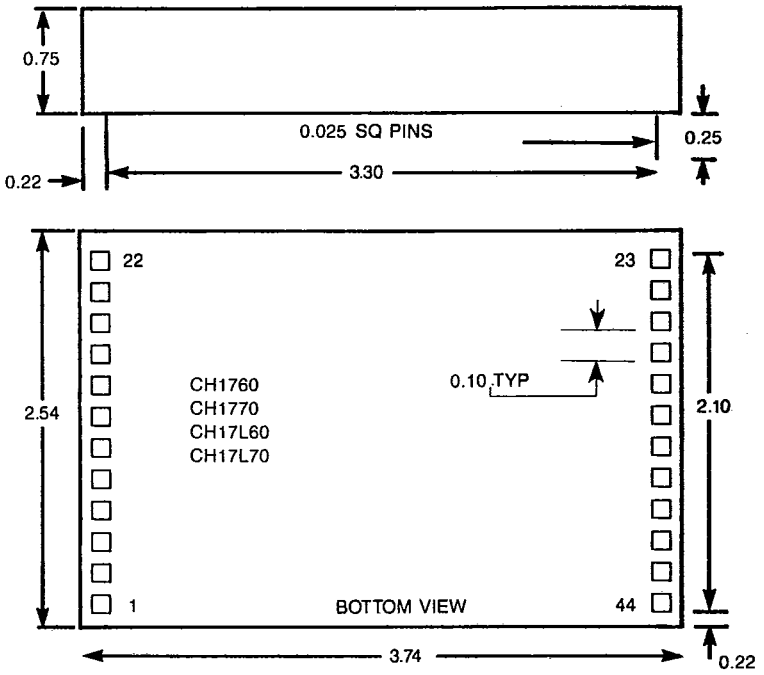
1700 SERIES

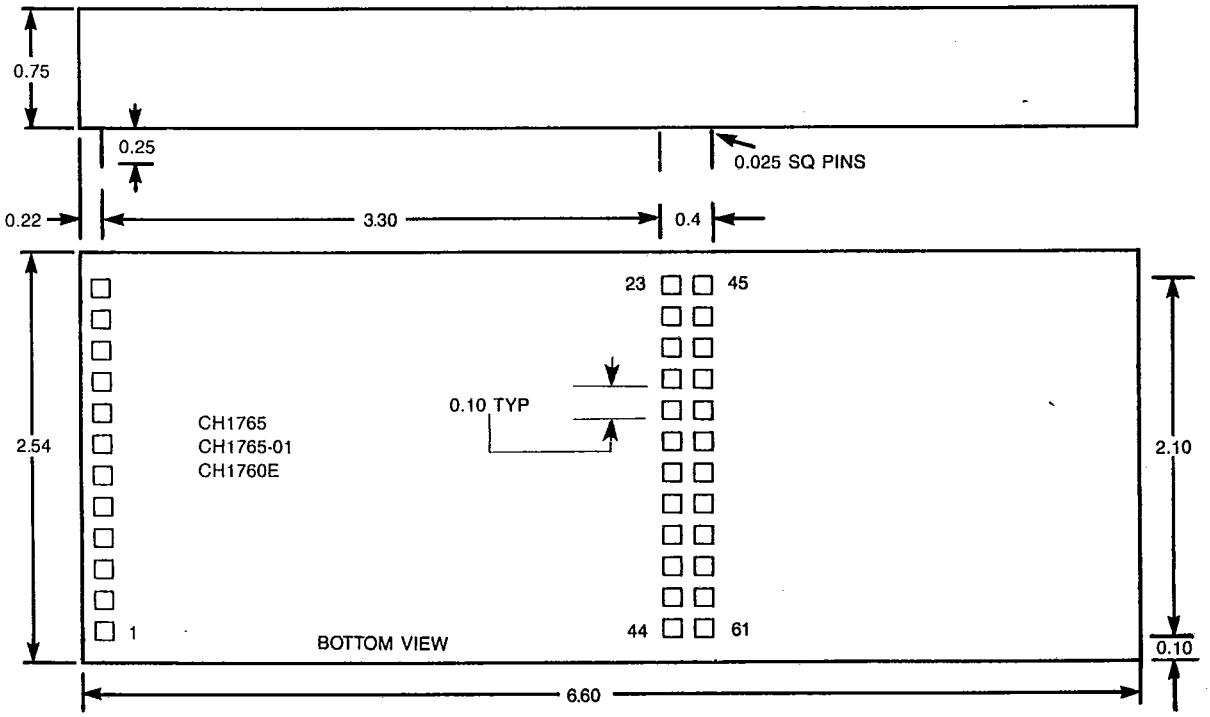
T-75-33-05

INTELLIGENT 1200/300/110 BPS MODEM COMPONENT MODULES

MECHANICAL DRAWING

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





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1.0 INTRODUCTION

1.1 MODEM INTEGRATION

Modem modules offer a quick and easy 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 that you are able to plug in and begin using right away.

In addition to conserving engineering design and integration time, modem modules shorten a product introduction cycle. Since they are already FCC (Federal Communications Commission) registered for phone line connection, the three to six month time normally needed to gain FCC Part 68 registration is eliminated.

The modem modules described here (CH1760A, CH1760E, CH17L60, CH1770, CH17L70, CH1765 and CH1765-01), are all Bell 212A compatible modems that can communicate with the vast majority of 1200, 300 and 110 bps full duplex modems installed today. They are not compatible with the Bell 202 type of half duplex modem which was popular in the 1960's and 1970's.

Every effort has been made to ease the integration of the modem into your product. The size of the modem has been reduced to 2.54" by 3.74" on most modules, which include the built-in FCC Part 68 registered phone line interface (DAA). Since the modem is often the last item integrated into a product, modem size is a critical factor.

Cermetek offers several modules with a variety of features. In most cases we will talk about the module families which are referred to in the following way: The CH1760A, CH1760E, and CH17L60 are indicated as the 1760 family. The CH1765, CH1765-01, and CH1765A are indicated as the 1765 family. The CH1770, CH17L70 are the 1770 family. Throughout this manual modules with unique features will be specified by model name as (1760E only).

1.2 MODULE SELECTION

As can be seen in the Table on the back cover, the modem modules discussed have many similar features. Slight variation in the modules have been offered to tailor them for specialized applications.

The CH1770 modem is equipped with a minimum amount of intelligent modem features for very low cost applications. It auto-dials and auto-answers but it doesn't recognize call progress tones such as busy or ring-back after dialing. It only recognizes modem answer tone to complete a call.

The CH1760A maintains the small 2.54" by 3.74" footprint of the CH1770 and additionally supports features often needed in industrial or business applications. These features include call progress detection, both asynchronous and synchronous data formats and extensive built-in diagnostic test modes.

Both the CH17L60 and CH17L70 are identical to the CH1760A and CH1770 except they require significantly less power. For power requirements see Table 4-2. The CH17L60 is also available on special request in ±5V, as well as its standard +5V and −12V power supply configuration.

The CH1760E is the most full-featured modem described here. The CH1760E's principle destinction is that it supports a memory expansion port that allows the modem to store up to 52 thirty-two digit phone numbers and perform advanced memory dialing and data base log-on.

The CH1765 is similar in features to the CH1760A except that it responds to commands that are "AT" compatible. The other modem modules all support a command set developed by Cermetek to support industrial applications. The CH1765 also supports an external set of option straps which allow vital modem parameters to be defined at power-up. These same parameters can be altered by serial commands as well, just like all of Cermetek's modem modules.

The last modem module, the CH1765-01, is identical to the CH1765, except it does not support call progress tone detection after dialing a call. It, like the CH1770 and CH17L70, detects modem answer tone to indicate the successful completion of a call and times out if answer tone is not received.

1.3 ADDITIONAL COMPONENTS

All modem modules have a built-in phone line interface (DAA). Cermetek also offers a full line of DAA components that meet the requirements of the United States' FCC, Canada's DOC, and Europe's PTT's.

Information on these and other products is available to you on request. Call your local Cermetek Sales Representative or call us directly.

2.0 PIN DESCRIPTION

2.1 TELEPHONE LINE INTERFACE PINS

RING, TIP : directly connects to the telephone line's RING and TIP leads through a user-supplied RJ 11C telephone line jack. Pins 1 and 5.

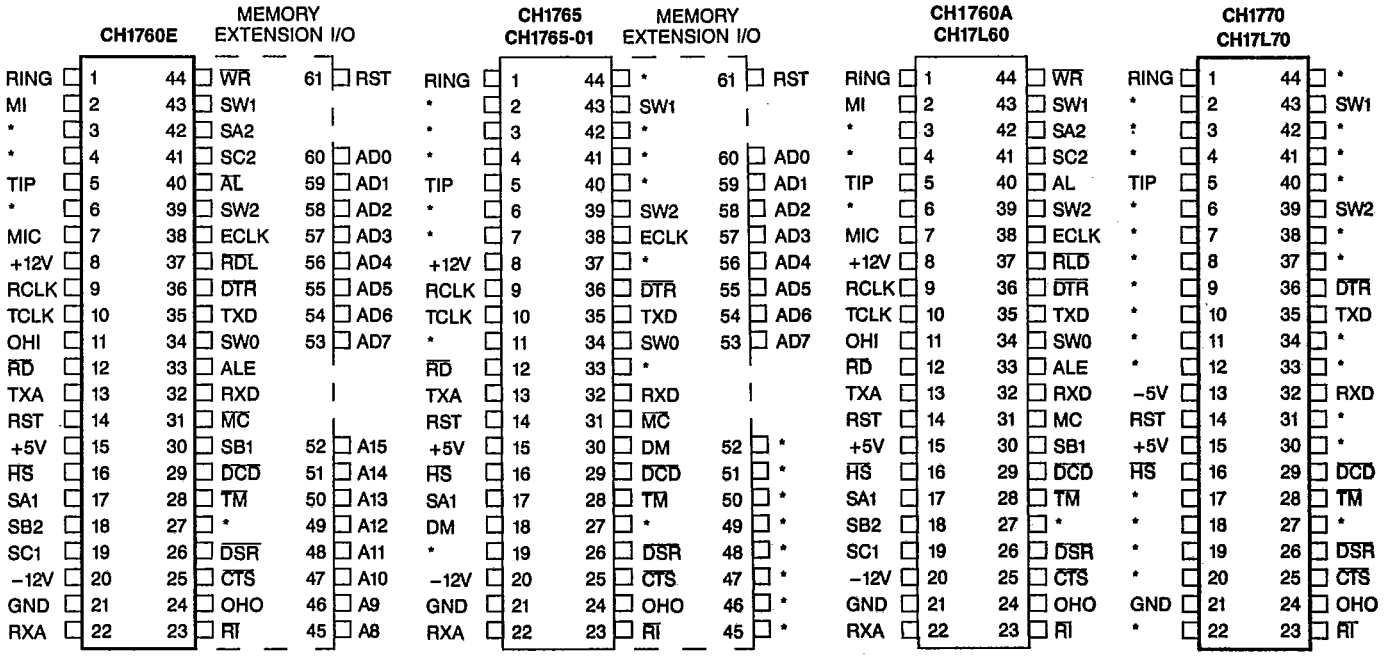
MI, MIC : a momentary connection between MI (Manual Initiate) and MIC (Manual Initiate Common) with a minimum duration of 250 milliseconds begins a data call if $\overline{DTR}$ is ON (LOW). An Originate data call is initiated unless phone line ringing has been detected in the past 30 seconds, in which case an Answer data call is initiated. After a call is established, a momentary connection between MI and MIC disconnects the call. (CH1760A family) Pins 2 and 7.

OHI : OFF-HOOK INPUT. A HIGH on this signal takes the telephone line interface OFF-HOOK. It should be directly connected to OHO, pin 24. (CH1760 family) Pin 11.

OHO : 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. Pin 24.

$\overline{RI}$: 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). Pin 23.

TXA : TRANSMIT AUDIO. An audio input referenced to ground. Audio applied to this input is transmitted to the telephone line without additional filtering. A gain of nominally −10 dB is maintained from this input to telephone line pins TIP and RING. (CH1760 and CH1765 families) Pin 13.



NOTES:
1) An asterisk indicates a factory test point. Make no connection to these pins.
2) On the CH1760 family, if not used, pins 37, 38 and 40 must be pulled high through a pull up resistor to +5V (4.7k Ohm normally used) for proper circuit operation. On the CH1765 family pin 38 must be similarly pulled up if not being used.
3) The CH17L60 may be purchased with a ±5V power supply configuration upon special request.

RXA : RECEIVE AUDIO. An audio output referenced to ground. Audio received from the telephone line is asserted on this pin. When the modem's 600 Ohm output impedance is not perfectly matched to the telephone line impedance, the modem transmit signal will partially be reflected back onto this pin. The reflected transmit audio will always be attenuated at least 10 dB if the telephone impedance is within ±30% of 600 Ohms. Audio from the phone line is amplified by 20 dB on this pin. (CH1760 and CH1765 families) Pin 22.

2.2 SPECIAL HOST INTERFACE

TXD : TRANSMIT DATA. Serial transmit data input. Marking or a binary 1 condition is transmitted when a HIGH is asserted. Pin 35.

RXD : RECEIVE DATA. Serial receive data output. Received marking or a binary 1 condition is indicated by a HIGH output. Pin 32.

$\overline{\text{DSR}}$: DATA SET READY output. A LOW output on this pin indicates the modem is OFF-HOOK. Pin 26.

$\overline{\text{CTS}}$: CLEAR-TO-SEND data output. When this signal is asserted LOW the modem has set up the data call and is ready to transmit data. Pin 25.

$\overline{\text{DCD}}$: DATA CARRIER DETECT output. When this output is asserted LOW the received data carrier is present on the telephone. Pin 29.

Note: $\overline{\text{DSR}}$, $\overline{\text{CTS}}$ and $\overline{\text{DCD}}$ may be forced to follow the state of the $\overline{\text{DTR}}$ input via option input, SW2.

$\overline{\text{DTR}}$: 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 $\overline{\text{DTR}}$ HIGH for greater than 50 ms. Pin 36.

$\overline{\text{TM}}$: TEST MODE output. This output is asserted LOW whenever the modem enters a diagnostic test mode. Pin 28.

$\overline{\text{HS}}$: SPEED INDICATION. High speed select output. A LOW on this pin indicates the modem is operating at 1200 bps. If $\overline{\text{HS}}$ is HIGH, 110/300 BPS is supported. $\overline{\text{HS}}$ is always HIGH until a call has been established. Pin 16.

ECLK : EXTERNAL TRANSMIT CLOCK input. For synchronous mode operation with an external clock. A 1200 bps ±.01% clock supplied on this pin controls the data rate. Transmit data applied to TXD, pin 35, is sampled on the negative going edge of this clock. This pin should be pulled up through a 4.7k Ohm resistor to +5V when it is not being used. (CH1760 and CH1765 families) Pin 38.

TCLK : 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

(CH1760 and CH1765 families) Pin 10.

RCLK : RECEIVE CLOCK output. The RCLK output is the high speed (1200 bps) recovered data clock. Receive data appears at pin 32 and should be sampled on the negative going edge of this clock. (CH1760 and CH1765 families) Pin 9.

2.3 MISCELLANEOUS SIGNALS

$\overline{\text{MC}}$: MODEM CHECK output. This output has two functions: 1) when the modem is placed in any one of the self test modes, $\overline{\text{MC}}$ is pulsed LOW for 300 ms if a receive data error is deteced, and 2) MC is asserted LOW in the absence of receive data carrier when not in a self test mode. Pin 31.

$\overline{RD}$: READ output. External phone number memory (CH1760E) or configuration port (CH1765, CH1765-01) read enable. A LOW enable memory outputs. Memories with an access time of 450 ns or less should be used. (CH1760E, CH1765 and CH1765-01 only) Pin 12.

$\overline{WR}$: WRITE output. External RAM memory write enable. A LOW is used to write data into external phone number RAM memory. (CH1760E only) Pin 44.

ALE : ADDRESS LATCH ENABLE clock output. ALE is asserted HIGH to latch the address portion of address/data signals (AD0-7) for CH1760E phone number memory port expansion applications. The modem address clock operates nominally at 1.228 MHz. (CH1760 family) Pin 33.

DM : DIAL MODE outputs. When the CH1765 or CH1765-01 is dialing or waiting for answer tone, this output is asserted HIGH. DM is usually used to enable a call progress monitoring speaker. Both pins 18 and 30 must be connected. (CH1765 family) Pins 30 and 18.

RST : RESET input active HIGH. This should be utilized in all systems. After each power-up cycle, this input should be asserted HIGH for at least 1 ms after the +5V supply is stable and greater than 4.5V. Pin 14 and on the CH1760E, CH1765 and CH1765-01 pin 61.

2.4 MODE CONTROL LINES

SW0 : DATA FORMAT inputs. Selects the serial data format as shown below. Pins 34 and 43.

SW0*	SW1*	SERIAL FORMAT
LOW	LOW	asynchronous, 11 bit data
LOW	HIGH	asynchronous, 10 bit data
HIGH	LOW	synchronous
HIGH	HIGH	synchronous

*NOTES:

1) SW0 is not supported by the CH1770 but operates effectively as if it were LOW.
2) An 11 bit data word includes 1 start bit, 1 or more stop bits, and 9 data bits (including parity). A 10 bit data word includes 1 start bit, 1 or more stop bits, and 8 data bits (including parity).
3) SW0 is sampled by the modem before entering a data call. SW1 is sampled at power-up or after a RESET command.
4) SW1 input on the CH1765 and CH1765-01 must be pulled HIGH through a 10K Ohm resistor to +5V. The CH1765 and CH1765-01 support only 10 bit data words.

SW2 : INTERFACE OPTION input. Used to set the operation of the modem interface lines $\overline{CTS}$, $\overline{DSR}$ and $\overline{DCD}$. If SW2 is LOW, these lines follow the state of the $\overline{DTR}$ input, pin 36. If SW2 is HIGH, normal RS-232C line signal sequencing is supported (see Section 3.2.4). Pin 39.

$\overline{AL}$: ANALOG LOOPBACK input. When this input is asserted LOW and the modem is not currently executing a command or is in the data mode, the analog loopback test mode is entered. Data transmitted on TXD, pin 35 is modulated, locally looped-back, then demodulated and asserted on RXD, pin 32. (CH1760 family) Pin 40.

$\overline{RDL}$: 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 the remote digital loop is complete, the modem asserts its $\overline{TM}$ output LOW. This test mode is only supported when the modem is in the 1200 bps speed mode. (CH1760 family) Pin 37.

2.5 EXTERNAL PHONE NUMBER MEMORY CONFIGURATION PORT EXPANSION

AD0-7 : ADDRESS/DATA lines for external configuration port (CH1765 and CH1765-01) or phone number memory (CH1760E). Data is separated from address with an ALE enabled latch. (CH1760E, CH1765, and CH1765-01 only) Pins 53, 54, 55, 56, 57, 58, 59 and 60.

A8-15 : external phone number memory address lines. (CH1760E only) Pins 45, 46, 47, 48, 49, 50, 51 and 52.

2.6 INTERCONNECTS

(CH1760 and CH1765 families)

SA1 : an output that must be directly connected to SA2, pin 42. Pin 17.

SA2 : an input that must be directly connected to SA1, pin 17. Pin 42.

SB1 : an output that must be directly connected to SB2, pin 18. (Called DM on the CH1765 or CH1765-01 — see Miscellaneous Signals) Pin 30.

SB2 : an input that must be directly connected to SB1, pin 30. (Called DM on the CH1765 or CH1765-01 — see Miscellaneous Signals) Pin 18.

SC1 : an output that must be directly connected to SC2, pin 41. Pin 19.

SC2 : an input that must be directly connected to SC1, pin 19. Pin 41.

2.7 POWER

+5V	power supply input, pin 15
+12V	power supply input, pin 8
−12V	power supply input, pin 20
GND	signal and power ground, pin 21
−5V	power supply input, pin 13

2.8 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 an 8 mA sinking load.

Table 2-1:
I/O Loading Summary

PIN	PIN NO.	INPUT/ OUTPUT	LOAD (LSTTL UNITS)
RCLK	9	O	3
TCLK	10	O	3
OHI	11	I	1
$\overline{RD}$	12	O	3
RST	14, 61	I	2
$\overline{HS}$	16	O	3
$\overline{RI}$	23	O	3
OHO	24	O	3
$\overline{CTS}$	25	O	10
$\overline{DSR}$	26	O	10
$\overline{TM}$	28	O	10
$\overline{DCD}$	29	O	10
$\overline{MC}$	31	O	10
RXD	32	O	3
ALE	33	O	3
SW0	34	I	1
SW1	43	I	1
TXD	35	I	1
DTR	36	I	1
RDL	37	I	1
ECLK	38	I	1
SW2	39	I	1
$\overline{AL}$	40	I	1
$\overline{WR}$	44	O	3
AD0-AD7	53-60	I/O	1/3
A8-A15	45-52	O	3
DM	18, 30	O	3

3.0 APPLICATIONS

The Cermetek Modem Component Modules integrate easily into most 1200, 300, 110 bps full duplex modem applications. Each application requires the user to connect it up 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.

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

PHONE USE CONNECTION GUIDELINES

1) Connection to the phone line must be made through a RJ-11C jack as shown in Figure 3-1.
2) 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.
3) 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.
4) No additional circuitry other than that shown in Figure 3-1 may be connected between the modem module and the phone line's RJ-11C jack.
5) The supplied FCC registration label must be applied visably on the outside of the host product.
6) The host product's User Manual must provide the user with connection and use instructions as recommended in Section 7.0.

Figure 3.1: Phone Line Connection

In Figure 3-1, a group of two resistors and one varistor are listed as "optional for United States use". All the modem modules meet the high voltage and transient requirements of the FCC which governs U.S. phone lines so these circuits are optional for U.S. applications. 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 mandatory. Adding these three devices will not affect FCC Registration.

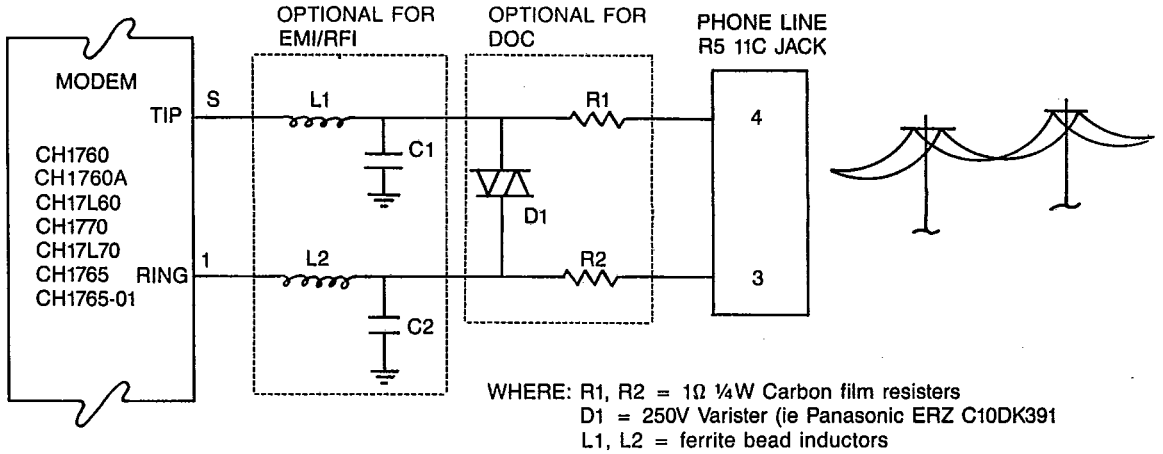
For applications that potentially will be connected to either U.S. or Canadian phone lines, it is recommended that additional transient protection be designed in from the very start, since their incremental cost is low.

Circuits L1, L2, C1, 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.

All the modules partially power their DAA circuits from the phone line's loop current. This loop current is guaranteed by the operating 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 CH1760 and the CH1765 families all provide additional audio coupling inputs (TXA and RXA) behind the protective DAA. These may be used as shown in the standalone modem design example (Section 3.5.3) to attach a speaker for line monitoring or to inject a voice signal for a voice/data application.

Drawing 1 - Phone Line Interface.



WHERE: R1, R2 = 1Ω ¼W Carbon film resisters
D1 = 250V Varister (ie Panasonic ERZ C10DK391
L1, L2 = ferrite bead inductors
C1, C2 = .001μf, +/– 20%, 5KV ceramic disc capaciters

3.2 Connecting to the Host UART/USART

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

3.2.1 The Serial Interface Lines

All the modules support 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 3-1. A complete description of each signal may be found in Section 2.0 — Pin Description.

Table 3.1
Host Serial Interface Summary

SIGNAL NAME	PIN NO.	DESCRIPTION	DIRECTION
TXD	35	Transmit Data	To Modem
RXD	32	Receive Data	From Modem
$\overline{CTS}$	25	Clear-to-Send	From Modem
$\overline{DSR}$	26	Data Set Ready	From Modem
$\overline{DCD}$	29	Data Carrier Detect	From Modem
$\overline{HS}$	16	Speed Indication	From Modem
TCLK	10	Transmit Clock	From Modem
RCLK	9	Receive Clock	From Modem
$\overline{DTR}$	36	Data Terminal Ready	To Modem
$\overline{RI}$	23	Ring Indication	From Modem
ECLK	38	External TX Clock	To Modem
$\overline{TM}$	28	Test Mode	From Modem

Three of these lines must be utilized for proper modem operation; TXD, RXD, and $\overline{DTR}$. The modem is controlled by sending it serial commands like data over TXD and can be monitored by received modem serial status messages on RXD. $\overline{DTR}$ 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.

3.2.2 Serial Data Format

Two serial data formats are supported by the CH1760 and CH1765 families, synchronous or asynchronous. Both the CH1770 and CH17L70 support only asynchronous operation.

Serial data format is selected by the level applied to SW0, pin 34. A LOW on this input selects asynchronous data operation whereas a HIGH in this pin sets synchronous operation. No connection should be made to this pin on CH1770 or CH17L70 applications.

The SW0 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 an asynchronous state before a call, independent of SW0 since its command interpreter and its status messages are only 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

Input SW1, pin 43, options the modem to operate with either 10 or 11 bit data words. This input is sampled at power-up or after a RESET command. An asynchronous data word is comprised of one start bit, one or more stop bits and, depending on the state of SW1, eight or nine data bits which includes parity.

Data or commands may be sent to the modem on pin TXD at either 110 or 300 bps ±2.5% or at 1200 bps +1%, −2.5%. Received data on pin RXD is sent to the host's UART/USART at about 1219 bps for 1200 bps calls, 307 for 300 bps calls and 112 on 110 bps connections. 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.

SYNCHRONOUS FORMAT

If SW0 is positioned 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 in by the synchronous USART on the negative going edge of the synchronous 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 ±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.

3.2.3 Speed and Parity Selection

Before a call, the modem adjusts to the host speed (1200, 300 or 110 bps) 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 uses the host's parity choice when it returns status messages to the host. During a data connection, however, the modem passes parity through without interpretation or alteration.

3.2.4 RS-232C Serial Line Sequencing

All modules have two RS-232C serial line sequencing options; 1) Standard RS-232C format is shown in Figure 3-2, and 2) $\overline{DCD}$, $\overline{MR}$, and $\overline{CTS}$ follows the state of $\overline{DTR}$. Modem input SW2, pin 39, is sampled before each call to adjust to the selected format. Asserting SW2 LOW, selects the "follows DTR" format, SW2 set HIGH instructs the modem to use standard RS-232C sequencing.

The "follows DTR" option should be selected if it is necessary to force modem control lines $\overline{DCD}$, $\overline{MR}$, and CTS all ON for proper host operation. Sometimes a terminal or computer must have all these lines asserted ON to send data or commands to the modem before a call. Since the host product is required to assert $\overline{DTR}$ ON, this will also turn $\overline{DCD}$, $\overline{MR}$, and $\overline{CTS}$ ON.

Figure 3-2 Handshake Timing Diagram

3.3 Connecting to Power

As can be seen in the pin configuration diagrams, the CH1760A, CH1760E, CH1765 and CH1765-01 all operate from a +5V, and ±12V power supply configurations. The CH1770 and CH17L70 both require ±5V supplies.

Table 3-2
Modem Power Supply Requirements

DEVICE	+12 VOLTS TYP	+12 VOLTS MAX	+5 VOLTS TYP	+5 VOLTS MAX	−5 VOLTS TYP	−5 VOLTS MAX	−12 VOLTS TYP	−12 VOLTS MAX
CH1760E	40	60	200	300	—	—	40	60
CH1760A	—	—	112	130	—	—	28	30
CH17L60	—	—	22	31	—	—	28	30
CH17L60	—	—	22	31	23	25	—	—
CH1765	40	60	280	300	—	—	40	60
CH1765-01	40	60	280	300	—	—	40	60
CH1765A	—	—	270	290	—	—	21	22
CH1770	—	—	111	120	23	25	—	—
CH17L70	—	—	22	31	23	25	—	—

Table 3-3
Power Supply Input Tolerance

SUPPLY	TOLERANCE
+12 Volts	±10%
+ 5 Volts	± 5%
− 5 Volts	± 5%
−12 Volts	±10%

Although the CH17L60 is normally offered in a +5V and −12V power supply configuration, ±5V supply configurations can be supplied on special request.

Each modem module is in effect a complex subsystem 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 disc capacitor is used. For other supplies, a 100μF Electrolitic should be substituted for the 220 μF capacitor.

A common cause of power supply noise is a condition caused by a ground loop or high impedance ground connection. When laying out your circuit

card you should avoid daisy chaining the ground signal from device to device. A good ground signal should use as wide a circuit card trace as is practical (typically exceeding .1") and connect all circuit grounds at a common or central point (star configuration).

3.4 Mounting the Modem

All 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 or Augat. Consult your socket distributor for further information.

3.5 Design Examples

Often times 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.

3.5.1 Minimal Asynchronous Integral Modem

The CH1770 family is used to implement an "asynchronous-only" integral modem. Any TTL compatible UART such as a 8251A, 6851, or a 8250 will operate satisfactorily. It should be noted, however, that if the integral modem is intended for use with the IBM PC/XT/AT or compatible, the UART selected should be a 8250 to insure IBM compatibility.

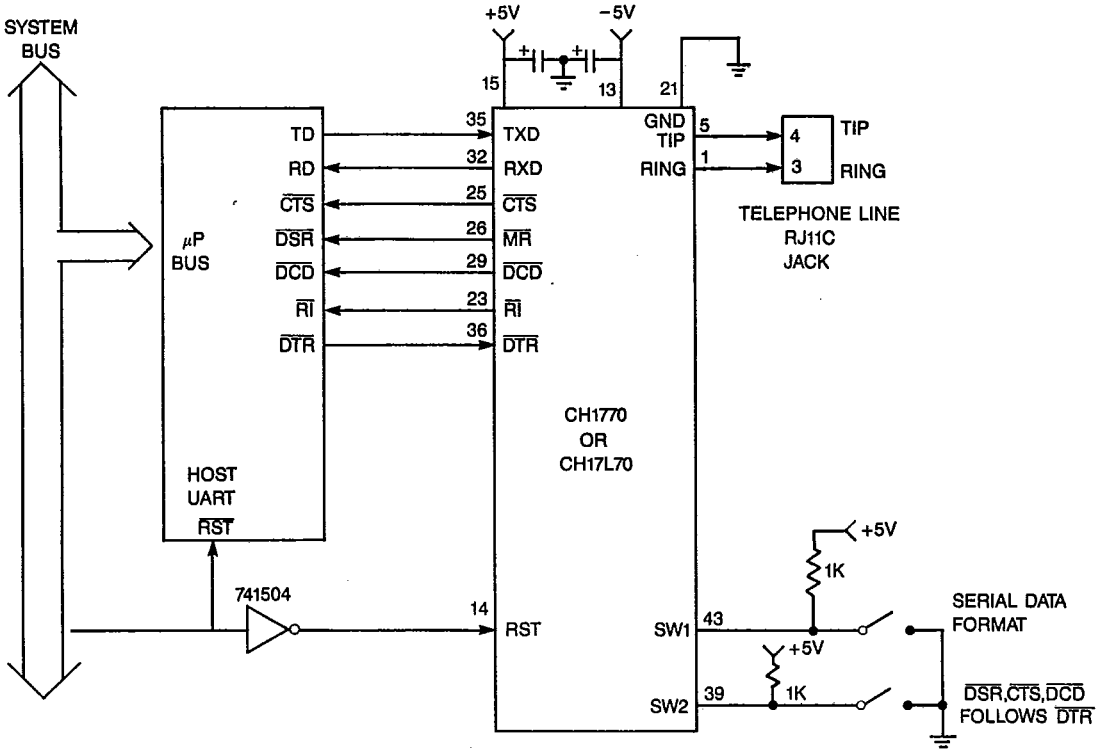
Inputs SW1 and SW2 are connected to option straps to select character length and the handshaking format. These could be connected to ground or pulled up through a 10K Ohm resistor to +5V. If these inputs are actively controlled by a TTL signal, SW1 must be valid during and after a RESET pulse applied to pin 14. SW2 may be altered any time before a call. After a call is initiated, it should not be changed.

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

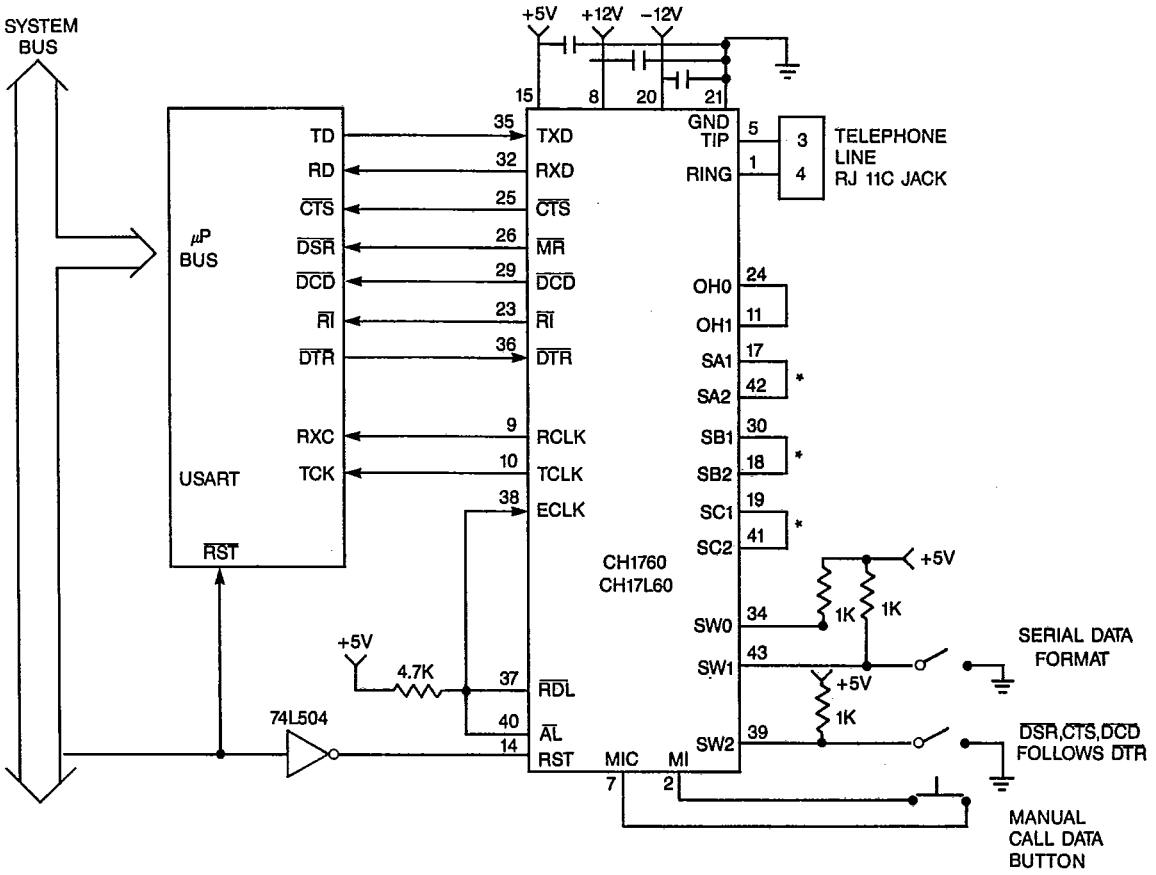
3.5.2 Synchronous Integral Modem

A synchronous modem communicates serial data timed to transmit (TCLK) and receive (RCLK) bit clocks. In this example, receive data is output on RXD, pin 32, and should be clocked in by the USART on the negative going edge of RCLK, pin 9. Transmit data is supplied to the modem on TXD, pin 35. The USART should clock out the data on the rising edge of TCLK, pin 10, the modem will sample the data on the falling edge of TCLK. This configuration illustrates the most common synchronous clock configuration. Here the modem supplies the transmit clock. Two other configurations also exist; a) the modem uses its receive clock as the transmit clock (often called slave mode), and b) the transmit clock is supplied by the USART to the modem. In both cases the receive clock, RCLK, or an external USART clock is applied to external clock input ECLK, pin 38.

Drawing 2 - Minimal Asynchronous Modem



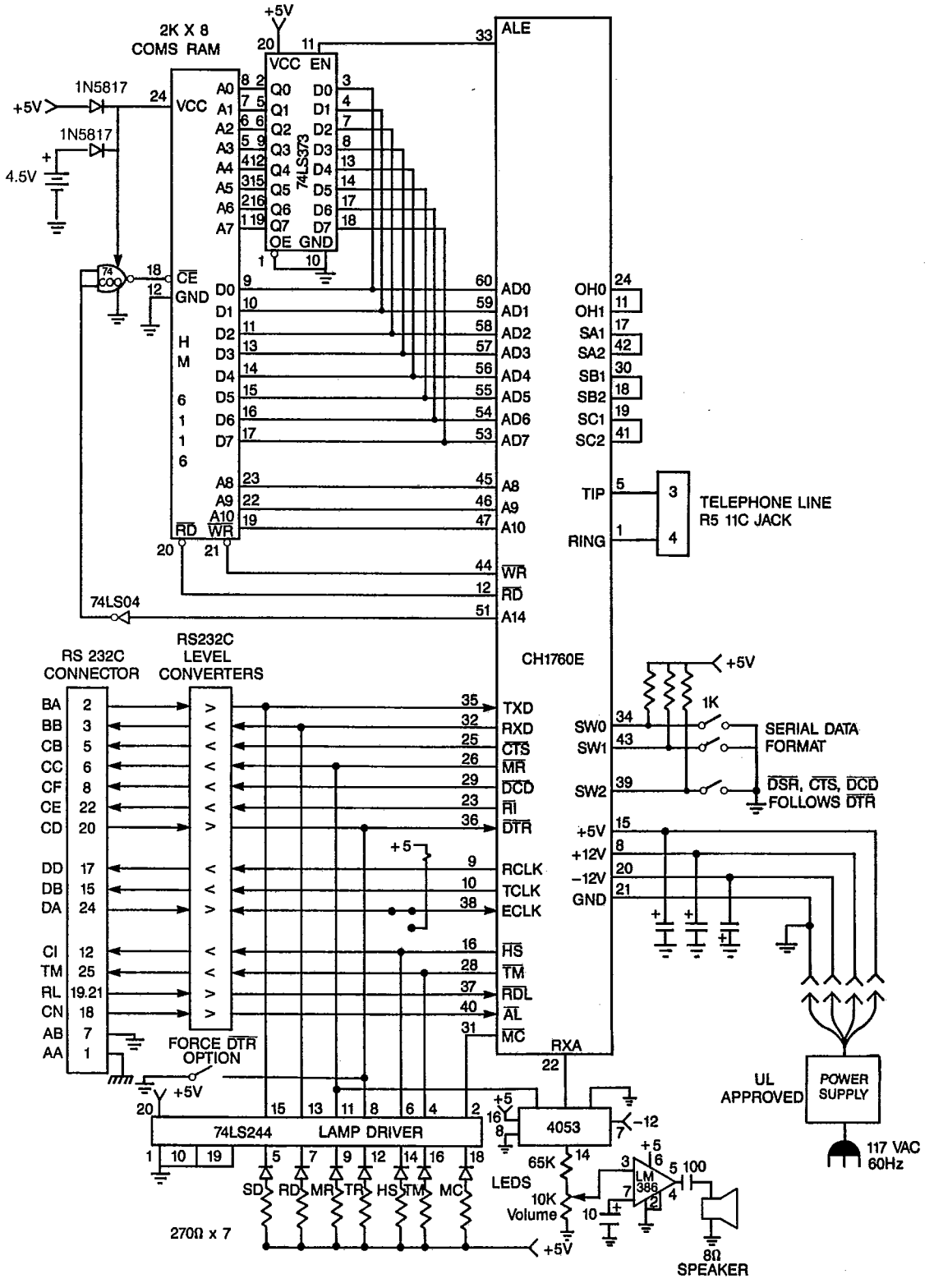
Drawing 3 - Synchronous Integral Modem



Before a call, the modem maintains an asynchronous communication state so that the USART may send it commands. When a data connection is established and after the "answered" status message is returned, the modem samples the SW2 input to see if it should enter the synchronous state. This input should not be changed while a call is under way.

Often it is desired to initiate a synchronous call

Drawing 4 - Standalone Modem With Memory



manually. This may be done with a normally open push button connected to inputs MI and MIC. Before a call, momentarily pushing this button starts an originate call if no phone line ringing has been detected in the past 30 seconds; otherwise, an answer mode call is started. After a call is set up, pressing this button again disconnects the call.

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

3.5.3 Standalone Modem with Memory

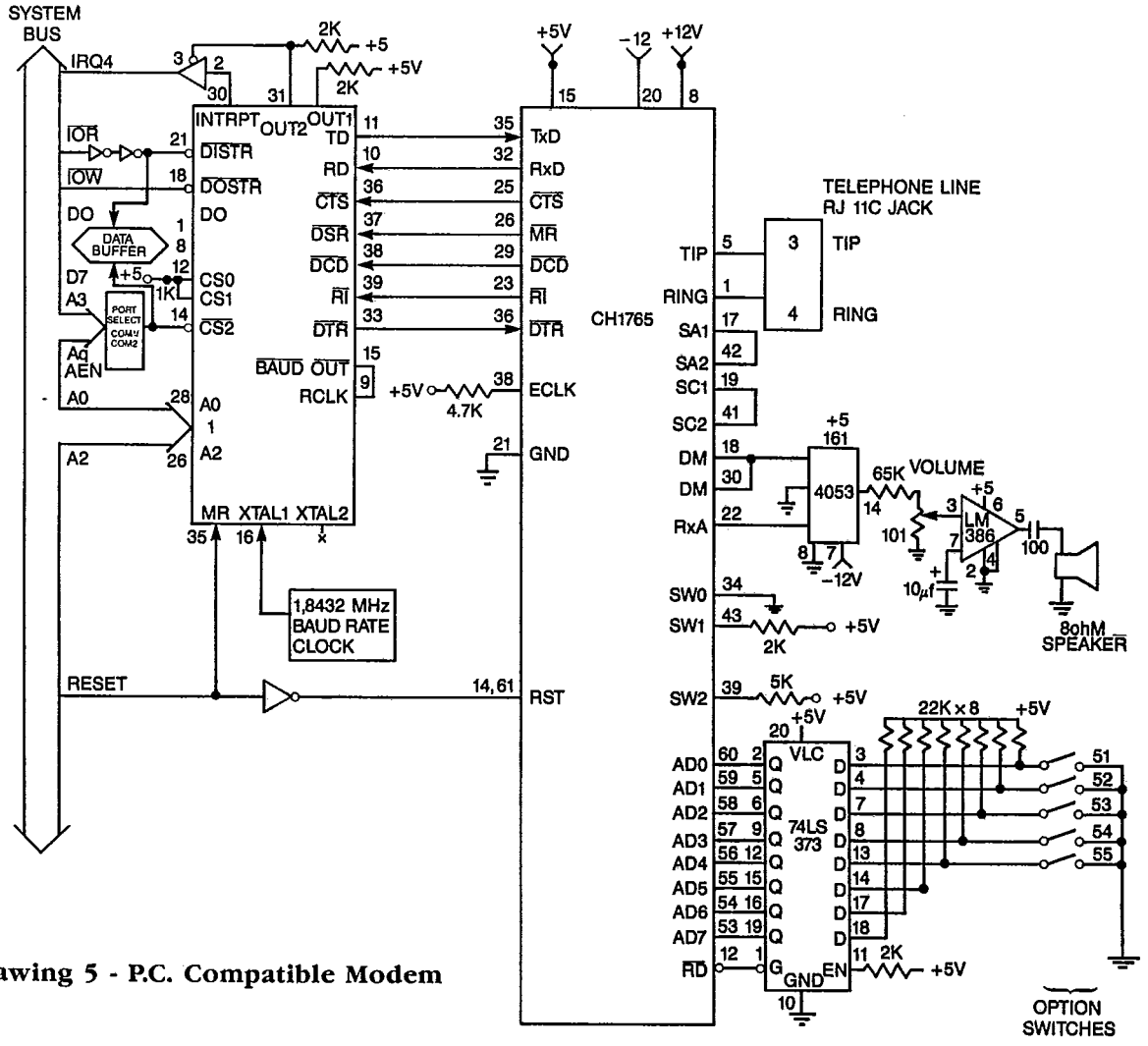
The CH1760E has the capability of addressing external memory for saving both dialed numbers and log-in messages. As shown in Figure 3-6, a 2Kx8 HM6116 CMOS RAM may be interfaced to the modem via a single 74LS374 latch. The latch separates data lines from address lines which are supplied on modem pins AD0-7. The modem must be equipped with exactly this amount of RAM.

After dialing, the modem will return status messages to the host terminal or computer screen to advise such phone line conditions to indicate the call's progress such as no dial tone, line busy, phone ringing, modem answer tone or voice answer. In addition, the modem has been equipped with a speaker driven from pin RXA which allows the user to hear these same call progress conditions. The speaker is turned off or disabled by the DM signal when a data call is completed.

Since a standalone modem must provide a RS-232C interface with ±12 Volt signals, level converters must be used to convert up from the CH1760E's TTL levels. MC1488 and MC1489 level converters may be used for this purpose.

3.5.4 IBM® PC COMPATIBLE MODEM

The CH1765 modem module is used to connect to the IBM PC through a INS8250 UART. Although all of the modem modules can be used in an IBM PC application, the CH1765 is chosen here because it and the CH1765-01 are the only modules that support the "AT" command set. This allows the modem to run with the vast majority of communications software written for the PC.



Drawing 5 - P.C. Compatible Modem

The example shown permanently selects SW0-SW2 to support asynchronous communication with 10 bit word frames and standard RS-232C signal sequencing. Also, five option switches (S1 – S5) are added to control the power-up setting of several modem parameters as shown below:

STRAP	STRAP STATE	MEANING
S1	Closed Open	Result codes are sent in English Result codes are sent as single digits
S2	Closed Open	No result codes are sent Result codes are enabled
S3	Closed Open	Echo command characters Does not echo command characters
S4	Closed Open	Does not auto-answer Auto-answer on the first ring
S5	Closed Open	Ignore commands Recognize commands

4.0 MODEM CONTROL

All the modem modules described here may be controlled by sending them serial ASCII command sequences. The commands are sent to the modem serially on TXD, pin 35, and then, after execution of the command, the modem returns a serial status message on RXD, pin 32 to indicate the completion status of the command.

The modem modules are divided into two groups: 1) those supporting the Cermetek serial commands, and 2) the CH1765 and CH1765-01 which support the "AT" command set. Although both command sets perform similar functions, they are implemented in a substantially different form. For this reason, this section will discuss modem control separately for these two groups. Sections 4.1.1 to 4.1.6 will discuss control for the CH1760 and CH1770 families. Sections 4.2.1 to 4.2.7 will discuss the CH1765 and CH1765-01.

1. Messages generated by the modem are underlined.
   Example: CONNECT
2. Commands sent to the modem are shown in **Bold.**
   Example: **ATDT5551212[CR]**
3. Symbols shown in brackets [ ] represent special characters or variables.
   [CR] = Carriage return
   [LF] = Line feed
   ␣ = indicates a space
   [com] = designates the command character
   { } = Optional characters

4.1 Cermetek Comand Set

4.1.1 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 (1200, 300, or 110 bps) and parity (odd, even, mark, space or none).

POWER-UP RESET

After applying power to the modem, a high-going reset signal must be asserted on RST, pin 14 (also pin 61 on the CH1760E, CH1765 and CH1765-01), for at least 1 msec after the +5V power supply has stabilized above +4.5V. This presets the modem to a known state.

No commands or training characters should be sent to the modem for a minimum of one second after removing 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/USART. The host must retrain the modem each time a reset signal is applied on RST or after a RESET command is sent to it over the serial TXD line. The modem is trained by sending it the following four-character asynchronous sequence:

TRAINING CHARACTER	DESCRIPTION
␣ ␣	adapt to host speed
␣ ␣ X Y	adapt to host speed and parity

It is important that each training character be followed by a minimum period of 200 ms where no characters are sent.

The modem may be retrained any time while it is idle. For example, in applications where the speed of a call is changing, it is convenient to insert the training sequence before each dialing command. This insures the modem will properly receive the host's command and also establishes the call at the proper speed.

4.1.2 Serial Command Format

All commands issued to the modem should be encoded in ASCII and preceded by a single command character, **[com]**. At power-up or after a RESET command, the command character, **[com]**, is set to control-N (ASCII 14). It may be altered to another character via the NEW command. Each command line must be terminated by a carriage return, **[CR]**.

Multiple commands can be placed on one line separated by commas. The commands themselves consist of the command character followed by the command word, a delimiter, all arguments, and then a closing carriage return or comma. The maximum length of any command line, however, is 40 characters. Some commands are treated as more than 1 character. See Table 4-2.

Two examples of commands would then look like the following:

[com]DIAL b '(408)555-1212'[CR]
[com]DIAL b '(408)555-1212',QUERY[CR]

In both cases, the notation **[com]** is equivalent to the single command character. The delimiter separating the command from the arguments is always a space. Only the first character of the command itself is significant. All remaining characters are ignored up to the first space following the command. In other words, 'DIAL' and 'DUMMY' are treated identically by the modem. Both upper and lower case characters are accepted.

The arguments are all ASCII numbers and/or characters. The numbers themselves are represented by the corresponding ASCII number and may take on hexidecimal values (0-9, A-F).

Commands can be aborted while in progress by sending the modem another command. The modem will abort the current command upon receiving the new command's **[com]** character and then begin executing the new command after receiving the complete command line.

The modem absorbs all commands without sending them on to the phone line. The modem considers anything between a **[com]** character and a carriage return, **[CR]**, a command. If you desire to send a file or other data containing a **[com]** character in it, you must alter the modem command interpreter to guard against unwanted modem responses. There are two ways of resolving the problem. The first way is to change the command character to another unused character and then transmit the data. The second and more practical way is to command the modem not to listen to commands while it is in the middle of a call. This is done with the UNLISTEN command. More on this later in Section 4.1.5.

4.1.3 Serial Modem Command Summary

The following commands may be sent to the modem to control its operation.

COMMAND SUMMARY

[com]ANSWER[CR] — Start an answer mode data call. The phone line is placed OFF-HOOK for 2 seconds then answer tone is returned for up to 45 seconds. One of the following three status messages will be returned.

[com]N[LF][CR]	Call not connected
[com]A[LF][CR]	Connected at the last trained speed
[com]W[LF][CR]	Connected, but at different speed than last trained speed. (i.e., if last trained at 300 bps, the call is answered at 1200 bps.)

[com]BREAK b n[CR] — Modem sends a break (constant null's) for **n** x 250 msec. **n** may be 1-9.

[com]COUNT b n[CR] — Sets ring and ring-back counter

n = 0 : disables auto-answer

n = 1-9 : enables auto-answer after n rings. Also for the CH1760A, CH1760E, and CH17L60 an auto-dialed call gives up after n + 4 rings. The CH17L70 and CH17L70 do not monitor ring-back tone.

[com]DIAL[CR] — dial last number

[com]DIAL b '[phone number]'[CR] — dial phone number. The phone number may contain numbers and control characters which are described in Table 4-2. Most control characters count as two digits. Up to 32 digits may be in the phone number. Both the CH1770 and the CH17L70 must specify the **[phone number]** preceded by either TB for tone dialing or **PB** for pulse dialing since both support only blind dialing.

[com]D b 'TB[phone number] ' [CR]
[com]D b 'PB[phone number] ' [CR]

[com]DIAL b '[phone number]' b n[CR] — Dial the phone number **n** times until answered. **n** may be 1-9.

[com]DIAL b [letter][CR] — Dial number from memory location indicated by **[letter]**. **[letter]** may be lower case a-z, or upper case A-Z and thereby defines 52 phone number storage locations. (Valid only for the CH1760E with external memory (see Stand Alone Modem with Memory in Section 3.5.3)

[com]DIAL b [letter] b n[CR] — Dial the number stored in the memory location indicated by **[letter]**, **n** times or until answered. n may be 1-9. (Valid only for the CH1760E with external phone number memory)

Table 4-2
Dialing Control Characters

DIALING CONTROL CHARACTER	CHARACTER COUNT	MEANING
T	2	Wait for dial tone then tone dial
P	2	Wait for dial tone then pulse dial
B	2	Pause 2 seconds. Modem versions with 4-second pause are also available on special request.
Z	2	Terminates dialing with modem off-hook and waits for another command. Useful for sending multiple dial commands to dial numbers larger than 32 digits.
TB	4	Waits 2 seconds without monitoring the dial tone then tone dials. This control sequence counts as 4 dialed digits.
PB	4	Waits 2 seconds without monitoring dial tone then pulse dials. This control sequence counts as 4 dialed digits.

Spaces are not allowed in the dialing string but parenthesis and dashes may be inserted for ease of readability. They each count as a single dialing digit.

[com]END[CR] — Hangs up a call.

[com]LIST[CR] — Lists the last number dialed. The CH1760E with external memory also lists the stored phone number memory locations.

[com]MESSAGE b [letter][CR] — Send memory storage location indicated by **[letter]**. **[letter]** may be a-z or A-Z. Valid for CH1760E with external phone number memory only. See the STORE command.

[com]NEW b n[CR] — Set the value of command character, **[com]**, to **n**.

[com]ORIGINATE[CR] — Start an originate data call. The phone is placed OFF-HOOK and for up to 45 seconds the modem will wait for answer tone to start the call. Either of the following status messages will result:

[com]A[LF][CR] Call connected
[com]N[LF][CR] Call not connected

[com]PROGRAM b nn[CR] — Set internal modem options. More on this in Section 4.1.6.

[com]QUERY[CR] — Request the modem's current status. The following status response is returned:

[com]OCHSARDUXZ/X_1X_2 [LF][CR]

CHARACTER	DESCRIPTION
O	off-hook asserted
C	carrier detected
H,M,L	speed (H:1200,M:300,L:110 bps)
S	self test enabled
A	analog loop test enabled
R	remote originated digital loop
D	digital loop locally enabled
U	unlisten mode enabled
X	modem echoes commands
Z	remote digital loop enabled
/X_1X_2	current hex TEST error count

If a period (.) replaces any of the status characters, it implies the negative or opposite status condition.

[com]RESET[CR] — Resets the modem to its idle reset state. The modem must be retrained following this command.

[com]STORE b [letter] b '[string]' [CR] — Stores the up to 32 character string indicated by **[string]** in the memory location identified by **[letter]**. **[letter]** may be a-z or A-Z. Valid only for the CH1760E with external phone number memory.

[com]TEST b n[CR] — Selects a diagnostic test mode. More on this in Section 6.0.

[com]UNLISTEN b n[CR] — Enable (listen) or disable (unlisten) recognition of commands sent to the modem. More on this in Section 4.1.5.

[com]ZZZZ[CR] — Quiet the modem. During a call, the modem carrier is silenced, the modem stays OFF-HOOK, and awaits further commands. Either an ORIGINATE or ANSWER command will restore the data call. An END command will terminate the call.

4.1.4 Serial Status Messages

The modem returns status messages to the host over its receive data line, RXD, to indicate the completion status of each command. All status messages are framed as shown below:

[com][status message][LF][CR]

A command character, **[com]**, precedes each message to let the host know that this is a status message and not data received from the remote modem. A [LF] and [CR] terminate each returned status message.

The modem defines two types of status messages — solicited and unsolicited. Messages are considered to be unsolicited if they result from an occurrence other than a serial host command. Such messages occur as a result of auto-answer, MI/MIC initiated answer/originate, incoming telephone line ringing, and disconnection resulting from loss of carrier or received long space. Unsolicited status messages are disabled after a power-up reset or after a serial RESET command. They may be further enabled or disabled via the program register with the PROGRAM command. This will be described more in the section to follow. Solicited status messages are always enabled.

Table 4-3
Status Message Summary

[com]A[LF][CR]
Data call connected at the previously trained modem speed.

[com]B[LF][CR]
Busy signal detected.

[com]D[LF][CR]
Modem disconnected. This message only occurs when unsolicited status messages are enabled.

[com]N[LF][CR]
Call not connected. The call was not connected due to number of rings allowed in ring counter.

[com]R[LF][CR]
Ring signal detected.

[com]W[LF][CR]
Data call answered but at a speed different than the previously trained speed. If the modem was last trained at 300 bps and the modem answered at 1200 bps, [com]W[LF][CR] is returned at 300 bps. After the status message, the modem switches to 1200 bps. You should readjust the host's UART/USART to match.

[com]X[LF][CR]
No dial tone detected for 5 seconds.

[com][LF][CR]
Command completed acknowledgment.

[com][Dialed number]{[R...R]}{[V]}[LF][CR]
After the dial command is accepted, the modem returns the number's dialed status as it is dialed. After dialing, it returns an [R] or [V] if ringback or voice signals are detected. [R] and [V] are not detected by the CH1770 family modems.

4.1.5 Giving Commands During a Call

Once in a data call, the modem may be programmed to not listen to further commands. This can protect against the modem falsely recognizing a command in a block of data that is being sent through the modem.

To turn command recognition off, the UNLISTEN command may be used.

[com]U[CR] — Turn command recognition back on.

[com]U ♭ 0[CR] — Turn command recognition off until the host sends a break (100 milliseconds minimum of continuous zeros). The modem will thereafter turn command recognition back on. The break will be absorbed by the modem.

[com]U ♭ 1[CR] — Turn command recognition off for the entire call. There is no way of re-enabling command recognition until the end of the call.

Commands are always recognized before a call. Only during a call does the UNLISTEN command affect whether commands are recognized.

Typical dialing and answer command strings are shown below that employ the UNLISTEN command.

[com]D ♭ 'T767-1111' ,U ♭ 0[CR] — Tone dial 767-1111, then after answering, disable command recognition until a break signal is received from the host.

[com]A,U ♭ 1[CR] — Answer a call and disable command recognition for the duration of the call.

4.1.6. Setting Internal Modem Options

The modem is equipped with a Program Register which you can control to set up several important modem parameters. The parameters are controlled by issuing a PROGRAM command to the modem. Since these commands are serial, they may only be given after you have trained the modem to the host UART's speed and parity. The general form of the PROGRAM command is shown below:

[com]PROGRAM[CR] — Host requests option status.

If the PROGRAM command is given without parameters, the modem will return the current H_1H_2 code as shown below. The H_1H_2 code at power-up or after a RESET command is 00.

[com]00[LF][CR]
Modem returns the current option status preceded by the [com] character and followed by a line feed and carriage return.

[com]P b H_1H_2 [CR]

If the PROGRAM command is given with H_1H_2 supplied, the modem will update the option status to use the newly supplied values:

[com]P b 64[CR] — Host sends the modem a H_1H_2 new value of 64. This instructs the modem to not disconnect on long receive spaces and not send long space on host initiated disconnects. Also the modem echos commands received back to the host and enables unsolicited status messages. All other parameters remain at their power-up state.

The table below summarizes the parameter controlled by the PROGRAM command. It is important to understand that the numeric H_1H_2 parameters sent with the command use the ASCII numeric codes (i.e., zero is ASCII 48).

INTERNAL MODEM PARAMETER SUMMARY

H_1				H_2				PARAMETER DESCRIPTION
X_3	X_2	X_1	X_0	X_3	X_2	X_1	X_0	
							0	disconnects on loss of receive carrier
							1	does not disconnect on loss of receive carrier
						0	...	does not assert OFF-HOOK during modem test
						1	...	does assert OFF-HOOK during modem test
					0	.....		enables sending & receiving of long space on disconnect
					1	.....		disables sending & receiving of long space on disconnect
				0	.....			must always be zero
			0	.....				enables answer mode speed switching
			1	.....				disables answer mode speed switching
		0	.....					disables unsolicited status messages
		1	.....					enables unsolicited status messages
	0	.....						disables echoing of commands
	1	.....						enables echoing of commands
0	.....							must always be zero

4.2 "AT" Command Set

4.2.1 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 (1200, 300, 110 bps) and parity (odd, even, mark, space or none).

POWER-UP RESET

After applying power to the modem, a high-going reset signal must be applied on RST, both pins 14 and 61, 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 be upper case
[CR] represents carriage return

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

0[CR] (abbreviated form)

[CR][LF]0K[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.

4.2.2 Serial Command Format

All modem commands begin with the serial ASCII attention sequence, "AT". Both "A" and "T" must be upper case but the commands that follow may be either upper or lower case ASCII. The modem uses the 'AT' characters to adapt to the host's speed (110, 300, or 1200 bps) and parity (odd, even, mark, space or none).

The speed chosen to send serial commands is also used to set the speed of data transmission.

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.

Typical commands then consist of three elements, an 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 key or control-H (ASCII 8) can be used to edit mistakes. "AT" and "A/" may not be edited however. Multiple commands may be placed in a 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]

Commands with arguments like the echo command above, "E" (argument of 0 for do not echo and 1 for echo), may be specified without their arguments. When this is done, an argument is assumed to be Zero by the modem, therefore an equivalent command sequence as above would be.

ATEA[CR]

4.2.3 Serial Modem Command Summary

The following commands may be sent to the modem to control its operation.

COMMAND SUMMARY

ATA[CR] — Start an answer mode handshake. The phone line is placed OFF-HOOK for two seconds, then answer tone is returned for nominally 30 seconds. One of the following status messages will be returned:

ABBR.	ENGLISH
3[CR]	[CR][LF]NO CARRIER[CR][LF]

Did not connect to the calling modem.

1[CR]	[CR][LF]CONNECT[CR][LF]

Connection made to the calling modem.

5[CR]	[CR][LF]CONNECT 1200[CR][LF]

Connection made to the calling modem at 1200 bps.

When a modem calls the CH1765 or CH1765-01, each ring is indicated with a RING status message.

110 or 300 bps connections are indicated with a CONNECT status message and 1200 bps connections with a CONNECT 1200 message if Extended Connect Status Messages are enabled (see ATX2 command). Otherwise, all connections are indicated with just the CONNECT status message.

The answering modem adapts to the caller's speed, which may be different than the speed previously trained by the local host. The modem, therefore, returns its status message at the previously trained speed, but thereafter switches to the new speed. For example, when a modem previously used at 300 bps answers a 1200 bps call, it returns a connection status of CONNECT 1200 at 300 bps.

An ANSWER command may be aborted by sending the modem any character before it indicates a CONNECT status.

ATC0[CR] — Turn carrier OFF. The carrier can only be turned back on by a **C1** command or by a reset.

ATC1[CR] — Enable carrier.

ATDs[CR] — Dial the number string s. A typical auto-dial command is shown below:

ATDT[number][CR]

- [CR] — enter or return key
- [number] — telephone number may include:
  - 0-9: numbers
  - –,*: tone only
  - , : interrupt dialing for 2 seconds
  - + : pauses for dial tone (CH1765 only)
  - spaces and punctuation ignored
- T — specifies tone dialing. P specifies pulse dialing.
- D — dial command
- AT — attention prefix (must be upper case)

, (comma)* — Pause for secondary dial tone. Default time is 2 seconds.

; (semicolon)* — Forces the modem to re-enter the command state after dialing. This is useful for auto-dialing voice calls.

+ (plus)* — Pause until dial tone is detected (enabled by the Extended Call Progress Status Message command, X2). CH1765 only.

R * — Reverse ccurrent connection mode. Useful for auto-dialing an originate-only type modem.

While waiting to connect, the call attempt may be aborted by typing any character. A NO CARRIER status is returned if dialing has been completed or OK is returned if dialing was in progress.

ATE0[CR] — Do not echo characters typed when in the command mode.

ATE1[CR] — Do echo characters typed when in the command mode.

ATF0[CR] — Half Duplex. Do echo characters when typed during a data call.

ATF1[CR] — Full Duplex. Do not echo characters when typed during a data call.

ATH0[CR] — Hang up.

ATH1[CR] — Go OFF-HOOK.

ATI0[CR] — Request the product revision code.

ATI1[CR] — Request the firmware date code.

ATO[CR] — Go back to the data mode. The answer or originate state will be the previously established state.

ATQ0[CR] — Enable status messages.

ATQ1[CR] — Disable or turn off status messages.

ATSr?[CR] — Read command register **r**. **r** may be 0-12 or 16 and the read result will be in the range 0-255.

ATSr=n[CR] — Set command register **r** to **n**.

ATV0[CR] — Status messages will be abbreviated to one digit.

ATV1[CR] — Status messages will be in English.

ATX0[CR] — Enable only the BASIC status message set. (see section 4.2.5)

ATX1[CR] — Extended Connect Status Message select command. Enable the 1200 bps connect status message (CONNECT 1200) in addition to the BASIC status set.

ATX2[CR] — Enable BASIC plus 1200 bps Connect Status Messages and the Extended Call Progress Messages. (CH1765 only.)

ATZ[CR] — Reset.

*These commands are typically placed in the dialing command string.

4.2.4 Command Registers

The modem refers to 14 registers to correctly execute many different operations. The function of each of these registers is explained below. The value of each register must be 0-255.

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 will 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. Only a call disconnection will return the modem to command mode.

S3 — End-of-line character. This is the character typed to terminate a command, and the character output after status messages. Defaults to carriage return (ASCII 13).

S4 — Line feed character. This is output after the end-of-line character of English status messages. Defaults to line feed (ASCII 10).

S5 — Backspace character. This is the character typed to erase one command character and this is the character that is output to move the cursor backwards on the host screen. To erase a character, the modem first outputs a backspace, then it outputs a space (ASCII 32), and then another backspace to move back over the space. Default is backspace (ASCII 8).

S6 — Dial tone wait. The pause, in seconds, after going OFF-HOOK. (Can't be less than 2 seconds, 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 set to 255, the modem acts as if a carrier is always present.

S11 — Touch-Tone speed. Time, in milliseconds, of tone duration. Default is 70 milliseconds. Only tens of milliseconds are actually used (i.e 80 and 85 both specify 80 milliseconds). The practical range of S11 is 60 to 250 milliseconds.

S12 — Time delay, in 1/50 seconds, required before and after the escape code. The time between the characters of the escape code must be less than S12 (the "guard time"). If S12 is 0, then timing is not a factor in recognizing the escape code. Default is 1 second.

S16 — Test Mode (see Section 6.0 for detailed description).

- S16=0 is normal (non-test) operation
- S16=1 puts the modem in analog loop-back
- S16=2 causes any Touch-Tone that is dialed to be transmitted continuously until a character is received from the host
- S16=3 analog loop self test
- S16=4 digital loop
- S16=5 remote digital loop
- S16=6 remote digital loop self test
- S16=7 self test, end-to-end

4.2.5 Serial Status Messages

After each command is executed, the modem will respond with a status message. The message may either be a single digit followed by a carriage return or it may be a carriage return and line feed followed by an English Status Message followed by another carriage return and line feed. The following are the different status messages that are transmitted to the host computer.

BASIC STATUS MESSAGE SET:

0[CR] or [CR][LF]OK[CR][LF]
Command executed

1[CR] or [CR][LF]CONNECT[CR][LF]
Carrier detected

2[CR] or [CR][LF]RING[CR][LF]
Incoming ring detected

3[CR] or [CR][LF]NO CARRIER[CR][LF]
Did not detect a carrier or carrier was lost

4[CR] or [CR][LF]ERROR[CR][LF]
Problem detected

EXTENDED CONNECT STATUS MESSAGE SET:

5[CR] or [CR][LF]CONNECT 1200[CR][LF]
Carrier detected at 1200 baud.

EXTENDED CALL PROGRESS STATUS MESSAGE SET:

6[CR] or [CR][LF]BUSY[CR][LF]
Busy signal detected

7[CR] or [CR][LF]VOICE[CR][LF]
Human voice detected

8[CR] or [CR][LF]NO DIAL TONE[CR][LF]
No dial tone detected for 5 seconds.

9[CR] or [CR][LF]RINGING[CR][LF]
Ringback detected

The result codes have two extensions. The first extension defines a 1200 bps CONNECT message. The second extension is defined only for the CH1765 and enables the return of the telephone line's condition to the host after dialing.

Both extensions are enabled via the "Extended Status Message Select" (**ATXn[CR]**) command. At power-up, both the extensions are disabled which means only the initial five status messages are enabled (abbreviated status codes 0-4).

4.2.6 Giving Commands During a Call

The modem has two states; command state and data mode state. The data mode is the state of the modem when it is in the middle of a data call. The modem is in the command state at all other times. In the data mode, the modem will not recognize commands. To recognize commands, the host must first send an "escape sequence" to the modem. This sequence forces the modem out of the data mode and temporarily into the command mode without disconnecting. In this mode, all modem commands are executed.

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

4.2.7 Setting Internal Modem Options

The modem supports an optional configuration port to define several important modem parameters at power-up or after a RESET command. The modem connects to the configuration port through the external data port (AD0-AD7) and is enabled via the I/O read line, $\overline{RD}$, as shown in Figure 4-1.

The modem attempts to read this port at power-up. Table 4-8 represents one byte (8 bits) of information. If bit 7 is low, the default configuration can be changed by reading the position of the bits. Serial commands can be issued after power-up to modify these settings (see Sections 4.2.3 and 4.2.4.).

If bit 7 is set HIGH (to one), the configuration port hardware is not implemented, and will automatically be set for the defaults listed. This means the modem will be set for the parameters listed in Sections 4.2.3 and 4.2.4.

Table 4-8
Configuration Port Definition

BIT POS.	LOGIC STATE	MEANING
0	Low	Status messages are sent in English
	High	Status messages are sent as single characters
	Default:	High
1	Low	No status messages are sent
	High	Status messages are enabled
	Default:	High
2	Low	Echo command characters
	High	Does not echo command characters
	Default:	High
3	Low	Does not auto-answer
	High	Auto-answers on the first ring
	Default:	High
4	Low	Ignore commands
	High	Recognize commands
	Default:	High
5&6	Used for making manual calls. (See Section 5.0).	
	Low	Set parameter states as indicated by the bit positions.
	High	Set all default parameter states
	Default:	High

5.0 MAKING CALLS

Besides communicating data, a modem performs three major tasks 1) dialing a call, 2) answering a call, and 3) hanging up a call. This section will explain how the modem may be controlled to perform each of these tasks.

Because two different serial command languages are available with Cermetek's modem modules, this section will discuss Making Calls separately for each command language. Section 5.1 will discuss call procedures for the CH1760 and CH1770 families, while Section 5.2 will cover the CH1765 family.

5.1 Calling with the CH1760 and CH1770 families

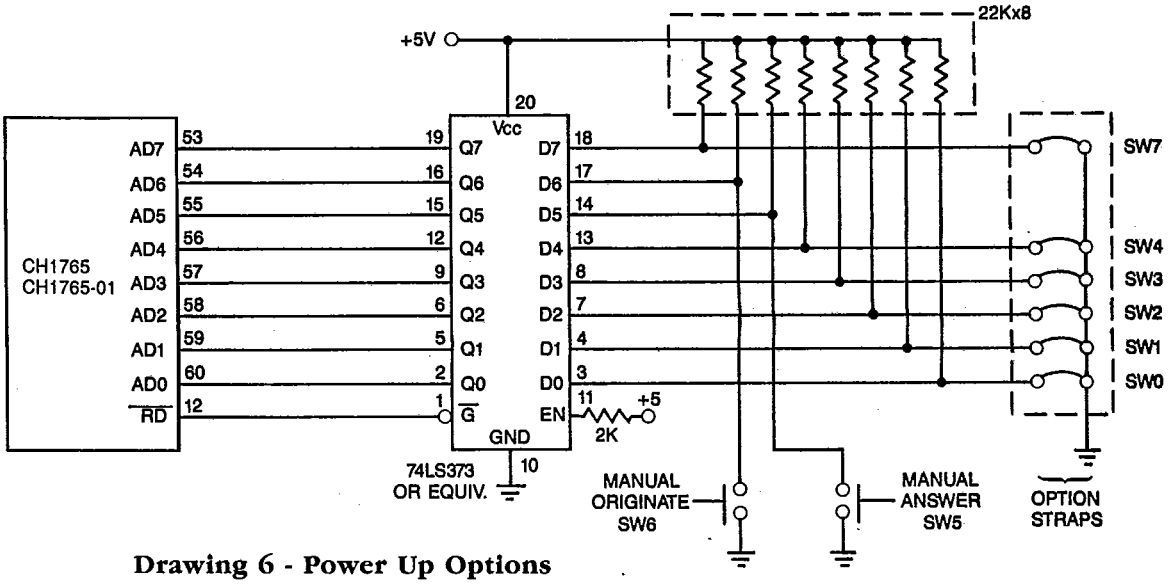
5.1.1 Dialing a Call

All modem modules support both manual and auto-dialing a call. A call is considered to be manually dialed if the user dials the call with a phone attached in parallel with the modem, whereas an auto-dialed call is dialed by the modem with a DIAL command. In either case the modem's $\overline{DTR}$ control line must be asserted ON (low) for dialing to be enabled.

MANUAL DIALING

When a call is manually dialed, the modem establishes the speed of the call at the last speed the modem was used. At power-up or after a RESET the last used speed defaults to 1200 bps.

To further select the speed of a manually dialed call, you must retrain the modem by sending it a training character sequence when it is idle as described in Section 4.1.2.



Drawing 6 - Power Up Options

MANUAL DIALING PROCEDURE

1. With a telephone connected to the modem's phone line, dial a call.
2. Wait for the called modem to answer and send a high pitched answer tone.
3. Initiate the data call either by
   a. sending the modem an ORIGINATE command **[com]O[CR]**
      or
   b. (for the CH1760A, CH1760E, CH17L60 only) by momentarily making a connection between MI and MIC I/O pins. The MI/MIC connection must be made for a minimum of 250 msec but not more than a maximum of 1.5 seconds
4. Hang up the telephone.

AUTO-DIALING A CALL

A call is auto-dialed by sending the modem a serial DIAL command. It is recommended that the retraining sequence as discussed in Section 4.1.2 precede the DIAL command if your application needs to communicate at more than just a single speed. The following variations of the dial command are supported:

1. Dial Last Number
   [com]D[CR]
2. Dial Number
   [com]D ♭ '[phone number]' [CR]
3) Dial Number "n" times or until answered
   [com]D ♭ '[phone number]' ♭ n[CR]
   where n = 1-9
4) Dial From Memory Location letter (CH1760E only)
   [com]D ♭ [letter][CR] —
   where [letter] = a-z or A-Z
5) Dial From Memory Location letter "n" times or until answered
   [com]D ♭ [letter] ♭ n[CR]
   where [letter] = a-z or A-Z
   n = 1-9

It is important to understand that the CH1760E, CH1760A, and CH17L60 are able to detect call progress tones such as dial tone and busy tone. Therefore, only they can execute dialing commands that instruct them to pause for dial tone. The CH1770 and CH17L70 must be commanded to dial without monitoring for dial tone which is normally referred to as blind dialing. This is accomplished by inserting a "TB" for tone dialing or a "PB" for pulse dialing in front of the phone number.

To specify the use of tone or pulse dialing for the CH1760 family a "T" (tone) or "P" (pulse) should precede the phone number. The modem will pause for dial tone then dial using tone or pulse dialing as directed. If neither "T" or "P" precedes the phone number, the modem will automatically select tone or pulse dialing. It first tries tone dialing and if after dialing the first digit, the dial tone goes away, the rest of the number is dialed using tones. If dial tone remains after the first tone dialed digit, the modem backs up and dials the entire number using pulse dialing.

Other control characters may also be inserted in the phone number to provide such functions as dialing delays. These are further described in Section 4.0 in the DIAL command description.

AUTO-DIAL COMMAND EXAMPLES

(Valid only for the CH1760E, CH1760A, and CH17L60)

[com]D ♭ '767-1111'[CR] — dials 767-1111 after automatically selecting tone or pulse dialing.
[com]D ♭ 'T767-1111' [CR] — dials 767-1111 using tone dialing after pausing for dial tone
[com]D ♭ 'P767-1111' [CR] — dials 767-1111 using pulse dialing after pausing for dial tone
[com]D ♭ 'T9T767-1111'[CR] — tone dials 9 after pausing for dial tone, then pauses for dial tone again and continues using tone dialing
[com]D ♭ 'T767-1111' ♭ 3[CR] — dials 767-1111 using tone dialing and redials the call up to 3 times if not answered

(Typical CH1770 or CH17L70 commands are also valid for the CH1760A, CH1760E and CH17L60)

[com]D ♭ 'TB767-1111'[CR] — blind dials 767-1111 using tone dialing after pausing 2 seconds
[com]D ♭ 'TB767-1111'[CR] — blind dials 9 using tone dialing after pausing 2 seconds then pauses again 2 seconds then dials 767-1111 using tone dialing
[com]D ♭ 'TB767-1111Z'[CR] — blind dials 767-1111 using tone dialing then returns to the idle state with the phone line OFF-HOOK. This is typically used to auto-dial voice calls

(VALID ONLY FOR THE CH1760E)

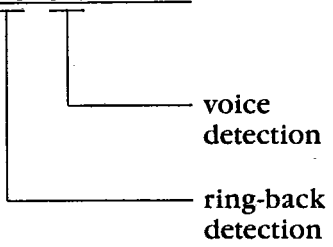
[com]D ♭ A[CR] — dials the number stored in memory location A
[com]D ♭ Z ♭ 3[CR] — dials the number stored in memory location Z and redials the call up to 3 times if not answered.

DIAL STATUS MESSAGE

After receiving the dial command, the modem returns up to two status messages. The first message returns the number as dialed plus voice

and ring-back signal indications as shown below:

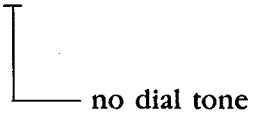
[com][dialed number][R]...[V][LF][CR]



NOTE: [R] occurs once for each ring-back signal after the second ring-back signal. Both [R] and [V] are not supported with the CH1770 and CH17L70

If this status message is terminated with an "X" as shown below, then the modem has aborted dialing due to a dial tone detection failure.

[com][partial dialed number[X][LF][CR]



After successfully dialing the number, the modem waits for remote modem answer tone up to 45 seconds or for the number of ring-back signals specified in the COUNT command (CH1760E, CH1760A, and CH17L60 only). The second message is next returned as shown below:

[com]A[LF][CR] — remote modem answered and ready to communicate.

[com]N[LF][CR] — no modem answer tone. The modem disconnects and returns to the idle state.

ABORTING A DIAL ATTEMPT

To abort or stop a dialing sequence before it is completed, the host may send the modem the following sequence:

[com][1-second pause]E[CR]

This aborts the dialing sequence and returns the modem to an idle state.

5.1.2 Answering a Call

Like dialing, the modem may be instructed to manually or automatically answer a call. Modem control line $\overline{DTR}$ must be asserted ON (low) to enable answering. The modem will automatically adapt to the calling modem's speed (1200/300/110 bps) for both automatic and manual answering.

MANUAL ANSWERING

To enable manual answering the modem must be programmed to disable auto-answer. This is done with the COUNT command.

[com]C Ƅ 0[CR] disables auto-answering

The host is able to monitor for phone ling ringing by enabling unsolicited status messages via the PROGRAM command and detecting ringing status messages ([com]R[LF][CR]) or by monitoring the $\overline{RI}$ line, pin 23.

The modem may be manually instructed to answer the ringing phone line by either the ANSWER command (**[com]A[CR]**) or by a momentary contact between I/O lines MI and MIC. The momentary contact must be a minimum of 250 ms and no longer than 1.5 seconds.

AUTO-ANSWERING A CALL

At power-up or after a RESET command the modem defaults to auto-answering after the second ring. The COUNT command selects when the modem answers.

[com]C Ƅ n[CR]

where n = 1-9 and programs the modem to auto-answer after n rings.

It is important to remember that when a modem auto-answers it will not receive an answer status message unless unsolicited status messages are turned on via the PROGRAM command.

ANSWER STATUS

The modem will return one of the following status messages after attempting to answer a call.

[com]A[LF][CR] — call answered at the previously trained modem speed.

[com]W[LF][CR] — call answered, but at a different speed than the previously trained speed.

[com]N[LF][CR] — no answer after 45 seconds.

In summary the modem will answer with an "A" status if the calling modem is set to its previously trained speed and with a "W" status if the calling modem is at a different speed than the previously trained speed. If the modem was trained at 300 bps and a call came in at 1200 bps, the modem would answer with a "W" status at 300 bps and then switch to 1200 bps. The host UART/USART should thereafter switch also.

If the modem cannot complete an answer within 45 seconds of the attempt, the call aborts with an "N" status.

ABORTING AN ANSWER ATTEMPT

If the host wishes to prematurely abort an answer-

ing attempt, it may send the following command sequence:

[com][1-second pause]E[CR]

This will interrupt the answer sequence and hang up the call.

5.1.3 Hanging Up a Call

The modem may be hung up in one of four ways.

1. BY COMMAND
   The END command (**[com]E[CR]**) disconnects a call and returns the modem to an idle state. The modem will not disconnect if it has been commanded to not listen to commands during a dial call with the UNLISTEN command.
2. BY CARRIER LOSS
   In its power-up or default state, the modem will disconnect on carrier loss but the modem may be optioned via the PROGRAM command to not disconnect on carrier loss.
3. BY RECEIVING A LONG SPACE
   In its power up or default state, the modem will disconnect when it receives a continuous 1.6-second or longer string of zeros. The modem may be optioned via the PROGRAM command to not disconnect upon receiving a long space.
4. FROM THE $\overline{\text{DTR}}$ PIN
   Asserting $\overline{\text{DTR}}$ OFF (high) will disconnect a call.

In the modem's power-up or default state it will send a constant 4-second string of zeros before disconnecting a call. The modem may be optioned via the PROGRAM command to not send a 4-second zero condition before disconnecting.

5.2 Calling With the CH1765

5.2.1 Dialing a Call

The modem has a built-in auto-dialer that can be used to make either data or voice calls using either tones or pulses for dialing.

MANUAL DIALING A CALL

The configuration port of the modem described in Section 4.2.7 defines two inputs that may be used to manually initiate either an originate or answer call.

The ORIGINATE (**ATO[CR]**) serial command may also be used to initiate a call after manual dialing.

MANUAL DIALING PROCEDURE

1. With a telephone connected to the modem's phone line, dial a call.
2. Wait for the called modem to answer the call and send an answer tone.
3. Initiate the data call by either:
   a. Sending the modem an ORIGINATE command (**ATO[CR]**). The call's speed will be the same speed that the host uses to send the ORIGINATE command.
   (or)
   b. Momentarily setting bit 6 LOW, on the configuration port (Table 4-8). The modem's originate speed will be the speed at which the modem was last used. If the modem was just powered-up or a RESET command was just issued, then the modem will be set to its default speed of 1200 bps.
4. Hang up the telephone.

AUTO-DIALING A CALL

1. The following serial DIALING command activates the modem's auto-dialer. The speed of the call established will be the same speed that the host uses to send the AUTO-DIAL command.

ATDT[phone number][CR]

- attention prefix (must be upper case)
- dial command
- tone-dialing command (or P to select pulse dialing)
- telephone number may include
  - 0-9: numbers
  - –,*: numbers (tone only)
  - , : 2-second wait for dial tone
  - + : pause for dial tone (CH1765 only)
  - R : reverse the calling mode from originate to answer

  Spaces and other punctuation marks are ignored. The phone number may contain a maximum of 38 characters.
- Carriage return (ASCII 13)

2. When the data call is completed, the modem sends one of the following status messages back to your screen:

   [CR][LF]CONNECT[CR][LF] or 1 [CR]

   [CR][LF]CONNECT 1200[CR][LF] or 5[CR]

   If the call is unsuccessful, the modem will time

out after nominally 30 seconds and return a NO CARRIER status message (abbreviated code 3).

If the CH1765 is used, extended call progress status messages may be enabled via the X2 command that allows the modem to return the following additional phone line status conditions after dialing: BUSY, NO DIAL TONE, RINGING, MODEM ANSWER TONE and VOICE . The CH1765-01 does not support these status messages.

AUTO-DIALING A VOICE CALL

1. Enter a dialing command as you would do for a data call, but end your phone number with a ; (semicolon).

   ATDT[phone number];[CR]

2. Pick up the phone to talk when the modem displays an OK on your screen.

3. Hang up the modem after you have picked up the phone. This is done by entering:

   ATH0[CR]

AUTO-DIALING THE LAST NUMBER

The modem may be instructed to re-execute the last command. If that command was a dialing command which failed, simply enter the following to try dialing again.

A/ ("A" must be upper case)

Note that a carriage return, **[CR]**, is not needed.

AUTO-DIALING COMMAND EXAMPLES

1. **ATDT5551212[CR]** — dials a modem at the number 5551212 using tone dialing.

2. **ATDT9,5551212[CR]** — dials a modem through a PBX using tone dialing. 9 is dialed followed by a 2-second pause caused by the , (comma) then 5551212.

3. **ATDP5551212[CR]** — dials a modem at the number 5551212 using pulse dialing.

4. **ATD5551212[CR]** — dials a modem at the number 5551212 using the previously specified selection of tone or pulse dialing. If Extended Call Progress Monitoring is enabled via the **ATX2[CR]** command on the CH1765, the selection of tone or pulse dialing will be automatically selected.

5. **ATDT5551212R[CR]** — dials a modem at the number 5551212 using tone dialing then switches from being the originating modem to the answering modem. The R causes the modem to "reverse" its calling state. This is useful if you are auto-dialing an "originate only" modem.

6. **ATDT5551212;[CR]** — dials a voice party at the number 5551212 using tone dialing

7. **ATDT9+5551212[CR]** — dials a modem through a PBX using tone dialing. 9 is dialed followed by a 2-second pause caused by the + (plus) then 5551212. Notice that the , (comma) and + (plus) perform the same operation — a pause. If Extended Call Progress Monitoring is enabled on the CH1765 via the **ATX2[CR]** command, the + (plus) function changes from a pause of fixed length to a wait until dial tone function.

8. **ATDT9,4085551212,,,12345,2027771234;[CR]** — tone dials the number 4085551212 through a PBX, pauses 6 seconds for dial tone from a value added carrier, then sends the I.D. number 12345. After pausing 2-seconds, the called number is dialed, 2027771234. The call reverts to voice because a ; (semicolon) terminates the number.

DIALING STATUS MESSAGES:

After receiving the dialing command, the modem begins dialing. First it goes OFF-HOOK, then pauses 2 seconds for dial tone. The 2-second pause may be extended by redefining the value of the S6 register (see Section 4.2.4). If Extended Call Progress Monitoring is enabled for the CH1765 via the **ATX2[CR]** command, the modem will pause until dial tone is detected for up to 5 seconds before returning a NO DIAL TONE status message.

After the initial pause, the number will be dialed. The modem will then allow 30 seconds for the called modem to answer. This time may be modified by redefining register S7. If no answer is received during this time, the modem returns a failed call status.

[CR][LF]NO CARRIER[CR][LF] (English)

or 3[CR] (abbreviated)

If Extended Call Progress Messages are enabled for the CH1765 via the **ATX2[CR]** command, the modem will additionally return the following status messages to indicate the line condition. These messages are disabled at power-up or after a RESET command and are not implemented on the CH1765-01.

EXTENDED CALL PROGRESS MESSAGES

ABBR.	ENGLISH
6[CR] or	[CR][LF]BUSY[CR][LF]

Busy signal detected.

7[CR] or [CR][LF]VOICE[CR][LF]
Voice detected.

8[CR] or [CR][LF]NO DIAL TONE[CR][LF]
Dial tone was not detected.

9[CR] or [CR][LF]RINGING[CR][LF]
Ring-back detected.

After a BUSY, VOICE, or NO DIAL TONE status message is returned, the modem hangs up. A RINGING status message shows line activity only. The modem returns this status once for each ring after the first two ring-back signals.

When a call is completed, either one of the following status messages is returned:

1[CR] or [CR][LF]CONNECT[CR][LF]
Call connected.

5[CR] or [CR][LF]CONNECT 1200[CR][LF]
Call connected at 1200 bps.

At power-up or after a RESET command, the CONNECT 1200 status message is disabled. All call connections are indicated by a CONNECT message when the CONNECT 1200 message is enabled via the **ATX1[CR]** or **ATX2[CR]** command, calls completed at 1200 bps are indicated with a CONNECT 1200 status message and completed calls that are 110 or 300 bps are indicated with a CONNECT message.

ABORTING A CALL ATTEMPT
If it is desired to stop the dialing process either while dialing or while waiting for call completion, send any character to the modem. The modem will respond with the message:

3[CR] [CR][LF]NO CARRIER[CR][LF]

5.2.2 Answering a Call
Like dialing, the modem is able to automatically answer or manually answer calls. After answering, the modem will automatically adapt to the originating modem's speed (1200/300/110 bps). Like all other modem functions, the $\overline{DTR}$ modem control line must be asserted low to enable answering.

MANUAL ANSWERING
To enable manual answering, the modem must be programmed to disable auto-answer operation. This is done by redefining the S0 register. At power-up, register S0 is set to either 1 or 0 indicated by configuration port bit 3 (see Table 5-8 of Section 5.2.7). When S0 equals 1, the modem auto-answers on the first ring and when S0 equals 0 auto-answering is disabled. Auto-answering may also be disabled by entering the following command:

ATS0=0[CR] disable auto-answer command

The host may then monitor the phone for ringing by sampling the modem $\overline{RI}$ pin for a LOW condition or the serial data line, RXD, for a RING status message ([CR][LF]RING[CR][LF] or 2[CR]).

The modem may then be instructed to answer a call by either issuing an ANSWER command **(ATA[CR])** or by momentarily asserting a low (250 ms minimum, 1.5-second maximum) on bit position 5 of the configuration port.

AUTO-ANSWERING A CALL
At power-up or after a RESET command, the modem defaults to auto-answer after the first ring. The host may vary this; however, by redefining the S0 register as shown below:

ATS0=NCR

where n = 1-255 to enable auto-answer after 1-255 rings

ANSWER STATUS:
The modem will return one of the following status messages to indicate the completion of an answered call.

ABBR.	ENGLISH
1 [CR] or	[CR][LF]CONNECT[CR][LF]
Call connected.	
5 [CR] or	[CR][LF]CONNECT 1200[CR][LF]
Call connected at 1200 bps	

At power-up or after a RESET command, only the CONNECT status message is enabled. It will be returned for both 110, 300, and 1200 calls. The CONNECT 1200 status message may be enabled with either the **ATX1[CR]** or **ATX2[CR]** command. With it enabled, 110 and 300 bps answer calls are indicated with a CONNECT message and 1200 bps calls are indicated with a CONNECT 1200 message.

The CONNECT status messages are always returned to the host at its previously trained speed. If, for example, the modem had been previously used at 300 bps and a call was answered at 1200 bps, the modem would return a CONNECT 1200 message at 300 bps but would then switch to 1200 bps to match the caller. The host UART/USART should also switch its speed to match.

ABORTING AN ANSWER ATTEMPT
If the host desires to abort an answer attempt before a connection, it may send any character to the modem. The modem will respond with a NO CARRIER status message.

5.2.3 Hanging up a Call
The modem may be hung up in one of four ways:

1. BY COMMAND
   a) The modem ignores commands when it is in the data mode, so first the modem must be instructed to enter the command mode by sending it an escape sequence. The following 3-character escape sequence must be preceded and followed by a 1-second minimum period where no characters are sent to the modem.

      [No Keys typed for 1 Second] + + +
      [No Keys typed for 1 Second]

      This escape sequence can be changed by varying the values of registers S2 and S12.
   b) The modem responds with a status message showing that it is ready:
      [CR][LF]OK[CR][LF] (English)
      or O[CR] (Abbreviated)
   c) Finally, send the hang-up command:
      ATH0[CR]
2. FROM LOSS OF CARRIER
   The modem $\overline{DCD}$ pin will go high and the NO CARRIER status message will be returned.
3. FROM THE CONFIGURATION PORT
   Applying a momentary low level to either bit position 5 or 6 of the configuration port disconnects the call in progress.
4. FROM THE $\overline{DTR}$ PIN
   Asserting $\overline{DTR}$ high will disconnect the call.

6.0 MODEM TESTING

6.1 Testing the Modem

A modem is a complex sub-system that adds valuable communications capability to the host product. All Cermetek modem modules are vigorously tested at the factory to insure consistent and reliable modem operation. This makes incoming modem testing optional and at the very most requires you to perform sample AQL testing.

Once the modem is integrated in the host product, many things can affect the performance of the modem. Such things as power supply noise, noise coupling into the modem from adjacent circuit traces or inappropriate modem commands can all degrade or impair the operation of the modem. For this reason, a good modem test is recommended that evaluates the host product's ability to communicate data accurately over the full quality range of phone lines in varying degrees of phone line noise and signal level.

6.2 Built-in Diagnostics

The modem itself can be instructed to perform several test sequences using the TEST command to isolate suspected line impairments to either the modem itself, the phone line, or the remote modem.
The following test modes are described:

1. analog loop test
   - originate call mode
   - answer call mode
   - self test — originate call mode
   - self test — answer call mode
2. digital loop
3. remote digital loop, remote digital loop self test
4. end-to-end self test
5. tone dialing test (CH1765, CH1765-01 only)

ANALOG LOOP TEST
In an analog loop test, 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.

In a successful test the same characters that are sent are also received.

An analog loop self test can also be performed. In a self test the modem loops sent characters back as before. In addition, the modem transmits an "almost random" 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 test set-up.

Detected data errors are indicated in two ways: 1) each error causes the $\overline{MC}$ line to momentarily pulse on, and 2) an error accumulator inside the modem counts errors (up to 15 for the CH1765 and CH1765-01 and FF hex for all other modems). The error count is displayed as a status message at the end of the analog loop self test.

ANALOG LOOP TEST PROCEDURES:
(The modem must be idle before all analog loop tests)

CH1760 and CH1770 Families

A. Analog Loop — Originate and Answer Modes

START TEST

send command...

[com]T b 0[CR] (originate mode)
[com]T b 1[CR] (answer mode)

modem responds...

[com][LF][CR]

BEGIN TESTING

Transmitted characters are looped back and received. Both originate and answer test modes should be tested separately.

TERMINATE TEST

send command...

[com]T[CR]

modem responds...

[com]OCHSARDUXZ/X_1X_2[LF][CR]

Where X_1X_2 is the hex error count and the entire status message is the same as the results from a QUERY command.

B. Analog Loop Self Test — Originate and Answer Modes

CH1760 and CH1770 Families

START TEST

send command...

[com]T b 2[CR] (originate mode)
[com]T b 3[CR] (answer mode)

modem responds...

[com][LF][CR]

BEGIN TESTING

The modem sends and then receives its own data pattern. No data from the host is transmitted or received. Detected errors are accumulated and then displayed upon terminating the test.

TERMINATE TEST

send command...

[com]T[CR]

modem responds...

[com]OCHSARDUXZ/X_1X_2[LF][CR]

Where X_1X_2 is the hex error count and the entire status message is the same that results from a QUERY command.

CH1765, CH1765-01

A. Analog Loop — Originate and Answer Modes

START TEST

send command...

ATS16=1C1D[CR] (originate mode)
ATS16=1A[CR] (answer mode)

modem responds...

[CR][LF]CONNECT[CR][LF] 1[CR]

or [CR][LF]CONNECT 1200[CR][LF] 5[CR] (abbreviated)

BEGIN TESTING

Transmitted characters are looped back and received. Both originate and answer test modes should be tested separately.

TERMINATE TEST

send command...

+++

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATS16=0[CR]

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

B. Analog Loop Self Test — Originate and Answer Modes

START TEST

send command...

ATS16=3C1D[CR] (originate mode)
ATS16=3A[CR] (answer mode)

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

BEGIN TESTING

The modem sends and then receives its own data pattern. No data from the host is transmitted or received. Detected errors are accumulated and then displayed upon terminating the test.

TERMINATE TEST

send command...

+++

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command

ATS16=0[CR]

modem responds...

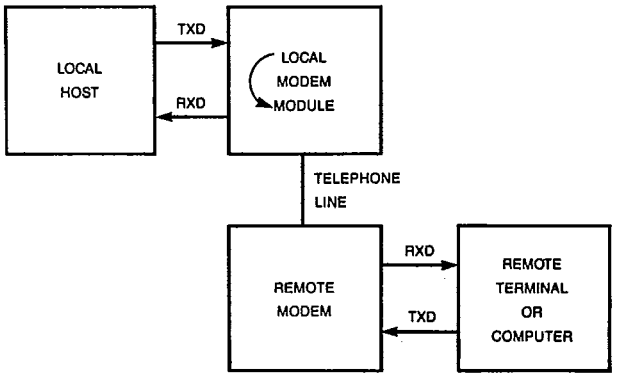
[CR][LF][error count][CR][LF]OK[CR][LF]

or [CR][LF][error count][CR][LF]0[CR] (abbreviated)

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. The digital loop test is terminated when the data connection has ended.

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 an incompatibility of 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.

This test may not be performed with a CH1770 or CH17L70.

DIGITAL LOOP TEST PROCEDURES:
(Test is only valid during a data call)

CH1760 Family

START TEST

send command...

[com]T b 4[CR]

modem responds...

[com][LF][CR]

BEGIN TESTING

Data that is sent by the remote modem is received and then re-sent to the remote modem. The data is not asserted on the modem modules receive data line, RXD.

TERMINATE TEST

send command...

[com]T[CR]

modem responds...

[com]OCHSARDUXZ/X_1X_2[LF][CR]

Where X_1X_2 is the hex error count and the entire status message is the same that results from a QUERY command.

CH1765, CH1765-01

START TEST

send command...

+++

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATS16=4O[CR]

modem responds...

[CR][LF]CONNECT[CR][LF] 1[CR]

or [CR][LF]CONNECT 1200[CR][LF] 5[CR]

BEGIN TESTING

Data that is sent by the remote modem is received and then re-sent to the remote modem. The data is not asserted ON the modem modules receive data line, RXD.

TERMINATE TEST

send command...

+++

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

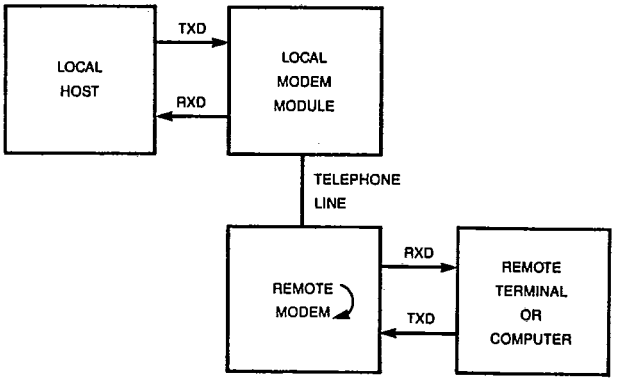
ATS16=0[CR]

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

REMOTE DIGITAL LOOP TEST

In the remote digital loop test a call is first established at 1200 bps (this test is not valid for 110 or 300 bps). The local modem module then



signals the remote modem through a special Bell 212A compatible data pattern to digitally loop back its received data. The remote modem then performs a digital loop test.

The telephone line can be tested through a process of elimination. First, the analog loop test may be used to verify the local modem is good. Next, perform a remote digital loop test to a known good remote modem. If the remote digital loop test fails, you may have a phone line problem. One suggested known good modem for you to try is connected at Cermetek's 24-hour test center and can be reached by dialing the telephone number (408) 745-0450.

Like analog loop, remote digital loop also includes a self-test option. When the remote digital loop self test is initiated, the modem signals the remote modem to loop back the data it receives. The data sent to the remote modem is an "almost random" data pattern generated by the local modem module. The modem module checks to see if this pattern is correctly looped back by the remote modem. It indicates errors in two ways: 1) each error causes the $\overline{MC}$ line to momentarily go LOW, and 2) an error accumulator is incremented. The error accumulator counts up to 15 errors for the CH1765 and CH1765-01 and up to FF hex for the CH1760A, CH1760E, and CH17L60. The CH1770 and CH17L70 do not support this test.

REMOTE DIGITAL LOOP TEST PROCEDURES:
(Test is only valid during a 1200 bps call)

CH1760 Family
A. Remote Digital Loop

START TEST

send command...

[com]T b 5[CR]

modem responds...

[com][LF][CR]

BEGIN TESTING

Data sent to the modem module is looped back by the remote modem. The data received should match that which is sent.

TERMINATE TEST

send command...

[com]T[CR]

modem responds...

[com]OCHSARDUXZ/X_1X_2[LF][CR]

Where X_1X_2 is the hex error count and the entire status message is the same that results from a QUERY command.

B. Remote Digital Loop Self Test

START TEST

send command...

[com]T b 6[CR]

modem responds...

[com][LF][CR]

BEGIN TESTING

The modem generates its own pseudo-random data pattern which is sent to the remote modem. No data from the local host is transmitted. The modem compares the data it receives against the data that is transmitted. Data errors are accumulated on an error counter and cause the $\overline{MC}$ line to pulse LOW.

TERMINATE TEST

send command...

[com]T[CR]

modem responds...

[com]OCHSARDUXZ/X_1X_2[LF][CR]

Where X_1X_2 is the hex error count and the entire status message is the same as the results from a QUERY command.

CH1765, CH1765-01

START TEST

send command...

+++

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATS16=5O[CR]

modem responds...

[CR][LF]CONNECT[CR][LF] 1[CR]

or [CR][LF]CONNECT 1200[CR][LF] 5[CR]

BEGIN TESTING

Data sent to the modem module is looped back by the remote modem. The data received should match that which is sent.

TERMINATE TEST

send command...

+++

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATS16=0[CR]

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

B. Remote Digital Loop Self Test

START TEST

send command...

+++

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATS16=6O[CR]

modem responds...

[CR][LF]CONNECT[CR][LF] 1[CR]

or [CR][LF]CONNECT 1200[CR][LF] 5[CR]

BEGIN TESTING

The modem generates its own pseudo-random data pattern which is sent to the remote modem. No data from the local host is transmitted. The modem compares the data it receives against the data that is transmitted. Data errors are accumulated on an error counter and cause the $\overline{MC}$ line to pulse LOW.

TERMINATE TEST

send command...

+++

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATS16=0[CR]

modem responds...

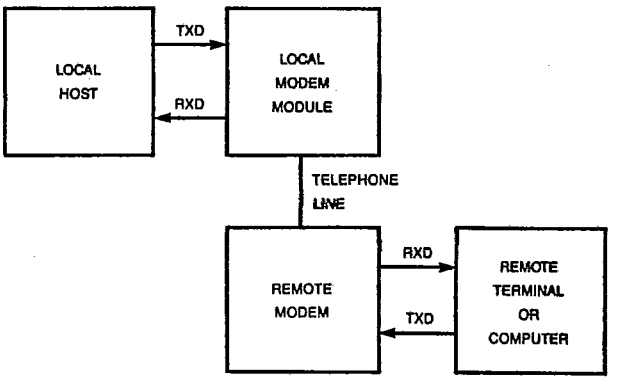
[CR][LF][error count][CR][LF]OK[CR][LF]

or [CR][LF][error count][CR][LF]0[CR]

END-TO-END SELF TEST

In this test both modems send a pseudo-random 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 during this test.

Data errors are indicated by the modem module in two ways: 1) each error causes the $\overline{MC}$ line to pulse low, and 2) an error accumulator is in-



cremented. The error accumulator counts up to 15 errors for the CH1765 and CH1765-01, and up to FF hex for CH1760A, CH1760E, and CH17L60. Its contents are displayed when the test is terminated. This test may not be performed with the CH1770 or CH17L70.

END-TO-END SELF TEST PROCEDURE:
(Test is only valid during a data call)

CH1760 Family

START TEST

send command...

[com]T ♭ 7[CR]

modem responds...

[com][LF][CR]

BEGIN TESTING

The modem generates a pseudo-random data pattern and sends it to the remote modem. It monitors the received data for the same data. The host neither sends nor receives data in this test. Received errors are accumulated in the error counter and displayed upon ending the test.

TERMINATE TEST

send command...

[com]T[CR]

modem responds...

[com]OCHSARDUXZ/X_1X_2[LF][CR]

Where X_1X_2 is the hex error count and the entire status message is the same as the results from a QUERY command

CH1765, CH1765-01

START TEST

send command...

+ + +

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATS16=7O[CR]

modem responds...

[CR][LF]CONNECT[CR][LF] 1[CR]

or [CR][LF]CONNECT 1200[CR][LF] 5[CR]

BEGIN TESTING

The modem generates an pseudo-random data pattern and sends it to the remote modem. It monitors the received data for the same data. The host neither sends nor receives data in this test. Received errors are accumulated in the error counter and displayed upon ending the test.

TERMINATE TEST

send command...

+ + +

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATS16=0[CR]

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

TONE DIALING TEST
This test evaluates the modem generated dialing tones. In this procedure a selected tone (0-9, *, and #) is sent until directed to stop. This gives the tone dialing test set enough time to accurately measure the output level and frequencies of the dialing tones. This test is only valid for the CH1765 and CH1765-01.

CH1765, CH1765-01

START TEST

send command...

ATS16=2[CR]

modem responds...

[CR][LF]OK[CR][LF] or 0[CR]

send command...

ATDT[tone number][CR]

BEGIN TESTING

The selected tone is sent continuously.

TERMINATE TEST

Send any character to the modem.

8.0 FCC REGISTRATION

Each of the modem modules are 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 required. 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.

FCC REGISTRATION NOTICE

The modem is registered with the Federal Communications Commission (FCC). The FCC places three restrictions on its use:

1) The modem cannot be connected to a party line.
2) The local telephone company must be notified that the modem is being installed. When you notify the telephone company of your intent to install the modem, they will ask you for three numbers: 1) your telephone number; 2) the Modem's FCC Registration Number, and 3) the Modem's Ringer Equivalence. These numbers are supplied to you on stickers included with the modem shipment.
3) The modem must be returned to Cermetek if any repairs are needed.

9.0 ELECTRICAL SPECIFICATIONS

TA: 0-60 C

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
LOGIC I/O LINES						
Input high	V_{IH}		2.0			V
Input low	V_{IL}		-.3		.8	V
Input current high	I_{IH}				500	µA
Input current low	I_{IL}				-500	µA
Output high	V_{OH}	I_{OH} = .1mA	2.4	3.5		V
Output low	V_{OL}	I_{OL} = 2mA	0.0	.2	.45	V
TELEPHONE LINE INTERFACE						
AC Impedance	Z_{Line}			600		Ω
Surge Protection		Conforms to all FCC Part 68 surge, hazardous voltage, and leakage				
Carrier Transmit Level	P_{TX}	600 Ohm line termination	-11	-10	-9	dBm
Audio Transmit Gain	TXA	Gain from TXA to TIP and RING terminated with a 600 Ohm line termination (excluding CH1770 and CH17L70)		-10		dB
Carrier Receive Sensitivity	R_{CAR}	OFF to ON detection ON to OFF drop out		-43 -48		dBm dBm
Audio Receive Gain	RXA	Gain from the telephone line to RXA (excluding CH1770 and CH17L70)		20		dB
Transhybrid loss	G_{TH}	600Ω ± 30% between TIP and RING	8	10		dB
ON-HOOK Impedance	Z_{ONHK}		20M			Ω
LOOP CURRENT	I_{LOOP}		20		100	mA
FCC Registration Number		provided on stickers included with your modem				
RINGER EQUIVALENCE				0.7B		

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DIALING						
DTMF LEVEL			-8	-6	-4	dBm
DTMF FREQ ACC.			-0.5		+0.5	%
DTMF ON TIME				100		ms
DTMF OFF TIME				100		ms
PULSE SPEED				10		pps
PULSE RATIO		make/break ratio		40/60		%
PULSE INTERDIGIT TIME				700		ms
HOST INTERFACE TIMING						
Carrier Detect	T_{CD}		150	—	300	ms
Clear to Send Delay (Answer)	T_{ENA}	110 or 300 bps	175	200	225	ms
		1200 bps	750	775	800	ms
Clear to Send Delay (Originate)	T_{ENO}	110 or 300 bps	125	150	175	ms
		1200 bps	1400	1475	1500	ms
Billing Delay	T_{BD}		2.0	2.5	3.0	sec
Ring Cycle ON	T_{RON}			2		sec
Ring Cycle OFF	T_{ROFF}			4		sec
DISCONNECT TIMING						
$\overline{DTR}$ Forced	T_{DTR}	$\overline{DTR}$ asserted OFF (HIGH)	50			ms
Long Received Space	T_{LRS}	Optional	1.6			sec
Loss of Carrier	T_{LC}	Carrier drop out, Optional	77			ms
Send Long Space	T_{SLS}	Optional	4		4.5	sec
Weight					0.5	lb
SIGNALING						
RATE		1200 bps, Synch. PSK	-.01		+.01	%
		1200 bps, Asynch. PSK	-2.5		+1.0	%
		110 or 300 bps, FSK	-2.5		+2.5	%