent Mode. Data is sent to the computer exactly as it is received over the radio, including all 8 bits of each byte received. Features such as auto-linefeed insertion and screen wrap are disabled, and echoing of input characters is disabled. The parameters that control these features in Command Mode and Converse Mode are not changed by entering Transparent Mode, and all display features are re-enabled when the TNC is returned to Command Mode. Most of the link status messages that appear as the TNC moves between disconnected and connected states are also disabled in Transparent Mode.

In order to permit the Command Mode entry character to be transmitted freely in Transparent Mode, the escape to Command Mode from Transparent Mode has been made a little more complicated. You can still return to Command mode by transmitting a BREAK signal, just as in Converse Mode. You can also utilize the Command Mode entry character in the following way.

You must wait for a time period after typing the last character to be sent. This time is set by the command CMDTIME. Following this wait, you must type three Command Mode entry characters (default <CTRL-C>) within an interval CMDTIME of each other. After a final CMDTIME interval in which no characters are typed, you will see the

        cmd:

prompt. If any characters are typed during this interval (even Command Mode entry characters) the escape will be aborted and all the Command Mode entry characters that have been typed will be sent as packet data. If you set CMDTIME to zero you will not be able to escape from Transparent Mode using this second procedure.

Flow Control

Whenever data is transferred to computers (home computers or TNCs), there is a chance that the data will be received faster than the computer can handle it. Some programs try to deal with this by providing data buffers for storing incoming data until the program is ready for it. However, this merely postpones the problem, since there is a limited amount of room in any buffer. In order to prevent loss of data the computer must be able to make whatever is sending data stop sending, and later tell it to resume sending. If you are a home computer user, you are probably already familiar with one type of flow control, which allows you to stop the output from the computer while you read it and restart it when you are ready for more.

The TNC's input buffer may fill up in Command Mode if you try to
type too long a command. In Converse Mode the buffer may fill up
for any of several reasons: you may be using a faster serial
port baud rate than the radio data rate; radio data transmission
may have slowed down because of noise or other users on the
channel; the person or computer at the other end may have stopped
output from that TNC.   The TNC will signal the computer to stop
sending data when there is room remaining for about 80 characters
in the buffer.   When the buffer fills up entirely, data will be
lost. When the buffer empties so that there is room for at least
270 characters, the TNC will signal the computer to start sending
data again.

A computer file transfer program may be unable to process data
fast enough to keep up with output from the TNC. In order to be
sure of reading every character, a computer must respond to
interrupts from its I/O devices. Some simple programs may poll
the input register for new data.   If the polling is not done
often enough, data may be lost.   Some computers disable
interrupts during disk accesses. If the program enters a routine
which will not allow it to check for data or respond to it, it
should signal the TNC to stop sending data.

There are two methods of providing flow control which are
supported by the TNC.   XON/XOFF flow control, sometimes called
"software flow control," is accomplished by sending a special
character (usually <CTRL-S>) to request that the output stop and
another special character (usually <CTRL-Q>) to restart output.
Hardware flow control may be used if both computers use the Clear
To Send (CTS) and Data Terminal Ready (DTR) lines of the RS-232C
standard.

Some commonly used terminal programs and file transfer programs
for home computers do not implement flow control in software, and
many serial ports do not support hardware flow control. Although
the DTR and CTS lines appear at the connector, they may not be
used on some computers unless the software reads the state of the
CTS line.   If you find that the TNC seems to lose data during
file transfers, you should immediately suspect a flow control
problem.

XON/XOFF Flow Control

If you are using a terminal (rather than a computer) or if your
computer does not support DTR/CTS flow control, you should use
XON/XOFF flow control, which is enabled by setting XFLOW ON. The
special flow control characters are set to <CTRL-S> and <CTRL-Q>
by default, but they may be changed. The commands XON and XOFF
set the characters which will be sent to the terminal by the TNC,

and the commands START and STOP set the characters to be sent to
the TNC by the terminal. Your computer may receive as many as 4
characters from the TNC after sending a STOP character, since
some characters may already be "in route" through serial I/O
chips.

If you send a STOP (START) character to the TNC when it is
already stopped (started), the character will be ignored. If the
STOP and START character are the same character, this character
will "toggle" the output, turning it off if it is on, and on if
it is off.

You can disable XON/XOFF flow control in one direction only by
setting the appropriate flow control characters to 0.   If you do
this, the TNC will automatically use CTS flow control to stop
input from the terminal. XON/XOFF flow control is normally
disabled in Transparent Mode, since all characters are treated as
data. If you cannot use DTR/CTS flow control, you may enable the
XON and XOFF characters (the commands from the TNC to the
terminal) by setting TXFLOW ON and XFLOW ON. The START and STOP
characters (the commands to the TNC from the terminal) can be
enabled in Transparent Mode by setting TRFLOW ON. Note that the
mode is no longer truly transparent when these features are
enabled.

Hardware Flow Control

Hardware flow control is less likely to depend on the programming
of a particular communications program.   DTR and CTS are
normally used for flow control signals in Transparent Mode. The
command XFLOW OFF enables hardware flow control in Converse Mode
and Command Mode.   Your computer may receive as many as 2
characters after it signals the TNC to stop sending, since some
characters may already be "in route" through serial I/O chips.
Refer to Chapter 7, Hardware for details on the interface
required for hardware flow control.

Type-in Flow Control

Type-in flow control, enabled with the command FLOW, is really a
display feature. It can keep the TNC from interrupting you with
incoming packets when you are in the middle of typing a command
line or an outgoing packet. As soon as you type the first char-
acter of a line, the TNC will put a "hold" on all output (except
for echoing your input). The "hold" remains in effect until you
type a <CR> to end the command line, or a send-packet character
to mark the end of a packet, or until you erase or re-display the
line you have started.

Some computers have difficulty simultaneously sending and receiving characters over the serial port. This is most commonly the case for computers with "software UARTs." Type-in flow control will improve the operation of such computers with the TNC.

Packet Operation

The previous chapter's discussion of "Basic Operation" contains enough information for most packet operation. This section describes a few other aspects of packet operation.

Station Identification

Your station identification (call sign) is set with the command MYCALL, as described in the previous chapter. If you will have more than one station on the air operating with the same call sign, they must be distinguished -- no two stations can have identical station identifications, or the packet protocol will fail. You can distinguish additional stations by setting the "secondary station ID", or SSID. This is a number from 0 to 15, appended to the call sign with a dash:

     cmd:MYCALL W3IWI-3

If you don't specify the SSID extension, it will be 0, and the TNC won't explicitly show SSIDs that are 0. If you want to connect to a station with a SSID other than 0, or use such a station as a digipeater, you must specify the SSID:

     cmd:CONNECT AD7I-2
  or
     cmd:CONNECT WA7GXD VIA N7CL-5

The TNC can send an automatic identification packet every 9-1/2 minutes when your station is operating as a digipeater. You can enable this feature with the command HID ON. An ID packet is displayed as follows by a monitoring station:

     W3IWI-3>ID:W3IWI/R

You can request a final identification as you take your station off the air with the command ID. The TNC will only send identification packets if it has been digipeating.

Automatic Operations

Normally, any packet station can be used by other stations for
relaying, or digipeating, packets to a more remote destination.
If you don't want your station digipeating packets, you can give
the command DIGIPEAT OFF.   Unless there are special
circumstances, such as a station operating on emergency power,
most packet operators set DIGIPEAT ON in the spirit of Amateur
cooperation.

Your station will normally accept a connect request from another
station if it isn't already connected.   You can disable this
capability by setting CONOK OFF. If you receive a connect
request when CONOK is OFF, the TNC will display the message

         *** connect request: <callsign>

and send a "busy signal" rejection packet to the other station.
If you receive a rejection packet from a station you try to
connect to, your TNC will display

         *** <callsign> busy
         *** DISCONNECTED

If you want to have a special message sent automatically to
stations connecting to you, you can specify the message with the
command CTEXT. This message can consist of any text string up to
120 characters, and you may include <CR>s by prefixing them with
the pass character:

         cmd:CTEXT Sorry, I can't talk right now.<CTRL-V><CR>
         I'll be on the air again after 8 PM.<CTRL-V><CR>
            Joe

In order for this message to be sent to stations connecting to
you, you must set CONOK ON so that the connection takes place
(default), and enable the automatic message with CMSG ON.

If you want to leave you station on but inhibit transmitting, you
can set XMITOK OFF. If you do this, you would normally set CONOK
OFF as well.

You can have your station periodically send an automatic message
by enabling "beacons."   A beacon can be used to make
general-interest announcements, provide packets for other
stations to use to test their ability to receive, or announce the
presence of a bulletin-board operation. The beacon message is
set with the command BTEXT, which works the same way as the CTEXT
command. You enable beacon transmission and set the frequency at
which beacons are sent with the command BEACON. To transmit the
beacon at 10-second intervals, for example, give the command

     cmd:BEACON EVERY 1

The beacon function also has a transmit-after mode, enabled by
using the keyword AFTER in place of EVERY, in which a beacon
packet is only transmitted after activity is heard on the
channel. This feature might be used to leave an announcement for
other packet users. If someone transmits on an otherwise idle
channel, a beacon can be sent a short time later. No beacons are
sent in this mode if there is a lot of packet activity on the
channel, since the required period of quiet will not occur.

Packet Formatting

The maximum length of a packet is determined by the command
PACLEN. If you type more than the maximum number of characters
without entering a send-packet character, the TNC will transmit a
maximum-length packet.   In Transparent Mode, a packet will be
sent if the maximum number of characters is entered before the
delay conditions set by PACTIME force a packet to be sent. Some
TNCs may not be able to accept packets longer than 128
characters.

If you have set the send-packet character to <CR>, you probably
want the <CR> to be included in the packet for display at the
other end. If you set the send-packet character to a special
non-printing character, you probably want the character to be
treated as a command only.   The command CR controls whether the
send-packet character is to be echoed and included in the packet.

You can add a <LF> after each <CR> included in your packets by
setting LFADD ON.   If the other station reports that lines are
overprinted on his display, and he can't remedy the situation at
his end, you can enable this function.

Commands Affecting Protocol

This section describes some of the commands that affect the
operation of the packet protocol.   Details of the protocol are
given in Chapter 9.

The TNC implements AX.25 Level 2 protocol, a set of rules for
formatting messages to other TNCs. The version of AX.25 Level 2
protocol used by the TNC can be set to Version 2.0 with the
command AX25L2V2 ON, or to Version 1.0 with the command AX25L2V2
OFF. Digipeating may not be successful if some TNCs are running
Version 1.0 and some are running Version 2.0. In addition, the
command CHECK controls a timing function that depends on the
protocol version selected.

You can specify the "address" to be used for unconnected packets,
as well as intermediate digipeaters with the UNPROTO command.
The format is similar to that of the CONNECT command:

        cmd:UNPROTO QST VIA NK6K

The default address for unconnected packets is CQ.

The following functions may be useful for tracking down protocol
problems. They are seldom useful for ordinary packet operations.
The error-checking function of the protocol is disabled for
monitored packets with the command PASSALL. If you set PASSALL
ON, any "packet" will be displayed if it meets the following
conditions: It must start with a flag sequence; and it must
contain an integral number of 8-bit bytes. The TRACE command
enables the display of the address and control fields of packets,
as well as the text. The trace function displays all bytes in
hex as well as ASCII equivalents.

Packet Timing Functions

Transmit Timing

Amateur radio equipment varies greatly in the time delays
required in switching from receive to transmit and from transmit
to receive. If the TNC starts sending data before the
transmitter is operating or before the receiver has had time to
switch from transmitting and lock up on the incoming signal, the
packet will not be received properly. The delay between trans-
mitter keyup and the beginning of data transmission is controlled
by the command TXDELAY. During the time the TNC is keying the
transmitter but not sending data, it will transmit a
synchronizing signal (flags).

If you are transmitting packets through an audio repeater, you
may require a considerably greater keyup delay than is required
for direct communications. Furthermore, the extra keyup delay is
not required if the repeater has not had time to "drop" since the
last transmission. The command AXDELAY allows you to specify an
additional keyup delay to allow the repeater receiver and
transmitter to lock up. The command AXHANG sets the time the TNC
will assume is required for the repeater to drop. If the TNC has
detected channel activity recently enough that the repeater
transmitter should still be on, it will wait only the TXDELAY
time before sending data, rather than adding an AXDELAY time as
well.
The commands TXDELAY, AXDELAY, and AXHANG all set times in units
of 10 ms. If AXDELAY is in effect the total keyup delay will be

   Keyup delay = (TXDELAY + AXDELAY) * 10

in milliseconds.   If channel activity has been heard more recently than AXHANG*10 ms ago, the keyup delay will only be

   Keyup delay = TXDELAY*10

in milliseconds.

Packet Timing

The AX.25 protocol provides for retransmitting packets if no acknowledgment is heard from the intended destination station within a certain period of time. A packet might not be acknowledged due to channel noise or "collision" with another packet transmission, and since there may be other stations on the channel, the receiving station may not be able to acknowledge the received packet immediately. The time lapse before the originating station retransmits the packet is set by the command FRACK (frame acknowledge time). The maximum number of retransmissions before the originating station terminates the connection is set by the command RETRY. The maximum number of transmissions of a packet is RETRY+1, since the initial transmission does not count as a retransmission. Setting RETRY to 0 specifies an infinite number of retries.

The frame-acknowledge time is automatically corrected for the additional time required for digipeating. The time in-terval before TNC 2 retransmits an unacknowledged packet is

   Retry interval = FRACK * (2*n + 1)

in seconds, where n is the number of digipeaters in use for this connection.

Acknowledgments of digipeated packets are made from end to end, and digipeaters do not acknowledge the packets they relay. If there are several intermediate relays, the chance of either the original packet or the acknowledgment to be lost increases dras-tically. To reduce this problem, an automatic wait time can be imposed on any station not transmitting a digipeated packet. Stations waiting for a clear channel to transmit packets wait for this time interval after the channel clears before transmitting. This wait does not apply if the station will be transmitting one or more digipeated packets. This usually gives the digipeater a clear chance at the channel.
The wait time is set by the command DWAIT, which specifies 40 ms intervals. If no digipeating is being done by anyone in the local area, this parameter can be set to 0, but in any event it

should be set to the same value by all members of a local packet group.

In order to avoid unnecessary packet retries, the TNC implements a collision-avoidance strategy which applies to all packets except those being digipeated. On the second and subsequent transmissions of a particular packet, the TNC waits an additional random time after detecting a clear channel before beginning transmission. This prevents repeated collisions of transmissions by the same two stations. The random time is a multiple (0-15) of the TXDELAY time.

The interval, in milliseconds, between the TNC detecting carrier-drop and beginning to transmit is

    Wait time = DWAIT * 10

for the first transmission of a packet. For subsequent transmissions of the same packet the interval is

    Wait time = DWAIT * 10 + (r * TXDELAY) * 10

where r is a random number from 0 to 15. Thus, if your TNC is forced to re-transmit packets, you will occasionally hear a fairly long delay before transmission begins.

Multiple packets may be transmitted before waiting for an acknowledgment. This permits more efficient channel use when large amounts of data are being transferred. The maximum number of packets which the TNC will send before waiting for acknowledgment is specified by the command MAXFRAME. This does not mean that the TNC will wait until several packets have been entered before transmitting. MAXFRAME in combination with the command PACLEN, which sets the maximum number of characters in a packet, determines how much information can be sent in a single transmission. The best combination for efficient data transfer is determined partly by the channel quality and partly by the rate at which the terminal can process data. For a 1200 baud terminal data rate, you should start with a combination that produces about 300 characters outstanding at one time.

Radio Baud Rate

The radio data transmission rate is set by switches 6, 7 and 8 of DIP switch SW2 (Do not change these switches while power is on, and make sure only one of these three switches is ON at any time while the TNC is powered). The rates available are:

Table 5-2. DIP switch settings for
radio baud rates.

Radio Data Rate (baud)	SW2 Switch Setting		
	6	7	8
300	ON	OFF	OFF
1200	OFF	ON	OFF
9600	OFF	OFF	ON

Note that there is no relationship between terminal baud rate and
radio baud rate. In order to communicate with another packet
station you must use the same radio baud rates.   The length of
time required to send a given amount of information increases as
the baud rate decreases. For example, it takes four times as
long to send data at 300 baud as at 1200 baud. If you use slow
radio baud rates, you should limit the length of transmissions by
setting MAXFRAME to 1 and choosing PACLEN so that the hardware
watchdog timer does not disrupt your transmissions and channel
traffic is broken up frequently.

The Bell-202 compatible modem is optimized for a 1200 baud radio
data rate.   For HF operation at low baud rates, you should
reconfigure the modem as described in Chapter 7.   The on-board
modem is not useful at rates higher than 1200 baud. The TNC can
provide data signals at 9600 baud, but an external modem is
required for such operation.

Special Protocol Times

You can set up a connection timeout with the command CHECK, which
specifies a time in multiples of 10-second intervals. This
function prevents your TNC from getting stuck in a connection
when the other station disappears for longer than the specified
time. The TNC uses this time somewhat differently depending on
the setting of AX25L2V2.

The command RESPTIME sets a delay between the receipt of a packet
and the transmission of the acknowledgment packet. This delay is
used to prevent collision between an acknowledgment and another
packet from the sending station.   This is primarily necessary
during file transfers; otherwise the delay is best set to 0.
During file transfers the stations receiving the file should set
RESPTIME to 10 or 12 (default).

The timing of packet transmission in Transparent Mode is
determined by the command PACTIME. You can choose the way packet
transmission is timed.   If you are typing input to a remote

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computer it is usually best to have packets transmitted at
regular intervals. If your computer is operating a remote-host
or bulletin board program you should send packets after an
interval with no further input from the computer. You can enable
the use of PACTIME in Converse Mode with the command CPACTIME.

Monitor Functions

The TNC's protocol is designed for setting up "circuits" between
two stations. However it can also operate in a mode more
suitable for a "net" or "round-table" discussion with several
participants, although reliable reception of all transmissions by
every station cannot be guaranteed. This is done by enabling the
monitor functions. Most of the monitor functions are described
in Chapter 4.

Monitoring is enabled by the command MONITOR ON, and separate
monitor functions are individually enabled.

If connected packet QSOs are taking place on the frequency of
your group conversation, you may wish to ignore all connected
packets while your group operates in unconnected mode. The
command MALL OFF causes the TNC to ignore connected packets.

If you want to be able to monitor packet activity when your
station is not connected, but have all monitoring automatically
cease when you connect to someone, set MCON OFF.

If you want to monitor stations selectively, you can set up a
list of up to eight callsigns with the command LCALLS. The
callsigns in this list are regarded as "buddies," i.e., the only
stations you want to listen to if BUDLIST is ON. Otherwise, the
stations in the list will be ignored, and all other stations will
be monitored.

You can operate a group conversation with some data integrity by
having the stations connect in pairs and setting MALL ON and MCON
ON. This does not insure that every packet is received at every
station, but it does insure that a packet involved in a collision
will be retried. If you have an odd number of stations
participating in this sort of conversation, one station can
connect to himself via another station as digipeater.

For example, WB6YMH, WD0ETZ, WA0TTW, W1BEL, and K9NG wish to
carry on a group conversation. In order to make all the
transmissions as reliable as possible, the following connections
are made.

    WB6YMH connects to W1BEL

    WA0TTW connects to K9NG
    WD0ETZ connects to WD0ETZ via W1BEL

If each station specifies MCON ON and MALL ON, each station will
see the packets sent by all the others.

Ordinarily, only text packets are displayed.   If you want to see
some of the protocol packets, you can set MCOM ON and connect,
disconnect, disconnect acknowledgments, and DM (connect-request
rejection) packets will be displayed. For example,

    WB9FLW>N7CL <C>
    KV7B>N2WX <D>

indicate connect and disconnect packets.   Disconnect ac-
knowledgments are designated <UA>, and DM packets are <DM>.

You can cause the TNC to "filter" certain characters from
monitored packets with the command MFILTER. This allows you to
remove, for example, form-feeds, bell characters, or extra <LF>s
that may be necessary to the stations involved in a connection,
but which may interfere with your display. You can specify up to
four characters by giving the ASCII character codes in hex or
decimal.

Real-Time Clock and Time Stamping

You can enable the TNC's real-time clock by setting the date and
time with the command DAYTIME.   Once you have set the clock, you
can request the time by entering DAYTIME with no parameters. The
format of date and time display is controlled by the command
DAYUSA. If the TNC is powered off, DAYTIME will have to be
reset.

Monitored packets can be time-stamped if DAYTIME has been set.
To enable this function, set MSTAMP ON. You can also time-stamp
connect and disconnect messages with the command CONSTAMP ON.

HF and OSCAR

The TAPR TNC 2 is optimized for a local VHF FM environment: The
modem is configured for best response at 1200 baud. The settings
of MAXFRAME and PACLEN provide the possibility of several con-
tinuous frames of long data length.

The requirements for optimum performance with a typical HF or
OSCAR 10 path are very different. Lower signal to noise ratios
require lower baud rates, noise spikes and fades require shorter

packet lengths, and a higher rate of false carrier detects lowers the total usable dynamic range in the audio input. The TNC hardware and software can be reconfigured to improve throughput in these environments. For HF operation at 300 baud, we recommend setting MAXFRAME to 1.

The TNC detects a busy channel by monitoring the lock-detect signal from the demodulator. The presence of a lock-detect signal is indicated by the Data Carrier Detect (DCD) LED. Each time DCD goes off the TNC will start a DWAIT interval which must elapse before the channel is considered to be available. On a noisy channel spurious lock-detect signals may be generated. For HF and OSCAR operation you should set DWAIT to 0. The random wait before retry transmissions can be disabled by setting TXDELAY 0 and using AXDELAY to set the required keyup delay. Of course, AXHANG should be 0 for this application.

If you are operating a full-duplex radio station (simultaneous transmit and receive) such as an OSCAR 10 station, you should set FULLDUP ON. The TNC is always electrically capable of full duplex operation, but this parameter causes the protocol to behave differently in acknowledging packets. In addition, the TNC will ignore the state of the DCD line. You may be able to improve operation somewhat by disconnecting the DCD line at the modem connector (J4 pins 1-2).

Although intuition tells you that lower baud rates will reduce the number of packet retries, there is usually a small range between "too fast" and "too slow." A slower packet takes longer to transmit and is therefore a larger target for fades and static crashes. The entire packet must be received correctly in order to be accepted. Data rates of 1200 baud have been used on both HF and through OSCAR 10.

You can improve the response of the modem for low baud rates by calibrating the modulator and demodulator tones for a narrow shift, as described in the next section, and modifying the demodulator. This also permits the use of a narrow filter by the receiving station. You should set the demodulator center frequency so that it is midway between the high and low tones when the packet tones are centered in your passband. The modem parameters and timing constants are determined by the parts on headers U15 and U19. Consult the EXAR notes listed in the Bibliography for the procedure for determining component values. If you are dedicating your TNC to 300 baud operation, consider increasing the time-constant of the filter at U20 pin 3 by a factor of 4 (increase the capacitor value, not the resistor).

The on-board modem can be completely bypassed at connector J4. You can supply an external modem which uses other modulation

methods or higher baud rates. The interfaces available on J4 are
TTL levels. Refer to Chapter 7 for more information.

Modem Calibration using CAL and RXCAL

The TAPR TNC 2 contains a versatile, user configurable FSK modem
that is suitable for both 1200 baud packet use as well as lower
data rate use, such as 200 Hz shift 300 baud use on HF links.
Calibration of the modem is usually only required when the unit
is initially put into operation or when you want to change the
modem characteristics. You may want to check the calibration if
you have difficulty connecting to other packet stations, but
recalibration is normally not necessary.

Calibration of the TNC on-board modem is straightforward. First,
determine the data rate at which you wish to operate. The
required shift may then be determined, followed by the actual FSK
frequencies to use. While you may select from any tones in the
normal audio range, there are a few simple rules that may help.

1. The TNC only supports 300 baud and 1200 baud operation of the
radio link using the on-board modem. While the modem is capable
of operating at other data rates, the TNC data-rate generator
circuit only supplies clocks for 300, 1200 and 9600 baud (9600
baud is for use with an external modem).

2. Most 1200 baud operation uses 1000 Hz shift and tones of 1200
Hz and 2200 Hz. These are the default tones for which the TNC
modem is optimized, using the components supplied in the kit.
However, 800 Hz shift with tones of 1300 Hz and 2100 Hz may
provide improved operation.   This tone-pair is compatible with
TNCs using 1000 Hz shift modems.

3.   Most HF operation below 28 MHz uses 300 baud, 200 Hz shift
FSK. TAPR recommends 1600 Hz and 1800 Hz as the modulator tone
frequencies, but any pair of frequencies with this separation,
modulating an SSB transmitter, will work. If your demodulation
center frequency is 1700 Hz, your transmissions will be readable
whenever you are able to copy the other station, regardless of
his actual modulation frequencies.   Incidentally, the sideband
may be chosen at will due to the nature of the data, although
most stations conventionally use LSB.

In the example below we will set up the modem for normal 1200
baud operation with 800 Hz shift.

The software calibration routine compares the frequency being
calibrated against a reference signal. The desired frequency is
specified by setting a count, n, using the command CALSET.

For the modulator, determine the calibration count according to the following formula:

$$n = (525{,}000 / f) + 1$$

where f is the desired frequency in Hertz. Substituting 1300 and 2100 Hz, we end up with:

    n = 405 (for 1300 Hz)
    n = 251 (for 2100 Hz)

To set the PLL demodulator, we use the RXCAL command, explained below.

Modulator Adjustment

The next step is to preset the trimpots for the modulator. When adjusting the trimpots, you should hear a soft "click" when the element is adjusted to the end of its travel. Turning the element past this point will not result in damage to the trimpot; however, it is suggested that you do not make a practice of turning the adjustment screw past this point too much. Use a small-tipped screwdriver or special trimpot adjusting tool when adjusting the trimpots.

Preset R77 20 turns counter-clockwise (CCW) or until you hear the element "click" at full CCW rotation. R77 controls the higher of the two modulator output tones and this sets it to its maximum frequency.

Preset R78 20 turns clockwise (CW) or until you hear the element "click" at full CW rotation. R78 controls the lower of the two modulator output tones and this sets it to its lowest frequency.

Turn off the power to the TNC and remove it from its cabinet. To protect the battery backed-up RAM, be sure to set the TNC on a non-conducting surface -- a sheet of paper will do. Attach your terminal and follow the standard power-up procedure. When you see the command mode prompt, enter

    cmd:CALSET 405

or use the value appropriate for the lower modulator tone. Next, enter

    cmd:CALIBRA

This starts the software calibration routine. The "commands" to the calibration routine are single characters, and require no carriage return.

Install a push-on jumper at JMP9 pins 1 and 6 (the top two pins of JMP9 nearest C44) and another push-on jumper at JMP4.

NOTE: During calibration the STA and CON LEDs are used as frequency indicators. When the STA LED is glowing, the frequency is too high, go lower. When the CON LED is glowing, the frequency is too low, go higher.

Press the K key on your computer. Either the STA or CON LED should illuminate. Next, press the space bar on your keyboard and verify that the other LED (CON or STA) illuminates in place of the one illuminated in the preceding step. Press the space bar again until the CON LED is illuminated.

Slowly rotate the adjustment screw on trimpot R78 in the CCW direction until both the STA and CON LEDs illuminate. The LEDs are a bit slow to respond, so be careful when the STA LED begins to flicker. You will probably notice a portion of the adjustment when both LEDs illuminate; set the adjustment screw to the center of this band. If you go too far, only the STA LED will be illuminated; in this case, turn the adjustment screw CW.

When both LEDs are steadily illuminated, press the Q key. Both LEDs should extinguish and the command mode prompt should reappear. The lower tone is now calibrated.

To calibrate the upper tone, enter

        cmd:CALSET 251

or use the value appropriate for the higher modulator tone. Next, enter

        cmd:CALIBRA

Now press the K key. Either the CON or the STA LED should illuminate. Tap the space bar until the STA LED glows.

Slowly rotate the adjustment screw of trimpot R77 CW, following the instructions above for setting R78. Continue the adjustment until both the STA and CON LEDs glow steadily.

When both LEDs are steadily illuminated, press the Q key. Both LEDs should extinguish and the command mode prompt should reappear. Remove the jumpers at JMP9 pins 1 & 6 and at JMP4.

Demodulator Adjustment

NOTE: Do not remove the jumper at JMP8 for demodulator calibration!

To calibrate the PLL demodulator, preset R79 20 turns clockwise (CW) or until you hear the element "click" at full CW rotation. Place a jumper across JMP9 pins 3 and 4 (the lowest two pins -- these are the two pins nearest the silkscreen legend "C43"). Install a push-on jumper at JMP4 (to disable the transmitter PTT watchdog timer) and another at JMP7 (to establish "analog loopback"). Enter

        cmd:RXCAL

at the computer or terminal keyboard.

Now press the K key. The STA LED should illuminate.

Slowly rotate the adjustment screw of R79 CCW until both the STA and CON LEDs glow. This is a very difficult condition to achieve, partly because the indicator is quite sensitive and partly because the LEDs lag the adjustment by a second or two. However, if you establish the position of the trimpot where the LEDs toggle and leave R79 set to within about 1/4 turn of that position there will be no degradtion in performance.

Type Q and note that the command mode prompt reappears.   Remove the jumpers at JMP4, JMP7 and JMP9.   Your TNC 2 modem is now calibrated to the tones you have selected.

Other Considerations

If you are operating at a data rate other than 1200 baud, the loop timing components on your demodulator will not be optimum. The table below lists the component values for the two most common FSK pairs as well as CALSET parameters.

Modem Calibration Parameters.

Data rate	1200 baud	300 baud
Shift	800 Hz	200 Hz
Center Freq	1700 Hz	1700 Hz
Upper Freq	2100 Hz	1800 Hz
Lower Freq	1300 Hz	1600 Hz
C54	2200 pF	0.01 uF
R93	47.5 k	226 k

CALSET Parameters

High Tone (R77)	251	293
Low Tone (R78)	405	329

NOTE: Components used for R93 and C54 should have temperature-stable characteristics.

Finally, it is best to match the IF bandwidth of your receiver to the data rate you will operate. For 300 baud HF operation, a filter of about 500 Hz bandwidth is optimum; any CW filter wider than this should be better than an SSB bandwidth filter!

Chapter 6 TAPR TNC 2 COMMANDS

This chapter serves as a complete reference to all TNC commands.
Commands are used to control the many variable values which
affect your TNC's operation, as well as causing it to perform
specific actions, such as connecting to another station to start
a QSO. You can enter a command to your TNC whenever you see the
command-mode prompt:

    cmd:

You will change parameters and issue instructions to the TNC by
typing   commands composed   of English-like   words or   word
abbreviations, which are called keywords, and variables which are
numbers or strings of characters chosen by the user.   You will
probably never change some of these parameters; however, one of
TAPR's goals is to allow each user maximum flexibility to adapt
the TNC to his environment.

Entering Commands

You may use either upper case (capital letters) or lower case
(small letters) when you enter commands.   In order to have your
TNC accept a command line, you must finish the line with a <CR>,
or carriage return character. This won't be mentioned explicitly
in the examples below. Before you type the final <CR> of your
command, you can correct typing mistakes or cancel the line
completely.   See Chapter 4 for a discussion of input line
editing.

This chapter will use UPPER CASE for commands and lower case for
explanatory text. In examples showing input typed by the user
together with the responses of the TNC, the user's input will be
shown in bold face.

Whenever the TNC accepts a command which changes a value, it will
display the previous value. For example, if you type

    XFLOW OFF

you might see the display

    XFLOW was ON

This reminds you of what you have done, and indicates that the
value has been successfully changed.

If you type something your TNC can't understand you will get an
error message. If you type an unrecognized command, you will see
the message ?EH.   If you get a command name correct, but the
arguments are wrong, you will see the message ?BAD. A complete
list of error messages appears at the end of this chapter. For
example,

        cmd:ASDFASDF || This isn't a command.
        ?EH
        cmd:BEACON E || A parameter was left out.
        ?BAD

Command List

The commands are listed alphabetically, and each command entry
contains several sections, as follows.

COMMAND NAME

The boldface command name at the top of the entry is the word you
will type in order to have your TNC execute this command. The
command name is printed with some letters underlined. These let-
ters form the minimum abbreviation that you may use and still
have your TNC understand your command. Of course, you may type
out the entire command word, or any abbreviation longer than the
minimum abbreviation, if you like.

For example, the command MYCALL may be specified by simply typing
MY.   The abbreviation M is not sufficient (and will be
interpreted as a different command), but MY, MYC, MYCA, MYCAL or
MYCALL are all acceptable.

If the command requires parameters, they will be indicated after
the command name.

Default

For commands that set values, your TNC assumes a "most often
used" or default condition.   The defaults are the values stored
in EPROM which are loaded into RAM when the system is first
powered up, or when you give the RESET command.   Immediate
commands perform actions rather than setting values, and don't
have defaults.

Parameters

There are several types of parameters. Some parameters can have
one of only two values, such as ON and OFF or EVERY and AFTER.
If a parameter must be one of two values, the choices are shown

separated by a vertical bar. You may use YES instead of ON and
NO instead of OFF.

A parameter designated as n is a numeric value. These values may
be entered as ordinary decimal numbers, or as hexadecimal, or
"hex", numbers by preceding the number with a $ symbol. When
the TNC shows some of these numeric parameters (those which set
special characters), they will be given in hex. The "digits" of
a hex number represent powers of 16, analogous to the powers of
10 represented by a decimal number. The numbers 10 through 15
are denoted by the hex digits A through F. For example,

   $1B = 1*16 + 11 = 27
   $120 = 1*16*16 + 2*16 + 0 = 288

A parameter designated as text, such as the argument to CTEXT,
may be entered in upper or lower case, and may include numbers,
spaces, and punctuation. The text is accepted exactly as typed
by the user.

Several commands require callsigns as parameters. While these
parameters are normally Amateur call signs, they may actually be
any collection of numbers and at least one letter up to six
characters; they are used to identify stations sending and
receiving packets. A callsign may additionally include
sub-station ID (SSID), which is a decimal number from 0 to 15
used to distinguish two or more stations on the air with the same
Amateur call (such as a base station and a repeater). The call
sign and SSID are entered and displayed as call-n, e.g., K0PFX-3.
If the SSID is not entered, it is set to 0, and SSIDs of 0 are
not displayed by the TNC.

Some commands have parameters which are actually lists of items.
For example, you may specify as many as eight callsigns to be
selectively monitored with the command LCALLS. The second and
later items in the list are optional, and you may separate the
list items with blank spaces or with commas.

   BEACON EVERY|AFTER n

means that the command BEACON requires an argument which must be
either EVERY or AFTER (abbreviated to E or A), and an argument n
which the user may choose from a range of values. An acceptable
command might be BEACON E 2.

   CONNECT call1 [VIA call2[,call3...,call9]]

means that the command CONNECT requires a callsign argument
call1. You may optionally include the keyword VIA, followed by a
list of one to eight callsigns, call2 through call9. The
callsigns in the list, if included, must be separated by commas
(as shown), or by blank spaces. An acceptable command might be C
N2WX V AD7I WB9FLW.

You can see the current value of the command's arguments by
typing the command name by itself, without any arguments. For
example,

```
cmd:CONOK Y       || Sets the value to YES (ON).
CONOK was OFF  || Displays previous value.
cmd:CONOK         || Command with no arguments
CONOK ON          || Displays present value.
```

A special command, DISPLAY, allows you to see the values of all
parameters or groups of related parameters.

Remarks

This section describes the command's action and the meaning of
each argument. Examples may be included of situations in which
the command might be used.

8BITCONV ON|OFF   Default: OFF
                         Display Group: A

Parameters:

   ON   The high-order bit is not stripped in Converse Mode.

   OFF The high-order bit is stripped in Converse Mode.

This command enables transmission of 8-bit data in Converse Mode.
If 8BITCONV is OFF, the high-order bit (bit 7) of characters
received from the terminal is removed before the characters are
transmitted in a packet. The standard ASCII character set
requires only 7 bits, and the final bit is used as a parity bit
or ignored. Setting bit 7 in text characters transmitted over
the air may cause confusion at the other end.

If you need to transmit 8-bit data, but don't want all the
features of Transparent Mode, you should set 8BITCONV ON and
AWLEN 8. This may be desirable, for example, if you are using a
special non-ASCII character set.

Bit 7 is always removed in Command Mode, since commands require
only the standard 7-bit ASCII character set.

ACKPRIOR ON|OFF   Default: ON
                         Display Group: L

Parameters:

   ON   Enables Prioritized acknowledgments.

   OFF Acknowledgments have the same priority as any other
        frames on the channel.

When ACKPRIOR is ON, acknowledgments have priority. This means
that is your TNC receives a frame that it must acknowledge (ACK),
it will immediately send the ACK if the channel is clear. If
other stations are running with ACKPRIOR ON, they will not access
the channel until you have had a chance to send the ACK, even if
they cannot hear your transmissions.

When OFF, acknowledgments are queued up for transmission the same
as any other frame.

ACKTIME n   Default: 14
                              Display Group: T

Parameters:

    n   0-250 in 10 mSec increments.

ACKTIME specifies the time required to send an RR or RNR response
frame (an acknowledgment) to an I frame at the radio port data
rate. This corresponds to about 510 mSec at 1200 bps with 8
digipeaters and about 140 mSec at 1200 bps with no digipeaters.
The default of 140 mSec (ACKT 14) allows for no digipeaters.

ANSWRQRA ON|OFF   Default: ON

Setting ANSWRQRA to OFF disables the TNC's ping-response func-
tion. When the parameter is set ON, the TNC responds to non-
digipeated UI frames addressed to QRA, within 1 to 16 seconds,
with an empty ID packet. TNC-2 ignores QRA packets when ANSWRQRA
is off.

AUTOLF ON|OFF   Default: ON
                             Display Group: A

Parameters:

   ON   A linefeed character (<LF>) is sent to the terminal
      after each carriage return character (<CR>).

   OFF   A <LF> is not sent to the terminal after each <CR>.

AUTOLF controls the display of carriage return characters
received in packets as well as echoing those that are typed in.

If the TNC's sign-on message lines appear to be typed over each
other, you should set AUTOLF ON. If the TNC's sign-on message
appears to be double-spaced, you should set AUTOLF OFF. If the
TNC's sign-on message appears to be single-spaced, you have
AUTOLF set correctly.

This command only affects what is displayed, not the data sent in
packets. If you want to add linefeed characters to outgoing
packets, use the command LFADD.

AWLEN n   Default: 7
                        Display Group: A

Parameters:

   n   7 - 8, specifying the number of data bits per
          word.

This value defines the word length used by the serial IO terminal
port.

For most packet operations, including conversation, bulletin
board operation, and transmission of ASCII files, you should set
AWLEN 7. If 8 bit words are transmitted to the TNC in Command
Mode or Converse Mode, the eighth bit is normally removed,
leaving a standard ASCII character, regardless of the setting of
AWLEN.

To transmit and receive packets retaining all 8 data bits of each
character, as you need to do if you send executable files or
other special data, you should use Transparent Mode and set AWLEN
8. Alternatively, you can use Converse Mode and set AWLEN 8 and
8BITCONV ON (however, the data you then send must handle the
Converse Mode special characters with the PASS prefix).

AX25L2V2 ON|OFF   Default: ON
                        Display Group: L

Parameters:

   ON   The TNC will use AX.25 Level 2 Version 2.0 protocol.

   OFF The TNC will use AX.25 Level 2 Version 1.0 protocol.

Some implementations of the earlier version of AX.25 protocol
(e.g., TAPR's TNC 1 running TAPR 3.x firmware) won't properly
digipeat version 2.0 AX.25 packets.   This command exists to
provide compatibility with these other TNCs until their software
has been updated.

In addition, some HF packet operators prefer AX.25 Version 1.0
protocol due to its reduced overhead during retries.

AXDELAY n   Default: 0
                                Display Group: T

Parameters:

    n   0 - 180, specifying the voice repeater keyup delay
          in 10 ms intervals.

AXDELAY specifies a period of time the TNC is to wait, in
addition to the normal delay set by TXDELAY, after keying the
transmitter and before data is sent. This feature will be used
by groups using a standard "voice" repeater to extend the range
of the local area network. Repeaters with slow mechanical
relays, split sites, or other circuits which delay transmission
for some time after the RF carrier is present require some amount
of time to get RF on the air.

If you are using a repeater that hasn't been used for packet
operations before, you will have to experiment to find the best
value for n. If other packet stations have been using the
repeater, check with them for the proper setting. This command
acts in conjunction with AXHANG.

Note that the TAPR TNC 1 and other TNCs using the same version
3.x firmware interpret n in 120 ms intervals. The value set by
AXDELAY on TNC 2 will thus be 12 times the value used by a TNC 1
user to give the same delay time.

AXHANG n   Default: 0
                          Display Group: T

Parameters:

   n   0 - 20, specifying the voice repeater hang time in
           100 ms intervals.

This value can be used to increase channel efficiency when an
audio repeater with a hang time greater than 100 ms is used. For
a repeater with a long hang time, it is not necessary to wait for
the repeater keyup delay after keying the transmitter if the
repeater is still transmitting. If the TNC has heard a packet
sent within the hang period, it will not add the repeater keyup
delay (AXDELAY) to the keyup time.

If you are using a repeater that hasn't been used for packet
operations before, you will have to experiment to find the best
value for n. If other packet stations have been using the
repeater, check with them for the proper setting.

Note that the TAPR TNC 1 and other TNCs using the same version
3.x firmware interpret n in 120 ms intervals. The value you set
on TNC 2 for AXHANG will thus be 6/5 the value used by a TNC 1
user for the same hang time (when converting, round down to the
nearest integer).

BBSMSGS ON|OFF   Default: OFF
                              Display Group: A

This command controls how the TNC displays certain messages in
COMMAND and CONVERSE modes. The messages affected are described
below:

MESSAGE   EFFECT WHEN BBSMSGS ON

*** CONNECTED to xxxx   - A newline added preceding "***"
*** DISCONNECTED   -   "   "
*** retry limit exceeded -   "   "
*** xxxx Busy   -   "   "
*** FRMR sent   -   "   "
*** FRMR rcvd   -   "   "

*** Connect request: xxxx   -   This message is omitted

The BBSMSGS command is primarily useful for host operation, such
as with W0RLI and similar bulletin board systems that require
link status messages to begin in the first output column.

The connect request message is omitted during BBSMSGS mode. This
should be most useful for preventing corruption of messages when
forwarding with small frames.

BEACON EVERY|AFTER n   Default: EVERY 0
                          Display Group: I

Parameters:

   EVERY   Send beacon at regular intervals.

   AFTER   Send beacon once after the specified time interval
          with no packet activity.

   n   0 - 250, specifying beacon timing in 10 second
          intervals. A value of 0 disables the beacon.

This command enables beacon sending and causes the first beacon
frame to be transmitted. A beacon frame consists of the text
specified by BTEXT in a packet addressed to "BEACON" and sent via
the digipeat addresses specified by the UNPROTO command, if any.

If the keyword EVERY is specified, a beacon packet is sent every
n*10 seconds.   This mode might be used to transmit packets for
testing purposes.

If AFTER is specified, a beacon is sent only after n*10 seconds
have passed with no packet activity. In this case, the beacon is
sent only once until further activity is detected. This mode can
be used to send announcements or test messages only when packet
stations are on the air. If you choose n properly you can avoid
cluttering a busy channel with unnecessary transmissions.

Beacon frames from other TNCs can be monitored by setting MONITOR
ON.

BKONDEL ON|OFF   Default: ON
                            Display Group: C

Parameters:

   ON   The sequence <BACKSPACE> <SPACE> <BACKSPACE> is echoed
       when a character is deleted from the input line.

   OFF The <BACKSLASH> character (\) is echoed when a
       character is deleted.

This command determines the way the display is updated to reflect
a character deletion in Command Mode or Converse Mode.

The <BACKSPACE> <SPACE> <BACKSPACE> sequence will properly update
the screen of a video display.   If you have a video display
terminal or computer, you should set BKONDEL ON.

The <BACKSPACE> <SPACE> <BACKSPACE> sequence on a printing
terminal would result in overtyped text.   If you have a
paper-output display, or if your terminal does not respond to the
<BACKSPACE> character (<CTRL-H>), you should set BKONDEL OFF.
The TNC will type a <BACKSLASH> for each character you delete.
You can display the corrected input line by typing the
redisplay-line character, which is set by the command REDISPLA.

NOTE: BKONDEL is only active in COMMAND and CONVERSE modes.

BTEXT text   Default: ""
                                 Display Group: I

Parameters:

   text Any combination of characters and spaces, up to a
     maximum length of 120 characters.

BTEXT specifies the content of the data portion of a beacon
packet. The default text is an empty string, i.e., no message.
Beacon packets are discussed in more detail under the BEACON
command.

You can send multiple-line messages in your beacon by including
carriage return (<CR>) characters in the text.   The <CR>
character can be included by preceding it with the pass charac-
ter. The pass character is set by the PASS command. If you
enter a text string longer than 120 characters, an error message
will appear and the command will be ignored.

For example, a Bulletin Board program might set the beacon text
to a message like this, updating the text after each connection:

   Mailbox on line. Messages for WB9FLW, AD7I, K9NG.

To clear the BTEXT text without issuing the RESET command, use a
% or & character as the first character in the text.

The BTEXT text is stored in battery-backed RAM.

BUDLIST ON|OFF   Default: OFF
                        Display Group: M

Parameters:

   ON   Ignore frames from stations which are not in the LCALLS
        list.

   OFF Ignore frame from stations which are in the LCALLS
        list.

BUDLIST works in conjunction with the command LCALLS, which sets
up a callsign list. These commands determine which packets will
be displayed when you have set MONITOR ON. BUDLIST specifies
whether the callsigns in the list are the ones you want to ignore
or, alternatively, are the only ones you want to listen to.

If you want to listen only for packets from a limited list, you
should enter this list with LCALLS and set BUDLIST ON.   You can
use this feature, for example, to have your TNC "keep an ear out"
for a particular station while you converse with someone else.

If you want to ignore packets from a limited list, you should
list the callsigns to ignore in LCALLS and set BUDLIST OFF. For
example, if there is a bulletin board on frequency, you can
ignore it while monitoring other conversations.

CALIBRA
                        Display Group: NONE

CALIBRA is an immediate command, and is used to transfer control
to the modem calibration routine. Calibration may be performed
at any time without altering the current link state.

Briefly, the commands available in the calibration routine are:

   <SPACE> Switch the transmit audio to the other tone.
      D   Alternate between the two transmit tones at a
               rate determined by the radio port data rate.
      K   Toggle PTT line on/off.
      Q   Quit calibration routine.

Calibration of the modem tones is described in the modem
calibration section of Chapter 5. Adjustment of the tone levels
using CALIBRA is described in Chapter 3. See also RXCAL.

CALSET n   Default: None
                              Display Group: T

Parameters:

   n   0 - 65535, specifying the count setting for use by
            the calibration routine.

The number to be specified by CALSET is determined by the
frequency f to be calibrated as follows.

   $n = (525,000 / f) + 1$ (modulator tones)
   $n = (262,500 / f) + 1$ (demodulator tones)

Round n to the nearest integer. To calibrate the modem tones,
you will set n for the desired frequency using CALSET, enter the
calibration routine with CALIBRA, and adjust the tone following
the instructions in Chapter 5. To calibrate the next tone, exit
the calibration routine and set n for the next frequency.

See also RXCAL.

CANLINE n   Default: $18 <CTRL-X>
                                   Display Group: C

Parameters:

   n   0 - $7F, specifying an ASCII character code.

This command is used to change the cancel-line input editing
command character.   The parameter n is the ASCII code for the
character you want to type in order to cancel an input line. You
can enter the code in either hex or decimal.

For example, to change the cancel-line character to <CTRL-U>, you
would set CANLINE $15 or CANLINE 21.

If you cancel an input line in Command Mode, the line will be
terminated with a <BACKSLASH> character, and you will see a new
cmd: prompt. If you cancel a line in Converse Mode, you will see
only the <BACKSLASH> and a new line.   You can cancel only the
line you are currently typing. Once a <CR> has been entered, you
can not cancel that input line using the cancel-line character.
Note that if your send-packet character is not <CR>, the
cancel-line character will cancel only the last line of a
multi-line packet. To cancel the entire packet, use the CANPAC
character.

Line cancellation, like all other input editing features, is
disabled in Transparent Mode.

CANPAC n   Default: $19 <CTRL-Y>
                                      Display Group: C

Parameters:

    n   0 - $7F, specifying an ASCII character code.

CANPAC is used to change the cancel-packet input editing command
character.   The parameter n is the ASCII code for the character
you want to type in order to cancel an input packet.   You can
enter the code in either hex or decimal.

If you cancel a packet in Converse Mode, the line will be
terminated with a <BACKSLASH> character and a new line. You can
only cancel the packet that is currently being entered. Once you
have typed the send-packet character, or waited PACTIME (if
CPACTIME enabled), the packet can not be canceled even if it has
not been transmitted.

Packet cancellation, like other input editing features, is
disabled in Transparent Mode.

Cancel Display Output

The cancel-packet character also functions to cancel display
output in Command Mode. If you are in Command Mode and type the
cancel-packet character, any characters that would be typed on
the screen (except echoed characters) are "thrown away" by the
TNC. Typing the cancel-output character a second time restores
normal output. To see how this works, try typing DISPLAY, then
type a <CTRL-Y>. The command list display will stop. You won't
see any response from the TNC to commands. Now type another
<CTRL-Y>, and type DISPLAY again to see that the display is back
to normal.

You can use the cancel-display feature if you inadvertently do
something that causes the TNC to generate large amounts of output
to the terminal, such as giving the DISPLAY command or setting
TRACE ON. If you are in Converse Mode or Transparent Mode and
want to cancel display output, you must exit to Command Mode and
then type the cancel-packet character.

CBELL ON|OFF   Default: OFF
                              Display Group: I

Parameters:

   ON   Connect bell enabled.

   OFF Connect bell disabled.

This command is used to control whether an ASCII $07 (BELL) character is sent as part of the connected message.

When set ON, the bell character immediately precedes the asterisk portion of the connected message, e.g.:

   <BELL>*** Connected to: <callsign>

CHECK n   Default: 12
                                Display Group: T

Parameters:

    n   0 - 250, specifying the check time in 10 second
            intervals. A value of 0 disables this feature.

This command sets a connection time-out. If a link connection
exists between your TNC and another station, and the other
station "disappears," your TNC could remain in the connected
state indefinitely, refusing connections from other stations.
This might happen if propagation changes unexpectedly or an
intermediate digipeater station is turned off.   In order to
prevent this sort of lockup, the TNC will try to clean up the
link if the specified time elapses without any packets being
heard from the other TNC. The operation of this feature depends
on the setting of AX25L2V2.

If AX25L2V2 is ON, the TNC will send a "check packet" to verify
the presence of the other station if no packets have been heard
from it for n*10 seconds.   This frame contains no information,
but is interpreted by the receiving station's TNC as an inquiry
as to whether it is still connected.   If the receiving TNC is
still connected, it sends an appropriate response packet. If the
TNC initiating the inquiry does not hear a response after RETRY+1
attempts, it commences a disconnect sequence, as if the DISCONNE
command had been given.

If AX25L2V2 is OFF and the other station has not been heard for
n*10 seconds, the TNC will not attempt an inquiry, but will send
a disconnect packet, just as if you had typed the command
DISCONNE, unless CHECKV1 is OFF. See also CHECKV1.

CHECKV1 ON|OFF   Default: OFF
                        Display Group: T

Parameters:

   ON   Enables CHECKtime (T3) when running AX.25 Level 2
      Version 1.0 protocol. This will result in an automatic
      disconnect when packets haven't flowed between this TNC
      and the remote TNC for CHECKtime. See CHECK, above.

   OFF Disables the CHECKtime timer (T3) and requires the
      operator to initiate a disconnect sequence. This is in
      accordance with AX.25 Level 2 Version 1.0 procedures.

When ON, the CHECK (T3) timer is used to automatically disconnect
an AX.25 Level 2 Version 1.0 link when data hasn't flowed for
CHECK time.   Note that T3 is not defined for Version 1.0
operation. See CHECK, above.

When OFF, T3 is ignored and normal Version 1.0 procedures apply.

NOTE: Many operators prefer using Version 1.0 protocol,
especially on marginal or noisy links in order to eliminate some
of the overhead of AX.25 Level 2 Version 2.0 protocol.

CLKADJ n   Default: 0
                        Display Group: T

Parameters:

   n   0 - 65535, specifying the correction factor to be
        applied to the real-time clock routine.

A value of "0" is a special case and means no correction factor
will be applied. If the value of CLKADJ is non-zero, then the
correction factor is calculated as:

  relative clock speed in % = $100 - (9.16667 * 1/n)$

The real-time clock routine is used to keep track of year, month,
day, hour, minute and second as specified in the DAYTIME command.
It should be noted that the real-time clock is not intended to be
your ham-shack reference clock, but is useful for approximate
time stamping information.

CMDTIME n   Default: 1
                              Display Group: T

Parameters:

    n   0 - 250, specifying Transparent Mode time-out
          value in 1 second intervals.   If n is zero, the
          only exit from Transparent Mode is to send a BREAK
          signal or interrupt power to the TNC.

This command sets the Transparent Mode time-out value. In order
to allow escape to Command Mode from Transparent Mode while
permitting any character to be sent as data, a guard time of n
seconds is set up.

The same Command Mode entry character used for exit from Converse
Mode is used to exit Transparent Mode, but the procedure is
different. (The Command Mode entry character is set by COMMAND.)
Three Command Mode entry characters must be entered less than n
seconds apart, with no intervening characters, after a delay of n
seconds since the last characters were typed.   After a final
delay of n seconds, the TNC will exit Transparent Mode and enter
Command Mode. You should then see the prompt

    cmd:

The diagram below illustrates this timing.

```
last       first     second     third      TNC
terminal   command   command    command    now in
input      mode      mode       mode       Command
|          entry     entry      entry      Mode
|          character character  character   |
|          |         |          |          |
|          |         |          |          |
|<---longer--->|<-shorter->|<-shorter->|<-----n----->|
    than n      than n     than n
```

CMSG ON|OFF   Default: OFF
                          Display Group: I

Parameters:

    ON   The CTEXT message is sent as the first packet after a
       connection is established.

    OFF The CTEXT message is not sent.

CMSG enables automatic sending of the message set by CTEXT
whenever your TNC accepts a connect request from another TNC.

For example, if you have left your station running even though
you don't want to operate just now, you might want to set CMSG ON
to let people know that you can't talk when they connect to your
TNC. When you are ready to operate, you would set CMSG OFF.

CMSGDISC ON|OFF   Default: OFF
                          Display Group: I

Parameters:

    ON   Automatic disconnect enabled.

    OFF Automatic disconnect disabled.

This command controls whether the TNC will initiate a disconnect
sequence after it is connected to.

If CMSG is OFF, or CTEXT has no connected text, the TNC initiates
a disconnect immediately upon receiving information or
acknowledgment frames from the other station.

If CMSG is ON and CTEXT contains some text information, the TNC
initiates a disconnect after the packet containing connect text
(CTEXT) is acknowledged.

This command may be useful to bulletin board operators or others
with a need to send a short message, confirm its receipt, and
disconnect.

NOTE: Use this command with care - If you find you're able to
receive connects, yet never get data, it's possible CMSGDISC has
been left on. It's also possible is that RS-232 DCD is holding
the terminal off -- see Chapter 5 for details on hardware flow
control.

COMMAND n   Default: $03 <CTRL-C>
                                 Display Group: C

Parameters:

   n   0 - $7F, specifying an ASCII character code.

This command is used to change the Command Mode entry character.
You can enter the code in either hex or decimal.

Command Mode is entered from Converse Mode when this character is
typed. If you type the Command Mode entry character while you
are already in Command Mode, nothing will happen. To see how
this works, enter Converse Mode by typing CONVERS. Anything you
type will become packet data. Now type a <CTRL-C>. You will see
the Command Mode prompt, indicating successful exit to Command
Mode. The display might look like this:

   cmd:CONVERS
   Hello World! I'm on the air on packet radio!
   [enter <CTRL-C>]
   cmd:

See the entry under CMDTIME for information on how to use the
Command Mode entry character to escape from Transparent Mode.

CONMODE CONVERS|TRANS   Default: CONVERS
Display Group: L

Parameters:

CONVERS Sets automatic entry to Converse Mode when a connection is established.

TRANS   Sets automatic entry to Transparent Mode when a connection is established.

CONMODE controls which mode the TNC will be placed in after a connection. The connection may result either from a connect request received over the air or a connect initiated by a CONNECT command that you issue. For most operations, you would set CONMODE to CONVERS. However, if you are using Transparent Mode for a bulletin board program, for example, you would set CONMODE to TRANS so that the correct mode will be entered when your bulletin board receives a connect request.

If you initiate a connection with the CONNECT command, the timing of the entry into Converse or Transparent Mode is determined by NEWMODE.

If the TNC is already in Converse or Transparent Mode when the connection is completed, the mode will not be changed. If you have typed part of a command line when the connection is completed, the mode change will not take place until you complete the command or cancel the line. This prevents the last part of your command from inadvertently being sent as a packet.

CONNECT call1 [VIA call2[,call3...,call9]]
Display Group: NONE

Parameters:

  call1   Callsign of TNC to be connected to.

  call2   Optional callsign of TNC to be digipeated through.
           As many as eight digipeat addresses can be
           specified.

The part of the command line in brackets, VIA call2[,
call3...,call9] is optional.   The double-bracketed text,
,call3...,call9, is also optional, but would only be used if VIA
call2 is present. The brackets are not typed.

Each callsign may include an optional sub-station ID specified as
-n immediately following the callsign. The digipeat fields are
specified in the order in which you want them to relay the
packets to the destination, call1.

CONNECT is an immediate command. It initiates a connect request
to TNC call1, optionally through digipeaters. If NEWMODE is ON,
the TNC will immediately enter Converse Mode or Transparent Mode,
as specified by the command CONMODE. If NEWMODE is OFF, the TNC
will enter Converse Mode or Transparent Mode when the connection
is successfully completed.

An error message is returned if the TNC is in a connected state,
or is already attempting to connect or disconnect. If no
response to the connect request occurs after the number of
attempts specified by RETRY, the command is aborted and a message
is typed. The TNC returns to Command Mode if NEWMODE is ON. If
NEWMODE is OFF, the mode does not change, i.e. the TNC remains in
Command Mode.

For example, to connect to WA7GXD using N0ADI-1 (who is near your
QTH) and WD0ETZ (who is near GXD's QTH) as digipeaters, you would
type

    CONNECT WA7GXD VIA N0ADI-1,WD0ETZ

Packets coming back from WA7GXD access the digipeaters in the
opposite order. Thus, packets from WA7GXD will first be repeated
by WD0ETZ, then by N0ADI-1.

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CONOK ON|OFF   Default: ON
                      Display Group: L

Parameters:

   ON   Connect requests from other TNCs will be accepted.

   OFF Connect requests from other TNCs will be rejected.

This command determines the action taken by the TNC when a connect request for it is received though the radio. If CONOK is ON, the request will be acknowledged, the standard connect message will be typed and either Converse or Transparent Mode will be entered, depending on the setting of CONMODE.

If CONOK is OFF and the TNC is not in Transparent Mode, the TNC will notify you of the connect attempt with the following message.

   connect request: <call>

The callsign of the station trying to connect will replace <call>.

The TNC will also issue a DM packet, or "busy signal" to the requesting station. The user may then issue his own connect command. If your TNC receives a DM packet in response to a connect request, it will type the message

   *** <call> station busy

with the callsign of the station that sent the DM packet in place of <call>.

For example, if you want to leave your station running as a digipeater you might set CONOK OFF until you are ready for a conversation. If you get a connect request in the meantime, you can change your mind. Stations attempting to connect to your TNC will be able to see that the station is up but not available for connection (it might still be useful as a digipeater).

CONPERM ON|OFF   Default: OFF
                              Display Group: L

Parameters:

   ON   The current connection on the current stream will not
      be allowed to enter the disconnected state.

   OFF The current stream may be connected to and disconnected
      from other stations.

This command, when switched ON, forces the TNC to always maintain
the current connection, even when frames to the other station
exceed RETRY attempts to get an acknowledgment.   RESTART and
power off/on cycling will not affect this connected state.

This command only takes effect when a connection is established.
It functions on a stream-by-stream basis when multiple connec-
tions are allowed.

It is useful for certain networking applications, meteor scatter
and other noisy, less-reliable links, while still allowing con-
nections on other streams to operate normally (automatic discon-
nect based on RETRY, etc.).

CONSTAMP ON|OFF   Default: OFF
                              Display Group: M

Parameters:

   ON   Connect status messages are time stamped.

   OFF Connect status messages are not time stamped.

This command enables time stamping of *** CONNECTED status
messages. The date and time information is then available for
use by Bulletin Board programs or other computer applications.
The date and time must be set initially by the DAYTIME command
before time stamping will occur. The date format is determined
by the DAYUSA command.

For example, if CONSTAMP is ON, DAYUSA is ON, and the date and
time have been set, a connect message might appear as follows.

   *** CONNECTED to N2WX [05/28/85 16:28:31]

CONVERS
                              Display Group: NONE

CONVERS is an immediate command, and will cause the TNC to exit
from Command Mode into Converse Mode. Any link connections are
not affected. Once in Converse Mode, everything you type is
packetized and transmitted over the radio.   Typing the Command
Mode entry character returns the TNC to Command Mode. See the
discussions of Converse Mode in Chapters 4 and 5.

NOTE: The letter "K" may be used to more quickly enter CONVERS
mode.

CPACTIME ON|OFF   Default: OFF
                        Display Group: T

Parameters:

    ON   Packet time-out is used in Converse Mode.

    OFF Packet time-out is not used in Converse Mode.

This command enables the periodic automatic sending of packets in
Converse Mode.   This feature may be used for computer
communications, such as Bulletin Board operation, when the full
Transparent Mode features are not desired.

If CPACTIME is ON, characters are packetized and transmitted
periodically as they are in Transparent Mode, but local editing
and display features of Converse Mode are enabled, and software
flow control may be used.   For a discussion of how periodic
packetizing works, see the command PACTIME, which controls the
rate and mode of packet assembly.

You should set CR OFF in this mode, since otherwise the
send-packet character will be inserted in the data being
packetized even though it was not typed. In order to include
<CR> characters in transmitted packets, set SENDPAC to a normally
unused character (e.g., <CTRL-P>), at which point the TNC will
treat <CR> as an ordinary character.

You can set CPACTIME ON for a mode of operation similar to full
break-in CW, in which your text is transmitted soon after you
type it, but in short bursts of a few characters, and the other
station may break in at will. Some operators find it easier to
carry on a conversation in this mode, since it eliminates the
delays while long packets are being typed.

CR ON|OFF   Default: ON
                        Display Group: L

Parameters:

   ON   The send-packet character, normally <CR>, is appended
      to all packets sent in Converse Mode.

   OFF The send-packet character is not appended to packets.

When CR is ON, all packets sent in Converse Mode will include, as
the last character of the packet, the send-packet character which
forces the packet to be sent. If CR is OFF, the send-packet
character is interpreted solely as a command to the TNC, not as
data to be included in the packet, and furthermore, it will not
be echoed to the terminal.

Setting CR ON and SENDPAC $0D results in a natural conversation
mode. Each line is sent when a <CR> is entered, and arrives at
its destination with a <CR> at the end of the line. If the
station at the other end reports overprinting of lines on his
display, you can set LFADD ON, or the other   station can set
AUTOLF ON.

CSTATUS
                    Display Group: NONE

CSTATUS is an immediate command which shows the stream identifier
and link state of all ten streams (links), the current input and
output streams, and whether or not each stream is "permanent"
(see CONPERM).

An example of a display resulting from issuing a CSTATUS command
is:

 cmd:CS
 A stream - IO Link state is: CONNECTED to 305MLB
 B stream -   Link state is: CONNECTED to AD7I P
 C stream -   Link state is: DISCONNECTED
 D stream -   Link state is: CONNECTED to N0ADI via K9NG-2

 ...

 I stream -   Link state is: CONNECT in progress
 J stream -   Link state is: CONNECTED to KV7B via NK6K-1

The example above shows the A stream is assigned both the input
and output streams. The B stream is connected to AD7I "perma-
nently."   All other streams' states are shown as they might
normally appear with multiple connections.

CTEXT text   Default: ""
                              Display Group: I
Parameters:

   text Any combination of characters and spaces, up to a
     maximum length of 120 characters.

CTEXT specifies the text of the packet to be sent after a
connection is made, if CMSG is ON. The default text is an empty
string, i.e., no message.

You can send multiple-line messages by including carriage return
(<CR>) characters in the text.   The <CR> character can be
included by using the pass character immediately preceding it
(see the PASS command). If you enter a text string longer than
120 characters, an error message will appear and the command will
be ignored.

For example, you might set your CTEXT message to

   I'm not here right now, but you may leave a message.

To clear the CTEXT text without issuing a RESET command, use a %
or & as the first character in the message.

The CTEXT text is saved in battery-backed RAM.

DAYTIME date&time   Default: None
                                Display Group: NONE

Parameters:

   date&time Current date and time to set.

This command allows you to set the current date and time for the
TNC. The format for entering the date&time is

   yymmddhhmm

where yy is the last two digits of the year, mm is the two-digit
month code (01-12), dd is date (01-31), hh is the hour (00-23),
and mm is the minute after the hour (00-59). All these codes
must be exactly two digits, so that numbers from 0 to 9 must be
entered with leading zeroes.   The TNC does not check thoroughly
for the correct number of days in a month, so you should use some
judgment when you set the date.

The date&time parameter is used by the commands CONSTAMP and
MSTAMP to "time stamp" received and monitored messages. Entries
in the "heard" (displayed by MHEARD) are also time stamped if
date&time has been set.   The TNC's time is updated continuously
as long as it is powered up. You must reset the date and time
each time you turn on the TNC.   If you don't do this, the
commands CONSTAMP and MSTAMP will not enable time stamping.

If you type DAYTIME without a parameter, the TNC will display the
current date and time. The format of the display is dd-mm-yy
hh:mm if DAYUSA is OFF, and mm/dd/yy hh:mm if DAYUSA is ON. The
format for entering date&time is not affected. For example,

   cmd:DAYTIME 8402291530

sets the date and time to February 29, 1984 at 3:30 P.M.   The
display of the date and time, with DAYUSA ON would be:

   cmd:DAYTIME
   02/29/84 15:30:26

DAYUSA ON|OFF   Default: ON
                              Display Group: M

Parameters:

   ON   Date is displayed in the format mm/dd/yy.

   OFF Date is displayed in the format dd-mm-yy.

This command determines the format for the TNC's display of the
date. If DAYUSA is ON, the standard U.S. format is used; if
DAYUSA is OFF, the standard European format is used.   This
command affects the format of the date display used in "time
stamps" as well as the display when DAYTIME is entered without
parameters.   The format for entering the time using DAYTIME is
not affected.

For example, if DAYUSA is ON, then July 2, 1984 at 9:28:44 AM
would be displayed as

   cmd:DAYTIME
   07/02/84 9:28:44

If DAYUSA is OFF the same date and time would appear as

   cmd:DAYTIME
   02-07-84 9:28:44

DEADTIME n   Default: 33
                              Display Group: T

Parameters:

   n   0-250 in 10 mSec increments.

DEADTIME specifies the time it takes a station's receiver to
detect the fact that a remote transmitter has keyed up. It
should be set to the time of the slowest acceptable radio on the
channel.   It must also allow for any squelch delays and DCD lock
time.   DWAIT and TXDELAY should also be set to this same value
for everyone in the LAN.

A fairly fast VHF FM radio-plus-TNC might take 210 mSec (DEA 21),
while an HF radio-plus-TNC will usually respond in 80 mSec (DEA
8).   Some multi-mode radio-plus-TNCs operating at 1200 bps may
respond in only 40 mSec (DEA 4). The default value (DEA 33) will
safely cover the majority of FM radios in common packet use.

DELETE ON|OFF   Default: OFF
                        Display Group: C

Parameters:

    ON The delete character input editing character is
      <DELETE> ($7F).

    OFF The delete character input editing character is
      <BACKSPACE> ($08).

This command is used to change the input editing command for
character deletion.   When this character is typed, the last
character from the input line is deleted.   How the TNC indicates
the deletion is controlled by the BKONDEL command.

You can not use this character to delete past the beginning of a
line, although you can delete <CR> characters that have been
entered in the text with the pass character.

To see a corrected display of the current line after you have
deleted characters, type the redisplay-line character, which is
set by the REDISPLA command.

This command does not work while in transparent mode.

DIGIPEAT ON|OFF   Default: ON
                          Display Group: L

Parameters:

   ON   The TNC will digipeat packets if requested.

   OFF The TNC will not digipeat packets.

When this parameter is ON, any packet received that has your
TNC's callsign (including SSID) in the digipeat list of its
address field will be retransmitted.   Each station included in
the digipeat list relays the packet in its turn, marking the
packet so that it will not accidentally relay it twice (unless so
requested), and so that the stations will relay the packet in the
correct order.   Digipeating takes place concurrently with other
TNC operations and does not interfere with normal operation of a
packet station.

In the spirit of cooperation typical of Amateur operation, you
will probably want to set DIGIPEAT ON most of the time. However,
you might want to disable digipeating if you're not home, or if
your transmit relay makes enough noise to wake you up at night.

The command HID enables automatic transmission of identification
packets if your station is acting as a digipeater.

DISCONNE
                    Display Group: NONE

DISCONNE is an immediate command. It will initiate a disconnect request with the currently connected station. A successful disconnect results in the display of:

   *** DISCONNECTED

Other commands may be entered while the disconnect is taking place, although connects are disallowed until the disconnect is completed. If the retry count is exceeded while waiting for the other station to acknowledge, the TNC moves to the disconnected state. If a disconnect command is entered while the TNC is disconnecting, the retry count is immediately set to the maximum number. In either case, the disconnect message is

   *** retry count exceeded
   *** DISCONNECTED

Disconnect messages are not displayed when the TNC is in Transparent Mode.

DISPLAY [class]
                    Display Group: NONE

Parameters:

   class   Optional parameter-class identifier, one of the
        following:

ASYNC   display asynchronous port parameters
CHARACTE   display special characters
HEALTH   display health counters/LEDs
ID   display ID parameters
LINK   display link parameters
MONITOR   display monitor parameters
TIMING   display timing parameters

DISPLAY is an immediate command, and with no class parameter will cause all control parameters and their current values to be displayed. Sub-groups of related parameters can be displayed by specifying the optional parameter-class (e.g., DISPLAY A will list all the asynchronous port parameters).   Individual parameters can be displayed by entering the parameter name with no options (e.g., entering AWLEN will cause the present value of AWLEN to be displayed).

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DWAIT n   Default: 33
                                   Display Group: T

Parameters:

    n   0 - 250, specifying default wait time in 10 ms
           intervals.

This value is used to avoid collisions with digipeated packets.
The TNC will wait the default wait time after last hearing data
on the channel before it begins its own keyup sequence, unless
the TNC is waiting to transmit digipeated packets.   This value
should be agreed on by all members of a local area when
digipeaters are used in the area.   The best value will be
determined by experimentation, but will be a function of the
keyup time (TXDELAY) of the digipeater stations.

This feature is intended to help alleviate the drastic reduction
of throughput that occurs on a channel when digipeated packets
suffer collisions.   It is necessary because digipeated packets
are not retried by the digipeater, but must be restarted by the
originating station. If all stations specify a default wait
time, and the right value of n is chosen, the digipeater will
capture the frequency every time it has data to send, since
digipeated packets are sent without this delay.

NOTE: DWAIT is used for other purposes in many LANs. Do not set
DWAIT to 0 just because you think there are no digipeaters in use
on the channel you are occupying!

ECHO ON|OFF   Default: ON
                         Display Group: A

Parameters:

   ON   Characters received from the computer or terminal are
     echoed by the TNC.

   OFF Characters are not echoed.

This command controls local echoing by the TNC when it is in
Command or Converse Mode.   Local echoing is disabled in
Transparent Mode.

If you don't see your input on the display, you should set ECHO
ON.   If you see two copies of every character you type, you
should set ECHO OFF.   If you see the characters you type
displayed correctly, you have ECHO set correctly.

ESCAPE ON|OFF   Default: OFF
                         Display Group: A

Parameters:

   ON   The <ESCAPE> character ($1B) is output as "$" ($24).

   OFF The <ESCAPE> character is output as <ESCAPE> ($1B).

This command specifies the character which will be output when an
<ESCAPE> character is to be sent to the terminal. The <ESCAPE>
translation is disabled in Transparent Mode.

This command is provided because some terminals, and computer
programs that emulate such terminals, interpret the <ESCAPE>
character as a special command prefix. Such terminals may alter
their displays depending on the characters following the
<ESCAPE>.   If you have such a terminal, you can protect yourself
from unexpected text sequences and from other packeteers by
setting ESCAPE ON.

See also the MFILTER command, which allows general character
stripping (rather than character translation) in monitored
packets.

FIRMRNR ON|OFF   Default: ON
                     Display Group: L

Parameters:

   ON   When this TNC's buffers fill, an RNR is sent. When the
      buffers are no longer full, an RR command frame is
      sent.

When this TNC receives an RNR, it will not poll the sending TNC
until [T0*10 seconds]. T0 = CHECKtime*8 unless CHECKtime*8 is
<30 or >253 in which case T0 = 12.

   OFF When this TNC's buffers fill, an RNR is sent as a
      response to an I frame.

When this TNC receives an RNR, it will resend the data every
FRACKtime (T1) until an RR is received.

When OFF, standard AX.25 Level 2 Version 2.0 protocol procedures
are used. If a TNC sending data receives an RNR, meaning the
remote TNC cannot accept more data, the sending TNC will
continuously re-send the data every T1 (FRACK) time until an RR
is received, meaning the remote TNC accepted the data.   This
often results in a lot of unnecessary channel congestion.

When FIRMRNR is ON, this TNC will stop sending data upon receipt
of an RNR. If the remote TNC does not send an RR before [T0]
(see above), this TNC will poll the remote TNC to be sure it is
still active. If this TNC sent the RNR, then it will send an RR
when its buffers have cleared to allow more data to be received.

NOTE: The remote TNC should be capable of FIRMRNR operation.
This mode is operable with all TNCs having a FIRMRNR settable to
ON, and with most network nodes. If the remote TNC is not
capable of FIRMRNR operation, and if the channel is poor, there
will be additional delays in getting data passed between the
TNCs.

FLOW ON|OFF   Default: ON
                         Display Group: A

Parameters:

   ON   Type-in flow control is active.

   OFF Type-in flow control is disabled.

When type-in flow control is enabled, any character entered from
the terminal will halt output to the terminal until: (1) a
packet is forced (in Converse Mode); (2) a line is completed (in
Command Mode); (3) the packet length is exceeded; or (3) the
terminal output buffer fills up.   Canceling the current command
or packet or typing the redisplay-line character will also cause
output to resume.   Type-in flow control is not used in
Transparent Mode.

Setting FLOW ON will keep received data from interfering with
data entry. If you (and the person you are talking to) wait for
a packet from the other end before starting to respond, you can
set FLOW OFF. Some Bulletin Board programs may work best with
FLOW OFF. Some computers with "software UARTs" may be unable to
send and receive data at the same time; users of such computers
should set FLOW ON.

FRACK n   Default: 8
                         Display Group: T

Parameters:

   n   0 - 15, specifying frame acknowledgment time-out
            (T1) in 1 second intervals.

After transmitting a packet requiring acknowledgment, the TNC
will wait for the frame acknowledgment time-out before
incrementing the retry counter and sending the frame again.   If
the packet address includes digipeater requests, the time between
retries will be adjusted to

       Retry interval = n * (2*m + 1)

where m is the number of digipeaters.

When a retried packet is sent, a random wait time is added to any
other wait times in use. This is to avoid lockups in which two
TNCs repeatedly send packets which collide with each other.

FULLDUP ON|OFF   Default: OFF
                        Display Group: L

Parameters:

    ON   Full duplex mode is enabled.

    OFF Full duplex mode is disabled.

When full duplex mode is disabled, the TNC makes use of the Data
Carrier Detect signal from the modem to avoid collisions, and
acknowledges multiple packets in a single transmission with a
single acknowledgment. When full duplex mode is enabled, the TNC
ignores the DCD signal and acknowledges packets individually.
The latter mode is useful for full-duplex radio operation, such
as through the Microsats. It should not be used unless both your
station and the station you are communicating with are
full-duplex stations.

You may find full-duplex mode useful for some testing operations,
such as analog- or digital-loopback tests.

Note that certain timers, such as DWAIT, are disabled when in
FULLDUP mode.

HEADERLN ON|OFF   Default: OFF
                        Display Group: M

Parameters:

ON The header for a monitored packet is printed on a
    separate line from the packet text.

OFF The header and packet text of monitored packets are
     printed on the same line.

This command affects the display format for monitored packets.
If HEADERLN is OFF, the address information is displayed with the
packet:

KV7D>N2WX: Go ahead and transfer the file.

If HEADERLN is ON, the address information is displayed, followed
by the packet text on a separate line:

N2WX>KV7D:
Sorry, I'm not quite ready yet.

If you have set MRPT ON or enabled MSTAMP, you may wish to set
HEADERLN ON, as the packet header quickly becomes long enough to
fill a line when these functions are active.

HEALLED ON|OFF   Default: OFF
                          Display Group: H

Parameters:

   ON   The TNC will "dither" the CON and STA LEDs.

   OFF The TNC will control the CON and STA LEDs in normal
       fashion.

This command allows the user to redefine the functions of the two
CPU controllable LEDs (i.e. the STAtus and CONnect LEDs).

When HEALLED is set ON, the two LEDs flash in a seeming random
fashion. At a glance, the user may make a judgment on whether
the software has crashed, since the LEDs will probably not flash
if the software fails catastrophically.

With HEALLED set OFF, the LEDs function normally.   The CON LED
glows when the current stream is in the connected or
disconnecting state, and the STA LED glows when the current
stream has unacknowledged packets in the transmit buffer.

HID ON|OFF   Default: OFF
                          Display Group: I

Parameters:

   ON   Enables HDLC identification by a digipeater.

   OFF Disables HDLC identification.

This command is used to enable or disable the sending of
identification packets by the TNC. If HID is OFF, the TNC will
never send an identification packet. If HID is ON, the TNC will
send an identification packet every 9.5 minutes if the station is
digipeating packets. The ID command allows the operator to send
a final identification packet if the station is being taken off
the air.

An identification consists of an unsequenced information (UI)
frame whose data field is your station identification. The
identification packet is addressed to the "CQ" address set by the
UNPROTO command. Your station identification is your callsign as
set by MYCALL, with "/R" appended.

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ID

Display Group: NONE

ID is an immediate command. It will send a special identi-
fication packet. ID can be used to force a final identification
packet to be sent as a digipeater station is being taken off the
air.   The identification packet will be sent only if the
digipeater has transmitted   since the last   automatic
identification.

An identification consists of an UI frame whose data field is
your station identification.   The identification packet is
addressed to the "CQ" address set by the UNPROTO command. Your
station identification is your callsign as set by MYCALL, with
"/R" appended.

KISS ON|OFF   Default: OFF
                          Display Group: L

Parameters:

    ON Serial Line Interface Protocol (SLIP) is used between
        the TNC and the attached computer. The TNC executes a
        very limited instruction set,   arbitrating channel
        access only and depending on the computer to handle all
        Level Two and higher protocol issues.

    OFF The TNC operates using the commands and messages
        documented herein.   This is the normal mode of
        operation.

This command is used to enter the "KISS" mode for operation with
various experimental protocols.   KISS is used with intelligent
host computers.   The most popular use has been in conjunction
with the KA9Q TCP/IP networking software, available from TAPR and
elsewhere.

To operate KISS with this release, enter the command KISS ON,
then the command RESTART (NOT RESET!). The CON and STA LEDs will
flash three times when initially activated. This command will
then have effect for subsequent power on/off cycles.   To return
to normal operation, enter the command PARAM <device> 255 at the

   NET>

prompt if you are running the KA9Q TCP/IP software package.   If
you are not using this package, send the three bytes $C0, $FF,
$C0 to the TNC to restore normal operation. If you cannot send
these character values with the software you intend to use, you
must power the TNC off, then disconnect the bbRAM battery for
several minutes, then reconnect the battery and power up again to
restore normal operation.

The commands available in Kiss Mode are:

Command   Function   Comments

0   Data Frame   The rest of the frame is data to be
                sent.

1   TXDELAY   The next byte is is the transmitter keyup
                time in 10 mSec units, with a default of 50
                (500 mSec).

2   P   The next byte is the persistence parameter,
                p, scaled to the range 0-255. The
                probability of transmitting at the next
                opportunity is p/255. The default is 64 (for
                a probability of 0.25).

3   SlotTime The next byte is the slot interval in 10 mSec
                increments. The default is 10 (100 mSec).

4   TXtail   The next byte is the time to hold the
                transmitter after the FCS has been sent,
                in 10 mSec units. The command is
                obsolete and is included for
                completeness with earlier im-
                plementations.

5   FullDuplex   The next byte is 0 for half-duplex
                (normal) or any other number for full
                duplex (e.g., for operation with
                MicroSats).

FF   Return   Exit KISS and resume normal TNC operation.

NOTE: The TNC will only return type 0 frames (received
information). Thus, the computer cannot interrogate the TNC to
find the values of the other command types.

KISSM   {immediate command}

This command may be used to cause the TNC to immediately begin
running the KISS code.

LCALLS call1[,call2...,call8]   Default: ""
                              Display Group: M

Parameters:

   call Callsign list. Up to 8 calls, separated by commas.

Each callsign may include an optional sub-station ID specified as
-n immediately following the call.   This command works in
conjunction with BUDLIST and allows selective monitoring of other
packet stations. These two commands determine which packets will
be displayed when you have set MONITOR ON. BUDLIST specifies
whether the callsigns in the list are the ones you want to ignore
or, alternatively, are the only ones you want to listen to.

If you want to listen only for packets from a limited list, you
should enter your selected list with LCALLS and set BUDLIST ON.

If you want to ignore packets from a limited list, you should
list the callsigns to ignore in LCALLS and set BUDLIST OFF.

The list of calls in the LCALLS buffer is saved in battery-backed
RAM. The calls may be cleared without issuing a RESET command by
entering a "%" or a "&" character as a callsign.

LCOK ON|OFF   Default: ON
                        Display Group: A

Parameters:

> ON   The TNC will send lower case characters to the computer
> or terminal.

> OFF The TNC will translate lower case characters to upper
> case.

If LCOK is OFF, lower case characters will be translated to upper
case before being output to the terminal. This case translation
is disabled in Transparent Mode. Input characters and echoes are
not case translated.

If your computer or terminal does not accept lower case
characters it may react badly if the TNC sends such characters to
it. This command allows you to translate all lower case
characters received in packets, as well as messages from the TNC,
to upper case.

Since echoes of the characters you type are not translated to
upper case, you can use this command to make your display easier
to read when you are conversing in connected mode.   If you and
the other station's operator set LCOK OFF, you can each type your
own messages in lower case and see incoming packets displayed in
upper case. This makes it easy to distinguish incoming and
outgoing lines.

LCSTREAM ON|OFF   Default: ON
                          Display Group: C

Parameters:

    ON The TNC will translate the character immediately
       following the STREAMSWITCH character to upper case
       before processing it.

    OFF The TNC will process the character immediately
       following the STREAMSWITCH character as it is entered.

When operating multi-connect, the user must enter a stream
identifier (default A through J) after the STREAMSWITCH character
(default |) to select a new logical stream to send data.
Normally, the stream identifier must be in upper case, or an
error message will result.

When LCSTREAM is ON, the character immediately following the
streamswitch character is converted to upper case before being
acted upon.   Thus, the case (upper or lower) becomes
insignificant. Use of LCSTREAM is useful if you are typing in
lower case and don't want to be bothered with remembering to
switch to upper case when changing streams.

LFADD ON|OFF   Default: OFF
                          Display Group: L

Parameters:

    ON   A <LF> character is added to outgoing packets following
       each <CR> transmitted in the packet.

    OFF No <LF> is added to outgoing packets.

This function is similar to AUTOLF, except that the <LF>
characters are added to outgoing packets rather than to text
displayed locally. This feature is included in order to maintain
compatibility with other packet radio controllers. If the person
you are talking to reports overprinting of packets from your
station you should set LFADD ON. This character insertion is
disabled in Transparent Mode.

LFIGNORE ON|OFF   Default: OFF
                        Display Group: L

Parameters:

    ON   TNC will ignore <LF> characters.

    OFF TNC will respond to <LF> characters.

This command controls whether TNC 2 responds to ASCII Line Feed
(<LF> $0A) characters or ignores them in command and converse
modes.

When turned on, line feeds are totally ignored except in trans-
parent mode.

MALL ON|OFF   Default: ON
                        Display Group: M

Parameters:

    ON   Monitored packets include both "connected" packets and
      "unconnected" packets.

    OFF Monitored packets include only "unconnected" packets.

This command determines the class of packets which are monitored.
If MALL is OFF, only otherwise eligible packets (as determined by
the BUDLIST and LCALLS commands) sent by other TNCs in the
unconnected mode are displayed.   This is the normal manner of
operation when this TNC is being used to talk to a group of TNCs
all of which are unconnected.

If MALL is ON, all otherwise eligible frames are displayed,
including those sent between two other connected TNCs. This mode
may be enabled for diagnostic purposes or for "reading the mail."

MAXFRAME n   Default: 4
                              Display Group: L

Parameters:

   n   1 - 7, signifying a number of packets.

MAXFRAME sets an upper limit on the number of unacknowledged
packets which the TNC can have outstanding at any one time. This
is also the maximum number of contiguous packets which can be
sent during any given transmission. If some but not all of the
outstanding packets are acknowledged, a smaller number may be
transmitted the next time, or new frames may be included in the
retransmission, so that the total unacknowledged does not exceed
n.

If you perform file transfers, you should experiment with
MAXFRAME and PACLEN. If the link is good, there is an optimum
relationship between the parameters set by these commands so that
the maximum number of characters outstanding does not exceed the
packet receive buffer space of the TNC receiving the data.

MCOM ON|OFF   Default: OFF
                        Display Group: M

Parameters:

  ON Connect, disconnect, UA, DM, I and UI frames are
      monitored.

  OFF Only information frames (I and UI) are monitored.

This command enables monitoring of connect and disconnect frames
when MONITOR is ON.   When MCOM is OFF, only I frames (packets
containing user information) will be displayed.

When MCOM is on, all control fields are decoded (invalid ones are
marked with ????).   For I and S frames, sequence number
information is also presented. Frames compatible with the AX.25
Level 2.0 standard are also decoded as to the state of the
Command/Response (C/R) and Poll/Final (P/F) bits.

  Ex: WA7GXD>KV7B <I C S0 R0>:
      Hi Dan,

      WA7GXD>KV7B <I C P S1 R0>:
      have you been on EIES lately?

      KV7B>WA7GXD <RR R F R2>
      KV7B>WA7GXD <I C P S1 R2>:
      I was just thinking about that. I heard that
      @(username) made some real unbelievable comment on it!

      WA7GXD>KV7B <RR R F R2>
      WB2SPE>KV7B <C>
      KV7B>WB2SPE <DM>
      KV7B>WA7GXD <I C P S2 R2):
      Good conditions now...

      WA7GXD>KV7B <RR R F R3>
      WA7GXD>KV7B <I C P S2 R3>:
      Yes @(username) did. It was quite remarkable.

As with other monitor commands, the stations monitored are
determined by BUDLIST and LCALLS.

MCON ON|OFF   Default: ON
                        Display Group: M

Parameters:

   ON   Monitor mode remains active when the TNC is connected.

   OFF Monitor mode is disabled while the TNC is connected.

If MCON is ON, the MONITOR command will enable monitoring while
your TNC is connected to another TNC. If MCON is OFF, the
display of monitored packets is suspended when a connect occurs,
and is resumed when the TNC is disconnected.

If you want to see all packets displayed when you are not
connected but have such display suppressed when you connect to
another station, you should set MCON OFF.

MFILTER n1[,n2[,n3[,n4]]]   Default: None
                        Display Group: M

Parameters:

   n   0 - $7F, specifying an ASCII character code.   Up
           to 4 characters may be specified.

This command allows you to specify characters to be "filtered,"
or eliminated from monitored packets. The parameters n1, n2,
etc., are the ASCII codes for the characters you want to filter.
You can enter the code in either hex or decimal.

For example, if a <CTRL-L> character causes your screen to be
cleared, and you don't want this to happen, you can set MFILTER
12. If you also want to eliminate <CTRL-Z> characters, which
some computers interpret as end-of-file markers, you can set
MFILTER 12,26.

MHCLEAR
                        Display Group: NONE

MHCLEAR is an immediate command. It causes the list of stations
heard to be cleared. You can use this command in conjunction
with MHEARD to keep track of the stations on the air over a given
period of time, such as an evening or a week. Clear the list of
stations heard when you first begin to monitor the packet
activity.

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MHEARD
                        Display Group: NONE

MHEARD is an immediate command. It causes the TNC to display the
list of stations that have been heard since the last time the
command MHCLEAR was given. Stations that are heard through
digipeaters are marked with a * in the heard log. If you clear
the list of stations heard at the beginning of a session, you can
use this command to easily keep track of the stations that are
active during that period. The maximum number of heard stations
that can be logged is 18. If more stations are heard, earlier
entries are discarded. Logging of stations heard is disabled
when PASSALL is ON.

If the DAYTIME command has been used to set the date and time,
entries in the heard log will be time stamped. For example,

    cmd:MHEARD
    K4NTA*   06/09/85 21:08:19
    WA4ITD* 06/09/85 21:08:17
    W1BEL-2* 06/09/85 21:06:18
    K4NTA-2* 06/09/85 20:57:35
    N2WX
    cmd:

Note that no daytime string is displayed next to N2WX. This
indicates that when N2WX was last heard the clock had not been
set.

MNONAX25 ON|OFF   Default: OFF
                        Display Group: M

Parameters:

    ON   Monitors all frames with valid CRC.

    OFF Monitors AX.25 Level 2 Protocol frames with no
         higher-level protocols (PID = F0).

When OFF, only AX.25 Level 2 protocol frames will be displayed.
Any packets with level 3 or level 4 protocols will be inhibited.
Thus, NET/ROM, TCP/IP, ROSE, etc., networking frames will not be
displayed. These frames often have binary values buried in them
which cause undesirable responses on a normal screen display.

When ON, any packet or frame with a valid CRC will be displayed
regardless of protocol.

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MONITOR ON|OFF   Default: ON
                        Display Group: M

Parameters:

   ON   Monitoring of packet activity is enabled.

   OFF Monitoring of packet activity is disabled.

If MONITOR is ON and the TNC is not in Transparent Mode, packets
not addressed to your TNC may be displayed. The addresses in the
packet are displayed along with the data portion of the packet,
e.g.:

   N2WX>W5FD-3: I'm ready to transfer the file now.

The calls are separated by a ">" and the sub-station ID field
(SSID) is displayed if it is other than 0. The MALL, BUDLIST,
and LCALLS commands determine which packets are to be monitored.
The MCON command controls the action of monitor mode when the TNC
is connected. All monitor functions are disabled in Transparent
Mode.

The format of the monitor display is controlled by HEADERLN. If
you want to see the station addresses on a separate line from the
text, you can set HEADERLN ON. MRPT enables monitoring of the
digipeater route as well as source and destination addresses for
each packet. MSTAMP includes a time stamp with the addresses if
DAYTIME has been set.

MRPT ON|OFF   Default: ON
                          Display Group: M

Parameters:

    ON   Display the stations in the digipeat path for monitored
      packets.

    OFF Display only the source and destination stations for
      monitored packets.

This command affects the way monitored packets are displayed. If
MRPT is OFF, only the originating station and the destination are
displayed for monitored packets.   If MRPT is ON, the entire
digipeat list is displayed for monitored packets, and stations
that have already relayed the packet are indicated with an
asterisk.

For example,

    WB9FLW>AD7I,K9NG*,N2WX-7:Hi Paul.

This packet, sent from WB9FLW to AD7I, has been relayed by K9NG
but not by N2WX-7.   With MRPT OFF, the same packet would be
displayed as

    WB9FLW>AD7I:Hi Paul.

Setting MRPT ON increases the length of the address display, and
you may wish to set HEADERLN ON as well to display this informa-
tion on a separate line.

MSTAMP ON|OFF   Default: OFF
                         Display Group: M

Parameters:

   ON   Monitored frames are time stamped.

   OFF Monitored frames are not time stamped.

This command enables time stamping of monitored packets.   The
date and time information is then available for use for automatic
logging of packet activity or other computer applications. The
date and time are set initially by the DAYTIME command, and the
date format is determined by the DAYUSA command.

Setting MSTAMP ON increases the length of the address display,
and you may wish to set HEADERLN ON as well to display this
information on a separate line.

MYALIAScall[-n]   Default: <blank>
                        Display Group: I

Parameters:

   call Alternative identity of your TNC.

   n   0 - 15, an optionally specified sub-station ID
(SSID).

This command specifies an alternative callsign (in addition to
the callsign specified in MYCALL) for use as a digipeater only.

In some areas, wide coverage digipeaters operators have changed
the callsign of their machine to a shorter and (usually) easier
to remember identifier. International Civil Aviation Organiza-
tion (ICAO) airport identifiers, sometimes combined with tele-
phone area codes, have been used.

Use of this command permits HID to identify normally with the
MYCALL-specified callsign yet permit an alternative (alias)
repeat-only "callsign."

MYCALL call[-n]   Default: NOCALL-0
                        Display Group: I

Parameters:

   call Callsign of your TNC.

   n   0 - 15, an optionally specified sub-station ID
(SSID).

This command tells the TNC what its callsign is. This callsign
will be placed in the FROM address field for all packets
originated by your TNC. It will accept frames with this callsign
in the TO field and relay frames with this callsign in the
digipeat field (if DIGIPEAT is ON). MYCALL will also be used for
identification packets (see HID and ID).

The default callsign must be changed for proper operation of the
protocols. There should never be more than one station with the
same callsign (including SSID) on the air at once. The SSID can
be used to distinguish two stations with the same Amateur call.
The SSID will be 0 unless explicitly set to another value.

NEWMODE ON|OFF   Default: OFF
                        Display Group: L

Parameters:

   ON   Switching to data transfer mode occurs at the time of
        connection, or the issuing of the CONNECT command, and
        return to command mode is automatic at the time of
        disconnection.

   OFF Switching to data transfer mode occurs at time of
        connection and no return to command mode occurs at
        disconnection.

The NEWMODE command may be used to select the way the TNC behaves
when connections are made and broken.

If NEWMODE is OFF, the TNC will remain in Command Mode after you
issue a CONNECT command until a connection is actually
established. When the connection is established, the TNC will
enter Converse Mode or Transparent Mode, depending on the setting
of CONMODE. When the connection is terminated, the TNC remains
in Converse or Transparent Mode unless you have forced it to
return to Command Mode. This is the same as the behavior of TNC
1 (running version 3.x software) under these conditions.

If NEWMODE is ON, the TNC will enter Converse Mode or Transparent
Mode as soon as you issue a CONNECT command, without waiting for
the connection to be established. Anything you type will be
packetized to be transmitted once the connection is complete.
When the connection is broken, or if the connect attempt fails,
the TNC will return to Command Mode.

If you have a Bulletin Board program designed to work with TNC 1
you should set NEWMODE OFF if the program relies on the sequence
of actions used by TNC 1. Otherwise, you should choose the
setting for NEWMODE that seems most convenient to you.

NOMODE ON|OFF   Default: OFF
                                    Display Group: L

Parameters:

    ON   The TNC will only switch modes (command, converse or
        transparent) upon explicit command.

    OFF The TNC will switch modes in accordance with the
         setting of NEWMODE.

When NOMODE is ON, the TNC will never change between CONVERSE or
TRANSPARENT mode to COMMAND mode (or vice-versa) on its own.
Only user commands (CONV, TRANS, or ^C) may change the type-in
mode.

If NOMODE is OFF, then automatic mode switching is handled
according to the setting of the NEWMODE command.

NUCR ON|OFF   Default: OFF
                                    Display Group: A

Parameters:

    ON   <NULL> characters are sent to the terminal following
        <CR> characters.

    OFF <NULL> characters are not sent to the terminal
         following <CR> characters.

This command causes transmission of <NULL> characters (ASCII code
$00), producing an effective delay following any <CR> sent to the
terminal. The number of <NULL> characters is determined by the
command NULLS. This delay is required by some hardcopy
terminals. You need to set NUCR ON if your terminal misses one
or more characters after responding to a <CR>. If this is the
case, you will sometimes see overtyped lines.

NULF ON|OFF   Default: OFF
                                Display Group: A

Parameters:

   ON   <NULL> characters are sent to the terminal following
     <LF> characters.

   OFF <NULL> characters are not sent to the terminal
     following <LF> characters.

This command causes transmission of <NULL> characters (ASCII code
$00), producing an effective delay following any <LF> sent to the
terminal. The number of <NULL> characters is determined by the
command NULLS. This delay is required by some display terminals.
You need to set NULF ON if your terminal sometimes misses
characters at the beginning of the line.

NULLS n   Default: 0
                                Display Group: A

Parameters:

   n   0 - 30, specifying the number of <NULL> characters
     to send after <CR> or <LF>.

This command specifies the number of <NULL> characters (ASCII
code $00) to send to the terminal after a <CR> or <LF> is sent.
In addition to setting this parameter value, NUCR and/or NULF
must be set to indicate whether nulls are to be sent after <CR>,
<LF>, or both. Devices requiring nulls after <CR> are typically
hard-copy devices requiring time for carriage movement. Devices
requiring nulls after <LF> are typically CRTs which scroll
slowly.   Extra null characters are sent only in Converse and
Command Modes.

OUT nn   0<=nn<=255

The value 'nn' is sent to the TNC's z/80 i/o port 0BFH.   Note
that the last value 'nn' is sent to the i/o port frequently, but
not immediately. In this context, 'frequently' means many times
per second, and 'not immediately' means within at most 100ms.

PACLEN n   Default: 128
                                Display Group: L

Parameters:

    n   0 - 255, specifying the maximum length of the data
             portion of a packet. The value 0 is equivalent to
             256.

The TNC will automatically transmit a packet when the number of
input bytes for a packet reaches n. This value is used in both
Converse and Transparent Modes.

If you perform file transfers, you should experiment with both
MAXFRAME and PACLEN. If the link is good, there is an optimum
relationship between the parameters set by these commands so that
the maximum number of characters outstanding does not exceed the
packet receive buffer space of the TNC receiving the data.

Note: Although there is no requirement for two TNCs exchanging
data to have the same PACLEN value, allowing more than 128
characters of data in a packet may be incompatible with some
varieties of TNCs.

PACTIME EVERY|AFTER n   Default: AFTER 10
                                Display Group: T

Parameters:

    n   0 - 250, specifying 100 ms intervals.

    EVERY   Packet time-out occurs every n*100 milliseconds.

    AFTER   Packet time-out occurs when n*100 milliseconds
             elapse with no input from the computer or
             terminal.

This parameter is always used in Transparent Mode, and will also
be used in Converse Mode if CPACTIME is ON. When EVERY is
specified, input bytes are packaged and queued for transmission
every n*100 ms. When AFTER is specified, bytes are packaged when
input from the terminal stops for n*100 ms. In no case will a
zero length packet be produced, and the timer is not started
until the first byte is entered. A value of 0 for n is allowed,
and causes packets to be generated with no wait time.

PARITY n   Default: 3 (even)
                                            Display Group: A

Parameters:

   n   0 - 3, selecting a parity option from the table
       below.

This command sets the parity mode for terminal or computer data
transfer according to the following table:

n	Parity
0	no parity
1	odd parity
2	no parity
3	even parity

The parity bit, if present, is automatically stripped on input
and   not checked in Command Mode and Converse Mode.   In
Transparent Mode, all eight bits, including parity if any, are
transmitted in packets. If "no parity" is set and AWLEN is 7,
the eighth bit will be set to 0 in Transparent Mode.

PASS n   Default: $16 <CTRL-V>
                                Display Group: C

Parameter:

  n   0 - $7F, specifying an ASCII character code.

This command selects the ASCII character used for the "pass"
input editing command. The parameter n is the ASCII code for the
character you want to type in order to include the following
character in a packet or text string. You can enter the code in
either hex or decimal.

You can use this character to send any character in packets, even
though that character may have some special function.   For
example, suppose you have set COMMAND 3, specifying that <CTRL-C>
is your Command Mode entry character. If you use a Bulletin
Board program that requires a <CTRL-C> to escape from some
operation, you will type

    <CTRL-V> <CTRL-C>

to insert a <CTRL-C> character in your packet. Of course, if you
do this frequently you would be better off to change your Command
Mode entry character.

A common use for the pass character is to allow <CR> to be
included in the BTEXT and CTEXT messages. Similarly, you can
include <CR> in text when you are in Converse Mode, to send
multi-line packets. (The default send-packet character is <CR>.)

PASSALL ON|OFF   Default: OFF
                         Display Group: L

Parameters:

   ON   TNC will accept packets with invalid CRCs.

   OFF TNC will only accept packets with valid CRCs.

This command causes the TNC to display packets received with
invalid CRC fields. Packets are accepted for display despite CRC
errors if they consist of an even multiple of 8 bits and up to
339 bytes.   The TNC will attempt to decode the address field and
display the callsign(s) in the standard monitor format, followed
by the text of the packet.

This mode is not normally enabled, since rejection of any packet
with an invalid CRC field is what insures that received packet
data is error-free. This mode might be enabled for testing a
marginal RF link or during operation under other unusual
circumstances.

If you set PASSALL ON and monitor a moderately noisy channel you
will periodically see "packets" displayed in this mode, since
there is no basis for distinguishing actual packets received with
errors from random noise.

Logging of stations heard (for display by MHEARD) is disabled
whenever PASSALL is ON, since the callsigns detected may be
incorrect.

RECONNECT call1 [VIA call2[,call3...,call9]]
                         Display Group: NONE

Parameters:

   call1   Callsign of TNC to be reconnected to.

   call2   Optional callsign(s) of TNC(s) to be digipeated
            through. As many as eight digipeater addresses
            may be specified.

RECONNECT is an immediate command. It may be used to change the
path through which you are currently connected to a station. It
may only be used when your TNC is connected on the current
stream.

REDISPLA n   Default: $12 <CTRL-R>
                          Display Group: C

Parameters:

  n   0 - $7F, specifying an ASCII character code.

This command is used to change the redisplay-line input editing
character.   The parameter n is the ASCII code for the character
you want to type in order to redisplay the current input line.
You can enter the code in either hex or decimal.

You can type this character to cause the TNC to retype a line you
have begun. When you type the redisplay-line character, the
following things happen: First, type-in flow control is
temporarily released (if it was enabled). This displays any
incoming packets that are pending. Then a <BACKSLASH> character
is typed, and the line you have begun is retyped on the next
line. If you have deleted and retyped any characters, only the
final form of the line will be shown. You are now ready to
continue typing where you left off.

You can use the redisplay-line character to see a "clean" copy of
your input if you are using a printing terminal and you have
deleted characters. If you have set BKONDEL OFF, deletions are
designated with <BACKSLASH> characters, rather than by trying to
correct the input line display. The redisplayed line will show
the corrected text.

You can also use this character if you are typing a message in
Converse Mode and a packet comes in. You can see the incoming
message before you send your packet, without concealing your
input.

RESET
                        Display Group: NONE

This is an immediate command. It sets all parameters to their
default settings and re-initializes the TNC.

WARNING: All parameter customizing and monitor lists will be
lost.

If you want to re-initialize the TNC using the parameter values
in battery backed-up RAM, you should turn the TNC off then on
again, or issue the RESTART command.

RESPTIME n   Default: 0
                        Display Group: T

Parameters:

   n   0 - 250, specifying 100 ms intervals.

This command sets a minimum delay that is imposed on acknow-
ledgment packets. This delay may run concurrently with default
wait set by DWAIT and any random wait in effect.

This delay can be used to increase throughput during operations
such as file transfer when the sending TNC usually sends the
maximum number of full-length packets. Occasionally, the sending
TNC may not have a packet ready in time to prevent transmission
from being stopped temporarily,   with the result that the
acknowledgment of earlier packets collides with the final packet
of the series. If the receiving TNC sets RESPTIME to 10, say,
these collisions will be avoided.

When using priority acknowledgment (see ACKPRIOR), this value
must be set to 0 for proper operation.

RESTART
                              Display Group: NONE

RESTART is an immediate command. It re-initializes the TNC using
the defaults stored in bbRAM. The effect of this command is the
same as turning the TNC OFF then ON again.

RESTART does not cause a reset of the parameters in bbRAM. See
also the RESET command.

RETRY n   Default: 10
                              Display Group: L

Parameter:

   n   0 - 15, specifying the maximum number of packet
            retries.

The AX.25 protocol allows for retries, i.e., retransmission of
frames that are not acknowledged.   Frames are re-transmitted n
times before the operation is aborted. The time between retries
is specified by the command FRACK.   A value of 0 for n specifies
an infinite number of retries.   If the number of retries exceeds
n, the TNC will go to the disconnected state (with an informative
message if not in Transparent Mode). See also the FRACK command.

RXBLOCK ON|OFF   Default: OFF
                              Display Group: A

Parameters:

 ON The TNC will send data to the terminal in RXBLOCK
    format.

 OFF The TNC will send data to the terminal in standard
    format.

RXBLOCK is designed for automated operations, such as packet
bulletin board stations. It is intended to help such systems
discriminate between data received from the connected station and
TNC-generated messages.

Correct operation of RXBLOCK is dependent on the AWLEN parameter
being set to 8 (bits) since the character FF hex marks the
beginning of a received data unit header.

When RXBLOCK is on, data from other stations will be sent from
the TNC in the following format:

```
 --------------------------------------------------------
 | $FF  | L0 | L1 | PID |     DATA         |
 --------------------------------------------------------
```

 (prefix) (length)   (pid)   (data)

The fields above are defined as follows:

prefix $FF   ::= A character with all 8 bits set
length   L0   ::= The high order length of the data,
                  length, and pid fields logically ORed
                  with the value $F0
        L1   ::= The low order length of the data, length,
                  and pid fields
pid   PID   ::= The Protocol IDentifier byte received for
                  the following data field
data   DATA   ::=[Optional], variable length data

For best operation it is suggested that parameters like AUTOLF,
MFILTER, etc. be set OFF in order to prevent uncertainties in the
size of the data field.

RXCAL
<div align="center">Display Group: NONE</div>

RXCAL is an immediate command. It is used for precise alignment
of the demodulator.   Briefly, after the modulator tones are set
using the normal CALIBRATE routines, analog loopback is entered
and RXCAL issued. You then tune the demodulator until the CON
and STA LEDs are both lit, or slowly alternate.   See the section
Modem Calibration using CAL and RXCAL for details on using this
command with a TAPR TNC 2.

SCREENLN n   Default: 0
<div align="center">Display Group: A</div>

Parameters:

   n   0 - 255, specifying the screen or platen width, in
            characters, of the terminal.

This value is used to format terminal output. A <CR> <LF>
sequence is sent to the terminal at the end of a line in Command
and Converse Modes when n characters have been printed. A value
of zero inhibits this action.

If your computer automatically formats output lines, you should
set SCREENLN 0 to avoid a conflict between the two line formats.

SENDPAC n   Default: $0D <CR>
                                    Display Group: C

Parameters:

   n   0 - $7F, specifying an ASCII character code.

This command selects the character that will force a packet to be
sent in Converse Mode. The parameter n is the ASCII code for the
character you want to type in order to force your input to be
packetized and queued for transmission. You can enter the code
in either hex or decimal.

For ordinary conversation, you will probably set SENDPAC $0D and
CR ON.   This causes packets to be set at natural intervals, and
causes the <CR> to be included in the packet.

If you have set CPACTIME ON, you will probably set SENDPAC to
some value not ordinarily used (say, <CTRL-A>), and set CR OFF.
This will allow you to force packets to be sent, but will not
result in extra <CR> characters being transmitted in the text.

SLOTS n   Default: 3
                                    Display Group: L

Parameters:

   n   0-127

SLOTS specifies the number of "slots" from which to choose when deciding to access the channel. For example, SLOTS 3 means there are three slots, each having a probability of 1/3 to be selected. Each slot is DEADTIME long. If SLOTS 0 is chosen, the TNC will act as if SLOTS 1 had been selected.

Other implementations of this idea of channel access use "PERSISTENCE" to decide the probability of channel access when the channel is clear and "PPERSISTENCE" to enable or disable this feature.

A low value means a greater chance of attempting to send data when the channel is clear, and a higher value means less chance. Normal AX.25 practice is to have every station jump on the channel when it goes clear, virtually assuring collisions and retries.

SLOTS and its relation to the more common PPERSISTENCE and PERSISTENCE commands are given below:

SLOTS   PPERSISTENCE PERSISTENCE   Probability to XMIT

SLOTS	PPERSISTENCE	PERSISTENCE	Probability to XMIT
1	OFF	255	Jump on = 100%
2	ON	127	50%
3	ON	85	33%
4	ON	63	25%
5	ON	51	20%

and so forth.

A typical value would be 2 or 3 for a channel with a few other users and 5 to 7 for a fairly busy channel. Higher values than about 10 imply the channel is too busy and other frequencies should be used if available.

Note: SLOTS is independent of ACKPRIOR.

START n   Default: $11 <CTRL-Q>
        Display Group: C

Parameters:

 n 0 - $7F, specifying an ASCII character code.

This command selects the User Restart character, which is used to
restart output from the TNC to the terminal after it has been
halted by typing the User Stop character. You can enter the code
in either hex or decimal.

The User Stop character is set by the STOP command.

If the User Restart and User Stop characters are set to $00,
software flow control to the TNC is disabled, and the TNC will
only respond to hardware flow control (CTS).

If the same character is used for both the User Restart and User
Stop characters the TNC will alternately start and stop
transmission upon receipt of the character.

STATUS
       Display Group: NONE

STATUS is an immediate command. It returns the acknowledged
status of the current outgoing packet link buffer. If all
outgoing packets are acknowledged, STATUS returns 'No Outstanding
packets', otherwise it returns the 'Outstanding packets' message.
Note that this command works independently of the RS-232
flow-control state of the TNC.

This command may be useful for special applications, like if you
can't see the STATUS LED on the TNC, or you want your computer to
watch the status...

STOP n   Default: $13 <CTRL-S>
                                    Display Group: C

Parameters:

   n   0 - $7F, specifying an ASCII character code.

This command selects the User Stop character, which is used to
stop output from the TNC to the terminal. You can enter the code
in either hex or decimal. This is the character you will type to
halt the TNC's typing so that you can read text before it scrolls
off your display.

Output is restarted with the User Restart character, which is set
by the START command.

If the User Restart and User Stop characters are set to $00,
software flow control to the TNC is disabled, and the TNC will
only respond to hardware flow control (CTS).

If the same character is used for both the User Restart and User
Stop characters the TNC will alternately start and stop
transmission upon receipt of the character.

STREAMCA ON|OFF   Default: OFF
                                    Display Group: C

Parameters:

    ON   Callsign of other station displayed.

    OFF Callsign of other station not displayed.

This command is used to enable the display of the connected-to
station after the stream identifier. This is particularly useful
when operating with multiple connections allowed. It is somewhat
analogous to the use of MRPT to show digipeat paths when mon-
itoring.

In the example below, the characters inserted by enabling STREAM-
CAll are shown in bold face type.

    |A:K4NTA:hi howie
    hello ted how goes it?
    |B:WA7GXD:*** CONNECTED to WA7GXD
    |Bmust be a dx record. ge lyle
    |Aunreal ted! fl-az no digis!
    |B:WA7GXD:big band opening...ge

etc.

The same sequence with STREAMCAll OFF would look like the fol-
lowing:

    |Ahi howie
    hello ted how goes it?
    |B*** CONNECTED to WA7GXD
    |Bmust be a dx record. ge lyle
    |Aunreal ted! fl-az no digis!
    |Bbig band opening...ge

etc.

Thus, what would have looked like "|B" now appears as
"|B:<callsign>:". This option is very useful for human operators
trying to operate multiple simultaneous connections.   It is pro-
bably less useful for "host" operations.

Note that, in the first example, the STREAMSWitch characters "|A"
and "|B" with no ":" after them were entered by the operator of
the TNC to switch streams for his multiple-connect QSO(s). If
you intend to operate multiple connections (as opposed to having

your "host" computer operate multiple connections), use of this
option is recommended.

STREAMDB ON|OFF   Default: OFF
                              Display Group: C

Parameters:

   ON   Double all received STREAMSWitch characters.

   OFF Do not "double" received STREAMSWitch characters.

This command is used to display received STREAMSWitch characters
by "doubling" them. The example below illustrates this action.

With STREAMDB on, and STREAMSWitch set to "|", the following
might be displayed from your TNC:

   || this is a test.

In this case the sending station actually transmitted

   | this is a test.

The same frame received with STREAMDB OFF would be displayed as:

   | this is a test.

When operating with multiple connections, this is useful for
differentiating between STREAMSWitch characters received from
other stations and STREAMSWitch characters internally generated
by your TNC.

Note: The STREAMSWitch character must NOT be one of the stream
letters (A - J) for this command to function properly.

STREAMSW n   Default: $7C < | >
                                Display Group: C

Parameters:

   n   0 - $FF, usually specifying an ASCII character
       code.

This command selects the character used by both the TNC and the
user that a new "stream" (connection channel) is being addressed.

The character can be PASSed in CONVERS mode. It is always ig-
nored as a user-initiated stream switch in TRANSPARENT mode, and
flows through as data.   This means that the outgoing stream can
not be changed while "on line" in TRANSPARENT mode (you must
escape to COMMAND mode to switch streams).

For further usage of this character, see the STREAMDBL and
STREAMCA commands.

TRACE ON|OFF   Default: OFF
                        Display Group: L

Parameters:

   ON   Trace mode is enabled.

   OFF Trace mode is disabled.

This command is used to enable the protocol debugging function.
When TRACE is ON, all received frames will be displayed in their
entirety, including all header information. In normal operation
you will probably never need this function; however, if you need
to report an apparent software bug, you may be asked to provide
trace information if possible.

A trace display will appear in four columns on an 80-column
display. Following is an example trace display. For comparison,
the frame shown in the trace example would be monitored as
follows:

   KV7B>CQ,KF7B*:this is a test message

The trace display would look like this:

byte ------------hex display------------ -shifted ASCII-- -----ASCII------
000: 86A24040 40406096 AC6E8440 4060968C CQ 0KV7B 0KF ..@@@@`..n.@@`..
010: 6E844040 E103F074 68697320 69732061 7B P.x:449.49.0 n.@@...this is a
020: 20746573 74206D65 73736167 650D   .:29:.6299032.   test message.

The byte column shows the offset into the packet of the beginning
byte of the line. The hex display column shows the next 16 bytes
of the packet, exactly as received, in standard hex format. The
shifted ASCII column attempts to decode the high order seven bits
of each byte as an ASCII character code. The ASCII column
attempts to decode the low order seven bits of each byte as an
ASCII character code.   In a standard AX.25 packet, the callsign
address field will be displayed correctly in the shifted ASCII
column. A text message will be displayed correctly in the ASCII
column.   Non-printing characters and control characters are
displayed in both ASCII fields as ".".   You can examine the hex
display field to see the contents of the sub-station ID byte and
the control bytes used by the protocol. Protocol details are
discussed in Chapter 9.

TRANS
<p align="center">Display Group: NONE</p>

This is an immediate command. It causes the TNC to exit from
Command Mode into Transparent Mode.   The current link state is
not affected.

Transparent Mode is primarily useful for computer communications.
In this mode, the "human interface" features such as input
editing capability, echoing of input characters, and type-in flow
control are disabled.   You may find Transparent Mode useful for
computer Bulletin Board operations or for transferring non-text
files. See the discussion of Transparent Mode in Chapter 5.

TRFLOW ON|OFF   Default: OFF
<p align="center">Display Group: A</p>

Parameters:

   ON   Software flow control can be enabled for the computer
     or terminal in Transparent Mode.

   OFF Software flow control is disabled for the computer or
     terminal in Transparent Mode.

If TRFLOW is ON, the settings of START and STOP are used to
determine the type of flow control used in Transparent Mode. If
TRFLOW is OFF, only hardware flow control is available to the
computer and all characters received by the TNC are transmitted
as data. If START and STOP are set to $00, disabling the User
Stop and User Restart characters, hardware flow control must
always be used by the computer.

If TRFLOW is ON, and START and STOP are non-zero, software flow
control is enabled for the user's computer or terminal. The TNC
will respond to the User's Restart and User's Stop characters
(set by START and STOP) while remaining transparent to all other
characters from the terminal. Unless TXFLOW is also ON, only
hardware flow control is available to the TNC to control output
from the terminal.

<p align="center">135</p>

TRIES n   Default: None
                         Display Group: L

Parameters:

     n   0 -15, specifying the current RETRY level on the
            currently selected input stream.

This command is used to retrieve (or force) the count of "tries"
on the currently selected input stream.

When used with no argument: if the TNC has an outstanding unack-
nowledged frame, it will return the current number of tries; if
the TNC has no outstanding unacknowledged frames, it will return
the number of tries required to obtain an acknowledgment for the
previous frame.

Note: If RETRY is set to 0, the value returned by issuing a
TRIES command will always be 0.

This command is useful for obtaining statistics on the perfor-
mance of a given path or channel. It should be especially useful
for automatic optimizing of such parameters as PACLEN and MAX-
FRAME by computer-operated stations, such as automatic message
forwarding stations using less-than-optimum paths (noisy HF or
satellite channels, for example).

When used with an argument, TRIES will force the "tries" counter
to the entered value. Use of this command to force a new count
of tries is not recommended.

TXDELAY n   Default: 33
                                Display Group: T

Parameters:

   n   0 - 120, specifying 10 ms intervals.

This value tells the TNC how long to wait after keying up the
transmitter before sending data. Some startup time is required
by all transmitters to put a signal on the air; some need more,
some need less. In general, crystal controlled rigs with diode
antenna switching don't need much time, synthesized rigs need
time for PLL lockup, and rigs with mechanical T/R relays will
need time for physical relay movement. The correct value for a
particular rig should be determined by experimentation. The
proper setting of this value may also be affected by the
requirements of the station you are communicating with. In
general, TXDELAY should be set to the same value as DEADTIME when
ACKPRIOR is ON.

A TAPR TNC 1 running version 3.x firmware interprets n in 40 ms
intervals. The value of TXDELAY on TNC 2 will thus be 4 times
the value used by a TNC 1 to give the same delay time.

TXDELAYC n   Default: 2
                          Display Group: T

Parameters:

   n   0-120 specifying additional transmit delay time
          added to TXdelay in terms of CHARACTER TIME at the
          current radio port data rate. Flags will be sent
          during this time, so a value of 1 is required as a
          minimum.

TXDELAYC is used to fine-tune transmit delay after a transmit
command is issued and before data is sent. Used in conjunction
with TXDELAY, it allows a link to be set for maximum performance.

TXDELAY should be used to account for the time it takes the radio
(the slower of this TNC's radio and the remote TNC's radio) to
switch between receive and transmit and allow the receiving
unit's data carrier detect (DCD) circuitry to respond. "0" bytes
are sent to allow the remote TNC to synchronize to the data
stream sent during TXDELAY.

TXDELAYC then sends flags to start the frame. If TXDELAYC 0 is
selected, the TNC will act as if TXDELAYC 1 had been chosen.

With this method of keying up, a user may operate at various HDLC
data rates without having to reset TXDELAY if the same radios are
used. The summation of TXDELAY and TXDELAYC will automatically
adjust the keyup time for the varying rates.

TXDIDDLE ON|OFF   Default: ON

The TNC sends NRZI 0s during TXDELAY/TXDELAYC intervals if TXDID-
DLE is ON, and 7EH flags when it is OFF. TXDIDDLE should be kept
ON unless you are certain the TNCs in your network require
lengthy flagging intervals.

A few 1.1.7 users (TXDIDDLE was forced to ON in 1.1.7) reported
problems with other TNCs that require flags during TXDELAY/TXDE-
LAYC for carrier detection. Now when this problem crops up, the
user has the ability to turn TXDIDDLE OFF and restore
connectivity.

TXFLOW ON|OFF   Default: OFF
                          Display Group: A

Parameters:

   ON   Software flow control can be enabled for the TNC in
      Transparent Mode.

   OFF Software flow control is disabled for the TNC in
      Transparent Mode.

If TXFLOW is ON, the setting of XFLOW is used to determine the
type of flow control used in Transparent Mode. If TXFLOW is OFF,
the TNC will use only hardware flow control and all data sent to
the terminal remains fully transparent.

If TXFLOW and XFLOW are ON, the TNC will use the TNC Restart and
TNC Stop characters (set by XON and XOFF) to control input from
the terminal. Unless TRFLOW is also ON, only hardware flow
control is available to the computer or terminal to control
output from the TNC.

Note that if the TNC Restart and TNC Stop characters are set to
$00, hardware flow control will always be selected regardless of
the setting of TXFLOW.

TXUIFRAM ON|OFF   Default: OFF
                            Display Group: L

Parameters:

ON   The TNC will "flush its buffers" to the radio port upon
     loss of a connection.

OFF The TNC will only send BEACON and ID frames as
    unconnected (UI) frames. It will discard information
    in its buffers upon loss of a connection.

This command determines whether the TNC will transmit most
unconnected information packets.

Setting TXUIFRAMe OFF will prevent all but BEACON and ID
unconnected ("UI") frames from being originated and transmitted.
This is most useful for BBS and other stations which tend to
leave unacknowledged data in the TNC transmit buffer when a
connection is lost. The normal behavior of a TNC would send the
buffered data as "UI" frames, adding to channel congestion.

The behavior with TXUIframe   OFF serves to reduce channel
congestion because the now-useless data is never sent.

Note: TXUIFRAM has no effect on the digipeating of UI frames.
It only affects frames being originated at this station.

UNPROTO call1 [VIA call2[,call3...,call9]]   Default: "CQ"
                            Display Group: I

Parameters:

call1   Callsign to be placed in the TO address field.

call 2 - 9 Optional digipeater call list, up to eight calls.

This command is used to set the digipeat and destination address
fields of packets sent in the unconnected (unprotocol) mode.
Unconnected packets are sent as unsequenced I (UI) frames with
the destination and digipeat fields taken from call1 through
call9 options. When no destination is specified, unconnected
packets are sent to CQ. Unconnected packets sent from other TNCs
can be monitored by setting MONITOR ON and setting BUDLIST and
LCALLS appropriately. The digipeater list is also used for
BEACON packets (which are sent to destination address BEACON).

USERS n   Default: 1
                                    Display Group: L

Parameters:

   n   0 - 10, specifying the number of active connec-
           tions that may be established to this TNC by other
           TNCs.

USERS affects only the manner in which incoming connect requests
are handled, and has no effect on the number or handling of
connections you may initiate with this TNC.

For example,

  USERS 0 allows incoming connections on any free stream
  USERS 1 allows incoming connections on stream A only
  USERS 2 allows incoming connections on streams A & B
  USERS 3 allows incoming connections on streams A, B & C

and so on through USERS 10.

XFLOW ON|OFF   Default: ON
                                    Display Group: A

Parameters:

  ON   XON/XOFF flow control is enabled.

  OFF XON/XOFF flow control is disabled and hardware flow
      control is enabled.

If XFLOW is ON, the computer or terminal is assumed to respond to
the TNC Restart and TNC Stop characters set by XON and XOFF. If
XFLOW is OFF, the TNC will communicate flow control commands via
RTS.

XMITOK ON|OFF   Default: ON
                        Display Group: L

Parameters:

    ON   Transmit functions are enabled.

    OFF Transmit functions are disabled.

When XMITOK is OFF, transmitting is inhibited.   All other
functions of the TNC remain the same. In other words, the TNC
generates and sends packets as requested, but does not key the
radio PTT line.

You might use this command to insure that your TNC does not
transmit in your absence if you leave it operating to monitor
packet activity. This command can also be used for testing using
loopback or direct wire connections when PTT operation is not
relevant.

XOFF n   Default: $13 <CTRL-S>
                                  Display Group: C

Parameters:

    n   0 to $7F, specifying an ASCII character code.

This command selects the TNC Stop character, which is sent from
the TNC to the computer or terminal to stop input from that
device. You can enter the code in either hex or decimal.

This character would ordinarily be set to <CTRL-S> for computer
data transfers. If you are operating your station in a Converse
Mode and there is some chance that you might fill up the TNC's
buffers, you might set this character to <CTRL-G> ($07), which
rings a bell on many terminals.

XON n   Default: $11 <CTRL-Q>
                                  Display Group: C

Parameters:

    n   0 to $7F, specifying an ASCII character code.

This command selects the TNC Restart character, which is sent
from the TNC to the computer or terminal to restart input from
that device. You can enter the code in either hex or decimal.

This character would ordinarily be set to <CTRL-Q> for computer
data transfers. If you are operating your station in Converse
Mode, and there is some chance that you might fill up the TNC's
buffers, you might set this character to <CTRL-G> ($07), which
rings a bell on many terminals.

Messages

This section describes the messages your TNC may produce and the
circumstances under which they will appear.

General Messages

|A

Tucson Amateur Packet Radio TNC 2
AX.25 Level 2 Version 2.0
Release n.n.n mm/dd/yy - nnK RAM
Checksum $xx
cmd:

This is the sign-on message that appears when you turn on your
TNC or when you issue the RESET command. The release number will
be updated whenever the firmware is changed. The checksum is a
hex number which you can compare against the correct checksum
given for the firmware version you are using.

   NOTE: The |A may display as a vertical bar and any capital
letter from "A" through "J".

bbRAM loaded with defaults

This message appears along with the sign-on message above if the
battery backed-up RAM checksum verification fails at power-on
time, causing the TNC to load the default parameters from ROM.
(This will be the case the first time you turn on your TNC.)

This message also appears if the TNC loads the defaults in
response to the RESET command.

cmd:

This is the Command Mode prompt.   When this prompt appears, the
TNC is waiting for you to issue a command. Anything you type
after this prompt will be interpreted as a command to the TNC.
If a monitored packet has been displayed, the prompt may not be
visible, even though you are in Command Mode. You can type the
redisplay-line character (set by REDISPLA) to retype the prompt.

was

Whenever you change the setting of one of the TNC's parameters,
the previous value will be displayed. This confirms that the TNC
properly interpreted your command, and reminds you of what you
have done.

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too many packets outstanding

This message will appear in response to a CONVERS or TRANS command, if you have previously entered packet data filling the outgoing buffer in Converse Mode or Transparent Mode and then returned to Command Mode. You will be allowed to exit Command Mode after some of the packets have been successfully transmitted.

Command Mode Error Messages

If you make a mistake typing a command to the TNC, an error message will be printed. You may see any of the following messages depending on the type of error you have made.

?bad

You typed a command correctly, but the remainder of the command line couldn't be interpreted.

?call

You entered a callsign argument that does not meet the TNC's requirements for callsigns.   A callsign may be any string of numbers and letters, including at least one letter.   Punctuation and spaces are not allowed. The sub-station ID, if given, must be a (decimal) number from 0 to 15, separated from the call by a hyphen.

?clock not set

This message appears if you give the command DAYTIME to display the date and time without having previously set the clock. DAYTIME sets the clock if it is given with the daytime parameters, and displays the date and time if it is given without parameters.

?EH

The first word you typed is not a command or a command abbreviation.

?not enough

You didn't give enough arguments for a command that expects several parameters.

?not while connected

You attempted to change MYCALL or AX25L2V2 while in a connected
or connecting state.

?not while disconnected

You attempted to perform an operation that can only be done while
connected. This message may appear when issuing a RECONNECT or
CONPERM command.

?already connected to that station

The multi-connect software will not permit you to connect to the
same station using multiple streams.

?range

A numeric argument for a command was too large.

?too long

You entered too long a command line, and the line was ignored.
This might happen, for example, if you try to enter too long a
message with BTEXT or CTEXT. If you get this message, the
previous text entry was not changed.

?too many

   You gave too many arguments for a command that expects
several parameters. For example, MFILTER can have up to 4
arguments.

    cmd:MFILTER $1B,$0C,$1A,$03,$07
    ?too many

?VIA

This message appears if you attempt to enter more than one
callsign for the CONNECT or UNPROTO commands without the VIA
keyword.

Link Status Messages

These messages inform you of the status of AX.25 connections your
TNC may be involved in. You can always interrogate the link
status by giving the CONNECT command without parameters. If you

attempt a connection when your TNC is not in the disconnected
state, the TNC will display the link status but will take no
other action. The following messages appear in response to the
CONNECT command.

Link state is: CONNECTED to call1
                    [VIA call2[,call3...,call9]]

This display shows the station your TNC is connected to and the
digipeater route if any.   The callsign sequence is the same
sequence you would enter to initiate the connection.

*** LINK OUT OF ORDER, possible data loss
                    [optional daytime stamp]

This message is issued upon failure of a CONPERMed link.

Link state is: DISCONNECTED

No connection currently exists.   You may issue the CONNECT
command to initiate a connection.

Link state is: CONNECT in progress

You have issued a connect request, but the acknowledgment from
the other station has not been received. If you issue a DISCONNE
command, the connect process will be aborted.

Link state is: DISCONNECT in progress

You have issued a disconnect request, but the acknowledgment from
the other station has not been received.   If you issue a second
DISCONNE command, the TNC will go immediately to the disconnected
state.

Link state is: FRMR in progress

The TNC is connected but a protocol error has occurred. This should never happen when two TAPR TNCs are connected. An improper implementation of the AX.25 protocol could cause this state to be entered. The TNC will attempt to re-synchronize frame numbers with the TNC on the other end, although a disconnect may result. Connects are not legal in this state, and a disconnect command will start the disconnect process.

The TNC will inform you whenever the link status changes. The link status may change in response to a command you give the TNC (CONNECT or DISCONNE), a connect or disconnect request packet from another station, a disconnect due to the retry count being exceeded, an automatic time-out disconnect (CHECK), or a protocol error.

*** CONNECTED to: call1 [VIA call2[,call3...,call9]]

This message appears when the TNC goes from the "disconnected" or "connect in progress" state to the connected state. The connection may be a result of a CONNECT command you issued, or of a connect request packet received from another station.

*** connect request:call1 [VIA call2[,call3...,call9]]

This message indicates that the TNC has received a connect request from another station which it has not accepted. This can happen if you have set CONOK OFF or if you are already connected to another station. When the TNC types this message it also sends a DM packet (busy signal) to the station that initiated the connect request. If the TNC rejects a connect request because you have set CONOK OFF, you can issue your own request to the station that called.

*** DISCONNECTED

This message is displayed whenever the TNC goes to the disconnected state from any other link state. This message may be preceded by a message explaining the reason for the disconnect, below.

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*** retry count exceeded
*** DISCONNECTED

This message is given if the disconnect was caused by a retry
failure rather than by a disconnect request from one of the
stations. It will also occur if you issue two (2) DISCONNE
commands before the remote TNC responds to the first one.

*** <callsign> busy
*** DISCONNECTED

This message indicates that your connect request was rejected by
a DM packet (busy signal) from the other station.   A TAPR TNC
will reject a connect request if CONOK is OFF or if it is already
connected to another station (or other stations up to the number
allowed by the USERS command).

frmr frame just sent:
FRMR sent: xxxxxx

The TNC is connected, and a protocol error has occurred. The TNC
has sent a special FRMR packet to attempt to re-synchronize frame
numbers with the TNC on the other end.   The string xxxxxx is
replaced with the hex codes for the three bytes sent in the
information part of the FRMR frame. This message will not appear
if your TNC is in Transparent Mode.

FRMR rcvd:

This message is followed by a display of the FRMR packet received
in the trace display format.   This format is explained in the
TRACE command entry. This message will not appear if your TNC is
in Transparent Mode.

Health Counters

A number of counters have been added to TNC 2. All of them are
16 bits wide, and are ALWAYS initialized to 0000 on power up or
"RESTART".

These counters are displayed using the HEALTH option of the
DISPLAY command.

   o- ASYFRERR: Increases when a character received on the
           serial port has a framing error. A large
           count may indicate problems in the serial
           link between the TNC and the computer or
           terminal.

o- ASYQOVER: Increases when the TNC's async input buffer
        overruns. A count greater than 0 indicates
        the host computer is not responding properly
        to flow control from the TNC. It also means
        that data have been lost, so you should take
        steps to find out why this is happening and
        get it fixed!

o- ASYRXOVR: Increases when the software does not service
        the asynchronous receiver in time. Indicates
        data from the user to the TNC is being
        dropped. This error counter should never
        become non-zero under supported data rates.

o- BBFAILED: Counts number of times bbRAM checksum was in
        error.

o- DIGISENT: Each frame digipeated by this TNC causes the
        counter to increase.

o- HOVRERR: Increases when HDLC receiver is not serviced
        rapidly enough and data is lost.   This
        counter should never increment at any
        supported data rate.

o- HUNDRERR: Increases when the HDLC transmitter is not
        serviced rapidly enough and frames are
        aborted.   This counter should never be
        non-zero at any supported data rate.

o- RCVDFRMR: Increases when Frame   reject frames   are
        received from a connected station.

o- RCVDIFRA: Increases for each reception of an I frame
        from a connectee.

o- RCVDREJ: Increases for each reception of an REJect
        frame from a connectee.

o- RCVDRNR: Increases when this TNC receives an RNR
        frame. A large count is normal.

o- RCVDSABM: Each received SABM frame addressed to the TNC
        causes this counter to be increased by one.

o- RXABORT: Increases when an aborted frame is received
        from the HDLC controller. Large counts are
        not uncommon.

o- RXCOUNT: Increases when any frame is received with
        good CRC (or any CRC if PASSALL is turned
        on).

o- RXERRORS: Increments each time a received frame is
        thrown out due to it being too short,
        suffering overrun(s), or it having a bad
        CRC. Latter occurs only when CRC checking is
        enabled (i.e. PASSALL is OFF). This counter
        will often increment in the presence of
        noise.

o- RXLENERR: Increases when a received frame has a length
        error and indicates the TNC has temporarily
        become confused. It may be a result of a bug
        in the SIO chip and a count above 0 is no
        cause for alarm.

o- RXRESYNC: Indicates the number of times the TNC has
        recovered from RXLENERR conditions.   In
        firmware prior to 1.1.7, the TNC would simply
        hang until RESTARTed or RESET.

o- SENTFRMR: Increments each time a Frame reject frame is
        transmitted.

o- SENTIFRA: Increases by one each time an I frame is
        sent.

o- SENTREJ: Whenever a REJect frame is transmitted, this
        counter is incremented.

o- SENTRNR: Increases when this TNC sends an RNR frame.
        This is useful for   determining   the
        effectiveness of the FIRMRNR routines.

o- TXCOUNT: Incremented whenever a frame is correctly
        transmitted.

o- TXQOVFLW: Counts how many times frames were discarded
        because the outgoing frame queue was too
        small.

o- TXTMO: Counts how many times as the TNC successfully
        recovers from HDLC transmitter time-outs.

Chapter 7 HARDWARE

This chapter includes detailed specifications and a functional
description of the hardware design of the TAPR TNC 2.

TNC 2 Specifications

Processor CMOS Z-80A

Clocks   Processor master clock input frequency: 2.4576 MHz
    jumper selectable to 4.9152 MHz (requires use of Z80B
    CPU, Z80B SIO/0 and 200 nSec EPROMs).

    User Port Clock: Switch selectable at 16x baud rate.

Memory   All memory in industry-standard JEDEC Byte-Wide
    sockets.

    Standard complement of ROM: 32k = 1 x 27C256

    Standard complement of RAM: 32k = 1 x 43256

    ROM complement jumper selectable for 8k-, 16k-, or
    32k-byte parts. Memory can be expanded to 32k ROM and
    32k RAM using currently available parts.

Serial   Z8440 SIO/0 port B configured as UART plus
    low-Portpower TTL-to-RS-232C signal level interface.

    Baud rates supported: 300, 1200, 2400, 4800 and 9600.

    Standard female DB-25S (DCE) RS-232C connector.

Modem   Input demodulation filter: MF-10 switched-capaci-
        tor filter permits use with unmodified FM trans-
        ceivers. Easily configured for SSB via replace-
        able DIP headers.

    Demodulator: XR2211 PLL demodulator circuit plus
    related components to receive up to 1200 baud 1200
    Hz/2200 Hz FSK modulation.

    Modulator: XR2206 modulator circuit plus related
    components to produce 1200 baud 1200 Hz/2200 Hz phase
    coherent FSK.

All important passive modem components mounted on plug-in DIP headers for ease in substitution and modification.

Built-in modem calibration system requires no additional equipment.

An external modem may be attached via a single connector which completely bypasses the on-board modem.

Support for an external modem tuning indicator is provided via a separate connector.

bbRAM   Non-volatile storage of all important operating parameters is accomplished by using a battery backed-up system for the entire 16k bytes of system RAM.

Protocol   AX.25 Level 2 is supported. Pre-Version 2.0 support is compatible with earlier TAPR TNCs running 3.x software. Full support of Version 2.0 protocol is provided. Full duplex radio link operation is supported.

Operating Command Mode: accepts commands via user port.
Modes
        Converse Mode: accepts digital data, transmits and receives packets, permits terminal editing features (character delete, line delete, input packet delete, output packet delete and redisplay input) via special characters trapped by the TNC. Escape to command mode via special character or BREAK signal. Optional use of packet completion timer as in Transparent mode.

        Transparent Mode: accepts digital data, transmits packets via packet completion timer or buffer full only, and receives packets. No local editing features permitted. Escape to command mode via specially timed character sequence or BREAK signal.

Power   +10 to +15 volts DC at less than 200 mA.
Required

General Description

The TNC 2 is based on the Zilog Z80 (tm) family of microprocessor components. All parts used in the TNC should be readily available to the Radio Amateur.

Major electronic devices in the TNC include a CPU (Central Processing Unit) for controlling the TNC and a SIO (Serial

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Input/Output) chip for providing serial interface ports to the
on-board modem (which connects to your radio) and to the RS-232C
serial terminal port (which   connects to your computer or
terminal).

The TNC also includes two types of memory.   ROM (Read Only
Memory) stores the program that tells the TNC how to implement
the AX.25 protocol. Battery backed-up RAM (Random Access Memory)
provides a scratch-pad area for temporary data as well as
non-volatile storage for operating parameters such as your
station call sign.   The battery back-up feature enables the TNC
to "remember" these values when power is off so you don't have to
enter them every time you want to operate.

Other integrated circuits are used for functions including clock
oscillator, baud-rate generator, memory-space decoder, power
supply and voltage inverter, clock recovery, transmit watch-dog
timer and modem. Refer to the schematic diagram while reading
the following circuit descriptions.

Detailed Circuit Description

Oscillator

U10a, U10b, U10c, R46, R47, R48, C24, C47, C51, and Y1 provide an
accurate crystal-controlled oscillator for system timing.

R48 forces inverter U10a into its linear region and provides a
load for crystal Y1. C47 provides an adjustable reactive element
to allow the oscillator's frequency to be precisely set (this
precision is not normally required).   Inverter U10c buffers the
clock for additional stability before driving additional
dividers.

R46 is used to bias "HCT" logic to the proper levels for best
oscillator operation; it is not necessary if U10 is an "HC" logic
element.

Dividers and Baud-rate Generator

U10e, U10f, U4a, U4b, U1, and SW2 provide clock outputs derived
from the oscillator. Only one of the first 5 switches (terminal
baud rate) and only one of the last 3 switches (RF baud rate)
should be on at any time.

Inverter U10f provides buffering and isolation between the
divide-by-two output of counter U4a and the capacitive load
presented by the CPU (U22) and the SIO (U21). U10f's input may

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be at 2.4576 MHz (standard) or 4.9152 Mhz via jumper JMP2. Operation at the faster clock may require the use of higher-speed parts. Capacitors C59 and C60 are used to slow the edges of the outputs of U4a, and capacitor C61 is used to slow the edges from U10f, helping to reduce RFI.

Counter U1 is a multiple-stage divide-by-two circuit that divides the signal at its input many times. This allows you to select, via switch SW2, the desired signaling (baud) rate to be used for your computer or terminal as well as the radio channel baud rate.

The output from counter U1 at pin 12 provides a real-time clock interval signal for the SIO. During normal operation, the SIO will be programmed to interrupt the CPU on every transition of this 600 Hz signal. This interrupt occurs 1200 times a second, and is used for protocol and calibration timing functions.

Inverter U10e buffers the radio port "16x" baud-rate signal in case it is routed, via modem disconnect J4 pins 11 and 12, to an external modem. If this buffer were not included, reflections from the distant termination might cause counter U1 to generate count errors.

Counter U4b provides a properly scaled clock for the transmit NRZ to NRZI encoder (see Serial Interface, below).

CPU Complex

EPROM U23 provides system ROM for program storage. Selector U12a acts as a ROM decoder, mapping the ROM into the CPU's memory address space beginning at address 0.

Static RAM U25 provide system RAM for temporary scratch-pad storage, message buffers, etc. Also, because the RAM is backed up by a battery and will not lose its contents when the main power is removed, it is used to provide semi-permanent storage of user-supplied information (such as your call sign). Selector U12b acts as a RAM address decoder, with RAM starting at address 8000 hex. JMP12 allows selection of 16k bytes (using 2 x 6264 8k RAMs) or 32k bytes (using 1 x 43256 32k RAM)) of RAM (only 32k bytes currently supported by TAPR firmware).

The sections of CMOS switch U13 are used to insure that the RAM is not selected when main power is removed. This ensures that the contents of the RAM are not accidentally scrambled as the CPU loses power; it also ensures that the RAM is in the "power-down" state for minimum battery power consumption.

Serial Interface

Serial Input/Output (SIO) device U21 provides two channels of serial I/O.

The B SIO channel is used for the computer or terminal interface. Operational amplifier sections U3a, U3b, and U3d act as RS-232C drivers while Schmitt trigger inverters U9a and U9b act as RS-232C receivers. These circuits consume less power than conventional RS-232C drivers and receivers.

The A SIO channel is used for the radio/modem interface and is normally operated as a full duplex HDLC channel for compatibility with the AX.25 protocol specification. Latch U5 and ROM U6 provide a "state machine" for recovering the clock from the received NRZI data. The state machine also converts NRZI data to NRZ for the SIO. Inverter U9c and flip-flop U11a provide NRZ to NRZI conversion for the transmit side of the radio channel. This conversion between NRZ formatted data and NRZI formatted data is necessary because the AX.25 protocol specification requires NRZI operation while the SIO is only capable of NRZ. Jumper JMP11 may be used to bypass the NRZ --> NRZI conversion for use with external modems, if required.

Watch-dog Timer

Inverters U7c, U7d, U7e, and Q10 provide a "watch-dog" timer on the transmit key line to ensure that the transmitter does not remain keyed for more than about 30 seconds if the TNC fails. This allows you to leave a station (such as a remote digipeater) on-the-air and unattended without much chance of having a malfunction "lock up" the packet channel. This also helps ensure compliance with FCC regulations regarding unattended station operation.

Jumper JMP4 is provided for testing purposes. When JMP4 is installed, timing capacitor C31 is shunted, disabling the watch-dog timer.

Modem

U16, an XR2206, is a Frequency Shift Keying (FSK) modulator that generates an audio data signal for use by the radio transmitter. Two tones are used, one for each digital level, and these tones may be calibrated via trimpots R77 and R78 in conjunction with the on-board calibration support circuitry and software. When the transmitter is not being keyed, transistor Q9 is switched on, thus preventing U16 from producing tones. This allows you to

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leave a microphone connected to your packet transmitter for voice
operation. DIP header U15 contains the three passive components
which determine the operation of the modulator, as well as R83,
the PTT watch-dog circuit timing resistor.

R76 is used to set the tone output level to the transmitter.

U20, an XR2211, provides a Phase Locked Loop (PLL) FSK
demodulator. It converts the received audio FSK signals into
digital data at standard logic levels. This data is sent to the
state machine clock recovery and NRZI to NRZ format conversion
circuits. R79 is used to calibrate the PLL demodulator's
free-running frequency which is set midway between the FSK tones
being received. This tone is measured by the calibration
software and the output signal produced by U8a and U8b, which is
a frequency doubling shaping circuit. DIP header U19 contains
all passive components which determine the behavior of the
demodulator, with the exception of R73 and C45, the DCD detection
filter. These two components normally do not need to be changed
when the modem is reconfigured. However, in the event the TNC
will be dedicated to 300 baud operation, the DCD detection filter
at U18 pin 3 should have its time constant increased by a factor
of 4, by increasing C45.

U18, an MF-10 switched capacitor filter, provides audio amplitude
and phase equalization to shape the received audio signal before
it goes to the XR2211 demodulator. This equalization helps the
demodulator properly process signals by correcting some of the
distortion that many FM radios introduce. By replacing the
components on DIP header U17, this filter may be configured at
will.

Power Supply

Regulator Q3 and associated components provide a +5 volt
regulated output for the TNC digital logic circuitry. In order
to reduce conducted RFI from the digital power source, series
inductor L1 is provided. Transistor Q4, in conjunction with CMOS
inverters in U14, provides a "power failure" circuit for the
battery-backed RAM chips to ensure that RAM is in the
"power-down" state when the main power is removed. In addition,
this circuit provides the main power-on reset signal via U7f.

Transistors Q5 and Q6 are used to isolate the battery from the +5
volt line when main power is available. R33 protects the lithium
battery from overload conditions and provides a convenient means
of monitoring battery current drain when the TNC is switched off.
JMP5 provides a means of disconnecting the lithium battery for
TNC 2 maintenance.

U2 and associated components form a charge-pump voltage inverter which generates an unregulated negative supply for the RS-232C drivers.

U3c, Q2, CR6 and surrounding components provide a regulated source of -5 volts for the modem chips.

The modem power sources and ground are isolated from digital logic switching noise by inductors L2 and L3.

RS-232C Handshaking Protocol

The CTS, DSR and DTR lines of the RS-232C port (J1) are used for hardware "handshaking" protocol to control the flow of data between the terminal (DTE) and the TNC (DCE).

The TNC always asserts (makes true) Data Set Ready (DSR) on J1 pin 6 via resistor R16. Thus, whenever the TNC is powered up, it signals to the terminal connected to J1 that the TNC is "on line."

The terminal indicates it is ready to receive data from the TNC by asserting its Data Terminal Ready (DTR) output, J1 pin 20. The TNC will send data when it has data to send and DTR is asserted. If the terminal is not ready to receive data, it should negate (make false) DTR to the TNC. Thus, data flow from the TNC to the terminal is controlled by the use of the DTR line. The state of the DTR line is ignored by the software if "software flow control" is enabled in this direction.

The TNC asserts its Clear To Send (CTS) output, J1 pin 5, whenever it is ready to receive data from the terminal. If the TNC's buffers fill, it will negate CTS, signaling the terminal to stop sending data. The TNC will assert CTS when it is again ready to receive data from the terminal. Thus, data flow from the terminal to the TNC is controlled by the use of the CTS line. The CTS line is always asserted if "software flow control" is enabled in this direction.

Some serial I/O ports do not implement CTS, DTR and DSR handshaking. If these pins are not connected at the terminal end, they will be pulled up (and thus asserted) by resistors at the TNC end. However, a non-standard serial connector may use some pins for other purposes, such as supplying power to a peripheral device, so be sure that your system either implements the CTS, DTR and DSR handshake or has no connections to these pins of J1 whatsoever. Note that reference to RS-232C "compatibility" or the presence of a DB-25 type connector does not guarantee that you have a full RS-232C serial port!

The TAPR TNC 2 supports most standard baud rates from 300 through 9600. The port supports standard parity options as well as 7- or 8-bit character lengths. Setting these terminal parameters is discussed in Chapter 4.

If you want to interface your TNC with a device configured as DCE, such as a telephone modem or another TNC, a so-called "null modem" cable may be constructed to interchange the data and handshake signals. See for example Byte, February, 1981, page 198.

Jumper Functions

The following table lists the function of each jumper on the TNC 2 PC board. The default positions for JMP7, JMP8, JMP9, and JMP10 are necessary for normal operation to occur.

Jumper	Position	Function
JMP1	ON	!DCD (RS-232C) stays on
	OFF (default)	!DCD reflects connect status
JMP2	LEFT	4.92 MHz CPU clock
	RIGHT (default)	2.46 MHz CPU clock
JMP4	ON	disable Tx watch-dog
	OFF (default)	enable Tx watch-dog
JMP5	ON	Lithium battery connected
	OFF (default)	Lithium battery disconnected
JMP6	ON (default)	U23 is type 27256
	OFF	U23 is not type 27256
JMP7	ON	analog loopback mode
	OFF (default)	normal modem operation
JMP8	ON	demodulator enabled
	OFF (default)	demodulator calibrate
JMP9	TOP	calibrate U16 tones
	MID	calibrate U20 tone
	LOW	bypass state machine
	OFF (default)	normal modem operation
JMP10	ON	digital loopback mode
	OFF (default)	normal modem operation

JMP11   LEFT   transmit data NRZ
          RIGHT (default)   transmit data NRZI

JMP12   TOP   16k RAM (2 x 6264)
        BOTTOM (default)   32k RAM (1 x 43256)

Modem Disconnect - J4

The modem disconnect, J4, on the TNC 2 PC board is provided for
using an external modem with the TNC.   This allows use of
higher-speed modems, such as 9600 baud, or more sophisticated,
higher-performance modems for OSCAR or other uses.

The following information is primarily for those who wish to
interface external modems to the TNC. Familiarity with modem and
serial data channel terms is assumed.

A physical connector for J4 is not supplied with the TNC. Any
standard 20-pin header for use with IDC cable connectors should
work.   Suitable parts are the Ansley 609-2027, the 3M 3428-6202,
etc.

When installing the connector, be sure to line up the marked pin
(pin 1) of the header with the lower edge of the PC board
nearest U21. Cut the traces on the bottom of the TNC PC board,
with a sharp knife or Moto-Tool, between each pair of adjacent
pins of J4. To use the on-board modem, install push-on jumper
links across these same pin pairs.

The signals used at connector J4 are at standard TTL interface
levels. A TTL high, or 1, is greater than +2.4 volts but less
than +5.25 volts. A TTL low, or 0, is less than 0.8 volts but
greater than -0.4 volts. DO NOT connect an RS-232C level modem
directly to J4!

   NOTE: The modem disconnect is similar, but not identical to
   that used in TNC 1. Be very careful about interfacing an
   external modem using the same cabling you may have prepared
   for use with TNC 1!

The connector pin-outs are as follows.

Pin 1   Carrier Detect Input

   This pin tells the SIO radio port that a valid data carrier
   has been detected. It should be pulled high when no carrier
   is detected and low when a carrier is present. This line
   must be implemented unless the software release notes
   indicate otherwise. It is normally jumpered to pin 2 when
   the on-board modem is used.

Pin 2   Carrier Detect Output

   This pin is an output from the the on-board modem and
   satisfies the requirements outlined for pin 1 above. It is
   normally jumpered to pin 1 when the on-board modem is used.

Pin 3   SIO Special Interrupt Input

   This signal is routed to the radio port DCD input pin on SIO
   U21. This signal is normally used during modem calibration.
   It may also be used for other purposes; if so, these
   functions will be listed in the software release notes.
   This pin is normally jumpered to pin 4 when the on-board
   modem is used.

Pin 4   SIO Special Interrupt Generator Output

   This signal is an output from the on-board modem. It is
   normally used for modem calibration only. If it is used for
   other functions, they will be stated in the software release
   notes. This pin is normally jumpered to pin 3 when the
   on-board modem is used.

Pin 5   SIO RTS Output

   This signal is used for transmitter activation. The SIO
   will pull this output low when the TNC wants to transmit;
   otherwise it will remain high. This pin is normally
   jumpered to pin 6 when the on-board modem is used.

Pin 6   Transmitter Key Input

   This signal is an input to the on-board modem. It activates
   the PTT pin of the radio connector via the watch-dog timer.
   It should be left high and pulled low only when transmission
   is desired. This pin is normally jumpered to pin 5 when the
   on-board modem is used.

Pin 7   CONNECT Status Output

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This pin is an output from the SIO. It is normally low and goes high only when the TNC is in the connected (error-free) mode with another packet station. Its status is monitored via the CON LED.

Pin 8   Unacknowledged Packets Pending Status Output

This pin is an output from the SIO. It is normally low and goes high only when this TNC has unacknowledged packets in its transmit buffer. Its status is monitored via the STA LED.

Pin 9   CTS Input

This pin is an input to the SIO. It is high when the attached modem is not ready to accept data, and low when the attached modem is ready to accept data. The TNC will not attempt to send data when this pin is high. This pin is normally jumpered to pin 10 when the on-board modem is used.

Pin 10   Transmitter Key Input

This pin is physically tied to pin 6, above. It is used in conjunction with pin 9, above, to allow the TNC to use the on-board modem whenever the transmitter is activated.

Pin 11   Transmitter Clock (16x) Input

This pin is tied to the NRZ-to-NRZI converter, which expects a clock signal at 16 times the desired radio port data rate, e.g., 4800 Hz for 300 baud. This pin is normally jumpered to pin 12 when the on-board modem is used.

Pin 12   Transmitter Clock (16x) Output

This pin is tied to the radio baud rate switch network. It provides a clock at 16 times the desired radio port data rate. This pin is normally jumpered to pin 11 when the on-board modem is used.

Pin 13   Receive Clock Input

This pin is tied to the SIO receive clock input pin. It expects a clock at the desired data rate (1200 Hz for 1200 baud), of the proper phase relationship to the received data. This pin is normally jumpered to pin 14 when the on-board modem is used.

Pin 14   Receive Clock Output

This pin is the received data clock signal derived from the
NRZI-to-NRZ state machine. This pin is normally jumpered to
pin 13 when the on-board modem is used.

Pin 15   TNC 2 Ground Reference

This pin ties to the TNC digital ground system, at the SIO.

Pin 16   No Connection

This pin is unused.

Pin 17   Receive Data Input

This pin is the received data input to the NRZI-to-NRZ state
machine. This pin is normally jumpered to pin 18 when the
on-board modem is used.

Pin 18   Receive Data Output

This pin provides receive data from the on-board modem.
This pin is normally jumpered to pin 17 when the on-board
modem is used.

Pin 19   Transmit Data Output

This line is the NRZ or NRZI (depending on the state of
JMP11) data output. This pin is normally jumpered to pin 20
when the on-board modem is used.

Pin 20   Transmit Data Input

This input line accepts data to be be transmitted by the
modem. This pin is normally jumpered to pin 19 when the
on-board modem is used.

If you elect to use an off-board modem, be sure to properly
shield the interconnecting cables for RFI protection.

Tuning Indicator Interface - J3

In order to facilitate communications on HF and OSCAR, the TAPR
TNC 2 includes a connector for attaching a tuning indicator. The
attached unit may range from an oscilloscope to a specialized,
LED-style unit such as the one described in the June 1984 PSR.
Refer to the Exar Application Note referenced in the Bibliography

for details on functions of the XR2211 signals available on this connector. A mating connector assembly (shell and 5 pins) may be obtained from TAPR.

NOTE: Exercise caution when using this connector.   Be especially aware that the TNC 2 modem circuitry is referenced to +5 volts and -5 volts, not +12 volts and 0 volts!

The connector pinouts are as follows.

Pin 1   -5 volts (Common)

   This pin is the on-board modem's analog common. It is not
   ground, but -5 volts. This pin should not be used to sink
   appreciable currents or excessive noise may be introduced
   into the modem, reducing its performance.

Pin 2   Loop Data Filter Output

   This pin is connected to the output of the XR2211 PLL data
   filter (U20 pin 8). It is a high-impedance source, and care
   should be exercised to ensure that no extraneous signals or
   low-impedance loads are attached.

Pin 3   Demodulator Reference Voltage

The internal XR2211 data comparator reference voltage is available on this pin. By comparing this voltage with the signal on J3 pin 2, correct tuning may be accomplished. As above, this pin must be carefully shielded from noise, and has a relatively high internal impedance.

Pin 4   Data Carrier Detect

   This pin is an open-collector output that goes near -5 volts
   (J3 pin 1) when valid data is not present. It is pulled to
   +5 volts by R74 when valid data is detected.

Pin 5   +5 Volts

   This pin is a source of +5 volts DC. It should not be used
   to source more than a few milliamperes of current or
   degradation of the on-board modem's weak-signal performance
   may result.

Chapter 8 TROUBLESHOOTING

WARNING: Never remove or insert an IC with power on!

Your TAPR TNC 2 is a complex piece of electronic equipment.
Servicing must be approached in a logical manner. The best
preparation for troubleshooting is to study the detailed hardware
description in Chapter 7. While it is not possible to present
all possible problems, symptoms and probable cures, this section
of the manual will give direction to troubleshooting based on our
experience.

General Tests

In most cases we have found that careful visual inspection
combined with simple measurements generally reveals the problem.
The most useful single instrument for troubleshooting is a good
DVM that can read AC and DC volts, and can non-destructively test
resistance while the ICs are still in their sockets.

While a number of checks may be made without the aid of an
oscilloscope, you will need one to check signals at various
points on the board if you fail to locate the problem by visual
means or with a meter. Be very careful about shorting pins on
ICs when applying meter or scope probes to the board. It is a
good idea to attach a secure ground lead to the meter or scope,
one that won't accidentally short across components on the board.
A good place to pick up this ground is on the threads of the
screw that mounts regulator Q3 to the printed-circuit board.

Step 1: Power Supply

The first thing to check in any malfunction is the power supply.
Check the power supply levels at the outputs of the voltage
regulators (Q2 and Q3) as well as the output of the inverter
(U2). Are they close to their nominal values? Do all the ICs in
the suspected area have the proper voltage on their power pins?
Is there excessive ripple in any of the DC voltage lines? If so,
check the regulator and associated components, working backwards
toward the input power switch. If the voltage is low, in
conjunction with a hot regulator, suspect a short circuit on the
board.

If the problem is in the -5 volt supply, work backwards from Q2's collector (also at U16 pin 1), which should be -5 volts regulated, to the junction of C9 and CR2 (-V unregulated). If no voltage appears at -V, then U2 or a related component may be at fault.   Verify that U2 is oscillating by looking at the wave form at U2 pin 5. If -V is more negative than -7 volts (i.e., normal), but the -5 volt regulated voltage is wrong, check the negative regulator components U3, Q2, R5, R6, R7, R8, CR6, C10, C11 and C158. If both -V and the -5 volt regulated voltage are wrong, look for shorts.

Step 2: Obvious Problems

Look for any unusual physical symptoms. Have you installed any ICs the wrong way? This is almost guaranteed to ruin the IC and produce a high current through it, detectable by the IC's high temperature. Are any components discolored? Does something smell burnt? Do any of the parts seems excessively warm? If you have never had your fingers on operating digital integrated circuits before you may erroneously conclude they are too hot when they are actually operating normally. In general their normal temperature will be well below the boiling point of water, but you may not want to keep your finger on them very long.

Step 3: Assembly Problems

Carefully inspect the PC board and component installation. Are any cold solder joints present? (See the soldering instructions in the TNC 2 Assembly Manual.) Is a metal screw shorting to the board anywhere? Are all ICs firmly seated in their sockets? Are any IC leads tucked under the chip or otherwise bent in such a manner that they aren't making proper contact with the IC socket? (This is a very common error, accounting for most problems!)

Inspect the diodes and electrolytic capacitors for proper installation. Are the diode cathodes pointing the correct way? Are the negative ends of the electrolytic capacitors pointing the correct way?

Step 4: Cabling Problems

Inspect the interconnection cabling. Does it work on another TNC? Has the radio and/or terminal been successfully used on packet with this or another TNC? Are all the connections tight? Has the cable frayed or broken?

Specific Symptoms

While the steps described above may seem obvious, careful inspection often will point to the problem or give significant clues as to the probable area of the TNC most suspect. After the above inspection has been completed and apparent problems dealt with, it is time to proceed to more specific analysis.

Symptom: TNC appears dead

If the TNC powers up with the PWR, STA, and CON LEDs lit, followed by STA and CON extinguishing a second or so later, the processor is working and the software is probably working correctly. You should suspect the terminal port at this point. Check all connections and verify the logic levels according to the terminal interface troubleshooting section in this chapter.

Oscillator and Reset Circuits

If no LEDs wink during the reset cycle the problem may be more serious. Check to see that the crystal oscillator is working and that an "M1" signal (154 kHz square wave, 0 to +5 volts) is coming from U22 pin 27. The crystal oscillator input to the processor (U22) is pin 6. The input clock should be a (possibly distorted) square wave signal. Verify that the clock input at pin 6 of U22 is running at the correct frequency (near 2.4576 MHz).

Verify that the battery backed-up RAM protection circuit, composed of Q4, U14 and associated devices, is going to +5 volts at U14 pin 6 after input power is applied. This signal enables normal operation of U24 and U25. There should be a logical low on the output of U7 pin 12 coincident with the application of power and lasting for a few hundred milliseconds. Without this RESET signal, the Z80 probably won't start up properly.

Digital Logic Lines

Remember that all the logic circuits operate at standard TTL levels (a "low" is less than +0.8 V and a "high" is greater than +2.4 volts), and all digital inputs and outputs switch between these two levels. Thus, if you see logic signals switching between 0 and, say, 1 volt, you can be sure there is a problem (usually a short). On the other hand, do not mistake switching transients on digital logic lines for improper operation -- these show up as ringing and other distortions.

Verify that there is activity on the control bus READ and WRITE lines, the 3 CHIP-ENABLE lines on the memories (U23-25, pins 20),

the IOREQ line on U21 pin 36, and the INT line on pin 16. Each of these lines should show activity, and if any line is quiet this is a sign of trouble.

Logic lines that show no activity may often be traced to a short on the pc board, probably due to a solder splash or bridge.

Address and data line shorts may also show up as lack of activity on the control bus lines, especially the chip selects. Check each of the 16 address and 8 data lines for activity. Any lines showing a lack of activity are not operating properly.

If you suspect problems with address or data lines, try removing all the memory chips. Each address and data line will now show a distinct pattern. The address lines should be (possibly distorted) square waves whose periods increase by a factor of two on successive lines as you step line by line from A0 to A15.

If you decide to use an ohmmeter to check for shorted lines, use a low voltage/low current test instrument. (Most modern DVMs are fine for this.) If in doubt, remove any ICs connected to the lines you are measuring. If you suspect a short, check the high density areas of the PC board for the problem. In most cases the short will be found there. It is very unlikely that the PC board itself will have a short, as every board shipped by TAPR has been electrically tested for shorts and opens on a commercial "bed-of-nails" board tester prior to acceptance by TAPR.

Symptom: Modem won't calibrate or key transmitter.

Double check the placement of parts on each DIP header assembly, measuring resistor values and checking for shorts between adjacent components and for shorted capacitors.

Calibration of the demodulator's 1700 Hz tone and the modulator's 1200 Hz and 2200 Hz tones is done in software by setting the specified device to generate the frequency in question and routing the signal to U21 pin 22 where it causes interrupts to the Z80 microprocessor. The software calibration routine then examines the ratio between this interrupt rate and a fixed 1200 Hz interrupt generated by a 600 Hz square wave at U21 pin 29, then sets the STA and CON LEDs appropriately. In the case of the 1700 Hz tone, it is first passed through U8, acting as a frequency doubling Schmitt trigger. The input signal to the Schmitt trigger is a modified sawtooth wave. In the case of the modulator, the signal presented to U21 pin 22 comes directly from U16 pin 11, and should be a reasonable square wave.

Troubleshooting improper calibration amounts to checking for proper signals at U21 and following up any improper signal. If the calibration signal is present, but you cannot successfully calibrate the frequency, you may have an out-of-spec frequency determining component. Check the values of the appropriate passive components. Also, check the placement of jumpers! As a last resort, check the signal frequency with a frequency counter. Note that, due to frequency jitter while calibrating the demodulator, the STA and CON LEDs may blink somewhat even when the 1700 Hz demodulator frequency is correct.

If the transmitter doesn't key, the problem may be in the watchdog timer, U7, or the PTT transistor, Q10. Check especially for an open timing capacitor C31 or a bad solder connection associated with R83 in header U15.

Symptom: Uncopyable transmitted or received packets

If no one seems able to decode your packet transmissions, it is often the case that your transmitter is being overdriven. The solution is to reduce the drive level via trimpot R76. Note that direct connection to typical microphone inputs requires R76 to be turned to near the minimum signal position to produce sufficiently low signal levels.

If you are having problems hearing other stations, the demodulator circuitry associated with U20 may be at fault. Check the center frequency of the VCO in U20 using the 1700 Hz calibration procedure. Working in the direction of flow of the input signal from the radio, verify that it is being passed through to pin 2 of U20, the input pin. The signal there should be above 50 mV and below 3 V peak-to-peak for proper operation of the demodulator. It should be relatively clean, although a few tens of millivolts of noise is normal, and the signal amplitude should not change by more than about 25% between high and low tones.

Terminal Interface Troubleshooting

If you can't get the TNC to sign on and accept data from your terminal or computer, the problem may be in the RS-232C interface. The troubleshooting guide below is provided as an aid to help in resolving problems that may be related to the RS-232C port.

Symptom: TNC won't sign on to the terminal.

If you find the TNC won't send data to your terminal, one of the
first things to do is to verify that the DTR line at pin 20 of J1
is not being held low.   If the software flow control option is
disabled, the TNC will not send data to the terminal unless its
DTR is asserted. If the terminal does not implement the DTR/CTS
protocol, the DTR/CTS lines (pins 20 and 5 on J1) should remain
unconnected.

Verify that the voltages on the TNC are correct.   If the TNC is
in otherwise good condition, check the following pins on the SIO,
U21 (Z8440). Pin 23 should be TTL low (between 0 and +0.8
volts).   If this voltage is incorrect, check the voltage at U9
pin 3 and verify that it is greater than +3 volts. If this
voltage is correct, U9 or the traces around it may be bad. If
this is not the problem, disconnect the terminal and check it
again. If this doesn't help, U9, R20 or R22 may be at fault.

If the above checks are ok, observe pin 26 of U21 with an
oscilloscope and cycle the power switch on the TNC. Transitions
on this pin shortly after reset indicate that the TNC is sending
data. Verify that transitions are also present on U3 pin 1. If
these tests fail, the fault could be with U13, R25, R26, U21, J1,
the attached cable or faulty soldering (shorts, cold joints,
etc.)

Symptom: The TNC appears to be signing on but only gibberish is
printed on the terminal.

This indicates that some combination of the data rate (baud
rate), parity option, or number of start and stop bits are not
set the same at the TNC and at the terminal.   If possible, set
your terminal to 300 baud. Also verify that the terminal is set
for seven data bits, space parity, and 1 stop bit. These are the
default settings stored in EPROM. For 300 baud, set DIP switch 1
ON (up) and set switches 2 through 5 OFF (down). Be sure only
one of these 5 switches is up! Perform a hard reset by the power
switch OFF then ON (out then in).   The sign on message should
appear.

If the TNC still prints gibberish, verify that the terminal is
set to 300 baud and do a power off then on cycle on both the TNC
and terminal.   If the message still fails to appear try
troubleshooting with an oscilloscope, looking first at the TXD
pin (pin 26) of U21 (Z8440), then at the x16 baud rate clock
(4800 Hz at 300 baud) on pin 27 of U21.

Symptom: The TNC signs on OK but won't accept commands.

After the TNC signs on, try giving it a command such as MYCALL or
any other command.   If the default settings are in effect, it
will attempt to echo each character you type back to the screen.
If it doesn't echo, be sure that U21 pin 23 has a voltage level
between 0 and +0.8 volts on it.   The voltage on U9 pin 3 should
be greater than +3 volts. If these voltages aren't correct, the
fault could be in U9, U21, J1, R20, R22, soldering, or the
interconnecting cable.

If the above checks are OK, use an oscilloscope to verify that
data is present on U21 pin 28 and U9 pin 1 when you strike a key
on your terminal. If not, the data isn't getting from your
terminal to the TNC. Check J1, the cable and U9 again. Finally,
be sure that your terminal actually uses levels less than -3
volts and greater than +3 volts for signal levels.   0 and +5
volts may not work, especially if they are being used direct from
a computer. For example, the Commodore 64 uses TTL levels that
will work only if they are inverted!   This is because RS-232C
logic polarity definitions are opposite those of TTL.

Chapter 9 PACKET RADIO PROTOCOL

Explanation of Protocol

The material in this chapter is intended to supply an overview of the protocol used to transmit data by the TAPR software. References are given to more detailed information required by those wishing to implement these protocols on other hardware. The material presented below is somewhat tutorial in nature for those who have not had previous exposure to layered network protocols, but it presumes some knowledge of general communications hardware and software. Persons already well versed in networking may want to skip this chapter and refer to the primary defining document, Amateur Packet-Radio Link-Layer Protocol, AX.25 Version 2.0, available from the ARRL, 225 Main Street, Newington, CT 06111 ($8.00 US, postpaid in the United States as of this writing).

The TAPR TNC hardware and software architecture is organized in accordance with the International Standards Organization (ISO) layered network model. The model describes seven levels and is officially known as the ISO Reference Model of Open Systems Interconnection, or simply the ISO Model. The model and many other interesting topics are discussed in Computer Networks by Andrew S. Tanenbaum.

The ISO model provides for layered processes, each supplying a set of services to a higher level process. The TAPR TNC currently implements the first two layers, the Physical layer and the Data Link layer.

   Physical Layer

The duty of the Physical Layer, layer one, is to provide for the transmission and reception of data at the bit level. It is concerned only with how each bit is physically transmitted, i.e., voltages on a hardwire line or modem tones on phone or RF links.

The physical layer of the TAPR TNC is described in Chapter 7, Hardware. It is compatible with the various TNCs currently available to radio Amateurs. The actual modem interface is compatible with the Bell 202 standard which is similar to the CCITT V.23 standard. Any other hardware device which is compatible with the Bell 202 standard should be compatible with the TAPR TNC, at least at level one of the ISO reference model.

Data Link Layer

The duty of the Data Link layer is to supply an error-free stream
of data to higher levels. Since level one simply passes any bits
received to level two and is unaware of the content or overlying
structure of the data, transmission errors are not detectable at
level one. Level two carries the responsibility of detecting and
rejecting bad data, retransmitting rejected data, and detecting
the reception of duplicate data.

Level two accomplishes this task by partitioning data to be
transferred by level one into individual frames, each with its
own error detection field and frame identification fields.   The
TAPR TNC supports two versions of a level-two layer, AX.25
version 1.0 and AX.25 version 2.0. Each of these protocols is
based on HDLC, the High-Level Data Link Control protocol defined
by the ISO.

HDLC Frames

Exact knowledge of the format of HDLC frames has been made
largely unnecessary by the advent of LSI and VLSI communications
chips which interface directly with the level one hardware. The
level two software need only supply data to fill in various
fields and the chip takes care of the rest. For completeness
however, an HDLC frame looks like this:

   | FLAG | ADDRESS | CONTROL | PID & DATA | FCS | FLAG |

FLAG A unique bit sequence (01111110) used to detect frame boun-
daries. A technique called "bit stuffing" is used to keep all
other parts of the frame from looking like a flag.

ADDRESSA field normally specifying the destination address.
AX.25 uses a minimum of 14 bytes and a maximum of 70 bytes
containing the actual call signs of the source, destination, and
optionally up to eight digipeaters.

CONTROLA byte which identifies the frame type.   In the AX.25
protocol, the control field may include frame numbers in one or
two 3-bit fields.

PID   A Protocol Identification byte appears as the first
byte of the HDLC DATA field in AX.25 Level Two information
frames, and identifies which Level 3 protocol is implemented, if
any. In the case where no Level 3 protocol is implemented, PID =
$F0.

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DATA This field contains the actual information to be
transferred. This field need not be present.   Most frames used
only for link control do not have data fields.

FCS Frame Check Sequence, a 16-bit error detection field.

The communications chip recognizes the opening and closing flags
and passes the address, control, and data (including PID) fields
to the software.   The FCS field is a Frame Check Sequence
computed by the transmitting chip and sent with the frame. The
receiving chip recomputes the FCS based on the data received and
rejects any frames in which the received FCS does not match the
computed FCS. There is virtually no chance of an undetected bad
frame using this method.   This satisfies the level two task of
bad data detection.

The communications chip used in the TAPR TNC 2 is a Zilog 8440
SIO operating in conjunction with a two-chip "state machine"
which is used to recover the data clock. The transmitted data is
encoded in NRZI form, which encodes a "0" data bit as a
transition in the encoded bit stream and a "1" data bit as no
transition.   This, in combination with the "bit-stuffing" which
ensures that no more than five "1"s occur in a row except when
FLAG bytes are being transmitted, guarantees that a logic level
transition occurs at least once every 5 bit times.   These
frequent transitions allow the receiver to synchronize its clock
with the transmitter. Other chips which are compatible with the
SIO + "state machine" are the Western Digital 1933/1935 (used on
the TAPR TNC 1, AEA PKT-1, Heathkit HD-4040, etc.), the Intel
8273 (used on the VADCG and Ashby TNCs) and the Zilog 8530 (used
on the Xerox 820 FAD adapter).

While the HDLC format supplied by the communications chips is
used by the AX.25 protocol, there are several other Layer Two
concerns.   These are duplicate frame detection, connection and
disconnection of the level two layers on different TNCs, and
buffer overrun avoidance.   The AX.25 protocol solves these
problems as described below.

AX.25 Level Two

AX.25 is based on the Balanced Link Access Procedure (LAPB) of
the CCITT X.25 standard.   LAPB in turn conforms to the HDLC
standard. Two extensions are made to LAPB in AX.25. These are
the extended address field, and the unnumbered information (UI)
frame. In LAPB, addresses are limited to eight bits, while AX.25
uses from 112 to 560 bits, containing the originator's call sign,
the destination call sign and an optional list of one to eight
digipeater (simplex digital repeater) call signs.

The UI frame is used to send information bypassing the normal flow control and acknowledgment protocol. The UI frame is not acknowledged but can be transmitted at layer two without fear of disturbing higher layers. It is used for beacon frames, for automatic identification packets, and for sending information frames when the TNC is not connected to another TNC, e.g., CQ and QST activities.

The exact specifications for AX.25 are supplied in the ARRL publication Amateur Packet-Radio Link-Layer Protocol, AX.25 Version 2.0. The TAPR implementation adheres to this standard for AX.25 version 2.0. The implementation of version 1.0 is almost identical to the TAPR TNC 1 version of AX.25 protocol in software releases 3.x. This provides compatibility with the majority of Amateur packet radio stations.

The following table lists the frame types used by AX.25 and describes their purpose. This material is provided to give a general understanding of the protocol, and is not intended to replace the published specification. The byte fields are given as they appear in memory after data is received, i.e., the high order bit is at the left and the low order bit is at the right. This is also the format of the display provided by the TRACE command. Some texts, including the AX.25 protocol specification, list the bits in the order in which they are transmitted, which is low order bit first.

The control bytes are presented in hex with "x" used to indicate four bits which depend on the acknowledge functions the packet is performing. Usually "x" is a frame number. Frame numbers fit into three bits and are used to ensure that frames are received in order and that no frames are missed. Since only three bits are available, the frame number is counted modulo 8. This is why the MAXFRAME parameter has a ceiling of 7: no more than seven frames can be "in flight" (transmitted but unacknowledged) at one time. A short description of the use of the frames is given after the table.

Table 9-1. AX.25 Control Codes

Code	Abbrv	Frame Type
x1	RR	Receive Ready
x5	RNR	Receive Not Ready
x9	REJ	Reject
03	UI	Unnumbered Information
0F	DM	Disconnected mode
2F	SABM	Connect request
43	DISC	Disconnect request

    63 UA   Unnumbered Acknowledge
    87 FRMR   Frame reject
    even I   Any frame ending in an even number (in-
cluding $A, $C, and $E) is an information frame.

I   This and UI frames are the only frame types containing user
    data. The control byte contains this frame's number and the
    number of the next frame expected to be received from the
    other end of the link.

RR   Usually used to acknowledge receipt of an I frame. The RR
    function can also be performed by sending an I frame with an
    updated "expected next frame number" field.

RNR Used when the buffer space on the receiving side is full.

REJ Used to request retransmission of frames starting from "x".
    Missed frames are detected by receiving a frame number
    different from that expected.

DM   Sent in response to any frame received other than a connect
    request (SABM) when the TNC is disconnected.   Sent in
    response to an SABM whenever the TNC is on the air but can't
    connect to the requesting user, e.g., if the TNC is already
    connected to someone else or if CONOK is OFF.

SABM Set Asynchronous Balanced Mode - initiates a connect.

DISC Initiates a disconnect.

UA   Sent to acknowledge receipt of an SABM or DISC.

FRMR Sent when an abnormal condition occurs, i.e., the control
    byte received is undefined or not proper protocol at the
    time received.
UI   An I frame without a frame number. It is not acknowledged.

Channel Use and Timing Functions

The following discussions mention timing parameters which are set
by various commands. These timing functions are also discussed
in Chapter 5.

An important part of any packet radio protocol is the means by
which many stations make efficient use of an RF channel, achie-
ving maximum throughput with minimum interference. The basis for

this time domain multiplexing   is Carrier-Sensed Multiple Access (CSMA) with collision detection and collision avoidance.

CSMA means simply that (as every Amateur knows) no station will transmit if the frequency is in use. The TNC continually moni- tors for the presence of an audio data carrier on frequency and transmits only if there is no carrier. (The RF carrier is not normally detected; however, an input is available on the TNC 2 radio interface connector to allow such an input.) In order to make detection of a busy channel more reliable, the TNC sends an audio signal (continuous flags) any time the transmitter is keyed and a packet is not being sent, as during the transmitter keyup delay (TXDELAY), or while a slow audio repeater is being keyed (AXDELAY).

By itself, CSMA is not enough to insure a minimum, or even low, interference rate, due to the likelihood of simultaneous keyup by two or more stations. This is where collision detection and collision avoidance come in. The TNC detects a collision by the absence of an ACK from the station it is sending to. The receiving station does not acknowledge the frame that suffered the collision, since either the FCS was incorrect or the packet was not heard. There are other possible reasons for non-receipt of the packet, but the TNC's response is based on the assumption of a collision.

After transmitting a packet, the TNC waits a "reasonable" length of time (FRACK) for an acknowledgment.   "Reasonable" is determined by the link activity, frame length, whether the packet is being digipeated, and other time-related factors. If no ACK is received, the packet must be re-sent. If the unACKed frame was lost due to a collision, the assumption is that there is at least one other packet station out there that also lost a frame and will probably have exactly the same criterion for deciding when to retry the transmission as this station is using.

In order to avoid a second collision, the collision avoidance protocol calls for the stations retrying transmissions to wait a random time interval after hearing the frequency become clear before they key their transmitters.   There must be enough different random wait times to provide a reasonable chance of two or more stations selecting different values. The difference between adjacent time values must be similar to the keyup time delay of typical stations on the frequency. This is the time lapse after a station keys its transmitter before other stations detect its presence on the channel, and is a function of the keying circuitry of the transmitter and the signal detection cir- cuitry of the receiver.   We have chosen the random time to be a multiple (0-15) of the transmitting station's keyup   delay

(TXDELAY). This is reasonable if one's own keyup delay is similar to that of other stations on the channel.

One other factor must be taken into consideration in optimizing data throughput. The currently implemented link protocols provide for relaying (digipeating) of packets. The acknowledgment procedure for such packets is that the relay station simply repeats packets without acknowledgment to the sending station. The receiving station sends its ACK back through the same digipeaters to the originating station. Since the digipeated packets are not acknowledged to the digipeater, an unsuccessful transmission must be retried from scratch by the originating station. In order to help alleviate the congestion of the frequency that tends to result when digipeated packets suffer collisions, the digipeater is given first shot at the frequency every time it becomesclear. Other stations, instead of transmitting as soon as they hear the channel clear, must wait a short time (DWAIT). This restriction applies to all stations except the digipeater, which is permitted to transmit relayed packets immediately. This prevents digipeated packets from suffering collisions except on transmission by the originating station.

A special time delay (RESPTIME) is used as the minimum wait time prior to transmitting acknowledgment frames, to prevent TNCs accepting data at high speed from the asynchronous port from colliding with acknowledgment frames when fewer than MAXFRAME packets are outstanding. The receiving TNC will wait long enough before sending the ACK so that it will hear the data packet which would have caused the collision, thus avoiding a fairly frequent source of delay in versions of AX.25 prior to 2.0.

Channel Flow Control

Flow control of data through the link is determined by the rate at which data is being supplied to a sending TNC and accepted from a receiving TNC.

A TNC receiving data from the link will send an RNR when the next I frame successfully received will not fit into the buffer for output to the serial port.

Whenever a TNC transmitting data received from the serial port over the link runs out of temporary buffer space, the serial port will be halted by an XOFF character or CTS signal. In the TNC 2 implementation this happens whenever there are 7 packets built and less than 210 characters left in the buffer for input from the serial port.

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When the TNC receiving data from the link clears out its buffers, it sends an RR to the transmitting TNC. In order to guard against the possibility of the RR being lost and the link becoming permanently locked, the transmitting TNC will periodically re-transmit the packet that provoked the RNR. The receiving TNC will continue to respond with RNR until it can accept the packet.

Appendix A Multi-Connect Survival Guide

This section is a very brief tutorial on the use of the multiple-connection capability included with this software release.

Why Multi-Connect?

Multiple connection capability is a powerful addition to your TNC 2. It is very useful for traffic net operation, multi-user bulletin boards, path checking and so forth.

What is Multi-Connect?

Multiple connection operation is not the same as multi-way operation. With multiple connect, you may establish several point-to-point "links" with various stations. Multi-way, which is not available, would enable multiple stations to be simultaneously interconnected to each other, with each station seeing all data passed from any station in the group, error free.

Multiple connection operation is another step on the road to proper networking, and networking should eventually allow multi-way operation.

What Commands Set my TNC 2 to Normal Operation?

Your TNC 2 defaults the multi-connect-related commands to the following parameters:

    CONPERM   OFF
    STREAMCAll   OFF
    STREAMDouBLe OFF
    STREAMSWitch |
    USERS   1

This sets up your TNC 2 to act just like a "normal" TNC does that doesn't support multiple connections. The key to obtaining this traditional operation is to set USERS 1.

How Do I Invoke Multi-Connect?

If USERS is not 1, you are telling the TNC to allow multiple connections to your stations from other stations. In addition, TRANSPARENT mode will operate differently, in that incoming data will be prefixed with the current STREAMSWitch character and identifier (such as "|A"). Thus, truly transparent multiple connection operation is not possible with this software release.

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The STREAMSWitch character, defaulted to "|", should be set to a
character you won't normally use. Note that this character may
be set to a hex value between $80 and $FF. This may allow you to
use 8-bit characters (AWLEN 8) if your terminal or computer is
capable of generating such "characters." This could help prevent
confusion in interpreting incoming data from other stations if
they happen to send data that includes your selected STREAMSWitch
character.

Although not foolproof, enabling STREAMDBL may also help in
sorting out STREAMSWitch characters included in the received data
from a valid stream switches generated by your TNC 2.

STREAMCAll should be especially helpful when manually operating a
station in which you allow multiple connections.

When in CONVERSE mode, you may switch streams by entering the
STREAMSWitch character (default "|"), followed by a stream
identifier ("A" through "J"), followed by the data you wish to
send to the station on that stream. See the example in the
description of STREAMCAll for an illustration of this.

If all this seems a bit confusing, don't worry, it is! The only
way to really understand multiple connect operation is to try it!
Once you have your TNC 2 on-the-air, and have gained confidence
in "normal" packet operation, try setting USERS 2 and get a
couple of friends to connect to you. Play with the commands (you
can't hurt the TNC by issuing commands to it!) and see their
effects.

Happy packeting!

Appendix B Prioritized Acknowledgment - An Overview

THE IDEA

The idea behind the prioritized acknowledgement (PriACK) protocol
is quite simple. Acknowledgments (ACKs) get priority access to
the channel so that time is not wasted retrying packets that have
already been correctly copied by the remote TNC. In normal AX.25
practice, for a variety of reasons, the ACK is often not received
within the time limit defined by the FRACK (T1) protocol timer.

In fact, because "channel access" methods are not clearly defined
in the AX.25 Level Two Version 2.0 protocol document, the present
protocol is more likely to synchronize collisions with
acknowledgement packets than with any other type of packet!

THE PROBLEM

When a channel becomes clear, if your TNC has something to send,
it will immediately send it. Unfortunately, if anyone else's TNC
has something to send, it will also "jump on" the channel as soon
as it becomes clear. The result is collisions and retries. Only
after a collision does the present protocol suggest using random
backoff.   Thus, an acknowledgment to a just-received packet is
almost assured of a collision-and-retry sequence, even thought
the TNC correctly received the packet. This will usually cause
the TNC which is awaiting the ACK to time out and re-send the
data.

To this collision synchronization mechanism, AX.25 Level Two
Version 2.0 adds a propensity to cause even ACKs which are not
from hidden terminals, and thus less susceptible to collision, to
be delayed beyond even generous FRACK timer settings when the
channel gets busy.

Once FRACK times out, even if the ACK finally makes it through
before the retry is sent, the original packet is retried anyway.
This wastes a lot of time which could be better used clearing the
channel of some of the legitimate offered load.

This feature of AX.25 Level Two protocol accounts for much of the
abysmal performance of the currently popular NETROM and THENET
nodes when used with omnidirectional antennas systems.

HOW IT WORKS

PriACK protocol avoids the above problems by giving ACKs priority
access to the channel. It does this in such a way that even ACKs
coming from hidden terminals are usually protected from
collision.

Standard AX.25 protocol gives a limited version of this priority access only to digipeated frames through the DWAIT timer.

Ack prioritization works with slotted channel access in the following way:

1. Response frames (ACKs) are always sent immediately upon receipt of a valid packet. Ultimately, not even DCD will be checked for sending an ACK. However, in this release DCD will still hold an ACK off the channel.

2. Stations queued up to access the channel but waiting for a channel busy condition (DCD true) to clear, will start a slotted access procedure only after enough time for a response frame to clear the channel has transpired (ACKTIME). This is true even if the TNC waiting to use the channel cannot hear the ACK being sent.

3. Slot time windows (DEADTIME) are set large enough to ensure the local TNC will be able to accurately determine if another detectable station has started transmitting in any slot preceeding the slot selected by the local TNC. This prevents two TNCs which have selected adjacent slots from colliding.

As you can see, under this protocol there will never be a condition where an ACK is delayed from being sent beyond the FRACK timer limitation. However, the FRACK timer is still active and must be set to a value that is long enough to allow time for (MAXFRAME * PACLEN) + ACKWAIT to expire before FRACK does. This time will depend on the radio and radio channel data rate in use. The TNC knows that if it doesn't see the ACK immediately when expected, it is probably never going to see it. (See discussion of new parameters below for definition of ACKWAIT.)

Forcing a channel access delay for all stations on the channel which are waiting for a chance to transmit allows ACKs from hidden terminals to get back to the expecting station. This clears that traffic from the offered channel load. If the packet was indeed copied and ACKed, further retrys of the same information will not be necessary.

NEW PARAMETERS

There are several new parameters needed for PriACK operation. See the command description elsewhere in this document for their meanings and settings.

1. ACKPRIOR
2. DEADTIME
3. ACKTIME
4. SLOTS
5. ACKWAIT (not directly user settable)

This timer actually consists of the sum of ACKTIME + DEADTIME. It represents the time the queued up TNC will wait before transmitting if it has selected the first slot. This allows time for a hidden station's ACK to be sent on the channel.

It is split into two timers because it has two unrelated components. One is related only to the data rate being used on the channel (ACKTIME). The other is related only to the absolute time the radios and TNC DCD circuits require to determine that a transmitter is active after PTT is asserted (DEADTIME).

OTHER RELATED PARAMETERS

Several of the "standard" TNC parameters will affect PriACK operation. Most of these are parameters in TNCs on the channel which are not using PriACK.

FRACK

FRACK must be set correctly in any TNC regardless of protocol.

FRACK should be set to a value which allows time for the TNC to
send its packet and receive the ACK. This value will depend on
the settings being used for PACLEN and the radio port data rate.
This is because, in many TNCs, the FRACK timer starts at the
beginning of the packet rather than at the end! Thus, it is best
to set FRACK to its worst case value for whatever data rate you
are using on the radio port and still allow for MAXFRAME 7 PACLEN
255 packets to be sent and allow other non-PriACK stations to
collide. This way you can make adjustments to PACLEN without
having to worry about interaction with the setting of FRACK.

FRACK should be set to 8 for 1200 baud work and 16 for 300 baud
operation.

RESPTIME

If you are running PriACK on a channel where some of the stations
have long RESPTIME delays, those stations will not be able to
successfully communicate with you after connecting. If you wish
to communicate with these stations you will have to set your
FRACK timer to a number which is longer than the other stations
RESPTIME delay.

RESPTIME should be set to 0 in your TNC when running PriACK.
With proper DCD operation, RESPTIME 0 will work in any event.

DWAIT

DWAIT is ignored when running PriACK. However, when PRiACK is
off, or if you are using a TNC which does not yet have PriACK
capability, DWAIT should be set to DEADTIME, or 33 (330 mSec) for
the default.

TXDELAY

TXDELAY should be set to allow for the slowest radio oin the
channel. It should be the same as DEADTIME and DWAIT. The
default of 33 (330 mSec) is adequate for most work.

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INITIAL PARAMETER SETTINGS SUMMARY

The settings for use at 1200 baud on a VHF FM channel are:

ACKPRIOR ON
SLOTS   3
DEADTIME 33
ACKTIME   14
RESPTIME 0   (If you require a nonzero value for this parameter
          in order to prevent ACKing individual packets in a
          MAXFRAME greater than 1 blast, your DCD circuit is
          not working. Please get it fixed.)
DWAIT   33
MAXFRAME   1-7 depending on channel quality
FRACK   8

The settings to use for 300 baud work on a linear mode HF channel
are:

ACKPRIOR ON
SLOTS   3
DEADTIME 8
ACKTIME   52
DWAIT   8
RESPTIME 0
MAXFRAME   1
FRACK   16
PACLEN   32 to 128 depending on channel quality

Appendix C Default Locations

The default parameters for the various TNC 2 commands are located in the 1.1.8 EPROM. The defaults are documented here for those of you who wish to change them for particular applications (such as remotely located units, etc.). For release 1.1.8, the defaults table is found at address 0B98 hex.

NOTE: In future releases of firmware, this location may change. There is a pointer at address 0055H which contains the location of the default area in Z80 low-byte/high-byte format.

WARNING! The TNC 2 firmware does not check for valid defaults. If you program an invalid default (for example, parity 5), unpredictable results may occur. Be sure you double-check any defaults you change!

The defaults are listed in the table below. All notes follow the table.

EPROM Address (Hex)	Value (Hex)		Meaning Command	Notes
0B98	21	33	DWAIT 33*10 mSec	
0B99	00	0	AXHANG 0*100 mSec	
0B9A	00	0	PACTIME EVERY/AFTER*	
0B9B	0A	10	PACTIME 10*100 mSec	
0B9C	21	33	DEADTIME 33*10 mSec	
0B9D	0E	14	ACKTIME 14*10 mSec	
0B9E	02	2	DLCTICKTIME (do not change this)	
0B9F	01	1	CMDTIME 1*1 Sec	
0BA0	21	33	TXDELAY 33*10 mSec	
0BA1	05	5	reserved - must be 5	
0BA2	1E	30	TXTMOTMR 30*1 Sec	Note 1
0BA3	01	1	TODVAL 1*1 Sec	Note 2
0BA4	39	57	IDVAL 57*10 Sec	Note 3
0BA5	00	0	RESPTIME 0*100 mSec	Stream A
0BA6	00	0	RESPTIME 0*100 mSec	Stream B
0BA7	00	0	RESPTIME 0*100 mSec	Stream C
0BA8	00	0	RESPTIME 0*100 mSec	Stream D
0BA9	00	0	RESPTIME 0*100 mSec	Stream E
0BAA	00	0	RESPTIME 0*100 mSec	Stream F
0BAB	00	0	RESPTIME 0*100 mSec	Stream G
0BAC	00	0	RESPTIME 0*100 mSec	Stream H
0BAD	00	0	RESPTIME 0*100 mSec	Stream I
0BAE	00	0	RESPTIME 0*100 mSec	Stream J
0BAF	0C	12	CHECK 12*10 Sec	Stream A
0BB0	0C	12	CHECK 12*10 Sec	Stream B
0BB1	0C	12	CHECK 12*10 Sec	Stream C
0BB2	0C	12	CHECK 12*10 Sec	Stream D

EPROM Address (Hex)	Value (Hex)		Meaning Command		Notes
0BB3	0C	12	CHECK	12*10 Sec	Stream E
0BB4	0C	12	CHECK	12*10 Sec	Stream F
0BB5	0C	12	CHECK	12*10 Sec	Stream G
0BB6	0C	12	CHECK	12*10 Sec	Stream H
0BB7	0C	12	CHECK	12*10 Sec	Stream I
0BB8	0C	12	CHECK	12*10 Sec	Stream J
0BB9	05	5	reserved - must be 5		
0BBA	00	0	reserved - must be 0		
0BBB	00	0	reserved - must be 0		
0BBC	00	0	reserved - must be 0		
0BBD	00	0	reserved - must be 0		
0BBE	00	0	reserved - must be 0		
0BBF	00	0	reserved - must be 0		
0BC0	00	0	reserved - must be 0		
0BC1	00	0	reserved - must be 0		
0BC2	00	0	reserved - must be 0		
0BC3	00	0	reserved - must be 0		
0BC4	01	1	BEACON EVERY/AFTER*,DEF EVERY		
0BC5	00	0	BEACON TIME (0 = never)		
0BC6	9C	'N'	MYCALL	Note 4	
0BC7	9E	'O'			
0BC8	86	'C'			
0BC9	82	'A'			
0BCA	98	'L'			
0BCB	98	'L'			
0BCC	60	SSID 0			
0BCD	00	0	must be 0 - end of callsign string		
0BCE	40	''	MYALIAS	Note 4	
0BCF	40	''			
0BD0	40	''			
0BD1	40	''			
0BD2	40	''			
0BD3	40	''			
0BD4	60	SSID 0			
0BD5	00	0	must be 0 - end of callsign string		
0BD6	08	8	FRACK	8*1 Sec	
0BD7	80	128	PACLEN		
0BD8	0A	10	RETRY		
0BD9	00	0	reserved - must be 0		
0BDA	04	4	MAXFRAME		
0BDB	07	7	AWLEN - must be 7 or 8		
0BDC	03	3	PARITY EVEN	Note 5	
0BDD	00	0	AXDELAY		
0BDE	02	2	TXDELAYC		
0BDF	03	3	SLOTS		
0BE0	7C	'|'	STREAMSW Character		
0BE1	01	1	USERS		

EPROM Address (Hex)	Value (Hex)		Meaning Command	Notes
0BE2	0D	^M	SENDPAC Character	
0BE3	18	^X	CANLINE Character	
0BE4	19	^Y	CANPAC Character	
0BE5	03	^C	COMMAND Character	
0BE6	08	^H	DELETE Character	
0BE7	16	^V	PASS Character	
0BE8	12	^R	REDISPLAY Character	
0BE9	13	^S	STOP Character	
0BEA	11	^Q	START Character	
0BEB	13	^S	XOFF Character	
0BEC	11	^Q	XON Character	
0BED	00	0	NULLS	
0BEE	00	0	SCREENLN	
0BEF	0000	0	CLKADJ	
0BF1	00	0	TAPRLATCH	
0BF2	00	0	MFILTER 1st Parameter	
0BF3	00	0	MFILTER 2nd Parameter	
0BF4	00	0	MFILTER 3rd Parameter	
0BF5	00	0	MFILTER 4th Parameter	
0BF6	00	0	MFILTER 5th Parameter	
0BF7	09		CMDS3	Note 7
0BF8	6A		CMDS4	Note 8
0BF9	44		CMDS5	Note 9
0BFA	00		CMDS6	Note 10
0BFB	20		CMDS7	Note 11
0BFC	3D		CMDS8	Note 12
0BFD	02		CMDS9	Note 13
0BFE	46		CMDS10	Note 14
0BFF	1F		CMDS11	Note 15
0C00	60		CMDS12	Note 16
0C01	B8		CMDS13	Note 17
0C02	60		CMDS14	Note 18
0C03	00	0	MYDLCNUM	
0C04	FE	254	DEFLTDLC	
0C05	00	0	Last Beacon Time - default to 0	
0C06	8D		reserved - must be 08DH	
0C07	00	0	reserved - must be 0	
0C08	00	0	reserved - must be 0	
0C09	00	0	reserved - must be 0	
0C0A	00	0	reserved - must be 0	
0C0B	00	0	reserved - must be 0	
0C0C	00	0	reserved - must be 0	
0C0D	00	0	reserved - must be 0	
0C0E	00	0	reserved - must be 0	
0C0F	00	0	reserved - must be 0	
0C10	00	0	reserved - must be 0	
0C11	00	0	reserved - must be 0	

EPROM Address (Hex)	Value (Hex)		Meaning Command	Notes
0C12	00	0	reserved - must be 0	
0C13	00	0	reserved - must be 0	
0C14	00	0	reserved - must be 0	
0C15	00	0	reserved - must be 0	
0C16	00	0	reserved - must be 0	
0C17	00	0	reserved - must be 0	
0C18	86	'C'	UNPROTO CALL	See Note 4
0C19	A2	'Q'		
0C1A	40	' '		
0C1B	40	' '		
0C1C	40	' '		
0C1D	40	' '		
0C1E	60	SSID 0		
0C1F	00	0	must be 0 - end of callsign string	
0C25		MFLAGS		Note 19
0C26		DFLAGS		Note 20
0C27		CONFLAG		Note 21
0C28		ENTRYSTA		Note 22
0C29		ENT2		Note 23

NOTES

Note 1
   This is the timer which, when it is exceeded, increments the
   TXTIMEOUT Health counter.

Note 2
   TODVAL specifies the number of "ticks" the DAYTIME clock
   increments each second. It should always be set to 1.

Note 3
   IDVAL is not otherwise settable. It specifies the number of
   10-second intervals which elapse between IDs when HID is ON.

Note 4
   Callsigns are encoded per the AX.25 standard document. A
   callsign consists of six (6) numbers and letters.   The
   letters must be upper case and, if the callsign is less than
   six (6) elements long, must be right-filled with blanks.
   The ASCII values corresponding to the letters and numbers
   must be left-shifted one bit.

The letters and numbers in HEX are:

Char	ASCII	Call		Char	ASCII	Call
(BLANK)	20	40		S	53	A6
A	41	82		T	54	A8
B	42	84		U	55	AA
C	43	86		V	56	AC
D	44	88		W	57	AE
E	45	8A		X	58	B0
F	46	8C		Y	59	B2
G	47	8E		Z	5A	B4
H	48	90		0	30	60
I	49	92		1	31	62
J	4A	94		2	32	64
K	4B	96		3	33	66
L	4C	98		4	34	68
M	4D	9A		5	35	6A
N	4E	9C		6	36	6C
O	4F	9E		7	37	6E
P	50	A0		8	38	70
Q	51	A2		9	39	72
R	52	A4				

A seventh callsign value is the secondary station ID (SSID). This is a value from 0 through 15 and is encoded as:

```
Bit 7  6  5  4  3  2  1  0
    0  1  1  D  C  B  A  0
```

where D is the most significant bit and A the least in the binary value (0 through 15).

Note 5

Parity for the asynchronous serial port is:

Value	Meaning
0	None
1	Odd
2	None
3	Even

Note 6

Binary status and parameter elements (commands whose arguments
are ON/OFF) are encoded as

   ON = TRUE = 1
   OFF = FALSE = 0

Commands which are "negative-true logic" (FALSE = 1 and TRUE = 0)
are indicated by trailing asterisks (*).
There are several defaults that are encoded on a bit basis.
These are listed below.

Note 7   CMDS3
   Bit Command   Default
   7- CMSG on/off
   6- CONMODE   trans/conv*
   5- NULF   on/off
   4- NUCR on/off
   3- LCOK   on/off
   2- PASSALL   on/off
   1- TXFLOW   on/off
   0- AX25L2V2 on/off

Note 8   CMDS4
   Bit Command   Default
   7- ESCAPE   on/off
   6- XMITOK   on/off
   5- DIGIPEAT on/off
   4- LFADD   on/off
   3- BKONDEL   on/off
   2- DELETE   on/off
   1- ECHO on/off
   0- BUDLIST   on/off

Note 9   CMDS5
   Bit Command   Default
   7- CONSTAMP on/off
   6- DAYUSA   on/off
   5- NEWMODE   on/off
   4- reserved
   3- MCOM on/off
   2- MALL on/off
   1- HID   on/off
   0- HEADRLN   on/off

Note 10   CMDS6
   Bit Command   Default
   7- STREAMCA on/off
   6- STREAMDB on/off
   5- reserved
   4- reserved
   3- reserved
   2- 8BITCONV on/off
   1- TRFLOW   on/off
   0- MSTAMP   on/off

Note 11   CMDS7
   Bit Command   Default
   7- reserved
   6- reserved
   5- LCSTREAM on/off
   4- reserved
   3- NOMODE   on/off
   2- RXBLOCK   on/off
   1- HEALLED   on/off
   0- CBELL   on/off

Note 12   CMDS8
   Bit Command   Default
   7- LFIGNORE on/off
   6- CMSGDISC on/off
   5- reserved
   4- reserved
   3- reserved
   2- reserved
   1- reserved
   0- reserved

Note 13   CMDS9
   Bit Command   Default
   7- reserved
   6- BBSMSGS   on/off
   5- reserved
   4- reserved
   3- reserved
   2- reserved
   1- reserved
   0- reserved

Note 14   CMDS10
   Bit Command   Default
   7- reserved
   6- reserved
   5- reserved
   4- reserved
   3- reserved
   2- reserved
   1- reserved
   0- reserved

Note 15   CMDS11
   Bit Command   Default
   7- reserved
   6- MNONAX25 on/off
   5- reserved
   4- reserved
   3- reserved
   2- reserved
   1- TXUIFRAM on/off
   0- FIRMRNR   on/off

Note 16   CMDS12
   Bit Command   Default
   7- reserved
   6- ACKPRIOR on/off
   5- TXDIDDLE on/off
   4- KISS   on/off
   3- CHECKV1   on/off
   2- reserved
   1- reserved
   0- reserved

Note 17   CMDS13
   Bit Command   Default
   7- reserved
   6- reserved
   5- reserved
   4- reserved
   3- reserved
   2- BLP   on/off
   1- reserved
   0- reserved

Note 18   CMDS14
   Bit Command   Default
   7- reserved
   6- ANSWRQRA on/off
   5- reserved
   4- reserved
   3- reserved
   2- reserved
   1- reserved
   0- reserved

Note 19   MFLAGS
   Bit Command   Default
   7- reserved
   6- reserved
   5- reserved
   4- reserved
   3- TRACE   Off
   2- MCON On
   1- MRPT On
   0- MONITOR   On

Note 20   DFLAGS
   Bit Command   Default
   7- reserved
   6- reserved
   5- reserved
   4- reserved
   3- reserved
   2- reserved
   1- reserved
   0- reserved

Note 21   CONFLAG
   Bit Command   Default
   7- reserved
   6- reserved
   5- reserved
   4- FLOW On
   3- CR   On
   2- reserved
   1- FULLDUP Off
   0- CONOK   On

Note 22   ENTRYSTA
   Bit Command   Default
   7- reserved
   6- reserved
   5- reserved
   4- reserved
   3- reserved
   2- reserved
   1- AUTOLF   On
   0- reserved

Note 23   ENT2
   Bit Command   Default
   7- reserved
   6- reserved
   5- reserved
   4- reserved
   3- reserved
   2- XFLOW   On
   1- reserved
   0- reserved

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