T-75-33-90

CH1780 — Intelligent Modem Module

INTRODUCTION

The CH1780 modem module offers perhaps the fastest and easiest way of integrating a high performance modem into a product. Integration consists of mounting the module on the product's circuit card, connecting it to power, the host UART/USART, and to the phone line through an RJ-11C jack. The component module is a fully assembled and tested subassembly ready to plug in and use.

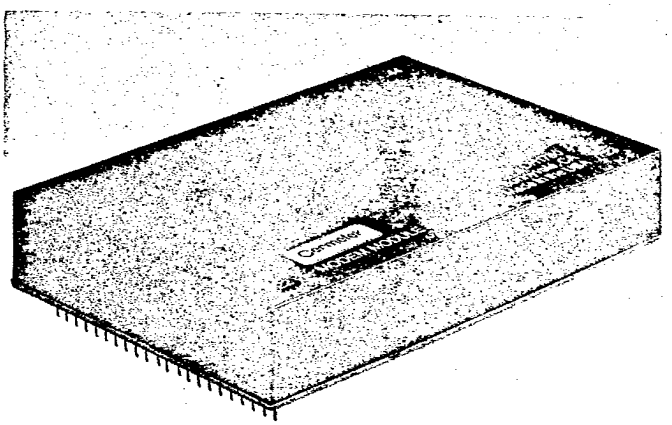
In addition to conserving the engineering design and integration time, the modem module shortens a product introduction cycle. Since it is FCC (Federal Communications Commission) registered for phone line connection, the three months or longer normally needed to gain FCC Part 68 registration is eliminated.

The CH1780 is CCITT V.22 bis, CCITT V.22, Bell 212A and Bell 103 compatible. It can communicate with the most commonly used modems at data rates of 2400, 1200, 0-300 bps. It will automatically adapt to the speed of the remote modem. The module responds to the popular "AT" command set allowing it to answer incoming calls, place outgoing calls — using true call progress detection — and execute diagnostic tests.

The CH1784 contains an international 4.5 KV isolation interface and is interchangeable with the CH1780 which has the North American Interface. Both modules can be selectively populated into a user's design to provide a universal solution.

FEATURES

- 2400 1200, 0-300 bits per second
- Compatible with CCITT V.22 bis, CCITT V.22, Bell 212A, Bell 103
- FCC registered
- 9.5 square inches
- Auto-dial, auto answer "AT" command compatible full call progress detection
- Full diagnostic test set
- Low power standby mode



GENERAL DESCRIPTION

Connecting to the Host UART/USART

Since a modem transmits data serially and most host products handle data in a parallel format, a UART or USART is needed to make parallel-to-serial and serial-to-parallel translations.

THE SERIAL INTERFACE LINES

The module supports a full RS-232C serial interface. Signal levels are TTL rather than RS-232C level compatible, which allows you to directly connect the modem to your host's UART/USART without level translating circuitry. These signals are summarized in Table 1. A complete description of each signal may be found in the Pin Description section.

Three of these lines must be utilized for proper modem operation; TXD, RXD and DTR. The modem is controlled by sending it serial commands over TXD and can be monitored by serial status messages returned on RXD. DTR must be asserted ON (LOW) for the modem to interpret commands sent to it on TXD and will disconnect a call if it is asserted OFF (HIGH) during a call.

All other serial interface lines may be utilized for the convenience of your application but are not required by the modem.

SERIAL DATA FORMAT

Two serial data formats are supported by the CH1780: synchronous or asynchronous.

Table 1. Host Serial Interface Summary

Serial Name	Pin No.	Description	Direction
TXD	35	Transmit Data	To Modem
RXD	32	Receive Data	From Modem
CTS	25	Send-to-Clear	From Modem
DSR	26	Data Set Ready	From Modem
DCD	29	Data Carrier Detect	From Modem
HS	16	Speed Indication	From Modem
TCLK	10	Transmit Clock	From Modem
RCLK	9	Receive Clock	From Modem
DTR	36	Data Terminal Ready	To Modem
RI	23	Ring Indication	From Modem
ECLK	38	External TX Clock	To Modem
TM	28	Test Mode *	From Modem

Serial data format is selected by the level applied to SYNC Pin 42. A LOW on this input selects asynchronous data operation whereas a HIGH on this pin sets synchronous operation.

The SYNC input is sampled by the modem during the set-up of a data call and the modem switches to the indicated data format during the data call.

The modem always maintains the asynchronous state before a call, independent of SYNC, since its command interpreter and its status messages are always asynchronous. This allows synchronous applications to command the modem to auto-dial, for example, if they are temporarily able to switch to an asynchronous format before a call.

ASYNCHRONOUS FORMAT

Data or commands may be sent to the modem on Pin TXD at either 300, 1200 or 2400 bps. Received data on Pin RXD is sent to the host's UART/USART at 300, 1200, or 2400 bps. The approximately ±3% received bit rate is well within your UART/USART's receive range (usually ±4.5%) and allows the modem to operate on data calls where the remote transmitting modem is sending data at a slightly overspeed rate. The signal rate for 300, 1200, or 2400 is within +2.3%/−2.5%.

SYNCHRONOUS FORMAT

If Sync is set HIGH, once a data call has been initiated the modem will operate with a synchronous format.

Data that is received from the remote modem is presented on RXD and should be clocked by the synchronous USART on the negative going edge of the receive clock, RCLK, Pin 9.

TRANSMIT DATA is supplied to the modem on TXD and is sampled by the modem on the negative going edge of TCLK, Pin 10.

Either the host or the modem can control the TCLK signal. The host can control this signal by asserting its own transmit timing clock on the external clock input, ECLK, Pin 38. This clock must be 1200 Hz (or 2400 Hz) ±0.01% and have a 50% ±1% duty cycle. If the modem senses no signal applied on ECLK, then it asserts its own internal timing clock on TCLK.

If it is desired to operate the modem in a SLAVE configuration (where the modem's receive clock is used as its transmit clock), RCLK should be externally connected to ECLK.

SPEED AND PARITY SELECTION

Before a call, the modem adjusts to the host speed (2400, 1200, or 300) and parity (odd, even, mark, space or none) via a host-initiated training sequence. This also selects the speed of the data call for originate calls. The modem automatically adapts to the caller's speed on answer calls.

The modem matches the host's parity when it returns status messages to the host. During a data connection, however, the modem passes parity through without interpretation or alteration.

Power Supply

The modem module is in effect a complex sub-system that may be treated as any other component. You should pay special attention to the power supply connections for the modem. The modem must decode analog signals from the telephone line that are in the millivolt range and even though the modem is designed to withstand significant induced power supply noise, there is a limit. You must take steps to guarantee that power supply noise on all supply lines, including ground, does not exceed 50 mV peak to peak. Failure to provide such operating conditions could cause the modem to malfunction.

It is recommended that you place by-pass capacitors on each modem power supply line and mount these elements as close to the module as practical. It is recommended that for the +5V supply, a 220 μF Electrolitic Capacitor in parallel with a 0.01 μF disc capacitor be used. For other supplies, a 100 μF Electrolitic should be substituted for the 220 μF capacitor.

Table 2. Power Supply Input Tolerance

Supply	Tolerance
+ 5 Volts	±5%
−12 Volts	±10%

Mounting the Modem

The modem modules contain static-sensitive devices and therefore should only be handled by personnel in areas that are properly protected against static discharge.

There are two popular mounting techniques that are recommended for physically connecting the modem to your circuit card; 1) sockets, and 2) direct soldering. Each approach has its own set of benefits and challenges to overcome.

The direct soldering approach solders the modem directly into the host circuit card. This approach provides the most sound mechanical mounting and also the best electrical connections. However, it does present a couple of challenges.

If the modem is wave soldered on a circuit card, flux and other corrosive chemicals can be left inside the modem's plastic housing. Care should be taken during the freon rinse cycle to fully wash the chemical residue away. Ideally, the modem should be soldered in by hand after the rest of the card is wave soldered to minimize this problem. Also, soldering can present a sizable challenge if the modem ever needs to be removed from the card. Unsoldering 44 contacts can prove damaging to the circuit card unless proper desoldering equipment is used.

If the direct soldering approach is selected, it is recommended that 0.040 inch diameter holes in the circuit card be used for each modem pin with 0.060 inch diameter minimum PC trace pads.

The socketing approach to modem mounting eliminates cleaning and desoldering concerns. When a socket is used, it must make a solid connection to all modem module pins. Failure to do so will cause unpredictable or unreliable modem operation. Also, steps should be taken to assure that the module remains tightly seated in the socket after the host product is shipped. One method of achieving this is to use a cable wrap fastened around the module to hold it to the circuit card.

If you decide to select the socket route, make sure that the socket is designed to accept square 0.025 inch pins. Generally, single-in-line sockets may be purchased from manufacturers such as SAMTEC, AMP, Robinson Nugent or Augat. Consult your socket distributor for further information.

APPLICATIONS

The Cermetek Modem Component Modules integrate easily into most 2400, 1200, 300 bps full duplex modem applications. Each application requires the user to connect it to the phone line, to the host product through a UART (Universal Asynchronous Receiver Transmitter) or USART (Universal Synchronous Asynchronous Receiver Transmitter), and to the power supply. The following discussion will guide you through these connections, give you design examples, and also make recommendations for printed circuit board layout.

Connecting to the Phone Line

Each module incorporates an FCC Part 68 registered DAA to make phone line connection easy. The DAA includes circuits that couple the modem signals to the phone line and provides FCC required isolation and protection. The modem's FCC registration

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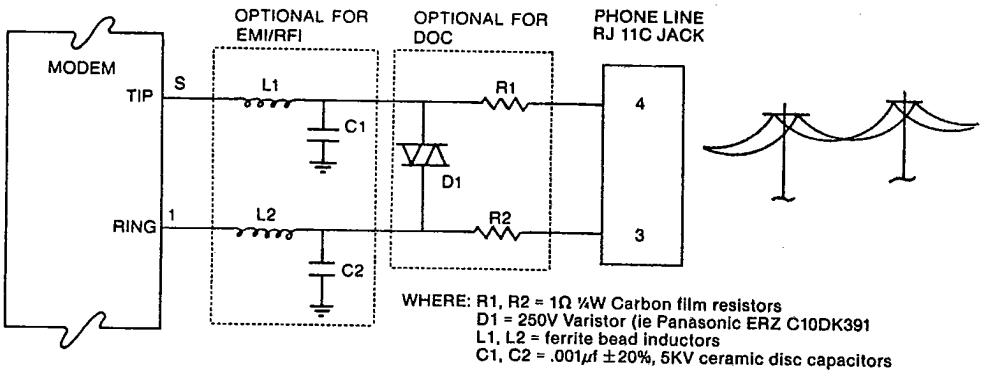


Figure 1. Telephone Line Interface

may be used by the host product without re-registration provided the following guidelines are followed.

PHONE USE CONNECTION GUIDELINES

1) The mounting of the CH1780 in the final assembly must be made so that it is isolated from exposure to any hazardous voltages within the assembly. Adequate separation and restraint of cables and cords must be provided.
2) The circuitry from the CH1780 to the telephone line interface must be provided in wiring that carries no other circuitry than that specifically allowed in the rules (such as A and A1 leads).
3) Connection to the phone line should be made through an RJ-11C jack as shown in Figure 1.
4) Traces from the modem's RING and TIP pins to the RJ-11C jack must exceed 0.1 inch spacing to one another and 0.2 inch spacing to all other traces. The traces should have a nominal width of 0.020 inches or greater.
5) The length of the RING and TIP traces should be as short as possible and should be oriented to prevent coupling from other high speed or high frequency signals on the host circuit card.
6) No additional circuitry other than that shown in Figure 1 may be connected between the modem module and phone line's RJ-11C jack.
7) The supplied FCC registration label must be applied visibly on the outside of the host product.
8) The host product's User Manual must provide the user with connection and use instructions as recommended in a later section, "FCC Registration."

The modem module meets the high voltage and transient requirements of the FCC which governs U.S. phone lines. For applications that connect to Canadian phone lines, governed by the DOC (Department of Communications), a higher level of transient protection is required, thereby making the two resistor and one varistor circuits (R1, R2 and D1 in Figure 1) mandatory. Adding these three devices will not affect FCC registration and so are optional for U.S. only applications.

For applications that may be connected to either U.S. or Canadian phone lines, it is recommended that the additional transient protection be designed in from the start, since their incremental cost is low.

Components L1, L2, C1 and C2 are optional and serve two purposes. First, they restrict high frequency signals from reaching the phone line and thereby add EMI protection. Second, they protect against externally generated RFI from degrading the modem's ability to operate on proper carrier signals.

The module partially powers the DAA circuit from the phone line's loop current. This loop current is guaranteed by the phone company to be at least 20 mA. If the modem is operated with any line other than a switched network phone line, additional circuitry must provide loop current for proper operation.

The CH1780 provides additional audio coupling inputs (RXA) behind the protective DAA. These may be used to attach a speaker for line monitoring.

Design Example #1

The best way to provide application information for a modem is by example. The following design examples will briefly show how the modem modules are utilized in common applications.

MINIMAL ASYNCHRONOUS INTEGRAL MODEM

The CH1780 can be used to implement a simple asynchronous integral modem. Any TTL compatible UART such as an 8251A, 6851 or an 8250 or the serial port of a microcontroller will operate satisfactorily.

After each power-up, it is important to apply a low-going RESET pulse to the modem on RST, Pin 14, for a minimum of 1 ms.

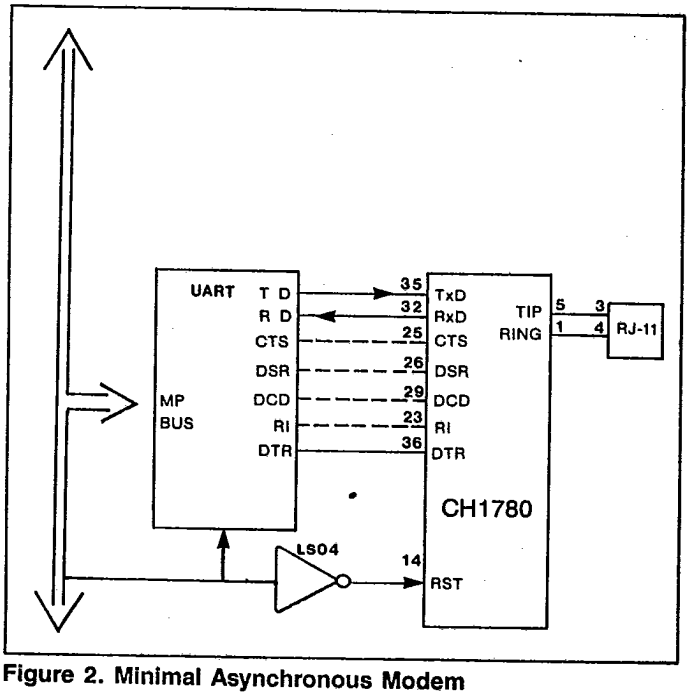


Figure 2. Minimal Asynchronous Modem

Table 3
CH1780 Pin Description

Pin	Name	I/O	Function
			TELEPHONE LINE INTERFACE PINS
1 & 5	RING, TIP*	I/O	Directly connects to the telephone line's RING and TIP leads through a user-supplied RJ-11C telephone line jack.
8	RI STBY	O	**STANDBY RING INDICATOR.** This output follows the ringing signal when present on the phone line. This output will operate as long as power is applied to the "+5V Stby" even though power has been removed from the main supply inputs.
11	OHI*	I	**OFF-HOOK INPUT.** A HIGH on this signal takes the telephone line interface OFF-HOOK. It should be directly connected to OHO, Pin 24.
22	RXA*	O	**RECEIVE AUDIO.** An audio output referenced to ground. Audio received from the telephone line is asserted on this pin.
23	RI/*	O	**RING INDICATION.** A LOW level indicates that the local telephone line is ringing. This signal follows the envelope of the ringing signal (normally 2 seconds ON, 4 seconds OFF).
24	OHO*	O	**OFF-HOOK OUTPUT.** A HIGH condition indicates the modem is OFF-HOOK. If pulse dialing is initiated, this pin will also follow the dial pulses.
			HOST INTERFACE
9	RCLK	O	**RECEIVE CLOCK** output. The RCLK output is the high speed (2400 bps) recovered data clock. Receive data appears at Pin 32 and should be sampled on the negative going edge of this clock.
10	TCLK	O	**TRANSMIT CLOCK** output. This output follows the selected transmit clock used by the modem. One of three different clocks may be chosen: —external clock, Pin 38 driven —internal clock, Pin 38 tied HIGH —receive clock, Pin 9 externally connected to Pin 38.
16	HS/*	O	**SPEED INDICATION.** High speed select output. A LOW on this pin indicates the modem is operating at 2400 bps. If HS is HIGH, 300 bps is supported. When the modem operates at 1200 bps the HS signal will toggle between LOW and HIGH. HS is always HIGH until a call has been established.
25	CTS/*	O	**CLEAR-TO-SEND** output. When this signal is LOW the modem has set up the data call and is ready to transmit data.
26	DSR/*	O	**DATA SET READY** output. A LOW output on this pin indicates the modem is OFF-HOOK.
28	TM/*	O	**TEST MODE** output. This output is asserted LOW whenever the modem enters a diagnostic test mode.
29	DCD/*	O	**DATA CARRIER DETECT** output. When this output is asserted LOW the received data carrier is present on the telephone.
32	RXD*	O	**RECEIVE DATA.** Serial receive data output. Received MARKING or a binary 1 condition is indicated by a HIGH output.
35	TXD*	I	**TRANSMIT DATA.** Serial transmit data input. Marking or a binary 1 condition is transmitted when a HIGH is asserted.
36	DTR/*	I	**DATA TERMINAL READY** input. This input must be asserted LOW before the modem can interpret commands, answer or initiate calls. Once a call has been established, this line can be used to disconnect the call by asserting DTR HIGH for greater than 50 ms.

Table 3. CH1780 Pin Description cont'd.

Pin	Name	I/O	Function
			HOST INTERFACE cont'd.
37	RDL	I	**REMOTE DIGITAL LOOPBACK** input. When this input is asserted LOW, the module signals the remote modem to enter the digital loop state. Upon receiving acknowledgement that remote digital loop is complete, the modem asserts its TM output LOW. This flat mode is only supported when the modem is in the 1200 or 2400 bps speed mode.
38	ECLK	I	**EXTERNAL TRANSMIT CLOCK** input. For synchronous mode operation with an external clock.
			MISCELLANEOUS SIGNALS
14	RST/*	I	**RESET** input (active LOW). This should be utilized in all systems. After each power-up cycle, this input should be asserted LOW for at least 1 ms after the +5V supply is stable and greater than 4.5V. RESET is then returned to HIGH for normal operation.
31	MC/	O	**MODEM CHECK** output. This output has two functions: 1) when the modem is placed in any one of the self test modes, MC is pulsed HIGH for 300 ms if a receive data error is detected, and 2) MC is asserted HIGH in the absence of receive data carrier when not in a self test mode.
43	ANS/	I	**MANUAL ANSWER** input. When DTR/ is LOW and the modem is in Idle mode, holding ANS/ LOW for at least 1 ms will cause the modem to go off hook and enter the Answer mode. When DTR/ is LOW and the modem is online, holding ANS/ LOW for at least 1 ms will drop the connection. When DTR/ is HIGH ANS/ has no effect. (not currently supported)
44	ORIG/	I	**MANUAL ORIGINATE** input. When DTR/ is LOW and the modem is in Idle mode, holding ORIG/ LOW for at least 1 ms will cause the modem to go offhook and enter the Originate mode. When DTR/ is LOW and the modem is online, holding ORIG/ LOW for at least 1 mS will drop the connection. When DTR/ is HIGH ORIG/ has no effect. (not currently supported)
			MODE CONTROL LINES The following signals control the default setting of the module. If left unconnected, the input will be treated as HIGH.
40	DUMB/ $\overline{\text{SMART}}$		LOW — Recognizes commands HIGH — Ignores all commands
41	BELL/ CCITT		LOW — Modem defaults to Bell 212A/103 when speed is less than 2400 bps HIGH — Modem defaults to CCITT V.22 when speed is less than 2400 bps
42	SYNC/ ASYNC		LOW — Modem operates synchronously HIGH — Modem operates asynchronously

Power

+5V* Power supply input, pin 15
−12V* Power supply input, pin 20
GND* Signal and power ground, pin 21
+5STDBY Power for ring detector, pin 17

*These pins are in common with the CH1784 and support basic asynchronous modem operations.

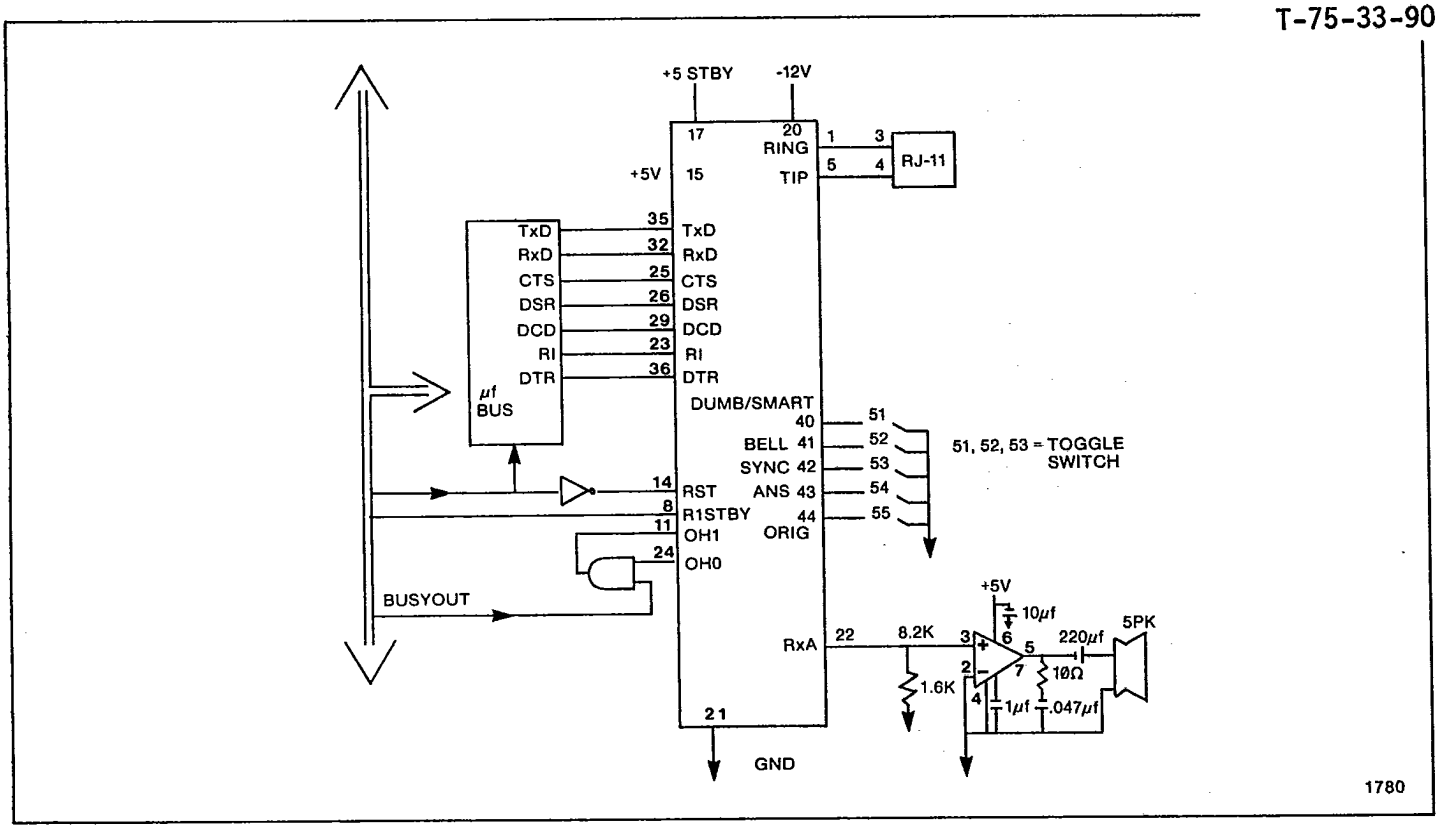


Figure 3. Full-Featured Integral Modem

Design Example #2

FULL FEATURED INTEGRAL MODEM

The circuit shown in Figure 3 shows a schematic using most of the hardware features of the CH1780. The switches on the right side of the drawing are all used to determine default setting for various commands. These defaults are restored each time the modem is reset. The momentary switches connected to ORIG and ANS are used to manually place the modem on-line.

This drawing demonstrates how to use the RXA output to monitor the progress of calls. The M command determines when the RXA output will have signals to the speaker.

In applications where it is important to conserve power the modem is usually turned off when not in use. This would normally prevent the host from detecting incoming calls. The CH1780 makes it possible to get around this problem. The +5VSTBY should always be connected to the 5 Volt supply. If power is turned OFF to +5V and −12V pins but +5SVTBY is powered then RISTBY will be activated when RINGING voltage is present at TIP and RING. RISTBY is normally LOW but when the RINGING voltage is present it will toggle from LOW to HIGH and back at typically 20Hz of the ringing voltage. The circuit shown can be used to convert this output to logic levels that follow the envelope of the ringing voltage.

With the HS, MC, and TM outputs, LED lamps can easily be driven by any output to display the output's STATE visually.

MODEM CONTROL

The CH1780 Modem Module may be controlled by sending serial ASCII command sequences. The commands are sent to the modem serially on TXD, pin 35. After execution of the command, the modem returns a serial status message on RXD, Pin 32, to indicate the completion status of the command.

Initializing the Modem

Before commands may be sent to the modem, the modem must be initialized. This consists of two events: 1) after power-up, a hardware reset pulse must be applied to the modem, and 2) the modem must be trained to the host UART/USART's speed (2400, 1200, 300 bps) and parity (odd, even, mark, space or none).

POWER-UP RESET

After applying power to the modem, a low-going reset pulse must be applied on RST, Pin 14, for at least 1 ms after the +5V power supply has stabilized above +4.5V.

No commands should be sent to the modem for a minimum of 1 second after releasing the reset signal.

TRAINING THE MODEM

The modem must be trained to match the host's speed and parity so that it is able to recognize serial asynchronous commands sent to it by the host UART. The host must retrain the modem each time a reset signal is applied on RST or after a RESET serial command. The modem is trained by sending it the following three character sequence:

AT[CR]

where: **A** and **T** must all be upper case or lower case
[CR] represents carriage return

The modem will respond with either one of the following status messages, depending on whether is is optioned for abbreviated or English status messages.

0[CR] (abbreviated form)
[CR][LF]OK[CR][LF] (English form)
where: **[CR]** represents carriage return (ASCII 13)
[LF] represents line feed (ASCII 10)

The modem may be retrained any time while it is idle.

Another attention sequence "A/" is much like the "AT" sequence except it repeats the previously entered command specified with an "AT" prefix. When given, it must also be in upper case ASCII. No carriage return is needed.

THE COMMAND FORMAT

Typical commands consist of three elements, the attention sequence, the commands themselves, and a terminating carriage return.

AT[commands][CR]
where: **[CR]** represents carriage return (ASCII 13)

When entering commands to the modem, the backspace character — control-H (ASCII 8) — can be used to edit mistakes. "AT" and "A/" may not be edited however. Multiple commands may be placed in the command line. A command line may be as long as 40 characters, excluding AT. The command below instructs the modem to configure itself to not echo characters in the command mode (E0) and then go to answer mode.

ATE0A[CR]

Table 4. Command Summary Table

COMMAND	DESCRIPTION
AT	: Command line prefix (ATtention code); precedes command lines except +++ (escape) and A/ (repeat) commands
A	: Go off-hook in answer mode
A/	: Re-execute last command line; (A/ is not followed by a carriage return)
B	: Selects CCITT V.22 operation when communicating at 1200 bps
B1	: Selects Bell 212A operation when communicating at 1200 bps
D	: Dial number which follows D in the command line (See Dial Discriptors)
E	: Modem does not "echo" commands back to terminal
E1	: Modem "echos" commands back to terminal
H	: On Hook (hang up)
H1	: Off Hook
I	: Request product Identification Code
I1	: Performs checksum on firmware ROM; returns checksum
I2	: Performs checksum on firmware ROM; returns OK or ERROR
L, L1	: Low speaker volume
L2	: Medium speaker volume
L3	: High speaker volume
M	: Speaker off
M1	: Speaker on until carrier detected
M2	: Speaker always on
M3	: Speaker on until carrier detected except during dialing
O	: Return to on-line state
O1	: Return to on-line state and initiate equalizer retrain
Q	: Modem returns result codes
Q1	: Modem does not return result codes
Sr=n	: Set register r to value n
Sr?	: Request contents of register r
V	: Short form numeric result codes
V1	: Full word result codes
X	: CONNECT result code enabled
X1	: Modem blind dials; all CONNECT XXXX result codes enabled; busy signal not detected
X2	: Modem waits for dial tone before dialing; ALL CONNECT XXXX result codes enabled; busy signal not detected
X3	: Modem blind dials; all CONNECT XXXX result codes enabled; modem sends BUSY result code if busy signal detected
X4	: Modem waits for dial tone before dialing; all CONNECT XXXX result codes enabled; modem sends BUSY result code if busy signal detected.
Y	: Long space disconnect disabled
Y1	: Long space disconnect enabled
+++	: The default escape code
&C	: DCD always ON
&C1	: DEC ON indicates presence of data carrier
&D	: Modem ignores DTR
&D1	: Modem assumes command state when ON-to-OFF transition detected on DTR
&D2	: Modem hangs up, assumes command state and disables auto answer upon detected in ON-to-OFF transition on DTR
&D3	: Modem assumes initialization state upon detecting an ON-to-OFF transition on DTR
&G	: No guard tone
&G1	: 550 Hz guard tone
&G2	: 1800 Hz guard tone
&L	: Selects dialup (switched) line
&L1	: Selects leased line
&M	: Asynchronous mode
&M1	: Synchronous mode 1 (Sync/Async mode)
&M2	: Synchronous mode 2 (Dial Stored Number mode)
&M3	: Synchronous mode 3 (DTR control of Data/Talk)
&P	: Pulse dial make/break ratio = 39/61 (USA)
&P1	: Pulse dial make/break ratio = 33/67 (UK/HK)
&R	: CTS follows RTS
&R1	: Modem ignores RTS; CTS always ON

(continued)

Table 4. Command Summary Table cont'd.

COMMAND	DESCRIPTION
&T	: Terminate test in progress
&T1	: Initiate Local Analog Loopback test
&T3	: Initiate digital loopback
&T4	: Modem grants request from remote modem for RDL
&T5	: Modem denies request from remote modem for RDL
&T6	: Initiate Remote Digital Loopback test
&T7	: Initiate Remote Digital Loopback with self test
&T8	: Initiate Local Analog Loopback with self test

THE REGISTERS

The modem accesses 15 registers to execute a variety of operations. The function of each of these registers is explained below. The value of each register must be 0-255.

REGISTER	DESCRIPTION
S0	: Number of rings before auto-answering a call. If set to 0, the modem will not auto-answer.
S1	: Counts incoming rings. If no ring occurs for 8 seconds, the counter is cleared to 0. The register only counts when the modem is set to auto-answer (S0 greater than 0).
S2	: Escape code character. Can be ASCII 0-127. Default is +. If S2 is greater than 127 then the escape code is completely disabled and only a call disconnection will return the modem to the command mode.
S3	: End-of-line character. This character is used to both terminate commands and to terminate status messages. Defaults to carriage return (ASCII 13).
S4	: Line feed character. This character is output following the end-of-line character after English status messages. Defaults to line feed (ASCII 10).
S5	: Backspace character. This character is typed to erase one command character and move the cursor back one space on the host screen. To erase a character, the modem first outputs a backspace, then it outputs a space and then another backspace to move over the blank. Default is backspace (ASCII 8).
S6	: Dial tone wait. Defines the pause after going off-hook (in seconds). Can't be less than 2 due to FCC regulations. Default is 2.
S7	: Time, in seconds, to wait for carrier before aborting a connection attempt. Default is 30 seconds.
S8	: Length of pause, in seconds, produced by the comma command. Default is 2 seconds.
S9	: Time, in 1/10 seconds, that carrier must be present to be detected. Default is 600 milliseconds.
S10	: Time, in 1/10 seconds, between loss of carrier and disconnect. Default is 700 milliseconds. If S10 is set to 255, then the modem acts as if a carrier is always present.
S12	: Time delay, in 1/50 seconds, required before and after an escape code. The time between the characters of the escape code must be less than the value of S12. (See guard time in the Modem States Section that follows.). If S12 is 0, then timing is not a factor in recognizing the escape code. Default is 1 second.

REGISTER	DESCRIPTION
S16	: Test mode (see "Diagnostic Tests" for a detailed diagnostic test mode description). S16, BIT 0 : Local Analog Loop — 0-Disable, 1-Enable S16, BIT 1 : Not used S16, BIT 2 : Local Digital Loopback — 0-Disable, 1-Enable S16, BIT 3 : Remote Digital Loopback initiated by remote modem — 0-Loopback off, 1-Loopback in progress S16, BIT 4 : Remote Digital Loopback — 0-Diabled, 1-Initiate Enabled S16, BIT 5 : Remote Digital Loopback with test message and error count — 0-Disable, 1-Enable S16, BIT 6 : Local Analog Loopback — 0-Disable, 1-Enable S16, BIT 7 : Not Used
S25	: Delay to DTR. Transitions on DTR that occur for less time specified by this register are ignored. DTR will only be examined after S25 has timed out.
S26	: RTS to CTS Delay Interval used in synchronous operation. Upon detection of a transition and RTS the CH1780 will wait the duration specified by this register before returning a CTS.

NOTE: All other Registers not indicated are not used.

The Status Messages

The modem responds with a status message after each modem command is executed. This status message may either be a single digit followed by a carriage return or it may be by a carriage return and line feed with a message in English followed by a carriage return and line feed.

BASIC STATUS CODE SET

Status Message	Meaning
0 or **OK**	Command executed
1 or **CONNECT**	Carrier detected
2 or **RING**	Ring detected on the phone line
3 or **NO CARRIER**	Did not detect a carrier
4 or **ERROR**	Entry Error

The status codes have 2 extensions. The first extension indicates a 1200 bps or 2400 bps connection. The second extension is used to indicate call progress conditions after dialing to the host. Both the extensions are enabled via the "Extended Status Message Select" command. The extended status messages are disabled at power-up.

STATUS MESSAGES

(enabled with the X1 and X2 commands)

9 or **CONNECT 600**	Carrier detected at 600 bps
5 or **CONNECT 1200**	Carrier detected at 1200 bps
10 or **CONNECT 2400**	Carrier detected at 2400 bps

EXTENDED CALL PROGRESS MONITORING SET

(enabled with the X2 command)

6 or **NO DIAL TONE**	Off-hook but no response after 5 seconds
7 or **BUSY**	Busy signal detected
8 or **RINGING**	Ringback detected

MODEM STATES

The modem can be in either a command state or a data mode state. When the modem is idle, it is in the command state. When a data call is in progress it is in the data mode state. The modem does not recognize commands when in the data state. To recognize commands, the computer must send an "escape sequence" to the modem that forces it out of the data mode and into the command mode.

The escape sequence consists of a "guard time" (a period where no characters are sent to the modem) followed by 3 escape characters followed by a "guard time" again. At power-up, the guard time is set to 1 second minimum and the escape character is set as "+". These two parameters can be modified via registers S2 and S12.

The modem will stay off-hook with its carrier on after the escape sequence is received. It returns an OK status message when it is ready to accept commands. You may re-enter the data mode by issuing the ONLINE command **ATO[enter].**

FCC REGISTRATION

The CH1780 is registered with the FCC (Federal Communications Commission) under Part 68. To maintain the validity of the registration, you must serve notice to the end user of the product that contains the modem of several restrictions the FCC places on the modem and its use. The notice shown below is recommended and should be included in the end product's USER MANUAL. Also, the FCC requires that Cermetek make all repairs to the modem. If repair is necessary after the modem is installed in your product and has been delivered to your customer, the modem must be returned to you and then forwarded to Cermetek for repair.

Sample Customer Instructions

The following, or similar, statement should be provided in the instruction manual to be provided the user. Additional information may be provided at your option.

FCC REQUIREMENTS

This equipment complies with Part 68 of the FCC rules. On the bottom of this equipment is a label that contains, among other information, the FCC Registration Number and Ringer Equivalence Number (REN) for this equipment. You must, upon request, provide this information to your telephone company.

The REN is useful to determine the quantity of devices you may connect to your telephone line and still have all of those devices ring when your telephone number is called. In most, but not all areas, the sum of the RENs of all devices connected to one line should not exceed five (5.0). To be certain of the number of devices you may connect to your line, as determined by the REN, you should contact your local telephone company to determine the maximum REN for your calling area.

If your telephone equipment causes harm to the telephone network, the Telephone Company may discontinue your service temporarily. If possible, they will notify you in advance. But if advance notice isn't practical, you will be notified as soon as possible. You will be informed of your right to file a complaint with the FCC.

Your telephone company may make changes in its facilities, equipment, operations or procedures that could affect the proper functioning of your equipment. If they do, you will be notified in advance to give you an opportunity to maintain uninterrupted telephone service.

If you experience trouble with this telephone equipment, please contact (company name/service center, phone number, etc.) for information on obtaining service or repairs. The telephone company may ask that you disconnect this equipment from the network until the problem has been corrected or until you are sure that the equipment is not malfunctioning. (Include repairs that customer can make — replacing fuses, plug-in cards, etc.)

This equipment may not be used on coin service provided by the telephone company. Connection to party lines is subject to state tariffs.

DIAGNOSTIC TESTS

The CH1780 supports the following tests to help diagnose the source of data communications problems you may encounter.

ANALOG LOOP TEST

In an analog loop test, command &T1, transmitted characters are looped back to the sending terminal or computer. This allows you to verify the operation of the modem's analog circuits. These circuits modulate and demodulate the host's data. Since the modem uses different circuits to originate and answer calls, it is important to test both answer and originate modes.

An analog loop self test, command &T8, can also be performed. In a self test the modem automatically generates characters back as before. In addition, the modem transmits an "alternate 0, 1 bit pattern" character stream and compares it with the received character stream for accuracy. This is a more rigorous test than is possible with the basic analog loop set-up.

An error accumulator inside the modem counts errors (up to 15). The error count is displayed as a status message at the end of the analog loop self test.

DIGITAL LOOP TEST

Local Digital Loopback command &T3, allows data to be looped back at the local end thus testing the data pattern from the internal CPS through the modem and back.

REMOTE DIGITAL LOOP TEST

In a digital loop test, data that is received from the remote modem is looped back or re-sent to the remote modem. This test is performed after a data connection has been established and after the local modem is enabled to enter this test mode with command &T4. Command &T5 disables the modem from responding to a request for loopback.

If the remote terminal or computer is having trouble exchanging data with the local host, the problem is usually related to either a poor modem-to-modem connection or incompatible communication settings (parity, data bits, etc.). If a digital loop test is performed and the remote modem receives exactly what is sent, then the data exchange difficulties are probably due to incompatible communication settings.

Once a connection has been established, this command makes it possible for a local operator to put the remote modem into Digital Loop. When this is done, characters sent to the remote modem are looped back to the local modem.

REMOTE DIGITAL LOOPBACK WITH SELF TEST

In this test, command &T7, both modems automatically send a test pattern over the telephone line and check to see if the same pattern is returned. Neither the remote nor the local terminal sends data over the phone line during this test.

Errors are accumulated by the modem in an error counter. The counter counts up to 15 errors. Its contents are displayed when the test is terminated.

Table 5. System Compatibility Specifications T-75-33-90

Parameter	Specification
Synchronous	2400 bps ±0.01% V.22 bis 1200 bps ±0.01% V.22 and 212A 600 bps ±0.01 V.22
Asynchronous	2400, 1200, 600 bps, character asynchronous. 0 - 300 bps asynchronous.
Asynchronous Speed Range	+2.3%-2.5%, extended range option of CCITT standards in character asynchronous mode.
Asynchronous Format	8, 9, 10, 11 bits, including start, stop, parity.
Synchronous Timing Source	Internal, derived from the local oscillator. External, provided by DTE through XTCLK. Slave, derived from the received clock.
Telephone Line Interface	Two wire full duplex over public switched network or 4 wire leased lines. On-chip hybrid and billing delay timers. Output level −1 to −16 dBm
Modulation	V.22 bis, 16 point QAM at 600 baud. V.22 and 212A, 4 point QAM at 600 baud. V.21 and 103, binary phase coherent FSK
Output Spectral Shaping	Square root of 75% raised cosine, QAM/PSK.
Transmit Carrier Frequencies V.22 bis, V.22, 212A	Originate 1200 Hz ± .01% Answer 2400 Hz ± .01%
V.21 at 300 bps	Originate 'space' 1180 Hz ± .01% Originate 'mark' 980 Hz ± .01% Answer 'space' 1850 Hz ± .01% Answer 'mark' 1650 Hz ± .01%
Bell 103 mode	Originate 'space' 1070 Hz ± .01% Originate 'mark' 1270 Hz ± .01% Answer 'space' 2020 Hz ± .01% Answer 'mark' 2225 Hz ± .01%
Receive Carrier Frequencies V.22 bis, V.22, 212A V.21 Bell 103	Originate 2400 Hz ± 7 Hz Answer 1200 Hz ± 7 Hz Originate 'space' 1850 Hz ± 12 Hz Originate 'mark' 1650 Hz ± 12 Hz Answer 'space' 1180 Hz ± 12 Hz Answer 'mark' 980 Hz ± 12 Hz Originate 'space' 2020 Hz ± 12 Hz Originate 'mark' 2225 Hz ± 12 Hz Answer 'space' 1070 Hz ± 12 Hz Answer 'mark' 1270 Hz ± 12 Hz
Receiver Sensitivity	OFF to ON threshold −45 dBm ON to OFF threshold −48 dBm
Line Equalization	Fixed compromise equalization, transmit. Adaptive equalizer for PSK/QAM, receive.
Diagnostics Available	Local analog loopback. Local digital loopback. Remote digital loopback. Local interface loopback modem.
Self Test Pattern Generator	Alternate 'ones' and 'zeros' and error detector, to be used along with most loopbacks. A number indicating the bit errors detected is sent to DTE.
Call Progress Tones Detected:	With speaker or quiet screen messages (no dial tone, busy, ring-back, modem answer tone and voice).
Computer Interface:	IBM PC/XT/AT bus compatible with an INS8250 UART as a serial controller.

T-75-33-90

Table 6. Transmission Performance Specifications

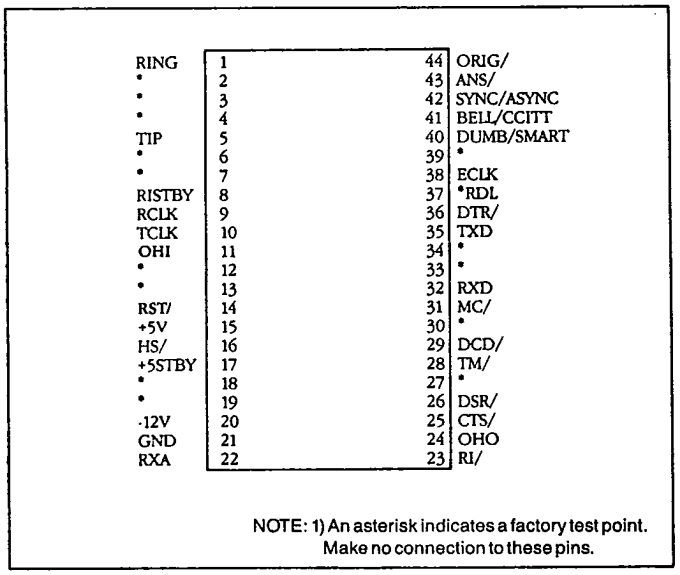
Parameter	Specification
Test condition: Unconditioned 3002 line, across the full dynamic range. The noise bandwidth is 3 KHz flat.	
Random Noise	Bit Error rate of 1 in 100000 or better at 7 dB SNR at 300 bps, 8 dB SNR at 600 bps, 10 dB SNR at 1200 bps and 17 dB SNR at 2400 bps.
Frequency Offsets (1)	±7 Hz.
Phase Jitter (1)	2400 bps −15° peak to peak, at up to 300 Hz. 600, 1200 bps −45° peak to peak, at up to 300 Hz

Table 7. Other Performance Specifications

Parameter	Min.	Typ.	Max.	Units	Comments
Tone 2nd Harmonic Distortion			−35	dB	HYB enabled into 600 Ω
DTMF Twist (Balance)		3		dB	
DTMF Tone Duration	50		255	ms	
Default Duration		70		ms	
Pulse Dialing Rate		10		pps	
Pulse Dialing Make/Break		39/61 33/67		% %	US UK, Hong Kong
Pulse Interdigit Interval		785		ms	
Billing Delay Interval			2.1	sec	
Guard Tone Frequency Amplitude Frequency Amplitude		540 −3 1800 −6		Hz dB Hz dB	referenced to High channel transmit.
High Channel Transmit Amplitude		−1		dB	referenced to Low channel, Guard Tone enabled.
Guard Tone 2nd Harmonic Distortion			−50	dB	
Tone Detection Passband Frequency	290		665	Hz	3 dB Point
Tone Detection OFF to ON Threshold	−33			dBm	Into 600 Ω
Tone Detection ON to OFF Threshold	−35			dBm	Into 600 Ω
Dial Tone Detect Duration	3.0			sec	
Ringback Tone Detect Duration Cadence	0.75 1.5			sec	Off/On Ratio
Busy Tone Detect Duration Cadence	0.2 0.67		1.5	sec	Off/On Ratio
Power:	Typical			+ 5V ± 5% 350 mA −12V ± 10% 30 mA	
	Standby			+ 5V ± 5% 10 mA	
Temperature:	Operating 0 - 60°C		Storage −40 - 125°C		

DEFAULT CONFIGURATION PROFILE

2400 bps
Bell 212A operation at 1200 bps
Even parity
Auto answer disabled
Command echo ON
All result codes enabled
Wait for dial tone before dialing
Detects busy signal
Full word result codes
Pulse dial make/break ratio = 39/61
Test timer set to 0 seconds
RJ-11 jack type
CTS follows RTS after delay in S26
RTS to CTS delay = 0 seconds
Modem ignores DTR
DCD always ON
Long space disconnect disabled
Speaker enabled but off when receiving carrier
Speaker volume set to medium
Local modem will grant RDL request from remote modem
Guard tones disabled
Minimum DTR pulse width = .05 seconds
Modem sources transmit clock (synchronous only)
Ring count — 00
Escape code character = 43
Carriage return character = 13
Line feed character = 10
Back space character = 08
Duration of wait for dial tone =02 seconds
Duration of wait for carrier after dialing = 30 seconds
Duration of dial pause (comma) = 02 seconds
Carrier detect response time = 01.4 seconds
Escape code guard time = 01 seconds



NOTE: 1) An asterisk indicates a factory test point. Make no connection to these pins.

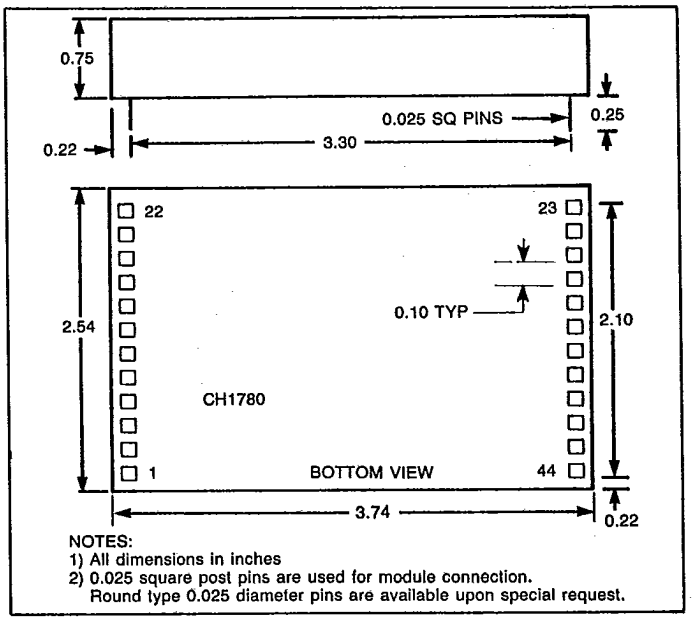
Figure 4. Pin Configuration

Pin Loading Summary

The loading table describes the modem's logic input load and logic output drive capability in terms of a standard LSTTL load. One LSTTL load represents a 400 μA sourcing load and a 9 mA sinking load.

Table 8. I/O Loading Summary

Pin	Pin No.	Input/ Output	Load (LSTTL Units)
RCLK	9	O	3
TCLK	10	O	3
OHI	11	I	1
RST	14	I	2
HS	16	O	3
RI	23	O	3
OHO	24	O	3
CTS	25	O	10
DSR	26	O	10
TM	28	O	10
DCD	29	O	10
MC	31	O	10
RXD	32	O	3
TXD	35	I	1
DTR	36	I	1
ECLK	38	I	1
RXA	22	O	ANALOG
RISTBY	8	O	3
ORIG	44	I	1
ANS	43	I	1
SYNC/ASYNC	42	I	1
BELL/CCITT	41	I	1
DUMB/$\overline{\text{SMART}}$	40	I	1



NOTES:
1) All dimensions in inches
2) 0.025 square post pins are used for module connection. Round type 0.025 diameter pins are available upon special request.

Figure 5. Physical Dimensions