1. INTRODUCTION

1.1 SUMMARY

The Rockwell RC9696AC V.32/V.42 bis Modem Device Set operates over dial-up or leased lines at communication speeds up to 9600 bps, and with data compression delivers effective throughput up to 38400 bps. The modem is compatible with CCITT V.32, V.22 bis, V.22, and V.21 recommendations, and Bell 212A and 103 modems.

The RC9696AC supports global connectivity via multimode operation and includes V.42 error correcting and V.42 bis data compression protocols. The RC9696AC also supports MNP classes 2, 3, and 4 error control and MNP 5 data compression. The modem can also operate in non-error-correcting modes.

A full-featured industry standard "AT" command set is implemented, which ensures operation with popular communications software packages. AT command extensions simplify the use of V.42, V.42 bis, and MNP capabilities. The modem provides auto-dial, auto-redial and auto-answer capabilities, and can operate in both synchronous and asynchronous modes.

The RC9696AC device set consists of a microcontroller unit (MCU), a multi-protocol communications controller (MPCC), and an RC9696/12 modem data pump (MDP) module. The OEM adds memory (64k bytes ROM, 32k bytes RAM, and 2048 bits NVRAM), supporting components (e.g., address demultiplex, chip select, data buffer, and line receivers/drivers), line interface circuitry, and power supply to complete the modem.

To aid in rapid product development, two complete modem evaluation boards are available—a parallel interface version and a serial interface version. The parallel version is a PC bus-compatible half card.

The RC9696AC can operate in US/Canada or Japan using call progress and tone detect parameters selected by strapping a hardware input.

1.2 FEATURES

- CCITT V.32, V.22 bis, V.22, and V.21 operating modes with automode detection
- Bell 212A and 103 operating modes
- V.42 compliant error correction (LAPM and MNP)
- V.42 bis and MNP 5 data compression
- Automatic V.42/MNP 4, V.42 bis/MNP 5 negotiation
- Asynchronous/synchronous mode
- Communication software compatible
- Enhanced "AT" command set
- Extended MNP commands
- Speed buffering/flow control
- Direct mode option (passthrough data path)
- Line quality monitor and retrain capability
- Built-in DTE interfaces
  - —Parallel 16C450 UART interface
  - —Serial CCITT V.24 (EIA-232-D)
- Programmable speaker volume control
- Diagnostics
  - —Remote digital loop and remote digital loop self test
  - —Analog loop and analog loop self test
  - —Digital loop test
  - —Power-on self test
- 144-digit telephone number directory allows four telephone numbers to be stored in NVRAM
- Hardware configurations
  - —MCU in 68-pin PLCC
  - —MPCC in 44-pin PLCC or 40-pin DIP
  - —MDP in DIP module with 8-, 11-, or 14-mm pins

1.3 GENERAL DESCRIPTION

1.3.1 Modem Data Pump (MDP)

The MDP is a Rockwell RC9696/12 V.32 9600 bps full-duplex modem data pump. It is a 3.2 in. x 3.73 in. (82 mm x 94.5 mm) module with dual-in-line pins for direct installation onto a host module.

1.3.2 Microcontroller (MCU)

The MCU is a Rockwell R65C19 microcomputer packaged in a 68-pin PLCC. The MCU connects to the host via a V.24 (EIA-232-D) serial interface or a parallel 8086-compatible microcomputer bus. The MCU connects to the modem data pump via dedicated lines and an external bus. The external bus also connects to the OEM-supplied 64k-byte ROM and 32k-byte RAM.

1.3.3 Multi-Protocol Communications Controller (MPCC)

The Rockwell Multi-Protocol Communications Controller (MPCC) is packaged in a 44-pin PLCC or 40-pin DIP. The MPCC interfaces a single serial communications channel between the MCU and the MDP using synchronous or asynchronous protocol.

1.3.4 MCU Firmware

MCU firmware performs processing of general modem control, AT command set, error correction, data compression, host interface, and external memory interface functions. The MCU firmware is provided in object code form for the OEM to program into 64k bytes of external ROM.

1.3.5 CONFIGURATION Byte

By default, the RC9696AC uses two hardware pins to determine if serial or parallel interface is selected and if US or Japan operation is selected. A CONFIGURATION byte can alternatively be used to select serial/parallel interface and US/Japan operation if the designer wants to reassign these pins to another use. The CONFIGURATION byte also allows the Test indicator output to be used as either a Modem Ready or Test indication. (See 2.9 for details.)

1.4 SUPPORTED INTERFACES

The major hardware signal interfaces of the RC9696AC modem device set are illustrated in Figure 1-1.

Parallel Host Interface

A 16C450 UART-compatible parallel interface is provided when parallel interface is selected (see 2.9).

Serial Host Interface

A V.24 (EIA-232-D) compatible serial interface to the DTE is provided when serial interface is selected (see 2.9). Three dedicated status outputs are also provided to drive LED indicators. In addition, three outputs (receive clock select, transmit data select, and transmit clock control) are provided to route serial clock and data signals.

NVRAM Interface

A serial interface to the OEM-supplied 2048-bit non-volatile RAM (NVRAM) is provided. The NVRAM can store up to two user-selectable configurations which can take precedence over the factory default setting, and can store up to four 36-digit (max.) dial strings.

Speaker Interface

An interface to an OEM-supplied speaker circuit is provided. The speaker can be used to monitor call progress. The AT Ln command can be used to adjust the volume.

External Bus Interface

An external bus interface to OEM-supplied 64k-byte ROM and 32k-byte RAM is provided. An address latch enable signal is output to enable demultiplexing of dedicated address lines from multiplexed data/address lines. Two ROM bank select outputs and a RAM bank select output allow decoding to dedicated chip select signals.

"AT" COMMANDS

AT commands may be interpreted via the parallel or serial host interface. A 256-character command line is provided. The command line starts with AT and may contain several commands. A separator is not required between the commands. The AT prefix is not counted in the character total. Spaces are counted; as are left and right parentheses.

1.5 GENERAL SPECIFICATIONS

The power and environmental requirements are specified in Tables 1-1 and 1-2, respectively.

Table 1-1. Modem Power Requirements

Voltage	Tolerance	Current (Typ.) @ 25°C	Current (Max.) @ 0°C
MCU			
+ 5 VDC	±5%	32 mA	48 mA
MPCC			
+ 5 VDC	±5%	170 mA	250 mA
MDP			
+ 5 VDC	±5%	300 mA	585 mA
+ 12 VDC	±5%	3 mA	6 mA
– 12 VDC	±5%	30 mA	36 mA

Note: Input voltage ripple ≤ 0.1 volts peak-to-peak. The amplitude of any frequency between 20 kHz and 150 kHz must be less than 500 microvolts peak.

Table 1-2. Modem Environmental Specifications

Parameter	Specification
Temperature	
Operating	0°C to + 70°C (32°F to 158° F)
Storage	– 40°C to + 80°C (–40°F to 176°F)
Relative Humidity	Up to 90% noncondensing, or a wet bulb temperature up to 35°C, whichever is less.

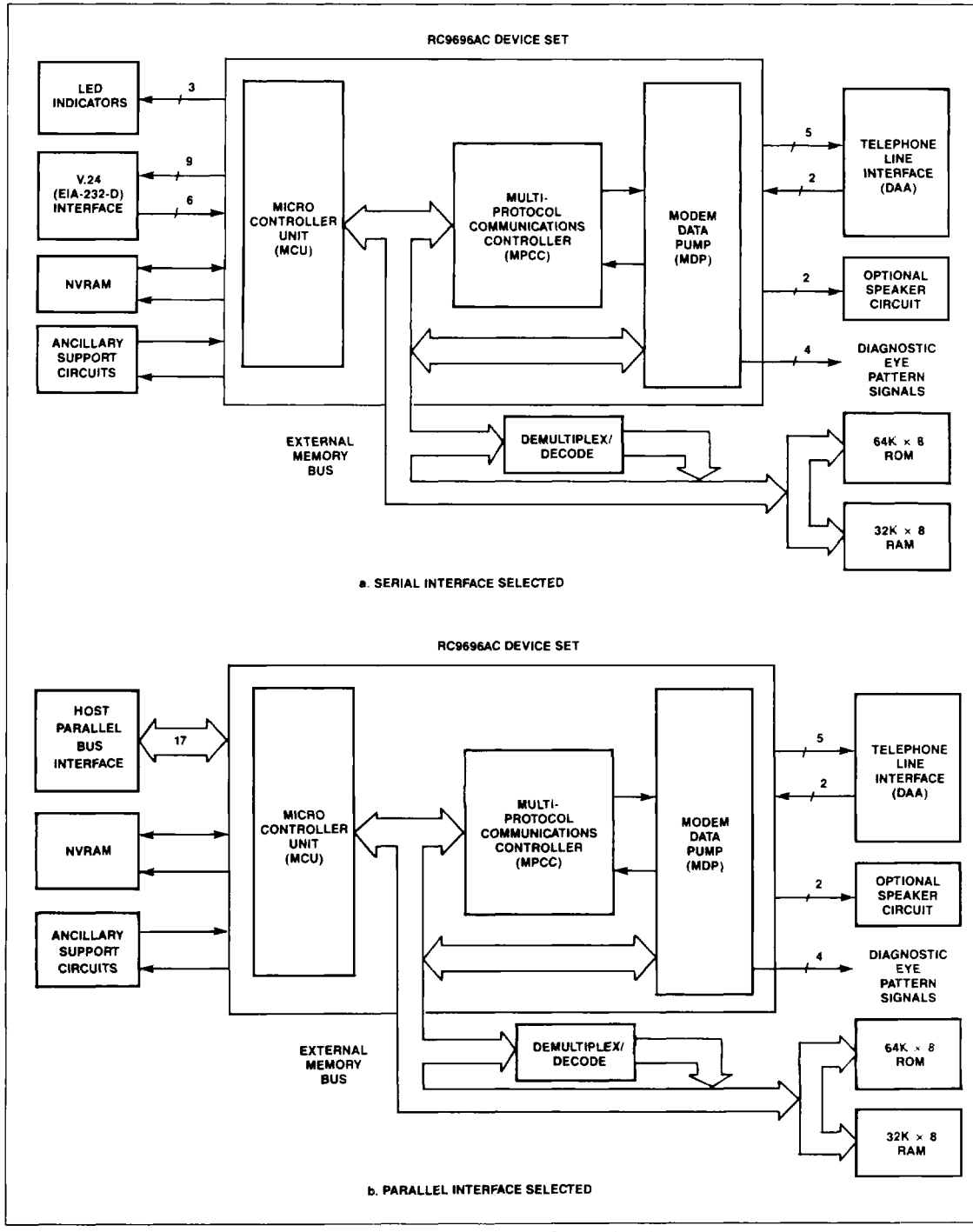


Figure 1-1. RC9696AC Modem General Interface

2. FUNCTIONAL DESCRIPTION

2.1 AUTOMATIC SPEED AND FORMAT SENSING

The modem can automatically determine the speed and format of the data coming into the modem from the DTE. This is done by a wake-up string of known characters sent from the DTE to the modem before every command line. The wake-up sequence is "AT" in upper or lower case followed by any legal commands, and ending in a carriage return. Both the 'A' character and the 'T' character must be typed in the same case, upper or lower.

It is not necessary that commands be entered after the "AT" sequence, but a carriage return must be entered at the end of the line.

The speed is determined by the letter 'A' or 'a' while the format is finalized by the letter 'T' or 't', which is performed at every command line. The modem senses speeds of 75, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 bps and the following data formats:

Parity	Data Length (No. of Bits)	No. of Stop Bits	Character Length (No. of Bits)
None	7	2	10
Odd	7	1	10
Even	7	1	10
None	8	1	10
Odd	8	1	11 *
Even	8	1	11 *

* 11-bit characters are sensed, but the parity bits are stripped off during data transmission in Normal and Error Correction modes. Direct mode does not strip off the parity bits.

The modem speed senses data with mark or space parity. However, the modem configures to different parities as follows:

DTE Configuration	Modem Configuration
7 mark	7 none
7 space	8 none
8 mark	8 none
8 space	8 even

2.2 ESTABLISHING MODEM CONNECTIONS

2.2.1 Connection Speeds

The possible modem to modem connection modes/speeds are V.32 9600 bps, V.32 4800 bps, V.22 bis 2400 bps, V.22 1200 bps, V.21 300 bps, Bell 212A 1200 bps, and Bell 103 300 bps.

The ATN command determines whether a modem will allow only particular connections, or automatically detect a remote modem's desired connection.

When ATN0 is in effect, the required telco connection is determined as shown in Table 2-1.

When the ATN1 command is in effect and in answer mode, automode detect is enabled which sets the preferred telco connection to V.32 9600. Table 2-2 shows what connections result when the modem configured for automode detect handshakes with a remote modem.

2.2.2 Dialing

Dial Tone Detection

Detection frequency range: 345 Hz to 645 Hz

Energy detection period: 2.0 ± 0.1 seconds

Detection ON threshold: ≥ –41 dBm

DTMF dialing commencement: 2.5 seconds after dial tone detection

Blind Dialing

Blind dialing allows the modem to dial in the absence of a dial tone. The calling unit waits the number of seconds specified in the S6 register (minimum 2 seconds), after going off-hook before reading the dial string initiating the dialing sequence. Blind dialing can be enabled by issuing the ATX0, ATX1, or ATX3 command.

2-Digit Adaptive Dialing

Adaptive dialing occurs when a modem is set up to dial a phone number using DTMF tones and the telephone system does not recognize DTMF tones. The modem detects this condition and reverts to pulse dialing to make the call.

After dialing the first digit in the dial string, the modem waits for 3 seconds for the dial tone to be released. If, after this time, the modem still detects dial tone, it checks the next dial parameter. If it is a 'W', it dials the following digit. If dial tone is still present, it re-dials the entire dial string in pulse mode. If the next digit was not a 'W', then the modem re-dials the entire dial string in pulse mode. The modem abandons an adaptive dial attempt if the 'T' dial parameter is the next character in the dial string.

Table 2-1. ATN0 Command Required Connections

ATN Setting	S37 Setting	ATB Setting	Speed Sensed	Required Telco Speed
0	0	0	300	V.21 300
0	0	0	1200	V.22 bis 1200
0	0	0	2400	V.22 bis 2400
0	0	0	4800	V.32 4800
0	0	0	9600	V.32 9600
0	0	0	Other	V.32 9600
0	0	1	300	Bell 103 300
0	0	1	1200	Bell 212A 1200
0	0	1	Other	Bell 212A 1200
0	1-3 (300)	0	X	V.21 300
0	5 (1200)	0	X	V.22 bis 1200
0	6 (2400)	0	X	V.22 bis 2400
0	8 (4800)	0	X	V.32 4800
0	9 (9600)	0	X	V.32 9600
0	1-3 (300)	1	X	Bell 103 300
0	5 (1200)	1	X	Bell 212A 1200
0	6 (2400)	1	X	Bell 212A 1200
0	7 Reserved	X	X	Reserved
0	8 (4800)	X	X	V.32 4800
0	9 (9600)	X	X	V.32 9600

Table 2-2. ATN1 Command Resulting Connections

Answering Modem Preferred	Originating Modem Preferred	Response If Modem Is Originator	Response If Modem Is Answerer	Actual Telco Speed Resulting
V.32 9600	V.32 9600	CONNECT 9600	CONNECT 9600	9600
V.32 9600	V.32 4800	CONNECT 9600	CONNECT 9600	9600
V.32 9600	V.22 bis 2400	CONNECT 2400	CONNECT 2400	2400
V.32 9600	V.22 1200	CONNECT 1200	CONNECT 1200	1200
V.32 9600	Bell 212A 1200	CONNECT 1200	CONNECT 1200	1200
V.32 9600	V.21 300	CONNECT	CONNECT	300
V.32 9600	Bell 103 300	CONNECT	CONNECT	300

The release of dial tone is dependent on the telephone company or PBX, however, the modem considers release of dial tone to be a 2.2 ± 0.1 second period without dial tone. If the modem detects the release of dial tone, it continues to dial the dial string using DTMF tones until otherwise instructed.

Adaptive dialing is operational when the user enters the ATT command followed by the ATD command.

Pulse Dialing

Pulse dialing consists of a sequence of momentary openings of the TIP to RING closed loop. The numerical value of each dialed digit is identical to the number of break intervals in each dialed pulse train, except for the digit '0' which is represented by 10 break intervals. The associated handset (500 series or equivalent) dialing operation is in accordance with EIA RS-496.

Pulse rate : 10 pulses per second ± 10%

Duty cycle : Relay open 53-80 ms

Interdigit delay: 700 to 1000 ms

Dual Tone Multi-Frequency (DTMF) Dialing

DTMF signals consist of two sinusoidal signals, one from a high group of four frequencies and one from a low group of four frequencies, which represent each of the characters shown in Table 2-3.

Frequency tolerance: nominal value ± 1.0%

Tone transmit level: Bell Publication 47001 compliant

Maximum output level: + 1 dBm

Minimum output level (low group): –10 dBm

Minimum output level (high group): – 8 dBm

High and low group tone power difference: ≤ 4 dB

High group tone power: ≥ low group tone power

DTMF signal duration: variable, 50 to 255 ms (S11 register)

DTMF interdigit interval: 70 ± 10 ms

2.2.3 Ring Detection

A ring signal can be detected from a TTL-compatible 15.3 Hz to 68 Hz square wave input.

2.2.4 Call Progress

Answer Tone Detection

Detection ON range (V.32, V.22 bis, V.22, and V.21): 2100 Hz ± 40 Hz

Detection ON range (212A/103): 2225 Hz ± 40 Hz

Detection OFF range: <1940 Hz and >2310 Hz

Detection ON threshold: ≥ –41 dBm

Minimum detection period: 50 ms

Maximum detection period: 215 ms from the initial reception of answer tone.

Busy Tone Detection

Busy tone is detected when four consecutive on/off periods have occurred that meet the following requirements.

Energy detected repetition rate: 50 to 135 impulses per minute with a duty cycle of 50 ± 5%

Detection ON range: 345 to 645 Hz

Detection ON threshold: ≥ –41 dBm

Detection OFF range: <295 Hz and >695 Hz

Ringback Detection

Energy detection duty cycle: ON for 2 seconds (range 1-3 seconds) and OFF for 4 seconds (range 3 to 4.5 seconds)

Detection ON range: 345 to 645 Hz

Detection ON threshold: ≥ –41 dBm

Detection OFF range: <295 Hz and >695 Hz

Billing Protection

When an incoming call is answered, both transmission and reception of data are prevented for at least 2 seconds after the modem transfers to the off-hook state to allow transmission of the telephone company's billing signal.

2.2.5 Automode Detect

Automode detection is enabled by the ATN1 command, and allows the modem to connect with a modem that is configured for differing connection modes (see Section 2.2.1).

Automode Detection - Originating Modem. When automode detection is enabled by ATN1, an originating modem will remain silent and enable detection of either BELL answer tone or V.25 answer tone. If BELL answer tone is detected, then the modem proceeds to perform V.22 bis handshaking. If V.25 answer tone is detected, then the modem will respond with AA until answer tone ends all the while timing how long of a period AA was transmitted. Once answer tone stops, the modem waits approximately 75 ms and then enables detection of AC or USB1. If AC is detected then the modem proceeds with V.32 handshaking. If 155 ms of USB1 is detected the modem then checks to see how long of a period V.25 answer tone was received. If it was less than 800 ms the modem will continue to enable detection of AC. If AC is detected then the modem proceeds to handshake in V.32 mode. If 1600 ms passes and AC has not been detected then the modem again looks for USB1. If USB1 is detected then the modem proceeds to handshake in V.22 bis. If USB1 is not detected at this point the modem proceeds to handshake in V.32 mode. If the amount of time that V.25 answer tone was received was more than 800 ms the modem stops sending the AA signal and waits for 456 ms of silence then starts sending S1 and SB1 and proceeds to handshake in V.22 bis mode.

Automode Detection - Answering Modem. When automode detection is enabled then the answering modem will first attempt V.32 mode. The modem initially sends V.25 answer tone for up to 3.5 seconds and monitors for the AA signal. If the AA signal is detected before the time expires then the modem proceeds to handshake in V.32 mode. If AA was not detected the modem begins to send USB1 while monitoring for S1 or SB1. If either S1 or SB1 is detected within 1600 ms then the modem will proceed to handshake in V.22 bis mode. If neither S1 or SB1 was detected the modem again monitors for AA for another 1000 ms. If AA is detected then the modem proceeds with V.32 handshaking. If AA is not detected then the modem proceeds to handshake in either BELL 103 mode or V.21 mode.

When the modem falls back to V.22 bis, the modem is initially configured for V.22 bis 2400 before attempting a telco connection. An originating modem waits for the answering modem to generate an answer tone. When the answer tone ends, if unscrambled 1s are being detected, the modem attempts a 2400 or 1200 speed connection for 2 seconds. If the carrier is not detected within that time, the modem switches to V.21 300 mode. If the carrier is still not detected, the modem hangs up. In the case where unscrambled 1s are not detected, the modem goes immediately to V.21 mode.

An answering modem generates a V.22 bis 2400 answer tone and attempts a 2400 or 1200 connection for 8 seconds. If the carrier is not detected within that time, the modem attempts a V.21 300 mode connection for up to 8 seconds. If carrier is still not detected, the modem hangs up.

Automode detection attempts CCITT type connections. However, if a Bell 1200 modem is detected, the modems will still connect, in which case RLSD will be asserted.

2.2.6 Modem Handshaking Protocol

An abort call timer is initiated when the last digit is dialed and is reset when the modem detects either answer tone or busy. If a tone is not detected during the time specified in the S7 register (default is 50 seconds), the modem aborts the call attempt. If the abort timer expires before the number of rings specified in S1 register has occurred, the call is aborted.

2.2.7 Phone Number Directory

The modem contains four telephone number entries in a directory that is saved in a serial NVRAM. Each entry has one field for the dial string which can be up to 36 characters in length. The four entries are manipulated using the AT&Zn=x and ATDS=n commands (see Section 4 for usage rules.)

2.3 DATA MODE

Data mode exists when a telco connection has been established between modems.

2.3.1 Speed Buffering (Normal Mode)

Speed buffering allows a DTE to send and receive data from a modem at a speed that differs from the speed of the physical, or modem to modem, connection.

Speed buffering is implemented by using buffers to hold data until a DTE or telco line is able to accept data from the modem. This data is stored in two buffers: the terminal buffer which holds data received from the DTE for the telco line, and the modem buffer which holds data from the telco line for transmission to the DTE.

Speed buffering can operate at telco speeds of 9600, 4800, 2400, 1200, or 300 bps with any permitted DTE speed (see Section 2.1).

2.3.2 Flow Control

Flow control is the process by which a receiving buffer tells the transmitting source to start and stop transmission. There are two data paths which require flow control and each path has flow control options that can be selected.

DTE to Modem Flow Control

The first path is between the DTE and the modem. If the speed of the telco connection differs from the speed of the DTE, then flow control must be used to ensure data integrity.

1. **XOFF/XON Flow Control.** When receiving data from the DTE, the modem sends the XOFF character (13H) to the DTE when the terminal buffer is nearly full. This point is known as the high water mark. When the terminal buffer empties to a point called the low water mark, the modem sends the XON character (11H) to the DTE to allow the buffer to fill.

Table 2-2. DTMF Tones

Dial Digit Code	Tone 1 (Hz)	Tone 2 (Hz)
1	697	1209
2	697	1336
3	697	1477
4	770	1209
5	770	1336
6	770	1477
7	852	1209
8	852	1336
9	852	1477
0	941	1336
*	941	1209
#	941	1477
A	697	1633
B	770	1633
C	852	1633
D	941	1633

When transmitting data to the DTE, the modem reacts to these flow control characters from the DTE by stopping transmission if an XOFF is received, or continuing transmission if an XON is received.

XON/XOFF flow control is enabled with the AT&K4 command, or for transparent flow control with the AT&K5 command.

Note: XON and XOFF characters are transmitted and detected according to the format that was sensed during speed and format sensing.

2. **RTS/CTS Flow Control.** The modem controls the $\overline{CTS}$ output. When $\overline{CTS}$ is OFF, the DTE is not allowed to send data to the modem. When $\overline{CTS}$ is ON, the DTE can send data.

   When $\overline{RTS}$ is OFF, the modem will not send data to the DTE. When $\overline{RTS}$ is ON, the modem is permitted to sent data to the DTE.

   RTS/CTS flow control is enabled by the AT&K3 command.

Modem to Modem Flow Control

The second data path is between local and remote modem over the telco line. When receiving data from the remote modem, the local modem sends the XOFF character to the remote modem when the local modem buffer reaches the high water mark. When the modem buffer empties to the low water mark, the local modem sends the XON character to allow the buffer to fill.

When transmitting data to the remote modem, the local modem reacts to these flow control characters from the remote modem by stopping transmission if an XOFF is received, or by continuing transmission if an XON is received.

XON/XOFF flow control cannot be used between modems during MNP. In this case, flow control is accomplished by credit allocation internal to MNP.

Buffers

The terminal and modem buffers each contain 1024 bytes. The high water mark is reached when the buffer is 75% full (768 characters) and the low water mark is reached when the buffer is 50% full (512 characters).

2.3.3 Escape Sequence Detection

The S2 register holds the decimal value of the ASCII code used for the escape character. The default character is a '+'. Detection of the escape sequence can be disabled by setting the S2 register to a value greater than 127.

When the escape sequence is executed, the escape characters are also transmitted to the telco line in all modes.

2.3.4 Break Detection

The modem can detect a break signal from either the DTE or the remote modem. The AT\Kn command determines the modem response to a received BREAK signal. A break is caused by a string of continuous start bits approximately 300 ms long, or by the Link Attention PDU in MNP.

2.3.5 Direct Mode

The Direct mode allows data to be transmitted and received directly from either the DTE or remote modem. The Direct mode is selected with the AT&Q0 or AT\N1 command.

When running Direct mode, no flow control characters are recognized or transmitted, and the modem cannot execute MNP. The purpose of the Direct mode is to make the modem 'dumb' for compatibility with older style modems. Direct mode is not available when parallel interface is selected (see 2.9).

2.3.6 Serial Interface Monitoring

The modem monitors the following serial interface signals while in data mode and takes the described actions when the indicated conditions occur. These signals are debounced for 10 milliseconds.

$\overline{DTR}$ - When loss of $\overline{DTR}$ occurs the modem follows the AT&Dn command.

$\overline{RDL}$ (circuit 140) - When this input is active, the modem enters a remote digital loop.

$\overline{AL}$ (circuit 141) - When this input is active, the modem disconnects and enters analog loop.

2.3.7 Telco Line Monitoring

The modem monitors the telco line and takes the described actions when the indicated conditions occur.

Loss of Carrier - If carrier is not detected for the period of time specified in the S10 register, the modem disconnects from the line.

Receive Space Disconnect - If optioned by the ATY0 command, the modem disconnects after receiving 1.6 ± 10% seconds of continuous SPACE.

Send Space on Disconnect - If optioned by the ATY0 command, the modem sends 4 ± 10% seconds of continuous SPACE if $\overline{DTR}$ goes OFF or if ATH is issued.

2.3.8 Retrain

AT 2400 bps or higher operation, the modem may lose synchronization with the received line signal if the automatic adaptive equalizer cannot compensate for line changes. If this occurs, retraining may be initiated to attempt recovery depending on the type of connection.

Error-Correction Connection (MNP, V.42). The modem initiates a retrain if any individual frame is retransmitted 5, 9, or 12 times. The modem initiates a retrain before attempting the sixth, tenth, or thirteenth re-transmission. After retransmitting a packet 13 times, the modem will hang up regardless of the S10 value.

Normal or Direct Connection. When an error-correction link is not being used, the modem continuously monitors the line quality. If the quality becomes unacceptable, the modem initiates a retrain. The modem continues to try to retrain until an acceptable connection is achieved; an event that causes telco disconnect occurs (carrier detect loss timer, inactivity timer, DTR drop, or commanded disconnect); or if three consecutive unsuccessful retrain attempts occur. If a retrain commanded by ATO1 fails the modem will hang up.

2.3.9 Synchronous Data Mode

The modem can establish a synchronous connection by following one of the methods described in the AT&Mn or AT&Qn command. Once the modem finishes the physical handshake, it enters the synchronous data mode. During synchronous data mode, the inactivity timer is inoperative.

Synchronous data mode is operative only when serial interface is selected (SER/$\overline{\text{PAR}}$ = high). If an attempt is made to enable synchronous data mode using the AT&Mn command when parallel interface is selected, the modem responds with 'OK', but operates as if AT&M0 was entered.

2.4 V.42/V.42 BIS

V.42 supports two methods of error correction: LAPM and, as a fallback, MNP 4 (see Section 2.5). The modem offers a negotiation technique for determining and establishing the best method of error correction between two modems. This technique involves two phases: detection and negotiation. In the detection phase, which occurs immediately after the establishment of the modem handshake, the communicating modems exchange a sequence of detection patterns to verify that both sides support the error-correction technique. In the negotiation phase, which follows the detection phase, the communicating modems exchange configuration information.

If the detection phase fails, or negotiation does not achieve the desired connection type, the modem can hang up, fallback to MNP, or fallback to a standard asynchronous mode. Desired action to take is selected with register S36. Since MNP does not support a detection phase, the selection of MNP 4 must be made as a forced fallback with registers S48 and S36.

The following S registers are used for V.42 LAPM operation:

S36 -- V.42 Negotiation Fallback

S46 -- Protocol Selection

S48 -- V.42 Negotiation Action

S82 -- Break Handling

S86 -- Connection Failure Cause Code

S95 -- Extended Result Codes

These registers are described in Table 5-2.

2.4.1 S Registers

S36 - V.42 Negotiation Fallback

Register S36 specifies the action to take when the desired connection cannot be made. The options are:

S36=0 Modem hangs up.

S36=1 Modem stays on-line and a Direct mode connection is established.

S36=2 Reserved.

S36=3 Modem stays on-line and a Normal mode connection is established.

S36=4 If S48 is 128, then an MNP connection is attempted; if it fails, the modem disconnects.

S36=5 If S48 is 128, then an MNP connection is attempted; if it fails, a Direct mode connection is established.

S36=6 Reserved.

S36=7 If S48 is 128, then an MNP connection is attempted; if it fails, a Normal mode connection is established.

These fallback options are initiated immediately on connection if register S48=128.

This register can be used with register S48=128 to force a connection with MNP. For example, if S48=128 and S36=5 or 7, MNP protocol is forced.

S46 - Protocol Selection

The following actions can be selected with the S46 register:

S46=136 Execute LAPM protocol with no V.42 bis compression.

S46=138 Execute LAPM protocol with V.42 bis compression.

In addition to V.42 bis, the modem also implements MNP 5 data compression. V.42 bis is used only with LAPM; MNP 5 is used only with MNP 4.

S48 - V.42 Negotiation Action

The negotiation process determines the capabilities of the remote modem. However, when the capabilities of the remote modem are known and negotiation is unnecessary, this process can be bypassed if desired. The following options are selectable using register S48:

S48=7 Enable negotiation (factory default).

S48=0 Disable negotiation; bypass the detection and negotiation phases; and proceed with LAPM.

S48=128 Disable negotiation; bypass the detection and negotiation phases; and proceed at once with the fallback actions specified in S36. This option can be used to force MNP.

S82 -- Break Handling Options

LAPM specifies three methods of break signal handling: "in sequence", "expedited", and "destructive". The break handling options for LAPM are selected with register S82.

S82=128 In sequence: Modem sends a break in sequence with any transmitted data; data integrity is maintained both ahead of and after the break. (factory default).

S82=3 Expedited: Modem sends a break immediately; data integrity is maintained both ahead of and after the break.

S82=7 Destructive: Modem sends a break immediately; data being processed by each modem at the time of the break is destroyed.

S86 -- Connection Failure Cause Code

When the modem issues a NO CARRIER result code, a failure code is written to register S86. S86 records the first event that contributes to a NO CARRIER message. The result code definitions are:

S86=0 Normal disconnect, no error occurred.

S86=4 Loss of carrier.

S86=5 V.42 negotiation failed to detect an error-correction modem at the other end.

S86=9 The modems could not find a common protocol.

S86=12 Normal disconnect initiated by the remote modem.

S86=13 Remote modem does not respond after 10 re-transmissions of the same message.

S86=14 Protocol violation.

S95 -- Extended Result Codes.

The bits in this register can be set to override some of the ATWn command options. A bit set to a 1 in this register will enable the corresponding result code regardless of the ATWn setting.

Bit 0 = CONNECT result code indicates DCE speed instead of DTE speed.

Bit 1 = Append /ARQ to verbose CONNECT XXXX result code if protocol is **not** NONE.

Bit 2 = Enable CARRIER XXXX result code.

Bit 3 = Enable PROTOCOL XXXX result code.

Bit 5 = Enable COMPRESSION result code.

Bits 4, 6, 7 = Reserved.

2.4.2 AT Commands

ATWn -- Negotiation Progress Reporting

The ATW1 command enables the following additional negotiation progress messages:

Number	Verbose	Connection Indicated
77	PROTOCOL:LAP-M	V.42 LAPM
80	PROTOCOL:ALT	MNP

The ATW0 command disables the messages.

AT%Dn -- Set Dictionary Size (V.42 bis).

V.42 bis dictionary size can be specified using the AT%Dn command. The size can be selected from 512, 1024, 2048 (default value), or 4096 bytes.For two-way compression, the dictionary size is set to 2048 bytes if 4096 bytes is selected.

AT%Mn -- Set One/Two-Way Compression Mode (V.42 bis).

One of four compression modes can be selected using the AT%Mn command: compression disabled, transmit compression only, receive compression only, or two-way compression (default setting).

AT%P -- Clear V.42 bis Encoder Dictionary

This command resets the V.42 bis encoder dictionary and sends a command code to the remote modem to reset the remote V.42 bis decoder dictionary.

AT%S -- Set Maximum String Length (V.42 bis).

The maximum number of characters to be compressed onto one word to be specified using the AT%Sn command. The number can range from 6 to 255 with the default value set to 32 characters.

2.5 MICROCOM NETWORKING PROTOCOL (MNP)

MNP is a data link protocol that uses error detection algorithms to ensure data integrity.

2.5.1 Compatibility

The modem supports classes 2 through 5. Class 5 uses a data compression algorithm to increase data throughput and is enabled by the AT%C1 command. If MNP 5 is disabled, the modem defaults to class 4.

The AT commands and S registers applicable to MNP are:

AT%C -- Compression Control
AT&Q5 -- Enable Error Correction Mode
ATWn -- Negotiation Progress Reporting
AT\An -- Maximum MNP Block Size
AT\Kn -- Break Control
AT\Ln -- MNP Block Transfer Control
AT\Nn -- Operation Mode Control
AT\O -- Originate Reliable Link Control
AT\Tn -- Inactivity Timer Control
AT\U -- Accept Reliable Mode Control
AT\Y -- Switch to Reliable Mode
AT\Z -- Switch to Normal Mode
S36 -- Negotiation Failure Treatment
S38 -- Delay Before Forced Hang Up
S40 -- MNP Bit Mapped Options
S41 -- MNP Bit Mapped Options
S46 -- Protocol Selection
S95 -- Extended Result Codes

2.5.2 MNP 3-Way Handshake

When establishing the MNP 3-way handshake, the originator sends the first Link Request Protocol Data Unit (PDU). The answerer responds by sending a Link Request PDU back. The originator then responds with a Link Acknowledge frame to complete handshake.

Establishing MNP Connections

The modem may be configured to execute the MNP handshake before or after a telco connection has been established. The AT&Q5, AT\N2, or AT\N3 command may be used to configure the modem before the connection,

To enter MNP after a telco connection in either Direct or Normal mode, use the AT\O, AT\Y, or AT\U command. These three commands have no effect once 3-way handshake has been completed.

At completion of the MNP 3-way handshake, the modem returns a message according to the ATW command setting. MNP can only operate at telco connection speeds of 1200 bps or greater.

2.5.3 MNP Data Mode

After establishing the MNP connection, the modem performs all of the functions performed during the Normal data mode with the following differences:

1. Retrains are performed as a result of retransmission rates (see Section 2.3.8).
2. When in the command mode during an MNP connection as a result of the escape sequence, the modem continues to accept data and acknowledge frames. The data is stored until the modem enters the data mode and is then delivered to the DTE. In non-MNP mode, any data received while the modem is in command mode is lost.

MNP Class 5 Data Compression

This MNP mode may be enabled or disabled by using the AT%Cn command, and is in operation if an MNP 5 connection has been successfully established. If the modem establishes an MNP 5 connection, the modem increases its throughput by compressing data into tokens before transmitting to the remote modem, and decompressing encoded received data before sending it to the DTE. The AT%C1 command has no effect if an MNP connection has already been established, except configuring the modem for a future MNP 5 handshake attempt.

Programmable Inactivity Timer

The modem can determine the length of time the modem will wait before disconnecting when no data is sent or received. In MNP mode, this inactivity timer is reset when data is either received from the DTE or is received from the telco line in the form of a Link Transfer PDU. This timer can be set using the AT\Tn command where n represents a value between 0 and 42 minutes.

The inactivity timer may also be programmed by S30 = n, where n = the number of tens of seconds.

Data Transfer

MNP may be operated in either block or stream mode. In stream mode, MNP sends data frames in varying lengths depending on the amount of time between characters coming from the DTE. The mode is selected by the AT\Ln command.

In block mode, MNP sends data frames of 256 characters in length. Special communication software must be used when using block mode.

2.6 JAPANESE REQUIREMENTS

2.6.1 Commands and Parameters

The modem can operate with either U.S. or Japanese commands and parameters. The Japanese commands and parameters are enabled when the Japan configuration is selected (see 2.9). The Japanese commands and parameters are the same as the U.S. commands and parameters except as described in this section.

2.6.2 DTMF Transmit Levels

High group output level: –9.0 dBm to –6.5 dBm

Low group output level: –10.9 dBm to –6.5 dBm

Minimum tone duration value in register S11: 60 ms

2.6.3 Pulse Dialing

Pulse rate: 10 pulses per second

Off-hook duty cycle: 33 ± 3%

On-hook duty cycle: 67 ± 3%

Interdigit delay: 600-1000 ms

2.6.4 Call Progress Requirements

Dial Tone Detection

When the modem goes off-hook to dial, it will not start dialing before at least 3.0 seconds unless it detects dial tone. If configured for blind dialing, the modem pauses 3 seconds unless the S6 register value is greater than 3 seconds.

The modem can detect three types of dial tone.

Type 1 - Continuous Tone

Tone detection frequency range: 380 to 420 Hz

Tone detection period: 2.5 ±0.1 seconds

Type 2 - 2 Hz Alternating Tone

Tone detection frequency: 380 to 420 Hz

Tone ON threshold: ≥ –35 dBm

Tone ON time: 200 ms to 300 ms

Tone OFF time: 500 ms minus the ON time

Tone repetition rate: 2 Hz

Type 3 - 4 Hz Alternating Tone

Tone detection frequency: 380 to 420 Hz

Tone ON threshold: ≥ –35 dBm

Tone ON time: 70 ms to 100 ms

Tone OFF time: 250 ms minus the ON time

Tone repetition rate: 4 Hz

Busy Tone

A signal is considered to be a busy tone if four consecutive periods meet the following requirements:

Detection frequency range: 380 Hz to 420 Hz

Detection ON threshold:d: ≥ –40 dBm

Repetition rate: 60 ± 12 ON/OFF cycles per minute

Duty cycle: 50 ± 10%

Ringback Tone

A signal is considered to be a ringback if one period (starting with ON) meets the following requirements:

Detection frequency range: 380 Hz to 420 Hz

Detection ON threshold: ≥ –34 dBm

Repetition rate: 20 ± 4 ON/OFF cycles per minute

Duty cycle: 33 ± 10%

Abort Call Timer (S7 Register)

The abort call timer maximum value is 60 seconds if the S7 register value is greater than 60 seconds.

2.6.5 Programmable Transmit Level

The transmit level is adjustable in register S91. Register S91 takes effect when the Japan configuration is selected (see 2.9). The transmit level may not be changed once a connection is made.

2.6.6 1200 /300 bps Connection

The ATBn commands defaults to 0 to select CCITT modes. The modem will use V.21 as the factory default for the 300 bps connection and will use V.22 as the default for the 1200 bps connection.

2.7 DIAGNOSTICS

The modem diagnostics comply with EIA Recommendation TR30.2. Tables 2-4 and 2-5 show the behavior of the serial and LED interface signals, respectively, during test modes.

In cases when the Test Indicator LED is to blink on and off, the TSTIND indicator output is turned ON for 800 ms ± 100 ms and then OFF for 800 ms ± 100 ms.

2.7.1 Analog Loopback

Description

Data from the local DTE is sent to the modem, which loops the data back to the local DTE. This test verifies the working condition of the path between the modem and the DTE.

Initiation/Termination

Analog loopback is initiated either by issuing the AT&T1 command or by asserting the AL input (the AL input is ignored in an error correction connection). In the case of a command initiated test, analog loopback is terminated when the modem receives the test termination command (AT&T0) or when the "test timer" (set using register S18) expires. If analog loopback is initiated by the AL input active, then the test is terminated when AL becomes inactive.

This test will always drop a connection if one exists.

Results

The DTE is responsible for comparing the data received with the data sent for test analysis.

2.7.2 Analog Loop Self Test

Description

An internally generated test pattern of alternating 1s and 0s (reversals) is sent to the modem. An error detector within the modem checks for errors in the string of reversals. This test verifies the working condition of the modem.

Initiation/Termination

Analog Loopback Self Test is initiated by issuing the AT&T8 command. Analog loopback is terminated when the modem receives the test termination command (AT&T0) or when the "test timer" (set using register S18) expires.

This test will always drop a connection if one exists.

Results

The modem checks for errors internally. Upon termination of the test, the modem sends a 3-digit error count to the DTE.

Table 2-3. Serial Interface Signals During Test

Signal	Start of Test	During Test	End of Test
During Analog Loopback			
EIARXD	Off	Follows EIATXD**	Off
CTS	On	On	On
RLSD	********** per AT&Cn Command **********		
DSR	********** per AT&Sn Command **********		
TM	Off	Flash	Off
RI	Functional	Functional	Functional
EIATXCLK	Normal	Normal	Normal
EIARXCLK	Normal	Normal	Normal
CI	Normal	Normal	Normal
** If Asynchronous Speed Buffer Mode, then EIARXD follows EIATXD on a character basis only.			
During Analog Loopback With Self Test			
EIARXD	Off	Follows EIATXD**	Off
CTS	On	On	On
RLSD	********** per AT&Cn Command **********		
DSR	********** per AT&Sn Command **********		
TM	Off	Flash	Off
RI	Functional	Functional	Functional
EIATXCLK	Normal	Normal	Normal
EIARXCLK	Normal	Normal	Normal
CI	Normal	Normal	Normal
** If Asynchronous Speed Buffer Mode, then EIARXD follows EIATXD on a character basis only.			
During Remote Digital Loopback			
Local Modem (Modem A) Initiates			
EIARXD	Off	Normal	Normal
CTS	On	Normal	On
RLSD	Normal	Normal	Normal
DSR	per AT&Sn	Off	per AT&Sn
TM	Off	Blinking	Off
RI	Off	Off	Off
EIATXCLK	Normal	Normal	Normal
EIARXCLK	Normal	Normal	Normal
CI	Normal	Normal	Normal
Remote Modem (Modem B)			
EIARXD	Off	Off	Off to Normal
CTS	Off	Off	Off to Normal
RLSD	Off	Off	Off to Normal
DSR	Off	Off	Off to Normal
TM	On	On	On to Off
RI	Off	Off	Off
EIATXCLK	Normal	Normal	Normal
EIARXCLK	Normal	Normal	Normal
CI	Normal	Normal	Normal

Table 2-4. Serial Interface Signals During Test (Cont'd)

Signal	Start of Test	During Test	End of Test
During Remote Digital Loopback with Self Test			
Local Modem (Modem A) Initiates			
EIARXD	Off	Normal	Normal
CTS	On	Normal	On
RLSD	Normal	Normal	Normal
DSR	per AT&Sn	Off	per AT&Sn
TM	Off	Blinking	Off
RI	Off	Off	Off
EIATXCLK	Normal	Normal	Normal
EIARXCLK	Normal	Normal	Normal
CI	Normal	Normal	Normal
Remote Modem (Modem B)			
EIARXD	Off	Off	Off to Normal
CTS	Off	Off	Off to Normal
RLSD	Off	Off	Off to Normal
DSR	Off	Off	Off to Normal
TM	On	On	On to Off
RI	Off	Off	Off
EIATXCLK	Normal	Normal	Normal
EIARXCLK	Normal	Normal	Normal
CI	Normal	Normal	Normal
During Digital Loopback			
EIARXD	Off	Follows EIATXD	Off
CTS	Off	Normal	Off
RLSD	Normal	Normal	Normal
DSR	Normal	Normal	Normal
TM	Off	On	On to Off
RI	Off	Off	Off
EIATXCLK	Normal	Normal	Normal
EIARXCLK	Normal	Normal	Normal
CI	Normal	Normal	Normal

Table 2-4. LED Indicator Signals During Test

Indicator	State
During Analog Loopback	
OHRELAY	Off
CI	Unchanged
DTRIND	Unchanged
EIATXD	From DTE
EIARXD	Per EIATXD
RLSDL	per AT&Cn command
AAIND	per S0 register
TSTIND	On-Off (Blinking)
During Analog Loopback With Self Test	
OHRELAY	Off
CI	Unchanged
DTRIND	Unchanged
EIATXD	From DTE
EIARXD	Per EIATXD
RLSDL	per AT&Cn command
AAIND	per S0 register
TSTIND	On-Off (Blinking)
During Remote Digital Loopback	
Local Modem (Modem A) Initiates	
OHRELAY	On
CI	Unchanged
DTRIND	Unchanged
EIATXD	From DTE
EIARXD	Per EIATXD
RLSDL	On
AAIND	per S0 register
TSTIND	On-Off (Blinking)
Remote Modem (Modem B)	
OHRELAY	On
CI	Unchanged
DTRIND	Unchanged
EIATXD	Unchanged
EIARXD	Off
RLSDL	Off
AAIND	per S0 register
TSTIND	On-Off (Blinking)

Table 2-5. LED Indicator Signals During Test (Cont'd)

Indicator	State
During Remote Digital Loopback with Self Test	
Local Modem (Modem A) Initiates	
OHRELAY	On
CI	Unchanged
DTRIND	Unchanged
EIATXD	From DTE
EIARXD	Per EIATXD
RLSDL	On
AAIND	per S0
TSTIND	On-Off (Blinking)
Remote Modem (Modem B)	
OHRELAY	On
CI	Unchanged
DTRIND	Unchanged
EIATXD	Unchanged
EIARXD	Off
EIATXD	Off
AAIND	per S0
TSTIND	On-Off (Blinking)
During Digital Loopback	
OHRELAY	On
CI	Unchanged
DTRIND	Unchanged
EIATXD	From DTE
EIARXD	Per EIATXD
RLSDL	On
AAIND	Off
TSTIND	On-Off (Blinking)

2.7.3 Remote Digital Loopback (RDL)

Description

Data from the local DTE is sent to the remote modem which loops the data back to the local DTE. This test verifies the working condition of the telco line and the remote modem.

Initiation/Termination

Remote digital loopback (RDL) is initiated either by issuing the AT&T6 command or by asserting the RDL input (the RDL input is ignored in an error correction connection). The remote modem must have RDL response enabled (AT&T4). In the case of a command initiated test, remote digital loopback is terminated when the modem receives the test termination command (AT&T0) or when the "test timer" (set using register S18) expires. If remote digital loopback is initiated by RDL input active, then the test is terminated when RDL input becomes inactive.

RDL can only be initiated if a telco connection exists at 1200 or 2400 bits per second. If an attempt is made to initiate RDL with the RDL input and the above requirements are not met (e.g., 300 bps, no connection, etc.) the TSTIND output will stay ON.

Results

The DTE is responsible for comparing the data received with the data sent for test analysis.

2.7.4 Remote Digital Loopback with Self Test

Description

An internally generated pattern is sent from the local modem to the remote modem which loops the data back to the local modem. This test verifies the working condition of the telco line and the remote modem.

Initiation/Termination

Remote digital loopback with self test is initiated by issuing a remote digital loopback with self test command (AT&T7). The test is terminated when the modem receives the test termination command (AT&T0) or when the "test timer" (set using register S18) expires.

Remote digital loopback with self test (RDLST) can only be initiated if a telco connection exists at 1200 or 2400 bits per second.

Results

The modem checks for errors internally. Upon termination of the test, the modem sends a 3-digit error count to the DTE.

2.7.5 Digital Loopback

Description

Digital loopback can be used to test the entire link. When digital loop is requested from the local DTE, two data paths are set up in the local modem. Data from the local DTE is looped back to the local DTE (path 1) and data received from the remote modem is looped back to the remote modem (path 2).

Initiation/Termination

Digital loopback is initiated by issuing the AT&T3 command. The test is terminated when the modem receives the test termination command (AT&T0) or when the "test timer" (set using register S18) expires. Digital loopback can only be initiated if a telco connection exists at 1200 or 2400 bps.

Results

Both the local DTE and the remote DTE are responsible for comparing the data received with the data sent for test analysis.

2.7.6 Asynchronous Diagnostic Commands

AT&T0: Ends the test in progress (provided the test was initiated via a command). If the test in progress is AT&T1 (analog loopback), AT&T3 (digital loopback), or AT&T6 (remote digital loopback), then an escape sequence must be issued prior to AT&T0. Note also that ATH or the expiration of "test timer" S18 will also terminate a command initiated test.

AT&T1: Initiates Analog Loopback.

AT&T3: Initiates Digital Loopback.

AT&T4: Enables the modem to respond to a remote modem's request for a remote digital loopback test.

AT&T5: Prohibits the modem from honoring a remote modem's request for remote digital loopback test.

AT&T6: Initiates Remote Digital Loopback.

AT&T7: Initiates Remote Digital Loopback with Self Test.

AT&T8: Initiates Analog Loopback with Self Test.

2.8 POWER ON RESET DIAGNOSTICS

Upon power on, or receipt of the ATZ command, the modem performs four diagnostic tests. If any errors are detected, the modem pulses the TSTIND indicator output.

RAM Test

The modem writes and reads to each RAM location to verify RAM integrity.

ROM Test

The modem calculates a checksum and compares it to a checksum value stored in the ROM. These values must be equal.

NVRAM Test

The modem stores the contents of NVRAM with a seeded checksum. At power up the checksum is tested; if found to be incorrect the modem initializes the contents to factory default value and tests the checksum again. If the test fails again, the modem indicates the test failure by pulsing the TSTIND indicator output.

Lamp Test

The modem executes the lamp test by asserting indicator outputs to turn on the RLSD, DTR, TM, CI, and AA LEDs while the modem executes the RAM test, ROM test and NVRAM test. Upon completion of these tests, the state of the indicator outputs are returned to the existing state of the modem. The user must verify by inspection that the LEDs remain on during these tests and are subsequently returned to their existing state.

If an error is detected in the RAM, ROM or NVRAM test, the modem pulses the TSTIND indicator output at the completion of the test after the other indicator outputs have returned to their normal state.

2.9 CONFIGURATION BYTE

By default, the RC9696AC uses hardware input pins to determine if either serial/parallel interface is selected or US/Japan operation is selected. If the designer has another use for those input/output lines then serial/parallel interface and US/Japan operation must be selected via the CONFIGURATION byte located at address 8001h. The default value of location 8001h is 00 but the designer may change this value before programming EPROMs. This location is not added into the program checksum so changing it does not require a new checksum calculation.

Serial/Parallel Interface and US/Japan Operation Select

Bit 7 of the CONFIGURATION byte controls how serial/parallel interface and US/Japan operation is selected.

If bit 7 is a 0, then the hardware input SER/PAR (port B bit 5) selects between serial (low) and parallel 16450 interface (high), and the input port JPN/US (port D bit 3) selects between US operation (low) and Japan operation (high).

If bit 7 is a 1, then bits 0 and 1 of the CONFIGURATION byte select parallel/serial interface and US/Japan operation, respectively. (See Table 2-7 for complete description of the CONFIGURATION byte).

Test Mode/Modem Ready Indicator Select

By default, the RC9696AC deploys the TSTIND output (LED 8) as a Test Mode indicator. In some applications, a designer may wish to have TSTIND deployed as a Modem Ready indicator instead. The function of TSTIND can be selected via the CONFIGURATION byte bit 2. If bit 2 is a 0 (default) then TSTIND functions as a Test indicator. If bit 2 is a 1 then TSTIND functions as a Modem Ready indicator. (See Table 2-6 for complete description of the CONFIGURATION byte).

Table 2-6. CONFIGURATION Byte Description

Bit	Description
7 (MSB)	Serial/Parallel Interface and Japan/US Operation Select Control 1 = Selects configuration controlled by CONFIGURATION byte 0 = Selects configuration controlled by hardware pins (JPN/US and SER/PAR)
6	Reserved (must be 0)
5	Reserved (must be 0)
4	Reserved (must be 0)
3	Reserved (must be 0)
2	Modem Ready/Test Indication Select 1 = Selects Modem Ready function on TSTIND output (LED 8) 0 = Selects Test function on TSTIND output (LED 8)
1	Japan/US Operation Select 1 = Selects Japan operation if bit 7 is set 0 = Selects US operation if bit 7 is set
0 (LSB)	Serial/Parallel Interface Select 1 = Selects serial interface if bit 7 is set 0 = Selects parallel interface if bit 7 is set

3. HARDWARE INTERFACE

3.1 INTERFACE SIGNALS

The RC9696AC hardware interface signals for the serial and parallel interfaces are shown in Figures 3-1 and 3-2, respectively.

The RC9696AC MCU pin assignments with serial interface selected (see 2.9) are shown in Figure 3-3 and are listed in Table 3-1.

The RC9696AC MCU pin assignments with parallel interface selected (see 2.9) are shown in Figure 3-4 and are listed in Table 3-2.

The RC9696AC MPCC pin assignments are shown in Figure 3-4 and are listed in Table 3-3.

The RC9696AC MDP pin assignments are listed in Table 3-4.

The functional hardware interface signals are listed by major interface in Table 3-5.

The digital and analog electrical characteristics for the hardware interface signals are listed in Tables 3-6 and 3-7, respectively.

The hardware interface signals are defined in Table 3-8.

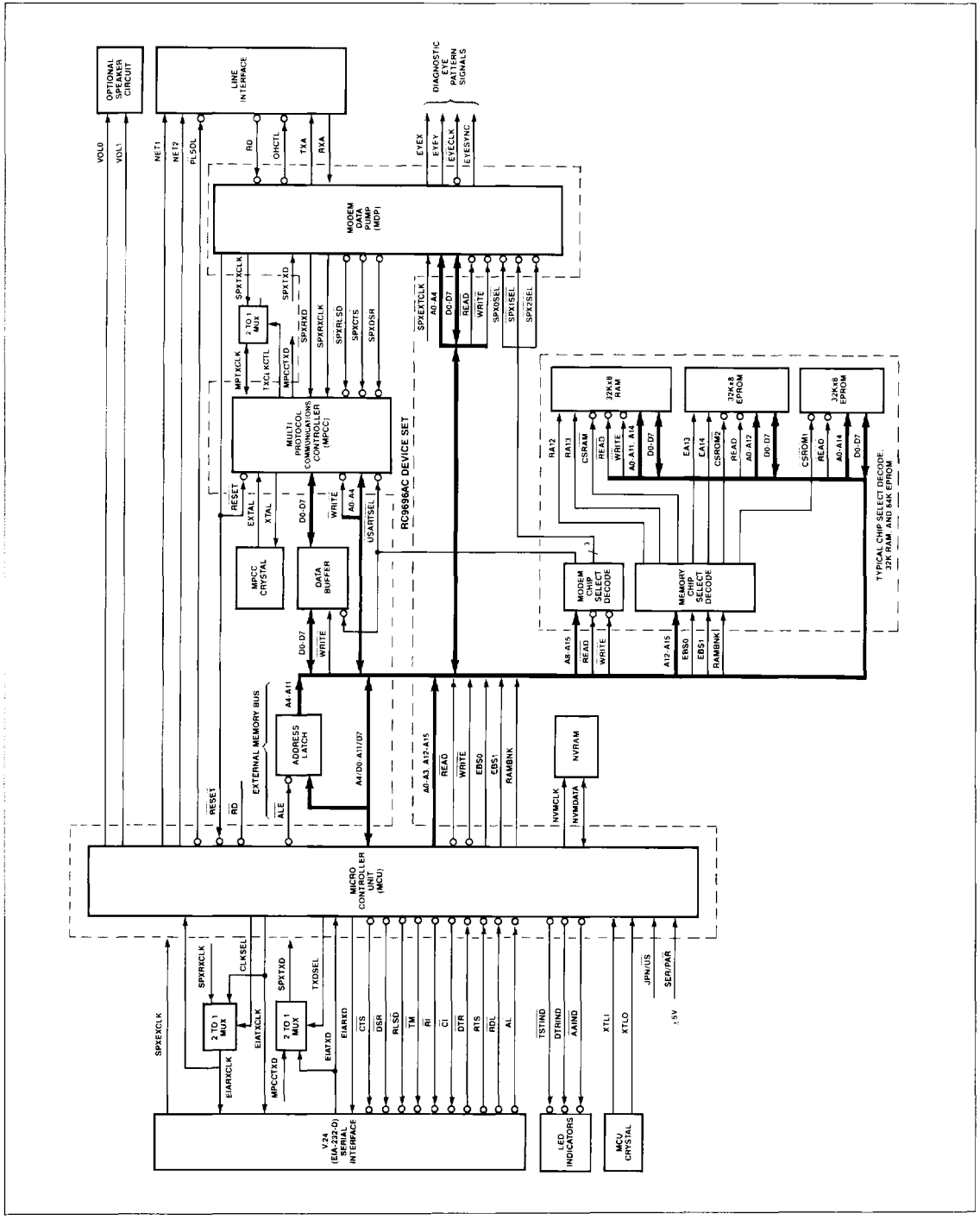


Figure 3-1. RC9696AC Interface Signals-Serial Interface

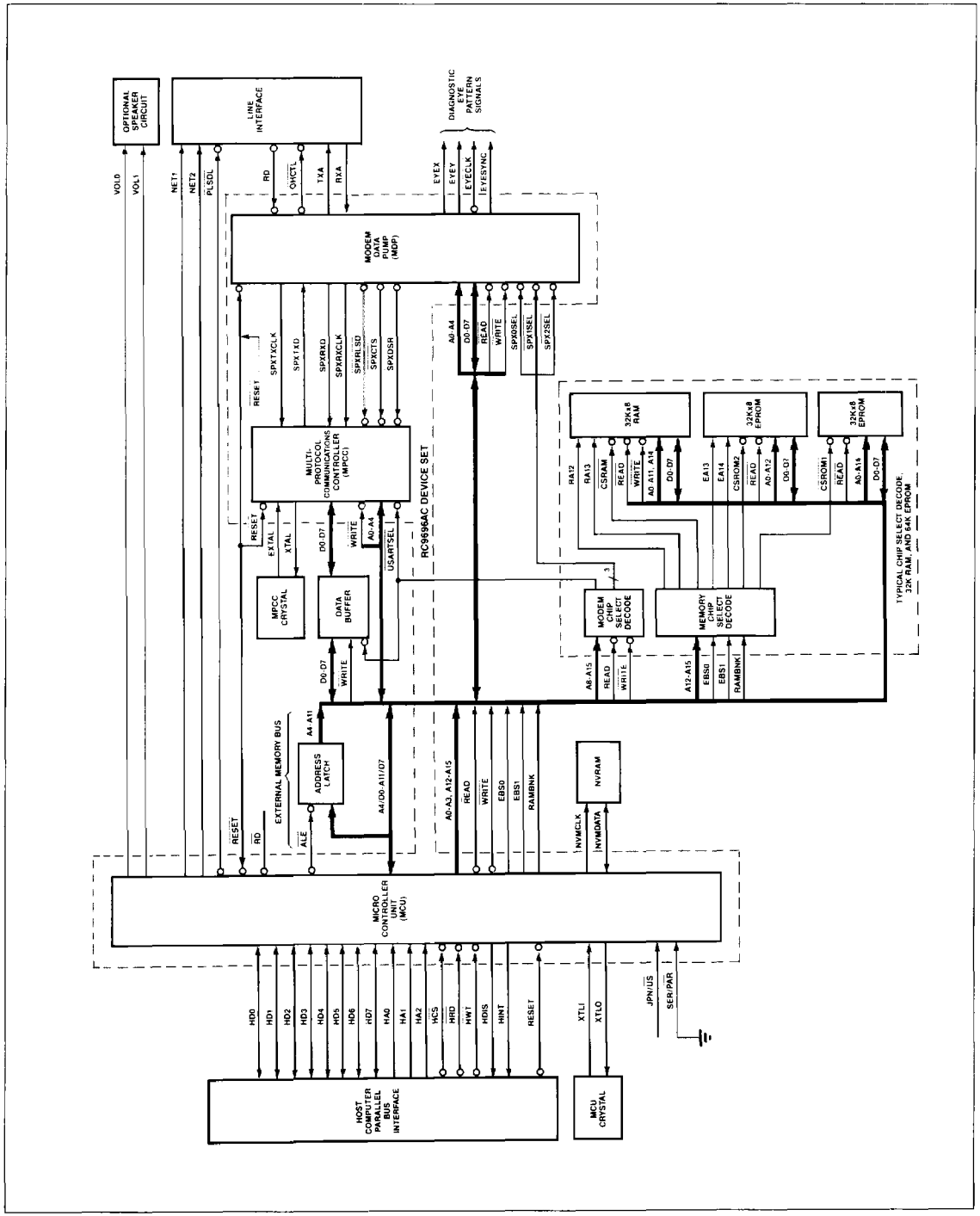


Figure 3-2. RC9696AC Interface Signals-Parallel Interface

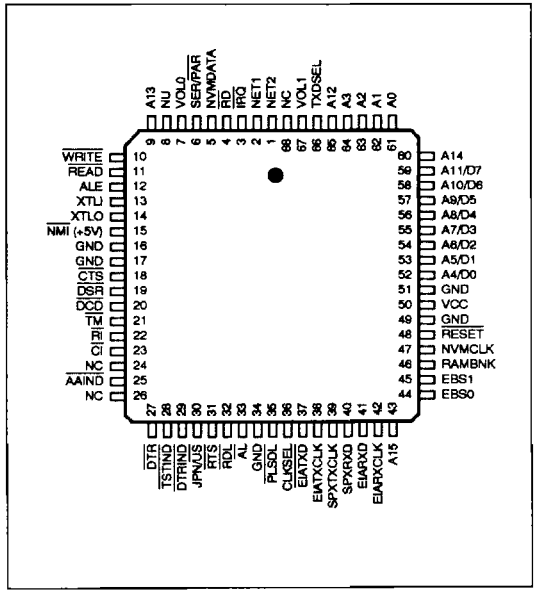


Figure 3-3. RC9696AC MCU Pins - Serial Interface

Table 3-1. RC9696AC MCU Pin Signals-Serial Interface

PLCC Pin	MCU Signal	I/O	RC9696AC Signal
1	PB0	OA	NET1
2	PB1	OA	NET2
3	PB2	IA	IRQ
4	PB3	IA	RD
5	PB4	IA/OA	NVMDATA
6	PB5	IA	SEL/PAR
7	PB6	OA	VOL0
8	PB7		NC
9	A13	OA	A13
10	WT	OA	WRITE
11	RD	OA	READ
12	ALE	OA	ALE
13	XTLI	IE	XTLI
14	XTLO	OE	XTLO
15	NMI	IA	To +5V thru 3.3 KΩ
16	VSS2		GND
17	VSS1		GND
18	PC0	OA	CTS
19	PC1	OA	DSR
20	PC2	OA	DCD
21	PC3	OA	TM
22	PC4	OA	RI
23	PC5	OA	CI
24	PC6		NC
25	PC7	OA	AAIND
26	SYNC		NC
27	PD0	IA	DTR
28	PD1	OA	TSTIND
29	PD2	OA	DTRIND
30	PD3	IA	JPN/US
31	PD4	IA	RTS
32	PD5	IA	RDL
33	PD6	IA	AL
34	PD7		GND
35	PA0	OA	PLSDL
36	PA1	OA	CLKSEL
37	PA2	IA	EIATXD
38	PA3	OA	EIATXCLK
39	PA4	IA	SPXTXCLK
40	PA5	IA	SPXRXD
41	PA6	OA	EIARXD
42	PA7	IA	EIARXCLK
43	A15	OA	A15
44	PE0/ES1	OA	EBS0
45	PE1/ES2	OA	EBS1
46	PE2	OA	RAMBNK
47	PE3	OA	NVMCLK
48	RES	IC	RESET
49	TEST		GND
50	VCC		VCC
51	VSS3		GND
52	AD0	IA/OA	A4/D0
53	AD1	IA/OA	A5/D1
54	AD2	IA/OA	A6/D2
55	AD3	IA/OA	A7/D3
56	AD4	IA/OA	A8/D4
57	AD5	IA/OA	A9/D5
58	AD6	IA/OA	A10/D6
59	AD7	IA/OA	A11/D7
60	A14	OA	A14
61	PF0/A0	OA	A0
62	PF1/A1	OA	A1
63	PF2/A2	OA	A2
64	PF3/A3	OA	A3
65	PF4/A12	OA	A12
66	PF5	OA	TXDSEL
67	PF6	OA	VOL1
68	PF7		NC

NOTES:
1. I/O Type: See Table 3-6.

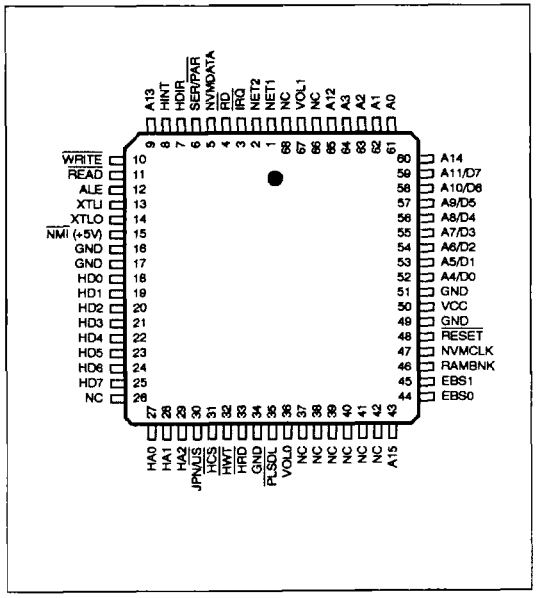
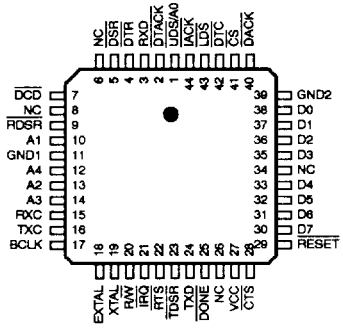


Figure 3-4. RC9696AC MCU Pins - Parallel Interface

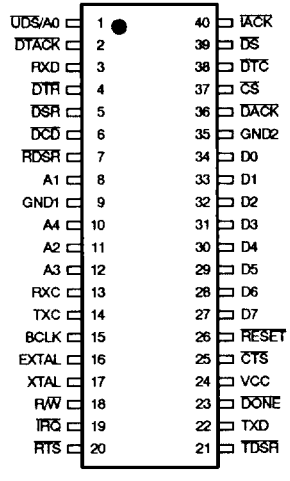
Table 3-2. RC9696AC MCU Pin Signals-Parallel Interface

PLCC Pin	MCU Signal	I/O	RC9696AC Signal
1	PB0	OA	NET1
2	PB1	OA	NET2
3	PB2	IA	IRQ
4	PB3	IA	RD
5	PB4	IA/OA	NVMDATA
6	PB5	IA	SEL/PAR
7	PB6	OA	HDIR
8	PB7	OA	HINT
9	A13	OA	A13
10	WT	OA	WRITE
11	RD	OA	READ
12	ALE	OA	ALE
13	XTLI	IE	XTLI
14	XTLO	OE	XTLO
15	NMI	IA	To +5V thru 3.3 KΩ
16	VSS2		GND
17	VSS1		GND
18	PC0	IA/OA	HD0
19	PC1	IA/OA	HD1
20	PC2	IA/OA	HD2
21	PC3	IA/OA	HD3
22	PC4	IA/OA	HD4
23	PC5	IA/OA	HD5
24	PC6	IA/OA	HD6
25	PC7	IA/OA	HD7
26	SYNC		NC
27	PD0	IA	HA0
28	PD1	IA	HA1
29	PD2	IA	HA2
30	PD3	IA	JPN/US
31	PD4	IA	HCS
32	PD5	IA	HWT
33	PD6	IA	HRD
34	PD7		GND
35	PA0	OA	PLSDL
36	PA1	OA	VOL0
37	PA2		NC
38	PA3		NC
39	PA4		NC
40	PA5		NC
41	PA6		NC
42	PA7		NC
43	A15	OA	A15
44	PE0/ES1	OA	EBS0
45	PE1/ES2	OA	EBS1
46	PE2	OA	RAMBNK
47	PE3	OA	NVMCLK
48	RES	IC	RESET
49	TEST		GND
50	VCC		VCC
51	VSS3		GND
52	AD0	IA/OA	A4/D0
53	AD1	IA/OA	A5/D1
54	AD2	IA/OA	A6/D2
55	AD3	IA/OA	A7/D3
56	AD4	IA/OA	A8/D4
57	AD5	IA/OA	A9/D5
58	AD6	IA/OA	A10/D6
59	AD7	IA/OA	A11/D7
60	A14	OA	A14
61	PF0/A0	OA	A0
62	PF1/A1	OA	A1
63	PF2/A2	OA	A2
64	PF3/A3	OA	A3
65	PF4/A12	OA	A12
66	PF5		NC
67	PF6	OA	VOL1
68	PF7		NC

NOTES:
1. I/O Type: See Table 3-6.



a. 44-Pin PLCC



a. 40-Pin DIP

Figure 3-5. RC9696AC MPCC Pin Signals

Table 3-3. RC9696AC MPCC Pin Signals

PLCC Pin	DIP Pin	MPCC Signal	I/O	RC9696AC Signal
1	1	UDS/A0	I	A0
2	2	DTACK		NC
3	3	RXD	I	SPXRXD
4	4	DTR	O	TXCLKCTL
5	5	DSR	I	SPXDSR
6	-	NC		NC
7	6	DCD		SPXRLSD
8	-	NC		NC
9	7	RDSR		NC
10	8	A1	I	A1
11	9	GND1		GND
12	10	A4	I	A4
13	11	A2	I	A2
14	12	A3	I	A3
15	13	RXC	I	SPXRXCLK
16	14	TXC	I/O	MPTXCLK
17	15	BCLK		NC
18	16	EXTAL		8.064 MHz Crystal
19	17	XTAL		8.064 MHz Crystal
20	18	R/W	I	WRITE
21	19	IRQ	O	IRQ thru Schottky diode
22	20	RTS		NC
23	21	TDSR		NC
24	22	TXD	O	MPCCTXD (Serial I/F) SPXTXD (Parallel I/F)
25	23	DONE	I/O	VCC thru 3.3KΩ
26	-	NC		NC
27	24	VCC		VCC
28	25	CTS		SPXCTS
29	26	RESET	I	RESET
30	27	D7	I/O	D7
31	28	D6	I/O	D6
32	29	D5	I/O	D5
33	30	D4	I/O	D4
34	-	NC		NC
35	31	D3	I/O	D3
36	32	D2	I/O	D2
37	33	D1	I/O	D1
38	34	D0	I/O	D0
39	35	GND2		GND
40	36	DACK		VCC thru 3.3KΩ
41	37	CS	I	USARTSEL
42	38	DTC	I	GND
43	39	DS	I	USARTSEL
44	40	IACK	I	VCC thru 3.3KΩ

NOTES:
1. NU = Not used; connect as described.
2. NC = No connection, leave pin disconnected (open).

Table 3-4. RC9696AC MDP Pin Signals

MDP Pin	MDP Signal	I/O	EB Pin	RC9696AC Signal
1	+5V		J5-1	VCC
2	POR	I/O	J5-2	RESET
3	D7	I/O	J5-3	D7
4	D6	I/O	J5-4	D6
5	D5	I/O	J5-5	D5
6	D4	I/O	J5-6	D4
7	D3	I/O	J5-7	D3
8	D2	I/O	J5-8	D2
9	D1	I/O	J5-9	D1
10	D0	I/O	J5-10	D0
11	IRQ	O	J5-11	IRQ
12	WRITE	I	J5-12	WRITE
13	CS2	I	J5-13	SPX2SEL
14	READ	I	J5-14	READ
15	RS4	I	J5-15	A4
16	RS3	I	J5-16	A3
17	RS2	I	J5-17	A2
18	RS1	I	J5-18	A1
19	RS0	I	J5-19	A0
20	CS0	I	J5-20	SPX0SEL
21	CS1	I	J5-21	SPX1SEL
22	RBCLK	O	J5-22	NC
23	RDCLK	O	J5-23	SPXRXCLK
24	RD	I	J5-24	RD
25	RI	O	J5-25	NC
26	RXD	O	J5-26	SPXRXD
27	RLSD	O	J5-27	SPXRLSD
28	NC		J5-28	NC
29	DGND		J5-29	GND
30	AGND		J5-30	AGND
31	AGND		J51-1	AGND
32	+12V		J51-2	P12V
33	RXA	I	J51-3	RXA
34	TXA	O	J51-4	TXA
35	OHRC	O	J51-5	OHCTL
36	−12V		J51-6	N12V
37	DGND		J51-7	GND
38	NU		J51-8	VCC thru 10KΩ
39	NU		J51-9	NC
40	DTR	I	J51-10	VCC thru 10KΩ
41	DSR	O	J51-11	SPXDSR
42	NU		J51-12	VCC thru 10KΩ
43	TMXCLK		J51-13	NC
44	NU		J51-14	NC
45	+5V		J51-15	VCC
46	TDCLK	O	J51-16	SPXTXCLK
47	TBCLK	O	J51-17	NC
48	TXD	I	J51-18	SPXTXD
49	CTS	O	J51-19	SPXCTS
50	RTS		J51-20	VCC thru 10KΩ
51	XTCLK	I	J51-21	SPXEXTCLK
52	NU		J51-22	NC
53	DGND		J51-23	GND
54	NU		J51-24	VCC thru 10KΩ
55	EYEY	O	J51-25	EYEY (P2)
56	EYEX	O	J51-26	EYEX (P1)
57	EXECLK	O	J51-27	EXECLK (P3)
58	EYESYNC	O	J51-28	EYESYNC (P4)
59	NU		J51-29	NC
60	NU		J51-30	NC
61	+5V		J51-31	VCC

NOTES:

1. NC = No connection; leave pin disconnected (open).
2. NU = Not used, however, circuitry may be connected; connect as described.

Table 3-5. RC9696AC Functional Signals

Name	I/O Type[1]	Description
Overhead		
XTLI	IE	MPU Crystal/Clock In
XTLO	OE	MPU Crystal Out
EXTAL	IE	MPCC Crystal/Clock In
XTAL	OE	MPCC Crystal Out
RESET	IC	Reset
VCC	PWR	+5 Volt Supply
P12V	PWR	+12 Supply
N12V	PWR	12 Supply
GND	GND	Digital Ground Return
AGND	GND	Analog Ground Return
SER/PAR	IA	Serial Interface Enable
JPN/US	IA	Japan Options Select
V.24 (EIA-232-D) Serial Interface (Serial Interface Only)		
EIARXCLK	OB	Receive Data Clock
EIATXCLK	OB	Transmit Data Clock
SPXEXTCLK	IA	External Transmit Clock
EIARXD	OA	Received Data
EIATXD	IA	Transmitted Data
CTS	OA	Clear To Send
RTS	IA	Request To Send
DSR	OA	Data Set Ready
RLSD	OA	Receive Line Signal Detector
DTR	IA	Data Terminal Ready
AL	IA	Analog Loop Test Select
RDL	IA	Remote Digital Loop Select
TM	OA	Test Mode Indicate
CI	OA	Speed Modem Indicator
RI	OA	Ring Indicator
LED Indicator Circuit Interface (Serial Interface Only)		
DTRIND	OA	DTR Indicator
AAIND	OA	Auto Answer Indicator
TSTIND	OA	Test Mode or Modem Ready Indicator
Parallel Host Interface (Parallel Interface Only)		
HA0	IA	Host Address Line 0
HA1	IA	Host Address Line 1
HA2	IA	Host Address Line 2
HD0	IA/OA	Host Data Line 0
HD1	IA/OA	Host Data Line 1
HD2	IA/OA	Host Data Line 2
HD3	IA/OA	Host Data Line 3
HD4	IA/OA	Host Data Line 4
HD5	IA/OA	Host Data Line 5
HD6	IA/OA	Host Data Line 6
HD7	IA/OA	Host Data Line 7
HCS	IA	Host Bus Chip
HRD	IA	Host Bus Read Enable
HWT	IA	Host Bus Write Enable
HDIS	OA	Host Bus Driver Disable
HINT	OA	Host Bus Interrupt

Table 3-5. RC9696AC Functional Signals (Cont'd)

Name	I/O Type[1]	Description
NVRAM Interface		
NVMCLK	OA	NVRAM Shift Clock
NVMDATA	OA	NVRAM Data In/Data Out
Speaker Interface		
VOL0	OA	Speaker Volume 0 Control
VOL1	OA	Speaker Volume 1 Control
External Memory Parallel Bus Interface		
A0	OA	Address Line 0
A1	OA	Address Line 1
A2	OA	Address Line 2
A3	OA	Address Line 3
A4/D0	IA/OA	Address Line 4/Data Bus Line 0
A5/D1	IA/OA	Address Line 5/Data Bus Line 1
A6/D2	IA/OA	Address Line 6/Data Bus Line 2
A7/D3	IA/OA	Address Line 7/Data Bus Line 3
A8/D4	IA/OA	Address Line 8/Data Bus Line 4
A9/D5	IA/OA	Address Line 9/Data Bus Line 5
A10/D6	IA/OA	Address Line 10/Data Bus Line 6
A11/D7	IA/OA	Address Line 11/Data Bus Line 7
A12	OA	Address Line 12
A13	OA	Address Line 13
A14	OA	Address Line 14
A15	OA	Address Line 15
ALE	OA	Address Latch Enable
READ	OA	Read Enable
WRITE	OA	Write Enable
RAMBNK	OA	RAM Bank Select
EBS0	OA	External Bank Select 0
EBS1	OA	External Bank Select 1
Line Interface (DAA)		
RXA	I(AB)	Receive Analog
TXA	O(AA)	Transmit Analog
OHCTL	OD	Off-Hook Relay Control
PLSDL	OA	Pulse Dial Relay Control
RD	IA	Ring Detect
NET1	IA	Network Select 1
NET2	IA	Network Select 2
DSP/Eye Pattern Generator (Diagnostic Circuit)		
EYEX	OC	Eye Pattern Data X-Axis
EYEY	OC	Eye Pattern Data Y-Axis
EYECLK	OB	Eye Pattern Clock
EYESYNC	OC	Eye Pattern Sync

Notes:

1. I/O types are described in Table 3-6 (digital signals) and Table 3-7 (analog signals).
2. Unused inputs tied to +5V or ground require individual 10K Ω series resistors.

Table 3-6. Digital Interface Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions[1]
Input High Voltage	V_{IH}				Vdc	
Type IA		2.0	–	V_{CC}		
Type IB		2.4	–	V_{CC}		
Type IC		3.5	–	V_{CC}		
Type ID		0.8 (V_{CC})	–	V_{CC}		
Type IE		–	4.0	–		Note 2.
Input Low Voltage	V_{IL}				Vdc	
Type IA, IB, & ID		-0.3		0.8		
Type IE		–	1.0	–		Note 2.
Input Leakage Current	I_{IN}				µAdc	
Type IA (Non-multiplexed)		–	–	±10		V_{IN} = 0 to V_{CC}
Output High Voltage	V_{OH}				Vdc	
Type OA		2.4	–	–		I_{LOAD} = – 100 µA
Type OB & OC		3.5	–	–		I_{LOAD} = – 100 µA
Type OD		–	–	V_{CC}		I_{LOAD} = 0 mA
Type OE						Note 3.
Output Low Voltage	V_{OL}				Vdc	
Type OA		–	–	0.4		I_{LOAD} = 1.6 mA
Type OB & OC		–	–	0.4		I_{LOAD} = 0.8 mA
Type OD		–	0.75	–		I_{LOAD} = 15 mA
Three-State (Off) Current	I_{TSI}				µAdc	
Type OA		–	–	±10		V_{IN} = 0.8 V to 4.5 V @ 500 kHz
Type OB & OC		–	–	±10		V_{IN} = 0.8 V to V_{CC} – 1 V
Power Dissipation	P_D					
MCU VCC		–	80	125	mW	
MPCC VCC			750	1000	mW	
MDP VCC		–	1500	2925	mW	
MDP P12V		–	15	30	mW	
MDP N12V		–	150	180	mW	

Notes:
1. Test Conditions: V_{CC} = 5V ± 5%, T_A = 0°C to 70°C, (unless otherwise stated).

Table 3-7. Analog Interface Characteristics

Name	Type	Characteristic
TXA	O(AA)	The transmitter output impedance is 604 Ω ± 1%
RXA	I(AB)	The receiver input impedance is 71.5K Ω ± 1%

Table 3-8. Hardware Interface Signal Definitions

Label	I/O Type	Signal Name/Description
		OVERHEAD
XTLI XTLO	IE OE	**MCU Crystal In and Crystal Out.** The MCU XTLI and XTLO pins must be connected to an external crystal circuit consisting of a 16.00000 MHz crystal and two capacitors to an oscillator circuit.
EXTAL XTAL	IE OE	**MPCC Crystal In and Crystal Out.** The MPCC EXTAL and XTAL pins must be connected to a external crystal circuit consisting of a 8.064 MHz crystal and two capacitors to an oscillator circuit.
$\overline{\text{RESET}}$	IC	**Reset.** The $\overline{\text{RESET}}$ is an active low bidirectional reset line used to reset the MCU, MPCC, and MDP upon power turn-on, upon detection of a low power condition by the MDP, or as commanded if connected to an external source. Upon a transition of $\overline{\text{RESET}}$ from high to low, the MCU AT command set returns to the original factory default values and/or "stored values" in NVRAM. The MCU, MPCC, and MDP $\overline{\text{RESET}}$ lines should be should be should be wire-ORed. When parallel interface is used, the $\overline{\text{RESET}}$ line should be connected to the host bus reset line through an open collector inverter.
VCC	PWR	**+ 5V Supply.** +5V ±5% is required by the MCU, the MPCC, and the MDP.
P12V	PWR	**+12V Supply.** +12V ±5% is required by the MDP.
N12V	PWR	**–12V Supply.** –12V ±5% is required by the MDP.
GND	GND	**Digital Ground.**
AGND	GND	**Analog Ground.**
SER/$\overline{\text{PAR}}$	IA	**Serial Interface Enable.** Unless controlled by the CONFIGURATION byte (see 2.9), SER/$\overline{\text{PAR}}$ input high selects serial interface or SER/$\overline{\text{PAR}}$ input low selects parallel interface.
JPN/$\overline{\text{US}}$	IA	**Japan Options Select.** Unless controlled by the CONFIGURATION byte (see 2.9), JPN/$\overline{\text{US}}$ input high selects Japan call progress options or JPN/$\overline{\text{US}}$ input low selects U.S. call progress options.
$\overline{\text{SPX0SEL}}$, $\overline{\text{SPX1SEL}}$, $\overline{\text{SPX2SEL}}$, $\overline{\text{USARTSEL}}$	IA IA IA IA	**MDP Chip Select 0.** **MDP Chip Select 1.** **MDP Chip Select 2.** **MPCC Chip Select.** Active low chip select inputs decoded from the Expansion Memory Bus to select MDP and MPCC devices.
TXDSEL	OA	**Transmit Data Select.** TXD Select from MCU to select EIATXD or MPCCTXD for sending to the MDP.
CLKSEL	OA	**Receive Data Clock Select.** RXCLK select from MCU to select EIATXCLK or SPXRXCLK for sending to the DTE.
		V.24 (EIA-232-D) SERIAL INTERFACE (SERIAL INTERFACE SELECTED , SEE 2.9)
EIARXD	OA	**Received Data.** The modem presents received data or modem command responses/status to the EIARXD output pin. Modem responses take priority over incoming data when the two signals are in competition for EIARXD.
EIARXCLK	OB	**Receive Data Clock.** In synchronous mode, EIARXCLK is the output clock for EIARXD.
EIATXD	IA	**Transmitted Data.** The modem obtains serial data to be transmitted or modem commands from the EIATXD input pin. The DTE should hold this circuit in the mark state when no data is being transmitted or during intervals between characters. Data should not be transmitted by the DTE unless $\overline{\text{CTS}}$ is ON.
EIATXCLK	OB	**Transmit Data Clock.** In synchronous mode, EIATXCLK is the output clock for EIATXD. When the Clock Source Selection command is set for External (AT&X1) or Slave (AT&X2), the signals on EIATXCLK are phase-locked to the external transmit clock (SPXEXCLK) from the DTE, or the received timing clock (EIARXCLK), respectively.
SPXEXCLK	IA	**External Transmit Clock.** In synchronous mode, the DTE may supply the external transmit data clock input (SPXEXCLK). The clock supplied at SPXEXCLK must exhibit the same characteristics of EIATXCLK. This circuit is used only when the Clock Source Selection command is set for External (AT&X1) in the synchronous mode.

Table 3-8. Hardware Interface Signal Definitions (Cont'd)

Label	I/O Type	Signal Name/Description
$\overline{CTS}$	OA	**Clear To Send.** The active low $\overline{CTS}$ output indicates whether or not the modem is ready to accept transmit data from the DTE for transmitting to the line. $\overline{CTS}$ ON (low) indicates the modem will accept data from the DTE. $\overline{CTS}$ OFF (high) indicates the modem will not accept data from the DTE. The $\overline{CTS}$ output is controlled by the AT&Rn command in the synchronous data mode and by the AT&Kn command in the asynchronous data mode.
$\overline{RTS}$	IA	**Request To Send.** The active low $\overline{RTS}$ input conditions the modem for data transmission. In the asynchronous speed buffering data mode, $\overline{RTS}$ ON (low) allows the modem to transfer received data from the line to the DTE; $\overline{RTS}$ OFF (high) inhibits the modem from transferring received data from the line to the DTE. In synchronous data mode, the AT&Rn command controls whether or not the state of the $\overline{CTS}$ output follows the state of the $\overline{RTS}$ input.
$\overline{DSR}$	OA	**Data Set Ready.** The active low $\overline{DSR}$ output indicates modem status to the DTE. $\overline{DSR}$ OFF (high) indicates that the DTE is to disregard all signals appearing on the interchange circuits except Ring Indicator ($\overline{RI}$). $\overline{DSR}$ output is controlled by the AT&Sn command. If the AT&S1 option is selected, $\overline{DSR}$ will come ON in the handshaking state when carrier is detected in the originate mode or when carrier is first sent in the answer mode. $\overline{DSR}$ goes OFF if $\overline{DTR}$ goes OFF.
$\overline{RLSD}$	OA	**Received Line Signal Detector.** When AT&C1 command is in effect or in a synchronous mode, the active low $\overline{RLSD}$ output is ON when a carrier is detected on the telco line or OFF when carrier is not detected. $\overline{RLSD}$ is ON when the AT&C1 command is not in effect.
$\overline{DTR}$	IA	**Data Terminal Ready.** The active low $\overline{DTR}$ input is turned ON when the DTE is ready to transmit or receive data. $\overline{DTR}$ ON prepares the modem to be connected to the telco line, and maintains the connection established by the DTE (manual answering) or internally (automatic answering). $\overline{DTR}$ OFF places the modem in the disconnect state. The effect of $\overline{DTR}$ ON and $\overline{DTR}$ OFF depends on the AT&Dn and AT&Qn commands.
$\overline{AL}$	IA	**Analog Loop.** $\overline{AL}$ input ON (low) causes the modem to assume the analog loop test mode. The analog loop test command (AT&T1) forces the modem into analog loop regardless of the state of $\overline{AL}$.
$\overline{RDL}$	IA	**Remote Digital Loop Select.** $\overline{RDL}$ input ON (low) activates remote digital loop request during a 2400 or 1200 bps mode. The command is ignored in other modes. The loop is executed at the speed for which the modem is currently configured.
$\overline{TM}$	OA	**Test Mode Indicate.** $\overline{TM}$ output is ON (low) when the modem is in test mode and is OFF (high) when the modem is not in a test mode.
$\overline{CI}$	OA	**Modem Speed Indicator.** The active low $\overline{CI}$ output is ON when the DTE speed is 4800 bps or faster in the command mode or the telco line speed is 4800 bps or faster in the on-line data mode. $\overline{CI}$ is OFF (high) otherwise.
$\overline{RI}$	OA	**Ring Indicator.** The $\overline{RI}$ output is ON (low) during the presence of an ON segment of a ring signal on the telco line. (The ring signal cycle is typically two seconds ON, four seconds OFF.) The OFF (high) condition of the $\overline{RI}$ output is maintained during the OFF segment of the ring cycle (between rings) and at all other times when ringing is not being received.
		LED INDICATOR SIGNALS (SERIAL INTERFACE SELECTED, SEE 2.9)
$\overline{DTRIND}$	OA	**DTR Indicator.** The active low $\overline{DTRIND}$ output state follows the $\overline{DTR}$ output state at the serial interface depending on the AT&D and AT&Q commands.
$\overline{AAIND}$	OA	**Auto Answer Indicator.** When the modem is configured for auto answer (ATS0 command ≠ 0), the active low $\overline{AAIND}$ output is ON (low). The $\overline{AAIND}$ output also pulses anytime a ring occurs.
$\overline{TSTIND}$	OA	**Test Mode or Modem Ready Indicator.** The active low $\overline{TSTIND}$ output pulses when modem is in test mode and if an error is detected or indicates modem ready as selected by the CONFIGURATION byte (see 2.9). $\overline{TSTIND}$ is OFF otherwise.

Table 3-8. Hardware Interface Signal Definitions (Cont'd)

Label	I/O Type	Signal Name/Description
		LINE INTERFACE (DAA)
RXA	I(AB)	**Receiver Analog.** The RXA input can originate from an audio transformer or data access arrangement. The input impedance is nominally 66.5K ohms. The RXA input must be shunted by an external 604 ohm ±1% resistor in order to match a 600 ohm source. The maximum received signal at RXA is 0 dBm. The maximum near-end echo at RXA that the modem can cancel in V.32 mode is –5 dBm. Transient protection for TXA and RXA is recommended when interfacing directly to a transformer. This protection can be back-to-back zener diodes or a varistor across the transformer.
TXA	O(AA)	**Transmit Analog.** The TXA output can drive an audio transformer or data access arrangement. TXA is a low impedance amplifier output in series with an internal 604 ohm ±1% resistor to match a standard telephone load of 600 ohms.
$\overline{\text{OHCTL}}$	OD	**Off-Hook Relay Control.** $\overline{\text{OHCTL}}$ is an output can directly drive a +5V reed relay coil with a worst case resistance of 360 ohms having a must-operate voltage no greater than 4.0 VDC. A clamp diode, such as a 1N4004, should be installed across the relay coil.
$\overline{\text{PLSDL}}$	OA	**Pulse Dial Relay Control.** The active low $\overline{\text{PLSDL}}$ output controls the pulse dial relay during pulse dialing. $\overline{\text{PLSDL}}$ ON activates the relay.
$\overline{\text{RD}}$	IA	**Ring Detect.** The $\overline{\text{RD}}$ input from an external ring detect circuit is monitored for pulses. The circuit driving $\overline{\text{RD}}$ should not respond to momentary bursts of ringing less than 125 ms in duration, or less than 40 VRMS (15 Hz to 68 Hz) across TIP and RING.
NET1 NET2	IA	**Network Select 1 and 2.** The NET1 and NET2 encoded outputs can be used to select resistor and capacitor networks in order to achieve better line impedance matching. When invoked by the AT\E command, the modem selects the network giving the best line impedance. The selected network is retained in NVRAM until the next occurrence of the AT\E command.
		PARALLEL HOST INTERFACE (PARALLEL INTERFACE SELECTED, SEE 2.9)
		The parallel interface emulates a 16C450 UART interface. The parallel interface is compatible with communications software designed to operate with a 16C450 interface on a PC. Table 15 identifies the parallel interface registers.
HA0-HA2	IA	**Host Bus Address Lines 0-2.** During a host read or write operation, HA0-HA2 select an internal MCU 16C450-compatible register. The state of the divisor latch access bit (DLAB) affects the selection of certain MCU registers.
HD0-HD7	IA/OA	**Host Bus Data Lines 0-7.** HD0-HD7 are comprised of eight tri-state input/output lines providing bidirectional communication between the host and the MCU.
HCS	IA	**Host Bus Chip Select.** $\overline{\text{HCS}}$ input low selects the host bus.
$\overline{\text{HRD}}$	IA	**Host Bus Read.** $\overline{\text{HRD}}$ is an active low, 8086-compatible read control input. When $\overline{\text{HCS}}$ is low, $\overline{\text{HRD}}$ low allows the host to read status information or data from a selected MCU register.
$\overline{\text{HWT}}$	IA	**Host Bus Write.** $\overline{\text{HWT}}$ is an active low, 8086-compatible write control input. When $\overline{\text{HCS}}$ is low, $\overline{\text{HWT}}$ low allows the host to write data or control words into a selected MCU register.
HDIS	OA	**Host Bus Driver Disable.** HDIS output is low when the host is reading data from the MCU over the host data bus (both $\overline{\text{HRD}}$ and $\overline{\text{HCS}}$ are low). HDIS is also used to disable the external transceiver drivers whenever the host is not reading data from the MCU.
HINT	OA	**Host Bus Interrupt.** HINT output is set high when the receiver error flag, received data available, transmitter holding register empty, or modem status interrupt has an active high condition. HINT is reset low upon the appropriate interrupt service or master reset operation.

Table 3-8. Hardware Interface Signal Definitions (Cont'd)

Label	I/O Type	Signal Name/Description
		NVRAM INTERFACE
NVMCLK	OA	**NVRAM Shift Clock.** The NVMCLK output is used to shift data to or from a serial NVRAM.
NVMDATA	IA/OA	**NVRAM Data In/Data Out.** The bidirectional NVMDATA serial line is used to read data from a serial NVRAM or to write data to a serial NVRAM.
		SPEAKER INTERFACE
VOL0, VOL1	OA	**Speaker Volume Control 0 and 1.** VOL0 and VOL1 are encoded outputs that can be used to control the speaker volume. When the AT command set is used for volume control, VOL0 and VOL1 react as follows:

Speaker Volume	Applicable AT Commands	VOL0	VOL1
Off	M0	H	H
Low	L0, L1	L	H
Medium	L2	H	L
High	L3	L	L

		MCU EXTERNAL MEMORY BUS INTERFACE
		Address, data, and control hardware interface signals implement an 8086-compatible parallel microprocessor interface to external RAM and ROM.
A0-A3, A12-A15	OA	**Address Lines 0-3 and 12-15.** A0-A3 and A12-A15 are the external memory bus dedicated address lines.
A4/D0-A11/D7	IA/OA	**Address Line 4/Data Line 0-Address Line 11/Data Line 7.** A4/D0-A11/D7 are the external memory bus multiplexed address/data lines.
ALE	OA	**Address Latch Enable.** A negative transition on ALE output latches the address on the multiplexed address/data bus.
$\overline{RD}$	OA	**Read Enable.** $\overline{RD}$ output low enables data to transferred from the A4/D0-A11/D7 lines to the MCU.
$\overline{WT}$	OA	**Write Enable.** $\overline{WT}$ output low enables data to be transferred from the MCU to the A4/D0-A11/D7 lines.
RAMBNK	OA	**RAM Bank Select.** RAMBNK output high selects the external RAM Bank 1; RAMBNK output low selects the external RAM Bank 0.
EBS0 EBS1	OA	**External Bank Select Lines 0 and 1.** EBS0 and EBS1 are encoded ROM bank select outputs.
		DIAGNOSTIC SIGNALS
		Four signals provide the timing and data needed to create an oscilloscope quadrature eye pattern. The eye pattern is a display of the received baseband constellation. By observing this constellation, common line disturbances can usually be identified. The EYEX and EYEY outputs are two serial bit streams containing data for display on the X axis and Y axis, respectively. This serial digital data must be converted to parallel digital form and then to analog form.
EYEX, EYEY	OA OA	**Serial Eye Pattern X and Y Output.** EYEX and EYEY outputs are 15-bit words, each with 8-bits of significance. The 15-bit data words are shifted out most significant bit first with the seven most significant bits equal to zero. EYEX and EYEY are clocked by the rising edge of $\overline{EYECLK}$.
$\overline{EYECLK}$	OA	**Serial Eye Pattern Clock.** $\overline{EYECLK}$ is a clock for use by the serial-to-parallel converters. The $\overline{EYECLK}$ output is a 288 kHz clock. $\overline{EYECLK}$ is also a common multiple of all the possible receiver data clocks.
EYESYNC	OA	**Serial Eye Pattern Strobe.** EYESYNC is a strobe for loading the D/A converters.

3.2 PARALLEL HOST INTERFACE REGISTERS

Table 3-9 shows the parallel interface registers and the corresponding bit assignments.

Table 3-9. Parallel Interface Registers

Register No.	Register Name	Bit No.							
		7	6	5	4	3	2	1	0
7	Scratch Register (SCR)	Scratch Register							
6	Modem Status Register (MSR)	Data Carrier Detect (DCD)	Ring Indicator (RI)	Data Set Ready (DSR)	Clear to Send (CTS)	Delta Data Carrier Detect (DDCD)	Trailing Edge of Ring Indicator (TERI)	Delta Data Set Ready (DDSR)	Delta Clear to Send (DCTS)
5	Line Status Register (LSR)	0	Transmitter Empty (TEMT)	Transmitter Holding Register (THRE)	Break Interrupt (BI)	Framing Error (FE)	Parity Error (PE)	Overrun Error (OE)	Data Ready (DR)
4	Modem Control Register (MCR)	0	0	0	Local Loopback	Out 2	Out 1	Request to Send (RTS)	Data Terminal Ready (DTR)
3	Line Control Register (LCR)	Divisor Latch Access Bit (DLAB)	Set Break	Stick Parity	Even Parity Select (EPS)	Parity Enable (PEN)	Number of Stop Bits (STB)	Word Length Select Bit 1 (WLS1)	Word Length Select Bit 0 (WLS0)
2	Interrupt Identify Register (IIR) (Read Only)	0	0	0	0	0	Pending Interrupt ID Bit 1	Pending Interrupt ID Bit 0	"0" if Interrupt Pending
1 DLAB = 0	Interrupt Enable Register (IER)	0	0	0	0	Enable Modem Status Interrupt (EDSSI)	Enable Receiver Line Status Interrupt (ELSI)	Enable Transmitter Holding Register Empty Interrupt (ETBEI)	Enable Received Data Available Interrupt (ERBFI)
0 DLAB = 0	Transmitter Holding Register (THR)	Transmitter Holding Register (Write Only)							
0 DLAB = 0	Receiver Buffer Register (RBR)	Receiver Buffer Register (Read Only)							
1 DLAB = 1	Divisor Latch (MSB) Register (DLM)	Divisor Latch (MS)							

Interrupt Enable Register (IER) (Addr= 1, DLAB = 0)

The Interrupt Enable Register (IER) enables four types of interrupts that can separately assert the HINT output. A selected interrupt can be enabled by setting the corresponding enable bit to a logic 1, or disabled by resetting the corresponding enable bit to a logic 0. All interrupt sources are disabled by setting bits 0-3 to a logic 0. Disabling all interrupts inhibits the Interrupt Identifier Register (IIR) and inhibits assertion of the HINT output. All other system functions operate normally, including the setting of the Line Status Register (LSR) and the Modem Status Register (MSR).

Bit 0: Enable Received Data Available Interrupt (ERBFI). This bit, when a logic 1, enables assertion of the HINT output when received data is available in the Receiver Buffer, i. e., the Data Ready bit in the Line Status Register (LSR0) is a logic 1. This bit, when a logic 0, disables assertion of HINT due to the LSR0.

Bit 1: Enable Transmitter Holding Register Empty Interrupt (ETBEI). This bit, when a logic 1, enables assertion of the HINT output when the Transmitter Holding Register Empty (THRE) bit in the Line Status Register (LSR5) is set to a logic 1. This bit, when a logic 0, disables assertion of HINT due to LSR5.

Bit 2: Enable Receiver Line Status Interrupt (ELSI). This bit, when a logic 1, enables assertion of the HINT output when any receiver status bit in the Line Status Register (LSR); i.e., bits 1, 2, 3, or 4, changes state. This bit, when a logic 0, disables assertion of HINT due to change of the receiver LSR bits.

Bit 3: Enable Modem Status Interrupt (EDSSI). This bit, when a logic 1, enables assertion of the HINT output whenever bit 0, 1, 2, or 3 in the Modem Status Register (MSR) is a logic 1. This bit, when a logic 0, disables assertion of HINT due to setting of any of these four MSR bits.

Bits 4-7: Not used (always logic 0).

Interrupt Identifier Register (IIR) (Addr = 2)

The Interrupt Identifier Register (IIR) identifies the existence and type of prioritized pending interrupts. Four priority levels are set to assist interrupt processing in the host.

When addressed during chip-select time, the IIR freezes the highest priority interrupt pending and acknowledges no other interrupts until the particular interrupt is serviced by the host.

Bit 0: Interrupt Pending. When this bit is a logic 0, an interrupt is pending. When this bit is a logic 1, no interrupt is pending. This bit can be used in a hardwired prioritized or polled environment to indicate whether an interrupt is pending. If an interrupt is pending, the IIR contents can be used as a pointer to the appropriate interrupt service routine in the host.

Bit 1-2: Highest Priority Pending Interrupt. These two bits identify the highest priority pending interrupt.

1	2	Priority Level	Pending Interrupt
1	1	(highest)	Receiver Line Status
0	1	2	Receiver Buffer Full
1	0	3	Transmitter Holding Register Empty
0	0	4	Modem Status

Bits 3-7: Not used (always 0).

Line Control Register (LCR) (Addr = 3)

The Line Control Register (LCR) specifies the format of the asynchronous data communications exchange.

Bits 0 and 1: Word Length Select (WLS0 and WLS1). These two bits specify the number of bits in each serial in or serial out character. The encoding of bits 0 and 1 is:

Bit 1	Bit 0	Word Length
0	0	5 Bits
0	1	6 Bits
1	0	7 Bits
1	1	8 Bits

Bit 2: Number of Stop Bits (STB). This bit specifies the number of stop bits in each serial out character. If bit 2 is a logic 0, one stop bit is generated regardless of word length. If bit 2 is a logic 1 when either a 5-, 6-, 7-, or 8-bit word length is selected, two stop bits are generated. The serial in logic checks the first stop bit only regardless of the number of stop bits selected.

Bit 3: Enable Parity (PEN). When bit 3 is a logic 1, a parity bit is generated in the serial out (transmit) data stream and checked in the serial in (receive) data stream. The parity bit is located between the last data bit and the first stop bit.

Bit 4: Even Parity Select (EPS). When parity is enabled (LCR3 = 1) and Stick Parity (LCR5) is a logic 0, the number of logic 1s transmitted or checked in the data word bits and parity bit is either even (LCR4 = 1) or odd (LCR4 = 0).

Bit 5: Stick Parity. When stick parity is selected (LCR5 = 1) parity is enabled (LCR3 = 1), and even parity is selected (LCR4 = 1), the parity bit is transmitted and checked by the receiver as a logic 0. When stick parity is selected (LCR5 = 1) parity is enabled (LCR3 = 1), and odd parity is selected (LCR4 = 0), the parity bit is transmitted and checked by the receiver as a logic 1.

Bit 6: Set Break. When this bit is set to a logic 1, the transmit data is forced to the space (logic 0) state. The break is disabled by setting this bit to a logic 0. The Set Break bit acts only on the transmit data and has no effect on the serial in logic.

Bit 7: Divisor Latch Access Bit (DLAB). This bit must be set to a logic 1 to access the Divisor latches of the baud generator during a read or write operation. It must be reset to a logic 0 to access the Receiver Buffer, the Transmitter Holding Register, or the Interrupt Enable Register.

Modem Control Register (MCR) (Addr = 4)

The Modem Control Register (MCR) controls the interface with the modem or data set.

Bit 0: Data Terminal Ready (DTR). This bit controls the Data Terminal Ready (DTR) function. When this bit is a logic 1, DTR is on. When this bit is a logic 0, DTR is off.

Bit 1: Request to Send (RTS). This bit controls the Request to Send (RTS) function. When this bit is a logic 1, RTS is on. When this bit is a logic 0, RTS is off.

Bit 2: Output 1. This bit is used in local loopback (see MCR4).

Bit 3: Output 2. When this bit is a logic 1, HINT is enabled. When this bit is a logic 0, HINT is in the high impedance state.

Bit 4: Local Loopback. When this bit is set to a logic 1, the diagnostic mode is selected and the following occurs:

1. Data written to the Transmit Holding Register will be looped back to the Receiver Buffer Register.
2. The four modem control bits (CTS, DSR, RI, and DCD) are internally connected to the four modem control outputs (RTS, DTR, OUT1, and OUT2), respectively.

Bit 5-7: Not used (always 0).

Line Status Register (LSR) (Addr = 5)

This 8-bit register provides status information to the host concerning data transfer.

Bit 0: Data Ready (DR). This bit is set to a logic 1 whenever a complete incoming character has been received and transferred into the Receiver Buffer Register. Bit 0 is reset to a logic 0 when the host reads the Receiver Buffer Register.

Bit 1: Overrun Error (OE). This bit indicates that data in the Receiver Buffer Register was not read by the host before the next character was transferred into the Receiver Buffer Register, thereby, destroying the previous character. The OE bit is reset whenever the host reads the Line Status Register.

Bit 2: Parity Error (PE). This bit indicates that the received data character does not have the correct even or odd parity, as selected by the Even Parity Select bit (LCR4) and the Stick Parity bit (LCR5). The PE bit is set to a logic 1 upon detection of parity error and is reset to a logic 0 whenever the host reads the Line Status Register.

Bit 3: Framing Error (FE). This bit indicates that the received character did not have a valid stop bit. Bit 3 is set to a logic 1 whenever the stop bit following the last data bit or parity bit is detected as a zero bit. The FE bit is reset to a logic 0 whenever the host reads the Line Status Register.

Bit 4: Break Interrupt (BI). This bit is set to a logic 1 whenever the received data input is a space (logic 0) for longer than two full word lengths plus 3 bits. The BI indicator is reset whenever the host reads the Line Status Register.

Bit 5: Transmitter Holding Register Empty (THRE). This bit indicates that the modem is ready to accept a new character for transmission. In addition, this bit causes the modem to issue an interrupt to the host when the Transmit Holding Register Empty Interrupt Enable bit (IIR1) is set to logic 1. The THRE bit is set to a logic 1 when a character is transferred from the Transmitter Holding Register into the Transmitter Shift Register. The bit is reset to logic 0 concurrently with the loading of the Transmitter Holding Register by the host.

Bit 6: Transmitter Empty (TEMT). This bit is set to a logic 1 whenever the Transmitter Holding Register (THR) and the Transmitter Shift Register (TSR) are both empty. It is reset to a logic 0 whenever either the THR or TSR contains a data character.

Bit 7: This bit is set to logic 0.

Modem Status Register (MSR) (Addr = 6)

The Modem Status Register (MSR) reports current state and change information of the modem. Bits 4-7 supply current state and bits 0-3 supply change information. The change bits are set to a logic 1 whenever a control input from the modem changes state from the last MSR read by the host. Bits 0-3 are reset to logic 0 when the host reads the MSR or upon reset.

Whenever Bits 0, 1, 2, or 3 are set to a logic 1, a Modem Status Interrupt is generated.

Bit 0: Delta Clear to Send (DCTS). This bit is set to a logic 1 when the CTS bit has changed since the MSR was last read by the host.

Bit 1: Delta Data Set Ready (DDSR). This bit is set to a logic 1 when the DSR bit has changed since the MSR was last read by the host.

Bit 2: Trailing Edge of Ring Indicator (TERI). This bit is set to a logic 1 when the RI bit changes from a 1 to a 0 state since the MSR was last read by the host.

Bit 3: Delta Data Carrier Detect (DDCD). This bit is set to a logic 1 when the DCD bit changes state since the MSR was last read by the host.

Bit 4: Clear to Send (CTS). This bit indicates the logic state of the $\overline{CTS}$ output. If Loopback is selected (MCR4 = 1), this bit reflects the state of RTS in the MCR (MCR1).

Bit 5: Data Set Ready (DSR). This bit indicates the logic state of the $\overline{DSR}$ output. If Loopback is selected (MCR4 = 1), this bit reflects the state of DTR in the MCR (MCR0).

Bit 6. Ring Indicator (RI). This bit indicates the logic state of the $\overline{RI}$ output. If Loopback is selected (MCR4 = 1), this bit reflects the state of OUT1 in the MCR (MCR2).

Bit 7. Data Carrier Detect (DCD). This bit indicates the logic state of the $\overline{DCD}$ output. If Loopback is selected (MCR4 = 1), this bit reflects the state of OUT2 in the MCR (MCR3).

Receiver Buffer Register (RBR) (Addr = 0, DLAB = 0)

The Receiver Buffer Register (RBR) is a read-only register at location 0 (with DLAB = 0). Bit 0 is the least significant bit of the data, and is the first bit received.

Transmitter Holding Register (THR) (Addr = 0, DLAB = 0)

The Transmitter Holding Register (THR) is a write-only register at address 0 when DLAB = 0. Bit 0 is the least significant bit and the first bit sent.

Divisor Registers (Addr = 0 and 1, DLAB = 1)

The Divisor Latch LS (least significant byte) and Divisor Latch MS (most significant byte) are two read-write registers at locations 0 and 1 when DLAB = 1, respectively.

The baud rate is selected by loading each divisor latch with the appropriate hex value. Table 3-10 lists the programmable values corresponding to the desired baud rate.

Scratch Register (SCR) (Addr = 7)

The Scratchpad Register is a read-write register at location 7. This register is not used by the DSP and can be used by the host for temporary storage.

Table 3-10. Programmable Baud Rates

Divisor Latch (Hex)			
MS	LS	Divisor (Decimal)	Baud Rate
06	00	1536	75
04	17	1047	110
03	00	768	150
01	80	384	300
00	C0	192	600
00	60	96	1200
00	30	48	2400
00	18	24	4800
00	0C	12	9600
00	06	6	19200
00	03	3	38400

3.3 INTERFACE TIMING AND WAVEFORMS

Table 3-11 lists the interface timing parameters.

Figure 3-6 illustrates the interface waveforms.

Table 3-11a. Timing - Parallel Host Bus Interface

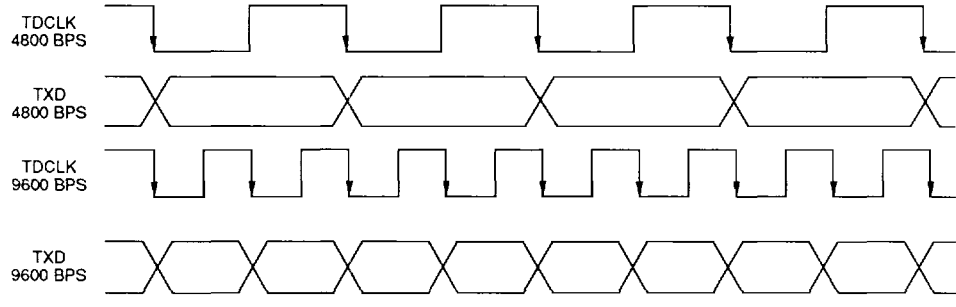
Symbol	Parameter	Min	Max	Units
t_{AS}	Address Setup	25	–	ns
t_{AH}	Address Hold	0	–	ns
t_{CS}	Chip Select Setup	10	–	ns
t_{CH}	Chip Select Hold	0	–	ns
t_{RD}	Read Strobe Width	100	–	ns
t_{DD}	Delay HRD to Data	–	75	ns
t_{DRH}	HRD to Data Hold	10	–	ns
t_{WT}	Write Strobe Width	75	–	ns
t_{DS}	Write Data Setup	30	–	ns
t_{DWH}	Write Data Hold	10	–	ns
t_{DF}	HRD to Driver Off	–	30	ns
t_{DIS}	HDIS Enable	–	40	ns
t_{DIH}	HDIS Hold	10	–	ns
t_{INH}	Interrupt Hold	–	100	ns

See Figure 3-6b.

Table 3-11b. Timing - External Memory Bus Interface

Symbol	Parameter	Min	Max	Units
t_{CYC}	Internal Operating Cycle	125	–	ns
t_{AD}	Address Valid to READ Data Valid	–	200	ns
t_{AF}	ALE↓ to Address Float	10	20	ns
t_{AS}	Address Valid to ALE↓	20	–	ns
t_{CA}	(READ or WRITE) ↑ to Address Valid	–	35	ns
t_{CW}	↓ (READ/ WRITE) to (READ/ WRITE) ↑	180	–	ns
t_{ESH}	(READ/WRITE) ↑ to ESi	10	–	ns
t_{ESV}	(READ/WRITE ↑ to ↓ ESi	–	35	ns
t_{FH}	(READ/WRITE) ↑ to Address Hold	10	–	ns
t_{FV}	(READ/WRITE) ↑ to Address Valid	–	30	ns
t_{LC}	ALE↓ to ↓ (READ/WRITE	0	–	ns
t_{LH}	(READ/WRITE) ↑ to ↑ ALE	5	–	ns
t_{LW}	↑ ALE to ALE↓	35	–	ns
t_{RDH}	READ ↑ to Read Data Hold ↑	0	–	ns
t_{RDS}	Read Data Valid to READ ↑	12	–	ns
t_{WTD}	↓ WRITE to Write Data Valid	–	30	ns
t_{WTH}	WRITE ↑ or Write Data Hold	10	–	ns

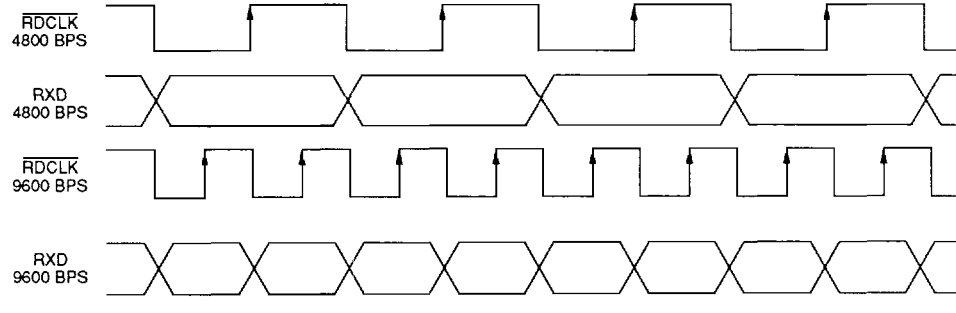
See Figure 3-6c.



NOTE: THIS FIGURE IS VALID FOR SYNCHRONOUS MODE ONLY. THERE IS NO RELATIONSHIP BETWEEN TXD AND TDCLK IN ASYNCHRONOUS MODE.

a. Transmit

91354/7

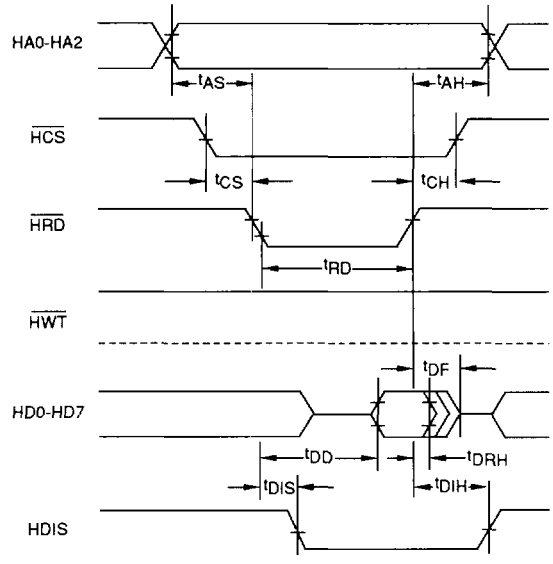


NOTE: THIS FIGURE IS VALID FOR SYNCHRONOUS MODE ONLY. THERE IS NO RELATIONSHIP BETWEEN RXD AND RDCLK IN ASYNCHRONOUS MODE.

b. Receive

91354/8

Figure 3-6a. Waveforms - Serial Interface (4800/9600 bps)



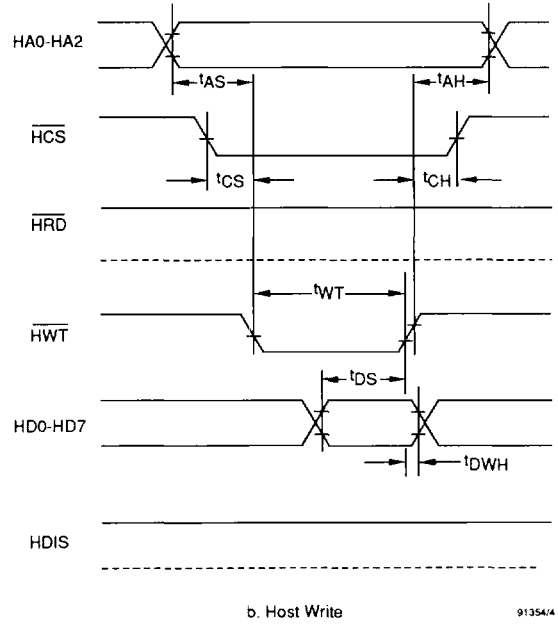
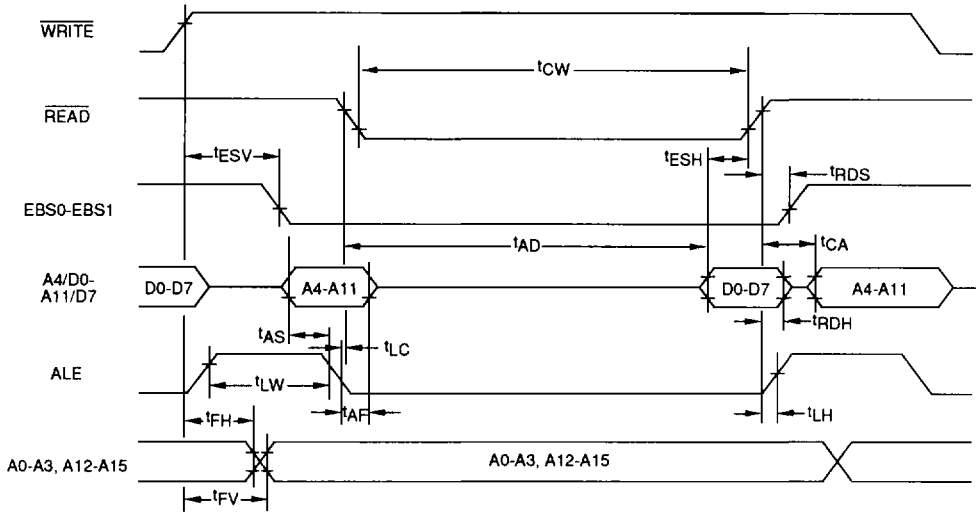


Figure 3-6b. Waveforms - Parallel Host Bus Interface



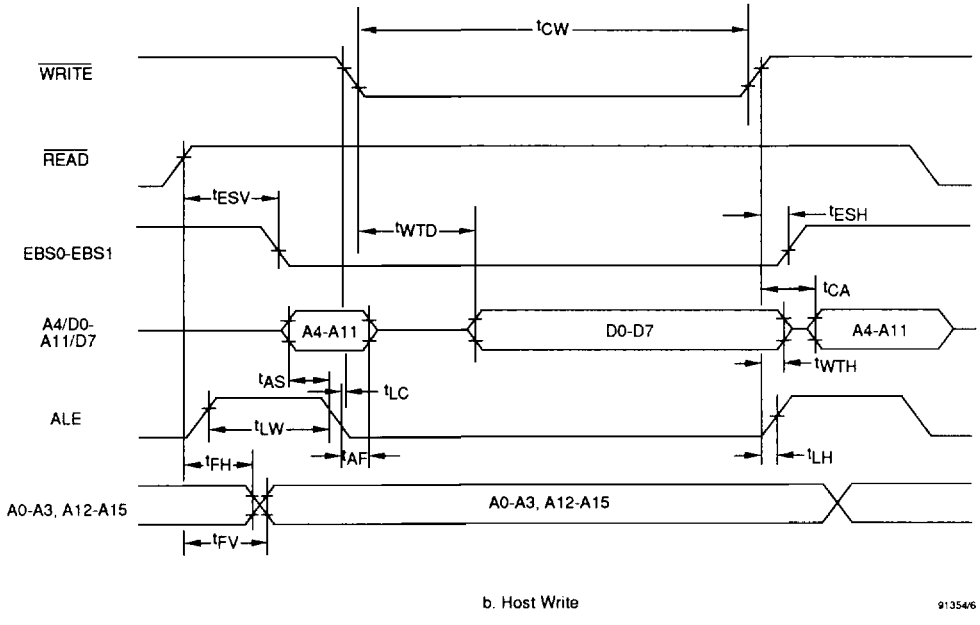


Figure 3-6c. Waveforms - External Bus Interface

3.4 MEMORY MAP CONSIDERATIONS

3.4.1 Memory Map

The memory map is shown in Figure 3-7.

3.4.2 Chip Select Logic

The chip select logic equations are described in Figure 3-8.

3.4.3 Banking vs. Physical Memory

On the RC9696AC demonstration design (see appendices A and B), the program code is split into two 32k x 8 EPROMs to supports a low cost design. The firmware routines which do not need to be executed at full speed are placed into the banked area which falls into U9. U9 is a 27256 (32k x 8) EPROM with a slower access time and contains the four banks that are all logically addressed at 6000h.

The physical addresses of U9 are as follows:

Bank No. EBS1	Bank No. EBS0	Physical Address (Hex)
0	0	0000 - 1FFF
0	1	4000 - 5FFF
1	0	2000 - 3FFF
1	1	6000 -7FFF

U7 is also a 27256 (32k x 8) EPROM but it requires a faster access time. It contains the code logically addressed from 8000h to FFFFh.

NOTE: If it is desired to use a single 64k x 8 EPROM in the design, the firmware code logically addressed from 8000h to FFFFh will map directly into physical addresses 8000h to FFFFh on the EPROM.

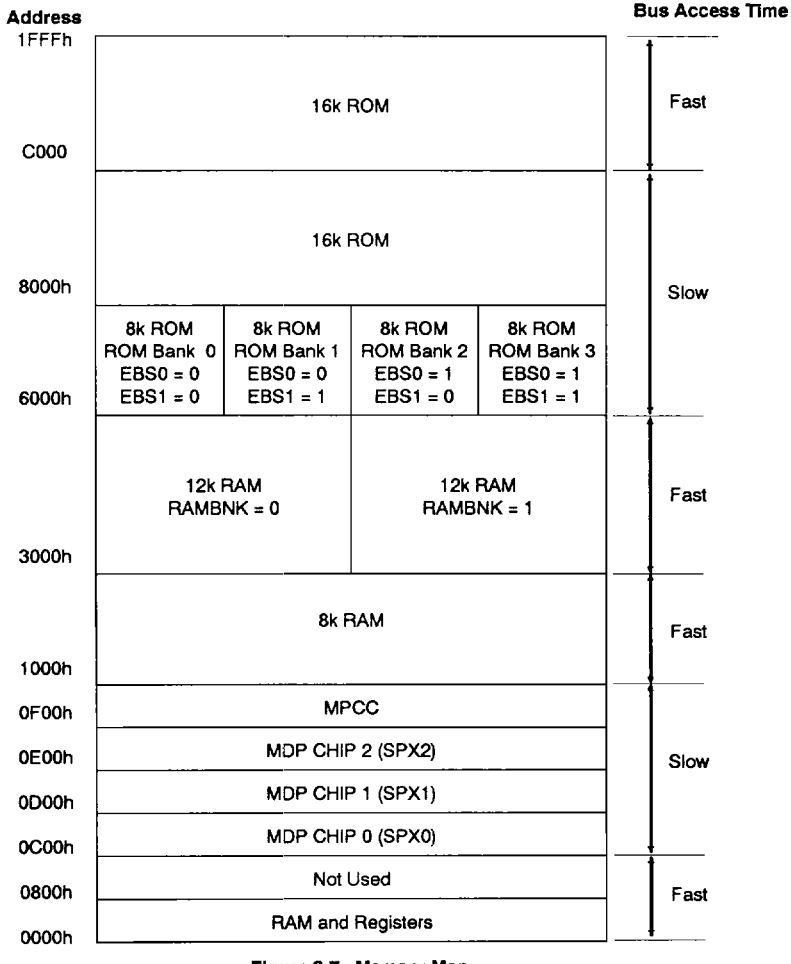


Figure 3-7. Memory Map

```
Modem Chip Select Logic
   /SPX0SEL (MDP Chip 0)= /A15 * /A14 * /A13 * /A12 * A11 * A10 * /A9 * /A8

   /SPX1SEL (MDP Chip 1)= /A15 * /A14 * /A13 * /A12 * A11 * A10 * /A9 *  A8

   /SPX2SEL (MDP Chip 2)= /A15 * /A14 * /A13 * /A12 * A11 * A10 *  A9 * /A8

   /USARTSEL (MPCC)      = /A15 * /A14 * /A13 * /A12 * A11 * A10 *  A9 *  A8 * /WRITE
                         + /A15 * /A14 * /A13 * /A12 * A11 * A10 *  A9 *  A8 * /READ
External Memory Select Logic
   /CSROM2           =     /A15 *  A14 *  A13

   /CSROM1           =      A15

   /CSRAM            =     /A15 * /A14 *  A12
                     + /A15 * /A14 *  A13
                     + /A15 *  A14 * /A13

   EA14              =      A15 * /A14
                     + /A15 * /EBS0

   EA13              =      A15 * /A13
                     + /A15 * /EBS1

   RA13              =     /A14 *  A12 *  RAMBNK
                     + /A13 * /RAMBNK

   RA12              =      A13 *  RAMBNK
                     + /A12
```

Figure 3-8. External Memory Chip Select Logic

4. AT COMMANDS

Table 4-1 summarizes the AT commands. The commands are described in detail in Tables 4-2 through 4-5.

4.1 COMMAND GUIDELINES

Each AT command has a list of possible parameters with its default value. The default value is loaded at initialization, i.e., power turn on or ATZ command. If a command requires a parameter but no parameter is entered, the modem assumes the parameter is zero. Invalid commands or parameters return the ERROR message.

The command line may contain a single command or a series of commands. The commands may be separated by a space for readability. The command line can be up to 40 characters in length. The command line is executed after a terminating character is entered. The default terminating character is a carriage return (ASCII 013), but this may be changed by writing a different value to register S3.

The command line may be edited using the backspace character (ASCII 008). This value may be programmed using the S5 register. However, the backspace will not work for values of 0 and greater than 127, or for the current value of the terminating character.

All command lines must begin with AT entered in capital or lower case letters. A command line can be terminated at any time by issuing CTRL-X (ASCII 018) after entering AT attention code. The command line will be ignored and an OK result message will be issued. The A/ command may be used to repeat the last command line. The A/ does not require a terminating character or the AT attention code.

The escape code sequence returns the modem to the command mode from the data mode. A time delay must occur between the last character transmitted and the first character of the escape code. The guard time delay can be changed by writing a value to register S12; (default 1 second). The escape code character must occur three times in succession for an escape.

Table 4-1. AT Command Summary

Command	Title	Default	
A/	Re-execute Command	none	
ATA	Answer	none	
ATBn	Set CCITT or Bell Mode	1 (US) 0 (Japan)	*
ATCn	Carrier Control	1	
ATDn	Dial	P	
ATE	Command Echo	1	*
ATFn	On-Line State Character Echo	1	*
ATHn	Switch-Hook Control	none	
ATIn	Identification	none	
ATLn	Speaker Volume	2	*
ATMn	Speaker Control	1	*
ATNn	Modulation Handshake	1	*
ATOn	Return To The On-line State	none	
ATP	Set Pulse Dial as Default	none	*
ATQn	Result Code Display	0	*
ATSn?	Reading S Registers	none	
ATSn=x	Writing To S Registers	none	
ATT	Set Tone Dial as Default	none	*
ATVn	Result Code Form (Message Control)	1	*
ATWn	Negotiation Progress Reporting	0	*
ATXn	Extended Result Codes	4	*
ATYn	Control Long Space Disconnect	0	*
ATZn	Reset	none	
AT&Cn	DCD Option	0	*
AT&Dn	DTR Option	0	*
AT&F	Restore Factory Configuration	none	
AT&Gn	Set Guard Tone	0	*
AT&Jn	Telephone Jack Selection	0	*
AT&Kn	DTE/Modem Flow Control	3	*
AT&Ln	Line Type	0	*
AT&Mn	Communication Mode	(&Qn)	*
AT&Pn	Dial Pulse Ratio	0 (US) 2 (Japan)	*

Table 4-1. AT Command Summary (Cont'd)

Command	Title	Default	
AT&Qn	Communication Mode	5	*
AT&Rn	RTS/CTS Option	0	*
AT&Sn	DSR Option	0	*
AT&Tn	Test And Diagnostic	4	*
AT&V	View Current Configuration and User Profiles	none	
AT&Wn	Store User Profile	none	
AT&Xn	Clock Source Selection	0	*
AT&Yn	Designate Default User Profile	0	*
AT&Zn=x	Store Phone Number	none	
AT\An	Maximum MNP Block Size	2	
AT\Bn	Transmit Break	3	
AT\E	Optimize Echo Cancellation	none	
AT\Gn	Modem to Modem Flow Control	0	
AT\Kn	Break Control	5	
AT\Ln	MNP Block Transfer Control	0	
AT\Nn	Operation Mode Control	none	*
AT\O	Originate Reliable Link Control	none	
AT\Tn	Inactivity Timer Control	0	*
AT\U	Accept Reliable Mode Control	none	
AT\Y	Switch To Reliable Mode	none	
AT\Z	Switch To Normal Mode	none	
AT%Cn	Compression Control	1	*
AT%Dn	Set Dictionary Size (V.42 bis)	2	
AT%En	Enable/Disable Auto Retrain	0	
AT%L	Report Received Signal Level	none	
AT%Mn	Set One/Two-Way Mode (V.42 bis)	3	
AT%P	Clear V.42 bis Encoder Dictionary	none	
AT%Q	Report Line Signal Quality	none	
AT%Sn	Set Maximum String Length (V.42 bis)	32	

* Command setting may be stored in one of two user profiles with the AT&Wn command.

Parameters that are entered for the AT and AT& commands are limited in value to 0-255, where the parameter is "MOD"ed with 256. The result must be within the specified range; if it is not, the ERROR message is issued.

Parameters entered for an S registers are also "MOD"ed with 256 and the result is stored in the S register. Parameters that are out of range are stored in the S register, however, no ERROR message is reported. Functionally, however, the lower or higher limit is observed.

Parameters entered for the AT\ and AT% commands follow the same method, except that if the parameter is out of range, the upper limit is stored and no ERROR message is reported.

Table 4-2. AT Command Definitions

Command	Description
A/	**Re-execute Command.** Re-executes the most recent AT command string. The principle application of this command is to place another call (e.g., Dial command) that failed to connect due to a busy line, no answer, or a wrong number. This command must appear alone on a command line and must be terminated by the "/" character. (A <CR> should not be entered to terminate the command.) Parameters: None Default: None
ATA	**Answer.** This must be the last command entered into the command line. The modem proceeds with the connect sequence in answer mode. The modem will enter the connect state after exchanging carrier with the remote modem. If no carrier is detected within a wait period specified in register S7 (default = 30 seconds), the modem will disconnect. Any character may be entered via the DTE during the connect sequence to abort the command. Parameters: None Default: None Result codes: CONNECT XXXX — if a connection is established (XXXX = telco line speed, e.g., 2400). NO CARRIER — if a connection cannot be established, the abort timer (register S7) expires, or if the command is aborted. ERROR — if in data mode.
ATBn	**Set CCITT or Bell Mode.** Selects between CCITT and Bell modes for 1200 and 300 bps. This command is not valid when the ATN1 command (automode detection enabled) is in effect. Parameters: 0, 1 Default: 1 for U.S., 0 for Japan (see 2.9) Result codes: OK — for all valid parameters. ERROR — otherwise. Command options: ATB0 = Selects CCITT V.22 and V.21 standards for communication at 1200 and 300 bps. ATB1 = Selects Bell 212A and 103 standards for communication at 1200 and 300 bps.
ATCn	**Carrier Control.** Controls the transmit carrier. The modem is preset to turn carrier on and off as necessary (the C1 option). The signal is on when the modem is calling, answering, or connected to a remote modem, and is off when it is not. The C0 option is NOT valid. Parameters: 0, 1 Default: 1 Result codes: OK — for 1. ERROR — otherwise. Command options: ATC0 = Not permitted; returns ERROR result code. ATC1 = Normal transmit carrier switching (preset).

Table 4-2. AT Command Definitions (Cont'd)

Command	Description
ATDn	**Dial.** This must be the last command on a command line. ATD causes the modem go off-hook, dial according to the parameters entered, and attempt to establish a connection. If there are no parameters, then the modem goes off-hook in originate mode without dialing a number. Punctuation may be used for clarity. Parentheses, hyphens and spaces are ignored. If an invalid character is entered, that character and all subsequent characters in the dial string are ignored. The modem truncates dial strings to 40 characters. Parameters: 0-9 A B C D * # L P T R ! @ W , ; ^ S=n Default: P Result codes: OK — if ";" dial modifier is used. OK — if key press abort during dialing process. NO DIALTONE — if ATX2 or ATX4 is selected and 1 second of dial tone is not detected within 5 seconds; or if W dial modifier is used and 3 seconds of dial tone is not detected within the time specified by S7. BUSY — if busy is detected, and ATX3 or ATX4 is selected or if W dial modifier is used. NO ANSWER — if "@" dial modifier is used and 5 seconds of silence is not detected within the time specified by S7. CONNECT XXXX — if a connection is established. NO CARRIER — if a connection cannot be established, the abort timer (register S7) expires, or a character is entered during the handshake process. ERROR — if in data mode. The ATD Parameters are: L — Dials the last dial string that was dialed. P — Use Pulse Dialing. Placed at the end of the command string and before the dial string. Causes the modem to pulse dial the numbers. T — Use DTMF Dialing. Placed at the end of the command string and before the dial string. Causes the modem to use DTMF tones to dial. R — Reverse Mode. Allows the modem to call an originate-only modem by forcing the call into "answer mode". Must be entered as the last character of the command string (just before the <CR>). ! — Hookflash. Causes the modem to go on-hook for 700 milliseconds and then off-hook. @ — Causes the modem to listen for 5 seconds of silence. If a 5 second silence has not been detected within the period specified in S7 (default = 30 seconds), the modem disconnects and returns the 'NO ANSWER' result code. If it detects a busy signal, it returns a 'BUSY' result code. If the 5 seconds of silence is detected, then the modem continues dialing the dial string. W — Wait For Dial Tone Before Dialing. Causes the modem to wait for a dial tone up to the period of time specified in register S7 (default = 30 seconds) before dialing the numbers that follow. If the modem detects a dial tone before the given time delay, it continues to dial. Otherwise, it goes on-hook. , — Pause During Dial. Inserted between digits in a dial string. Causes the modem to pause for the value given by register S8 (default = 2 seconds), before dialing the next digit. This delay can be used in place of the "Wait For Dial Tone Before Dialing". ; — Return To Command Mode After Dialing. Added to the end of a dial string. Causes the modem to remain in the command mode after it dials the digits preceding the command. This allows the user to issue additional dial commands or dial strings without overflowing the command buffer. The modem looks for the carrier after the final dial command is issued. "ATHn" aborts this command. ^ — Turn On Calling Tone. Turns on the periodic 1300 Hz calling tone if originating the call. Calling tone is enabled only on a call-by-call basis. S=n — Dial Stored Number. Follows the dial command string. Causes the modem to dial a telephone number previously stored in directory location n using AT&Zn command. If "ATD" is entered without parameters, the modem goes off-hook and waits for carrier; if the handshake is not completed within the period of time specified by register S7 (default = 30 seconds) the modem goes on-hook. The ATD command will be aborted in progress upon receipt of any character from the DTE before completion of the handshake.

Table 4-2. AT Command Definitions (Cont'd)

Command	Description
ATE	**Command Echo.** Controls the echo of characters received by the modem from the local DTE while the modem is in the command mode. Parameters: 0, 1 Default: 1 Result codes: OK — for 0 and 1. ERROR — otherwise. Command options: ATE0 = Inhibits the echoing of commands. ATE1 = Enables the echoing of commands.
ATFn	**On-Line State Character Echo.** Determines if the modem will echo data from the DTE. The modem does not support the ATF0 command. However, the modem will accept ATF1, which may be issued by some communication software packages. Parameters: n = 0, 1 Default: 1 Result codes: OK — for 1. ERROR — otherwise. Command options: ATF0 = Error. ATF1 = Disables on-line echo.
ATHn	**Switch-Hook Control.** Applies to asynchronous operation only. If the user enters the command mode from the data mode by issuing the escape sequence (+++), or as a result of an ON-to-OFF transition of DTR with the AT&D1 option in effect, the user may cause the modem to go on-hook (disconnect) by issuing the ATH command. Parameters: n = 0, 1 Default: none Result codes: OK — for 0 and 1. ERROR — otherwise. Command options: ATH0 = Causes the modem to go on-hook (hang up). ATH1 = If modem is on-hook, modem goes off-hook, returns an OK response, and awaits further commands.

Table 4-2. AT Command Definitions (Cont'd)

Command	Description
ATIn	**Identification.** Returns the product code, returns the checksum of the firmware ROM, or computes the checksum of the firmware ROM and reports its error status. The product code contains 3 digits. The checksum result consists of three ASCII numeric characters followed by a carriage return and a line feed. The error status is either OK or ERROR. Parameters: n = 0-2 Result codes: OK Default: none Command options: ATI0 = Reports the product code. ATI1 = Reports the checksum computed on the firmware ROM. ATI2 = Performs a checksum on the firmware ROM and indicates OK or ERROR. ATI3 = Reports firmware manufacturer identification and checksum. ATI4 = Reports product capabilities.
ATLn	**Speaker Volume.** Controls the internal speaker volume. Parameters: n = 0-3 Default: 2 Result codes: OK for 0 to 3. ERROR otherwise. Command options: ATL0 = Selects low speaker volume. ATL1 = Selects low speaker volume. ATL2 = Selects medium speaker volume. ATL3 = Selects high speaker volume.
ATMn	**Speaker Control.** Controls the internal speaker while the modem is receiving a carrier signal or dialing. This command also enables or disables the speaker. Parameters: n = 0-3 Default: 1 Result codes: OK for 0 to 3. ERROR otherwise. Command options: ATM0 = Speaker is always off. ATM1 = Speaker goes off while the modem is receiving a carrier signal from a remote modem. ATM2 = Speaker is always on. ATM3 = Speaker goes off while the modem is receiving a carrier signal from a remote modem and while the modem is dialing.

Table 4-2. AT Command Definitions (Cont'd)

Command	Description
ATNn	**Modulation Handshake.** This command can be used to assure that a connection is made only at the specified speed. If leased line is selected, this command is ignored and the modem operates as if ATN0 were selected. Parameters: 0, 1 Default: 1 Result codes: OK — for 0 and 1. ERROR — otherwise. Command options: ATN0 = Requires that the speed of the connection be that specified by the value held in S37; if S37=0, the speed of the connection must match that at which the last AT command was issued. If the selected speed can be achieved using more than one communication standard (e.g., Bell 212A or CCITT V.22 at 1200 bps), the modem also references the selection made with the ATB command. ATN1 = Permits handshaking to occur at any speed supported by both modems. Enables automode detection. The ATB command is ignored in this mode and the modem attempts only CCITT mode connections.
ATOn	**Return To The On-line State.** Applies to asynchronous operation only. If the user enters the command mode from the data mode by issuing the escape sequence, or as a result of an ON-to-OFF transition of DTR with the AT&D1 option in effect, the user may return to the data mode without terminating a call by issuing the ATO command. This command may also be used to force a retrain. If the modem is on-hook, then the modem behaves as if it went off-hook to originate without actually taking the relay off-hook. Parameters: 0, 1 Default: None Result codes: ERROR — if &T1, &T3, or &T6-&T8 is active. CONNECT XXXX — if a connection is established. NO CARRIER — if retrain is not successful in the time specified by S7. Command options: ATO0 = Causes the modem to return to the data mode. ATO1 = Causes the modem to return to the data mode and to initiate a retrain when operating at 2400 bps.
ATP	**Set Pulse Dial as Default.** Causes the modem to assume that all subsequent dial commands are pulse dialed. The user may omit the "P" from the dial strings. Parameters: None Default: None Result codes: OK — if issued outside dial string.

Table 4-2. AT Command Definitions (Cont'd)

Command	Description
ATQn	**Result Code Display.** Determines whether or not the modem sends the result codes to the DTE. (See ATXn command.) Parameters: n = 0, 1, 2 Default: 0 Result codes: OK — for 0 and 2. none — for 1. ERROR — otherwise. Command options: ATQ0 = Allows the modem to send result codes to the DTE. ATQ1 = Prohibits the modem from sending result codes to the DTE. ATQ2 = Modem returns result codes to the DTE when originating a call; does not return result codes when answering a call.
ATSn?	**Reading S Registers.** Reads the contents of the S register. All the S registers may be read. Parameters: n = 0-95 Default : None Result codes: OK — for all parameters.
ATSn=x	**Writing to S Registers.** Writes the value of x to the specified S register. All the registers will return the OK response if x is a legal value, however, some registers will not actually write the value anywhere. These registers are S1, S13-S15, S17, S20-S24, and S27. Parameters: n = 0-95, x = 0-255 Default : None Result codes: OK — for parameters n=0-95. OK — for no argument. ERROR — otherwise.
ATT	**Set Tone Dial as Default.** Causes the modem to assume that all subsequent dial commands are tone dialed. The user may omit the "T" from the dial string. Parameters: None Default: None Result codes: OK — if issued outside dial string.
ATVn	**Result Code Form (Message Control).** Selects whether the modem sends long form or short form result codes to the local DTE. All responses are ASCII values. Long-form (verbose) responses are preceded and terminated with both carriage return and line feed control characters. Short-form (numeric) responses are only terminated with a carriage return control character. (See ATXn command.) Parameters: 0, 1 Default: 1 Result codes: 0 — for 0. OK — for 1. ERROR — otherwise. Command options: ATV0 = Allows short-form (numeric) result codes to be sent. ATV1 = Allows long-form (verbose) result codes to be sent.

Table 4-2. AT Command Definitions (Cont'd)

Command	Description.
ATWn	**Negotiation Progress Reporting.** An additional set of result codes can be enabled with the W command to report progress of the negotiation phase of error-correction mode. These codes report the carrier speed (300 bps-2400 bps) and the error-correction protocol. These messages can also be reported in either numeric or verbose form. For example, both 77 and PROTOCOL:LAP-M indicate that the error correction protocol is LAP-M. (See ATXn command.) If the error-correction link is negotiated and a connection is made, the appropriate CONNECT XXXX message is reported. When in error-correction mode, the CARRIER XXXX message may indicate one speed, while the CONNECT XXXX message reports another. Parameters: 0-2. Default: 0 Result codes: OK for parameters 0-2. ERROR otherwise. Command options: ATW0 = Error-correction call progress not reported. ATW1 = Error-correction call progress reported. ATW2 = Error-correction call progress not reported. CONNECT XXXX message reports DCE speed.
ATXn	**Extended Result Codes.** Determines whether the modem responds to dial tone and busy signals, and how it displays result codes for CONNECT messages. When the modem ignores dial tone, it waits for a time delay given by register S6 (default = 2 seconds) and then dials regardless of presence or absence of dial tone; this is called blind dialing. Parameters: 0-4. Default: 4 Result codes: OK for parameters 0-4. ERROR otherwise. Command options: ATX0 = Modem ignores dial tone and busy signal. Sends CONNECT message when a connection is established by blind dialing. ATX1 = Modem ignores dial tone and busy signal. Sends CONNECT XXXX message reflecting bit rate when a connection is established by blind dialing. ATX2 = Modem ignores busy signal but waits for dial tone before dialing. If dial tone is not detected within 5 seconds, the NO DIAL TONE message is sent. Sends CONNECT XXXX message reflecting bit rate when a connection is established. ATX3 = Modem ignores dial tone. Sends BUSY message if a busy signal is detected. Sends CONNECT XXXX message reflecting bit rate when a connection is established by blind dialing. ATX4 = If dial tone is not detected within 5 seconds, sends NO DIAL TONE message. If busy signal is detected, sends BUSY message. Sends CONNECT XXXX message reflecting bit rate when a connection is established.

Table 4-2. AT Command Definitions (Cont'd)

Command	Description
	Result Codes - Q,V,X,W, S95

Short Form	Long Form
0	OK
1	CONNECT
2	RING
3	NO CARRIER
4	ERROR
5	CONNECT 1200
6	NO DIALTONE
7	BUSY
8	NO ANSWER
9	CONNECT 0600
10	CONNECT 2400
11	CONNECT 4800
12	CONNECT 9600
40	CARRIER 300
46	CARRIER 1200
47	CARRIER 2400
66	COMPRESSION CLASS 5
67	COMPRESSION V.42BIS
69	COMPRESSION NONE
70	PROTOCOL:NONE
77	PROTOCOL:LAPM
80	PROTOCOL:ALT

ATYn **Control Long Space Disconnect.** Determines whether the modem disconnects when it receives a continuous break from a remote modem for a period equal to, or greater than, 1.6 seconds, and sends a break for 4 seconds before disconnecting due to an ON-to-OFF transition of DTR if an AT&D2 option is in effect, or upon receiving an ATH command.

Parameters: 0, 1

Default: 0

Result codes:

OK	for 0 and 1.
ERROR	otherwise.

Command options:

ATY0 =	Disable long space disconnect.
ATY1 =	Enable long space disconnect.

ATZn **Reset.** Causes the modem to disconnect and performs a warm start. This command must be the last command on the command line. The reset actions are:

Clear serial port buffers.

Set the baud rate and parity to match the local DTE when any AT command is issued.

Restore the active configuration with the user profile denoted by the parameter.

Parameters: 0, 1

Default: 0

Result codes:

OK	for 0 and 1.
ERROR	otherwise.

Table 4-3. AT& Command Definitions

Command	Description
AT&Cn	**DCD Option.** Controls the Received Line Signal Detected ($\overline{\text{RLSD}}$) [Carrier Detect (DCD)] signal of the serial port. If synchronous mode is selected, this command is ignored and the modem functions as if the AT&C1 command has been entered. Parameters: n = 0, 1 Default: 0 Result codes: OK for 0 and 1. ERROR otherwise. Command options: AT&C0 = $\overline{\text{RLSD}}$ is ON regardless of the state of the data carrier from the remote modem. AT&C1 = $\overline{\text{RLSD}}$ follows the state of the data carrier from the remote modem.
AT&Dn	**DTR Option.** Determines actions taken by the modem in relation to the Data Terminal Ready ($\overline{\text{DTR}}$) signal of the serial port. The effect of $\overline{\text{DTR}}$ loss depends upon the AT&D and AT&Q (AT&M) commands. Parameters: n = 0-3 Default: 0 Result codes: OK for 0 to 3. ERROR otherwise. The action for the event that follows $\overline{\text{DTR}}$ loss is indicated in the following table:

	&D0	&D1	&D2	&D3
&Q0	NONE	2	3	4
&Q1	1	2	3	4
&Q2	3	3	3	3
&Q3	3	3	3	3
&Q4	1	2	3	4

The DTR-going-off events corresponding to the action numbers in the above table are:

1. Modem disconnects and sends OK result code.
2. Modem goes into command mode if in data mode and sends the OK result code.
3. Modem disconnects, sends the OK result code, and disables auto answer while $\overline{\text{DTR}}$ is OFF.
4. Modem performs a warm start (i.e., same as ATZ command). This is the DTE/AT&D3 abort.

AT&F	**Restore Factory Configuration.** Loads the modem active configuration area with the factory default values. Parameters: None Default: None Result codes: OK
AT&Gn	**Set Guard Tone.** Normally controls the generation of guard tones. This command is not implemented, however, the command structure is provided for application compatibility. Parameters: n = 0-2 Default: 0 Result codes: OK for 0 to 2. ERROR otherwise.

Table 4-3. AT& Command Definitions (Cont'd)

Command	Description
AT&Jn	**Telephone Jack Selection.** Determines how the auxiliary relay is controlled. Parameters: n = 0, 1 Default: 0 Result codes: OK — for 0 and 1. ERROR — otherwise. Command options: AT&J0 = Suitable for RJ-11, RJ-41S, or RJ-45S type phone jack. The auxiliary relay is never operated. AT&J1 = Suitable for RJ-12 or RJ-13 type phone jack. The A lead is connected to A1 lead while modem is off-hook. If AT&J0 is selected, the auxiliary telco relay is opened. If AT&J1 is selected and the modem is off-hook, the auxiliary telco relay (A/A1) is closed (shorting A to A1).
AT&Kn	**DTE/Modem Flow Control.** Determines how the modem controls the flow of data between the local DTE and the modem. When the modem terminal buffer is nearly full, the modem will either send an XOFF or drop CTS to stop the data flow. When the buffer is nearly empty, the modem will either send an XON or raise CTS to start the data flow. The modem also responds to XON/XOFF characters or RTS stimulus from the DTE by suspending or resuming transmission accordingly. The modem responds to DTE XON/XOFF characters and also passes the XON/XOFF characters to the remote modem as data if transparent flow control is selected. When in the Direct mode (AT&Q0), flow control is not used and the modem ignores the setting of this command. Parameters: n = 0, 3, 4, or 5 Default: 3 Result codes: OK — for 0, 3, 4, or 5. ERROR — otherwise. Command options: AT&K0 = Disables flow control. AT&K3 = Enables RTS/CTS flow control. AT&K4 = Enables XON/XOFF flow control. AT&K5 = Enables transparent XON/XOFF flow control.
AT&Ln	**Line Type.** Controls selection of leased line or dial-up line. Although the modem has only a single line connection, the power level is changed when setting leased line operation. (See S91 register.) Parameters: n = 0, 1 Default: 0 Result codes: OK — for 0 and 1. ERROR — otherwise. Command options: AT&L0 = Dial-up line. AT&L1 = Leased line.
AT&Mn	**Communication Mode.** Same as AT&Q0-AT&Q3. Parameters: n = 0-3 Default: &Qn Result codes: OK — for 0-3. ERROR — otherwise.

Table 4-3. AT& Command Definitions (Cont'd)

Command	Description
AT&Pn	**Dial Pulse Ratio.** Selects the ratio of the off-hook (make) to on-hook (break) interval used when pulse dialing. Parameters: n = 0, 1, or 2 Default: 0 for U.S.; 2 for Japan (see 2.9) Result codes: OK — for n = 0-2 in U.S. or for n = 1-2 in Japan ERROR — otherwise. Command options: AT&P0 = 39%/61% make/break ratio @ 10 pps. AT&P1 = 33%/67% make/break ratio @ 10 pps. AT&P2 = 33%/67% make/break ratio @ 20 pps.
AT&Qn	**Communication Mode.** The modem supports three basic communication modes: asynchronous, synchronous, and error correction. Synchronous and Direct modes are not available when the parallel host interface is selected (see 2.9). Parameters: n = 0-6 Default: 5 Result codes: OK — for 0-6. ERROR — otherwise. Command options: AT&Q0 = **Selects asynchronous operation in the Direct mode.** In this mode, the DTE speed must match the telco line speed. AT&Q1 = **Selects synchronous mode 1 operation.** Supports terminals that are able to communicate in both asynchronous and synchronous protocols. Uses the dial command to place a call in asynchronous mode then switches to synchronous mode once the connection is made. The modem goes on-hook and switches back to the asynchronous mode when it detects an ON-to-OFF transition on $\overline{DTR}$ or a loss of carrier from the remote modem exceeding the time interval given by register S10 (default = 1.4 seconds). AT&Q2 = **Selects synchronous mode 2 operation.** Supports synchronous terminals with stored number dialing. The modem automatically dials a stored number when it detects an OFF-to-ON transition on $\overline{DTR}$. An asynchronous terminal is still needed to save or change the phone number stored in the NVRAM; the number is saved using the "AT&Z0=x" command. The modem dials the number stored in the first entry. The modem goes on-hook and switches back to the asynchronous mode when an ON-to-OFF transition on $\overline{DTR}$ is detected or a loss of carrier occurs from the remote modem exceeding the time interval given by register S10 (default = 1.4 seconds). AT&Q3 = **Selects synchronous mode 3 operation.** This mode allows $\overline{DTR}$ to act as a Talk/Data switch. The operator manually initiates a call with $\overline{DTR}$ OFF, implying the modem is in Talk mode. To complete the call, the operator switches the modem to Data mode by turning $\overline{DTR}$ ON after the last number is dialed. The modem goes on-hook and switches to the asynchronous mode when an ON-to-OFF transition on $\overline{DTR}$ is detected or a loss of carrier occurs from the remote modem exceeding the time interval given by register S10 (default = 1.4 seconds). AT&Q4 = This command causes the modem to issue OK result code but has no effect on operation. AT&Q5 = **Selects error correction mode.** Modem negotiates an error-correction link. The modem can be configured to either disconnect or fallback to a normal asynchronous connection if the link cannot be negotiated (refer to register S36). AT&Q5 and S36=0: same as AT\N2 (no fallback). AT&Q5 and S36=1: same as AT\N3 (fallback) (see AT\N command). AT&Q6 = **Selects asynchronous operation in Normal mode (Speed Buffering).** In this mode, the DTE speed can differ from the telco line speed.

Table 4-3. AT& Command Definitions (Cont'd)

Command	Description
AT&Rn	**RTS/CTS Option.** Controls the state of the $\overline{CTS}$ signal in the synchronous mode. $\overline{CTS}$ is always on in the asynchronous mode. Parameters: n = 0, 1 Default: 0 Result codes: OK — for 0 and 1. ERROR — otherwise. Command options: AT&R0 = $\overline{CTS}$ tracks $\overline{RTS}$. $\overline{CTS}$ is turned ON in response to an OFF-to-ON transition of $\overline{RTS}$ from the local DTE after a delay period specified by register S26 in increments of 10 milliseconds (default = 0). AT&R1 = The modem ignores $\overline{RTS}$; $\overline{CTS}$ is held ON.
AT&Sn	**DSR Option.** Determines whether $\overline{DSR}$ operates in accordance with EIA-232-D specification or remains ON. Parameters: n = 0, 1 Default: 0 Result codes: OK — for 0 and 1. ERROR — otherwise. Command options: AT&S0 = $\overline{DSR}$ is always ON. AT&S1 = $\overline{DSR}$ is turned ON at start of handshaking and OFF when in a test mode or idle state. $\overline{DSR}$ is turned OFF when carrier is lost.
AT&Tn	**Test And Diagnostic.** Selects the test command. Test commands must be initiated in the command mode with asynchronous operation in the Direct mode selected (AT&Q0) at a speed of 1200 bps or faster. A telco line connection must be established prior to initiating digital loopback tests. If these conditions are not met, the modem issues the ERROR result code and pulses the $\overline{TML}$ output to indicate an error. If local analog loopback is initiated while the modem is connected, the modem disconnects before performing the test. During a test, the modem sets the $\overline{TML}$ output low to turn the TEST indicator on. If an error is detected, or the line was not connected for remote digital loopback test, the $\overline{TML}$ output is pulsed to blink the TEST indicator. An initiated test is active for a period of time specified by register S18 (test timer) before returning to the command mode. If S18 is zero, the test aborts when the user issues the AT&T0 command. Parameters: 0, 1, or 3-8 Default: 4 Command options: AT&T0 = End test in progress. The escape sequence must be issued to return the modem to the command mode prior to sending this command. Subsequent issuing of the ATO command while in the command mode will cause the local and remote modems to return to normal data mode operation if the interrupted test was digital loopback. AT&T1 = Initiates local analog loopback. This test verifies the working condition of the path between the local DTE and the local modem. The characters received from the DTE are looped back to the DTE by the modem. AT&T3 = Initiates remote digital loopback locally. The characters received from the remote modem are looped back to the remote modem by the local modem. This test verifies the working condition of the path from a remote modem, through a local modem, and back to the remote modem. AT&T4 = Allows the modem to respond to a request from a remote modem for a remote digital loopback test. AT&T5 = Prohibits the modem from granting a request from a remote modem for a remote digital loopback test.

Table 4-3. AT& Command Definitions (Cont'd)

Command	Description
	AT&T6 = Initiates remote digital loopback. The characters received from the local DTE are transmitted to the remote modem and looped back from the remote modem to the local modem and DTE. This test verifies the working condition of the path between the local DTE and the remote modem. AT&T7 = Initiates remote digital loopback with self test. This test works similarly to AT&T6 except that the modem sends an alternating zeros and ones (0101) test pattern to the remote modem and continuously examines the validity of the returned data. The modem increments an internal error counter each time an error is detected. At the end of the test, the modem returns a 3-digit error count to the DTE. AT&T8 = Initiates local analog loopback with self test. This test works similarly to AT&T7 except that the test pattern is checked in the local analog loopback mode (as in AT&T1). This allows a thorough testing of the local modem transmit and receive functions without an actual telco line connection.

AT&V	**View Current Configuration and User Profiles.** Displays the active configuration and user profiles.
	Parameters: None
	Default: None
	Result codes:
	OK
	Example:
	`AT&V`
	
	`ACTIVE PROFILE:`
	`B1 E1 L2 M1 N1 P G0 V1 W0 X4 Y0 &C0 &D0 &G0 &J0 &K3 &Q5 &R0 &S0 &T4 &X0 &Y0`
	`S00:000 S01:000 S02:043 S03:013 S04:010 S05:008 S06:002 S07:030 S08:002 S09:006`
	`S10:014 S11:095 S12:050 S18:000 S25:005 S26:001 S36:005 S37:000 S38:020 S44:003`
	`S46:138 S48:007 S49:008 S50:255`
	
	`STORED PROFILE 0:`
	`B1 E1 L2 M1 N1 P G0 V1 W0 X4 Y0 &C0 &D0 &G0 &J0 &K3 &Q5 &R0 &S0 &T4 &X0`
	`S00:000 S02:043 S06:002 S07:030 S08:002 S09:006 S10:014 S11:095 S12:050 S18:000`
	`S25:005 S26:001 S36:005 S37:000 S38:020 S44:003 S46:138 S48:007 S49:008 S50:255`
	
	`STORED PROFILE 1:`
	`B1 E1 L2 M1 N1 P G0 V1 W0 X4 Y0 &C0 &D0 &G0 &J0 &K3 &Q5 &R0 &S0 &T4 &X0`
	`S00:000 S02:043 S06:002 S07:030 S08:002 S09:006 S10:014 S11:095 S12:050 S18:000`
	`S25:005 S26:001 S36:005 S37:000 S38:020 S44:003 S46:138 S48:007 S49:008 S50:255`
	
	`TELEPHONE NUMBERS:`
	`0 =  1=`
	`2 =  4=`
	
	`OK`

AT&Wn	**Store User Profile.** Saves the current configuration into NVRAM as one of two user profiles. The current configuration is comprised of a list of storable parameters illustrated in the AT&V command. These settings are restored to the active configuration upon receiving an ATZn command or at power up (see AT&Y command). The user profile saved is denoted by the parameter value. Parameters: n = 0, 1 Default: None Result codes: OK for 0 and 1. ERROR otherwise. Command options: AT&W0 = Save as user profile 0. AT&W1 = Save as user profile 1.

Table 4-3. AT& Command Definitions (Cont'd)

Command	Description
AT&Xn	**Clock Source Selection.** Selects the source of the synchronous transmit clock for the modem during synchronous operation. In asynchronous mode, the transmit and receive clocks are turned OFF. In synchronous mode, the clocks are turned ON with the frequency of 2400 Hz or 1200 Hz corresponding to the speed that is selected for modem operation. Parameters: n = 0-2 Default: 0 Result codes: OK — for 0 to 2. ERROR — otherwise. Command options: AT&X0 = **Internal timing.** The modem generates the transmit clock signal and applies it to the EIATXCLK output at the serial interface. AT&X1 = **External timing.** The local DTE sources the transmit clock signal on the SPXEXTCLK input of the serial interface. The modem applies this clock to the EIATXCLK output at the serial interface. AT&X2 = **Slave receive timing.** The modem derives the transmit clock signal from the incoming carrier and applies it to the EIATXCLK output at the serial interface.
AT&Yn	**Designate Default User Profile.** Designates which of two user profiles will be loaded into the active configuration at power up. The user profile is denoted by the parameter value. Parameters: 0, 1 Default: 0 Result codes: OK — for 0 and 1. ERROR — otherwise. Command options: AT&Y0 = Selects user profile 0. AT&Y1 = Selects user profile 1.
AT&Zn=x	**Store Phone Number.** Stores a 36-digit dial string(x) in the specified entry(n) for later dialing. (See ATDS=n command.) Parameters: n = 0-3, x = dial string Default: None Result codes: OK — for all parameters. ERROR — if storage number (n) is outside allowable range, the dial string (x) is longer than 36-digits, or if the total number of stored digits in all entries exceeds 114.

Table 4-4. AT\ Command Definitions

Command	Description
AT\An	**Maximum MNP Block Size.** Sets maximum block size for MNP stream link connections. Use this command to transmit smaller blocks of data in a reliable link connection. Parameters: n = 0-3 (If n is greater than 3, 3 is used.) Default: 2 Result codes: OK Command options: AT\A0 = Sets maximum block size to 64 characters. AT\A1 = Sets maximum block size to 128 characters. AT\A2 = Sets maximum block size to 192 characters. AT\A3 = Sets maximum block size to 256 characters.
AT\Bn	**Transmit Break.** When this command is entered during a non-MNP connection, the modem sends a break signal to the remote modem. The length of the break is 100 times the n parameter value in milliseconds. If this command is entered in MNP mode, the modem sends a Link Attention PDU to the remote modem. Parameters: n = 1-9 (If n = 0, the default value 3 is used; if n is greater than 9, 9 is used.) Default: 3 Result codes: OK if connected. NO CARRIER if not connected.
AT\Gn	**Modem to Modem Flow Control.** Enables or disables modem to modem flow control during a Normal mode connection. Since the reliable link (error correction) has its own method of flow control, the AT\Gn command is ignored when error correction is selected (AT&Q5). However, the DTE to modem flow control remains active during a reliable link. Parameters: n = 0, 1 (If n is greater than 1, 1 is used.) Default: 0 Result codes: OK Command options: AT\G0 = Disables flow control (XON/XOFF). AT\G1 = Enables flow control (XON/XOFF).
AT\Kn	**Break Control.** Determines what the modem will do when a BREAK is received from the DTE or the remote modem. During MNP mode, the remote modem's BREAK control setting determines how the local modem will handle the BREAK. Parameters: n = 0-5 (If n is greater than 5, 5 is used.) Default: 5 Result codes: OK Command options: When a BREAK is received from the DTE during Normal or MNP mode, the modem takes the following action: AT\K0,2,4 = Modem enters the command mode (waiting for AT) without sending a BREAK to the remote modem. AT\K1 = Modem clears the terminal and modem buffers and sends a BREAK to the remote modem. AT\K3 = Modem does not clear the buffers but sends a BREAK to the remote modem. AT\K5 = Modem sends a BREAK to the remote modem in sequence with any transmitted data.

Table 4-4. AT\ Command Definitions (Cont'd)

Command	Description
	When a BREAK is received from the remote modem during Normal mode, the modem takes the following action: AT\K0,1 = Modem clears the terminal and modem buffers and sends a BREAK to the local DTE. AT\K2,3 = Modem does not clear buffers but sends a BREAK to the local DTE. AT\K4,5 = Modem sends a BREAK in sequence with any data being buffered. When a BREAK is received from the DTE during Direct mode, the modem takes the following action: AT\K0,2,4 = Modem sends a BREAK to remote modem and enters command mode (waiting for AT). AT\K1,3,5 = Modem sends a BREAK to remote modem. **Note:** In LAPM, breaks are "timed", meaning the modem attempts to preserve the duration of the break when transmitting it to the remote modem. In MNP4, breaks are not "timed", as MNP4 has no facility for maintaining the duration of the signal; a long break is the same as a short break.
AT\Ln	**MNP Block Transfer Control.** Determines whether the modem will use Block or Stream mode for MNP link. Parameters: n = 0, 1 (If n is greater than 1, 1 is used.) Default: 0 Result codes: OK Command options: AT\L0 = Uses Stream mode for MNP link connections. AT\L1 = Uses Block mode for MNP link connections.
AT\Nn	**Operation Mode Control.** Selects the operating mode the modem uses while connected (see AT&Qn command). Parameters: n = 0-3 (If n is greater than 3, 3 is used.) Default: 3 Result codes: OK Command options: AT\N0 = **Selects Normal (speed buffering) mode.** This option takes effect at physical connection time. AT\N1 = **Selects Direct (pass through) mode.** This option takes effect at physical connection time. If the parallel interface is selected (see 2.9), the AT\N1 is interpreted as AT\N0 since Direct mode is not available with the parallel interface. AT\N2 = **Selects reliable link mode.** This defines the modem-to-modem connection to require error correction. If an attempt to establish the reliable link fails, the modem disconnects. This command takes effect at physical connection time only. To establish MNP after a physical connection, use the AT\O, AT\U, or AT\Y command. AT\N3 = **Selects auto-reliable link mode.** The modem will attempt an error-correction connection but will fallback to Normal mode if unable to establish an MNP link. This command takes effect at physical connection time only. To establish MNP after a physical connection, use the AT\O, AT\U, or AT\Y command.
AT\O	**Originate Reliable Link Control.** Forces the modem to originate an MNP connection regardless of whether the modem is in originate or answer mode. The modem will send up to two link requests. If the remote modem does not respond after the second request, the modem returns to its previous state. This command can be executed only if a physical connection exists, and will return the NO CARRIER message if there is no connection, or an appropriate connect message if a reliable link connection already exists. This command must be the last command on a command line. Parameters: None Default: None

Table 4-4. AT\ Command Definitions (Cont'd)

Command	Description
AT\Tn	**Inactivity Timer Control.** Determines the length in 1-minute intervals that the modem will wait before disconnecting when no data is sent or received. In MNP mode, any data transmitted or received by the modem will reset the timer. In non-MNP mode, any data transmitted will reset the timer. The inactivity timer is inoperative in synchronous mode and in direct mode. Parameters: n = 0-42 (If n is greater than 42, 42 is used.) Default: 0 Result codes: OK
AT\U	**Accept Reliable Mode Control.** Causes the modem to wait up to 12 seconds for a link request from the remote modem to establish an MNP link, regardless of whether the modem is in originate or answer mode. If the Link Request is not received within this time period, the modem returns to its previous state. This command can be executed only if a physical connection exists, and will return the NO CARRIER message if there is no connection, or an appropriate connect message if a reliable link connection already exists. This command must be the last command on a command line. Parameters: None Default: None
AT\Y	**Switch To Reliable Mode.** Causes the modem to try to establish a reliable link. Depending on whether the modem is in originate or answer mode, the modem either accepts a link request from the remote modem or sends a link request, respectively. If the MNP connection attempt fails, the modem returns to its previous state. This command can be executed only if a physical connection exists, and will return the NO CARRIER message if there is no connection, or an appropriate connect message if a reliable link connection already exists. This command must be the last command on a command line. Parameters: None Default: None
AT\Z	**Switch To Normal Mode.** Causes the modem to switch to normal mode after a reliable link is established. Switching to normal mode erases any data that may be in the terminal and modem buffers. This command can be executed only if an MNP connection exists, and will return the NO CARRIER message if there is no connection, or an appropriate connect message if a reliable link connection previously existed. This command must be the last command on a command line. Parameters: None Default: None

Table 4-5. AT% Command Definitions

Command	Description
AT%Cn	**Compression Control.** Determines whether or not the modem will use data compression. Parameters: 0, 1 (If n is greater than 1, 1 is used.) Default: 1 Result codes: OK Command options: AT%C0 = Disables data compression. AT%C1 = Enables data compression.
AT%Dn	**Set Dictionary Size (V.42 bis).** Sets the V.42 bis dictionary size. Parameters: 0-3 Default: 2 Result codes: OK Command options: AT%D0 = 512. AT%D1 = 1024. AT%D2 = 2048. AT%D3 = 4096 (one-way compression only).* * For two-way compression (AT%M3), the dictionary size is set for 2048 if AT%D3 is issued.
AT%En	**Enable/Disable Auto-Retrain.** Determines whether or not the modem automatically monitors the line quality and requests a retrain when necessary during a 9600, 4800, or 2400 bps connection. Parameters: n = 0, 1 (If n is greater than 1, 1 is used.) Default: 0 Result codes: OK Command options: AT%E0 = Disables auto-retrain. AT%E1 = Enables auto-retrain.
AT%L	**Report Received Signal Level.** Returns a value indentifying the received signal level. The possible values are: 009 = Received level of –9 dBm 010 = Received level of –10 dBm 011 = Received level of –11 dBm . . . 043 = Received level of –43 dBm If the received level is greater than –9 dBm, 009 will be reported. If the received level is less than –43 dBm, 043 will be reported. Parameters: None Default: None Result codes: OK

Table 4-5. AT% Command Definitions (Cont'd)

Command	Description
AT%Mn	**Set One/Two-Way Compression Mode (V.42 bis).** Selects the one/two-way compression mode when using V.42 bis compression. Parameters: 0-3 Default: 3 Command options: AT%M0 = Compression disabled AT%M1 = Transmit compression only AT%M2 = Receive compression only AT%M3 = Two-way compression
AT%P	**Clear V.42 bis Encoder Dictionary.** Resets the local modem V.42 bis encoder dictionary and sends a command code to the remote modem to reset the remote V.42 bis dictionary. Parameters: None Default: None Result codes: OK if encoder dictionary is in use ERROR if encoder dictionary is not in use
AT%Q	**Report Line Signal Quality.** Returns the high-order byte of the calculated Eye Quality Monitor (EQM) value. The high-order byte can range from 0 to 255. However, when the value is 8 or greater, the modem will automatically retrain if enabled by the AT%E1 command. The value for a normal connection ranges from about 0 to 2 and approaches 8 for a progressively poorer connection. Parameters: None Default: None Result codes: OK
AT%Sn	**Set Maximum String Length (V.42 bis).** Sets the maximum number of characters that can be compressed onto one word. Parameters: 6-250 Default: 32 characters

5 S REGISTERS

The S registers are summarized in Table 5-1 along with their default values. Registers denoted with an '*' in Table 5-1 may be stored in one of the two user profiles by entering the AT&Wn command. One of these profiles may be loaded at any time by using the ATZn command. The S registers are described in detail in Table 5-2.

5.1 FACTORY DEFAULTS

The factory default values are stored in ROM and are loaded into the active configuration at power up or by the ATZn command. In addition, the designated default profile is subsequently loaded, and may change some of the factory default values. The designated default profile can be changed by entering the AT&Yn command where n is one of the two possible user profiles.

All of the factory default values may be loaded at any time by entering the AT&F command.

Table 5-1. S Register Summary

Register	Title	Default	
S0	Number of Rings till Auto-Answer	0	*
S1	Ring Counter	0	
S2	Escape Character	43	
S3	Carriage Return Character	13	
S4	Line Feed Character	10	
S5	Back Space Character	8	
S6	Wait For Blind Dialing	2	*
S7	Wait For Carrier After Dial	50	*
S8	Pause Time For Dial Delay	2	*
S9	Carrier Detect Response Time	6	*
S10	Lost Carrier To Hang Up Delay	14	*
S11	DTMF Tone Duration	95	*
S12	Escape Code Guard Time	50	*
S13	Reserved	none	
S14	Bit Mapped Options	none	*
S15	Reserved	none	
S16	Bit Mapped Test Options	none	
S17	Reserved	none	
S18	Test Timer	0	*
S19	Reserved	0	
S20	Reserved	none	
S21	Bit Mapped Options	none	*
S22	Bit Mapped Options	none	*
S23	Bit Mapped Options	none	*
S24	Reserved	none	
S25	Delay To DTR	5	*
S26	RTS To CTS Delay Interval	1	*
S27	Bit Mapped Options	none	*
S28 - S29	Reserved	none	
S30	Inactivity Timer	0	*
S31 - S35	Reserved	none	
S36	Negotiation Failure Treatment	7	*
S37	Desired Telco Line Speed	0	*
S38	Delay Before Forced Disconnect	20	*
S39	Reserved	none	*
S40	Bit Mapped Options (MNP)	77	
S41	Bit Mapped Options (MNP)	1	
S44	Unused	3	*
S46	Protocol Selection	none	*
S48	V.42 Negotiation Action	7	*
S49	Speed Buffer Lower Limit	8	**
S50	Speed Buffer Upper Limit	255	**
S82	Break Handling	128	*
S86	Connection Failure Cause Code	none	*
S91	Programmable Transmit Level	0 (US) 15 (Japan)	*
S95	Extended Result Codes	0	*

* Register value may be stored in one of two user profiles with the AT&Wn command.

** Not used.

Table 5-2. S Register Definitions

Register	Description
S0	**Number of Rings till Auto-Answer.** Establishes the number of the rings required before the modem answers the incoming calls. Setting this register to zero disables auto-answer mode. Range: 0-255 rings Default: 0
S1	**Ring Counter.** Number of the rings which the modem detects before it answers a call. If no rings occur over an eight second interval, this register is cleared. Range: 0-255 rings Default: 0
S2	**Escape Character.** S2 holds the decimal value of the ASCII character used for the escape character. The default value corresponds to an ASCII '+'. A value over 127 disables the escape process, i.e., no escape character will be recognized. Range: 0-255, ASCII decimal Default: 43
S3	**Carriage Return Character.** Sets the command line and result code terminator character. Pertains to asynchronous operation only. Range: 0-127, ASCII decimal Default: 13 (Carriage Return)
S4	**Line Feed Character.** Sets the character recognized as a line feed. Pertains to asynchronous operation only. The Line Feed control character is output after the Carriage Return control character if verbose result codes are used. Range: 0-127, ASCII decimal Default: 10 (Line Feed)
S5	**Backspace Character.** Sets the character recognized as a backspace. Pertains to asynchronous operation only. The modem will not recognize the Backspace character if it is set to a value that is greater than 32 ASCII. This character can be used to edit a command line. When the echo command is enabled, the modem echoes back to the local DTE the Backspace character, an ASCII space character and a second Backspace character; this means a total of three characters are transmitted each time the modem processes the Backspace character. Range: 0-32, ASCII decimal Default: 8 (Backspace)
S6	**Wait Time for Blind Dialing.** Sets the length of time to pause after the modem goes off-hook and before the modem dials the first digit of the telephone number. The modem always pauses for a minimum of 2 seconds even if the S6 register is set to a value less than 2 seconds. The "Wait for Dial Tone" call progress feature (W in the dial string) will override the value in register S6. If option ATX2 or ATX4 is in effect, this register is ignored. Range: 2-255 seconds Default: 2
S7	**Wait For Carrier After Dial.** Defines two delay times: 1. During call establishment, this register establishes the time that the local modem waits for carrier from the remote modem before hanging up. 2. Sets the length of time that the modem waits when the "Wait For Dial Tone" call progress feature (W in the dial string) is in effect. Range: 1-255 seconds Default: 50

Table 5-2. S Register Definitions (Cont'd)

Register	Description
S8	**Pause Time For Dial Delay.** Sets the length of time to pause when the modem encounters the "Pause During Dial" call progress feature , i.e., the comma (,). Range: 0-255 seconds Default: 2
S9	**Carrier Detect Response Time.** Determines how long a carrier signal must be present before the modem recognizes it as a carrier and turns on $\overline{\text{RLSD}}$. As this time is increased, there is less chance to detect a false carrier due to noise from the telco line. Range: 1-255 tenths of a second Default: 6 (0.6 second)
S10	**Lost Carrier To Hang Up Delay.** Sets the length of time the modem waits before hanging up after a loss of carrier. This allows for a temporary carrier loss without causing the local modem to disconnect. When register S10 is set to 255, the modem functions as if a carrier is always present. The actual interval the modem waits before disconnecting is the value in register S10 minus the value in register S9. Therefore, the S10 value must be greater than the S9 value or else the modem disconnects before it recognizes the carrier. Range: 1-255 tenths of a second Default: 14 (1.4 seconds)
S11	**DTMF Tone Duration.** Sets the duration of tones in Dual Tone Multifrequency (DTMF) dialing. This value has no effect on pulse dialing. Range: 50-255 milliseconds Default: 95 milliseconds
S12	**Escape Code Guard Time.** Sets the time delay required immediately before and after entering the escape code. The time interval between the sending of the first and second, or the second and the third escape code character must be less than the value of the guard time. Range: 0-255 fiftieths of a second Default: 50 (1 second)
S13	**Reserved.**
S14	**Bit Mapped Options.** Indicates the status of command options. Bit 0 = AFT 0 -- Disabled 1 -- Enabled Bit 1 = ATE 0 -- Disabled 1 -- Enabled Bit 2 = ATQ 0 -- Disabled 1 -- Enabled Bit 3 = ATV 0 -- Numeric 1 -- Verbose Bit 4 = reserved Bit 5 = ATP or ATT 0 – ATT 1 – ATP Bit 6 = Part of ATQ 0 – ATQ0,1 1 – ATQ2 Bit 7 = Originate / Answer 0 -- Answer 1 -- Originate

Table 5-2. S Register Definitions (Cont'd)

Register	Description
S15	**Reserved.**
S16	**Bit Mapped Test Options.** Indicates the test in progress. The $\overline{\text{TSTIND}}$ output is turned ON when S16 is non-zero to indicate that a test is in progress. The AT&T0 command terminates any test and sets S16 to zero. **Note:** If the Modem Ready LED function is selected in the CONFIGURATION byte (see 2.9), the Modem Ready indication ($\overline{\text{TSTIND}}$) will be turned off during test modes. Default: 0 Bit 0 = Local analog loopback (AT&T1) 0 -- Disabled (default) 1 -- Enabled Bit 1 = Not used Bit 2 = Local digital loopback (AT&T3) 0 -- Disabled (default) 1 -- Enabled Bit 3 = Remote digital loopback status (AT&T4 and T5) 0 -- Loopback off 1 -- Loop-back in progress Bit 4 = Remote digital loopback (AT&T6) 0 -- Disabled (default) 1 -- Enabled Bit 5 = Remote digital loopback with self test (AT&T7) 0 -- Disabled (default) 1 -- Enabled Bit 6 = Local analog loopback with self test (AT&T8) 0 -- Disabled (default) 1 -- Enabled Bit 7 = Not used
S17	**Reserved.**
S18	**Test Timer.** Sets the length of time the modem conducts a test before returning to the command mode. If this register is zero, the test will not automatically terminate; the test must be terminated from the command mode by issuing an AT&T0 or ATH command. Range: 0-255 seconds Default: 0
S19	**Reserved.**
S20	**Reserved.**

Table 5-2. S Register Definitions (Cont'd)

Register	Description
S21	**Bit Mapped Options.** Indicates the status of command options. Bit 0 0 = AT&J0 1 = AT&J1 Bit 1 0 = AT&Y0 1 = AT&Y1 Bit 2 0 = AT&R0 1 = AT&R1 Bit 3,4 0 = AT&D0 1 = AT&D1 2 = AT&D2 3 = AT&D3 Bit 5 0 = AT&C0 1 = AT&C1 Bit 6 0 = AT&S0 1 = AT&S1 Bit 7 0 = ATY0 1 = ATY1
S22	**Bit Mapped Options.** Indicates the status of command options. Bit 0,1 0 = ATL0 1 = ATL1 2 = ATL2 3 = ATL3 Bit 2,3 0 = ATM0 1 = ATM1 2 = ATM2 3 = ATM3 Bit 4,5,6 0 = ATX0 1 = ATX1 2 = ATX2 3 = ATX3 4 = ATX4 5 = Invalid code 6 = Invalid code 7 = Invalid code Bit 7 0 = AT&P0 1 = AT&P1

Table 5-2. S Register Definitions (Cont'd)

Register	Description
S23	**Bit Mapped Options.** Indicates the status of command options. Bit 0 0 = AT&T5 1 = AT&T4 Bit 1,2,3 - Local DTE Rate 0 = 0 - 300 bps 1 = 600 bps 2 = 1200 bps 3 = 2400 bps 4 = 4800 bps 5 = 9600 bps 6 = 19200 bps 7 = 38400 bps Bit 4,5 Parity Option 0 = even 1 = not used 2 = odd 3 = none Bit 6,7 0 = AT&G0 1 = AT&G1 2 = AT&G2
S24	**Reserved.**
S25	**Delay To DTR.** Register S25 serves two purposes. When the modem is operating in synchronous mode 1, the value assigned to S25 specifies the length of time the modem waits after a connection has been made before examining $\overline{DTR}$. This allows the modem to ignore an ON-to-OFF transition of $\overline{DTR}$ giving the user sufficient time to disconnect the modem from the asynchronous terminal and attach it to a synchronous terminal, without forcing the modem back to the asynchronous command mode. During this time, the value for S25 is read in seconds (e.g., the factory-set value of 5 equals 5 seconds, instead of 0.05 seconds). In all other modes, and after call establishment in synchronous modes 1 and 4, the value is read in 1/100 seconds. In any mode, a change in $\overline{DTR}$ (ON or OFF) that persists for a period shorter than the value held in S25 is ignored by the modem while it is in data mode. Range: 0-255 (0.01 second if mode 1 or 4 when in data mode, 1 second otherwise) Default: 5
S26	**RTS To CTS Delay Interval.** Pertains to synchronous operation only. When $\overline{CTS}$ tracks $\overline{RTS}$ (AT&R0) and the modem detects an ON-to-OFF transition on $\overline{RTS}$, this register sets the time delay before the modem turns $\overline{CTS}$ ON. Range: 0-255 hundredths of a second Default: 1

Table 5-2. S Register Definitions (Cont'd)

Register	Description
S27	**Bit Mapped Option.** Indicates the status of command options. Bit 0,1,3 0 = AT&Q0 1 = AT&Q1 2 = AT&Q2 3 = AT&Q3 4 = AT&Q4 5 = AT&Q5 6 = AT&Q6 7 = AT&Q7 Bit 2 0 = AT&L0 1 = AT&L1 Bit 4,5 0 = AT&X0 1 = AT&X1 2 = AT&X2 Bit 6 0 = ATB0 1 = ATB1 Bit 7 - Reserved
S28 - S29	**Reserved.**
S30	**Inactivity Timer.** Determines the length of time, in tenth of a second intervals, that the modem will wait before disconnecting when no data is sent or received. In MNP or V.42 mode, any data transmitted or received will reset the timer. In other modes, any data transmitted will reset the timer. The inactivity timer is inoperative in synchronous mode. Range: 0-255 Default: 0 (disabled)
S31 - S35	**Reserved.**
S36	**Negotiation Failure Treatment.** This register is read when the S48 register contains the value 128 or if an attempted error correction link fails. These fallback options are initiated immediately upon connection if S48=128. Range: 0-7 If an invalid number is entered, the number is accepted into the register, but S36 will act as if the default value is entered. Default: 5 The S36 actions are: S36=0 Modem disconnects. S36=1 Modem stays on-line and a Direct mode connection is established. S36=2 Reserved. S36=3 Modem stays on-line and a Normal mode connection is established. S36=4 An MNP connection is attempted and if it fails, the modem disconnects. S36=5 An MNP connection is attempted and if it fails, a Direct mode connection is established. S36=6 Reserved. S36=7 An MNP connection is attempted and if it fails, a Normal mode connection is established.

Table 5-2. S Register Definitions (Cont'd)

Register	Description
S37	**Desired Telco Line Speed.** Range: 0-7 If an invalid number is entered, the number is accepted into the register, but S37 will act as if the default value is entered. Default: 0 S37=0 Attempt to connect at speed of last AT command issued. For DTE speeds greater than 9600 bps, the modem will attempt to connect at 9600 bps. S37=1-3 Attempt to connect at 300 bps S37=4 Reserved. S37=5 Attempt to connect at 1200 bps S37=6 Attempt to connect at 2400 bps S37=7 Reserved S37=8 Attempt to connect at 4800 bps S37=9 Attempt to connect at 9600 bps
S38	**Delay Before Forced Disconnect (Error correction mode only).** This register specifies the delay between the modem's receipt of the ATH command to disconnect (or ON-to-OFF transition of DTR if the modem is programmed to follow the signal) and the disconnect operation. For an error-correction connection, this register can be used to ensure that data in the modem buffer is sent before the modem disconnects. If S38 is set between 0 and 254, the modem will wait that number of seconds for the remote modem to acknowledge all data in the modem buffer before disconnecting. If time expires before all data is sent, the NO CARRIER result code will be issued to indicate that data has been lost. If all data is transmitted prior to time-out, the response to the ATH0 command will be OK. If S38 is set to 255, the modem does not time-out, and continues to attempt to deliver data in the buffer until the connection is lost, or the data is delivered. Range: 0-255 seconds Default: 20
S39	**Reserved.**
S40	**Bit Mapped Options (MNP).** Indicates the status of command options. Range: None Default: 0111 0111 Bit 0,1 = AT\N3 Bit 2,3,4 = AT\K5 Bit 5,6 =AT\A3 Bit 7 = AT\G0
S41	**Bit mapped options (MNP).** Indicates the status of command options. Range: None Default: 0000 0001 Bit 0 = AT%C1 Bit 1 = AT%E0 Bit 2 = AT\L0 Bit 3, 4, 5, 6, 7 = Not used
S46	**Protocol Selection.** Controls selection of compression. The following actions are executed for the given values: S46=136 Execute error correction protocol with no compression. S46=138 Execute error correction protocol with compression. In addition to V.42 bis, the modem also implements MNP 5 data compression. V.42 bis is used only with LAPM, and MNP 5 only with MNP 4.

Table 5-2. S Register Definitions (Cont'd)

Register	Description
S48	**V.42 Negotiation Action.** The V.42 negotiation process determines the capabilities of the remote modem. However, when the capabilities of the remote modem are known and negotiation is unnecessary, this process can be bypassed if desired. Range: 0, 7, or 128 — If an invalid number is entered, it is accepted into the S register, but S48 will act as if 128 is entered. Default: 7 S48=0 Disable negotiation; bypass the detection and negotiation phases; and proceed with LAPM. S48=7 Enable negotiation. S48=128 Disable negotiation; bypass the detection and negotiation phases; and proceed at once with the fallback action specified in S36. Can be used to force MNP.
S82	**Break Handling Options.** Break signals provide a way for the user to get the attention of the remote modem. The break type depends on the specific application. LAPM specifies three methods of break signal handling: in sequence, expedited, and destructive. Range: 3, 7, or 128 — If an invalid number is entered, it is accepted into the S register, but S82 will act as if the default value is entered. Default: 128 S82=3 Expedited: Modem sends a break immediately; data integrity is maintained both ahead of and after the break. S82=7 Destructive: Modem sends a break immediately; data being processed by each modem at the time of the break is destroyed. S82=128 In sequence: Modem sends a break in sequence with any transmitted data; data integrity is maintained both ahead of and after the break.(factory default).
S86	**Connection Failure Cause Code.** When the modem issues a NO CARRIER result code, a value is written to this S register to help determine the reason for the failed connection. S86 records the first event that contributes to a NO CARRIER message. The cause codes are: S86=0 Normal disconnect, no error occurred. S86=4 Loss of carrier. S86=5 V.42 negotiation failed to detect an error-correction modem at the other end. S86=9 The modems could not find a common protocol. S86=12 Normal disconnect initiated by the remote modem. S86=13 Remote modem does not respond after 10 re-transmissions of the same message. S86=14 Protocol violation.
S91	**Programmable Transmit Levels.** The transmit level is adjustable in S91 from –0 dBm (U.S. default value) to –15 dBm (Japan default value) in 1 dB increments for data transmission in both synchronous and asynchronous operation. This S register takes effect when the Japanese parameters are enabled (see 2.9) or a leased line is selected. S91 = 0 0 dBm (default value for U. S.) S91 = 1 –1 dBm S91 = 2 –2 dBm . . . S91 = 14 –14 dBm S91 = 15 –15 dBm (default value for Japan) The transmit level may not be changed once a connection exists.

Table 5-2. S Register Definitions (Cont'd)

Register	Description
S95	**Extended Result Codes.** The bits in this register can be set to override some of the ATWn command options. A bit set to a 1 in this register will enable the corresponding result code regardless of the ATWn setting. Bit 0 = CONNECT result code indicates DCE speed instead of DTE speed. Bit 1 = Append /ARQ to verbose CONNECT XXXX result code if protocol is **not** NONE. Bit 2 = Enable CARRIER XXXX result code. Bit 3 = Enable PROTOCOL XXXX result code. Bit 4 = Reserved. Bit 5 = Enable COMPRESSION result code. Bit 6 = Reserved. Bit 7 = Reserved.

6. DESIGN CONSIDERATIONS

6.1 PC BOARD LAYOUT GUIDELINES

6.1.1 Host Module Design Guidelines

1. Locate the MCU, MPCC, RC9696/12 module and all supporting analog circuitry, including the Data Access Arrangement (DAA), on the same area of the printed circuit board (PCB).
2. Route all digital ground pins separately from analog ground pins.
3. Supply an analog ground plane beneath all analog components. Tie analog ground pins together to analog ground directly under the device.
4. Supply a digital ground plane to cover the remaining allocated area. Connect the digital ground plane to the DGND pins and to all digital ground points.
5. Maximize the areas of the analog ground plane area under and in close proximity to devices handling analog signals.
6. As a general rule, route digital signals on the component side of the PCB and analog signals on the solder side. Reverse the sides to match particular OEM requirements.
7. Route the modem signals to provide maximum isolation between noise sources and noise sensitive inputs. When layout requirements necessitate routing these signals together, separate them by neutral signals.
8. Supply all power and ground traces of at least 0.1 inch width.
9. Keep all traces and component leads connected to XTLI and XTLO short in order to reduce induced noise levels and to minimize any stray capacitance that could affect the crystal oscillator. Ground all crystal cans.
10. Tie DGND pins to digital ground either under or very near the Microcontroller.
11. Keep any traces carrying high frequency signals as short as possible.
12. Decouple Vcc to ground with decoupling capacitors (0.1 uF and 0.01 uF) as close to the device as possible.
13. Decouple the power cord at the power cord interface with decoupling capacitors.
14. Locate high frequency circuits in a separate area to minimize capacitive coupling to other circuits.
15. Locate cables and connectors to avoid coupling from high frequency circuits.
16. Lay out the highest frequency signals traces next to the ground plane.
17. A 4-layer host PCB is recommended to improve performance and minimize noise.

6.1.2 RC9696/12 Placement Guidelines

1. The area not covered the analog ground plane (shown in Figure 6-1) contains components which are sensitive to electromagnetic interference (EMI). Do not position this portion of the module near radiating circuitry on an adjacent modeule.
2. Position the RC9696/12 module on the host module so that the host module analog and digital ground planes are adjacent to RC9696/12 analog and digital circuitry, respectively.

6.2 CRYSTAL SPECIFICATIONS

The specifications for the MCU and MPCC crystals are listed in Tables 6-1 and 6-2, respectively.

6.3 COMPONENT SUPPLIERS

Recommended suppliers for some components are listed in Table 6-3.

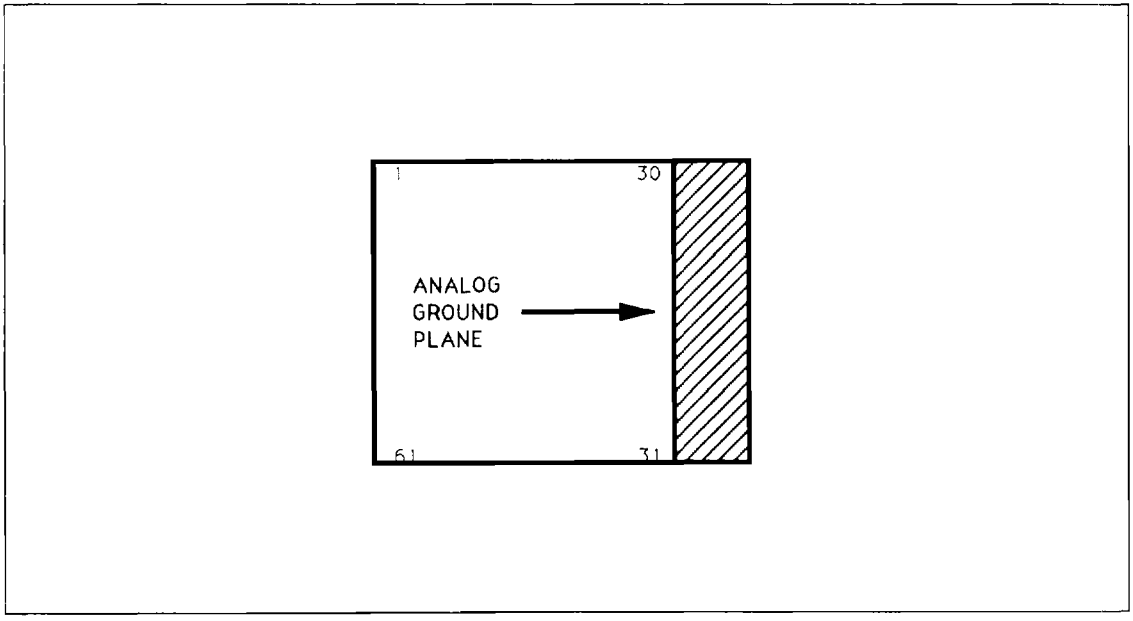


Figure 6-1. RC9696/12 Analog Ground Plane Location

Table 6-1. MCU Crystal Specifications

Parameter	Value
Operating Temperature	0°C to 70°C
Storage Temperature	–55°C to 85°C
Nominal Frequency @ 25°C	16.0000 MHz
Frequency Tolerance @ 25°C	±0.005% (±50 PPM)
Temperature Stability	±0.010% (±100 PPM)
Calibration Mode	Parallel resonant
Shunt Capacitance	7 pF max.
Load Capacitance	18 ±0.3 pF
Drive Level	2.5 mW max.
Aging, per Year Max.	0.0005% (± 5 PPM)
Oscillation Mode	Fundamental
Series Resistance tested at 20 nW	25 ohms max.
Max. Frequency Variation with 16.5 or 19.5 pF Load Capacitance	±0.0035% (±35 PPM)

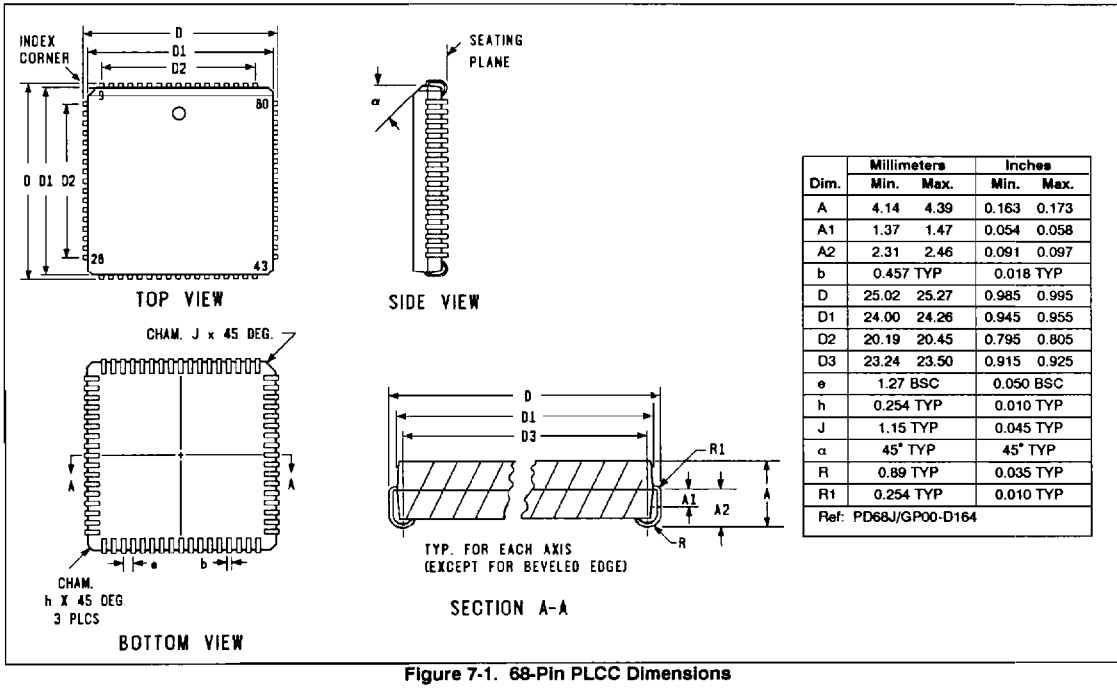
Table 6-2. MPCC Crystal Specifications

Parameter	Value
Operating Temperature	0°C to 70°C
Storage Temperature	–55°C to 85°C
Nominal Frequency @ 25°C	8.064000 MHz
Frequency Tolerance @ 25°C	±0.0015% (±15 PPM)
Temperature Stability	±0.0030% (±30 PPM)
Calibration Mode	Parallel resonant
Shunt Capacitance	7 pF max.
Load Capacitance	18 ±0.3 pF
Drive Level	2.5 mW max.
Aging, per Year Max.	0.0005% (± 5 PPM)
Oscillation Mode	Fundamental
Series Resistance tested at 20 nW	70 ohms max.
Max. Frequency Variation with 16.5 or 19.5 pF Load Capacitance	±0.0035% (±35 PPM)

Table 6-3. Recommended Component Suppliers

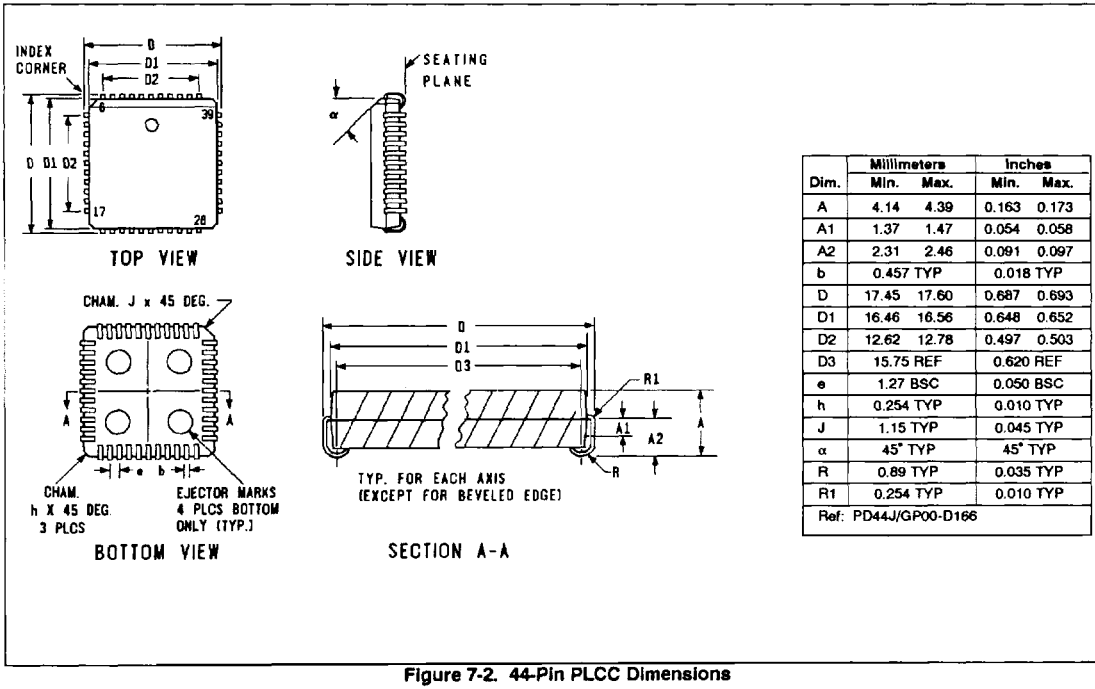
Part	Manufacturer	Model No.	Location
Crystal, 16.000000 MHz	M-Tron Ind., Inc	MP1-16MHz	Yankton, SD
Crystal, 8.0640 MHz	M-Tron Ind., Inc.	333R14-013	Yankton, SD
	Daiwa Shinku Corp.	333R14-013	Kakogawa, JApan
	Fox Electronics	333R14-013	Fort Myers, FL
Transformer	Midcom, Inc.	671-1538	Watertown, SD
Reed Relay, SPDT, 2 Form	Aromat Corporation	DS2E-S-DC5	Garden Grove, CA
	Communication Inst., Inc.	MDS05-01	Fairview, NC
Reed Relay, SPST, N.O.	Aleph International	SD1A05CWJ	San Fernando, CA
	Hamlin	HE3351A5989	Lake Mills, MA
Isolator, Photon coupled	Motorola Semiconductor Products	4N35	Phoenix, AZ
	General Electric	4N35	Syracuse, NY
	Siemens Comp., Inc., Opto Div.	4N35	Cupertino, CA
Varister, Surge Suppressor	Harris (GE)	V150LT10A	Somerville, NJ
	Panasonic	ERZTC147VK241U	Secaucus, NJ
	Philips (Mepco)	23220595-31516	Anaheim, CA
Transistor, 2N2102 npn	Motorola Semiconductor Products	2N2102	Austin, TX
	SGS-Thomson Microelect.	2N2102	Santa Clara, CA
Transistor, FET, P-channel	National Semiconductor	J177	Santa Clara, CA
	Siliconix, Inc.	J177	Santa Clara, CA
Switch, 4PDT, 8 Position, P-channel	Electronic Comp. Group	LTPB 4UEE C-TAC/RED	Minneapolis, MN

7. PACKAGE DIMENSIONS



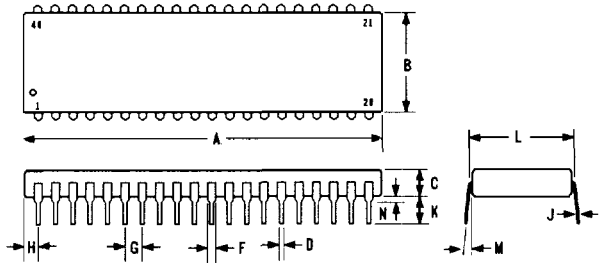
Dim.	Millimeters Min.	Millimeters Max.	Inches Min.	Inches Max.
A	4.14	4.39	0.163	0.173
A1	1.37	1.47	0.054	0.058
A2	2.31	2.46	0.091	0.097
b	0.457 TYP		0.018 TYP	
D	25.02	25.27	0.985	0.995
D1	24.00	24.26	0.945	0.955
D2	20.19	20.45	0.795	0.805
D3	23.24	23.50	0.915	0.925
e	1.27 BSC		0.050 BSC	
h	0.254 TYP		0.010 TYP	
J	1.15 TYP		0.045 TYP	
α	45° TYP		45° TYP	
R	0.89 TYP		0.035 TYP	
R1	0.254 TYP		0.010 TYP	
Ref: PD68J/GP00-D164				

Figure 7-1. 68-Pin PLCC Dimensions



Dim.	Millimeters Min.	Max.	Inches Min.	Max.
A	4.14	4.39	0.163	0.173
A1	1.37	1.47	0.054	0.058
A2	2.31	2.46	0.091	0.097
b	0.457 TYP		0.018 TYP	
D	17.45	17.60	0.687	0.693
D1	16.46	16.56	0.648	0.652
D2	12.62	12.78	0.497	0.503
D3	15.75 REF		0.620 REF	
e	1.27 BSC		0.050 BSC	
h	0.254 TYP		0.010 TYP	
J	1.15 TYP		0.045 TYP	
α	45° TYP		45° TYP	
R	0.89 TYP		0.035 TYP	
R1	0.254 TYP		0.010 TYP	
Ref: PD44J/GP00-D166				

Figure 7-2. 44-Pin PLCC Dimensions



Dim.	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	51.82	52.32	2.040	2.060
B	13.46	13.97	0.530	0.550
C	3.56	5.08	0.140	0.200
D	0.38	0.53	0.015	0.021
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.65	2.16	0.065	0.085
J	0.20	0.30	0.008	0.012
K	3.05	3.56	0.120	0.140
L	15.24 BSC		0.600 BSC	
M	7°	10°	7°	10°
N	0.51	1.02	0.020	0.040
Ref: PD40P/GP00-D135				

Figure 7-3. 40-Pin Plastic DIP Dimensions

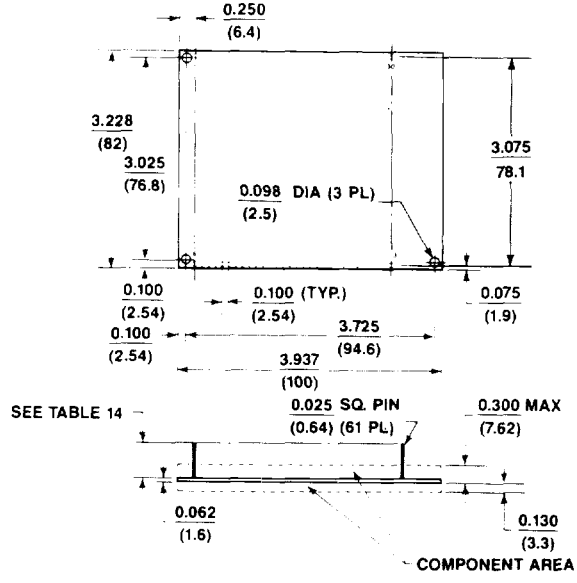


Figure 7-4. RC9696/12 MDP Dimensions