OPERATING MANUAL

for the

Model NB-96 MODEM CARD

The PacComm NB-96 Series
Narrowband 9600 Baud Packet Radio System

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PacComm provides a rapid repair service for our products, whether in or out of warranty. Shop rates are modest. Carefully pack the unit and send it to the PacComm address with a written description of the problems experienced and the repair service desired. Normal service turnaround is under five days. We stock all parts for our units.

The PacComm Narrowband 9600 Baud Packet Radio System

"The NB-96 Series"

PacComm is introducing the next generation in packet performance: The PacComm Narrowband 9600 Baud Packet Radio System. The NB-96 Series is a complete line of affordable 9600 baud packet equipment to support both network nodes and local packet users. The NB-96 modem is based on PacComm's successful 9600 baud commercial modem design (exclusively licensed from James Miller, G3RUH). It is a high performance design using innovative signal processing techniques to comply with FCC bandwidth limitations on the 6 and 2 meter amateur bands as well as higher frequencies. The modem connects to the radio internally and may not be suitable for use with all existing radios.

Other packet manufacturers plan to offer equipment compatible with The PacComm Narrowband 9600 Packet Radio System.

The standard packet VHF/UHF radio data rate is 1200 bauds because all amateur packet controllers provide an internal modem for this speed, and the two-tone AFSK audio spectrum suits unmodified voiceband radios comfortably. However, all TNCs can generate much higher data rates, and most FM radios have an unrealized audio bandwidth of some 7-8 kHz or more. So in many cases 9600 baud radio transmission is entirely practical with them.

The PacComm Narrowband 9600 Baud Packet Radio System consists of the following products:

NB-96 MODEM CARD - Add on internal modem card for TNC-2 and clones, and all PacComm TNCs.

NB-96 EXTERNAL MODEM - Encased 9600 baud modem with front panel LED displays and cabling for most popular packet controllers, including the PK-232.

NB-96 DIGITAL TRANSCEIVER - A digital radio consisting of digital 2-5 watt RF deck and 9600 baud modem. Available for several popular amateur VHF and UHF frequency bands. Available with front panel LED displays and cabling for most popular packet controllers, including the PK-232.

NB-96 INTEGRATED PACKET RADIO - A complete high speed packet unit - Integrated digital transceiver, packet TNC, and 9600 modem ready to attach to your computer or terminal and antenna. Available for several popular amateur VHF and UHF frequency bands.

A key feature of the NB-96 Series is the modem design which features digital generation of the transmit audio waveform. Precise shaping compensates exactly for the amplitude and phase response of the receiver. This results in a "matched filter" system, which means that the received audio offered to the data detector has the optimum charcteristic for minimum errors. It also allows very tight control of the transmit audio bandwidth. Here is a summary of the NB-96 Series modem features:

* MODULATION: Direct FM. Audio is applied direct to the radio's transmit varactor. Deviation of +/- 3kHz gives an RF spectrum 20 kHz wide (-60db). Fits standard channels easily. Fully compliant with FCC amateur bandwidth limitations above 50 MHz.

* TRANSMIT MODULATOR: 8 bit long digital F.I.R. transversal filter in EPROM for transmit waveform generation with a "brick-wall" audio spectrum. Typically -6 db at 4800 Hz, -50 db at 7500 Hz. Allows compensation for the characteristics of the transmitter and receiver pair to acheive perfect received "eye" pattern. Thirty two transmit waveforms, jumper selectable. Output adjustable 0-8v peak-to-peak.

* SCRAMBLER (Randomizer): 17 bit maximal length LFSR scrambler, as used in the K9NG 9600 baud modem and UoSAT-D. Jumper selectable Data or BERT (bit error rate test) mode.

* RECEIVE DEMODULATOR: Audio from receiver discriminator, 50mv-10v peak-to-peak. 3rd order Butterworth filter, 6kHz. Data Detect circuit for use on simplex (CSMA) links. Independent un-scrambler.

* CLOCK RECOVERY: New digital PLL clock recovery circuit with 1/256th bit resolution. Average lock-in time 50 bits (depends on SNR).

* OTHER FEATURES: The only set-up is Transmit Audio level. Will run speeds other than 9600 bauds if some filter capacitors are changed. Channel calibration and audio loopback capabilities.

SECTION 1 - APPLICATION

1.1 APPLICATION - Amateur Packet Controllers (TNCs)

Attaches to a TNC-2 Style "Modem disconnect" header. Suitable for any TNC in which the internal modem can be bypassed, however the NB-96 External Modem may be more suitable for use in many installations since it provides a housing and convenient cabling.

Standard TNC digital TTL connections needed: Transmit Data, Transmit Clock (16x bit rate), Receive Data, Data Detect ("DCD") and GND. Receive Clock is available for those PADs which do not have on board clock recovery.

All PacComm packet controllers provide the proper signals. This includes the TNC-200, TNC- 220, DR-100, DR-200, TINY-2, MICROPOWER-2, TNC-320, and PC-320. Other TAPR TNC-2 based designs provide the proper signals, typified by the TNC-2, PK-80, MFJ1270, MFJ1274, etc. The PK-87, PK-88 may also be used. The PK-232 will only operate with the NB-96 External Modem.

Power Consumption is +5 and +12 VDC at 40ma (CMOS ROMS), 170ma (NMOS ROMS).

The circuit board is 3.1"x4.8", top professional quality, double sided, plated-through holes, max copper ground plane, solder masked, silk-screen/legend.

See APPENDIX A for specific packet controller hookup information.

1.2 APPLICATION - RADIOS

Signal connections required to the radio: Transmit Audio, Receive Audio, Ground. In addition, the PTT signal from the packet controller must be wired directly to the radio.

The ideal radio link would have a flat DC-8 kHz bandpass. The "better" the transmit and receive specification, the better the received data at the detector, and hence less suceptability to errors.

Some apparently horrid receiver responses still offer useable service, but with a typically 2.5 db reduction in performance. A good radio achieves about 1.5 db implementation loss (compared with a perfect link).

Remember that you are pushing most radios to their limit since they were designed for speech where even 100% distortion is still intelligible. A little more finesse is required for data transmission.

1.2.1 REQUIRED RECEIVER CHARACTERISTICS

* NBFM design
* Output from discriminator (essential)
* Response to DC (essential)
* Response no worse than -4 db at 4.8 kHz
* No worse than -10 db at 7.2 kHz
* As smooth/flat a phase delay as possible
* As smooth an amplitude response as possible.
* Little change in response with 2kHz de-tuning off-channel
* Symmetric, linear FM discriminator charcteristic

On the whole, most receivers will perform as required. Those with the least complicated IF filtering appear best, especially with 20 kHz channel filters, though 16 kHz is also acceptable.

8 kHz filters for 12.5 kHz channel spacing are too narrow for 9600 bauds, but can be used at 4800 bauds with +/-1.5 kHz deviation. However in this case all filter capacitors must be doubled in value (C26-32).

Radios with dozens of cascaded tuned circuit IFs tend to be fussy, and should be properly aligned for good response, particularly linearity, phase delay and mistuning performance.

1.2.2 REQUIRED TRANSMITTER CHARACTERISTICS

* Must generate true FM, as linear as possible
* Deviation response DC to 7.2 kHz flat (essential)
* Deviation at 4800 Hz to be +/- 3 kHz peak (maximum)

Transmitters based on Xtal oscillator/multipliers are likely to be the most appropriate. ("Base stations").

Tranceivers (synthesized or not) that have quite separate oscillator sub-systems for generating FM and possibly SSB/CW, which is then mixed with a synthesized source to produce the final carrier are OK.

Simpler synthesized FM transmitters, where the varactor modulated oscillator is within the systhesis PLL are generally not useable, at the PLL tracks the modulation, and so get no low frequency response.

Remember you need true FM, which means a varactor diode pulling the oscillator frequency, NOT phase modulating a tuned circuit.

See APPENDIX B for specific radio interconnection information.

SECTION 2 - HARDWARE DESCRIPTION

The modem consists of two independent parts - transmitter and receiver - sharing only clock and power supplies. See circuit diagram.

2.1 TNC INTERFACE

The NB-96 has circuitry to allow the unit to be taken out of the 'modem header' circuit of the TNC without physically removing the modem card. JPS controls the 74HC157 and 4053 ICs to perform this function. Jumpering JPS will cause the NB-96 modem board to 'disappear.'

2.2 MODEM TRANSMIT

Outgoing transmit data is clocked into D-type bistable U17a on a high going edge of the TX Clock (P2 pin 3), and then enters a randomizer/scrambler comprising 17 stage shift register U14/U18/U17b and XOR gates U13. So, in transit through U14 are 8 bits of the TX Data sequence, scrambled.

These 8 bits are used to look up a waveform profile for one period of that bit sequence, from transmit EPROM U15. Four samples/bit make up the waveform, and jumpers JP1-4 allow pre-selection of 16 different characteristics. JPROM selects an alternative 16 waveform selections.

The EPROM output is passed to digital-to-analog converter (DAC) U19, which generates a discrete staircase-like waveform. This is them smoothed by a four pole "anti-alias" filter and the transmit audio (TA) is output at P3 pin 1 to modulate the FM radio transmitter.

If jumper JP5 is set to T (pins closest to JP5 label) or OFF (removed), the scrambler generates a repeated sequence of 131071 random bits (duration 13.7 sec) which can be used for bit error rate testing BERT (see section 7.1 Reference - Jumpers).

Jumper JP1-4 set to BC may, in conjunction with a special EPROM, be used to generate higher precision waveforms, say those optimized for dedicated radio links (see section 5 - calibrating a Radio Link).

Jumper JP6 is for audio loopback testing. Jumper JP7 allows the DAC to be disconnected, and a test signal to be injected at TP2. R4 is the same as the DAC output impedance, 10k ohms.

The scrambling "polynomial" is 1 + X 12 + X 17, one of the eight maximal length generators possible using a one-tap 17 bit shift register.

2.3 MODEM RECEIVE

Received audio (RA) is passed through a 3 pole low pass filter, and limited by U10 pin 1. It is then sampled by the receive clock (from U11 pin 10) and latched in D-type bistable U5a.

Detected data next enters a 17 bit shift register U12/U7/U5b, is unscrambled by XOR gates U6, and sent to the TNC as received data (RX Data) on S1 pin 17.

Eight bit shift register U4 is a 1/2 bit delay, and with XOR U6 pin 3 forms a zero- crossing detector (ZCD) that generates one cycle of 9600 Hz for each zero crossing of the incoming audio.

This ragged "proto-clock" is used by a digital phase locked loop (PLL) to regenerate a continuous received clock (RX Clock). U1/U3 is an up/down counter phase detector, counting up if the proto-clock input at pin 15 is late, DOWN if early with respect to the local clock at pins 10.

This counter looks up one of the 256 sinewave profiles (16 steps per cycle) stored in EPROM U2, which is converted to analog by DAC U9, smoothed by C18, and limited to a square wave at U10 pin 2. Thus the recovered clock is pulled into phase with the incoming data at U10 pin 1.

Recovered clock and proto-clock are "multiplied" in XOR U6 pin 6 and if in phase, a net DC rise accumulates on C21. Comparator U10 pin 13 senses this, pulling the data carrier detect line (DCD) S1 pin 1 low. An alternative DCD high is available at U10 pin 14.

There are test points for receiver monitoring (see section 9.2)

SECTION 3 - INSTALLATION

The modem interconnects at connectors S1 (digital) and P5 (power and radio). Full specifications for the signals are given in section 9.3)

3.1 POWER

A regulated supply connects to modem P5 (+12), five volts (+5), and a ground pin (GND). The current consumption will be about 40 ma if CMOS EPROM are used, and up to 170 ma with NMOS devices. Either performs equally well.

3.2 DIGITAL CONNECTIONS

Standard TNC digital TTL connections needed: Transmit Data, Transmit Clock (16x bit rate), Receive Data, Data Detect ("DCD") and GND. Receive Clock is available, but not used by most amateur TNCs.

See APPENDIX A for specific informtion on interfacing the NB-96 modem to commercially available packet controllers.

3.3 RADIO CONNECTIONS

There are four connections to the radio: Transmit Audio (TA), Receive Audio (RA), PTT, and ground (GND).

3.3.1 TRANSMITTER

PTT is the normal signal obtained from a TNC on its conventional 5 pin DIN audio connector pin 3, ground pin 2. This signal is not needed by the 9600 baud modem, but it must be wired to the appropriate radio connection. The NB-96 modem does not generate a PTT signal.

Transmit Audio should be taken from modem P5 pin 2 (TA), directly to the transmitter varactor diode as noted in section 1.2.2, Application - Transmitters. You CANNOT inject the signal into the Microphone socket. The signal lead MUST be shielded.

Modem adjustment VR1 allows you to set the drive level, which should result in a peak FM deviation of no more than +/- 3 kHz for normal 20 kHz wide channels. The modem should operate properly with deviations between 2.0 and 3.0 KHz.

A signal of up to 8 volts peak-to-peak is available, but if less than 1 volt is needed, it is recommended that a higher level be used, and a simple resistive attenuator be fitted at the transmitter.

IMPORTANT: The output has been designed for an optimum load of 500 ohms. If you use a higher impedence load, reduce C34 in proportion. This will ensure the correct low frequency response (down to 3 Hz), and hence control any key-up "chirp". for example, if the transmitter load is 10k ohms, use a coupling capacitor of 10uf x 500/10000 = 0.5uf. This may be placed in series with C34, and can be conveniently located in the transmitter.

There will always be a TX Audio signal, even when the PTT is not active. If possible the modulated oscillator should remain powered during receive to avoid keying chirp. Chirp will cause the distant receiver to take longer to lock-in.

3.3.2 RECEIVER

Receive Audio MUST be brought direct from the receiver FM discriminator, and connected to modem P5 pin 1 (RA). The Receive Audio (RA) lead MUST be shielded.

A decoupling RC network of time constant not exceeding 10 us is permissible at the discrimminator to remove extraneous IF noise, but is not essential. The signal should be unsquelched (it almost certainly is anyway).

You CANNOT use the receiver loudspeaker for this system, though you can monitor reception by ear on it. The signal sounds like a burst cf noise.

The modem audio input impedance is approximately 50k ohms, AC coupled. In a full-duplex system ONLY, i.e. continuous transmit and receive, modem capacitor C25 may be increased to 1 uf. Do NOT alter it for normal simplex services or the modem receive transient performances will be affected, resulting in slow lock-in.

SECTION 4 - OPERATION

4.1 JUMPER SETTINGS

Nine jumpers are provided on the modem PCB to configure the system, and allow user experimentation. Positions for NORMAL operation are:

Jumper	Function	Normal Position	Result
JP1-4	Transmit Waveform	As required	(See EPROM Sheet)
JP5	Data/BERT Mode	D	Data Mode
JP6	Audio Loopback	OFF (removed)	No loopback
JP7	Transmit DAC connect	ON	Connected
JPROM	Alt Transmit Waveform	OFF (removed)	(See EPROM Sheet)
JPS	Enable modem selection	OFF (removed)	Modem enabled

The data sheet supplied with the Transmit waveform EPROM will indicate its contents, and the settings for JP1-4 and JPROM. Note that the selection compensates for the DISTANT receiver - not your local receiver.

The receivers your link uses may not be featured in the EPROM contents list. Nevertheless, most NBFM radios responses are quite similar, and one selection should be found acceptable.

You should examine the received "eye" diagram (see section 8 - Eye Diagrams) while the sender tries different JP1-4 combinations. At least one of them will be "best". Repeat for the other transmit/receive combination. Obviously this is more easily tried out with all radios in one room. You may well find the "loopback" selection is useable.

You can also calibrate a radio channel, and have a custom EPROM created for it (see section 5 - Calibrating a Radio Link). This would be most appropriate for a dedicated network link with limited signal margin.

It is vital that the radios are tuned to the correct frequency. If they are mis-tuned by more that 2-3 kHz, distortion will be apparent on the received signal, which will rapdily degrade performance. Some receivers have AFC, which will be helpful if it pulls in within 50 ms and also does not try to track the data and so impair the link's LF performance.

4.2 OPTIMUM TNC SETTINGS

These are a matter for individual experimentation. TXDELAY = 0 can be used on a full duplex link and also for audio loopback testing.

More efficient use of the channel can be made if packets are long and concentrated, so set MAXFRAME = 7, and PACLEN = 0. Sometimes it's better to use a SENDPAC character other than $OD

In some instances data is sent faster from terminal to TNC if ECHO = OFF. Better still, use TRANSPARENT mode.

The TNC radio data rate should be set for 9600 bauds.

SECTION 5 - CALIBRATING A RADIO LINK

There may be occasions where the transmit waveform in the standard transmit EPROM is not suitable and you would like a characteristic customized to your specific link. You can do this by making measurements on the receiver, and submitting them to PacComm. There is a charge for generating a special EPROM, and the time required may exceed 60 days.

What you must do is measure the amplitude and phase response of the receiver(s) you will use from 0-9000 Hz, in steps of 300 Hz, i.e. 33 points, WITHOUT the modem.

You will need a sinewave audio oscillator which covers up to 9600 Hz, an RF signal generator and an accurately calibrated dual trace oscilliscope. Use the audio to frequency modulate (FM) the RF with a deviation +/- 1 kHz. Display the audio source on scope channel 1 which should also be used as Trigger.

Inject RF into the radio. On scope channel 2 display the receive output. Obtain audio output DIRECT from the discriminator with none of the de-emphasis components affecting things. You may have to make some mods to do this. A tiny bit of RC filtering is permissible to remove the 910 kHz IF noise (say a 10 microsecond time-constant, no more).

Using the scope measure the amplitude response, AND the phase response. The latter is vital, and should be the phase delay (not group delay) in microseconds. It's simply the input-to-output delay as you see it on the scope, and will be of the order of 150-250 us, fairly constant. If you see a delay of some 1700 us at 300 Hz you are looking on the wrong edge on channel 2. Look carefully 1/2 cycle earlier for the correct zero crossing at around 200 us delay; it could be high or low going. You may like to use x5 expansion for the delay, and measure it relative to the center of the screen. The absolute delay is not important. Your data is required in a table like this:

RADIO: FT999R Transceiver

Freq	AMP	Delay us	Freq	AMP	Delay us
0	1.00	210	...		
300	1.00	210	9000	0.13	245
600	0.99	213	9300	0.12	245
900	0.98	214	9600	0.11	246

Amplitude should be absolute (i.e. volts, NOT in db), as measured directly on the scope. Please be as accurate as possible. +/-2% is very easy to determine. "Jumps" caused by careless readings necessarily show up again in your customized transmit EPROM - as unwanted "noise".

CALIBRATING A WHOLE CHANNEL. If you wish you can characterize the entire channel including transmitter, modem filters and receiver. With the modem connected to transmitter and receiver, set jumper JP7 OFF (removed), and inject audio at TP2. Measure the system response as above. When sending the data make sure you identify the test conditions used explicitly.

SECTION 6 - FOLLOW UP SUPPORT

You are invited to contact PacComm with any technical inquiries about this modem. Or you may choose to contact the modem's designer at the address below. Be sure to include a self addressed envelope and 4 International Reply Coupons if corresponding with Mr. Miller.

- James R. Miller G3RUH,
  3 Benny's Way, COTON, Cambridge, CB3 7PS, England
- AMSAT TMAIL Address:
  via MSWEETING. Packet: G3RUH @ GB7SPV
- TEL: UK 0954-210388, International +44 954 210388

SECTION 7 - TROUBLESHOOTING AND TEST

7.1 TRANSMITTER

1. Install jumpers JP1-4 on AB side (toward JPROM), JP5 OFF, JP6 OFF, JP7 ON, JPROM OFF. Set VR1 to mid position.

2. Switch power OFF then ON, and install JP5 on T (pins nearest JP5 label).

3. Check that a 9600 Hz pulse train is obtained at test point TPO, and then trigger the scope from this, time base 20 us/div.

4. Examine TP2. You should see a rather coarse "eye" pattern at an amplitude of about 2 volts peak-to-peak. Examine the signal at JP6 (left), and you should see a smooth "eye". Vary VR1 and note that the amplitude changes.

5. Try changing jumpers JP1-4 to positions AB and OFF (removed), and observe the variety of waveforms. (Do NOT install any of the jumpers on the BC position).

6. Whenever you power up in test mode, always remove and replace JP5 on T (pins nearest JP5 label). If you don't do this the scrambler can jam, and no transmit Audio will be generated.

7.2 RECEIVER

1. Install jumpers JP1-4 on AB (Nearest JPROM), JP5 OFF, JP6 ON, JP7 ON, JP ROM OFF. Set VR1 to mid position.

2. Switch power OFF then ON, and install JP5 on T (pins nearest JP5 label). The modem is now in audio loopback and BERT mode. (See section 9.1 - Reference, Jumpers for explanations of these modes.

3. Examine TP4, the received "eye" point. If the correct selection has been made from the transmit EPROM U15 (JP1-4 as required, and JPROM OFF), you should see a perfect eye waveform.

4. Now use the other trace of the scope to view the received clock (RX Clock) at TP8. This should show a LOW going edge at the same moment as all the eye traces converge to a point. There may be a little jitter, and possibly a slight displacement.

5. Momentarily remove JP6, put your finger on TP4, and this Receive Clock will drift. Replace JP6 and the clock should pull again.

6. Examine RX Data at TP6. With JP5 on T (pins nearest JP5 label) the signal should be LOW. With JP5 OFF it should be HIGH. With JP6 OFF it will go completely random. With JP6 OFF you should also notice the DCD LED on the TNC extinguish.

7.3 TNC DIGITAL LOOPBACK

1. Install jumpers JP1-4 on AB (nearest JPROM), JP5 on T (pins nearest JP5 label), JP6 ON, JP7 ON, JPROM OFF. Set VR1 to mid position.

2. Examine RX Data at TP6. With a TNC-2 type of packet controller you should see "flags", one bit in eight, i.e. 00010000 or 11101111 repeated (Not all TNCs do this; some will simply show high or low).

3. Set FULLDUP - ON at the TNC, and MYCALL to your callsign.

4. Now type CONNECT YCALL, and you should get the ***CONNECTED to YCALL message. Type "test" and you should get a repeat of "test". Now disconnect. Observe data at TP6 during this test.

5. Experiment a bit; try CONNECT YCALL VIA YCALL YCALL, YCALL, ETC. When you have finished don't forget to remove JP6, and set FULLDUP = OFF.

SECTION 8 - "EYE" DIAGRAMS

The "eye" diagram is a simple yet powerful way of deciding whether or not the received audio is of satisfactory quality. You can see what a "good" eye looks like using audio loopback.

Install the modem on the TNC. Disconnect the radio. Install jumpers JP1-4 on AB (nearest JPROM. This is the "loopback" selection 0), JP5 on D (pins away from JP5 label), JP6 ON, JP7 ON, JPROM. Set VR1 to mid position. Trigger the scope from TP0, timebase set to 1ms/div. Apply power to the TNC. Put a probe on TP4, the "Eye" point. At this slow speed

the waveform looks rather like familiar digital "data" but with sloping edges, and a little overshoot.

Now gradually speed up the timebase to 20us/div. See how the data bits become superimposed, fusing into a characteristic "eye", the diamond shape in the center of the screen:

Notice the traces converge at two distinct points, one high corresponding to a "1" bit, the other low for a "0" bit. It is at these points the modem samples the audio to detect a "1" or a "0".

Also shown is the RX Clock waveform from TP8.

The goodness of this convergence is an indication of the way the modem will perform. Vertical scatter at the sample point reduces the systems tolerance to noise, because some bits pass closer than others to the "0" "1" decision threshold. This scatter is "self- noise", and adds to any real noise present.

Now as an example, change jumpers JP1-4 to select another transmit waveform. You will see the eye change somewhat, with scatter at the sample point, as well as some asymmetry. However if this audio were passed through its matched transmitter/receiver combination it would convolve back to the ideal shape. It is this compensatory feature of the modem which contributes mainly to its high performance.

When using a real radio link, trigger the scope from TP8, the Receive Clock. It will add lateral jitter due to the clock recovery process, and give a more valid (and stationary) eye.

SECTION 9 - JUMPER FUNCTIONS

Nine jumpers are provided on the modem PCB to configure the system, and allow user experimentation. Positions for NORMAL operation are:

Jumper	Function	Normal Position
JP1-4	Transmit Waveform	As required
JP5	Data/BERT Mode	D
JP6	Audio Loopback	OFF (removed)
JP7	Transmit DAC connect	ON
JPROM	AltTransmitWaveform	OFF (removed)
JPS	Enable modem selection	OFF(removed)

JP1-4 TRANSMIT WAVEFORM SELECT

NOTE: JP1-4 are three pin headers. The pin of each jumper closest to JPROM is pin A, the center pin is B, and the pin farthest from JPROM is pin C. The transmit waveform generator uses a look-up table of values stored in EPROM U15. Depending on the contents of this EPROM, and the selections of JP1-4, a variety of transmit waveform characteristics may be acheived to suit differing raido channels.

JPx Position Function (x = 1, 2, 3, or 4)

OFF (removed)	Transmit Waveform Selection	bit x = 1
AB	Transmit Waveform Seleciton	bit x = 0
BC	Transmit Waveform uses DATA	bit x + 8

In the standard configuration, the generator operates on a span of 8 data bits at once via shift register U14. A 27256 EPROM can hold up to 32 different waveform characteristics:

Bit x 4321	**Tx Waveform Selection**	**Bit x 4321**	**Waveform Selection**
0000	0	1000	8
0001	1	1001	9
0010	2	1010	10
0011	3	1011	11
0100	4	1100	12
0101	5	1101	13
0110	6	1110	14
0111	7	1111	15

Alternatively, it could hold eight charcteristics operating on 9 data bits (JP1 = on BC) and so on, up to one charcteristic spanning 12 data bits (JP1, 2, 3, 4 = on BC).

Non-standard or customized EPROMs are supplied with linking information their data sheet. For example a type 27256 EPROM can hold 32 waveforms in 2 banks of 16, selected by jumper JPROM.

JP5 DATA/BERT MODE SELECT

NOTE: JP5 is labeled with designations of D(ata) and T(est, but these labels are hidden by the nearby IC socket. Position D is the postion closest to the nearby EPROM, while position T is that position closest to the JP5 label.

BERT = Bit Error Rate Testing. In BERT mode, the transmitter generates a specific sequence of 131071 pseudo-random bits. At the receiver, after unscrambling, the received data (RX Data) should be constant 0 or a constant 1. However, if a received bit is corrupted, then there will be burst of exactly 3 pulses on Receive Data. These are easily counted, and provide an accurate measure of the channel quality.

If there are N counts in T seconds, the channels bit error rate is (N/3) (T*9600). For example a count of 30 in 10 seconds would equate to an error rate of approximately 1 in 10000 bits (10E-4).

JP5	**Position**	**Function**
D	Normal	DATA
T	BERT mode	all 0
OFF (removed)	BERT mode	all 1

NOTE: If the modem is powered up with JP5 set for a BERT mode, the transmit scrambler can jam, and no transmit Audio will be generated. Remove and replace the jumper as required. The NORMAL position of

JP5 is on D (pins nearest JP5 label).

JP6 AUDIO LOOPBACK

Installing JP6 connects the transmitted analog audio signal to the modem receiver input. This allows a modem performance check to be carried out without radios. The NORMAL position of JP6 is OFF.

JP7 TRANSMIT DAC CONNECT

Removing JP7 disconnects the transmitter waveform generator. This allows a test source to be connected to test points TP2 and TP3. You would do this to perform radio checks. The NORMAL position of JP7 is ON.

JPROM TRANSMIT WAVEFORM SELECT

JPROM should be OFF (removed) for transmit waveform selections 0-15, and ON for selections 16-31. See JP1-4.

9.2 TEST POINTS

Five test points facilitate monitoring:

Point	**Function**	**Ground**
TP0	9600 Hz Sync	TP1
TP2	Transmit audio inject	TP3
TP4	Receive "Eye" Point	TP5
TP6	RX Data	TP7
TP8	RX recovered Clock	TP7

TP0: 9600 Hz Sync

This is a high going 5 volt pulse of duration 1/16th bit, at 9600 Hz. It should be used as a "sync" to trigger a scope when examining waveform.

TP2: TRANSMIT AUDIO INJECT

With JP7 removed this point allows a test audio signal to be injected into the transit system. In this way the radio may be checked, and a radio transmitter/receiver combination can be checked/calibrated.

TP4: RECEIVE "EYE" POINT

This point allows the received audio to be examined just prior to the data detector. The characteristic trace of numerous bits superimposed resembles an "eye". This analog signal is samples on the low going edge of Receive Clock (TP8). The desired trace has symetry, an open "eye", with all trajectories converging to a spot at the sample point, once per bit.

TP6: RECEIVE DATA (RX DATA)

This is the 5 volt TTL signal sent the the TNC. In data mode this will be essentially random. In BERT mode it will be high or low, punctuated by any errors. (See notes on JP5).

TP8: RECEIVE RECOVERED CLOCK (RX CLOCK)

This is a 5 volt TTL symetric 9600 Hz clock signal recovered from the received audio. It goes HIGH mid-bit. NOTE: Receive Clock will take the frequency of the transmitter. It will only be identical with TPO in Audio Loopback Mode (see notes on JP6).

9.3 CONNECTORS

9.3.1 P5 - POWER SUPPLY / RADIO INTERFACE

P5	Signal/Power
1	Receive Audio (RA)
2	Transmit Audio (TA)
3	+12v (+10 to 15 volts DC at 10 ma.)
4	+5v (30ma (CMOS parts))
5	GND

Note that the power and ground signals are duplicated on S1 pins numbered greater than 20 for use with the PacComm TNC-320 and PC-320.

9.3.2 S1/S1A - DIGITAL SIGNALS TO TNC

NOTE: There are two possible locations for connector S1 to allow proper clearances when attaching to the modem disconnect header of a variety of TNCs. The connector has 26 positions for compatibility with recent PacComm models with a modem disconnect header of that size. When using a 20 pin header, use care to match pin 1 of S1 or S1A to pin 1 of the TNC connector.

S1	Signal	S1	Signal
1	DCD	2	
3		4	
5		6	
7		8	
9		10	
11	Transmit Clock	12	
13	Receive Clock	14	
15	GND	16	
17	Receive Data	18	
19	Transmit Data	20	
21		22	
23		24	
25		26	

S1 connects to the "modem disconnect" or "External Modem" facility of the associated TNC. All signals are standard 5 volt TTL. A TTL high or "1" is greater than 2.4 volts, but less that 5.25 volts. A TTL low, or "0", is less than 0.8 volts, but greater then -0.4 volts. DO NOT connect anything other than a TTL device (or appropriate test equipment) to P2.

Pin 1 DCD al Pin 2 conn TSTeam - Pin 19 Sio

A signal to the TNC, "data detect". It is a LOW when the modem recognizes that the received audio is a valid data stream.

Pin 11 Transmit Clock Pin 12el4 Conn TsTeam - Pin3 74HC86

A signal from the TNC, and provides a timing for the modem. Its speed must be 16 times the data rate (153.6 kHz for 9600 bauds).

Pin 13 Receive Clock - non collegato -

A symetric 9600 Hz clock signal extracted from the received audio, and goes HIGH in the middle of a Receive Data bit (P2 pin 4). This signal is NOT required by a TNC which has an internal clock recovery system.

Pin 15 GND Massa del TNC

Common connection for the digital signals.

Pin 17 Receive Data Pin 7 conn Modem TSTeam - Pin 2 74HC74

A signal to the TNC, the received data as decoded by the modem.

Pin 19 Transmit Data Pin 9 conn Ts Team - Pin 5 74HC107

A signal from the TNC, and is the data to be transmitted. It is read by the modem on a high going edge of transmit Clock.

9.3.3 RADIO CONNECTIONS

The radio connections are made via P5, or via S1 or S1A.

Transmit Audio (TA) P5 Pin 1

The audio signal to the transmitter, used to modulate the varactor diode to generate true FM. The level is adjustable by VR1 from 0 to about 8 volts peak-to-peak. The cable MUST be shielded.

Receive Audio (RA) P5 Pin 4

The audio signal direct from the receiver's FM discrimminator. A level exceeding 50mv is sufficient, but a probe on TP4 should show clipping. The cable MUST be shielded.

APPENDIX A

DIGITAL CONNECTIONS

PacComm TINY-2, Rev. 1.1 to 1.4 Circuit Boards

1. On the solder side of the 9600 modem board, cut the trace at JPC from the middle pad to the pad closest to "ACLK". Cut the trace from the middle pad to pin 12 of S1, and cut the trace from JPC to pin 11 of S1. Add a jumper from the JPC middle pad to the pad closest to "JPC" label.

(NOTE: This step should already have been performed for you if you specified the 9600 board for installation on a TINY-2 or MICROPOWER-2 Rev. 1.1 to Rev. 1.4.)

2. On the TINY-2 circuit board, cut the following traces on the solder side of the board at J5 (the modem disconnect header). Use care not to cut any other traces in the area.

a. 1 to 2 DCD
b. 17 to 18 RXDATA

3. Solder in a 20 pin header at J5.

4. Remove components R10, C7, and C8 from the TNC circuit board.

5. Locate the wire from the 9600 modem board which has a jumper to 'ACLK' attached. Install the jumper on the 9600 baud position of the Radio Baud Rate (JPR) jumpers located near the LEDs on the TNC circuit board. Remove any other jumper at JPR.

6. Attach wires coming from the plug (P5) attached to J5 on the 9600 baud modem board as follows:

a. P5 pin 5 to J2 pin 4 (RA).
b. P5 pin 4 to J2 (5 pin DIN) pin 1 (TA).
c. P5 pin 3 to D3 cathode (band) (+12v).
d. P5 pin 2 to U5 (7805) leg near U14 (+5).
e. P5 pin 1 to C8 negative end (GND).

7. Plug in the 9600 modem board at J5. Insure pin 1 of the header is in pin 1 of the socket S1.

PacComm MICROPOWER-2, Rev. 1.1 to 1.4 Circuit Boards

1. On the solder side of the 9600 modem board, cut the trace at JPC from the middle pad to the pad closest to "ACLK". Cut the trace from the middle pad to pin 12 of S1, and cut the trace from JPC to pin 11 of S1. Add a jumper from the JPC middle pad to the pad closest to "JPC" label.

(NOTE: This step should already have been performed for you if you specified the 9600 board for installation on a TINY-2 or MICROPOWER-2 Rev. 1.1 to Rev. 1.4.)

2. On the MICROPOWER-2 circuit board, cut the following traces on the solder side of the board at J5 (the modem disconnect header). Use care not to cut any other traces in the area. NOTE: A 20 pin header is installed at the factory, but several pins are bridged on the solder side of the board.

a. 1 to 2 DCD
b. 17 to 18 RXDATA

3. Remove components R10, C7, and C8 from the TNC circuit board.

4. Cut the black jumper off the wire coming from "ACLK" on the 9600 modem board. Strip 1/8" of the insulation from the end of this wire and solder this to U7 (74HC4060) pin 5. Make sure there are no solder bridges to any other pins.

5. Attach wires coming from the plug (P5) attached to J5 on the 9600 baud modem board as follows:

a. P5 pin 5 to J2 pin 4 (RA).
b. P5 pin 4 to J2 (5 pin DIN) pin 1 (TA).
c. P5 pin 3 to D3 cathode (band) (+12v).
d. P5 pin 2 to U5 (7805) leg near U14 (+5).
e. P5 pin 1 to C8 negative end (GND).

6. Plug in the 9600 modem board at J5. Insure pin 1 of the header is in pin 1 of the socket S1.

TINY-2 / MICROPOWER-2 Rev. 1.5 and up.

(NOTE: All steps apply to both TINY-2 and MICROPOWER-2 boards unless otherwise noted.)

1. Cut the following traces on the solder side of the circuit board at J5 (the modem disconnect header). Use care not to cut any other traces in the area.

a. 1 to 2 DCD
b. 17 to 18 RXDATA

2. (TINY-2 ONLY) Solder in a 20 pin header at J5.

3. (TINY-2 ONLY) Change the radio baud selector jumper to the 9600 baud position.

(MICROPOWER-2 ONLY) Change the radio DIP switch selector to 9600 baud position. Be sure no more than one baud rate switch is enabled on the radio side and one switch enabled on the terminal side.

4. Remove components R10, C7, and C8 from the TNC circuit board.

5. Plug in the 9600 modem board at J5. Insure pin 1 of the header is in pin 1 of the socket S1.

6. Attach wires coming from the plug (P5) attached to J5 on the 9600 baud modem board as follows:

a. P5 pin 5 to J2 pin 4 (RA).
b. P5 pin 4 to J2 (5 pin DIN) pin 1 (TA).
c. P5 pin 3 to D3 cathode (band) (+12v).
d. P5 pin 2 to U5 (7805) leg near U14 (+5).
e. P5 pin 1 to C8 negative end (GND).

The PacComm TNC-200, TAPR TNC-2 and its clones (PK-80, TNC-2A, MFJ1270 etc)

1. Cut the following traces on the solder side of the circuit board at J4 (the modem disconnect header). Use care not to cut any other traces in the area.

a. 1 to 2 DCD
b. 11 to 12 TXCLOCK
c. 13 to 14 RXCLOCK
d. 17 to 18 RXDATA

2. Turn on switch 8 (SW2) and make sure 6 and 7 are off.

3. Remove components C34 and C35 from the TNC circuit board.

4. Attach wires coming from the plug (P5) attached to J5 on the 9600 baud modem board as follows:

a. Wire P5 pin 5 to J2 pin 4 (RXA) [C35 closest to J2]
b. Wire P5 pin 4 to J2 (5 pin DIN) pin 1 (TXA) [C34+ closest to J2]
c. Wire P5 pin 3 to CR8 cathode (banded end) (+12)
d. Wire P5 pin 2 to L2 side near C22 (+5)
e. Wire P5 pin 1 to R24 near side R5 (GND) [Near L2]

5. Plug in the 9600 modem board at J5. Insure pin 1 of the header is in pin 1 of the socket S1. Be careful of the crystal and 32K RAM select header (if installed). It may be necessary to insulate the NB-96 card from these components with tape.

The PacComm TNC-220

Be sure to check your schematic carefully as there are several revisions of the TNC-220.

Signal	TNC-220 J5	Modem S1	Notes:
TX Data	19	19	Transmit Clock: Obtain 153.6 KHz from
GND	15	15	the TNC's 74HC4020 divider chip pin 5,
TX Clock	see note	11	and connect to modem P2-3.
RX Data	3	17	Cut trace between TNC J5 pins 3 & 4:
DCD	1	1	Cut trace between TNC J5 pins 1 & 2

Receive Data: Use caution, some models have a second path in parallel with this trace! Locate and cut it too.

The PacComm DR-100

Call PacComm for assistance

The PacComm DR-200

Call PacComm for assistance

The PacComm TNC-320

Call PacComm for assistance

The PacComm PC-320

Call PacComm for assistance

The AEA PK-87

(AEA circuit 012-060 Rev A & E). This TNC provides signals at the "Ext Modem" socket J4:

Signal	PK-87 J4	Modem S1
TX Data	1	19
GND	2	15
TX Clock	3 ***	11
RX Data	4	17
DCD	5	1

NOTE: Old & new PK-87 Models differ. OLD have 2.5 MHz xtal, and a Transmit Clock of 9600 Hz (X1 clock) NEW have 4.9 MHz xtal, and a Transmit Clock of 153.6 kHz (X16 clock) Transmit DATA, Receive DATA, and DCD: Cut links at JP3, JP4, and JP5, and rebridge to other side.

***Transmit CLOCK: NEW models only.
On Old models obtain 153.6 kHz from PK-87 U20 pin 11.

The AEA PK-88

(AEA circuit 012-060-88 Rev G). This TNC provides signals within the RS232 connector J1.

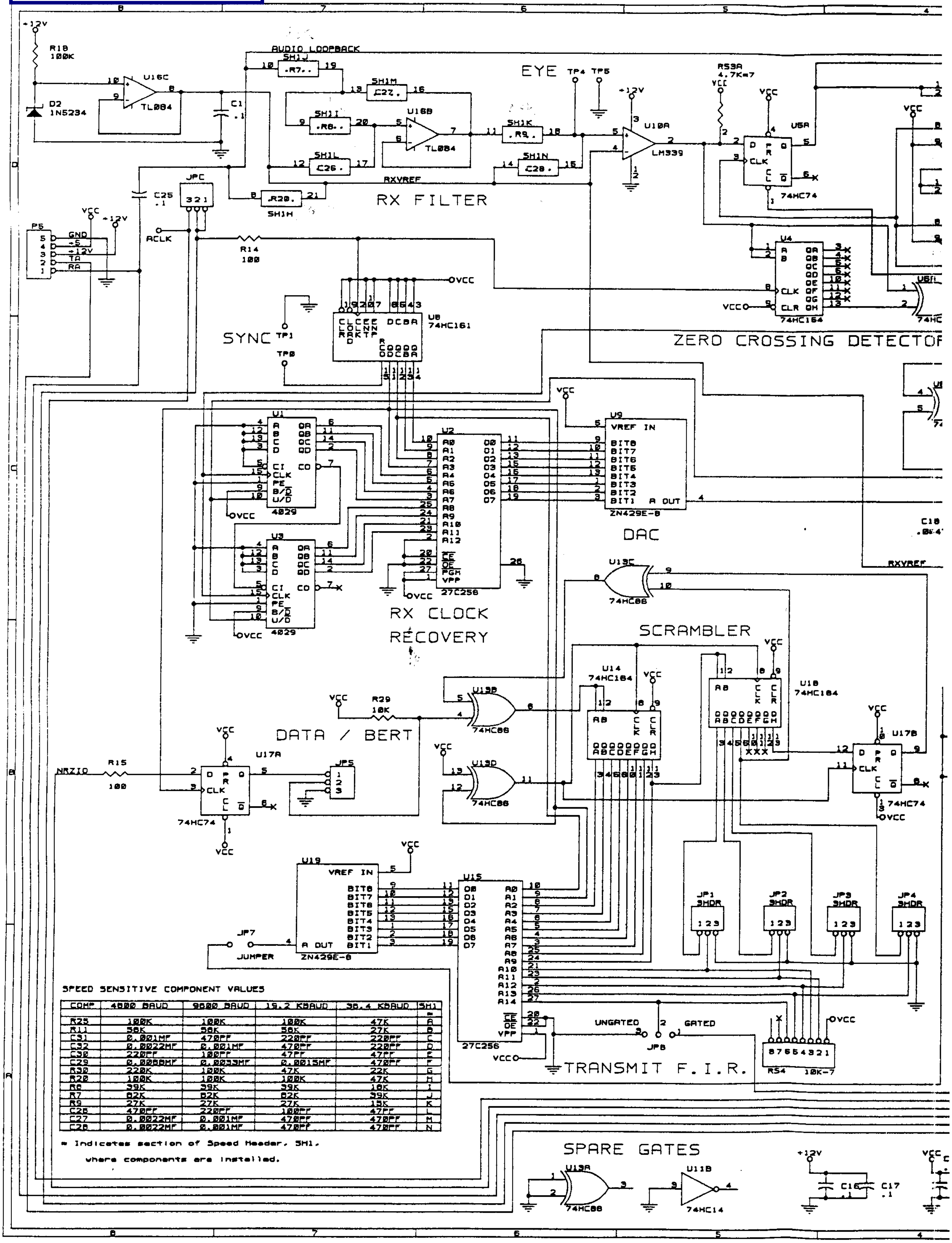
Signal	PK-88 J1	Modem S1
TX Data	16	19
GND	17	15
TX Clock	13 see note	11
Data(RX)	15	17
DCD	14	1

Note:
Transmit Clock: Cut internal trace to J1 and obtain 153.6 kHz from U20 pin 11

Receive Data, Transmit Data, DCD: Cut the 3 jumper traces at JP4 and re-bridge to the other side.

APPENDIX B - RADIO INTERFACING INFORMATION

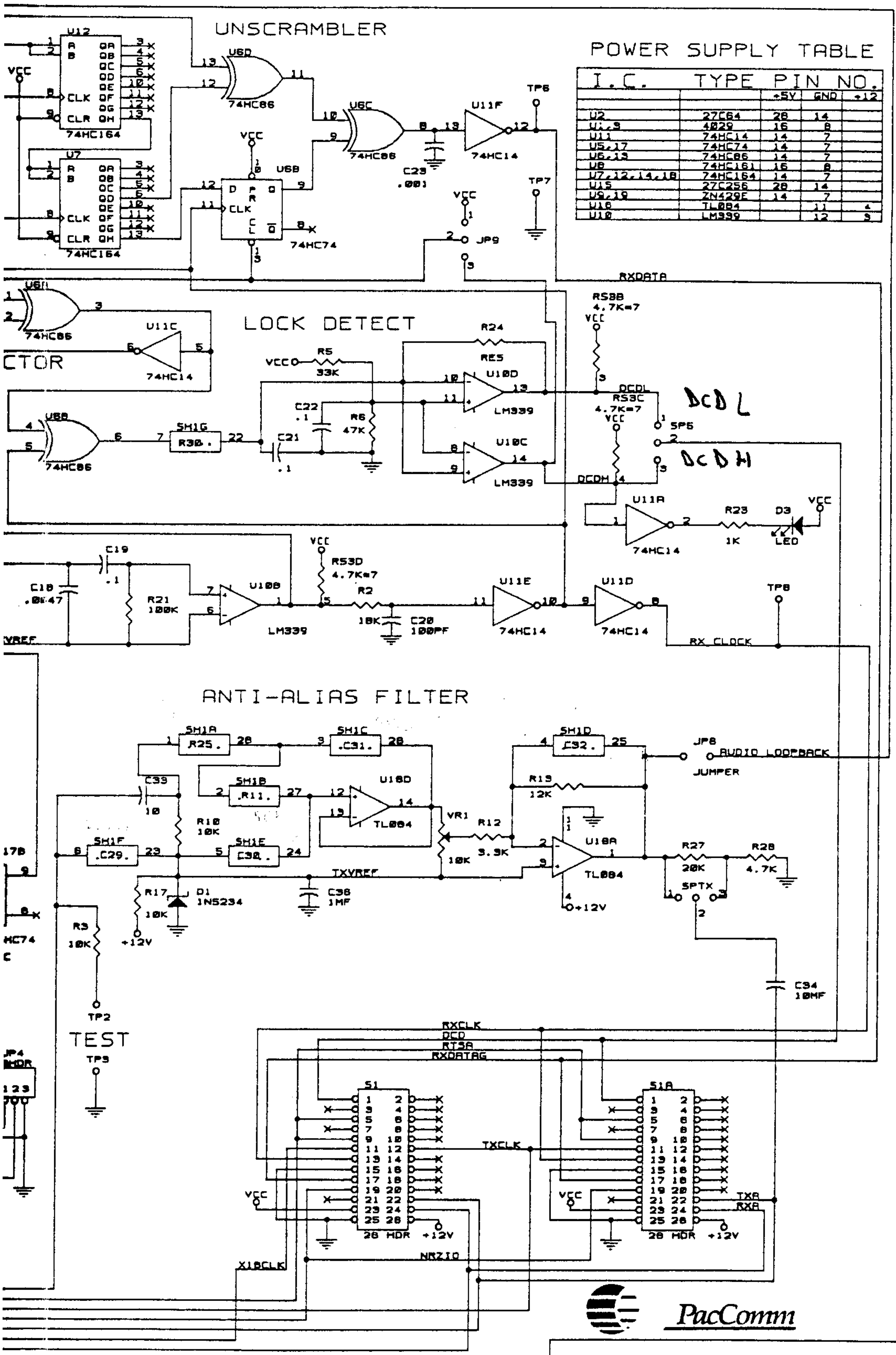
This section will be added as users provide the interfacing information they have recorded in the process of interfacing the NB-96 modem to their various radios.



SPEED SENSITIVE COMPONENT VALUES

COMP	4800 BAUD	9600 BAUD	19.2 KBAUD	38.4 KBAUD	SH1
					*
R25	100K	100K	100K	47K	A
R11	56K	56K	56K	27K	B
C31	0.001MF	470PF	220PF	220PF	C
C32	0.0022MF	0.001MF	470PF	220PF	D
C30	220PF	100PF	47PF	47PF	E
C29	0.0068MF	0.0033MF	0.0015MF	470PF	F
R30	220K	100K	47K	22K	G
R20	100K	100K	100K	47K	H
R8	39K	39K	39K	10K	I
R7	82K	82K	82K	39K	J
R9	27K	27K	27K	15K	K
C26	470PF	220PF	100PF	47PF	L
C27	0.0022MF	0.001MF	470PF	470PF	M
C28	0.0022MF	0.001MF	470PF	470PF	N

* Indicates section of Speed Header, SH1, where components are installed.



POWER SUPPLY TABLE

I.C.	TYPE	PIN NO. +5V	GND	+12
U2	27C64	28	14	
U1,3	4029	16	8	
U11	74HC14	14	7	
U5,17	74HC74	14	7	
U6,13	74HC86	14	7	
U8	74HC161	16	8	
U7,12,14,18	74HC164	14	7	
U15	27C256	28	14	
U9,19	ZN429E	14	7	
U16	TL084		11	4
U10	LM339		12	3

PacComm

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