

OPERATING INSTRUCTIONS

MC-NB96
and
EM-NB96

Narrowband 9600 baud
Packet Modems



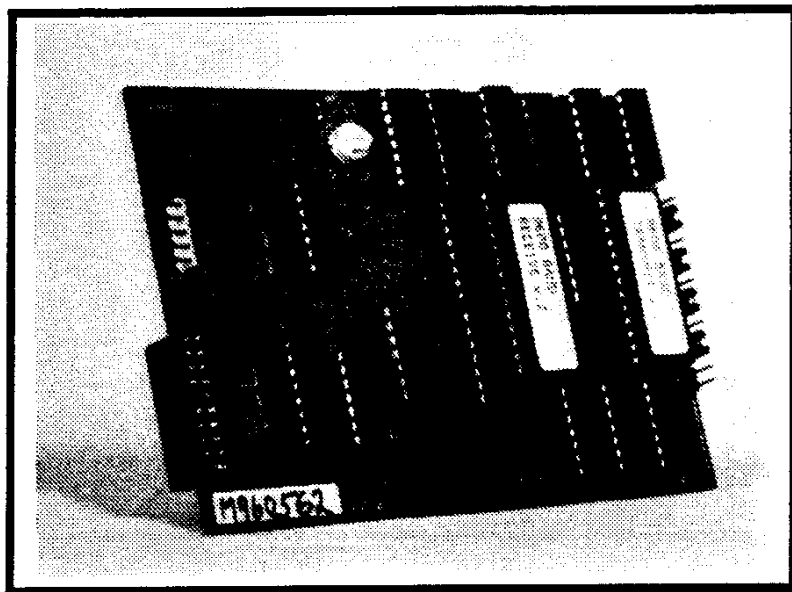
PacComm

TECHNICAL MANUAL

for the

PacComm MC-NB96 Modem Card

**The PacComm NB96 Series
Narrowband 9600 Baud Packet Radio System**



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Table of Contents

INTRODUCTION	1
This Manual.....	1
The PacComm NB96 Series	1
MC-NB96 Modem Card	2
SPECIFICATIONS.....	2
Packet Controller Interface	3
Radio Interface	4
Required Receiver Characteristics	4
Required Transmitter Characteristics	5
THEORY OF OPERATION	5
TNC Interface	5
Modem Transmit	5
Modem Receive	6
INSTALLATION	7
Power	7
Digital Connections.....	7
Radio Connections	7
OPERATION	9
Jumper Settings.....	9
Optimum TNC Settings	10
Calibrating A Radio Link	10
Calibrating a Whole Channel.....	10
TROUBLESHOOTING AND TEST	11
Follow Up Support	11
Modulator (Transmit Section).....	11
Modulator (Receive Section).....	12
TNC Digital Loopback.....	12
" EYE " Diagrams	13
JUMPERS and CONNECTORS	14
Test Points	16
Connectors.....	17
P5 - Power Supply / Radio Interface.....	17
S1/S1A - Digital Signals To TNC	17
Radio Connections	19
APPENDIX A, Packet Controller Interfacing.....	21
The PacComm TINY-2	21
The PacComm MICROPOWER-2	21
The PacComm TNC-200, TNC-2 Clones, MFJ	23
The PacComm TNC-220	24
The PacComm TNC-320.....	25

Table of Contents, Page 2.

The PacComm DR-200	26
The PacCom DR-100	26
The AEA PK-87, PK-88, PK-232	26
The Kantronics DE56	27
APPENDIX B, Radio Interfacing	28
Perfect Modulation with the FT726R	28
FT736 & 9600 Baud Operation	28
Other Radios	30
APPENDIX C, MC-NB96 Alternate Data Rates	31

WARNING:The equipment must be installed and operated in accordance with the printed procedures and should NOT be used for any purpose which involves the safety of life or limb. There are no lethal voltages present in the equipment. Careful connection of the unit to power sources and radio, computer, or packet controller equipment will insure that no hazardous situation is created through the interconnection. Carefully ground all units to a solid earth ground.

Introduction

This Manual

This Technical Manual provides installation and operational information for the PacComm MC-NB96 Modem Card.

The PacComm NB96 Series

PacComm provides a complete set of products which use the G3RUH 9600 baud standard: The PacComm Narrowband 9600 Baud Packet Radio System. The NB-96 Series is a line of affordable 9600 baud packet equipment to support network nodes, local packet users on higher speed channels, and AO-14 UOSAT-D access. This is the standard for medium speed FSK work. The AO-14 satellite now in orbit uses this type of modulation. It is compatible with the TAPR K9NG/TEXNET and proposed PacketRadio modems, and all implementations of the G3RUH design. Most major packet manufacturers now or will soon support this same modem signal format.

The standard packet VHF/UHF radio data rate is 1200 bauds because amateur packet controllers traditionally 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.

A key feature of the NB96 Series modem design is digital generation of the transmit audio waveform. Precise shaping limits the signal bandwidth and may optionally be used to compensate exactly for the amplitude and phase response of the receiver on dedicated circuits. This results in a "matched filter" system, which means that the received audio offered to the data detector has the optimum characteristic for minimum errors.

The PacComm Narrowband 9600 Baud Packet Radio System (NB96 Series) modem design is licensed from James Miller, G3RUH and is in use in dozens of countries worldwide. It is a high performance design using innovative signal processing techniques to limit the occupied bandwidth to significantly less than conventional FSK modems. The design complies with United States Federal Communications Commission (FCC) bandwidth limitations on the 6 and 2 meter amateur bands as well as higher frequencies. The modem must be connected to the radio internally and may not be suitable for use with all radios.

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

MC-NB96 MODEM CARD - Add on internal modem card for all PacComm packet controllers and the TAPR TNC-2 and many of its clones.

EM-NB96 EXTERNAL MODEM - Encased 9600 baud modem with front panel LED displays and cabling for most popular packet controllers.

DT-NB96 DIGITAL TRANSCEIVER - A digital 2-5 watt RF deck and NB96 modem in one package. Now available for the 70 cm amateur band. Soon to be available for several popular amateur VHF and UHF frequency bands. Comes with front panel LED displays and cabling for most popular packet controllers.

IPR-NB96 INTEGRATED PACKET RADIO - A complete high speed packet unit. Integrated RF transceiver, packet controller, and 9600 modem ready to attach to your computer or terminal and antenna. Soon to be available for several popular amateur VHF and UHF frequency bands.

In addition, PacComm offers several RF digital transceivers for use with NB96 modems for those operators who desire to dedicate a radio to this specific purpose.

MC-NB96 Modem Card

The MC-NB96 modem card attaches to a TNC-2 Style "Modem disconnect" header, and obtains its mechanical support and most electrical signals from the header pins. It fits into the case of all packet controllers which have TNC-2 stype modem disconnect headers.

The NB96 External Modem may be more suitable for use in many custom installations since it provides a housing and convenient cabling and other features.

Specifications

- **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. Optionally allows compensation for the characteristics of the transmitter and receiver pair to achieve 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. (See the Appendices for details.) Channel calibration and audio loopback capabilities.

The MC-NB96 circuit board is 3.1"x 4.8", double sided, plated-through holes, solder masked, with silk-screened legend.

The current consumption will be about 40 ma. with factory installed CMOS EPROMs. If NMOS EPROMs are used about 170 ma. will be consumed. Either type of EPROM performs equally well.

Packet Controller Interface

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

All PacComm packet controllers provide the proper signals. Other TAPR TNC-2 based designs, typified by the TNC-2, PK-80, MFJ1270, MFJ1274, etc. also provide the proper signals.

The PK-87, PK-88, and PK-232 may also be used, but only with the EM-NB96 External Modem.

See APPENDIX A for specific packet controller hookup information.

Radio Interface

Signal connections required to the radio: Transmit Audio, Receive audio, PTT (radio keying) and Ground. 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 susceptibility 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.

Required Receiver Characteristics

- NBFM design
- Output from discriminator (essential)
- Response to DC (essential)
- Response no worse than -4 db at 4.8 kHz
- Response 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 characteristic

On the whole, most receivers will perform as required. Those with the least complicated IF filtering appear best, especially with 20 Hz 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. See Appendix C for details.

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

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 synthesis PLL, are generally not useable, as 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.

Theory of Operation

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

TNC Interface

The MC-NB96 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 MC-NB96 modem board to 'disappear.'

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 set of 16 waveform selections.

The EPROM output is passed to digital-to-analog converter (DAC) U19, which generates a discrete staircase-like waveform. This is then 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 EPROM) 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).

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.

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.

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 11 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 1 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 600 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 pin 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.

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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) 1 pin 1 low. An alternative DCD high is available at U10 pin 14.

There are test points for receiver monitoring.

Installation

The modem interconnects at connectors S1 (digital) and P5 (power and radio). If the MC-NB96 is used with a PacComm product having an expanded modem disconnect header, the power and ground connections are made via that header. Radio connections may also be made via the header, but in most cases it is preferable to attach to S5 with shielded cable.

Power

Apply unregulated twelve volts to J5 pin 3 (marked +12), regulated five volts to J5 pin 2 (marked +5), and attach the ground return to J5 pin 1 (marked GND). If the MC-NB96 is used with a PacComm product having an expanded modem disconnect header, the power and ground connections are made via the set of pins numbered 21-26 and P5 need not be used.

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 information on interfacing the MC-NB96 modem to commercially available packet controllers.

Radio Connections

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

Transmitter

PTT is the normal signal obtained from a TNC on its conventional 5 in 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 MC-NB96 modem does not generate a PTT signal.

Transmit Audio should be taken from modem P5 pin 4 (TA), directly to the transmitter varactor diode. You CANNOT inject

the signal into the Microphone socket. The transmit audio (TA) 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 impedance 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 $10\mu\text{f} \times 500/10000 = 0.5\mu\text{f}$. 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.

Receiver

Receive Audio **MUST** be brought direct from the receiver FM discriminator, and connected to modem P5 pin 5 (RA). The receive audio (RA) lead **MUST** be shielded.

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

You **CANNOT** use the receiver loudspeaker for this system, though you may monitor reception by ear on it. The signal sounds like a burst of 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 from 0.1 μf to 1 μf . Do **NOT** alter it for normal simplex service or the modem receive transient performances will be affected, resulting in slow lock-in.

Scan by Dan

Operation

Jumper Settings

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

Jumper	Function	Normal Position	Result
JP1-4	Transmit Waveform	AB	Uncompensated
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)	
JPS	Enable modem selection	OFF (removed)	Modem enabled

The transmit waveform EPROM contains a variety of general compensation waveforms. The normal selection should be used in most all cases and certainly for AO14 (UoSAT-D) access and general purpose terrestrial packet work.. If difficulty is experienced with a particular radio, try each of the transmit settings to find the most optimum one. Note that the selection compensates for the DISTANT receiver - not your local receiver. The receivers your link uses may not be exactly compensated by the EPROM contents. Nevertheless, most NBFM radios responses are quite similar, and one selection should be found acceptable.

You should examine the received "eye" diagram 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 may also calibrate a radio channel, and have a custom EPROM created for it. 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 in the received signal, which will rapidly 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 low frequency performance.

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.

Calibrating A Radio Link

There may be occasions where the transmit waveforms in the standard transmit EPROM are not suitable and you would like a characteristic customized to your specific link. You may 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 30 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. 30 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 oscilloscope. Use the audio to frequency modulate (FM) the RF with 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).

Use the scope to 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

Troubleshooting And Test

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 may 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.

Troubleshooting And Test

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,
Benny's Way, COTON, Cambridge, CB3 7PS, England

AMSAT TMAIL Address:
via MSWEETING. Packet: G3RUH @ GB7SPV

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Fascimile: UK 0954-211 256, international +44 954-211 256

Modulator (Transmit section)

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 EPROM).

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

Demodulator (Receive section)

1. Install jumpers JP1-4 on AB (Nearest JPROM), JP5 OFF, JP6 ON, JP7 N, JPROM OFF. Set VR1 to mid position.
2. Switch power OFF then ON, and install JP5 on T (pins nearest EPROM). The modem is now in audio loopback and BERT mode.
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 the Receive clock will drift. Replace JP6 and the clock should pull again.
6. Examine RX Data at TP6. With JP5 on T (pins nearest EPROM) 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.

TNC Digital Loopback

1. Install jumpers JP1-4 on AB (nearest JPROM), JP5 on T (pins nearest EPROM), 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 MYCALL, and you should get the ***CONNECTED to MYCALL 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 MYCALL VIA MYCALL MYCALL, MYCALL, etc. When you have finished, don't forget to remove JP6, and set FULLDUP OFF.

"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), JP5 on D (pins away from EPROM), JP6 ON, JP7 ON, JPROM OFF. Set VR1 to mid position. Trigger the scope from TP0, timebase set to 1 ms/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.

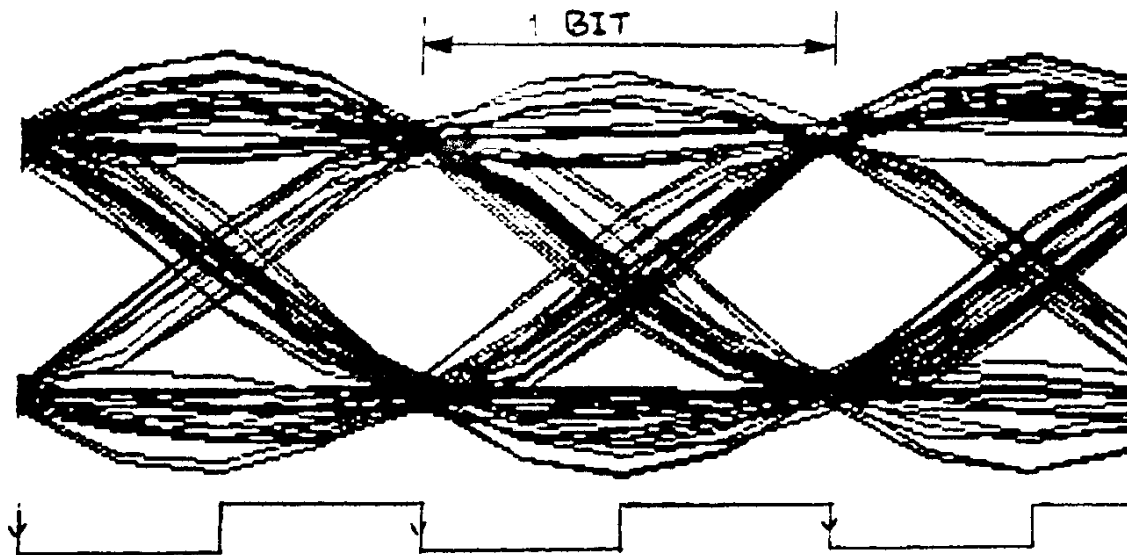
Now gradually speed up the timebase to 20us/div. See how the data bits become superimposed, fusing into a characteristic "eye", the diamond shape in the center of the screen:

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 "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



Typical "eye" Patterns

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 lock. It will add lateral jitter due to the clock recovery process, and give a more valid (and stationary) eye.

JUMPERS and CONNECTORS

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 achieved to suit differing radio channels.

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

OFF(removed)	Transmit Waveform Selection bit x = 1
B	Transmit Waveform Selection bit x = 0
C	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 in 2 banks of 16, selected by jumper JPROM.

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 characteristics operating on 9 data bits (JP1 = BC) and so on, up to one characteristic spanning 12 data bits (JP1, 2, 3, 4 = BC).

Non-standard or customized EPROMs are supplied with linking information on their data sheet.

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 T is the position closest to the nearby EPROM, while position D is that position closest to the JP5 label and the edge of the circuit board.

BERT = Bit Error Rate Testing. In BERT mode, the transmitter generates 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 board edge).

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.

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 the 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 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 sampled on the low going edge of Receive Clock (TP8). The desired trace has symmetry, 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).

Connectors

P5 - Power Supply / Radio Interface

P5	Function	Marking
1	Ground	GND
2	Five volt dc input	+5
3	Twelve volt dc input	+12
4	Transmit Audio (TA) output	TA
5	Receive Audio (RA) input	RA

Note that the power and ground signals are duplicated on S1 pins numbered greater than 20 for use with the PacComm controllers having the expanded modem disconnect header (TNC-320 and PC-320).

S1/S1A - Digital Signals To TNC

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 connectors have 26 positions for compatibility with recent PacComm models with a modem disconnect header of that size.

Hold the MC-NB96 card over the modem disconnect header of the TNC to which it will be married. Try aligning S1 and then S1A with the modem disconnect header to determine which provides the best positioning of the card. Carefully solder the connector in the selected location. When using 20 pin header, use care to match pin 1 of S1 or S1A to pin 1 of the TNC connector.

S1 and S1A connect 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 than 5.25 volts. A TTL low, or "0", is less than 0.8 volts, but

Troubleshooting And Test

greater than -0.4 volts. DO NOT connect anything other than a TTL device (or appropriate test equipment) to S1 or S1A.

Signal Definitions, Connectors S1 and S1A

S1	Signal	S1	Signal
1	DCD output of MC-NB96	2	DCD input from TNC - Switched
3	Tied to 4	4	RFDCD from TNC-Tied to pin 3
5	PTT from TNC -Tied to pin 6	6	Tied to pin 5
7	n/c	8	n/c
9	n/c	10	n/c
11	Tied to 12	12	TNC 16x TX Clock-Tied to pin 11
13	RX Clock output of MC-NB96	14	RX Clock from TNC - Switched
15	Signal Gnd-Tied to 16	16	Tied to 15
17	RX Data output of MC-NB96	18	RX Data from TNC - Switched
19	TX Data from TNC-Tied to 20	20	Tied to 19
21	TX Audio from TNC- Switched	22	TX Audio output of MC-NB96
23	+5vdc input	24	RX Audio input to MC-NB96
25	Power Gnd	26	+ 12 vdc input

Pin 1, DCD

Data Carrier Detect from the MC-NB96 to the TNC. It goes LOW when the modem recognizes that the received audio is a valid data stream.

Pin 2, TNC Modem DCD

The DCD signal from the TNC's on-board modem. This signal is switched to Pin 1 when the MC-NB96 is disabled by JPS.

Pin 12, Transmit Clock

A signal from the TNC, which provides transmit timing for the MC-NB96. Its speed must be 16 times the data rate (153.6 kHz for 9600 bauds). Connected to pin 11 to insure it is available to the TNC's on-board modem when the MC-NB96 is disabled by JPS.

Pin 13, Receive Clock

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

Pin 14, TNC Receive Clock Output

The Received Clock signal from the TNC's on board modem. This signal is switched to Pin 13 when the MC-NB96 is disabled by JPS.

Pins 15 / 16 Signal Grounds

Common connection for the digital signals.

Pin 17, Receive Data

A signal to the TNC; the received data as decoded by the MC-NB96 modem.

Pin 18, TNC RX Data

A signal from the TNC's on board modem. This signal is switched to pin 17 when the MC-NB96 is disabled by JPS.

Pin 19, TNC TX Data

The data from the TNC to be transmitted. It is read by the MC-NB96 modem on a high going edge of transmit Clock.

Pin 20, TNC TX Data Input

Tied to pin 19 to allow TNC transmit data to reach TNC's on-board modem for transmission when MC-NB96 is disabled by JPS.

Pin 21, TNC TX Audio Input

A connection to the TNC's on board modem to allow TX audio from the MC-NB96 to be output to the radio if P5, Pin 4 is not used.

Pin 22, TX Audio Output

The transmit audio output generated by the MC-NB96 or the switched input from Pin 21 when when the MC-NB96 is disabled by JPS.

Pin 23, Vcc Input

The +5 vdc input to the MC-NB96. An alternate input to P5, Pin 2.

Pin 24, RX Audio Input

Source of audio input to MC-NB96. An alternate input to P5, Pin 5.

Pin 25, Power Ground

Power ground for the MC-NB96. An alternate to P5, Pin 1.

Pin 26, Vdd Input

The +12 vdc input to the MC-NB96. An alternate input to P5, Pin 3.

Radio Connections

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

Transmit Audio (TA), P5 Pin 4

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 5

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

Power Connections

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

Vcc (+5 vdc), P5 Pin 2

+ 5 vdc input to the MC-NB96. An alternate input to S1, Pin 23.

Vdd (+12 vdc), P5 Pin 3

+ 12 vdc input to the MC-NB96. An alternate input to S1, Pin 26.

Power Ground, P5 Pin 1

Common for Vcc and Vdd. An alternative to S1, Pin 25.

Appendix A, Packet Controller Interfacing

TINY-2 / MICROPOWER-2 Rev. 1.5, 1.6 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 if not already present.

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 the 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. Cut the 26 pin dual row connector down to 20 pins with a sharp knife. Insert the 20 pin connector into the MC-NB96 board at the S1 (not S1A) position. Be sure to install it beginning at the pin 1 position (marked by a square pin marking on the silkscreen.) Carefully solder all 20 pins.

5. Plug in the MC-NB96 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 (J5) attached to P5 on the MC-NB96 modem board as follows:

- a. P5 pin 5 to radio discriminator (RA).
- b. P5 pin 4 to radio varactor (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).

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.)

Appendix A, Packet Controller Interfacing Power Connections

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. Cut the black connector off the wire coming from "ACLK" on the MC-NB96 board. Strip 1/8" of the insulation from the end of his wire and solder this to U7 (74HC4060) pin 5 on the MICROPOWER-2 board. Make sure there are no solder bridges to any other pins.

4. Cut the 26 pin dual row connector down to 20 pins with a sharp knife. Insert the 20 pin connector into the MC-NB96 board at the S1 (not S1A) position. Be sure to install it beginning at the pin 1 position (marked by a square pin marking on the silkscreen.) Carefully solder all 20 pins.

5. Plug in the MC-NB96 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 (J5) attached to P5 on the MC-NB96 modem board as follows:

- a. P5 pin 5 to radio discriminator (RA).
- b. P5 pin 4 to radio varactor (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).

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.

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. Locate the wire from the MC-NB96 modem board which has a jumper plug 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.

4. Cut the 26 pin dual row connector down to 20 pins with a sharp knife. Insert the 20 pin connector into the MC-NB96 board at the S1 (not S1A) position. Be sure to install it beginning at the pin 1 position (marked by a square pin marking on the silkscreen.) Carefully solder all 20 pins.

6. Plug in the MC-96 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 (J5) attached to P5 on the MC-NB96 modem board as follows:

- a. P5 pin 5 to radio discriminator (RA).
- b. P5 pin 4 to radio varactor (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)

NOTE: MFJ manufactures a G3RUH type of modem which is designed to fit their packet controllers.

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. 13 to 14 RXCLOCK
- c. 17 to 18 RXDATA

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

3. Cut the 26 pin dual row connector down to 20 pins with a sharp knife. Insert the 20 pin connector into the MC-NB96 board at the S1 (not S1A) position. Be sure to install it beginning at the pin 1 position (marked by a square pin marking on the silkscreen.) Carefully solder all 20 pins.

4. 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 MC-NB96 card from these components with tape.

5. Attach wires coming from the plug (J5) attached to P5 on the MC-NB96 modem board as follows:

- a. P5 pin 5 to radio discriminator (RA).
- b. P5 pin 4 to radio varactor (TA).

Appendix A, Packet Controller Interfacing

- 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]

The PacComm TNC-320

1. Place a piece of electrical tape on top of the TNC-320 lithium battery to insulate it from the bottom of the MC-NB96 board.
2. On the solder side of the TNC-320 board at J5 (26 pin header), cut the traces between pins 1 & 2, 13 & 14, and 17 & 18, 19 & 20.
3. Remove the black shorting jumper from the header at JPD2 on the TNC-320.
4. Solder a wire to a push on terminal and attach the terminal to the pin of JPS on MC-NB96 board which is closest to the "corner" of the circuit board.
5. Solder the other end of this wire to the 8530 (U4) pin 16.
6. Attach the wire from the MC-NB96 (from U10, LM339 pin 13), to the center pin of JPD2 on the TNC-320 board.
7. Use the BAud command to change to radio baud rate of port 2 to 9600.

NOTE: Step 4 restores the normal operation of PORT 1. Steps 3, 4 and 5 are required to restore the proper operation of the PORT 2 DCD LED on the front panel.

8. When the TNC-320 modem disconnect is used to access an auxiliary modem, use of both port 1 and port 2 lost. Use JPS to disable the MC-NB96 and regain use of the on-board modems.

The PacComm PC-320

There are two errors in the layout of the PC-320 rev 1.3 circuit board modem disconnect header which must be corrected to use an external modem attached to the modem disconnect header. These modifications are made during production but a number of early production units did not receive the modification.

1. The received data (RXD) output of the on board modems (via the 4053 switch) is incorrectly routed to pin 17 of the modem disconnect header (J5). This causes no problems during operation with the on-board modems, but when the bridging trace between J5 pins 17 and 18 is cut, the on board modems remain connected to the 8530 input in parallel with the RXD output of the accessory modem.

To correct the problem, cut the trace on the component side of the PC-320 board which runs between U19 pins 4 and 5. (This

disconnects U19 pin 14 from J5 pin 17.) Connect a wire from U19 pin 14 (the modem RXD signal) to J5 pin 18.

2. The CTS signal at J5 pin 10 is grounded. This causes no problems when using the on-board modems, but causes the PTT LED to be continuously on when using an accessory modem on J5. To correct the problem, cut the trace on the solder side of the board at J5 pin 10 which runs to ground.

Installing the MC-NB96 modem card

1. On the bottom of the PC-320 board at J5 (26 pin header), cut the traces between pins 1 & 2, 13 & 14, and 17 & 18.

2. Solder the 26 pin connector at the S1A position on the MC-NB96 board.

3. Install the MC-NB96 card on the PC-320 by pressing the connector at onto the pins of J5.

4. Use the BAud command to change to radio baud rate of port 2 to to 9600.

5. When the PC-320 modem disconnect is used to access an auxiliary modem, use of both port 1 and port 2 lost. Use JPS to disable the MC-NB96 and regain use of the on-board modems.

The PacComm TNC-220

Applies to all revisions of the TNC-220 and MC-NB96

There are several extra steps needed when installing the MC-NB96 to a TNC-220. Refer to the TNC-220 manual and schematic regarding the modem disconnect header. Be sure to check your schematic carefully as there are several revisions of the TNC-220. Use caution, some models have a second path in parallel with the receive data trace!

1. The TNC-220 does not have a x16 clock at pin 11/12 of the modem disconnect header. Obtain the clock signal from U11 pin 13 and route to J5 pin 11. Run the jumper wire on the solder side of the board.

2. Cut traces between pins 1-2 and 3-4 of J5. These bridging traces are on the component side of the board.

3. Install the 20 pin header at J5 and solder in place.

Construct a short ribbon cable or harness of individual wires to allow the modem card to be turned 90 degrees with respect to the modem header for cabinet clearance. It is acceptable to solder the wires directly to the MC-NB96 S1 or S1A locations.

The PacComm DR-200

Refer to the DR-200 manual and schematic regarding the modem disconnect header.

1. Remove the 7910 modem IC (U16) which will no longer be used. This makes it unnecessary to cut any traces on J1.

There is not sufficient clearance to install the MC-NB96 directly onto the DR-200 modem disconnect header. Instead, make a short wire harness to connect the needed signals and mount the MC-NB96 card as needed for cabinet clearance.

1. The 8530 SCC on the DR-100 and DR-200 requires a x1 clock for TXC and a x32 clock for RXC. The DR-200 clock signal at pin 11/12 of the modem disconnect header is hard-wired for 1200 bps operation. Obtain the correct clock signal from U12 pin 5 and route to J1 pin 11 or run the jumper wire directly to the MC-NB96.

2. Other signals which must be connected to use the MC-NB96 on the disconnect port): Power (+5, +12), Ground -> J1 Pin 15, Tx data -> J1 Pin 19, DCD -> J1 Pin 1, RX data -> J1 Pin 3, PTT -> J1 Pin 5.

The PacComm DR-100

Refer to the DR-100 manual and schematic regarding the modem disconnect header.

There is not sufficient clearance to install the MC-NB96 directly onto the DR-100 modem disconnect header. Instead, make a short wire harness to connect the needed signals and mount the MC-NB96 card as needed for cabinet clearance.

1. Remove the 7910 modem IC (U16) which will no longer be used. This makes it unnecessary to cut any traces on J1.

2. The DR-100 does not have a x16 clock at pin 11/12 of the modem disconnect header. Obtain the clock signal from U11 pin 12 and route to J1 pin 11 or run the jumper wire directly to the MC-NB96 card.

3. Other signals which must be connected (assuming permanent conversion of DR-100 to use of the MC-NB96: Power (+5, +12), Ground -> J1 Pin 15, Tx data -> J1 Pin 19, DCD -> J1 Pin 1, RX data -> J1 Pin 3, PTT -> J1 Pin 5.

The AEA PK-87, PK-88, PK-232

It is not possible to install the MC-NB96 modem card on these AEA models since the required transmit clock signal is not

provided. The PacComm EM-NB96 has additional circuitry to enable it to operate properly with the AEA equipment.

The Kantronics DE56

NOTE: Kantronics manufactures a G3RUH type of modem which is designed to fit the DE56 cabinet and connectors.

Refer to the article 9600 Baud Operation , Interfacing the Kantronics DataEngine and DVR2-2 Transceiver with the G3RUH External Modem by Phil Anderson and Karl Medcalf. Pages 1-5, Proceedings of the 9th ARRL/CRRL 9th Computer Networking Conference. Available from ARRL, Newington, CT 06111.

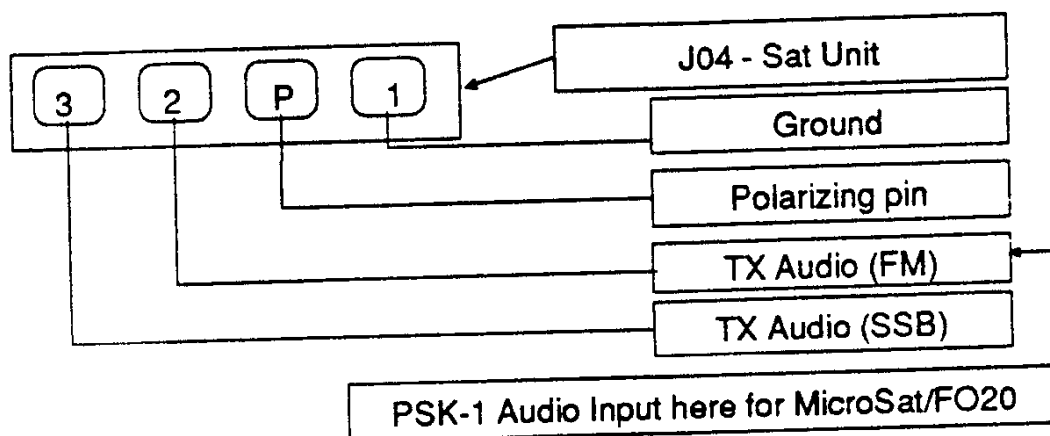
Appendix B, Radio Interfacing

Perfect Modulation with the FT726R

by James Miller G3RUH

Inject your modem TX audio directly to the transmitter varactor in the SAT unit via J04 pin 2.

1. Remove the main lid; remove the SAT unit lid.
2. Locate J04 which is a 3 wire connector in the front left-hand corner
3. Unplug J04, and inject your audio on pin 2, ground on pin 1, using a screened cable.



FT-726 Connections

FT736 & 9600 Baud Operation

by James Miller G3RUH

These notes tell you where to get FM RX audio direct from the discriminator, and where to modulate the FM TX varactor directly. These mods are non-destructive and take no more than a few minutes. The signal bypass the "DATA SOCKET" for high grade FM operations. The RX mod is suitable for:

- UOSAT-D 9600 baud downlink and terrestrial links
- 1200 baud AFSK/FM Standard Packet - BUT IT'S UNSQUELCHED.

The TX mod is suitable for:

- FO-20/PACSAT uplink (1200 bps Manchester FM)
- UOSAT-D 9600 baud uplink direct FSK and terrestrial links
- 1200 baud AFSK/FM Standard Packet.

FT736 - FM Direct from Discriminator

Detected FM direct from the receiver discriminator is available from the RX UNIT at the junction of R91 and C83. These components are shown in the top right-hand corner of the schematic. Proceed thus:

1. Disconnect FT736 from the mains electricity. (Safety).
2. Remove top cover only.
3. RX Unit is the vertical module on the left.
4. Locate R91 which is about 25mm from the top, 50mm from the radio rear. The resistor is "on-end", and near a couple of glass diodes.
5. Scrape any paint off R91's free end and wet with solder.
6. Your RX audio lead should be a fine screened cable; connect the inner to R91, and the outer braid to a ground point (e.g. can of TO09)
7. Route the cable out though any convenient aperture in the case.
8. The discriminator sensitivity (FM Normal) is about 6 kHz/volt.

Important note on 9600 Baud Use

Some FT736 receivers are fitted with an LFH12-S IF filter for FM. (CF01 at the top front of the RX Unit). This is a 12 kHz bandwidth filter which is a little too narrow for 9600 bps FSK operation. It is recommended you change this to 15 kHz or better still for UOSAT-D use, 20 kHz bandwidth which will allow more tolerance for doppler shift, and give a far better "eye". Suitable filters are: LFH-15S or CFW455E, and LFH-20S or CFW455D.

The first of these is a Yaesu spare part, and is often already fitted.

FT736 DIRECT VARACTOR FM MODULATION

Refer to the circuit diagram; inject your TX audio at the junction of R32/C29 on the TX Unit. The signal level at this point should be 800 mV peak-peak, and will give +/- 3 kHz deviation. **DO NOT EXCEED THIS LEVEL.**

Set Mic Gain to min.

Modulating the FM transmitter this way you get an LF response down to 18 Hz (at which point the associated synthesiser PLL begins to track the modulation), and an HF response which is flat to some 10 kHz.

Appendix B, Radio Interfacing

Proceed thus:

1. Disconnect FT736 from the mains electricity. (Safety).
2. Remove top cover only.
3. TX Unit is the module flat on the left (not the one tucked down the side vertically).
4. R32 is just to the left of the rectangular shielded enclosure. The resistor is "on end". Scrape any paint off the free leg.
5. Your TXaudio lead should be a fine screened cable; connect the inner to R32, and the outer braid to the adjacent enclosure.
6. Route the cable out though any convenient aperture in the case.
7. 9600 BAUD FSK MODEM: Adjust TXAudio level with VR1

Other Radios

John Branegan GB7MAC of Scotland reports in the September 1990 issue of the AMSAT Journal various connections of popular radios and 9600 baud modems. You must run a wire (preferably shielded coax) from the FM Discriminator to the input of the modem. The location for this wire is as follows for the following radios:

FRG 9600 UHF Rx: A shielded coax from pin 9 of IC MC3357 FM discriminator on N. FM unit F268201 (accessory board near middle of Main Board), to Record socket at back of receiver, replacing existing R53 feed.

Kenwood R2000: A shielded coax is connected from the FM discriminator on the IF unit at the common point of R207, R209, R210, C200, and C202 to a spare position on the Receiver (Rx) back plate.

Icom 451 UHF Transceiver: For 9600 bps reception wire a shielded coax from pin 9 of IC7 MC3357, to one of the spare terminals at the rear of the transceiver.

Icom R7000: A shielded coax comes from the FM discriminator on the IF unit at the common point of R97 and R96, to a spare position on the rear back plate of Rx.

Yeasu FT221R 2m Transceiver: Used for 2m reception tests of uplink to UoSAT-Oscar 14 by taking Rx audio out from card PB-1463 (FM IF) connection 2, via a shielded coax to one of the relay sockets on the back panel after first disconnecting the original output.

Appendix C, MC-NB96 Alternate Data Rates

The NB-96 modem design is not sensitive to the data speed. The only changes that need to be made are time constants in the audio filters and the time constant in the Lock Detect Filter.

	4800 Baud	9600 Baud	19200 Baud
C26	470pf	220pf	100pf
C27	.0022uf	.001uf	470pf
C28	.0022uf	.001uf	470pf
C29	.0068uf	.0033uf	.001uf
C30	.001uf	470pf	220pf
R*	220k	100k	51k

R* is RS2 on the MC-NB96 modem card, a SIP resistor pack. You can either cut the traces to that section of the SIP or leave the value unchanged.

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