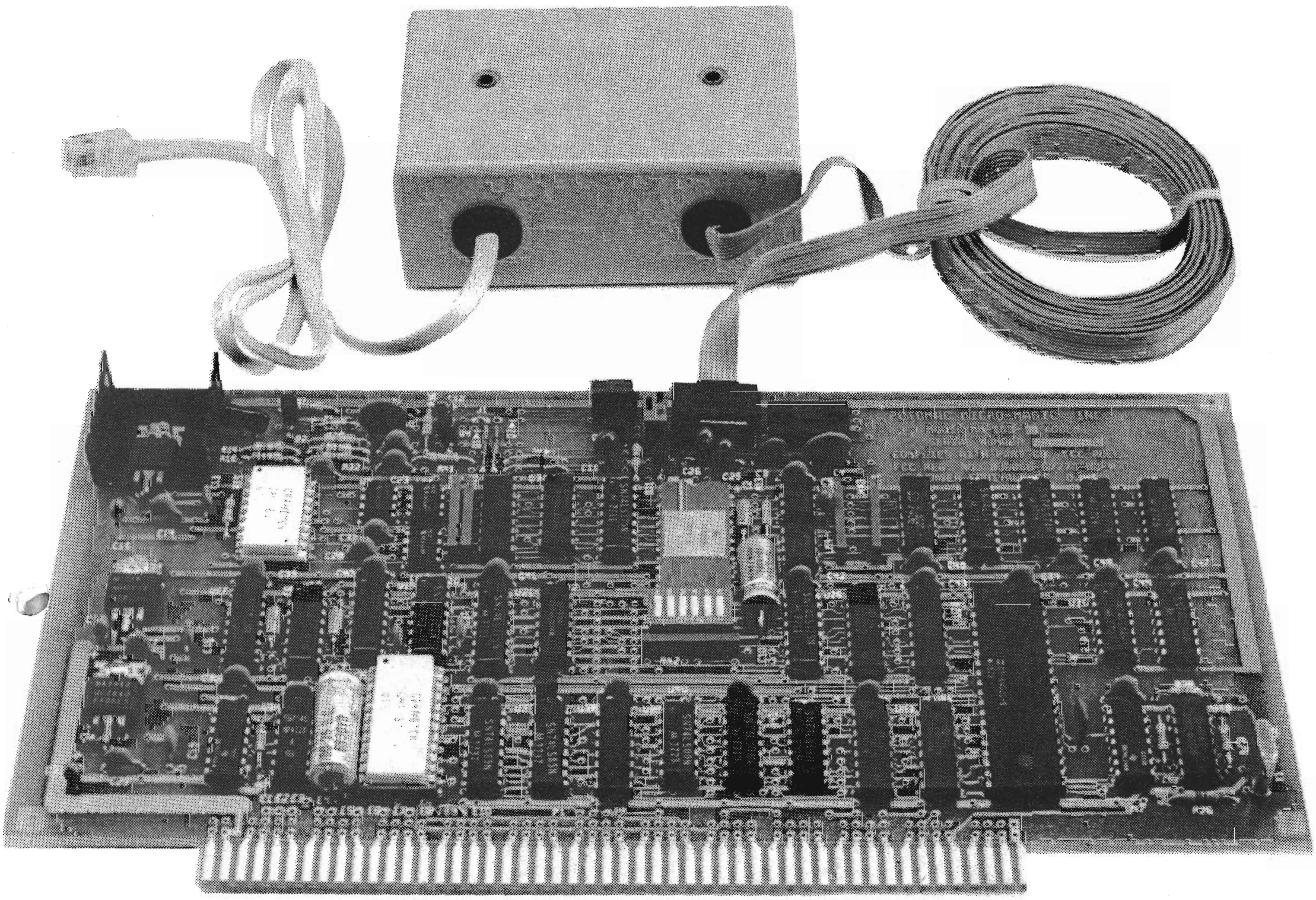
MM-103 MODEM
and Communications Adapter

OWNER'S MANUAL

MM-103 MODEM AND PROTECTIVE COUPLER

The Protective Coupler is attached to the top of the MM-103 MODEM at P2. The cable runs up from the board.



COMMUNICATIONS
[POTOMAC MICRO-MAGIC, INC.]

Instructions for Return of Modem for Repair

Should it ever be determined, either through use of the diagnostic software provided by PMMI or through some other means, that your modem-protective device has malfunctioned, both the PC board and the protective device **must** be returned to PMMI for repair, either directly or through the distributor from whom the unit was pruchased.

Under the FCC direct connect program, no user is authorized to repair this equipment. This applies, whether the equipment is in or out of warranty. If any unauthorized repair is attempted, the FCC registration of the equipment immediately becomes null and void. In addition, unauthorized repair immediately nulifies the warranty.

It is the responsibility of the user to insure that unauthorized repairs are not attempted. If the user believes the equipment needs repair, he must contact Potomac Micro-Magic, Inc., for instructions for return of the equipment. If the Modem-protective device is in warranty, repair will be at no cost to the user. If the equipment is out of warranty, repair will be accomplished for a fixed fee.

Instructions to the user

This combination modem and protective device has been approved by the Federal Communications Commission for direct connection to the public switched telephone network through standard plugs and jacks prescribed by Part 68 of the FCC rules and regulations. No connection can be made to party line or coin operated telephones. Before connecting the modem to the telephone line, you must do the following:

1. Call your local telephone office and inform them that you wish to connect an FCC registered device to your telephone line. Provide them with the FCC registration and ringer equivalence numbers which are on the label on the outside of the protective coupler unit.
2. Inform the telephone company that the jack required for your equipment is an RJ11C for a single line −9 dBm unit.
3. When the telephone company has installed the jack required by your modem, the equipment is connected by inserting the PC board in your computer, connecting the flat cable connector on the protective device to the PC board, and inserting the protective device mating plug into the jack provided by the phone company.
4. Operating and service instructions are included with the MM-103 Modem-Protective Device.

Should it ever appear that your modem is malfunctioninng, it **must** immediately be disconnected from the phone line. The modem must remain disconnected until the source of the problem can be determined and either the modem or the phone line repaired. If you modem needs repair, it must be returned to PMMI.

Should the telephone company determine that your modem is causing harm to the telephone network, they may temporarily discontinue your service. In such a case, they are required by the FCC to promptly notify you and give you the opportunity to correct the problem. You have the right to bring a complaint to the FCC in accordance with the procedures set forth in Subpart E of Part 68 of the FCC rules and regulations.

Should the telephone company find it necessary to make changes in its communications facilities, equipment, operations, or procedures that can reasonably be expected to make your modem incompatible with the telephone network, they must notify you in writing sufficiently in advance of implementing the change so that you have the opportunity to maintain uninterrupted service.

If your modem is permanently disconnected from the telephone network, the telephone company **must** be notified.

One Year Limited Warranty

Potomac Micro-Magic, Inc. warrants to the original purchaser only the material and workmanship of this MM-103 Data Modem and Communications Adapter for one year after delivery to the original pruchaser.

Potomac Micro-Magic, Inc. or its authorized service centers will repair or replace and return to the original purchaser, without charge, the equipment which shall fail due to defective material or workmanship within said prescribed period, provided and on condition that:

1. The warranty card has been properly completed and returned to Potomac Micro-Magic, Inc., Alexandria, Virginia; and
2. The MM-103 and Data Coupler are promptly delivered, with all handling and freight charges prepaid, to a PMMI, Inc. authorized service center. Call (703) 379-9660, or write to the company as follows:

PMMI COMMUNICATIONS
Three/Skyline Place
5201 Leesburg Pike
Falls Church, VA 22041

3. The seal on the Data Coupler has not been broken.

This supercedes any written or implied warranty.

Effective Date — March 1, 1979

WARNING: The MM-103 **alone** must not be relied upon for total data integrity, in particular when used in critical applications such as life support systems and industrial control applications. The user must incorporate other recognized means of detecting data failure if absolute data integrity is required.

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SPECIAL NOTES

Installation

Do not install or remove board with power on.

The coupler ribbon cable is attached to the circuit board at P2 which is marked coupler. The cable runs up and away from the top of the board--see photograph inside front cover.

Setting the address switch is described on page 4. The switch represents the 6 high order bits of the address. "Open" represents one bit, therefore, address C0 HEX is open-open-closed-closed-closed-closed, or 1100 00 xx binary. Most of the software provided with the MM-103 is addressed at C0. Some systems may already use this address for another purpose. For example, The North Star DOS system uses C0 for memory protect control, therefore, PMMI North Star software has been readdressed to E0.

1.0 INTRODUCTION

1.1 WHAT IS A MODEM?

The term MODEM is a contraction of MOdulator-DEModulator. Therefore, to understand what a MODEM is and why it is required, we must consider modulators and demodulators.

Information (signals) of all types comes in two basic forms: analog and digital. Analog signals can assume any value between some upper and lower limit. Digital signals, on the other hand, are restricted to assuming only a relatively small number of specified states (levels). The example of digital information with which we are all most familiar is the binary information contained in a computer. Binary information is restricted to two states or levels: one/zero, on/off or mark/space. A telephone signal is a familiar example of analog information. Since telephone end-instruments generate and accept analog information, it is reasonable that the telephone transmission system is designed to handle analog signals. Since computers represent one of the largest existing information sources, and the public switched telephone network is an extensive, economical, easily accessible means of information transmission, it is reasonable to expect that a need would arise to transmit computer (digital) information through the telephone (analog) network. This need for an interface between digital and analog systems is where the MODEM requirement comes in.

Modulation is the process whereby the form of a signal is changed so that it may be more efficiently transmitted through the available transmission medium. Demodulation is simply the inverse of modulation—changing the signal back to its original form.

There are many types of modulation. However, in the process of converting computer information into a form suitable for transmission over the telephone network, we are interested in the modulation class called "continuous-wave." In continuous-wave modulation, the basic information carrier is a sine wave. The amplitude, phase or frequency of the sine wave is altered in a pattern corresponding to the "ones" and "zeros" to be transmitted. In the MM-103 MODEM, it is the frequency of the sine wave that is altered, and the modulation process is called frequency shift keying, or FSK.

In an FSK MODEM the modulation process is extremely simple: binary "ones" (marks) are transmitted as one sine wave frequency, and binary "zeros" (spaces) are transmitted as a different frequency. At the receive end, the two "tones" are convered back into binary "ones" and "zeros."

A MODEM uses two frequencies (tones) to transmit information in one direction. If information is to be simultaneously transmitted in both directions, two different tones must be used. Thus, some means must be provided to keep the two sets of tones separate in the modem, but combined on the telephone line. This is accomplished with filters and a device called a duplexer. The block diagram in **Figure 1.1-1** shows all the basic elements of a simple MODEM, including the filters and duplexer.

As shown by the block diagram, within the MODEM the transmit and receive data are kept separate by the filters, but the duplexer allows both sets of signals to exist together on the telephone line.

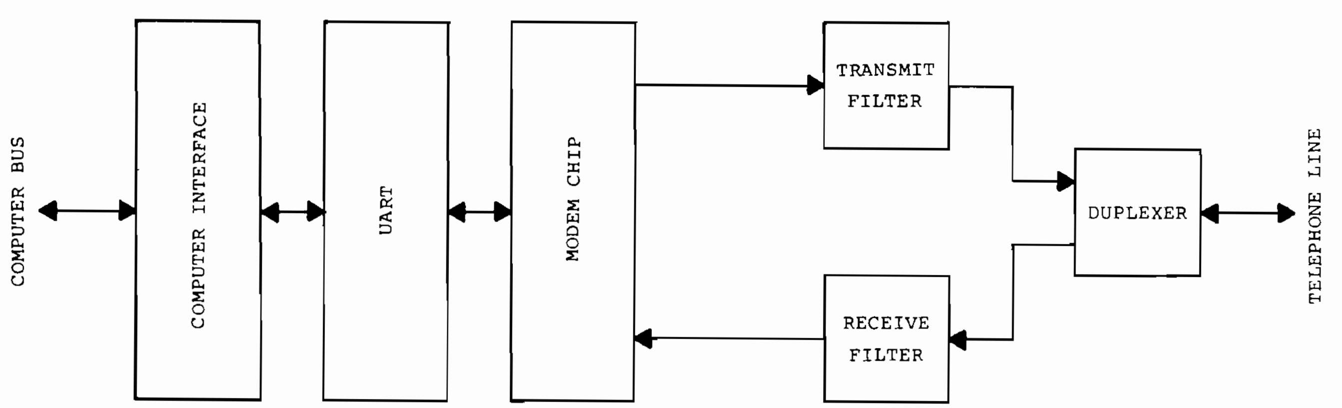


FIGURE 1.1-1 MODEM BLOCK DIAGRAM

1.2 MODEM PERFORMANCE

The performance of low-speed MODEMs such as the MM-103 is primarily determined by the filters and the duplexer. The transmit filter shown in the block diagram may or may not be required, depending on the type of analog (tone) signal generated by the modulator. Most modern FSK MODEMS utilize all-digital circuitry in the modulator and demodulator sections. A digital modulator (such as the Motorola MC6860 used in the MM-103) uses a digital-to-analog converter to generate the two-tone, sine wave output. The output signal from such devices is not a smooth sine wave, but contains steps.

In addition to the desired fundamental sine wave frequency, such signals contain many undesirable harmonic frequencies. The transmit filter removes the undesirable harmonics and thereby converts the stepped signal into a smooth sine wave. The removal of harmonics from the transmitted signal is an important requirement associated with FCC registration, as discussed in Section 4, herein.

The receive filter is the most important element in determining how a given MODEM will perform. The receive filter accomplishes three major functions:

1. Keeps the transmitted signal from feeding back into the demodulator circuitry.
2. Minimizes the telephone line noise that is allowed to reach the demodulator circuitry.
3. Minimizes intersymbol interference between the two tones of the received signal.

As shown by the dotted lines in the block diagram, some portion of the transmitted signal appears at the input to the receive filter. The portion of this signal that is allowed to reach the input of the demodulator is determined by the characteristics of both filters and the duplexer. In a good MODEM, the transmit signal that is allowed to reach the input to the demodulator is 50 to 60 dB below the level of the transmitted signal.

The receive filter minimizes the amount of telephone line noise that is allowed to reach the input to the demodulator. The full bandwidth of a telephone circuit is on the order of 3,000 Hertz. The bandwidth of the receive filter is approximately 500 Hertz. Therefore, assuming that the telephone line noise is evely distributed over its total bandwidth, the receive filter reduces the noise by a factor of six. Actually, the real situation is probably slightly better than this, since telephone line noise tends to be greater at low frequencies which are almost totally rejected by the receive filter. The low frequency noise in question is at power line frequencies and harmonics thereof.

The receive filter has two major characteristics that must be considered: amplitude response and phase response. The dicussion above has primarily concentrated on the filter's amplitude response. However, phase response is of equal importance.

The phase response of a filter has to do with the amount by which different frequencies are delayed (phase shifted) in passing through the filter. Ideally, all frequencies passed by the filter would be delayed by exactly the same amount. However, this type of performance can not be attained in practice. In particular, the phase shift is rather severe for frequencies near the filter skirts (band edges). For this reason, even though the "mark" and "space" tones are separated by only 200 Hertz, the receive filter is considerably wider to minimize phase shift between the two tones.

The function of the duplexer is to separate the transmit and receive signals on the MODEM side, and combine them on the telephone line side. The dotted lines in the block diagram imply this characteristic. The degree to which the duplexer is able to accomplish its intended function depends upon the impedances associated with the MODEM and the telephone line. If all the impedances were constant, a practically perfect duplexer could be built. However, whereas the MODEM input and output impedances are relatively constant, telephone line impedance (nominally 900 ohms) varies from one line to another. Therefore, each time a number is dialed, the line impedance varies somewhat. When these factors are considered, a real duplexer operating over real telephone lines can be expected to reliably separate the transmit and receive signals by a minimum of 10 dB.

When everything is considered, the performance capability of a MODEM can ultimately be stated in terms of three parameters: minimum received signal level, dynamic range, and signal-to-noise ratio for some specified error rate. The values that these three parameters must have to characterize a "good" MODEM are primarily determined by the characteristics of the telephone systems. That is, what is the maximum and the minimum loss that will be encountered (determines required minimum received signal level and dynamic range), and what are the telephone system noise characteristics?

In the majority of cases, the local loop loss (loss from the user's location to his local telephone office) will be in the approximate range of 2 to 12 dB. On a long distance call, a maximum of approximately 12 to 15 dB additional loss may be encountered. Therefore, in the majority of cases, the total telephone system loss will be between 4 and 40 dB, with 40 dB being extremely rare. In more than 90 percent of the cases, the total loss will be less than 30 dB.

Since the MM-103 transmit signal level is −9 dBm, in the majority of cases, the received signal level (assuming the same type of MODEM is on the send end) will be greater than −40 dBm. Since we can expect received signals in the range of −40 dBm, a "good" MODEM should operate down to at least this level. In order to provide a reasonable margin, a MODEM should operate somewhat below the expected receive signal level, and

−50 dBm is a reasonable threshold value. This value is also reasonable when considered from the telephone line noise standpoint, as discussed below.

An FSK MODEM such as the MM-103 needs a signal-to-noise ratio of approximately 12 to 15 dB for satisfactory performance (one error in 100,000 bits). On local telephone calls, the noise level is relatively low and the received signal level is very high. Under such circumstances, practically any MODEM (even relatively poor designs) will perform satisfactorily. However, on long distance calls, noise levels in the range of −50 dBm are not uncommon. Therefore, the −40 dBm received signal level discussed above will produce very satisfactory performance, since the receive filter produces a 3 to 6 dB improvement by filtering out a portion of the total line noise. A MODEM threshold level of −50 dBm is also consistent with expected noise levels. For example, if the noise level were −50 dBm and the MODEM threshold were −60 dBm, the threshold detector would not be able to recognize that the signal had disappeared. This would produce a very undesirable situation, since the MODEM would not hang up the phone at the completion of data transmission.

We can now specify the set of characteristics that a "good" MODEM should possess:

1. Minimum received signal level of −50 dBm, with an adjustable threshold level.
2. Dynamic range of at least 40 dB.
3. On the order of one error in 100,000 bits, with a telephone line signal-to-noise ratio of 6 dB.

1.3 TELEPHONE LINE PROBLEMS

The telephone system in the United States is one of the best in the world, and its characteristics, capabilities, and limitations are well understood by data transmission professionals. However, the need for digital data transmission has expanded so drastically in the past few years that MODEMS are presently being used and applied (and even designed and built) by individuals who do not fully understand and appreciate the telephone system or the requirements of a good MODEM design. Particularily in the hobby area, there are a variety of MODEM designs and devices available that are not satisfactory for long distance operation. These devices perform reasonably well over local telephone circuits. However, when the user discovers that satisfactory performance can not be achieved over long distance telephone circuits, the inclination is to blame the telephone system. **The telephone network is rarely at fault.** In more cases than not, the MODEM design is simply inadequate.

1.4 MODEM-COMPUTER COMBINATION

The MM-103 MODEM performs data transmission and telephone line handling functions that in the past could be performed only by a combination of devices costing approximately four times as much. This low-cost, high-performance capability is to a great extent due to the synergistic combination of a MODEM and an S-100 computer. Neither device is capable of performing all the required functions, but in combination they produce a digital data transmission capability that is unexpectedly versatile.

The S-100/MM-103 combination not only handles the telephone line, dials the phone, and transmits/receives the data, it allows almost limitless capability for automation of the data exchange function. This is due to the fact that virtually everything is under software control. Therefore, each system can be tailored to the user's needs.

2.0 TECHNICAL CHARACTERISTICS

1. Modulation .... FSK
2. Frequencies:

	ORIGINATE		ANSWER	
	SPACE	MARK	SPACE	MARK
Transmit	1070 Hz	1270 Hz	2025 Hz	2225 Hz
Receive	2025 Hz	2225 Hz	1070 Hz	1270 Hz

3. Sensitivity .... -50 dBm
4. Dynamic Range .... 50 dB
5. S/N For 10^5 Error Rate .... Approx. 10 dB
6. Baud Rate (software controlled)............ 61 to 600 Baud
7. Modes (software controlled) .... Originate and Answer
8. Frequency/Rate Control .... On-Board Crystal Oscillator — 10.00 MHz
9. Interrupts (maskable) .... 1. T_x Buffer Empty
   2. R_x Buffer Full
   3. Ring "OR" Dial Tone
   4. Baud Rate Generator Output

10. On-Board Dial Tone Detector	Screwdriver Adjustable
11 On-Board Threshold Detector	Screwdriver Adjustable
12. Both MODEM and Telephone Line Coupler are FCC approved as Multifunction Data Equipment (Reg. #BJ686B-67773-MD-R)	
13. On-Board Pulse Dialer	Rate and 60-40 Duty Cycle Under Software Control
14. Interface Provided for Control and Sensing of External Devices	Allows Telephone Ring to Power up the Computer

3.0 THEORY OF OPERATION

3.1 GENERAL

The MM-103 MODEM/Telephone line coupler performs all the functions necessary to provide an S-100 bus computer with a high-quality digital communications capability:

1. Fulfills the interface requirements of the S-100 bus:
   a. Provides tri-state drivers controlled by DATA IN instructions
   b. Provides bus buffers for DATA OUT lines so that the MM-103 represents only one output bus load
   c. Decodes four DATA IN and DATA OUT addresses
   d. Provides circuitry necessary to synchronize data transfers
2. Accomplishes serial-to-parallel and parallel-to-serial data conversions
3. Controls the telephone line switch-hook relay
4. Detects dial tone when originating calls
5. Dials the telephone using dial pulsing (as opposed to touch tone)
6. Detects ring on incoming calls
7. Converts outgoing binary data to "mark" and "space" tones suitable for insertion into the telephone system
8. Converts incoming "mark" and "space" tones to binary data
9. Fulfills Federal Communications Commission (FCC) requirements for *approved* direct connection to the telephone system:
   a. Limits the amount of signal power delivered to the telephone line
   b. Limits the bandwidth of the signal delivered to the telephone system
   c. Accomplishes timing functions (on incoming calls) associated with operation of the telephone company automatic billing equipment
   d. Prevents high voltages (that could damage telephone equipment) from entering the telephone system. This feature also protects the computer from high voltages that may come from the telephone lines as a result of lightning and power line accidents
10. Accomplishes threshold detection and MODEM tone identification. Prevents the MM103 from reacting to line noise and other foreign signals that could otherwise cause an unattended long distance call to fail to terminate properly.
11. Implements computer interrupts on a variety of MODEM conditions

Figure 3.1-1 is a block diagram of the MM-103 MODEM/Telephone line coupler.

3.2 FUNCTIONAL BLOCKS

3.2.1 OUTPUT DATA BUS BUFFERS

The MM-103 MODEM uses 74LS08 "AND" gates for S-100 output data bus buffers. Thus, even though many chips are tied indirectly to the output data bus, the MM-103 represents only one output data bus load.

3.2.2 ADDRESSING

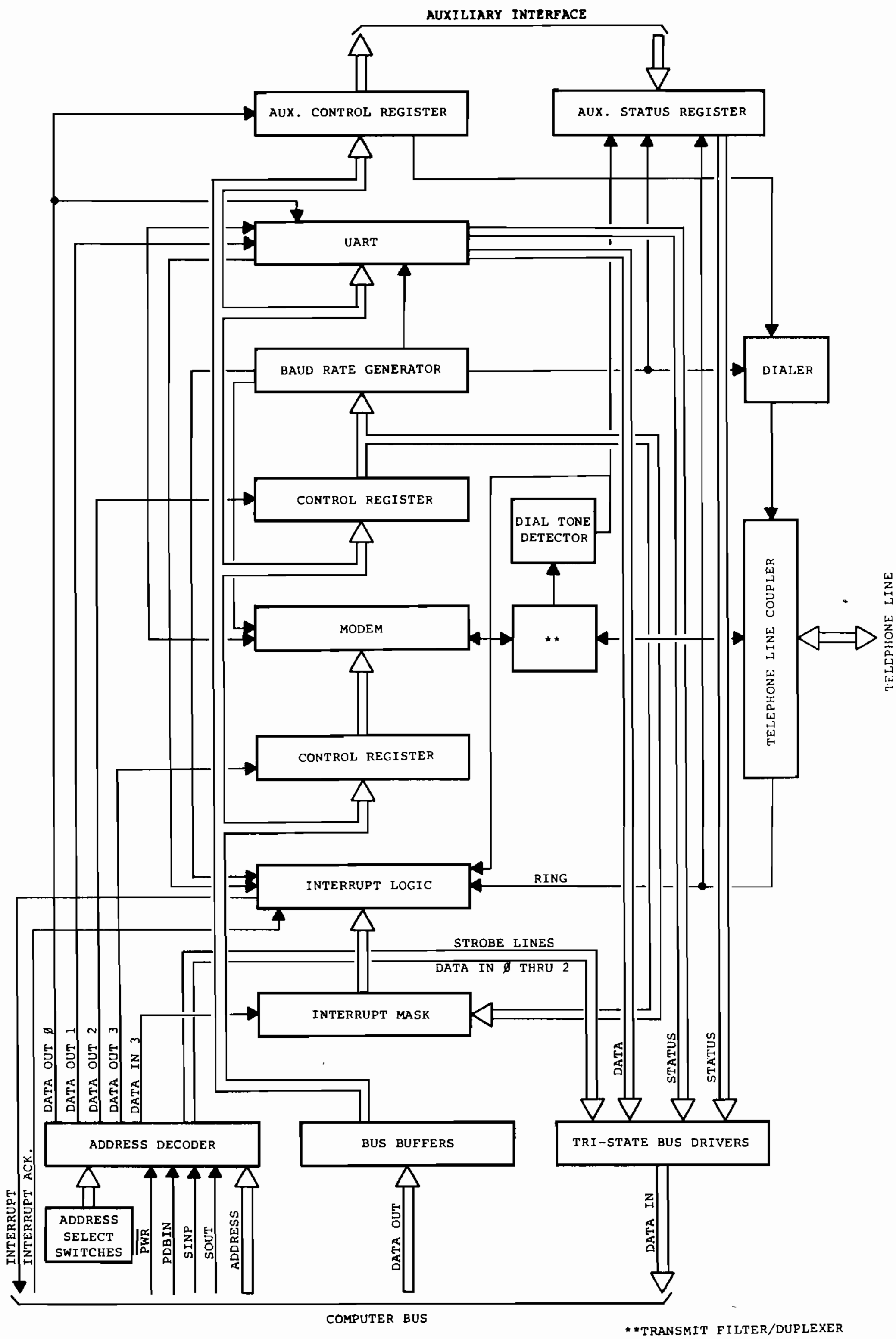
The MM-103 allows the computer to output data to five different destinations and to read data from three sources. This is accomplished using a total of four I/O addresses.

INPUTS (To the Computer)

BA (Base Address)..	UART status and auxiliary inputs
BA + 1	UART data
BA + 2	Auxiliary status (dial tone detect, ring detect, clock signal, and MODEM chip status)
BA + 3	Reading from this address loads the contents of the Baud rate generator control register into the interrupt mask register, which includes four interrupt mask bits & two auxiliary output bits. The input data, all ones, is ignored.

OUTPUTS (From the Computer)

BA (Base Address)...	UART control, MODEM control, dial control and interrupt enable
BA + 1	UART data
BA + 2	Baud rate generator
BA + 3	MODEM control



**TRANSMIT FILTER/DUPLEXER
RECEIVE FILTER
LIMITER/SQUELCH
THRESHOLD DETECTOR
ANSWER/ORIGINATE CONTROL
BILLING DELAY

FIGURE 3.1-1 MM-103 MODEM/TELEPHONE LINE COUPLER BLOCK DIAGRAM

3.2.3 ADDRESS DECODER

MM-103 address decoding is accomplished by a six bit base address decoder in combination with a dual 2-input, 4-output decoder. The six bit base address decoder, compares the upper six address bits (A2 through A7) with the setting of a six position DIP switch. When the comparison is TRUE (BA, BA + 1, BA + 2 and BA + 3), the base address decoder generates a high output. The 2-in, 4-out decoder uses the single output from the base address decoder, the two low order address bits (A0 and A1), and the four S-100 I/O control lines (PDBIN, $\overline{PWR}$, SINP and SOUT) to generate four input and four output address strobe lines synchronized with the S-100 bus I/O operations.

3.2.4 PARALLEL-TO-SERIAL AND SERIAL-TO-PARALLEL CONVERSION

The Universal Asynchronous Receiver/Transmitter (UART) that is part of the MM-103 MODEM accomplishes the parallel-to-serial and serial-to-parallel data conversions necessary to interface the S-100 bus data signals, which are 8-bit parallel, to the MODEM chip, which is serial. The UART accomplishes a variety of other functions associated with asynchronous data transmission/receiption and interfacing with the computer:

1. Allows computer controlled selection of:
   a. Number of data bits in each character
   b. Parity characteristics
   c. Number of STOP bits
2. Provides a status signal indicating when another character can be accepted for transmission
3. Provides a status signal indicating that a character has been received and is ready for transfer to the computer
4. Accepts parallel data from and delivers parallel data to the computer
5. Provides a send/receive serial interface with the MODEM chip

3.2.5 MODEM CHIP

The basic function of the MODEM chip is to accept serial binary transmit data from the UART and generate "mark" and "space" tones for delivery to the telephone system, and accomplish the inverse function in the receive direction. The MODEM chip accomplishes a variety of additional functions such as "break" detection, distant-end MODEM tone identification and self test.

3.2.6 FILTERS AND ASSOCIATED CIRCUITRY

Between the MODEM chip and the telephone coupler, the MM-103 includes a block of analog and digital circuitry that accomplishes a variety of functions:

1. Filters the digitally generated outgoing (transmit) signal to remove all undesirable harmonics
2. Filters the incoming (receive) signal to remove undesirable line noise, remove undesirable line signals, and suppress the transmit signal that is not rejected by the duplexer
3. Accomplishes the duplexer function of separating (by approximately 10 dB) the transmit and receive signal paths
4. Hard limits the receive signal to remove all amplitude disturbances (the MODEM chip responds only to frequency information)
5. Accomplishes the threshold detection function
6. Switches the MODEM chip, transmit filter and receive filter to accomodate the answer and originate modes
7. Accomplishes the billing delay function—when answering an incoming call, the transmit and receive signals are inhibited for two seconds after the phone goes off-hook

3.2.7 TELEPHONE LINE COUPLER

The telephone line coupler is a miniaturized, FCC approved device that fulfills the following FCC requirements:

1. Limits leakage current
2. Limits hazardous voltages introduced into the telephone system
3. Fulfills the longitudinal balance requirements
4. Fulfills the on-hook impedance requirements

As a very beneficial side effect, the coupler protects the computer from hazardous voltages that can result from electrical storms or power line accidents.

In addition to the above functions, the coupler provides the line control relay used for taking the phone off-hook and dialing, and it provides a separate output signal (DC pulses) to indicate ringing.

3.2.8 BAUD RATE GENERATOR

All MM-103 time related functions are controlled by the baud rate generator, and are derived from an on-board 10.00 MHz crystal oscillator. Independently of the S-100 bus timing signals, the Baud rate generator:

1. Furnishes the 1 MHz clock required by the MODEM chip
2. Provides transmit and receive clocks to the UART (the UART clocks are 16 times the Baud rate, e.g., 300 Baud requires a 4,800 Hz clock)
3. Sets the dial rate when dialing
4. Determines the dial pulse 60-40 duty cycle

The Baud rate generator uses a 10.00 MHz crystal, operating in its series resonant mode, in a 7400 gate oscillator circuit. The 10.00 MHz crystal oscillator output signal is divided by 10 to produce the 1 MHz clock required by the MODEM chip. The 1 MHz signal is divided by 2 and introduced into a variable rate divider using 74193s in the down counter mode. The divider can be programmed by the computer to divide by any integral value from 1 to 255, inclusive. The divider output signal is divided by 2 and provided to the UART as the transmit and receive clocks. A further division by 100 produces the timing signal used in accomplishing the dialing function.

3.2.9 DIALER

The MM-103 uses a combination hardware-software dialer that has the advantages of both and the disadvantages of neither. Normally, hardware dialers are accurate, complex, and require little software support. Software dialers, on the other hand, tend to be inaccurate (depending upon how timing is derived), very simple, and require considerable software support.

The MM-103 dialer derives timing from the crystal controlled Baud rate generator and uses software loops to control the number being dialed and the dial pulse 60-40 duty cycle. This makes a very inexpensive, simple, high accuracy dialer that is independent of S-100 bus and software timing.

3.2.10 DIAL TONE DETECTOR

The MM-103 uses active, band pass filtering to detect dial tone. The filter stages are followed by a half-wave rectifier and gain setting stage using a 1458 operational amplifier. The dial tone detector gain is user adjustable so that it may be optimized to local dial tone characteristics. The rectifier/gain stage is followed by an integrator and transistor switch. The transistor switch drives both an interrupt line (combined with ring detect, since the two signals are mutually exclusive) and a status bit that can be read under software control.

3.2.11 RING DETECTOR

The MM-103 uses the ring indication line from the telephone line coupler to accomplish ring detection. The signal provided by the coupler is the half-wave rectified ringing signal. This signal is fed into an on-board integrator and transistor switch. The ring indication drives both an interrupt line (combined with the dial tone detect signal since the two are mutually exclusive) and a status bit that can be read under software control.

3.2.12 INTERRUPTS

The MM-103 MODEM provides a maskable interrupt capability that accomodates five status signals:

1. Transmit buffer empty
2. Receive data available
3. Ring detect "OR" dial tone detect
4. Last output on Baud rate generator divider chain

The interrupt system includes a four-bit mask that is loaded under software control to selectively enable/disable the individual interrupts. The interrupt system does not generate interrupt vector addresses. Therefore, the interrupt routine must read the status register to determine what has occurred.

3.2.13 AUXILIARY INTERFACE

The MM-103 includes the ability to interface with external, auxiliary devices. Using external circuitry, the auxiliary interface can be used to:

1. Power up the computer on a telephone ring or external alarm/status signal
2. Control external devices
3. Switch voice announcement/recording equipment into the telephone line

4.0 FCC REGISTRATION

A few years ago, all equipment connected to the public switched telephone network had to be supplied by the telephone company. This is no longer the case. The Federal Communication Commission (FCC) has ruled that devices not supplied by the telephone companies may be connected to the telephone system, provided that certain requirements are met. Data MODEMs, such as the MM-103, are among the non-telephone-company-provided devices being connected to the telephone system.

For a MODEM connection to the telephone network to be legal in the eyes of the FCC, it must either be accomplished through an FCC approved Data Access Arrangement (DAA - CBT or CBS) or the MODEM itself must be approved by the FCC for direct connection. In either case, certain functions must be accomplished to prevent "harm" to the telephone system:

1. High voltage introduced into the telephone cable must be prevented from reaching the telephone office and damaging expensive equipment.
2. The telephone line must be kept "balanced" so that interference to and from other users is minimized.
3. Timing functions necessary for proper operation of the telephone company billing equipment must be accomplished.
4. High frequency signals must not be allowed to enter the telephone system.
5. The amount of signal power that the user can introduce into the telephone system must be controlled.

There are presently a relatively large number of devices illegally connected to the telephone network. These devices not only violate federal regulations, but in most cases the method of connecting fails to protect the user's equipment (e.g., from high-voltage surges introduced into the telephone cables during electrical storms) and, in the case of data MODEMs, produce poor performance which is generally blamed on the telephone system. However, the truth is, the U.S. public switched telephone network is rarely responsible for poor performance of low-speed data MODEMs. The problem is generally in inadequate MODEM design or poor performance of the telephone system interface (the coupler).

The MM-103 is the first S-100 bus MODEM to be approved by the FCC for direct connection to the public switched telephone network. The registration required an extensive design and testing effort, and submission to the FCC of a lengthy application and test report.

The MM-103 accomplishes all the protective functions required by the FCC. It uses a miniaturized, proprietary protective coupler (to keep any possible high voltages away from your computer) and proprietary, on-board circuitry to accomplish billing delay and level control. The MM-103 removes the need for a DAA and allows you to make a legal direct connection satisfactory to both the FCC and the telephone company. The design of the MM-103 has been accomplished in such a way that not only is the DAA avoided, but the cost of the DAA is also removed.

5.0 ADJUSTMENTS

There are only two adjustments on the MM-103 MODEM: threshold level and dial tone detector gain. The threshold level is factory set at −50 dBm, and should not require adjustment. However, should the user have an unusually poor access line to the telephone central office, it is conceivable, but highly unlikely, that the line noise level could exceed −50 dBm. In such a case, the MODEM could fail to properly terminate an unattended call. Under such circumstances, the threshold level should be raised until it is above the noise level.

To raise the threshold level, the 20-turn threshold adjustment potentiometer (R6 on the upper edge of the board) is turned clockwise when looking down on it from the front of the board. The adjustment should be made in one-half turn increments of the potentiometer. After each adjustment, the MODEM should be called from another phone and checked to see if it hangs up properly. Once the point is found where it just hangs up properly, the threshold should be raised by one additional half turn of the potentiometer, so that a margin for noise variations is provided.

Adjustment of the dial-tone detector gain is discussed in the software section of this manual.

6.0 AUXILIARY INTERFACE

The MM-103 includes an auxiliary interface, accessiblle through a 14-pin DIP connector on the top edge of the board, that can be used to accomplish a variety of functions and to interface with different types of external equipment. For example:

1. Computer system power-up on telephone ring or external input.
2. Voice recorder-announcement equipment
3. Alarm recognition and automatic dial equipment

The external interface provides for the following connections into the MODEM board:

1. 1 each TTL output
2. 2 each buffered outputs (using open collector inverting drivers)
3. 2 each inputs that can be sensed by the computer
4. Telephone line connection (tip and ring)
5. "Ringing" signal from the telephone line coupler
6. A line that allows the telephone line coupler to be powered from an external device when the computer is not powered up

All the inputs and outputs are under software control. **Figure 6.0-1** is the schematic of the MODEM board portion of the auxiliary interface. **Figure 6.0-2** is a suggested schematic for a useful external interface adapter (not presently available from PMMI).

7.0 SOFTWARE

7.1 PROGRAMMING REQUIREMENTS

This section describes the programming requirements for the MM-103 MODEM and data communications adapter. The first part describes the programming specifications, giving the details at each register and data bit within the register. The second part describes actual applications programs with examples of test and diagnostic programs which allow for interactive data communications.

The software described herein is also available on floppy disks. The disk version will have additional programs not listed here because of their size and because they are designed for specific operating systems such as CPM. The current ordering literature will describe the disk software versions.

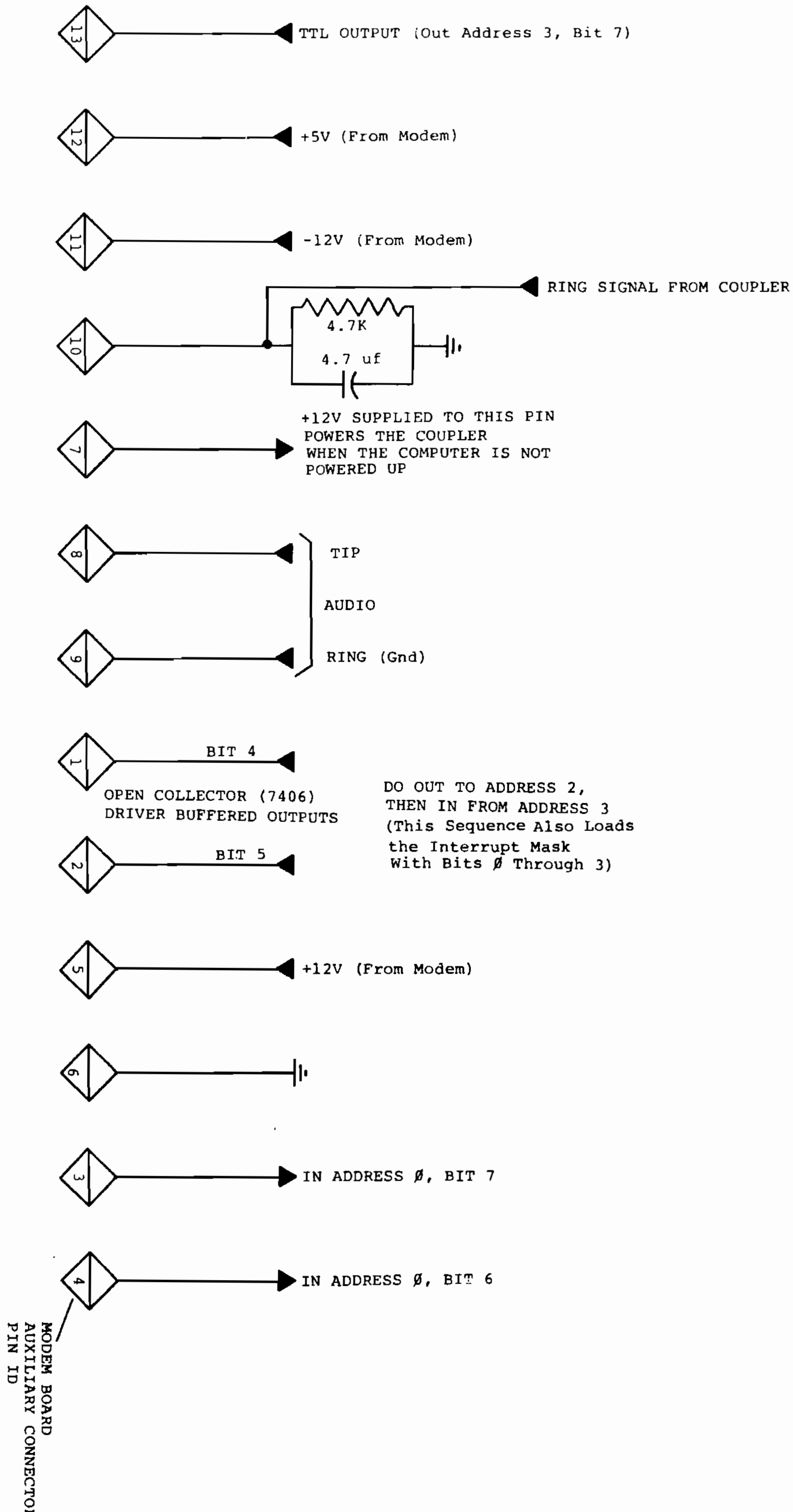


FIGURE 6.0-1 MM-103 AUXILIARY INTERFACE CONNECTOR PIN IDENTIFICATION

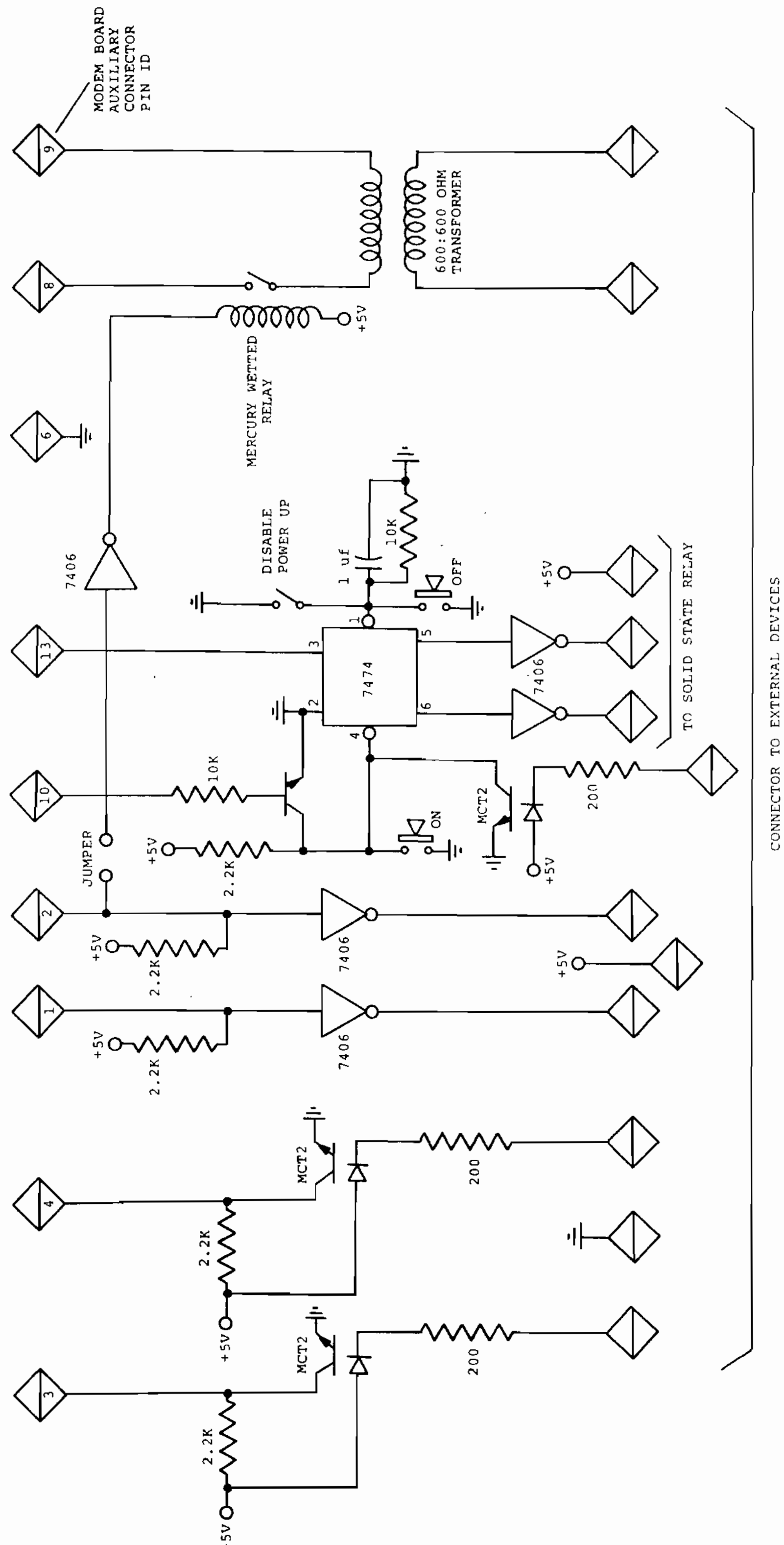


FIGURE 6.0-2
SUGGESTED AUXILIARY INTERFACE SCHEMATIC

We have attempted to make the software available with the MM-103 as general as possible, and to test it on as many different S-100 operating systems as we could. However, there are many different systems in use and to try them all would not be possible. Specific limitations, when known for each system, will be indicated in the description of each program. The Assembly programs should work with any S-100 system, with the only limitations being associated with the use of the system's I/O devices. For example, if you are receiving data at 300 Baud, you cannot output this data to a 110 Baud teletypewriter without losing data. Some disk systems cannot tolerate other interrupts within the system while disk I/O is taking place. This may restrict the use of MM-103 interrupts. Not all BASIC interpreters are fast enough to operate in an inter-active communications MODEM at 300 Baud. The users should try 110 Baud first and then try 300 Baud after it has been established that there are no problems at this rate. Another problem with most basic interpreters and their programs is that BASIC interpreters are always looking for control characters from the console keyboard (such as control "C" to abort a program). This will generally prohibit the use of this keyboard for interactive full duplex communication with the MM-103. A solution is to use a separate keyboard, or to patch out the control commands in your BASIC

S-100 BUS LINES UTILIZATION

ADDRESS: A0 THRU A7
PINS 79, 80, 81, 31, 30, 29, 82 & 83
DATA OUT: DO0 THRU DO7
PINS 36, 35, 88, 89, 38, 39, 40 & 90
DATA IN: DI0 THRU DI7
PINS 95, 94, 41, 42, 91, 92, 93 & 43
INTERRUPTS:
VECTORED INTERRUPTS PINS 4 THRU 11
INTERRUPT REQUEST PIN 73
INTERRUPT ACKNOWLEDGE PIN 96
I/O CONTROL: SOUT PIN 45, SINP PIN 46, PDBIN PIN 78 & PWR PIN 77
POWER ON CLEAR: POC PIN 99
POWER: +8 VOLTS PINS 1 & 51, +16 VOLTS PIN 2, −16 VOLTS PIN 52

CONTROL REGISTERS

DATA IN

7	6	5	4	3	2	1	0	
AUX 2	AUX 1	FE	OR	RPE	TEOC	DAV	TBMT	INPUT 0 UART STATUS
D7	D6	D5	D4	D3	D2	D1	D0	INPUT 1 DATA
TIMER PULSES	MODE	DIGITAL FO	$\overline{\text{ANS PHONE}}$	RX BRK	$\overline{\text{CTS}}$	$\overline{\text{RINGING}}$	$\overline{\text{DIAL TONE}}$	INPUT 2 MODEM STATUS
X	X	X	X	X	X	X	X	INPUT 3 LOADS INTERRUPT MASK FROM TIMER REG TO MASK REG

DATA OUT

7	6	5	4	3	2	1	0	
ENABLE INTERRUPT	TSB	EPS	NP	NB2	NB1	RING INDICATOR (ANS)	SWITCH HOOK (ORG)	OUT ADDRESS 0 UART CONTROL MODEM CONTROL
D7	D6	D5	D4	D3	D2	D1	D0	OUT 1 DATA
B7	B6	B5	B4	B3	B2	B1	B0	OUT 2A TIMER RATE
X	X	AUX OUT 2	AUX OUT 1	TIMER PULSES	RING-DIAL TONE	DAV	TBMT	OUT 2B INTERRUPT MASK OUT 2 + INP 3 LOADS MASK FM RATE REGISTER
AUX OUT 3	DTR	RX RATE	$\overline{\text{ST}}$	$\overline{\text{BRK REL}}$	$\overline{\text{TX BRK}}$	$\overline{\text{ESD}}$	ESS = 1 ELS = 0	OUT 3 MODEM CONTROL

FIGURE 7.0 CONTROL REGISTERS

interpreter or to use assembly subroutines called from BASIC. It is highly recommended that BASIC users convert to Assembly if they are experiencing unsatisfactory performance with the MM-103 in BASIC.

7.2 PROGRAMMING SPECIFICATIONS

7.2.1 ADDRESSING

The MM-103 is addressed and controlled by input and output instructions via the S-100 bus. The rate generator, interrupt latch and UART chips are connected to latch registers which are loaded by "OUT" commands. The status bits generated by these devices are read into the computer by "IN" instructions

The MM-103 uses 4 input and 4 output addresses which can be set anywhere within the 256 address range of the S-100 bus. The MM-103 can be addressed to any 4 address boundaries by setting the address switch which is mounted in the center of the printed circuit board. ("OPEN" indicates a 1 bit.) **Figure 7.0**, Control Registers, shows the control register assignments.

7.2.2 MODEM CHIP CONTROL

The MM-103 uses the Motorola MC6860L digital MODEM chip. The MODEM provides the necessary modulation, demodulation and supervisory control functions to implement a serial data communications link, over the voice grade channel, utilizing frequency shift keying (FSK) at bit rates up to 600 bps.

The MODEM requires that certain control lines be set to ones or zeros depending upon the desired function: originate, answer, etc. The chip also provides sense outputs which indicate the status at the communications channel and provide digital, serial data signals.

The digital signal inputs and outputs are connected directly to the UART and to the limiter threshold circuits. Control and sense lines are connected to latches and registers which are directly addressed by the computer.

7.2.3 UART CHIP CONTROL

The MM-103 uses a universal asynchronous receiver/transmitter (UART) to change the bit parallel structure of the data character which is normal for the S-100 computer to a bit serial data string required for data transmission.

The UART accepts binary characters from either the MODEM chip (receive) or from the computer (send). This character is appended with control (start-stop) and error detecting bits. All data characters contain a start bit, 5 to 8 data bits, one, one and one half, or two stop bits, and either odd, even or no parity. In order to make the UART universal, the Baud, bits per word, parity mode and the number of stop bits are software selectable. This is accomplished by an OUT command to relative address 0. Bits 2 through 6 control the UART. Refer to **Figure 7.0.**

7.3 OUTPUT CONTROL REGISTERS

The MM-103 uses 5 output control registers, two of which are addressed via a single out address. (These 2 are associated with the timer rate generator and the interrupt mask which are to be described later.) The MODEM chip is connected to the 2 low order bits of the register addressed by OUT 0 (relative) and by bits 0-6 of the register addressed by OUT 3. Refer to **Figure 7.0** which shows all of the data OUT registers.

The control software constructs a control word consisting of 8 bits with each bit directly controlling an individual line to the MODEM chip. The status words indicate the active condition of each bit. That is, when the bit is set as indicated, the specified function will be requested. A bar over the bit description indicates that the bit is set to zero to be active; no bar indicates that the bit is to be set to a 1 to activate the function. For example, of Bit 6 is on OUT 3, then DTR (Data Terminal Ready) will be on or active.

The following describes each bit, and the MODEM chip control line it actives. (The MODEM chip has additional data control lines which are not software addressable. These are identified by the fact that there is no word, or bit designator for them in the block diagram.)

7.3.1 REGISTER AT RELATIVE ADDRESS 0

This register has 3 functions:

1. Enables or disables interrupts—Bit 7
2. UART control—Bits **2**-6
3. MODEM control—Bits 0-1

Because each register is "multipurpose" it is necessary that the setting for all control bits be in the required state for the desire/operation before the register is loaded. For example, if interrupts are required along with the setting of the Switch Hook command (for getting an interrupt on dial tone), then the interrupt Enable bit and the Switch Hook bit must be set to a 1. Lastly, the register must be loaded with the UART control word and any other applicable bits.

The two MODEM control bits directly control the Switch Hook and Ring Indicator control lines of the 6960 MODEM chip. The MM-103 logic inverts these bits from that indicated in the 6860 manual. This was necessary to simplify certain software functions and to allow for better power-on-clear reset for most S-100 bus computers.

7.3.1.1 Bit 0 Switch Hook

The SH bit when high (set to 1) places the MODEM in the Originate Mode. SH is pulsed (off-on) during dialing for call origination. It is normally left low once communications have been established. This action starts a timer within the 6860 chip which will automatically cause the Answer Phone bit ($\overline{\text{Ans Phone}}$), Bit 4 in Word **2** to go high if communications have not been established within 17 seconds. The SH bit directly controls the telephone line switch hook relay. The SH bit may be left active (1) for testing and diagnostic purposes where automatic disconnect is undesirable.

Ans Phone and SH operate in parallel. SH is used for direct software control of the telephone line relay for dial tone detect and dialing. After communications have been established, the Ans Phone bit from the MODEM chip holds the telephone line for communications. The SH bit is set to 0 during communications so that the Ans Phone bit can disconnect if communications are lost. The Ans Phone bit is described further in the section which describes the data input words.

7.3.1.2 Bit 1—Ring Indicator

The Ring indicator bit is an input to the MODEM chip and is inverted from that shown in the Motorola manual. This bit is not the ringing signal from the telephone line and the protective coupler. The MM-103 separates these signals (RI and Ringing) to allow for direct software control over the answering of the phone.

Normally, the Ringing bit (IN Word 2 Bit 1) is monitored for a ring; under software control, if it is desirable to answer the phone the Ring Indicator bit is set high. This places the 6860 chip in the Answer Mode and causes the Ans Phone bit to go low and answer the phone by operating the Switch Hook Relay in the protective coupler. At this time, the Ring Indicator Should be reset to 0. The Ans Phone bit will now hold the telephone line for 17 seconds. If communications have not been established, automatic disconnect will occur.

NOTE: Either the Ring Indicator (Bit 1) or Switch Hook (Bit 0) must be held high for about 51 ms to be accepted by the 6860 chip. The software must provide this delay when pulsing the bit. For example, when ring has been detected, the Ring Indicator must be left in the ONE state for at least 51 ms to answer the phone. This delay in accomplished by the use of the Timer Pulse bit which is described later. The software examples show proper use of the Timer Pulse bit.

The Ring Indicator bit may be left in the ON condition for diagnostics and testing, causing the telephone line to stay off hook regardless of the MODEM chip status. This feature may be used for a go-to-voice function after the end of data transmission, allowing time for the user to pick up the phone. At this time, the software should turn off this bit, since the telephone bit is now holding the line.

7.3.1.3 UART Control Bits (NB1 and NB2)

Bits 2 and 3 (NB1 and NB2) select the number of bits per character. These two bits will be internally decoded to select either 5, 6, 7 or 8 data bits per character.

7.3.1.4 Bit 4—No Parity (NP)

A logic "1" on this bit will eliminate the parity bit from the transmitted and received character (no PE indication). The stop bit(s) will immediately follow the last data bit.

7.3.1.5 Bit 5—Odd/Even Select (EPS)

The logic level on this bit selects the type of parity which will be appended immediately after the data bits. It also determines the parity that will be checked by the receiver. A logic "0" will insert odd parity and a logic "1" will insert even parity.

7.3.1.6 Bit 6—Number of Stop Bits (TBS)

This bit will select the number of stop bits (1, 1½ or 2) to be appended immediately after the parity bit. A logic "0" will insert 1 stop bit and a logic "1" will insert 2 stop bits. If a 5 bit code was selected, the 1½ stop bits will be transmitted.

7.3.1.7 Control Definition Summary

CONTROL WORD					CHARACTER FORMAT			
		BIT			START	DATA	PARITY	STOP
2	3	4	5	6	BIT	BITS	BIT	BITS
0	0	0	0	0	1	5	ODD	1
0	0	0	0	1	1	5	ODD	1.5
0	0	0	1	0	1	5	EVEN	1
0	0	0	1	1	1	5	EVEN	1.5
0	0	1	X	0	1	5	NONE	1
0	0	1	X	1	1	5	NONE	1.5
1	0	0	0	0	1	6	ODD	1
1	0	0	0	1	1	6	ODD	2
1	0	0	1	0	1	6	EVEN	1
1	0	0	1	1	1	6	EVEN	2
1	0	1	X	0	1	6	NONE	1
1	0	1	X	1	1	6	NONE	2
0	1	0	0	0	1	7	ODD	1
0	1	0	0	1	1	7	ODD	2
0	1	0	1	0	1	7	EVEN	1
0	1	0	1	1	1	7	EVEN	2
0	1	1	X	0	1	7	NONE	1
0	1	1	X	1	1	7	NONE	2
1	1	0	0	0	1	8	ODD	1
1	1	0	0	1	1	8	ODD	2
1	1	0	1	0	1	8	EVEN	1
1	1	0	1	1	1	8	EVEN	2
1	1	1	X	0	1	8	NONE	1
1	1	1	X	1	1	8	NONE	2

The UART register bits will normally be loaded last (after Dialing or Ring Detect) just before normal communications are to take place. Since this register is shared with the Ring Indicator, Switch Hook and Enable Interrupts bits, the desired final setting of these bits must be included in the UART command.

7.3.1.8. Interrupt Control Bit

Control register 0, Bit 7, Enable Interrupts, allows the MM-103 to generate interrupt requests to the S-100 bus interrupt request line. A 1 enables and 0 bit disables this function. The interrupt mask register must have been previously loaded with the desired bit pattern to enable the interrupt desired. The CPU interrupts must also be enabled. The section which describes the interrupt register will explain the use of interrupts further.

7.3.1.9 Ring Indicator and Switch Hook Control Bits

The purpose of the Ring Indicator is to place the MM-103 into the Answer Mode. The Switch Hook places the MM-103 into the Originate Mode. Both allow for holding the telephone line in the off-hook condition until communications have been established. The telephone line is held open by the $\overline{\text{Ans Phone}}$ bit. At this time, the applicable bit should be set to 0 so that the automatic disconnect feature will operate. The setting of the applicable bit to 0 normally takes place when the UART register is loaded, since the UART also shares OUT Address 0.

7.3.2. REGISTER AT RELATIVE ADDRESS 1

This output register will hold the data character to be transmitted. It is loaded as each character is to be sent. The number of bits used and the data code used will depend upon the desired use of the MM-103. In most cases, it will be the ASCII character to be sent. Because it is possible to load this register at a rate faster than the Baud rate, the TBMT bit (Transmit Buffer Empty) at Address 0 must be tested to insure that the buffer is empty and another character may be sent. This bit is described further in the section which describes the input functions. The UART control register setting will have determined transmission bit size and parity.

7.3.3 REGISTER AT RELATIVE ADDRESS 2

This register has a dual function. First, it directly controls the rate generator which contains the divisor for the countdown chain which determines the Baud rate, the dialer rate and the timer pulse rate. Second, its contents may be transferred to the Interrupt Mask holding register by an input command to Relative Address 3. It is therefore possible to load the interrupt mask by providing OUT Address 2 with the mask pattern followed by IN 3. Since this also loads the rate generator with the interrupt mask pattern, the mask is loaded first (if it is to be used) and then the desired rate is loaded for normal operation.

7.3.3.1 Rate Generator

The MM-103 derives all timing from a 10 MHz crystal oscillator. The signal is divided by 10 which provides the 1 MHz signal required by the 6860 MODEM chip, thus crystal controlling all data MODEM transmission frequencies. The 1 MHz signal is then divided by 4 providing a 250,000 Hz signal to the rate generator. The rate generator is a binary divider which is loadable by an output command to Relative Address 2, thus the 250,000 Hz signal may be divided by any value from 0 to 255 depending upon the binary value at the control word. This signal is connected to the clock inputs of the UART chip allowing the setting of Baud rates from 61 to over 600 Baud. The UART internally divides the rate generator by 16 to determine the final Baud rate. The actual rate is determined by the following:

Rate = 250,000 *di* (Reg x 16) where Reg = the binary value loaded into the rate generator.

For example, if the register is loaded with the following:

Decimal	Baud Rate
142	110
52	300
26	600

Other rates within the 61-600 Baud range may be used. If non-standard rates are selected, communications will only be possible between MM-103s set to the same rate. The MM-103 hardware further divides the output of the rate generator by 100 and connects this signal to Input Bit 7 of IN Address 2 (Timer Pulses). This signal has a 40% ON and 60% OFF duty cycle, the correct characteristics for dialing the telephone. This signal ranges from 25,000 down to 9.8 pulses per second, which allows a wide range of usable timing elements. The primary purpose of the Timer Pulses is to provide precision 40/60 intervals for telephone dialing. The rate generator is loaded with the proper divisor to get the desired dial rate. Normal dialing rates are 10 and 20 pps; however, some electronic switching offices allow much higher rates. The user should determine the highest rate allowed for his location, and use that rate for auto dialer.

For example:

Register value Decimal	Dialing Rate
250	10 PPS
125	20 PPS

Because the same rate generator is used for both dialing and Baud rate generation, it must be changed each time a new rate is required, and be left at the Baud rate during communications. The Timer Pulse may be used for other purposes such as time of day and real time interrupts when not required for communications.

7.3.3.2 Interrupt Mask

The MM-103 has a maskable interrupt system which is loaded via OUT Address 2 and then IN Address 3. IN 3 has no other purpose and does not load data into the computer.

Refer to **Figure 7.0** for the bit pattern for the

Interrupt Mask. Interrupts, if enabled, will be generated by TBMT (Transmitter Buffer Empty), DAV (Data Available), from the UART and the Dial Tone or the Ring Detector from the protective coupler and from Timer Pulses. The register also has 2 TTL level output bits which may be used to enable or disable auxiliary devices (described in the hardware section). A 1 bit selects the desired interrupt. The interrupt system does not stack or queue interrupts, so if more than one has been enabled it is necessary to read in the MODEM status register or the UART status register to determine which of the multiple interrupts are requiring attention. To use the interrupts, the interrupt system must be enabled (Bit 7 at OUT Control Word 0) and the CPU must be interrupt enabled.

7.3.3.3 Auxiliary Outputs

Auxiliary Outputs 1 and 2, Bits 4 and 5 of the Interrupt Mask Register may be used to set or reset 2 TTL level output pins on the auxiliary output plug located on the top edge of the MM-103 board. These bits were provided for the use of future products to be produced by PMMI, such as interfaces to voice recorders, speech generators and alarm control devices.

7.3.4 REGISTER AT RELATIVE ADDRESS 3

OUT Address 4 latches the 6860 chip control registers with the bit pattern required to establish the MODEM chip functions.

7.3.4.1 Bit 0—ELS and ESS Control

When this bit is set to a 1, ESS (Enable Short Space Disconnect) is active. When set to 0, ELS (Enable Long Space Disconnect) is active. When active, ELS will automatically hang up the phone upon receipt of a continuous space for 1.5 s. When active, ESS will automatically hang up the phone upon receipt of a continuous space for 0.3 s.

7.3.4.2 Bit 1—Enable Space Disconnect (ESD)

When ESD is active and DTR (Data Terminal Ready) is pulsed to initiate a disconnect, the MODEM transmits a space for either 3 s or until a loss of threshold is detected—whichever occurs first. If ESD is active, data, instead of a space, is transmitted. A disconnect occurs at the end of 3 s.

7.3.4.3. Bit 2—Transmit Break (Tx Brk)

The Tx Brk command is used to signal the remote MODEM to stop sending data. A Transmit Break (low) greater than 34 ms forces the MODEM to send a continuous space signal for 233 ms. Transmit Break must be initiated only after CTS has been established. Prior to a break, Tx Brk must be held high for a minimum of 34 ms. NOTE: The Timer Pulse may be used via software to provide the delay requirements.

7.3.4.4 Bit 3—Break Release (Brk Rel)

After receiving a 150 space signal, the high condition (read by IN 2, Bit 3) of the Receive Break output can be removed by holding Break Release low for at lease 20 microseconds.

7.3.4.5 Bit 4—Self Test (ST)

When this bit is set to 0, the demodulator is switched to the modulator frequency and demodulates the transmitted FSK signal. Channel establishment which occurred during the inital handshake is not lost during Self-Test. The Mode Control output changes state during Self-Test, permitting the receive filters to pass the local Transmit Carrier. The telephone line connection must be disconnected for this test. The test should only be done in the Answer Mode. To use the Originate Mode, a test oscillator is required.

7.3.4.6 Bit 5—Receive Data Rate (Rx Rate)

The demodulator has been optimized for signal-to-noise performance at 300 bps and 600 bps. The Receive Data Rate Input must be set to 0 for 0-600 bps and should be set to 1 for 0-300 bps.

7.3.4.7 Bit 6—Data Terminal Ready (DTR)

The Data Terminal Ready signal must be set to 1 before the MODEM function will be enabled. To initiate a disconnect, DTR is held low for 34 ms minimum. A disconnect will occur 3 s later. NOTE: DTR must not be active during dialing since DTR also controls the telephone line Switch Hook, via the Ans Phone Bit.

7.3.4.8 Bit 7—Auxiliary OUT 3

An OUT to this bit sets or resets Aux OUT 3 which is a TTL level line on the auxiliary output plug.

7.4 INPUT CONTROL REGISTERS

7.4.1 GENERAL

The MM-103 utilizes 4 addresses for IN and OUT commands. **Figure 7.0** shows the Bit configurations for the input registers.

Data is read into the computer's "A" register by executing an "IN" instruction at the designated address. Of the 4 input addresses assigned, only the first 3 actually bring data into the computer. The 4th at Relative Address 3 causes the contents of the Rate Generator Register to be transferred to the Interrupt

Mask Register. Relative Address 0 brings in the UART status and Auxiliary Bits 1 and 2. Address 1 is the data input register and Address 2 brings in the status of the 6860 MODEM chip. Also included in Address 2 are the Timer Pulses and the status of the ring and dial tone detectors.

7.4.2 INPUT REGISTER AT RELATIVE ADDRESS 0, BIT 0—TBMT

This bit when high (1 state) indicates that the UART transmitter buffer is empty and another character may be transmitted to the distant MODEM. This will be done by outputting to OUT Address 1.

7.4.2.1. Bit 1—DAV

The UART Data Available Bit, when high, indicates that a full character has been received by the UART and is ready for inputting to the computer. This is done by reading the data word at IN Address 1.

7.4.2.2 Bit 2—TEOC

The transmitter serializer has sent the last data bit, and the transmitter buffer is empty when this bit is set to 1. This bit is not normally used, but was included in the MM-103 for users who might want to know when the last bit has been transmitted. This might be required in systems which require a faster "ACK-NAK" operation than would otherwise be possible.

7.4.2.3 Bit 3—RPE

The Received Parity Error Bit will be set to ONE whenever the parity of the received character does not agree with that specified by the contents of the UART control register that was loaded by OUT Address 0.

7.4.2.4 Bit 4—OR

The Over-Run Error Bit will be set to 1 if a new character has been received before the previous character has been read into the computer. If set, it will indicate that the software is too slow in processing the data and that the previous character has been lost.

7.4.2.5 Bit 5—FE

The Framing Error Bit will be set whenever a new character has been received without the proper number of stop bits. This bit will also be set whenever the MM-103 receives a "BREAK" from the distant end. The 6860 MODEM also detects the break. The MODEM break detector sets Bit 3 of IN Word 2. Since the MODEM break is a more reliable method of detecting a break, its bit should be used for this purpose, and the OR bit used for the detection of all other Over-Run types of errors.

7.4.2.6 Bits 6 and 7

These bits show the status of Auxiliary IN 1 and 2, which are TTL level inputs to the auxiliary connector on the MM-103. The hardware describes the interconnection. These bits are useful for alarm inputs or other external status sensors the user may desire to connect to the MM-103.

7.4.3 INPUT REGISTER AT RELATIVE ADDRESS 1

This 8 bit register will contain the data character sent by the distant MODEM. It is read into the computer's "A" register by the IN command to this address. The number of bits, parity, etc., will be specified by the command to OUT Register 0.

7.4.4 INPUT REGISTER AT RELATIVE ADDRESS 2

This is a multipurpose register which shows the 6860 MODEM chip status, the Timer Pulses and the status of the Dial Tone and Ring Detectors.

7.4.4.1 Bit 0—Dial Tone

The Dial Tone Bit is set to 0 whenever there is a sufficient signal level in the dial tone filter band. The dial tone amplifier sensitivity will have been set for the user's dial tone level as described in the Software section of the manual titled "Program to Set and Test the Dial Tone Detector." The dial tone filter circuit has a long-time constant and will not respond to noise or other extrenuous signals, if set properly. Some telephone systems use signals other than dial tone, such as ringing and busy signals, or telephone-off-hook-too-long. The Dial Tone Detector will set Bit 0 to ZERO, if these signals are within the dial tone band and the proper amplitude. Voice transmission will also cause the bit to change state. Although the purpose of the Dial Tone Detector is for dial tone detection, it may provide additional information to the software; however, PMMI makes no claims for its usefulness other than for dial tone detection. Note that the Dial Tone Bit may change state during local ringing. This is normal since the ringing signal is quite strong, however it is not a reliable ring detector. The Ringing bit should be used for this purpose.

7.4.4.2 Bit 1—Ringing

The Ring Detector is a combination of circuits which provide a reliable ring indication by setting Bit 1 to 0. The ring signal is integrated over a period of about .1 s so that the bit will not follow the cyclic ring pulses, but will pulse 0 and 1 following the ring interval. Software may count the number of rings desired. The phone is not actually answered without an OUT to Address 0 with Bit 1 set to 1, which places the MODEM in the answer mode. In special situations where it is desired to go in to the originate mode upon ring, Bit 0 of OUT Address 0 would be set to 1.

7.4.4.3 Bit 2—$\overline{CTS}$

When set to 0, the $\overline{\text{Clear-to-Send}}$ bit indicates that the transmit data input has been unclamped from a steady mark, thus allowing data transmission. This bit should be monitored fairly frequently. If it goes to a ONE, indicating that the transmission has been broken, the software should direct the program to an exit routine or error diagnostic.

7.4.4.4 Bit 3—Rx Break

The Receive Break Bit, when high, indicates that a continuous 150 ms space signal has been received. The MODEM chip automatically clamps this bit high until $\overline{\text{Clear-to-Send}}$ has been established.

7.4.4.5 $\overline{\text{Answer Phone (AP)}}$ (Bit 4)

The $\overline{\text{Answer Phone}}$ Bit is set low (0) by the MODEM chip upon the receipt of RI (OUT Address 0, Bit 1), or SH (OUT Address 0, Bit 0) and DTR (OUT Address 3, Bit 6). The telephone line is held Off Hook for data transmission. The software should reset either RI or SH 51 ms after $\overline{CTS}$. Monitoring $\overline{AP}$ will show this delay, establishing the fact that $\overline{CTS}$ has occurred. The MODEM chip will then, via the $\overline{AP}$ Bit, keep the MODEM connected to the phone line until automatic disconnect occurs. The $\overline{AP}$ bit will be reset in about 1.5 second after the $\overline{CTS}$ bit resets, this timing provided by the MODEM chip. This bit differs in function from $\overline{CTS}$ in that it is used while communications are being established. $\overline{CTS}$ is used during communications.

7.4.4.6 Bit 5—Digital FO

The FO bit is the digital carrier signal. It is monitored for test and diagnostic purposes only.

7.4.4.7 Bit 6—Mode

The Mode Bit indicates the answer (low) or originate (high) status of the MODEM. The output changes when a $\overline{ST}$ command is applied. This bit is used for diagnostic purposes only, but could be monitored by software if desired.

7.4.4.8 Bit 7—Timer Pulses

This bit pulses between zero and one at the timer rate, determined by the setting of the rate generator register (see description of the rate generator). The bit has a duty cycle of 40% One and 60% Zero which provides the correct ON/OFF ratio for dialing. The bit may also be used for clock timing and for providing delays necessary for pulsing certain MODEM control bits which require delays in operating. When communications are taking place this bit will be pulsing at 16 times the data Baud rate divided by 100. This fact should be considered if the bit is used for clock or timing functions during data transmission.

7.4.5 INPUT REGISTER AT RELATIVE ADDRESS 3

An input to this address does not provide input data. Its purpose is to allow the loading of the interrupt mask register from the rate generator. The transfer occurs at the time the instruction is executed.

SOFTWARE EXAMPLES

The following pages list and describe several BASIC and Assembly programs written for the PMMI MM-103 MODEM and data communications adaptor. All of the examples assume that the MODEM is addressed to C0 Hex (192 decimal). If these addresses conflict with addresses used by one of your other devices, a change must be effected. It is easy to change the MM-103 by re-setting the address switch on the MODEM board. This switch represents the 6 high-order bits of the address (AAAAAAXX). XX represents the 4 base addresses for the MODEM. A switch set to OFF = 1 and set to ON = 0. When set to OFF OFF ON ON ON ON it is set to C0 Hex or 192 decimal.

The symbols [and] in the listings represent > and <.

Microsoft BASIC was used for listing the programs. Additionally, most have been tested with C BASIC. Some BASICs will not operate correctly because their interpreters are too slow.

These and other programs are available on eight inch CPM and 5¼ inch North Star disks. Write or call PMMI for further details.

PROGRAM TO DEMONSTRATE THE CLOCK FUNCTION

When not communicating, and when the computer is otherwise idle, this program will keep fairly accurate wall clock time. It also includes an alarm feature which compares the set time with the alarm time, and, when the comparison is true, rings the terminal bell. The program could be useful for activating the MODEM at some future time, for example, to send data when the telephone rate charges are lower during the late evening hours.

Line 20 requests the operator to enter the alarm time in hours, minutes and seconds.

Line 30 requests the current time.

Line 40 loads the timer to produce 0.1 second clock ticks.

Line 50 waits for each tick pulse to go high.

Line 60 counts the ticks.

Line 70 converts the ticks to seconds.

Line 80 accumulates minutes.

Line 90 waits for the ticks to go low.

Line 100 accumulates the hours.

Line 120 accumulates days, if required.

Line 130 compares current time with alarm time, and goes to statement 150 at alarm time.

Line 140 loops to continue the process.

Lines 150 through 170 rings the terminal bell.

There will be a slight drift in the seconds over a long period of time. This is due to the fact that the crystal, while highly accurate in controlling the MODEM tones, is not compensated or adjustable for long-term time-of-day stability.

```
FILE: TCLOCK   BAS     PAGE 001
10 REM PROGRAM  TO DEMONSTRATE CLOCK OPERATION
20 PRINT "ENTER ALARM TIME HOUR,MIN,SEC":INPUT AH,AM,SA
30 PRINT "ENTER TIME OF DAY, HOUR,MIN,SEC":INPUT H,M,S
40 OUT 194,250
50 IF(INP(194)AND 128)=0THEN 50
60 B=B+1
70 IF B=10 THEN S=S+1:B=0
80 IF S=60 THEN M=M+1:S=0
90 IF(INP(194)AND 128)=128THEN 90
100 IF M=60 THEN H=H+1:M=0
120 IF H=24 THEN H=0
130 IF AH=H AND AM=M AND SA=S THEN 150
135 IF B=0 THEN PRINT H;":";M;":";S
140 GOTO 50
150 FOR J=1 TO 100
160 PRINT CHR$(7)
170 NEXT J
```

PROGRAM TO SET AND TEST DIAL TONE DETECTOR

The MM-103 has a precision dial tone filter which passes the band of frequencies used by most dial tone generators (200-600 Hz). The dial tone sensitivity adjustment is at the top center of the MM-103 (the square trim pot closest to the heat sink). THE ADJUSTMENT NEXT TO THE PROTECTIVE COUPLER CONNECTOR IS THE THRESHOLD SENSITIVITY CONTROL AND SHOULD NOT BE TOUCHED (factory set at −50 dBm).

PROCEDURE:

1. Load and verify the test program.
2. Rotate the dial tone sensitivity adjustment fully counter clockwise.
3. Activate the program.
4. Type in a "1".
5. Slowly rotate the adjustment clockwise.
6. When the message "Dial Tone Received In XX Seconds" appears, additionally rotate the adjustment approximately 5 to 10 degrees. The time XX will be equal to the time it took you to make the adjustment.

   If the "NO Dial Tone In 15 Seconds" message appears, you either took too long to make the adjustment, the MM-103 and/or program is not installed properly, or the MM-103 has failed.
7. Reactivate the program (type in a "1").
8. The program should then print the time it takes to get dial tone, plus about 0.2 seconds. Dial tone should appear in 0.6 to several seconds.
9. If the "No Dial Tone" message appears (15 seconds), re-try Step 1 and verify that the program and protective coupler are installed properly. If the "False Dial Tone Received" message appears, it indicates that the extra amount added (5 to 10 degrees) in Step 6 was excessive, or that the telephone line was very noisy. If this message appears, re-try Step 1.

```
 BAS      PAGE 001
10 REM PROGRAM TO TEST THE DIAL TONE DETECTOR.
20 A0=192        :REM BASE PORT ADDRESS IN DECIMAL.
30 P0=A0
40 P1=P0+1
50 P2=P0+2
60 P3=P0+3
70 B7=128
80 Z=0
90 N=1
100 OUT P3,0 :  REM CLEAR MODEM CHIP TO IDLE.
110 OUT P2,255  :REM SET THE TIMER FOR .1 SECOND INTERVALS.
120 PRINT "TYPE IN AN 1 TO START TEST"
130 OUT P0,0    :REM CLEAR TO ON HOOK CONDITION.
140 INPUT A
150 IF A[] 1 THEN 120
160 OUT P0,1    :REM GO OFF HOOK.
170 T=1
180 IF(INP(P2)AND B7)=B7 THEN 180
190 T=T+1
200 IF T=150 THEN 290
210 IF(INP(P2)AND B7)=Z THEN 210
220 IF(INP(P2)AND N) =N THEN 180
230 REM DIAL TONE RECEIVED.
240 OUT P0,0    :REM GO ON HOOK.
250 IF T[5 THEN 320
260 PRINT "DIAL TONE RECEIVED IN ";T/10;"SECONDS"
270 OUT P0,0
280 GOTO 120
290 OUT P0,0    :REM GO ON HOOK.
300 PRINT"NO DIAL TONE RECEIVED IN ";T/10;"SECONDS."
310 GOTO 120
320 OUT P0,0    :REM GO ON HOOK.
330 PRINT"FALSE DIAL TONE RECEIVED IN ";T/10;"SECONDS."
340 GOTO 120
350 END
```

PROGRAM TO DEMONSTRATE THE DIALER FUNCTION

The BASIC version of this program sets up the MM-103 control and data ports at C0HEX, or 192 decimal. Each digit is entered followed by a carriage return. The digit is then dialed. The dial tone detector is not used. The program is used in conjunction with a standard telephone. After dialing the number with the computer, pick up the telephone. A good number to use is your own, since in this case you should hear a busy signal. Enter "11" to exit the program after the last digit. Lines 110-120 synchronize the dial pulse control to the start of an open or a space condition. The loop at 130-180 controls the number of pulses to be dialed. Statement 140 puts the line on-hook. 150 waits for the on-hook period (60 percent of the dial pulse). 160 puts the line off-hook. 170 times the off-hook interval (40 percent of the dial pulse). 190 loops, waiting for the next digit.

```
FILE: DIALER   BAS      PAGE 001
1 REM PROGRAM TO DEMONSTRATE THE DIALER FUNCTION.
2 REM ENTER EACH DIGIT FOLLOWED BY A CR
3 REM ENTER AN 11 TO HALT TEST.
4 REM TO CHANGE THE DIALING RATE TO 20PPS CHANGE LINE 50 TO OUT A,125
10 A=194
20 B=128
30 C=192
40 E=0
45 F=1
50 OUT A,250
60      OUT C,F
70      INPUT Z
80      IF Z=0 THEN Z=10
90      IF Z=11 THEN OUT C,0
100 IF Z=11 THEN STOP
110 IF INP(A)]B THEN 110
120 IF INP(A)[B THEN 120
130 FOR J= F TO Z
140     OUT C,E
150 IF INP(A)]B THPN 150
160     OUT C,F
170 IF INP(A)[B THEN 170
180 NEXT J
190 GOTO 70
1000    END
```

PROGRAM TO TEST THE RING DETECTOR AND AUTOMATIC ANSWER FEATURE

This program will verify that the MM-103 MODEM is properly addressed and installed. Use either the BASIC or assembly language version. The program does not communicate, but does verify that the ring detector and automatic answer features are operating and that the timer and MODEM chip are functional. Set the address switches to C0HEX (OFF OFF ON ON ON ON), or if desired, change the statement in line 40 to some other address (192 decimal is C0HEX).

```
5 REM PROGRAM TO TEST THE RING DETECTOR AND MODEM AUTOMATIC ANSWER FEATURE.
20 REM LOAD AND START PROGRAM, THEN DIAL INTO THE MM 103
30 REM A SINGLE TONE WILL BE HEARD FOR 15 SECONDS. THEN DISCONNECT
40 P0=192          :REM MM-103 BASE ADDRESS IN DECIMAL.
50 P1=P0+1
60 P2=P0+2
70 P3=P0+3
80 OUT P0,0     :REM CLEAR MODEM.
90 OUT P3,0
100 REM PROGRAM WILL LOOP HERE AND WAIT FOR A RING.
105 PRINT"WAITING FOR RING.  DIAL THE MM103 FROM ANOTHER PHONE."
110 IF(INP(P2)AND 2)=2 THEN 110
120 PRINT"RINGING"
130 OUT P0,2     :REM TELL MODEM TO ANSWER THE PHONE.
140 OUT P3,127  :REM TURN ON DATA TERMINAL READY.
150 IF(INP(P2)AND 16)=16 THEN 150        :REM WAIT FOR MODEM TO ANSWER THE PHONE.
160 PRINT"PHONE ANSWERED - START OF TEST."
170 OUT P0,0     :REM TELL MODEM TO DEACTIVATE RING INDICATOR.
180 REM  MODEM WILL NOW WAIT 15 SECONDS FOR INCOMMING CARRIER.
190 REM  SINCE THIS IS A TEST AND NO CARRIER IS EXPECTED,
200 REM  DISCONNECT SHOULD OCCURE IN 15 SECONDS.
210 IF(INP(P2)AND 16)=0 THEN 210        :REM WAIT FOR DISCONNECT.
220 PRINT"DISCONNECTED  END OF TEST."
230 STOP
240 END
```

SIMPLE DATA COMMUNICATIONS TEST PROGRAM

These are BASIC programs which allow interactive communications between the MM-103 and remote computers. Not all BASIC interpreters will be fast enough to operate at 300 Baud. They have been run successfully with several versions or micro-soft BASIC interpreters.

Both programs are identical in operation, but use different methods of coding, one uses integer variables in defining I/O functions and data control word bit selection. The other assigns these variable to letter constants. Most BASIC interpreters will run faster with the second version. The first version is easier to follow, so it is described below.

Manual dialing of the number is required. The program is loaded, but not operated. Using a "Y" connector for the telephone line connection to the MM-103, plug in a standard dial telephone. Manually dial the remote computer center. When the answer tone is heard, activate the program and hang up the manual telephone. Then, interactivate communications may take place. The program assumes that the local keyboard display unit has its own I/O port (not the one associated with the BASIC interpreter). This is necessary because most interpreters are always looking for control characters, such as control "C" to abort a program. This prevents full duplex operation where the program is continuously scanning for input from the MODEM or the local keyboard. The statements operate as follows:

Line 55 puts the MODEM in the originate mode and causes the MODEM to hold the telephone line so that the manual telephone can hang up.

Line 60 on OUT to this address loads the rate generator. In this case 52 sets it for 300 baud. Use 142 for 110 baud.

Line 70 initializes the MODEM chip by turning on DTR and activates other control bits for break detect, and sets the MODEM up for communications.

Line 80 waits for $\overline{\text{Clear-to-Send}}$.

Line 90 sets up the UART for 8 bits no parity, and 2 stop bits. It also resets the switch hook by de-activating Bit 1, since the MODEM Answer Phone Bit is now holding the line. (If Bit 1 is left set, automatic disconnect cannot occur).

Lines 100-170 form the main connections loop.

Line 110 checks to be sure Clear-to-Send remains active. If this bit goes high it indicates that automatic disconnect has occurred, jumping to 180 to end the program.

Line 180 tests the UART for input from the remote MODEM. If none, transfer is made to 140 to test the local keyboard.

Line 130 retrieves the data from the UART and sends it to the local terminal which is at Address 13. No testing of the display is done because it is assumed that it will operate faster than 300 baud.

Line 140 tests at Address 0 for input from the local keyboard. If no input, the program goes to 110 to test for Clear-to-Send.

Line 150 retrieves the character to be sent from the keyboard.

Line 160 sends it to the UART and MODEM.

Line 170 loops for more data.

Line 180 ENDS.

```
1 REM MCENTER PGM
10 REM SIMPLE DATA COMMUNICATIONS TEST PROGRAM.
20 REM MANUALLY DIAL THE REMOTE COMPUTER, WHEN THE ANSWER TONE
30 REM APPEARS, RUN THIS PROGRAM, HANGE UP THE PHONE.
40 REM THEN YOU CAN COMMUNICATE WITH THE REMOTE SYSTEM.
50 REM SET UP FOR COMMUNICATIONS.
55 OUT 192,1
60 OUT 194,52
70 OUT 195,127
80 IF(INP(194)AND 4)=4 THEN 80
90 OUT 192,92
100 REM MAIN DATA LOOP.
110 IF(INP(194)AND 4)=4 THEN 180
120 IF(INP(192)AND 2)=0 THEN 140
130 OUT 13,INP(193)
140 IF(INP(0)AND 1)=1 THEN 110
150 X=INP(1)
160 OUT 193,X
170 GOTO 120
180 OUT 195,0
```

```
1 REM TCENTER PGM
10 REM SIMPLE DATA COMMUNICATIONS TEST PROGRAM.
20 REM MANUALLY DIAL THE REMOTE COMPUTER, WHEN THE ANSWER TONE
30 REM APPEARS, RUN THIS PROGRAM, HANGE UP THE PHONE.
40 REM THEN YOU CAN COMMUNICATE WITH THE REMOTE SYSTEM.
50 REM SET UP FOR COMMUNICATIONS.
60 A=192
70 B=193
80 C=194
90 D=195
100 E=0
110 F=1
120 G=2
130 H=4
140 I=13
150 OUT A,F
160 OUT C,52
170 OUT D,127
180 IF(INP(C)AND H)=H THEN 180
190 OUT A,92
200 REM MAIN DATA LOOP.
210 IF(INP(C)AND H)=H THEN 280
220 IF(INP(A)AND G)=E THEN 240
230 OUT I,INP(B)
240 IF(INP(E)AND F)=F THEN 210
250 X=INP(F)
260 OUT B,X
270 GOTO 220
280 OUT D,E
```

This program is an expansion of the previous two, with automatic dialing added. The data statement in line 160 holds the number to be dialed.

- Lines 30-130 are variables set up to speed up a slow interpreter.
- Line 160 holds the number to be dailed. It must end with an 11.
- Lines 180-200 wait for dial tone.
- Line 210 reads in the number from the data statement.
- Line 220 prints the number as it is dialed.
- Lines 230 and 240 convert a 0 to a 10.
- Line 250 ends dialing if an 11 is found.
- Lines 260 and 270 synchronize the dialing program and the rate generator.
- Lines 280-330 dial the number. See th P2 program for a description of the dialer routine.
- Lines 340-380 wait for the interdigit time (space between numbers).
- Line 390 loops for the next digit.
- Lines 400-610 operate in the same way as programs P6 and P7; however, a few messages have been added.

NOTE: this program has been tested with several versions of micro-soft BASIC. It will not operate at 300 Baud with C BASIC or PT BASIC, and not at all with North Star DOS BASIC because this BASIC does not have logical "AND" operations. North Star users may want to purchase our small disk which has several similiar programs with DOS. These programs are too lengthy to list here.

```
1 REM COMUNICA PROGRAM
10 REM PROGRAM TO DEMONSTRATE THE AUTO-DIAL AND THE
20 REM AUTO TIME-OUT FEATURES OF THE MM-103 MODEM.
30 A=194
40 B=128
50 C=192
60 D=195
70 E=0
80 F=1
90 H=4
100 K=2
110 L=3
120 M=13
130 I=193
140 CUT D,E     :REM CLEAR MODEM .
150     OUT A,125
160 DATA 7,5,0,0,9,3,0,11
170     OUT C,F
180 REM WAIT FOR DIAL TONE.
190 IF(INP(A)AND F)=F THEN 190
200 PRINT"DIAL TONE RECEIVED NOW DIALING"
210 READ Z
220 IF Z[]11 THEN PRINT Z;
230 IF Z[]0 THEN 250
240 Z=10
250 IF Z=11 THEN 400
260 IF (INP(A)AND B)=E THEN 260
270 IF(INP(A)AND B)=B THEN 270
280 FOR J= F TO Z
```

```
290     OUT C,E
300     IF (INP(A)AND B)=E THEN 300
310     OUT C,F
320 IF(INP(A)AND B)=B THEN 320
330 NEXT J
340 REM WAIT FOR INTER-DIGIT TIME.
350 FOR J=1 TO 7
360 IF(INP(A)AND B)=E THEN 360
370 IF(INP(A)AND B)=B THEN 370
380 NEXT J
390 GOTO 210
400 REM SET UP FOR COMMUNICATIONS.
410 OUT A,52
420 OUT D,127
430 IF(INP(A)AND 16)=16 THEN 430
440 OUT C,92
450 IF (INP(A)AND 16)=16 THEN 610
460 IF(INP(A)AND H)=H THEN 450
470 PRINT:PRINT
480 PRINT"CLEAR TO SEND RECEIVED. START TRANSMISSION."
490 REM MAIN DATA LOOP.
500 IF(INP(A)AND H)THEN 570
510 IF(INP(C)AND K)=E THEN 530
520 OUT M,INP(I)
530 IF(INP(E)AND F)=F THEN 500
540 X=INP(F)
550 OUT I,X
560 GOTO 510
570 OUT 195,0
580 PRINT:PRINT"END OF TRANSMISSION"
590 STOP
600 PRINT:PRINT
610 PRINT:PRINT:PRINT:PRINT"NO ANSWER.  TELEPHONE LINE DISCONECTED."
```

ORIGINATE PROGRAM WITH MANUAL DIALING

This program closely simulates an acoustic, coupled MODEM (manual dialing is required). The MM-103 MODEM is connected to the telephone line along with a standard dial telephone by the use of a "Y" connector, which is available at most "phone stores".

The telephone number of the distant computer is manually dialed. When the answer tone is heard the program is activated. When the MM-103 tones are heard, answering the distant computer, hang up the manual telephone. The MM-103 will automatically disconnect and return to the monitor program when the distant computer disconnects. The automatic disconnect feature may be disabled by eliminating lines 010E through 0134 and 015F through 0163. Line 0134 is re-entered as COMMO: IN 0. In this case, be sure to manually disconnect the MM-103 from the telephone line when you are finished communicating.

```
                    ; ORIGINATE PROGRAM WITH MANUAL DIALING.
0100                        ORG     0100H
                    ;MANUALLY DIAL THE NUMBER.
                    ;THEN EXECUTE THIS PGM. WHEN DISTANT MODEM ANSWERS,HANG-UP.
0100 DB01           START:  IN      1       ;DUMP THE KEYBOARD.
0102 3E7F                   MVI     A,7FH   ;MODEM SETUP FOR DTR.
0104 D3C3                   OUT     0C3H    ;MODEM CONTROL PORT.
0106 3E5D                   MVI     A,5DH   ;SWITCH HOOK + UART CONTROL.
0108 D3C0                   OUT     0C0H    ;CONTROL PORT.
010A 3E34                   MVI     A,34H   ;300 BAUD.
010C D3C2                   OUT     0C2H    ;RATE PORT.
010E DBC2           ANSPH:  IN      0C2H    ;WAIT UNTIL MODEM HOLDS THE LINE.
0110 E610                   ANI     10H
0112 C20E01                 JNZ     ANSPH
0115 3E5C                   MVI     A,5CH   ;TURN OFF SWITCH HOOK, LEAVE UART SETUP.
0117 D3C0                   OUT     0C0H    ;CONTROL PORT.
0119 DBC2           WCTS:   IN      0C2H
011B E610                   ANI     10H
011D C25F01                 JNZ     RTMON
0120 DBC2                   IN      0C2H
0122 D3FF                   OUT     0FFH
0124 E604                   ANI     04H     ;CTS TEST BIT.
0126 C21901                 JNZ     WCTS    ;WAIT FOR CTS.
0129 3E43                   MVI     A,'C'   ;PROMT TO TERMINAL FOR CTS ON.
012B D301                   OUT     1       ;TERMINAL DATA PORT.
012D DBC2           COMMO:  IN      0C2H    ;CHECK FOR LOSS OF CTS.
012F E604                   ANI     04H     ;CTS TEST BIT.
0131 C25F01                 JNZ     RTMON       ;RETURN TO MONITOR.
0134 DB00                   IN      0       ;KBD TEST PORT.
0136 E601                   ANI     1       ;KBD TEST BIT.
0138 C25101                 JNZ     MDATA
013B DB01                   IN      1       ;KBD    DATA PORT.
013D E67F                   ANI     7FH     ;MASK OFF PARITY.
013F 47                     MOV     B,A     ;SAVT IT.
0140 FE04                   CPI     04H     ;IF CONTROL D ABORT PROGRAM.
0142 CA5F01                 JZ      RTMON       ;GOTO MONITOR.
0145 D301                   OUT     1       ;ECHO IT FOR HALF DUPLEX.
0147 DBC0           DAOUT:  IN      0C0H    ;MODEM TEST PORT.
0149 E601                   ANI     1       ;TX TEST BIT.
014B CA4701                 JZ      DAOUT
014E 78                     MOV     A,B     ;RETREIVE CHARACTER.
014F D3C1                   OUT     0C1H    ;SEND IT.
0151 DBC0           MDATA:  IN      0C0H    ;MODEM  TEST    PORT.
0153 E602                   ANI     2       ;RECEIVE TEST BIT.
0155 CA2D01                 JZ      COMMO   ;LOOP IF NO DATA.
0158 DBC1                   IN      0C1H    ;DATA IN PORT.
015A D301                   OUT     1       ;PRINT IT.
015C C32D01                 JMP     COMMO   ;LOOP FOR MORE DATA.
                    ;
015F 3E00           RTMON:  MVI     A,0
0161 D3C3                   OUT     0C3H
0163 C30000                 JMP     0
0166                        END
```

LOOP BACK TEST PROGRAM

This BASIC program loops the Send Signal back through the filters to the Receive Demodulator. The receiver is switched to the transmit frequency and the filters are switched to the answer mode. The program transmits all possible bit combinations 3 times. The operator is prompted to enter the Baud rate. Rates from 65 to 600 Baud are acceptable. Rates much higher than 600 Baud will cause an error message to be printed. The protective coupler must be disconnected from the phone line for this test and left un-terminated, since a mismatch is required so that the duplexer will allow some of the transmitted signal to couple back to the receive filter.

```
1 REM LOOPBACK TEST PROGRAM.
2 REM UN-PLUG YOUR MM-103 PROTECTIVE COUPLER FROM THE TELEPHONE LINE.
10 REM TEST ALL DATA TRANSMISSION FUNCTIONS AT ALL BAUD RATES.
20 REM RATES ABOVE 650 BAUD WILL SHOW ERRORS.
30 REM HIGHER RATES ARE POSSIBLE IN THE LOOP BACK MODE THAN
40 REM MIGHT BE EXPECTED OVER TELEPHONE LINES, BECAUSE LINE
50 REM NOISE CONTRIBUTES TO ERRORS. A MM-103 WHEN IN GOOD
60 REM CONDITION WILL LOOP BACK WITHOUT ERROR AT 600 BAUD.
70 REM ERRORS AT 65 BAUD WILL INDICATE THAT THE MM-103 HAS
80 REM HARDWRE PROBLEMS.
90 REM EACH TEST LOOP WILL TAKE ABOUT 15 TO 55 SECONDS.
100 REM
110 REM LOOP BACK TEST .
120 PRINT"REMOVE TELEPHONE LINE PLUG FOR THIS TEST.
130 PRINT"ENTER BAUD RATE TO TEST":INPUT BR
140 S=250000!/BR/16
150 IF S]255 THEN 130
160 J=0
170 L=1
180 OUT 194,S
190 OUT 192,94 :   REM SET UP UART AND ANS MODE.
200 OUT 195,64 :REM TEST MODE
210 X=INP(193):X=INP(193) :REM CLEAR OUT UART REGISTER.
220 IF(INP(194)AND4)=4 THEN 220  :REM WAIT FOR CTS.
230 IF(INP(192)AND1)=0 THEN 230  :REM CHECK TX BUFFER EMPTY.
240 OUT 193,J
250 J=J+1 : IF J=256 THEN J=0
260 IF (INP(192)AND2)=0 THEN 260
270 T=INP(193)
280 IF T[]J-1 AND J[]0 THEN PRINT"ERROR","WAS",T,"HOULD BE",J,:E=T1
290 IF J=0 THEN PRINT"LOOP NO. "L:L=L+1
300 IF L=5 THEN 320
310 GOTO 230
320 OUT 195,0
330 OUT 192,0
340 PRINT"END OF TEST. ERRORS = ",E
```

```
;QUICK COMMUNICATIONS PROGRAM.
;DEMONSTRATING THE ABOSLOUTE MINIMUM PGM TO
;ESTABLISH COMMUNICATIONS IN ORIGINATE MODE.
;
;REQUIRES MANUAL DIALING THEN LOAD AND RUN THIS
;PROGRAM WHEN YOU HEAR THE ANSWER TONE FROM THE
;CALLED MODEM.
;
;THE MODEM MUST BE UN-PLUGGED FROM THE PHONE
;LINE AT END OF COMMUNICATIONS.
;
;LINKAGE TO CPM IS VIA THE BDOS.
;FOR CP/M 1.4 UP.
;
BDOS     EQU      5H       ;BDOS ENTRY POINT.
CONIN    EQU      1        ;CONSOLE INPUT.
CONST    EQU      11       ;CONSOLE STATUS CHECK.
CONOUT   EQU      2        ;CONSOLE OUTPUT.
;
;
         ORG      0100H    ;LOAD ADDRESS.
         MVI      A,93     ;SETS UART TO 8 BITS NO PARITY.
         OUT      0C0H     ;BASE ADDRESS OF MODEM BOARD.
         MVI      A,52     ;ESTABLISHES THE TIMER FOR 300 BAUD.
         OUT      0C2H     ;ADDRESS OF TIMER PORT.
         MVI      A,127    ;SETS UP MODEM FOR POIGINATE MODE.
         OUT      0C3H     ;ADDRESS OF MODEM CONTROL PORT.
         ;
;
;COMMUNICATIONS LOOP.
COMMO:   IN       0C0H     ;UART STATUS PORT.
         ANI      2        ;DATA AVAILABLE TEST BIT.
         JZ       KBD      ;IF ZERO NO MODEM DATA.
         IN       0C1H     ;GET DATA FROM MODEM UART.
         MOV      E,A      ;PUT RECEIVED CHARACTER IN E REG.
         MVI      C,CONOUT
         CALL     BDOS     ;OUTPUT TO CONSOLE
KBD:     MVI      C,CONST
         CALL     BDOS
         ANA      A        ;SET THE FLAGS.
         JZ       COMMO    ;LOOP IF NO INPUT.
         MVI      C,CONIN  ;GET CHARACTER TO SEND
         CALL     BDOS     ;FROM KEYBOARD.
         OUT      0C1H     ;SEND IT TO THE MODEM.
         JMP      COMMO    ;LOOP FOR MORE DATA.
         END


A>
```

```
;QUICK COMMUNICATIONS PROGRAM.
;DEMONSTRATING THE ABOSLOUTE MINIMUM PGM TO
;ESTABLISH COMMUNICATIONS IN ORIGINATE MODE.
;
;REQUIRES MANUAL DIALING THEN LOAD AND RUN THIS
;PROGRAM WHEN YOU HEAR THE ANSWER TONE FROM THE
;CALLED MODEM.
;
;THE MODEM MUST BE UN-PLUGGED FROM THE PHONE
;LINE AT END OF COMMUNICATIONS.
;
;LINKAGE TO CPM IS VIA THE BDOS.
;
BDOS    EQU     5H      ;BDOS ENTRY POINT.
CONIN   EQU     6       ;CONSOLE INPUT.
CONST   EQU     6       ;CONSOLE STATUS CHECK.
CONOUT  EQU     6       ;CONSOLE OUTPUT.
;
;
        ORG     0100H   ;LOAD ADDRESS.
        MVI     A,93    ;SETS UART TO 8 BITS NO PARITY.
        OUT     0C0H    ;BASE ADDRESS OF MODEM BOARD.
        MVI     A,52    ;ESTABLISHES THE TIMER FOR 300 BAUD.
        OUT     0C2H    ;ADDRESS OF TIMER PORT.
        MVI     A,127   ;SETS UP MODEM FOR POIGINATE MODE.
        OUT     0C3H    ;ADDRESS OF MODEM CONTROL PORT.
        ;
;
;COMMUNICATIONS LOOP.
COMMO:  IN      0C0H    ;UART STATUS PORT.
        ANI     2       ;DATA AVAILABLE TEST BIT.
        JZ      KBD     ;IF ZERO NO MODEM DATA.
        IN      0C1H    ;GET DATA FROM MODEM UART.
        MOV     E,A     ;PUT RECEIVED CHARACTER IN E REG.
        MVI     C,CONOUT
        CALL    BDOS    ;OUTPUT TO CONSOLE
KBD:    MVI     C,CONST
        MVI     E,0FFH  ;REQUEST STATUS.
        CALL    BDOS
        ANA     A       ;SET THE FLAGS.
        JZ      COMMO   ;LOOP IF NO INPUT.
        OUT     0C1H    ;SEND IT TO THE MODEM.
        JMP     COMMO   ;LOOP FOR MORE DATA.
        END


A>
```

TO USE THE INTERRUPTS

1. The interrupt mask register is loaded with the desired pattern, (OUT to relative address 2, see Fig. 7.0 on page 11) with data described in 2B, then an IN to relative address 3 transfers this mask to the interrupt holding register.

2. Relative address 2 must be reloaded with the baud rate or dial rate.

3. Bit 7 at relative address 0 must be set to 1 (together with other necessary bits required to set for UART control).

4. The CPU interrupts must be enabled.

5. If it is necessary to change the interrupt vector from RST7 (38 HEX) to some other location, a vectored interrupt card or a CPU card capable of responding to the S-100 interrupt lines E1 to E7 is required.

On the lower edge of the MM-103 board (near the edge connector) there are 8 unsoldered holes marked E1 to E8. There is a jumper soldered between E9 and E10 (this is for RST7, 8080 interrupt mode). The hole at E9 is the INT line on the S-100 bus. E10 is the interrupt request line from the PMMI MM-103.

To change the interrupt request from the PMMI MM-103 to any other S-100 vectored interrupt line, carefully remove the jumper, then jump E10 to the desired location (E1-E7) as required. E1-E7 are the S-100 vectored interrupt lines. Refer to the manual that accompanied your CPU or vectored interrupt card for further information regarding the use of vectored interrupts.

An alternate method of providing for the INTA signal which normally comes from line 96 of the S-100 bus must be provided if:
A. Your CPU does not provide for the interrupt acknowledge signal on line 96 of the S-100 bus.
B. When multiple MM-103 modems are operating on the same CPU, and you want full interrupt control over each MM-103 modem (not a soft ware polling mode). You may return the MM-103 to PMMI for this no-charge modification, or if you have the technical skill required, you may modify the MM-103 as follows:

A. Cut the track that runs from the edge connector at PIN 96 (interrupt acknowledge), near the first feed thru hole at the lower edge of the board.
B. Install a jumper using #30 wire-wrap wire from pin 5 of U12 a 7406 to pin 13 of the AUX OUT socket labled P3 at the top of the board.
After this modification; the MM-103 will not respond to the INTA signal from the CPU. It will be necessary to provide the INTA via software by controlling the level of AUX OUT 3, which is bit 7 of the modem control word at relative address 3, this would be done in your interrupt service routine.

8.1 MOTOROLA 6860 MODEM CHIP

8.1.2 GENERAL

The block diagram shows the MODEM and its interconnections. The data to be transmitted is presented in serial format to the modulator for conversion to FSK signals for transmission on the telephone line. The modulator output is filtered before driving the line.

The FSK signal from the remote MODEM is received via the telephone line and filtered to remove extraneous signals such as the local Transmit Carrier. This filtering can be either a bandpass which passes only the desired band of frequencies or a notch which rejects the known interfering signal. The desired signal is then limited to preserve the axis crossings and fed to the demodulator where the data is recovered from the received FSK carrier.

The Supervisory Control provides the necessary commands and responses for handshaking with the remote MODEM, along with the interface signals to the data coupler and computer.

8.1.3 ANSWER MODE

Automatic answering is first initiated by receipt of a Ring Indication (RI) signal. The presence of the Ring Indicator signal places the MODEM in the Answer Mode; if the Data Terminal Ready line is high indicating that the communication termain is ready to send or receive data, the Answer Phone output goes high. This output is designed to drive a transistor switch which will activate the Off Hook (OH) and Data Transmission (DA) relays in the protective coupler. Upon answering the phone the 2225-Hz Transmit Carrier is turned on.

The originate MODEM at the other end detects this 2225-Hz signal and after a 450 ms delay (used to disable any echo suppressors in the telephone network) transmits a 1270-Hz signal which the local answering MODEM detects, provided the amplitude and frequency requirements are met. The amplitude threshold is set external to the MODEM chip. If the signal level is sufficient the Threshold Detector (sensitivity) input should be low for 20 microseconds at least once every 32 ms. The absence of a threshold indication for a period greater than 51 ms denotes the loss of Receive Carrier and the MODEM begins hand-up procedures. Hang-up will occur 17 s after RI has been released provided the handshaking routine is not re-established. The frequency tolerance during handshaking is ± 100 Hz from the Mark Frequency.

After the 1270-Hz signal has been received for 150 ms, the Receive Data is unclamped from a Mark condition and data can be received. The Clear-to-Send output goes low 450 ms after the receipt of carrier and data presented to the answer MODEM is transmitted.

8.1.3.1 Automatic Disconnect

Upon receipt of a space of 150 ms or greater duration, the MODEM clamps the Receive Break high. This condition exists until a Break Release command is issued at the receiving station. Upon receipt of a 0.3 s space, with Enable Short Space Disconnect at the most negative voltage (low), the MODEM automatically hangs up. If Enable Long Space Disconnect is low, the MODEM requires 1.5 s of continuous space to hang up.

8.1.4 ORIGINATE MODE

Upon receipt of a Switch Hook (SH) Control Word 0, Bit 0 command, the MODEM function is placed in the Originate Mode. If the Data Terminal Ready input is enabled (low) the MODEM will provide a logic high output at Answer Phone. The MODEM is now ready to receive the 2225-Hz signal from the remote answering MODEM. It will continue to look for this signal until 17 s after SH has been released. Disconnect occurs if the handshaking routine is not established.

Upon receiving 2225 ± 100 Hz for 150 ms at an acceptable amplitude, the Receive Data output is unclamped from a Mark condition and data reception can be accomplished. 450 ms after receiving a 2225-Hz signal, a 1270-Hz signal is transmitted to the remote MODEM. 750 ms after receiving the 2225-Hz signal, the Clear-to-Send output is taken low and data can now be transmitted as well as received.

8.1.4.1 Initiate Disconnect

In order to command the remote MODEM to automatically hang up, a disconnect signal is sent by the local MODEM. This is accomplished by pulsing the normally low Data Terminal Ready into a high state for greater than 34 ms. The local MODEM then sends a 3 s continuous space and hangs up provided the Enable Space Disconnect is low. If the remote MODEM hangs up before 3 s, loss of Threshold Detect will cause loss of Clear-to-Send, which marks the line in Answer Mode and turns the carrier off in the Originate Mode.

If ESD is high the MODEM will transmit data until hang-up occurs 3 s later. Transmit Break is clamped 150 ms following the Data Terminal Ready interrupt.

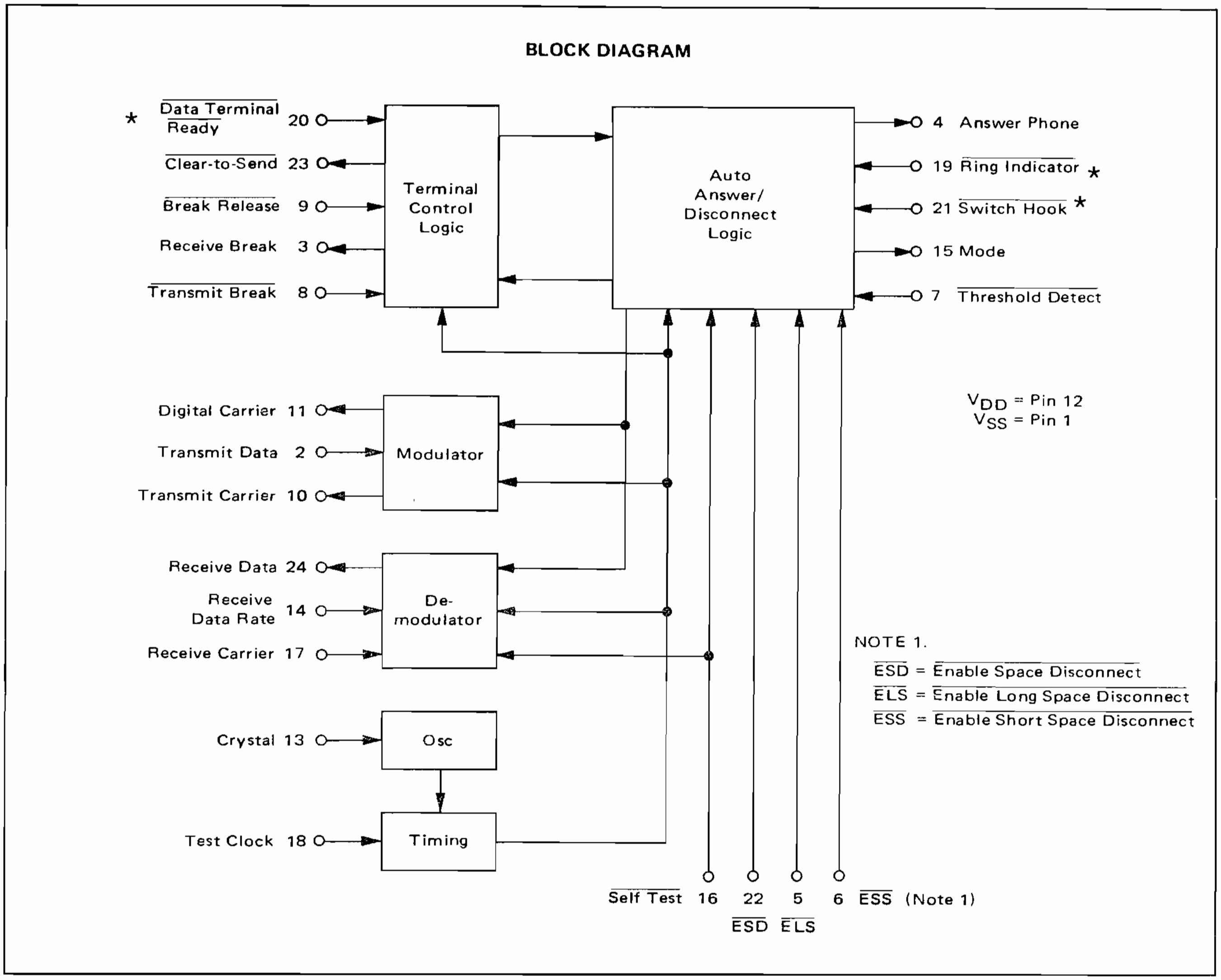


FIGURE 8.0-1
6860 MODEM CHIP BLOCK DIAGRAM

*NOTE: THESE BITS HAVE BEEN INVERTED IN THE MM-103 LOGIC

North Star Users Test And Verify Programs.

North Star Basic returns a one or zero as the results of a logical "AND" operation. The examples in this manual require that the "AND " function provide a logical operation where each individual bit is masked, with only the status of a single bit being returned.

The following programs are for the North Star and other users whose Basic does not provide for logical "AND".

```
10 REM ***MM-103 MODEM LOOPBACK TEST***
20 PRINT"THIS PROGRAM LOOPS THE OUTPUT SIGNAL FROM YOUR MODEM BACK"
30 PRINT"THROUGH THE RECEIVER CIRCUITRY.  THE PROGRAM TRANSMITS"
40 PRINT"ALL POSSIBLE BIT PATTERNS 5 TIMES.  A RATE FROM 65 TO 600"
50 PRINT"BAUD IS SELECTABLE.  A RATE HIGHER THAN 600 WILL CAUSE"
60 PRINT"ERRORS.  ERRORS AT 65 BAUD INDICATE THAT THE MM-103 HAS"
70 PRINT"HARDWARE PROBLEMS.  NOTE THAT HIGHER RATES CAN BE"
80 PRINT"TESTED IN LOOPBACK THAN MIGHT BE USABLE OVER A REAL"
90 PRINT"TELEPHONE LINE.  THE PROTECTIVE COUPLER MUST BE"
100 PRINT"DISONNECTED FROM THE PHONE LINE FOR THIS TEST."
110 PRINT
115 ERRSET 400,L1,E1
120 P0=224\P1=P0+1\P2=P0+2\P3=P0+3
130 INPUT"ENTER TEST BAUD RATE (65-600)\ ",B
140 S=250000 /B/16
150 IF S>255 THEN 130
165 E=0
180 OUT P2,S\REM SET RATE
190 OUT P0,94\REM SET UP UART AND ANSWER MODE
200 OUT P3,64\REM TEST MODE
210 X=INP(P1)\X=INP(193)\REM CLEARLIST
220 X=INP(P2)\IFINT(X/4)-2*INT(X/8)=1THEN220\REM WAIT FOR CLEAR TO SEND
222 FOR L=1 TO 5
225 J=0
229 REM WAIT FOR TRANSMIT BUFFER EMPTY
230 X=INP(P0)\IFINT(X)-2*INT(X/2)=0THEN 230
240 OUT P1,J\REM SEND BIT PATTERN J
255 REM WAIT FOR DATA AVAILABLE
260 X=INP(P0)\IFINT(X/2)-2*INT(X/4)=0THEN260
270 T=INP(P1)\REM GET LOOPBACKED CHARACTER
280 IF T=J THEN 310
290 PRINT"ERROR.  SENT\ ",J,".  RECEIVED\ ",T
300 E=E+1\REM INCREMENT ERROR COUNTER
310 J=J+1\REM NEXT BIT PATTERN
320 IF J<256 THEN 230
330 PRINT "PASS ",L," COMPLETE."
340 NEXT L
350 OUT P3,0
360 OUT P0,0
370 PRINT "END OF TEST."
380 PRINT E," TOTAL ERRORS."
390 STOP
400 PRINT"TEST ABORTED."
410 GOTO 350
420 END
```

```
10 REM PROGRAM TO SET THE DIAL TONE DETECTOR
20 REM VERSION 1.0 (11/19/79) FOR N STAR BASIC
30 P0=224\ REM BASE PORT IN DECIMAL.(E0 HEX)
40 P1=P0+1
50 P2=P0+2
60 P3=P0+3
70 OUT P3,0\REM CLEAR MODEM TO IDLE.
80 OUT P3.255\REM SET THE TIMER FOR .1 SECOND INTERVALS.
90 OUT P0,0\REM CLEAR TO ON HOOK CONDITION.
100 PRINT"THIS PROGRAM IS USED TO SET THE DIAL TONE DETECTOR."
110 PRINT"ON A PMMI MM-103 MODEM BOARD."
120 PRINT
130 PRINT
140 PRINT"THE MODEM BOARD SHOULD BE INSTALLED IN THE COMPUTER."
150 PRINT"THE COUPLER SHOULD BE CONNECTED TO THE BOARD AND ALSO"
160 PRINT "TO THE PHONE LINE.  THE ADDRESS SWITCHES SHOULD BE SET"
170 PRINT "FOR ADDRESS E0 HEXADECIMAL.  (1,2,3 OPEN.  4,5,6 CLOSED.)"
175 PRINT
180 PRINT "IF NOT, TURN OFF THE COMPUTER, CONNECT IT UP"
190 PRINT "AND RERUN THIS PROGRAM."
195 PRINT
200 PRINT "IF ALL IS CONNECTED CORRECTLY, PRESS RETURN."
220 INPUT "",X$
225 PRINT
230 PRINT "ROTATE THE DIAL TONE SENSITIVITY CONTROL (R9 AT THE TOP"
240 PRINT "CENTER OF THE BOARD) FULLY COUNTER-CLOCKWISE."
250 PRINT "PRESS RETURN WHEN YOU HAVE DONE THIS."
260 PRINT
270 INPUT "",X$
280 PRINT
290 PRINT "NOW SLOWLY ROTATE THE SENSITIVITY CONTROL CLOCKWISE UNTIL"
300 PRINT "A MESSAGE IS DISPLAYED."
305 GOSUB 800
310 IF T=150 THEN 500
320 IF T<5 THEN 560
330 PRINT "DIAL TONE RECEIVED IN ",T/10," SECONDS."
340 PRINT
350 PRINT "NEXT, ROTATE THE CONTROL AN ADDITIONAL 5 TO 10 DEGREES"
360 PRINT "CLOCKWISE.  PRESS RETURN WHEN YOU HAVE DONE THIS."
370 INPUT "",X$
380 GOSUB 800
390 IF T<5 THEN 440
400 IF T=150 THEN 480
410 PRINT "DIAL TONE RECEIVED IN ",T/10," SECONDS."
420 PRINT "THIS COMPLETES THE DIAL TONE DETECTOR ADJUSTMENT."
430 STOP
```

```
440 PRINT "FALSE DIAL TONE RECEIVED IN ",T/10," SECONDS."
445 PRINT
450 PRINT "ADDITIONAL 5 TO 10 DEGREES ROTATION WAS TOO MUCH."
460 PRINT "START OVER AGAIN."
470 GOTO 225
480 PRINT "NO DIAL TONE RECEIVED IN ",T/10," SECONDS."
485 PRINT "PERHAPS THE ADDITIONAL ROTATION WAS IN THE"
486 PRINT "WRONG DIRECTION.  START OVER AGAIN."
490 GOTO 225
500 PRINT
510 PRINT "*** NO DIAL TONE RECEIVED IN ",T/10," SECONDS."
520 PRINT "VERIFY THAT THE BOARD AND PROTECTIVE COUPLER ARE"
530 PRINT "INSTALLED CORRECTLY, AND THAT THE BOARD ADDRESS"
540 PRINT "SWITCHES ARE SET PROPERLY."
550 GOTO 130
560 PRINT "FALSE DIAL TONE RECEIVED IN ",T/10," SECONDS."
570 PRINT "COULD BE NOISY PHONE LINE.  BE SURE SENSITIVITY CONTROL"
580 PRINT "IS FULLY COUNTER CLOCKWISE.  PRESS RETURN TO TRY AGAIN."
600 GOTO 270
610 END
800 REM SUBROUTINE TO MEASURE DIAL TONE DETECT TIME
810 OUT P0,1\REM GO OFF HOOK
820 T=1\REM INITIALIZE TIME COUNTER
830 IF INP(P2)>=128 THEN 830\REM WAIT FOR TIMER PULSE OFF
840 T=T+1\REM COUNT ANOTHER CLOCK TICK
850 IF T=150 THEN 890\REM IF TOOK TOO LONG
860 IF INP(P2)<128 THEN 860\REM WAIT FOR TIMER PULSE ON
870 X=INP(P2)\IF INT(X)-2*(INT(X/2))=1 THEN 830
880 REM DIAL TONE RECEIVED
890 OUT P0,0\REM GO ON HOOK
900 RETURN
```

NOTES: