

TECHNICAL REFERENCE MANUAL

for

PacComm Packet Controller Models TINY-2 and MICROPOWER-2



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INTRODUCTION

This manual applies to both the TINY-2 and MICROPOWER-2 packet controllers. These units share the same basic design and interface to radios and computer terminals identically. The term TINY-2/MICRO-2 is used throughout this manual to refer to both units when dealing with components and procedures which are the same for both units.

The terms "Computer and terminal" are used interchangeably to refer to the computer or terminal used to communicate with the packet controller. This is not meant to imply that a computer is necessary for operation of a packet controller.

Every effort has been made to make this manual complete and accurate, however PacComm assumes no responsibility for damages incurred as a result of using this documentation. PacComm reserves the right to make changes to equipment specifications or documentation at any time without notice or obligation to previous purchasers. Your comments and suggestions for improvement are welcome.

Be sure to read any errata, manual updates, and software release notes before operating the packet controller.

Features

Firmware

- Completely TNC-2 firmware Compatible
- Supports all 'TAPR' commands plus many PacComm additions.
- Personal Message System (optional on TINY-2)

Hardware

- NMOS Z-80 CPU and SIO (MDLC) [MICROPOWER-2: CMOS]
- 4.9 MHz CPU clock speed
- 32k EPROM and 32k RAM
- Typical Power Consumption: 9 – 14 VDC @ 220 mA [40 mA]
- Crystal controlled IC modem supports 1200/2200 Hz tones
- DE-9P (male) for RS-232 Computer
- TNC-2 type modem disconnect header
- Power, Connect, Status, PTT, Carrier Detect LEDs
- Extruded aluminum case 5 × 7 × 1 3/8 inches with gray, oven baked wrinkle finish
- Metal end panels grounded to prevent RFI
- MICROPOWER-2 printer port and hardware clock options

NET/ROM and ROSE Compatibility

The TINY-2/MICRO-2 are TNC-2 compatible meaning that an EPROM designed for a TNC-2 compatible (such as both NET/ROM and ROSE networking EPROMs) will operate in a TINY-2/MICRO-2. Please refer to Appendix A for interconnection cable Information for dual/multi-node units.

COMPUTER INTERFACING

The TINY-2/MICRO-2 packet controller communicates with the computer or terminal through a serial port using either RS-232C or "TTL" level signals. One of these signal levels should properly interface to most computers. See the Appendices to this manual for specific computer interfacing instructions.

RS-232 Port Signals

The serial port connectors on the TINY-2/MICRO-2 packet controller are on the rear panel marked "RS-232" and "TTL Computer". The pins on the serial port connector of packet controller that must be connected are shown in the following table. This is commonly called a "three-wire" RS-232 cable.

RS-232 Serial Port "3 Wire" Cable Wiring for DB-25

Computer DB-25	TINY-2/MICRO-2
1 and 7	5
2	3
3	2

RS-232 Serial Port "3 Wire" Cable Wiring for DE-9

Computer DE-9	TINY-2/MICRO-2
5 and Shell	5
2	2
3	3

The packet controller is configured as Data Communications Equipment (DCE), the technical term for an RS-232C modem. Most computers and terminals are configured as Data Terminal Equipment (DTE). Specifically, the packet controller connector is an IBM "AT style" using a male DE-9 connector, wired as DCE rather than DTE. If you use an "AT" PC or portable Computer with a 9-pin serial port, you can wire cable connector pins 2 through 8 directly (pin 2 to pin 2, etc.).

Pin 1 on the TINY-2/MICRO-2 is the Data Carrier Detect (DCD) signal which goes high (true) when the packet controller is in the "connected" state. This is analogous to the DCD signal on telephone modems, i.e. the pin is asserted when a communication connection exists. Pin 9 is used as an auxiliary radio carrier detect input. This pin may also be used when two or more packet controllers are mated for use with network firmware such as the NET/ROM or ROSE EPROM. More detailed information is presented later in the manual.

Some computers require that Clear To Send (CTS) of the computer serial port connector (pin 5 of a DB-25 or pin 8 of a DE-9) be connected to an appropriate signal. Others may require connections for Data Carrier Detect (DCD) (pin 8/pin 1) and Data Terminal Ready (DTR) (pin 20/pin 4). You may jumper the computer's input and output signals on DB-25 pins 4/5 (DE-9 pins 7/8), and on DB-25 pins 6/8/20 (DE-9 pins 6/1/4) in addition to the connections shown in the "3 wire" RS-232 diagram above, or build an "8 wire" interface cable as shown below:

Jumpering RTS/CTS and DTR/DSR/DCD at the Computer Gable End

DB-25:	DE-9:
4 ——— 5	7 ——— 8
6 ——— 8 ——— 20	1 ——— 4 ——— 6

"Eight-wire" RS-232 Cable

Computer DB-25 or DE-9 to	TINY-2/MICRO-2 DE-9P
1 ————— Shell	5
2 ————— 3	3
3 ————— 2	2
4 ————— 7	7
5 ————— 8	8
6 ————— 6	6
7 ————— 5	5
8 ————— 1	1
20 ————— 4	NC

"connected" signal

Non-Standard RS-232C Serial Ports

NOTE: Some computers which require an external TTL to RS-232 adapter to support an RS-232 serial port may be interfaced to the TINY-2/MICRO-2 without the RS-232 adapter unit by using the TINY- 2/MICRO-2 TTL level signals.

Computers with non-standard RS-232 serial ports must meet the following conditions:

- Voltage levels sent by the computer must be greater than +3 Volts in one state and less than -3 Volts in the other state.
- The polarity of the signals must conform to the RS-232C standard, i.e. the low voltage state is a logical "1" and the high voltage state is a logical "0".

Make or buy a cable that provides the following connections:

- The computer serial port common (ground) pin must be tied to the TINY-2/MICRO-2 serial port connector pin 5.
- The signal line that sends data from the computer must be tied to the TINY-2/MICRO-2 connector pin 3.
- The pin on which the computer receives data must be tied to the TINY-2/MICRO-2 connector pin 2.

The documentation provided with the computer or its accessory serial port should clarify any requirements for additional signals.

Serial Port Operation At TTL Levels

The TINY-2/MICRO-2 packet controller is designed to operate with computers which have a TTL level serial port without requiring the use of an RS-232C adapter. This includes such popular computers as the Commodore VIC-20, C-64, and C-128. TTL signals are routed through an 8 pin connector on the rear panel. TTL signal levels must be greater than +2.4 Volts in one state and less than +.4 Volts in the other state.

Use caution in connecting the TTL cable to insure that pin one of the cable is attached to pin one of the connector. Pin one is clearly marked on the rear panel of the controller. Pin one of the cable connector is marked with a red stripe, Be sure to observe this marking both in constructing and attaching the cable.

TTL serial port signals used by the TINY-2/MICRO-2 controller.

<u>P3</u>	<u>Signal Name</u>	<u>Description</u>
1	Receive Data	Serial data to computer from the TINY-2/MICRO-2
2	Carrier Detect	Goes high when connection exists
3	Frame Ground	Common ground for case and data lines
4	Clear to send	Computer Signal Clearing Controller to send data
5	Transmit Data	Serial data to the TINY-2/MICRO-2 from computer
6	Signal Ground	Common ground for both data lines and case
7	Request to send	Controller signal to computer when data is ready
8	No Connection	

Serial Data Signal Definitions

This section describes the pins used on the packet controllers serial port connectors. Since the pins are defined with respect to the Data Terminal Equipment (DTE) (computer) end of the circuit, and the packet controller is wired as Data Communications Equipment (DCE) (modem), some standard pin names appear to be the reverse of the packet controller function. A complete RS-232 signal table appears in the Appendices.

Serial Port Pin Functions

- Frame Ground (FG) is provided for attachment to the chassis of the packet controller and the chassis of the attached computer terminal. This is common to the signal ground on the TINY-2/MICRO-2.
- Transmit Data (TXD) is an input line to the packet controller on which the attached computer terminal device sends data.
- Receive Data (RXD) is an output line from the TINY-2/MICRO-2 on which it sends data to the attached computer terminal device.
- Request to Send (RTS) is an input to the packet controller signaling that the attached computer terminal device is ready to accept data from the TINY-2/MICRO-2. This line is used for hardware flow control.
- Clear To Send (CTS) is an output from the packet controller signaling the attached computer terminal device to send data to the TINY-2/MICRO-2. This line is used for hardware flow control.
- Data Set Ready (DSR) is an output from the packet controller telling the attached computer terminal device that the packet controller is operational. On the TINY-2/MICRO-2 this pin is tied high (ready).
- Signal Ground (SG) is the common, or return, path for all signals between the TINY-2/MICRO-2 and the attached Computer terminal device. It is common with the frame ground.

- Data Carrier Detect (DCD) is an output from the packet controller. DCD reflects the status of the CON LED: It is high when a packet connection exists and it is low when no connection exists. This Signal is useful when the packet controller is used with telephone style and BBS software, since the connect signal, like a modem carrier on the telephone, indicates the presence of a user.
- Data Terminal Ready (DTR) is an input to the TINY-2/MICRO-2 signaling that the attached computer terminal device is ready to accept data from the packet controller. Not used on the TINY-2/MICRO-2.

The table below provides a cross reference to the pinouts of the industry standard 25 pin connector as used on many computers and terminals. The TNC-2 and PacComm TNC-200, and relates them to the newer 9 pin connectors used on many modem computers and the TINY-2/MICRO-2. Note that connecting a DTE device to a DCE device using either 25 pin connectors or 9 pin connectors at both ends of the cable provides a 'straight through' wiring of pin numbers, i.e. connect column 1 to column 4 OR connect column 2 to column 3. However, when a 25 pin connector and 9 pin connector are used on the same cable, i.e. column 1 to column 3, several pairs of signal lines must be crossed.

TINY-2/MICROPOWER-2 RS-232 Serial Port Signal Cross Reference

Conventional RS-232	Conventional RS-232 DTE DB-25	IBM AT RS-232 DTE DE-9P	TINY/MICRO RS-232 DCE DE-9P	TNC-2(00) RS-232 DC DB-25
Definition	Pin Nr.	Pin Nr.	Pin Nr.	Pin Nr.
FG	1	shell	5	1
TXD	2	3	3	2
RXD	3	2	2	3
RTS	4	7	7	nc
CTS	5	8	8	5
DSR	6	6	6	6
SG	7	5	5	7
DCD	8	1	1 ^a	8 ^a
Test	9	V+	-	+12V
Test	10	V-	-	-12V
DTR	20	4	nc	20
RI	22	9	9 ^b	(23)

^a This line goes high when a connection exists

^b RFDCD (Also used for multi-node NET/ROM and ROSE)

RS-232C Handshaking Protocol

The CTS and RTS lines of the TINY-2/MICRO-2 serial port (labeled P4 on the circuit board and RS-232C on the rear panel) are used by the TINY-2/MICRO-2 firmware for hardware "handshaking" to control the flow of data between the computer and the packet controller.

The TINY-2/MICRO-2 always asserts (makes true) Data Set Ready (DSR) on P4 pin 6 via a pullup resistor. Thus, whenever the TINY-2/MICRO-2 is powered up, it signals to the computer connected to P4 that the packet controller is "on line".

The computer terminal indicates it is ready to receive data from the TINY-2/MICRO-2 by asserting its Request To Send (RTS) Signal on P4 pin 4. The packet controller will send data when RTS is asserted (if there is data to be sent). If the computer is not ready to receive data, it negates (make false) RTS to the TINY-2/MICRO-2. Thus, data flow from the packet controller to the computer is controlled by the use of the RTS line.

The packet controller asserts its Clear To Send (CTS) Output, P4 pin 5, whenever it is ready to receive data from the computer; if the TINY-2/MICRO-2's buffers fill, it will negate CTS, signaling the computer to stop sending data. The packet controller will assert CTS when it is again ready to receive data from the computer. Thus, data flow from the computer to the packet controller is regulated by the use of the CTS line. The CTS line is always toggled, even if "software flow control" is enabled in this direction.

If "software flow control" is preferred, or if the computer terminal serial I/O port does not implement CTS/RTS and DTR/DSR handshaking, then a three wire cable should be used. If these RS-232 control lines are not connected they will be pulled up (and thus asserted) by resistors at the TINY-2/MICRO-2 end and proper operation will result. However, a non-standard serial port may use some pins for other purposes, such as supplying power to a peripheral device, so be sure that the system either implements the CTS, RTS and DSR handshake or has no connections to these pins of P4 whatsoever. Note that reference to RS-232C "compatibility" or the presence of a DB-25 type connector does not guarantee that you have a standard RS-232C serial port!

The PacComm TINY-2/MICRO-2 packet controller supports asynchronous computer terminal baud rates of 300, 1200, 2400, 4800, 9600 and 19,200. The port supports standard parity options as well as 7- or 8-bit character lengths. Factory settings are 1200 bauds, eight bit wordlength, no parity and one stop bit. (UK = 1200, 7, E, 1)

If you want to interface the TINY-2/MICRO-2 with a device configured as DCE, such as a telephone modem or another packet controller, a so-called "null modem" cable may be constructed to interchange the data and handshake signals.

RADIO INTERFACING

This section describes how to connect the signal cable between the TINY-2/MICRO-2 and the radio. The interconnection should be planned so as to minimize pickup of stray audio and RF noise by the lines. You should use shielded wire for all signal-carrying leads.

Read the remainder of this chapter carefully before starting to interface the packet controller to the radio.

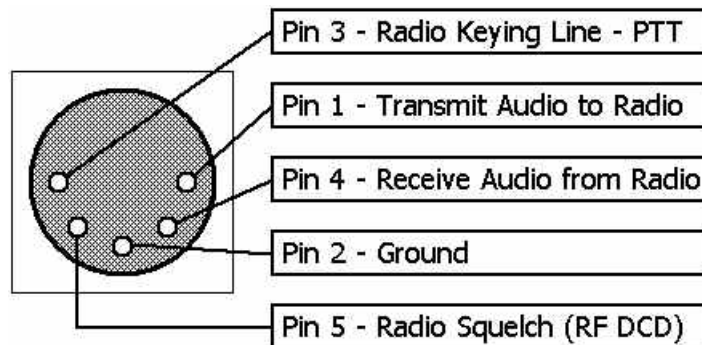
Connect the TINY-2/MICRO-2 and radio according to one of the following methods. Then turn on the packet controller and computer and start the computer communications program. Connect the radio to a dummy load and listen to the transmission with another nearby radio. Set the transmit level by the procedure in the Adjustments Chapter.

You should use shielded wire for all signal-carrying leads. If you notice a significant hum level in the monitored audio, take measures to remove it. If the transmitter has an adjustable microphone gain control, try reducing the sensitivity of the transmitter microphone circuit and increasing the signal level from the TINY-2/MICRO-2 to minimize hum or other noise problems.

Radio Connector (J2) Pin Definitions

Interfacing the TINY-2/MICRO-2 to a radio involves connecting the following signals at J2, the five pin DIN connector.

- Pin 1 - Audio output from the TINY-2/MICRO-2 to the transmitter.
- Pin 2 - Ground for both audio and PTT.
- Pin 3 - Push-to-talk to allow keying the transmitter.
- Pin 4 - Receive audio from the receiver speaker or auxiliary jack to the TINY-2/MICRO-2.
- Pin 5 - Optional Radio Squelch input for RF Carrier Detection.



Radio Connector Viewed from Rear of Packet Controller

Direct Connection to Microphone and Speaker

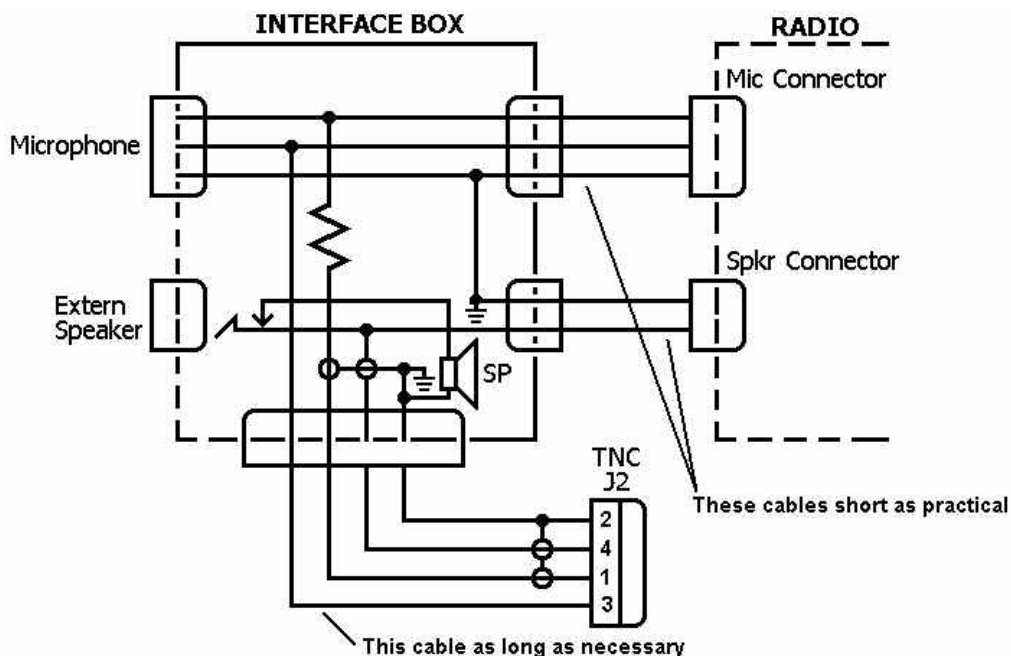
The packet controller was designed to allow hookup and testing to be done without any modifications to the radio or any signal level balancing devices in the cables. The direct interconnection method is useful if you devote the radio exclusively to packet. If you share the radio between packet and voice, you may want to use the external interface method below. The packet controller's audio signals are fed directly into the microphone connector or similar auxiliary input of the radio, and the TINY-2/MICRO-2 output is adjusted to give a proper modulation level. The receiver audio is taken from an auxiliary audio output or Speaker jack and fed directly to the packet controller.

Accessory Jack Connection

If the radio has an accessory jack with PTT, transmit audio, and receive audio signals, all connections between the radio and TINY-2/MICRO-2 may be done through this jack. The TINY-2/MICRO-2 is designed to operate with from 10 to 700 millivolt audio input. This is compatible with the signal level provided by most modern transceivers at the "Fixed Audio Output" connector on the rear panel. It is recommended that a squelched fixed audio output be used if available. If the audio output is squelched or can be adjusted to a low enough level to prevent false carrier detection, a direct connection to the TINY-2/MICRO-2 audio input may be made.

External Interface Box

If you desire to use the radio for both packet and voice, and the radio does not have an accessory jack and you don't wish to add a connector to the radio, you should construct a separate interface box to permit simultaneous connection of the TINY-2/MICRO-2 and a microphone. It may either have its own speaker or pass the signal through to a speaker so that you can monitor the receive audio while the packet controller is hooked up. A schematic of an external interface box is shown below.



External Interface Circuit Schematic

HARDWARE DESCRIPTION

This section includes detailed hardware specifications and a functional description of the hardware design of the TINY-2 and MICROPOWER-2 packet controllers. Specifications apply to both packet controller models unless specified otherwise. MICROPOWER-2 specifications (when different) will be placed in square brackets []. Firmware specifications and operating instructions are contained in the Operating Manual.

LEDs

- PWR** The POWER LED is illuminated whenever the TINY-2/MICRO-2 is connected to a power source and the power switch is on.
- CON** The CONNECT LED illuminates when an AX.25 connection exists on the selected stream for that port. (See multi-connection explanation in Operating Manual).
- STA** The STATUS LED illuminates whenever an AX.25 frame has been sent but not yet acknowledged. If a connection is to be terminated (DISCONNECTED) and the STA LED is lit, some frames which were sent but not acknowledged may be lost.
- PTT** The PTT LED illuminates whenever the TINY-2/MICRO-2 activates the radio keying line.
- DCD** The DCD LED illuminates when the modem senses a signal.

Detailed Circuit Description

- **Oscillator:** The crystal, capacitors and resistors in the 74HC4060 (U7) circuit provide for a stable clock source for the 4.9152 MHz master clock. The 74HC4060 also provides all baud clocks (X16) and a 600 Hz signal for the real time clock interrupt applied to the SIO (U14) SYNC-B input.
- **CPU Complex:** The microprocessor (U1) is an NMOS Z-80 (8400-06) [CMOS, 84C00-06]. Both asynchronous serial and HDLC functions are performed by a Z80 SIO/0 (8440-06) [84C40-06] (U14). The 27256 [27C256] EPROM (32k bytes) (U2) contains all the firmware, addressed from 0 to 7FFF. The 32k × 8 RAM (U8) holds all buffered data and battery backed parameters for the 8400-06 [84C00-06](Z-80) CPU (U1). RAM is addressed from 8000 to FFFF. Each memory device's chip select is provided by the 74HC139 decoder (U3), and the RAM chip select is also buffered by a power failure detection circuit. When voltage is low or removed, the RAM enters low power mode, drawing approximately one microamp while retaining memory contents.
- **Serial Port:** SIO (U14) channel B performs asynchronous communications through either a MAX231 single chip CMOS RS232 transceiver (U15), or at TTL levels, via an 8-pin connector (P3). RS232 signals are interfaced via an "IBM AT" style DE-9P connector with a DCE pinout. Baud rates of 300, 1200, 2400, 4800, 9600 and 19.2k are supported.
- **HDLC:** The HDLC function is performed by SIO (U14) channel A connected to the modem disconnect header (J5), and to the on-board integrated circuit modem. Data rates of 300 bauds to 19.2 kilobauds are supported at the header. The SIO HDLC data signal is converted from NRZ to NRZI in two logic stages enroute to the modem.
- **Watchdog Timer:** The SIO (U14) RTSA (pin 17) provides the signal that ultimately keys the radio transmitter. When the TINY-2/MICRO-2 is transmitting, RTSA goes low, which is fed to a Schmidt trigger gate (U6 pin 9) which turns on the PTT LED and returns a high signal to the gate of a VN10 (FET) transistor (Q2). This high state on the VN10 gate causes it to conduct to ground, keying the transmitter, and starts C26 charging through R17. If the RTSA Signal remains low more than 60 seconds, C26 reaches the Schmidt trigger voltage, causing the gate (U6) to turn off the PTT LED and the VN1 0, thus unkeying the transmitter.

- **Modem:** The TCM3105 modem (U16) employs a Bell 202 modulator and demodulator in a single CMOS package. The modulator transmits either 1200 or 2200 Hz depending on the state of the SIO TXD line (U14 pin 14). The modem tone output (U16 pin 11) goes through a 10k trim-pot to allow amplitude adjustment to achieve proper transmitter deviation.

Since the TCM 3105 always produces tones when powered, there is an audio cut-off circuit employed using a VN10 FET (Q3) and a 2.2k resistor that swamps most transmit audio to ground when the RTSA line is high (receive). This allows normal voice use of the radio while the TINY-2/MICRO-2 is connected.

The demodulator contains a switched capacitive filtering network, and is sensitive to audio levels down to 10 mV. The receive bias adjustment (R9) allows optimizing the bias level for a particular TCM3105 modem IC. Received data is output on U16 pin 8 and is routed through the clock recovery circuit before the SIO (U14).

NOTE: The on-board radio modem is only capable of 1200 baud operation as installed. For higher (or lower) radio data rates, attach an external modem to the J5 modem disconnect header.

- **Battery backed RAM (bbRAM):** The entire 32k of RAM (U8) is backed up with a 3 Volt lithium battery. The 74HC132 IC (U3) is also battery powered keeping pin 20 (CE) of the RAM disabled (high) during periods of low power to the TINY-2/MICRO-2 (typically 7.5 Volts and below).
- **Power Supply:** The 7805 regulator (U5) supplies the main portion of the board with clean, stable 5 Volt power. The incoming positive voltage is routed through a choke (L1) and diode (D6) for reverse polarity protection and to the power switch. It feeds the 7805 regulator and pin 14 of the MAX231 IC (U15). The MAX231 has internal oscillators which allow it to generate a negative voltage to support the RS232 levels. A voltage approximately one Volt below the incoming supply voltage can normally be measured. The battery circuit is isolated by diodes to keep the RAM and the 74HC132 powered whenever JP-B is installed. The TINY-2 requires approximately 220 mA at 9 – 14 VDC [MICROPOWER-2 = 40 mA.]

Modem Disconnect - J5

The modem disconnect on the TINY-2/MICRO-2 PC board (J5) is provided for using higher-speed modems, or more sophisticated, higher-performance modems for satellite or other uses. This connector is the same as the TAPR TNC-2 header.

A physical connector for J5 is installed on the MICROPOWER-2, but not on all versions of the TINY-2. Any Standard 20-pin header for use with IDC cable connectors should be suitable for installation on the TINY-2. Parts are available from PacComm. When installing the connector, be sure to line up the marked pin (pin 1) of the header with the the PC board pin 1 marking.

To use an external modem, it is necessary to cut the traces between pins 1-2 and 17-18 on the bottom of the TINY-2/MICRO-2 PC board with a sharp knife or MotoTool. If RX Clock is provided by the external modem, then cut 13-14. If CTS is provided, cut 9-10.

CAUTION: DO NOT CUT ANY OTHER TRACES WHICH PASS THROUGH THE J5 AREA AND WHICH ARE NOT TO J5 PINS!

Once the traces are cut at J5, you must install push-on jumpers or a shorting connector on the above pin pairs to use the on-board modem. This also applies to the MICROPOWER-2.

The signals used at connector J5 are at standard TTL interface levels. A TTL high is greater than +2.4 Volts but less than +5.25 Volts. A TTL low is less than 0.4 Volts but greater than 0 Volts.

DO NOT connect an RS-232C level modem directly to J5!

If you elect to use an off-board modem, be sure to properly shield the interconnecting cables for RFI protection.

J5 Pin Definitions

The following information is primarily for those who wish to interface external modems to the packet controller. Familiarity with modem and serial data channel terms is assumed.

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. 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 on-board modem (via an inverter gate) and provides the necessary signals required by pin 1 above. It is normally jumpered to pin 1 when the on-board modem is used.

Pin 3 SIO Special Interrupt Input

This pin is routed to the radio port DCD input pin on the SIO. 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 jumpered to pin 3 when the on-board modem is used.

Pin 5 SIO RTS Output

This signal is used for transmitter activation. It activates the PTT pin of the radio connector via the watch-dog timer. The SIO will pull this output low when the TINY-2/MICRO-2 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 Modem RTS Input

This Signal is an input to the on-board modem. 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

This pin is an output from the SIO. It is normally low and goes high only when the TINY-2/MICRO-2 is in a connected state. Its Status is reflected by 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 the TINY-2/MICRO-2 has unacknowledged packets in its transmit buffer. Its Status is reflected by the STA LED.

Pin 9 SIO 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 packet controller 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 Modem CTS Output

This pin is used by the on-board modem to signal the SIO when it is ready to accept data. This pin is normally jumpered to pin 9.

Pin 11 Transmitter Clock (16×) 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 bauds. This pin is normally jumpered to pin 12 when the on-board modem is used.

Pin 12 Transmitter Clock (16×) 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 bauds), 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 converter. This pin is normally jumpered to pin 13 when the on-board modem is used.

Pin 15 TINY-2/MICRO-2 Ground Reference

This pin ties to the TINY-2/MICRO-2 digital ground at the SIO.

Pin 16 Additional Ground Reference**Pin 17 Receive Data Input**

This pin is the received data input to the NRZI-to-NRZ Converter. 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 SIO 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 transmitted by the modem. This pin is normally jumpered to pin 19 when the on-board modem is used.

ADJUSTMENTS

Jumper Functions

The following table lists the function of each jumper on the TINY-2/MICRO-2 PC board. The normal (Standard jumper setting) positions for each are shown.

JP B : Lithium Battery

- ON (normal) Lithium battery connected
- OFF Lithium battery disconnected

JP D: NET/ROM + RFDDB

- N (normal) NET/ROM input to DCDB
- RF RF Squelch to DCDB

JP L: Digital Loopback

- N (normal) Normal Modem Operation
- L Digital loopback mode

JP RA: Audio Input Impedance

- ON (normal) Speaker audio input
- OFF High impedance audio input

JP Aux: Auxiliary I/O

- Auxiliary I/O lines for MICROPOWER-2 with printer option

JP 8: Power Connection

- Auxiliary connection point for 12 V and gnd for accessories

Trimpot/Varicap Adjustments

Most of the following adjustments must be performed with the TINY 2/MICRO-2 removed from its cabinet. Remove the packet controller from its cabinet by removing both front and rear end plates and plastic bezels. Use caution not to damage the grounding straps attached to some of the end plate screws.

- C17 CPU oscillator frequency
- R9 Modem bias level
- R12 Transmit output level
- R26 Modem carrier detect level

Baud Rate Setting

To set the baud rate on the packet controller, remove the TINY-2/MICRO-2 from its cabinet. There are two sets of jumper headers [DIP switches] along the front edge of the circuit board with labels of 3, 12, 24, 48, 96, and 19.2 for both TERMINAL and RADIO. These numbers correspond to 300, 1200, 2400, 4800, 9600, or 19,200 baud rates. Place the jumper on the two pins [turn the section of the DIP switch ON] for the desired rate for both the computer and radio.

WARNING: Place one and only one jumper for the computer side, and only one on the radio side. [Only one switch on the MICROPOWER-2 should be ON per section.]

Audio Input Level

The TINY-2/MICRO-2 is designed to operate with from 10 to 700 mV audio input. If you obtain audio from the headphone or external speaker jack on the radio, place a shorting block on the pins of JPR (factory default) and adjust the audio level to approximately 20 mV with the aid of a high impedance Voltmeter or oscilloscope. If no such measuring equipment is available, set the volume control at a position below that normally used.

If direct connection is made to the radio's discriminator (demodulator) or any other high impedance audio source, remove the shorting block from JP R.

NOTE: The audio level should be set as to as low a value as possible if an unscquelched radio is used. The TINY-2/MICRO-2 modem will show false DCD indications on noise if the audio level is set too high.

Transmit Level Setting

Connect the TINY-2/MICRO-2 and radio as shown in the radio interfacing chapter. Turn on the packet controller and computer and start the computer communications program. Connect the radio to a dummy load and listen to the transmission with another nearby radio. The output level is set by adjusting trimpot R12 which is accessible through the rear panel opening marked "TTL Computer."

1. Enter the command CAL<CR> and the letter 'K' to cause the TINY-2/MICRO-2 to key the radio with a steady tone. The high or low tone is selected by pressing the space bar. NOTE: The watchdog timer will cause the PTT circuit to reset approximately one minute after the 'K' key is depressed. If you need a longer adjustment time, type 'Q'<CR> to return to the command prompt and restart the procedure.
2. With the TINY-2/MICRO-2 keying the transmitter and the higher frequency tone selected, adjust the transmit audio level trimpot (R12) while observing a service monitor or deviation meter tuned to the transmitting frequency. Set the deviation for 3 to 3.5 kHz on the higher pitched tone and check that the lower tone is at least 2.5 kHz deviation.
3. If the proper equipment is not available as described above, make the deviation adjustment by turning the adjustment screw on the trimpot until no increase in output level is heard at the monitoring receiver. Then rotate the adjustment screw of the trimpot in the opposite direction until the audio signal on the monitoring receiver is slightly, but noticeably, reduced from the maximum level.

NOTE: It is better to have too low than too high a drive level. A high drive level causes over-deviation, unnecessary interference, and makes your signal less copyable. Listeners may also notice some low-level packet tones when using the radio for voice work.

4. The transmitter deviation is now set to approximately the correct level. Type the command 'Q' to unkey the transmitter.

Modem Receive Bias Adjustment

Trimpot (R9 100k) is the modem bias adjustment. The factory procedure below is used to adjust the modem bias. It normally results in a value of 2.65 to 2.70 VDC on pin 7 of the TCM3105 modem chip (U16). The setting does not seem to drift over time but may need to be changed if a different modem chip is substituted. If it is necessary to adjust the modem bias, the following procedure should be used.

1. Prepare to perform an audio loopback by jumpering pins 1 and 4 of J2, the radio connector.
2. Give the commands: **CAL**<CR>, **KD**<CR> to provide a 'dithered' transmit signal for loopback demodulation. When the adjustment is completed, type '**Q**' to discontinue the tone. NOTE: The watchdog timer will cause the PTT circuit to reset approximately one minute after the 'KD' Keys are depressed. If you need a longer adjustment time, type '**Q**'<CR> to return to the **cmd**: prompt and restart the procedure.
3. Observe the signal output on pin 8 of the TCM3105 (U16) with an oscilloscope. It may be necessary to increase the modem output level by adjusting trimpot R12 to get a strong enough signal for decoding. The signal should be a square wave. Adjust R26 to cause the positive and negative portions of the square wave to be of equal duration.
4. Enter **Q**, remove the jumper from J2 and readjust R12 if needed.

Carrier Detect Level

Trimpot R26 should be adjusted to cause the DCD LED to illuminate when a weak input signal to the modem is present and to go out when no signal is present. See the section on audio input levels.

Crystal Oscillator Adjustment

You may adjust the oscillator with the variable capacitor C17, to within a 5 kHz range (typical) from its 4.9152 MHz nominal frequency to move a harmonic a few kilohertz off of a favorite operating frequency. The setting of this frequency is not critical. A 30 kHz error at the oscillator frequency will result in only a .6 % error at 1200 baud.

TROUBLESHOOTING

WARNING: Never remove or insert an IC with power on!

The PacComm packet controller 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 above. 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.

Press all socketed ICs into their socket along each edge. If there is any sign of corrosion on any IC pins, remove each IC, one at a time, and burnish the pins. Often simply removing and reinstalling the ICs will cure intermittent problems caused by vibration or humidity affecting the IC sockets. Inspect all solder joints for a smooth shiny appearance. A dull gray appearance may be an indication of a crystallized solder joint. Use a small soldering iron designed for printed circuit work and resolder the connection.

Remember that all the logic circuits operate at standard TTL levels (a "low" is less than plus 0.4 V and a "high" is greater than plus 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 V, 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 CHIP ENABLE lines on the memories (U2 and U8 pins 20), the IOREQ line on CPU (U1) pin 20 and the INT line on CPU (U1) pin 16. Each of these lines should show activity, and if any line is quiet this is a sign of trouble. Address and data line problems 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.

Logic lines that show no activity may often be traced to a short on the pc board, probably due to a defective solder joint. Follow the instructions above for inspecting solder joints. If you decide to use an Ohmmeter to check for shorted lines, use a low voltage/low current test instrument. (Most modem 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.

If an oscilloscope is not available, then a Voltmeter can help you find serious difficulty on digital signal and address lines. Set the meter for the scale where a full 5 Volts can be displayed. A reading of 1.5 to 3.5 volts indicates some varying digital signal. A reading of over 3.5 V or under 1.5 V is most likely an indication of trouble. A very low, or very high voltage reading is a sign of no activity, or open and shorted circuits. If you cannot pinpoint the trouble using this set of guidelines, then you must either obtain an oscilloscope, or send the board back to PacComm for repair.

If you have an oscilloscope available, the trouble shooting is much easier! The checks made above still apply, but now you can "see" trouble on the oscilloscope waveforms. If you see a 'stair-stepped' waveform on two different pins, then it is likely they are shorted together. Also, square waves of half amplitude, or lines with no activity are dead giveaways on the scope. The scope also allows you to trace the analog sections of the device, including the modem.

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 ground bus that completely encircles the perimeter of the board. Avoid connecting in the area where power leads run to and from the power switch to avoid the possibility of a short.

Loopback testing

Loopback testing consists of having the transmit section of the packet controller communicate with the receive section. If this procedure is successful, the correct operation of both transmit and receive sections can be verified. If data is not successfully passed, clues to the malfunction may be obtained.

There are two types of loopback testing, analog and digital. For both types of test, the command FULLDUP must be ON and some type of connection must be made between the transmit output and the receive input. Once the proper arrangements are made, testing consists of attempting to pass information from the transmit section to the receive section of the packet controller. One method is to send data to and from the PMS (if the PMS option is installed) by connecting to MYP-CALL. You may also connect to MYCALL and send and receive from the terminal, or send UI frames and monitor them. Be sure to undo all the loopback steps once the testing is completed.

Analog loopback

Remove JPR to place the input circuit in a high impedance state. Install a homemade jumper between pins 1 and 4 of the radio connector J2. Send UI frames and monitor for their reception or try a connection as described above. The output level trimpot R12 may have to be turned to near maximum to allow the modem to hear itself. Failure of the analog loopback test does not necessarily mean there is a modem problem since the transmit circuits and receive circuits are not optimized for direct connection.

Digital loopback

Move the JP L jumper to 'LOOP' and attempt to pass UI frames or connect. Digital loopback is very reliable and should work every time if there is no problem in the digital portion of the board.

General Tests

The TINY-2/MICRO-2 has status LEDs which are powerful tools in troubleshooting. Many suspected problems may be disproved by the following simple tests. Connect a power source to the TINY-2/MICRO-2 and a Voltmeter (15 Volt scale) to pin 2 of the RS-232 connector. Do not connect any computer or radio cables. Turn on the TINY-2/MICRO-2. Observe the LEDs. If the TINY-2/MICRO-2 powers up with the PWR, CON and STA LEDs lit, followed by the CON and STA LEDs extinguishing a second or so later, and the Voltmeter shows a lot of activity for about ½ second, the TINY-2/MICRO-2 digital section is operating and attempting to send a sign on message out the serial port.

Step 1: Obvious Problems

Look for any unusual physical symptoms. Is the unit drawing excessive current? Are any components discolored? Does something smell burnt? Do any of the parts seem excessively warm? In general, their normal temperature (NMOS) will be quite warm to the touch. CMOS parts should not show any heating.

Step 2: Power Supply

The first thing to check in any malfunction is the power supply.

NOTE: A frequent problem is the use of a poorly filtered or undervoltage DC power supply.

Check that the voltage under load is not low and that excessive ripple is not present. Check the power supply levels at the output of the voltage regulator. 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.

Computer Terminal Interface

If you can't get the packet controller to sign on and accept data from the terminal or computer, the problem may be in the serial interface.

NOTE: The primary cause of non-communication between the packet controller and the computer is improper cabling setup.

Inspect the interconnection cabling. Does it work on another controller or RS-232 device? Has the radio and/or computer been successfully used on packet with this or another packet controller? Are all the connections tight? Has the cable frayed or broken?

Packet Controller won't sign on to the computer

If you find the TINY-a/MICRO-2 won't send data to the computer, but appears to operate properly as described in General Tests above, verify that the CTS line at RS-232 connector P4 pin 8 or TTL connector P3 pin 4 is not being held low. The packet controller will not send data to the computer unless its CTS line is asserted. If the computer does not implement the RTS/CTS protocol, the RTS/CTS lines (pins 7 and 8 on P4) should remain unconnected to the computer or else tied together.

Check the baud rates set on the packet controller and computer terminal. Some mismatched combinations of baud rate on controller and terminal will cause nothing to be displayed.

If the above checks are ok, observe pin 26 of the SIO (U14) with an oscilloscope and cycle the packet controller power switch. Transitions on this pin shortly after reset indicate that the packet controller is sending data. If no signal transitions are seen, recheck that the CPU appears to be operating {see below.} If data appears to be present, verify that TTL transitions are also present on the MAX231 (U15) pin 8 and RS-232 Signal transitions are present on MAX231 (U15) pin 11 and P2 pin 2.

The Controller prints only gibberish

This indicates that some combination of the data rate (terminal baud rate), parity option, or number of start and stop bits are not set the same at the packet controller and at the computer terminal. Verify that the computer terminal is set for eight data bits, no parity, and 1 stop bit. These settings may be made with DIP switches, jumper pins, or software commands depending on the computer terminal in use. The above settings are the default sign-on settings stored in the TINY-2/MICRO-2 EPROM. Perform a hard reset by pressing the power switch OFF then ON (out then in). The sign-on message should appear.

If the packet controller's sign-on message lines appear to be typed over each other, you should set the packet controller command AUTOLF ON. If the sign-on message appears to be double-spaced, you should set AUTOLF OFF. If the sign-on message appears to be single-spaced, AUTOLF is correct.

The Controller won't accept commands

After the packet controller signs on, try giving it any 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 the SIO (U14) pin 23 has a voltage level between 0 and +0.4 Volts on it. The voltage on MAX231 pin 5 should be greater than +3 Volts. If these conditions are not met, check the cable wiring and refer to the section about terminal interface troubleshooting.

If the above checks are OK, use an oscilloscope to verify that data is present on SIO (U14) pin 28 and MAX231 (U15) pin 10 when you strike a key on the computer. If not, the data isn't getting from the computer to the packet controller. Check the serial connector in use (P4-RS-232, or P3-TTL), the cable and MAX231 (U15) again. Finally, be sure that the computer actually uses levels less than -3 Volts and greater than +3 Volts for signal levels. 0 and +5 Volts will not work unless the TTL port is used.

Other Symptoms

TINY-2/MICRO-2 appears dead

If no LEDs wink during the start-up cycle the problem is more serious. Check to see that the crystal oscillator is working (4.1952 MHz) and that the signal appears on the output of U7 (74HC4060) pin 9. The clock signal is a (possibly distorted) square wave signal. Also check for clock signals Z80 CPU (U1) pin 6 and SIO (U14) pin 20.

Verify that the battery backed-up RAM protection circuit is working by measuring that pin 28 of the RAM (U8) at least +4.7 Volts after input power is applied.

If the unit is operating and accepting commands from the terminal, an overall check of the CPU complex may be conducted using the HEALTH command (see Operating Manual).

Modem won't key transmitter

Check to see the commands XMITOK and TXUIFRAM are ON. If the transmitter doesn't key, the problem is most likely in the connecting cable, or a carrier present (DCD) indication. If DCD is active and the command FULLdup is off, the controller will not activate the keying line. If this is the problem, see the DCD section below. If the connections appear to be in order, check 8440 (U14) pin 17 for keying (PTT) transitions. If nothing is seen on pin 17, either software or digital hardware are faulty. If pin 17 is active, trace the signal through 74HC14 (U17) pin 9 to U17 pin 8 (now inverted) to the gate of the keying FET (Q2). The FET output line changes from high impedance to low when a keying signal is present. This can be checked with an Ohmmeter.

Uncopyable transmitted packets

If other stations seem unable to decode your packet transmissions, it is possible that your transmitter is being overdriven. Listen to the sound of your TINY-2/MICRO-2 transmissions on another receiver. Extremely weak signals indicate inadequate modem output. Refer to the Transmit Level Adjustment Procedure. You may also be able to hear the beginning of transmissions clipped or weak if inadequate transmit delay (RXD command) is being used for your transmitter. You can confirm that the digital logic and modem on the packet controller are operating properly by perform-

ing an Analog Loopback. If the loopback works properly, then reset the output level taking care to set the drive level lower than previously. Note that direct connection to typical microphone inputs requires the drive trimpot to be turned to near the minimum signal position for proper signal levels. If the Analog Loopback falls to operate properly, perform a digital loopback. If this test operates correctly, the CPU, Software, and SIO are operating correctly and the modem circuit is suspect.

Uncopyable received packets

If some but not all packets are copied, set the command MCOM ON. Many packet transmissions are control frames and contain no printable information. MCOM will cause these frames to be displayed. Confirm proper wiring of the radio cable by opening the radio squelch and raising the volume level with some type of signal tuned in. If the DCD LED flickers or solidly illuminates then receiver audio is reaching the packet controller modem. Test the modem by performing an audio loopback. If the test fails, perform a digital loopback to be sure the problem is really in the modem section. Listen to the audio signal from the radio applied to the packet controller or examine the signal with a scope for hum or other noise which might make the packet signals uncopyable. Confirm the proper level of the audio signal is applied to the packet controller with a digital meter or scope.

DCD LED flickers excessively or stays on

If the DCD LED flickers on and off excessively or remains constantly on only with the signal cable connected, be sure the radio is operating with squelch closed, that shielded signal cable is being used, and that the audio drive level from the radio is not excessive. If audio is being obtained from a speaker output or other low impedance output, place a jumper on JPR located near R12. If high impedance audio is being used, JPR should be off. If these areas all check out, consider changing the value of resistor R10 to a lower value between 10 and 100 Ohms.

Transmitter locks in transmit condition

The TINY-2/MICRO-2 is protected against PTT malfunction by a watchdog timer on the keying line. However, if unshielded, improperly grounded cabling is used to feed the transmitter key line, and other signal cables, RF energy can get back into the packet controller and lock up the keying transistor. Precautions are especially necessary if a high power amplifier is being used and there is a strong RF field in the area of the packet controller.

APPENDICES

Node Interconnection Cables

These diagrams are intended for use with NET/ROM, ROSE and other network EPROMs. If these diagrams do not agree with those suggested by the network software manual, use those provided by the software manual, modified as necessary for the TINY-2/MICRO-2 9 pin connector.

Dual TINY-2/MICRO-2 Node

Pin #	Unit 1	Pin #	Unit 2
2	_____	3	
3	_____	2	
7	_____	8	
8	_____	7	
5 & 9	_____	5 & 9	

Note; Lines 7 and 8 are optional.

Dual Node, TINY-2/MICRO-2 and TNC-2(00)

Pin #	Unit 1	Pin #	Unit 2
2	_____	2	
3	_____	3	
7	_____	5	
8	_____	20	
5 & 9	_____	10 & 23	

Note: Lines 7 & 8 to 5 & 20 are optional.

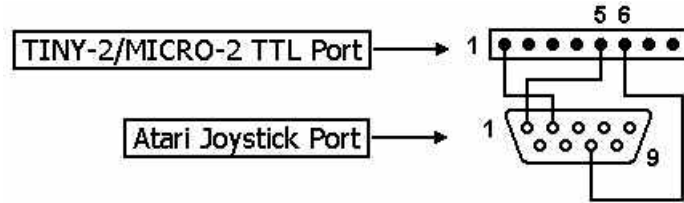
Triple Node

Follow the cable assembly instructions in the NET/ROM manual substituting pin numbers according to this table.

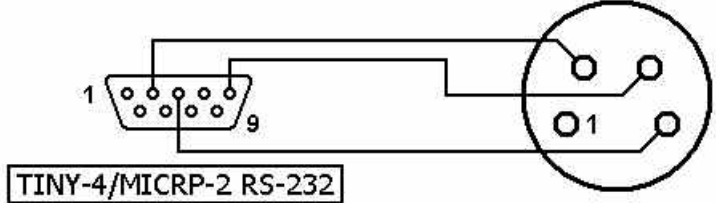
TINY-2/MICRO-2	TNC-2(00)
2	_____ 3
3	_____ 2
7	_____ 1 & 7
8	_____ 5
9	_____ 23

Triple (and larger) node cable diode matrices may be easily constructed using the "TNC Octopus" diode matrix board by John Painter. The Octopus is available from PacComm.

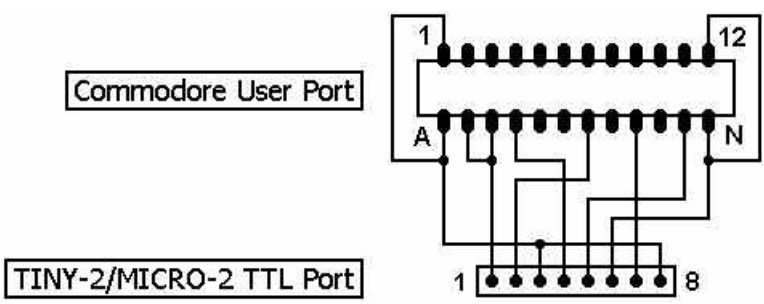
Computer Interfacing Diagrams



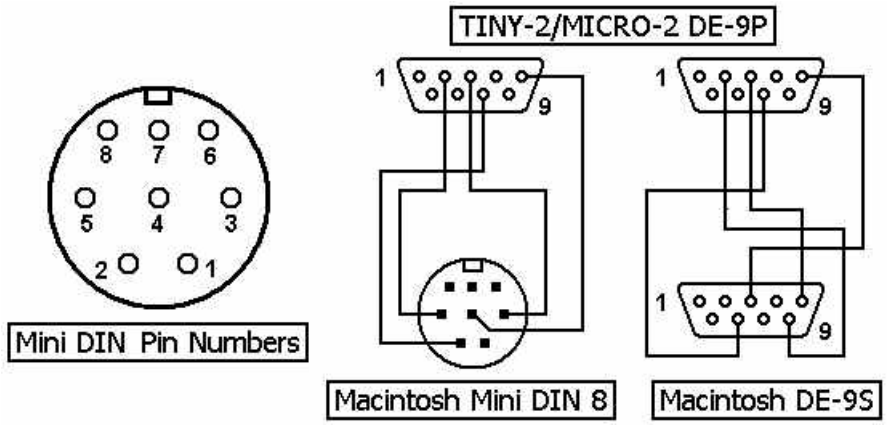
Atari Joystick Port to TINY-2/MICROPOWER-2 TTL Port



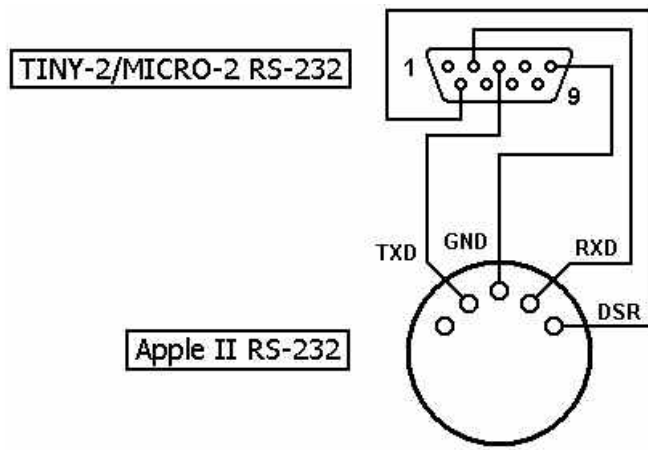
Tandy/Radio Shack Color Computer to TINY-2/MICRO-2 RS-232 Port



Commodore VIC-20/C-64/C-128 User Port to TINY-2/MICRO-2 TTL Port

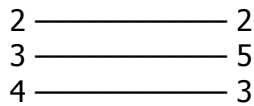


Apple Macintosh Computers



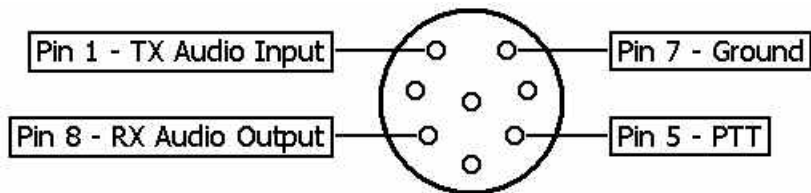
Apple II

Color Computer TINY-2/MICRO-2 RS-232



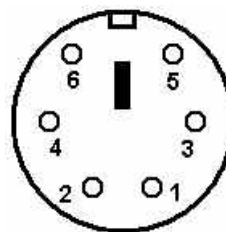
Tandy/Radio Shack Color Computer

Radio Interfacing Diagrams



ICOM 8-pin (IC-27 etc.) Mic Jack Pinout

- 1 Data IN
- 2 GND
- 3 PTT
- 4 Data OUT (before Squelch)
- 5 Squelch
- 6 Data OUT (after Squelch)



Mini-DIN

Data Output of New Transceivers (TS-2000, FT-817 etc.)

RS-232 Signal Table

The EIA RS-232C Standard

The Electronic Industries Association (EIA) RS-232C Standard defines the interfacing between data terminal equipment and data communication equipment employing serial binary data interchange. Electrical signal and mechanical aspects of the interface are well specified. The complete RS-232C interface consists of 25 data lines. This would seem to be enough signals for a complex parallel communication line, but many of the 25 lines are very specialized and few are undefined. Most computer terminals only require from 3 to 5 of these lines to be operational.

Because RS-232C was originally intended for data communications equipment, a few lines must be swapped between a computer and terminal if no modem or other data communications equipment is used. These wires are swapped within the cable connecting the two devices. This line is called a null modem cable.

Pin	Description
1	Protective Ground
2	Transmitted Data
3	Received Data
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Signal Ground (Common Return)
8	Received Line Signal Detector
9	(Reserved for Data Set Testing)
10	(Reserved for Data Set Testing)
11	Unassigned (See section 3.2.3)
12	Sec. Rec'd. Line Sig. Detector
13	Sec. Clear to Send
14	Secondary Transmitted Data
15	Transmission Signal Element Timing (DCE Source)
16	Secondary Received Data
17	Receiver Signal Element Timing (DCE Source)
18	Unassigned
19	Secondary Request to Send
20	Data Terminal Ready
21	Signal Quality Detector
22	Ring Indicator
23	Data Signal Rate Selector (DTE/DCE Source)
24	Transmit Signal Element Timing (DTE Source)
25	Unassigned

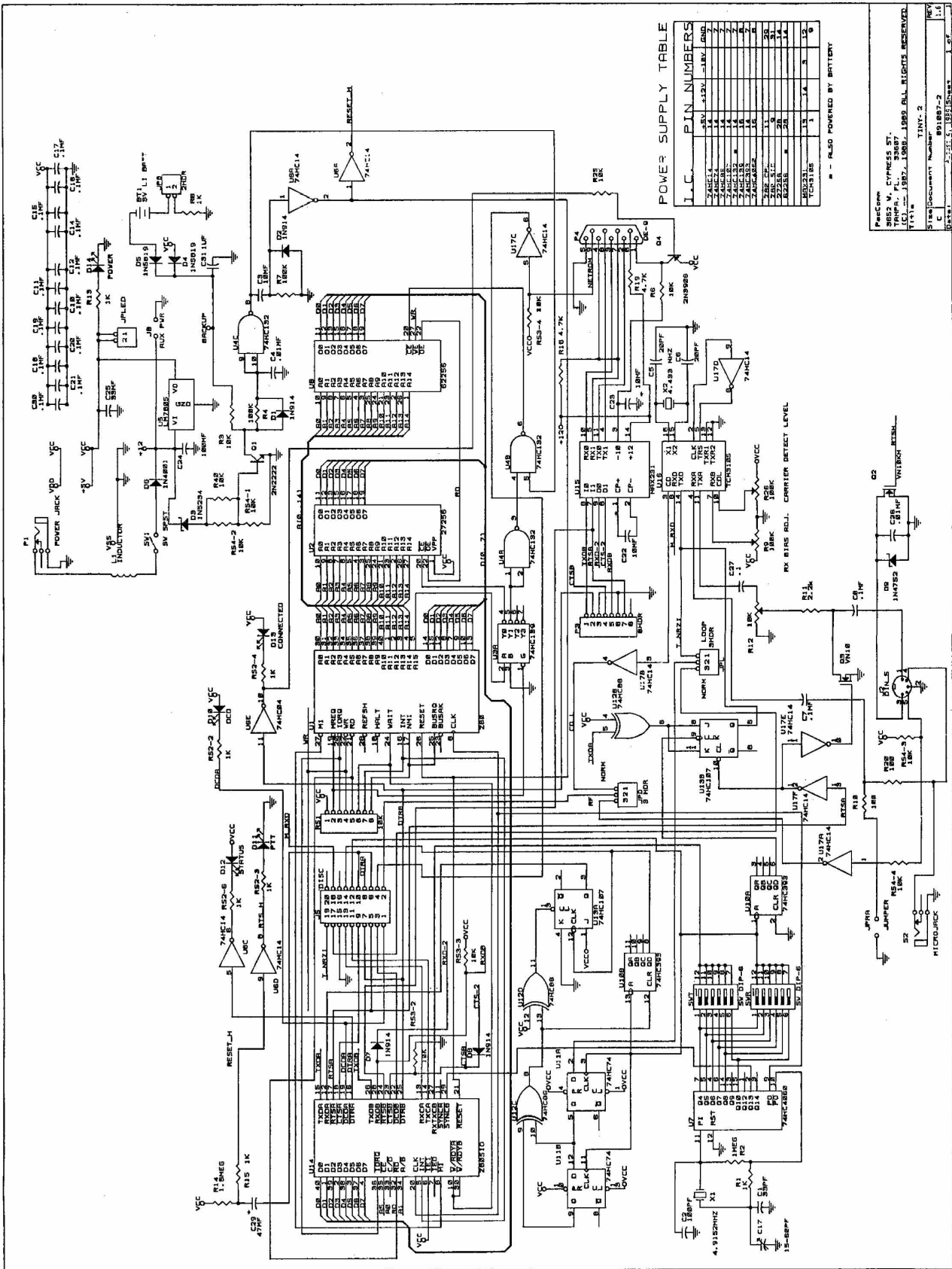
Bit-Shifted ASCII Character Table

The characters of AX.25 callsigns are standard 7 bit ASCII characters shifted to occupy the upper 7 bits of the byte. The following table contains the hexadecimal values for the characters of the alphabet and digits 1 - 0 bit shifted one place for use in callsign definitions in packet controller EPROMs.

Format:

Character		ASCII Hex		Bitshifted Hex		
A	B	C	D	E	F	G
41 82	42 84	43 86	44 88	45 8A	46 8C	47 8E
H	I	J	K	L	M	N
48 90	49 92	4A 94	4B 96	4C 98	4D 9A	4E 9C
O	P	Q	R	S	T	U
4F 9E	50 A0	51 A2	52 A4	53 A6	54 A8	55 AA
V	W	X	Y	Z	space	
56 AC	57 AE	58 B0	59 B2	5A B4	20 40	
1	2	3	4	5	6	7
31 62	32 64	33 66	34 68	35 6A	36 6C	37 6E
8	9	0				
38 70	39 72	30 60				

Example: Normal hex values for W1AW = 57 31 41 57
 Bit-shifted hex values for W1AW = AE 62 82 AE



POWER SUPPLY TABLE

IC	PIN NUMBERS
74HC14	14 15 16
74HC13	14 15 16
74HC08	14 15 16
74HC04	14 15 16
74HC00	14 15 16
74HC02	14 15 16
74HC03	14 15 16
74HC05	14 15 16
74HC06	14 15 16
74HC07	14 15 16
74HC09	14 15 16
74HC10	14 15 16
74HC11	14 15 16
74HC12	14 15 16
74HC15	14 15 16
74HC16	14 15 16
74HC17	14 15 16
74HC18	14 15 16
74HC19	14 15 16
74HC20	14 15 16
74HC21	14 15 16
74HC22	14 15 16
74HC23	14 15 16
74HC24	14 15 16
74HC25	14 15 16
74HC26	14 15 16
74HC27	14 15 16
74HC28	14 15 16
74HC29	14 15 16
74HC30	14 15 16
74HC31	14 15 16
74HC32	14 15 16
74HC33	14 15 16
74HC34	14 15 16
74HC35	14 15 16
74HC36	14 15 16
74HC37	14 15 16
74HC38	14 15 16
74HC39	14 15 16
74HC40	14 15 16
74HC41	14 15 16
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