



Features

- Easy Integration
- Small Footprint 1.00" x 2.50"
- Full Duplex 2400bps
- Low Power Consumption
- V.24 DTE Interface
- Single +5V Supply Operation
- Supported Protocols: V.22bis, V.23, V.22
- UL Recognized Component
- FCC Part 15B Compliant
- FCC Part 68 Approved (User Transferrable)

Applications

- Vending/Gaming Machines
- Set Top Box Back Channel
- Direct Broadcast Satellite
- Utility Meters
- Point of Sale Terminals
- Remote Diagnostics
- Remote Telemetry
- Remote Monitoring
- Embedded Applications

Description

The CPC2400E is a 2400 baud embedded modem module intended for applications that require a data communications link to the Public Switched Telephone Network (PSTN). The CPC2400E is a complete module on a small 1.0" x 2.5" printed circuit board that can be socketed or soldered into the host system mother board. The module is FCC Part 68 approved and includes a user transferrable registration number. It also is a UL recognized component. The CPC2400E can be used in a variety of applications including set top box back channel communications, vending machines, remote utility metering, remote data acquisition, plus a host of other applications. The CPC2400E supports a standard serial V.24 TTL interface to the DTE equipment.

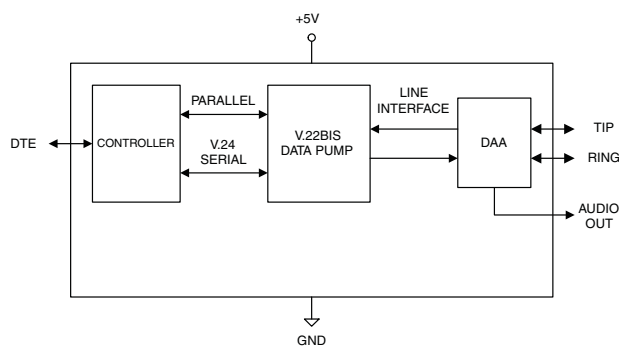
Approvals

- UL/C-UL: 174201
- FCC Reg. # LVRPHL-25931-MD-E

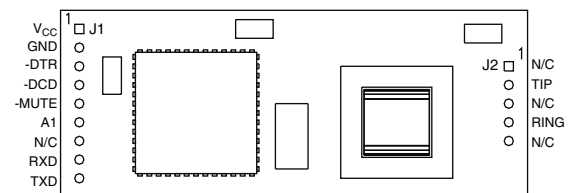
Ordering Information

Part #	Description
CPC2400E	2400 Baud Embedded Modem Module

Block Diagram



Pin Configuration



Absolute Maximum Ratings @ 25°C

Parameter	Min	Max	Units
Dielectric Withstanding Voltage	-	1000	V_{rms}
Tip/Ring Current (Continuous)	20	120	mA
Operating Temperature	0	70	°C
Storage Temperature	0	100	°C
Relative Humidity (Non-Condensing)	10	85	%

¹ Derate linearly 3.33 mW / °C

Absolute Maximum Ratings are stress ratings. Stresses in excess of these ratings can cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this data sheet is not implied. Exposure of the device to the absolute maximum ratings for an extended period may degrade the device and effect its reliability.

Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Units
DC Electrical Characteristics @ 25°C					
V_{CC} Supply Voltage	-	4.75	5	5.25	V
V_{CC} Supply Current - Idle (Sleep Mode)	$V_{CC}=5V$	-	5	10	mA
V_{CC} Supply Current - Active	$V_{CC}=5V$	-	70	100	mA
Line Matching Impedance	$V_{CC}=5V$	-	600	-	Ω
Ringing Voltage	$V_{CC}=5V, f=20Hz$	-	22	30	V_{rms}
Ringer Equivalence Number (REN)	$V_{CC}=5V$	-	0.6B	-	-
Telephone Line Loop Current	$V_{CC}=5V$	20	-	120	mA
DTE DC Characteristics @ 25°C					
Input High Voltage V_{IH}	-	2	-	$V_{CC}+0.3$	V
Input Low Voltage V_{IL}	-	0	-	0.8	V
Input Leakage Current I_L	$GND < V_O < V_{CC}$	-10	-	10	μA
Output High Voltage V_{OH}	$I_{OH}=-2mA, V_{CC}=5V$	4	-	-	V
Output Low Voltage V_{OL}	$I_{OH}=+2mA, V_{CC}=5V$	0	-	0.4	V
Input High Voltage V_{IH}	$V_{CC}=5.5V$	0.7	2.6	$V_{CC}+0.3$	V
Input Low Voltage V_{IL}	$V_{CC}=5.5V$	$GND-0.3$	1.6	$0.2V_{CC}$	V

Definitions

Pin	I/O	Name	Function
J1-1	I	V _{CC}	Connects to external host power source of +5V +/-5%
J1-2	I	GND	Power supply return
J1-3	I	-DTR	Data Terminal Ready. An active Low input on this pin indicates that the host system is ready to communicate with the modem.
J1-4	O	-DCD	Data Carrier Detect. When active, indicates carrier signal has been detected. For options see AT Command reference section under &C command.
J1-5	O	-MUTE	Mutes external speaker. Uses AT "M" command.
J1-6	O	A1	Analog output that can be used to monitor modem activity via an external audio amplifier.
J1-7	-	N/C	No Connection
J1-8	I	RXD	Serial data input from host DTE
J1-9	O	TXD	Serial data output to host DTE

Pin	I/O	Name	Function
J2-1	-	NC	No Connection
J2-2	I/O	TIP	Tip connection to telephone line
J2-3	-	N/C	No Connection
J2-4	I/O	RING	Ring connection to telephone line
J2-5	-	NC	No Connection

*The Performance data shown in the graphs above is typical of device performance. For guaranteed parameters not indicated in the written specifications, please contact our application department.

Functional Description

The CPC2400E is a small, full featured, 2400 baud module intended for embedded applications and is fully FCC Part 68 approved. The CPC2400E includes a user transferable FCC registration number which the end product must display (see section for more details). The module consists of a Data Access Arrangement (DAA), V.22bis data pump, and a microcontroller on a 1.00" x 2.50" PCB.

The CPC2400E connects to the telephone lines TIP and RING leads and must be made through an approved RJ-11 jack. The CPC2400E supports the industry standard AT command set (see AT Command set section for further details).

The CPC2400E operates off a single +5V supply and supports low power modes of operation. When the device is not in use, it automatically enters sleep mode, reducing supply current to a minimum. An incoming ring signal from the phone lines powers up the device (wake-on ring).

An evaluation board is available for testing the CPC2400E. This evaluation board includes an RS232 line driver, LED status indicators and an amplified speaker circuit. When used with the evaluation board, the CPC2400E also meets the FCC Part 15B emissions test. Contact IXYS IC Division for more information on the CPC2400E Evaluation Board.

DAA

The DAA portion of the CPC2400E has been designed to interface directly with the U.S. PSTN as governed by the FCC. The DAA includes the circuitry for hookswitch, ring detection, gyrator, surge protection and analog signal coupling transformer. The DAA circuitry provides up to 1000 V_{rms} of longitudinal surge protection. For countries using a PSTN similar to the U.S. (Canada, Japan), the product using the CPC2400E must be submitted to a suitable test house for approval. Consult IXYS IC Division for further information.

FCC Part 68: Connecting to the PSTN

1. General

The CPC2400E complies with FCC Part 68 rules which regulates equipment connected to the telephone network. The CPC2400E provides a user transferable Part 68 registration which means that customers can use IXYS IC Division's registration number for the CPC2400E. Customers who wish, can reregister the modem under their name. Reregistration

assigns the customer a unique registration number. No additional FCC Part 68 submittal is required for equipment using the CPC2400E module.

2. Repairs

The FCC requires that IXYS IC Division makes all necessary repairs to the modem. If you are experiencing problems with the CPC2400E, call 1-800 272-5273 for further information. If repairs are necessary after the modem has been installed in your product and delivered to your customer, the modem must be returned to you where the CPC2400E can be removed and sent back to IXYS IC Division.

3. Label Instructions

A label similar to the following should be made visible on the outside of the end user product.

Complies with Part 68 of FCC Rules

Registration Number:	LVRPHL-25931-MD-E
Ringer Equivalence:	0.6B
Required Connection:	RJ-11

4. Design Guidelines

The following design guidelines should be followed to insure compatibility to FCC Part 68 tests:

4.1. The CPC2400E, the RJ-11 jack and the interface circuitry must be mounted on a PCB the should meet UL 94V-0 flammability standard.

4.2. Tip and Ring traces from the CPC2400E to the RJ-

11 jack should be isolated by a minimum of 1.5mm (0.06in) to prevent breakdown. Traces must have a minimum width of 0.5mm (.02in).

4.3. Insure that module is securely installed to the host system. Vibration and drop tests will loosen components

that are not securely mounted. One of two methods for securing the module should be used:

4.3.1 Soldered to the main PCB. This method is well suited for harsh environments where the end product may be subjected to shock and vibrations in industrial

environments (equipment monitoring, etc.).

4.3.2 Socketed to the main PCB. This method is well suited for environments where the end product is not subjected to shock and vibrations as in consumer applications (set top boxes, etc.).

4.4. Components used must be able to withstand temperature and humidity extremes per FCC Part 68.

4.5. When connecting to the PSTN, an FCC approved telephone jack must be used in the host system and must meet the mechanical requirements per FCC Part 68.3 Sub-part F. For RJ-11 jacks, refer to FCC Public Notice #42269 for a list of approved vendors.

4.6. The supplied FCC Registration Number including REN must be visible on the outside of the end user product. See Section 3.

5. Exhibit J: User Instructions

Instructions to our customers:

The FCC Part 68 Rules require the following information (or equivalent) to be provided for the end user product.

FCC Requirements for Consumer Products

This equipment complies with FCC rules, Part 68. On the,

FRONT side BOTTOM side
 BACK side [] TOP side

of this equipment is a label that contains, among other information, the FCC Registration Number and Ringer Equivalence Number (REN) for this equipment. If requested, provide this information to your telephone company.

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

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

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

If you experience trouble with this equipment, please contact (your company name) at (your company phone number) for warranty/repair information. The telephone company may ask that you disconnect this equipment from the network until the problem has been corrected or until you are sure that the equipment is not malfunctioning.

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

FCC rules prohibit the use of non-hearing aid compatible telephones in the following locations or applications:

- (1) All public or semipublic coin-operated or credit card telephones.
- (2) Elevators, highways, tunnels (automobile, subway, railroad or pedestrian) where a person with impaired hearing might be isolated in an emergency.
- (3) Places where telephones are specifically installed to alert emergency authorities such as fire, police, or medical assistance personnel.
- (4) Hospital rooms, residential health care facilities, convalescent homes, and prisons.
- (5) Workstations for the hearing impaired.
- (6) Hotel, motel, apartment lobbies; in stores where telephones are used by patrons to order merchandise; in public transportation terminals where telephones are used to call taxis, or to reserve lodging or rental cars.
- (7) Hotel and motel rooms. At least ten percent of the rooms must contain hearing aid compatible telephones; or jacks or plug-in hearing-aid compatible telephones which will be provided to hearing impaired customers upon request.

Applications

Figure 1 is a schematic of the CPC2400E in a typical host system application. The host system communicates to the CPC2400E through a standard V.24 serial interface. Refer to the Pinout and Definitions section for functional descriptions of the pins. The transmit and receive data is sent over the TXD and RXD pins. The -DCD and -DTR pins are used for handshaking. The audio output pin, A1 is used for monitoring the analog data and can be amplified to drive a speaker. The -MUTE can be used to enable or disable the speaker.

The ferrite beads FB1 and FB2 may be required to reduce EMI emissions per FCC Part 15. Determining the value for the ferrite beads depends solely on the emissions generated by the end user product.

Figure 2 is a schematic of the CPC2400E in a standalone RS232C configuration. This circuit uses the Linear Technologies LT1181A RS232 line driver. Note that the LT1181A line driver inverts the signals. Both figures 1 and 2 are for reference purposes only. Exact component values should be determined by the user.

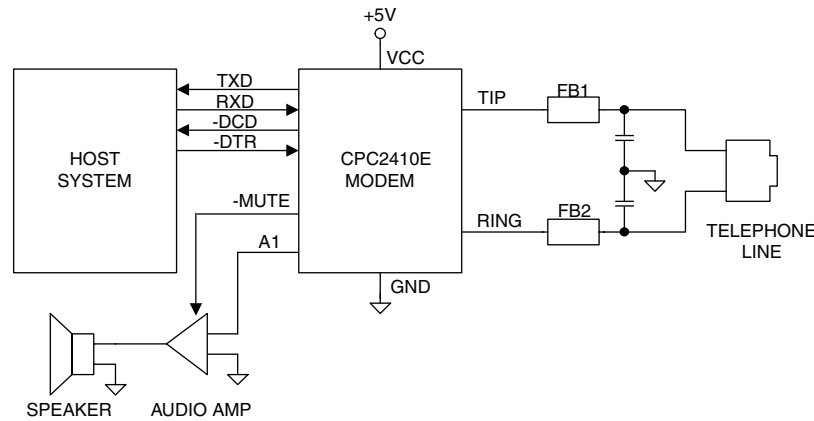


Figure 1. CPC2400E System Environment

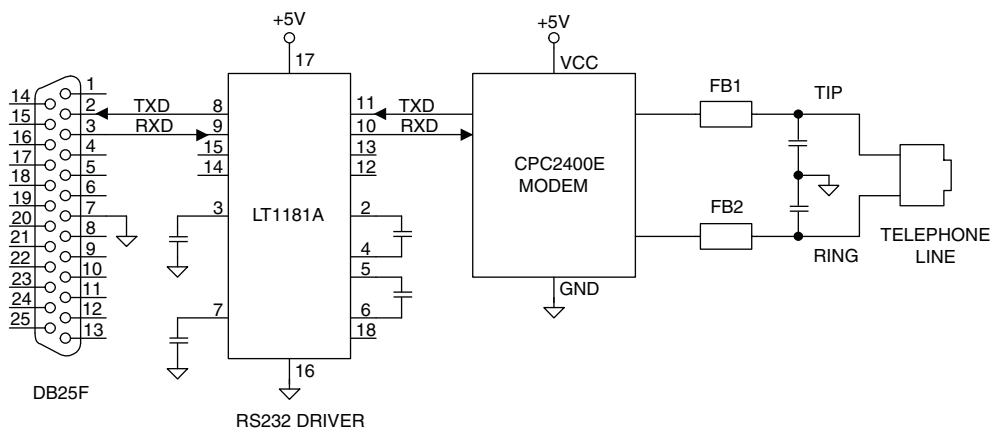


Figure 2. Stand Alone Modem with RS232C Interface

Command lines are typed to the modem from the terminal when the modem is in the Idle or Command state. The modem does not execute any of the commands in a command line until after the command line is ended by the end of line character <CR>. A command line is a string of characters starting with the A and T characters and ending with a special end of line character, <CR>. Characters typed before the AT are ignored. Command lines contain at most 40 characters after the AT, not counting spaces. The modem does not execute any of the commands in a command line that is too long.

To Echo command line characters, use the E1 command.

Typing mistakes can be aborted by using a special Back-Space character, <BS>, after the initial A and T characters have been entered.

A partial command line can be aborted by typing a Ctrl-X character. The modem returns an OK result code and ignores the partial AT command line.

Command lines may contain several commands one after another. The Answer (A), Dial (D), and Go On-Line (O) commands usually cause any following commands in the command line to be ignored.

Command Line Execution

The characters in a command line are executed one at a time. Any unexpected characters, except control characters, stop command line execution and return an ERROR result code. Unexpected characters include numbers out-side the range of values accepted by the command. All control characters in a command line except Ctrl-X and the special characters such as <CR> and <BS> are ignored.

The numerical argument of a command is assumed to be 0 if it was not provided. For example, the commands ATH<CR> and ATH0<CR> both hang up the telephone line.

When the modem has executed a command line the result code of the last command executed is returned to the terminal. If the value to be written to a modem S-register is outside the range of values accepted by the S-register then its value is set to the nearest allowed value.

Leading zeros in numeric arguments, including S-register numbers, are ignored. For example, ATS1=2 and ATS01=2 both set S-register S1 to 2.

All numeric arguments, including S-register numbers, are decimal (base 10).

AT Command Prefix

Each modem command line begins with the letters A and T. The modem uses these characters to determine the data rate and parity of data from the terminal.

A/Repeat Last Command

To repeat the commands in the last command line type the letters A and / instead of A and T.

<CR>End Of Line Character

This character is typed to end a command line. The value of the <CR> character is stored in S-register S3. The de-fault is 13, the ASCII carriage return character.

When the <CR> character is entered, the modem executes the commands in the command line.

Note: default values in the AT Command Tables are denoted by **bold face type**.

AT Command Set

Command		Function and Description				
A	Answer	<p>The A command makes the modem go off hook and respond to an incoming call. Use this command after the modem has returned the RING result code.</p> <p>If the modems successfully complete the answering process they each return a CONNECT result code and enter the On-Line state.</p> <p>If no transmit carrier signal is received from the calling modem within the time specified in S-register S7, the modem hangs up, returns the NO CARRIER result code, and enters the Idle state.</p> <p>Any commands following the answer command on the command line are ignored.</p> <p>This command is aborted if a key is pressed before the answer process is completed, or when DTR is off if some options in the &Q or &D commands have been used.</p>				
B	Communication Standard Option	<p>The B command tells the modem which special telephone line modulation standards to use. The modem can be configured to use:</p> <table border="1"> <tr> <td>B0</td> <td>Use the ITU-T modulation standards for all telephone line data rates. This includes V.22 for the 1200 bps telephone line data rate and V.21 for the 300 bps telephone line data rate.</td> </tr> <tr> <td>B1</td> <td>Not Supported</td> </tr> </table>	B0	Use the ITU-T modulation standards for all telephone line data rates. This includes V.22 for the 1200 bps telephone line data rate and V.21 for the 300 bps telephone line data rate.	B1	Not Supported
B0	Use the ITU-T modulation standards for all telephone line data rates. This includes V.22 for the 1200 bps telephone line data rate and V.21 for the 300 bps telephone line data rate.					
B1	Not Supported					
&C	Data Carrier Detect Options	<p>&C determines how the modem's DCD signal relates to the carrier signal from the other modem. This option takes effect only at the beginning of a telephone line connection. If &C is issued from the Command state it will not have an immediate effect.</p> <table border="1"> <tr> <td>&C0</td> <td>During asynchronous operation (&Q0 in effect) DCD is on at all times. During synchronous operation (&Q1) DCD reflects the state of the carrier signal from the other modem using S-registers S9 and S10. This is the default value in North America.</td> </tr> <tr> <td>&C1</td> <td>Reflects the state of the carrier signal from the other modem using S-registers S9 and S10.</td> </tr> </table>	&C0	During asynchronous operation (&Q0 in effect) DCD is on at all times. During synchronous operation (&Q1) DCD reflects the state of the carrier signal from the other modem using S-registers S9 and S10. This is the default value in North America.	&C1	Reflects the state of the carrier signal from the other modem using S-registers S9 and S10.
&C0	During asynchronous operation (&Q0 in effect) DCD is on at all times. During synchronous operation (&Q1) DCD reflects the state of the carrier signal from the other modem using S-registers S9 and S10. This is the default value in North America.					
&C1	Reflects the state of the carrier signal from the other modem using S-registers S9 and S10.					
D	Dial	<p>The D command makes the modem dial a telephone call according to the digits and dial modifiers in the dial string following the command. Any commands following the dial string on a command line are ignored unless the semicolon dial modifier is the last character in the dial string. If the modem was already off hook when the Dial command was given, the modem dials immediately without trying to detect a dial tone. Characters other than digits and dial modifiers in a dial string are ignored, but are counted as characters in the command line buffer.</p> <p>If line current sensing is enabled, and line current is detected before the modem is taken off-hook when the modem needs to dial, a NO CARRIER result code is displayed and the modem enters the Idle state. If the modem does not need to dial (i.e., ATD with no dial string), the modem assumes the call was manually established and attempts to make a connection.</p> <p>The D command is not valid when the modem is in the On-Line state.</p> <p>See DIAL MODIFIERS and MODEM RESULT CODES for more information.</p>				

AT Command Set

Command	Function and Description															
&D	<p>Data Terminal &D determines how the modem responds to the DTR signal from the terminal. The country Ready Options configuration may prevent the modem from detecting terminal DTR. In this case, the modem assumes DTR is always on. In North America, terminal DTR is normally detected. If DTR detection has been prevented, the modem will respond with an ERROR result to this command.</p> <p>The response to changes in DTR also depends on the &Q and &D commands. This table defines what happens when DTR goes off for all possible combinations of the &D and &Q commands. To see what happens when DTR goes on refer to the &Q command. The default value is &D0 in North America:</p> <table border="1"> <thead> <tr> <th></th> <th>&D0</th> <th>&D1</th> <th>&D2</th> <th>D3</th> </tr> </thead> <tbody> <tr> <td>&Q0</td> <td>None</td> <td>B</td> <td>C</td> <td>D</td> </tr> <tr> <td>&Q1</td> <td>A</td> <td>B</td> <td>C</td> <td>D</td> </tr> </tbody> </table> <p>A The modem hangs up the telephone line and issues an OK result code. B If in the On-Line state, the modem goes into the Command state and issues an OK result code. C The modem hangs up the telephone line and issues an OK result code. Auto-Answer is disabled as long as DTR stays off. D The modem resets.</p>		&D0	&D1	&D2	D3	&Q0	None	B	C	D	&Q1	A	B	C	D
	&D0	&D1	&D2	D3												
&Q0	None	B	C	D												
&Q1	A	B	C	D												
E	<p>Command Mode E tells the modem whether or not to echo characters sent from the terminal when the modem is Character Echo accepting AT commands.</p> <p>E0 Does not echo characters sent from the terminal. E1 Echo characters sent from the terminal. This is the default value in North America.</p>															
%E Automatic Retrain Options	<p>The %E command controls whether the modem will initiate retrain with the other modem during a telephone line connection during operation in data modes supporting retrain. The modem always responds to a retrain operation initiated by the remote modem. The modem can be forced to initiate a retrain by the On-Line (O1) command.</p> <p>%E0 Do not initiate a retrain. %E1 Initiate a retrain if the datapump indicates one is required.</p>															
&F Recall Factory Profile	<p>&F changes these AT command options and S-registers to their default values. The default values may be changed for use in different countries. The values for North America are:</p> <p>S-registers</p> <table border="1"> <tbody> <tr> <td>S0=0 S1=0</td> <td>S2=43</td> <td>S3=13</td> <td>S4=10</td> <td>S5=8</td> </tr> <tr> <td>S6=2 S7=30</td> <td>S8=2</td> <td>S9=6</td> <td>S10=14</td> <td>S11=95</td> </tr> <tr> <td>S12=50</td> <td>S17=10</td> <td>S25=5</td> <td>S28=0</td> <td>S29=25 S37=0</td> </tr> </tbody> </table> <p>Commands</p> <p>B1 E1 M1 P Q0 V1 X4 &C0 &D0 &G0 &P0 &Q0 %E1</p>	S0=0 S1=0	S2=43	S3=13	S4=10	S5=8	S6=2 S7=30	S8=2	S9=6	S10=14	S11=95	S12=50	S17=10	S25=5	S28=0	S29=25 S37=0
S0=0 S1=0	S2=43	S3=13	S4=10	S5=8												
S6=2 S7=30	S8=2	S9=6	S10=14	S11=95												
S12=50	S17=10	S25=5	S28=0	S29=25 S37=0												
&G Guard Tone Options	<p>&G tells the modem which guard tone to transmit when the modem is transmitting the high band (i.e., answer handshake and answer mode).</p> <p>&G0 No guard tone. This is the default value in North America. &G1 550 Hz guard tone (V.22 and V.22bis only) &G2 1800 Hz guard tone (V.22 and V.22bis only)</p>															

AT Command Set

Command		Function and Description	
H	Hook	H0	Hang up the telephone line.
		H1	Go off hook without answering a telephone call. This may be disabled in countries prohibiting its use.
&HT	PTT Test Command	The &HT command causes the modem to transmit tones for PTT testing. The test tone is generated until a character is typed on the modem's terminal. The country configuration may disable this command. The modem returns an ERROR result if this command is issued.	
		&HT0-9	EMMF tone for digit n where the command was &HTn.
		&HT10	EMMF tone "*"
		&HT11	EMMF tone "#"
		&HT12	EMMF tone "A"
		&HT13	EMMF tone "B"
		&HT14	EMMF tone "C"
		&HT15	EMMF tone "D"
		&HT16	V.21 channel 1 mark
		&HT17	V.21 channel 2 marks
		&HT18	V.23 1200bps marks
		&HT19	V.23 75bps marks
		&HT20	V.21 channel 1 spaces
		&HT21	V.21 channel 2 spaces
		&HT22	V.23 1200bps spaces
		&HT23	V.23 75bps spaces
		&HT24	V.22 originate mode
		&HT25	V.22 answer mode
		&HT26	V.22bis originate mode
		&HT27	V.22bis answer mode
		&HT28	V.25 calling tone
&HT29	550Hz guard tone		
&HT30	1800Hz guard tone		
&HT31	Silence		
I	Identification	The I command asks the modem for information that can be used to determine the modem's compatibility with other software and to ensure the modem is operating properly.	
		I0	Display product code. The modem reports its product code to the terminal. The modem produces information text dependent upon its features and capabilities.
		I1	Display ROM checksum. The modem reports the value of its ROM checksum. The decimal number displayed is the eight bit sum (from 0 to 255) of all the bytes in ROM.
		I2	Test the ROM checksum. The modem checks its ROM to ensure it is correct. The modem reports a result code indicating whether the ROM is OK or in ERROR.
		I3	Display Software Versions. The modem reports the modem controller and data pump software versions, and the modem controller software release date, to the terminal.
		I4	Display Modem Identification. The modem reports a configurable identification message to the terminal.

AT Command Set

Command		Function and Description
M	Speaker On/Off Options	The country configuration may disable the speaker. If so, this command will return an ERROR result.
		M0 Speaker always off.
		M1 Speaker on until carrier detected. This is the default value in North America.
		M2 Speaker always on; stays on after carrier is detected.
		M3 Speaker off as digits are dialed, but on during ringback and on until carrier signal is detected.
O	Return to On-Line Mode	This command returns the modem to the on-line mode. It is frequently used after the escape character sequence (+++) to resume communication with the remote modem. If handshaking is started, the modem uses Originate or Answer mode handshaking depending upon whether the modem originated or answered the telephone call.
		O0 Return the modem to the On-Line state from the Command state during a telephone line connection. The modem starts handshaking if there was no telephone line connection but the modem was off hook.
		O1 Return the modem to the On-Line state and retrain its data pump during a telephone line connection. The modem starts handshaking if there was no telephone line connection but the modem was off hook.
&P	Pulse Dial Make/Break Ratios	Sets cadence of pulse dial. The country configuration may disable this command, forcing particular pulse dialing parameters. In this event, the modem returns an ERROR result if this command is issued.
		&P0 39%/61% make/break ratio and 10 pulses per second when pulse dialing. This is the default value.
		&P1 33%/67% make/break ratio and 10 pulses per second when pulse dialing.
		&P2 39%/61% make/break ratio and 20 pulses per second when pulse dialing.
		&P3 33%/67% make/break ratio and 20 pulses per second when pulse dialing.
Q	Result Code Display Options	This command allows the user to either display result codes or to not display result codes.
		Q0 Result codes will be displayed. This is the default value for North America.
		Q1 Result codes will not be displayed.
Sn	Set the current S-register to n	This command sets the current S-register to the value "n" selected by the user. For example, AT\$S7 will set the current S-register to S7. Default value is 0. Sn addresses a particular S-register number so future commands like ? and = will read or write the S-register. Modem reset and the &F command select S0 as the default S-register.
?	Read an S-Register	This command displays the value of the last S-register named in the Sn command.
=x	Write an S-Register	This command writes the value x to the last S-register named in the Sn command. The range of valid values for x depends upon which S-register is being written. 0 is assumed if no value is given for x.
T	Tone Dialing	Selects the tone method of dialing.
V	Result Code Format	This command changes the format in which result codes are displayed.
		V0 All result codes will be displayed as numbers.
		V1 All result codes will be displayed as words (verbose form). This is the default value for North America.

AT Command Set

Command		Function and Description
X	Call Progress	The X command controls whether or not a busy signal or dial tone should be detected when dialing. The X command also limits the result codes the modem may return when dialing. The operation of the X command is configurable for operation in different countries.
	X0	Neither busy signal nor dial tone are detected. When a telephone line connection is made the result code does not indicate the telephone line data rate.
	X1	Neither busy signal nor dial tone are detected. When a telephone line connection is made the result code indicates the telephone line data rate.
	X2	Busy signal is not detected. Dial tone is detected. When a telephone line connection is made the result code indicates the telephone line data rate.
	X3	Busy signal is detected. Dial tone is not detected. When a telephone line connection is made the result code indicates the telephone line data rate.
	X4	Both busy signal and dial tone are detected. When a telephone line connection is made the result code indicates the telephone line data rate. This is the default value in North America.
<p>The @ and W dial modifiers are not affected by the X command. The @ dial modifier may return the result codes 8 (NO ANSWER) or 7 (BUSY) each time it appears in the dial string. The W dial modifier may return the result codes 6 (NO DIALTONE) or 7 (BUSY) each time it appears in the dial string.</p>		

Dial Modifiers

Dial modifiers perform special functions within a dial command. For example,

```
ATDT9W1552368!@#71234;<CR>
```

instructs the modem to use tone dialing (T), to access a number outside a PBX (9), to wait for dial tone (W), to dial the number 1552368, to do a hook-flash (i.e. timed break recall), to wait for quiet answer, and to

issue the PBX transfer code #7 before dialing extension number 1234, then to return to the Command state before initiating the handshake.

Modifier	Function
0-9 A B C D # *	Dialing digits and characters. The digits and characters 0-9 A B C D # * specify what numbers the modem dials. The characters A B C D # * work only when tone dialing is used, they are ignored when pulse dialing is used. The characters A, B, C, and D may be disabled in countries prohibiting their use.
P	Pulse dialing. P selects the pulse method of dialing. P can be issued within a dial command or as a separate command. The default method of dialing is Pulse.
R	Originate a Call in Answer Mode. R makes the modem handshake in answer mode so it can originate a call to an originate-only modem.
T	Tone dialing. T selects the tone method of dialing. T can be issued within a dial command or as a separate command. The default method of dialing is Pulse.
W	Wait for dial tone. W makes the modem wait for a dial tone before proceeding. If no dial tone is detected the modem hangs up the telephone line and returns the NO DIALTONE result code.
,	Delay Processing of Next Character. A comma (,) makes the modem pause for the length of time in Sregister S8 before processing the next character in a dial string.
@	Wait for Quiet Answer. @ makes the modem listen for 5 seconds of silence before continuing. The modem will wait up to the length of time in S-register S7. If 5 seconds (configurable by country) of silence are not detected within the time period in S-register S7, the modem hangs up and returns the NO ANSWER result code. If 5 seconds of silence are detected, the modem continues processing the other characters in the dial string.
!	Timed Break Recall (Hookflash). A ! makes the modem hang up the telephone line for the length of time in S-register S29, then take the telephone line off hook again. This is frequently used to access a PBX's call transfer function.
;	Return to Command State after dialing. A semicolon (;) tells the modem to return to command state after dialing without breaking the telephone line connection and without handshaking with the other modem. The semicolon may only be used when calling a voice mail system that permits tones to transmit numbers once a connection has been established.

Modem S-Registers

The value of an S-register is modified by $ATSn =x$, where n is the register number and x is the value to be stored in that particular register. Each S-register has three values that may be configured for different

countries: a default value, an upper limit and a lower limit. The values shown in this manual are for North America.

Command	Range	Units	Description
S0	0 - 255	Rings	Set number of rings to auto-answer. The country configuration may disable the modem's ability to detect a telephone line ring signal. In this case the modem will never automatically answer the telephone regardless of the S0 setting. Default = 0 (auto-answer disabled)
S1	0 - 255	Rings	Returns the number of times the phone rings. Default = 0
S2	0 - 255	ASCII	Set Escape Sequence Character. Setting S2 to a value greater than 127 disables the character escape sequence, preventing the modem from returning to Command state when in the On-Line state. Default = 43
S3	0 - 127	ASCII	Set the End of Line character. Default = 13
S4	0 - 127	ASCII	Set the Line Feed Character. Default = 10
S5	0 - 127	ASCII	Set the BackSpace Character. Default = 8
S6	2 - 255	Seconds	Delay to Wait Before Performing a Blind Dial. Default = 2 seconds
S7	1 - 255	Seconds	Delay to Wait for Carrier after dialing. Default = 30 seconds
S8	0 - 255	Seconds	Delay to Wait when a Comma Dial Modifier is Processed. Default = 2 sec.
S9	1 - 255	1/10th sec	Time Carrier Must be Present Before Being Recognized. Default = 0.6 sec.
S10	1 - 255	1/10th sec	Delay Between Lost Carrier and Hang Up. Setting S-register S10 to 255 makes the modem never hang up the telephone line because of a loss of carrier. Default = 14 tenths of a second
S11	50 - 255	msec	Multi-Frequency Tone duration. Default = 95 milliseconds
S12	0 - 255	1/50th sec	Escape Prompt delay time. This is the prompt delay time for escape sequences from the On-Line state to the Command state. Default = 50 fiftieths of a second
S13	Reserved	Reserved	Reserved
S14	Reserved	Reserved	Reserved
S15	Reserved	Reserved	Reserved
S16	Reserved	Reserved	Reserved
S17	-6 to -43	dBm	Set Transmit level. Default = -10 dBm
S18	Reserved	Reserved	Reserved
S19	Reserved	Reserved	Reserved
S20	Reserved	Reserved	Reserved

Command	Range	Units	Description
S21	Reserved	Reserved	Reserved
S22	Reserved	Reserved	Reserved
S23	Reserved	Reserved	Reserved
S24	Reserved	Reserved	Reserved
S25	0 - 255	Seconds or 1/100th sec	During synchronous operation with the &Q1 command in effect, S-register S25 is the number of seconds after a telephone line connection is made before the modem examines DTR. This allows sufficient time to disconnect the modem from an asynchronous terminal and attach it to a synchronous terminal. In the On-Line or Command state during any mode of operation, changes in DTR for less than S25 hundredths of a second are ignored.
S26	Reserved	Reserved	Reserved
S27	Reserved	Reserved	Reserved
S28	0 - 255	Minutes	Terminal inactivity timeout. Hangs up the modem after S28 minutes if no characters are received from the modem's terminal. Default = 0
S29	0 - 255	1/50th sec	Hook Flash On-Hook time. The amount of time in 20 millisecond units the modem will leave the telephone on-hook while performing a hook-flash according to the "!" dial string modifier. Default = 25 fiftieths of a second.
S37	0 - 6	Code	Set Highest Line Rate - determines the highest telephone line data rate the modem will use when connecting with a remote modem. See "Setting the Highest Line Rate" section below. Default = 0.

Setting the Highest Line Rate

The connect rate can be selected by S-register S37. The following connect rates are supported.

S-37 Value	Carrier	Data Rate
0		The data rate of the last AT command
4		Reserved
5	V.22, Bell 212A	1200 bps. See the B command
6	V.22bis	2400 bps

Dial Modifiers

A result code is a line of text or a number the modem sends to the terminal to indicate the result of a command execution. Some CONNECT result codes

indicate the telephone line data rate. The following table provides a list of the available result codes.

Number	Word	Result Code Description
0	OK	Command Line Executed without errors
1	CONNECT	The modem is in the On-line state, ready to transfer data.
2	RING	The modem has detected a ring signal on the telephone line. The country configuration may disable the modem's ability to detect a telephone line ring signal.
3	NO CARRIER	No carrier signal was detected when answering or placing a telephone call, or carrier was lost during a call. The modem also returns this response message when the telephone line connection is broken for any reason.
4	ERROR	An invalid command was issued, or there was an error at any place in the command line.
5	CONNECT 1200	The modem is in the On-line state, ready to transfer data.
6	NO DIALTONE	No dial tone was detected when the modem took the telephone line off hook.
7	BUSY	The modem detected a busy signal on the telephone line.
8	NO ANSWER	Not enough silence was detected when the @ dial modifier was used.
10	CONNECT 2400	The modem is in the On-line state, ready to transfer data. The telephone line data rate is 2400bps.
16	CONNECT 1200/75	The modem is in the On-Line state, ready to transfer data. This modem transmits at 1200 bps and receives at 75 bps.
17	CONNECT 75/1200	The modem is in the On-Line state, ready to transfer data. This modem transmits at 75bps and receives at 1200 bps.
20	BLACKLISTED	The modem will not allow any number to be dialed until after the modem is reset.
21	DELAYED	The modem will not allow any number to be dialed now, but will allow dialing at some future time.

Escape Sequences

An escape sequence is one or more particular characters sent from the terminal to the modem during the On-Line state. This is done to switch the modem to the command state so modem commands may be entered during a telephone line connection. The Escape Sequence characters are typically sent to the other modems as data.

An escape sequence should not occur accidentally during an exchange of data between two modems. Unfortunately, it is impossible to guarantee any escape sequence will never occur naturally since there are no restrictions on the data or timing between characters sent between two modems during the On-Line state.

The only method of switching from the On-Line state to the Command state that does not ever occur naturally during an exchange of data is the Data Terminal Ready signal (the &D1 command). The terminal has complete control of this signal and it is not part of the data exchanged between the modems.

The Hayes escape sequence was adopted by many modem manufacturers and communication programs before Hayes was granted a patent for the escape sequence guard times. Now the unpatented Time Independent Escape Sequence (TIES) has gained popularity with many modem manufacturers.

TIES Escape Sequence

TIES stands for Time Independent Escape Sequence. TIES was developed by a number of modem manufacturers in response to Hayes enforcing patent rights for their escape sequence guard time patent.

The Time Independent Escape Sequence is a sequence of 3 escape characters (+ characters by default). Once these characters have been recognized, the modem enters the Command state without sending a confirming result code to the terminal and the modem starts a prompt delay timer.

Then:

- a. If one of the recognized AT commands is received before the timer expires, the timer is stopped, the command is executed and its result code is sent to the terminal.
- b. If any other data is received while the timer is running, the timer is stopped, the modem returns to the On-Line state and the received data is sent to the other modem.
- c. If the timer expires, a confirming result code is sent to the terminal, indicating the modem is in the Command state. The escape character can be changed through S-Register S2. The prompt delay timer can be changed (in 1/50 second increments) through S-Register S12 (see S-Registers section).

Carrier Detection

After handshaking, the modem determines if a telephone line connection exists by detecting the carrier signal from the other modem. If the carrier is not detected for a long enough period of time, the modem assumes the telephone line connection with the other modem has been broken. The modem uses S-register S9 to determine how long a carrier must be present before it is "detected." The modem uses S-register S10 to determine how long a carrier may not be detected before the telephone line is hung up.

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