OKI Semiconductor

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MSC2121A

14.4 kbps Full Duplex Modem Chip Set With Built-in Protocols

GENERAL DESCRIPTION

The MSC2121A is a modem chip-set that provides full duplex data transmission capability of up to 14400 bits/s conforming to ITU-T Recommendation (V.32 bis, V.22 bis, V.22, and V.21) and Bell Standard (212A and 103J), and also provides facsimile transmission capability conforming to ITU-T Recommendation (V.17, V.33, V.29, and V.27 ter). The MSC2121A supports the function as a facsimile activated by FAX Class 1 Command in EIA Standard, as well as the function to set a modem and to control calls originating and terminating with AT Commands and the function as a data modem including error correction and data compression. So, the use of this chip-set enables easy implementation of terminals that have those functions, which are being widely employed in personal computer communication, as a full-duplex modem of 14400 bits/s and as a facsimile reciever and transmitter. In the MSC2121A, no external program memory will be required because the control program codes are stored in the program memories that a general-purpose MCV has. General-purpose SRAMs (which are essential) and EEPROMs (which are removable) should be used for external memories.

This chip-set comprises the following two LSIs:

MSM66507	General-purpose MCU
MSM7564-01	Single-chip modem

The above ICs are available in a FLAT or PLCC package. For details, please refer to the individual semiconductor specifications of each IC.

FEATURES

- Communication Modes

ITU-T Recommendation	V.32bis	14,400/12,000/9,600/ 7,200/4,800 bps	Full duplex, SYNC/ASYNC
ITU-T Recommendation	V.22bis	2,400 bps	Full duplex, SYNC/ASYNC
ITU-T Recommendation	V.22	1,200 bps	Full duplex, SYNC/ASYNC
ITU-T Recommendation	V.21	300 bps	Full duplex, ASYNC
BELL Standard	212A	1,200 bps	Full duplex, SYNC/ASYNC
BELL Standard	103J	300 bps	Full duplex, ASYNC
ITU-T Recommendation	V.17	14,400/12,000/9,600 /7,200 bps	Half duplex, SYNC
ITU-T Recommendation	V.29	9,600/7,200 bps	Half duplex, SYNC
ITU-T Recommendation	V.27ter	4,800/2,400 bps	Half duplex, SYNC
ITU-T Recommendation	V.21ch.2	300 bps	Half duplex, SYNC

- Command Set
  Hayes AT commands.
  EIA/TIA-578 (Class 1) fax commands

- Dial Function
  DTMF send function (tone dialing)
  DP send function (pulse dialing): 20 pps, 10 pps (Make/break ratio: 33%, 39%)

- Error Correction Function
  ITU-T V.42 (LAP-M)
  MNP Class 3, 4
- Data Compression Function
  ITU-T V.42bis
  MNP Class 5

- Protocol To Support Mobile Telephones: MNP Class 10

- Various Test Functions
  Various tests including local AC loopback, local DC loopback, remote DC loopback and self-test function

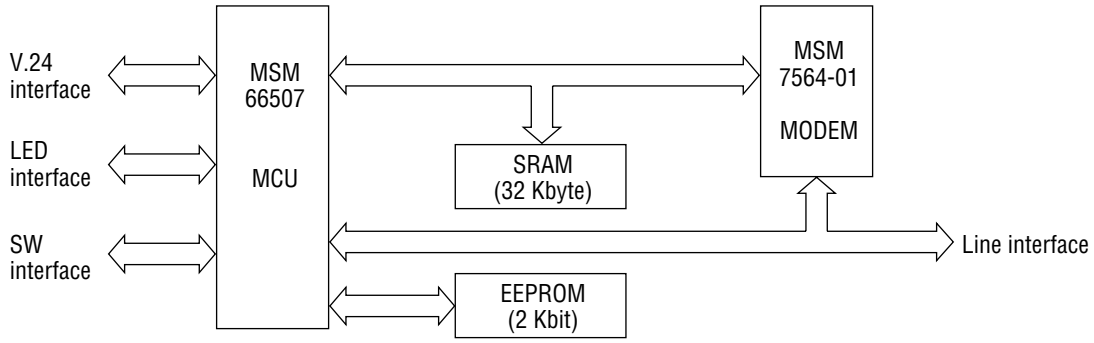
- Transmission Attenuator Function: 0 to 7 dB, (in a 1 dB step)

- +5 V Single Power Supply

- Power Consumption: 900 mW (typical)

BLOCK DIAGRAM

The MSC2121A block diagram is shown below.
The MSM66507 performs command processing and control of the various interfaces. The interfaces controlled are the V.24 interface, the LED interface, the SW interface, the modem control interface and the line interface.
The MSM7564-01 is a single-chip modem LSI which executes all of the modem standards of the MSC2121A. It performs modulation/demodulation, DTMF signal transmission and call progress tone detection.
Auxiliary memory comprises SRAM (32 Kbyte) and EEPROM (2 Kbit). These are respectively used as the internal memory of transmission/reception buffers and as nonvolatile memory for storing internal settings.



MSC2121A Block Diagram

List of Interface Signals

• V.24 Interface

Signal Name	Symbol	I/O	Explanation
Transmission data	SD	Input	Input signal of the transmit data. Mark signal = 1, space signal = 0.
Reception data	RD	Output	Output signal of the receive data. Mark signal = 1, space signal = 0.
Request-To-Send	RTS	Input	1 = Stop receive data. 0 = Send transmit data.
Clear-To-Send	CTS	Output	1 = Data transmit disabled. 0 = Data transmit enabled.
Data Terminal Ready	DTR	Input	1 = Transmit/receive to/from the modem disabled. 0 = Transmit/receive to/from the modem enabled.
Data Set Ready	DSR	Output	1 = Modem is in transmit/receive disabled state. 0 = Modem is in transmit/receive enabled state.
Carrier Detect	DCD	Output	1 = Carrier not detected. 0 = Carrier detected.
Call Indicator	CI	Output	1 = No incoming call signal. 0 = Incoming call signal.
Transmission Timing (DTE source)	ST1	Input	Transmission timing clock from the DTE. Used in the synchronization mode.
Transmission Timing (DCE source)	ST2	Output	Transmission timing clock from the DCE. Used in the synchronization mode.
Reception Timing	RT	Output	Recieve timing clock. Used in the synchronization mode.

• Signals for Line Control

Signal Name	Symbol	I/O	Explanation
Dial relay	RLY1	Output	Dial relay control signal. 1 = Relay ON. (Make) 0 = Relay OFF. (Break)
Hook relay	RLY2	Output	Line connection relay control signal. 1 = Relay ON. (Make) 0 = Relay OFF. (Break)
Incoming call signal input	$\overline{\text{RII}}$	Input	For input from the NCU unit incoming call signal detection circuit. 1 = No incoming call signal. 0 = Incoming call signal.
Speaker	$\overline{\text{SPK}}$	Output	Speaker control signal. 1 = Speaker ON. 0 = Speaker OFF.

• Display Signals

Signal Name	Symbol	I/O	Function
Auto answer	AA	Output	Indicates that the modem is in an auto-answer state. 1 = Auto answer state. 0 = Not auto answer state.
Error correction mode	EC	Output	Indicates connection to the remote modem made in error correction mode. 1 = Connected in error correction mode. 0 = Connected in normal mode.
High speed	HS	Output	Indicates communication at 9,600 bps or higher. 1 = High speed transmission at 9,600 bps or higher. 0 = Low speed transmission at 7,200 bps or lower.
Modem ready	MR	Output	Lights when power is turned ON. During the loopback test, cycles ON-OFF in 1 second cycles. 1 = Lamp ON 0 = Lamp OFF

• Signal Input for Switch Settings

Port	Symbol	Function
P2.7	SW1	Determines the setting of the carrier transmission levels. When P2.7=1, the carrier transmission levels are set by the commands (registers S34 and S35). Refer to registers S34 and S35 requirements for more details. When P2.7=0, the carrier transmission levels are set by the ports (SW2 to SW4).
P3.0 P3.3 P4.1	SW2 SW3 SW4	When P2.7=0, the carrier transmission levels are set. SW4 SW3 SW2 Carrier transmission level. (Note1). 0 0 0 – 10 dBm 0 0 1 – 11 dBm 0 1 0 – 12 dBm 0 1 1 – 13 dBm 1 0 0 – 14 dBm 1 0 1 – 15 dBm 1 1 0 – 16 dBm 1 1 1 – 17 dBm
P4.2	SW5	Determines whether the JATE retransmission security function is provided or not. When P4.2=1, the JATE retransmission security function is not provided. When P4.2=0, the JATE retransmission security function is provided.
P4.3	SW6	Determines the command set types. When P4.3=1, typeA command set is determined. When P4.3=0, typeB command set is determined.
P7.2	SW7	P7.2 should be always set to 0, which is reserved for future use.
P7.4	SW8	P7.4 should be always set to 0, which is reserved for future use.
P7.5	SW9	Selects the nonvolatile memory types to be used. When P7.5=1, X24C02 ( ) or an equivalent is selected. When P7.5=0, AT59C22 (produced by ATMEL) or an equivalent is selected.

Note1: The carrier transmission levels indicate the values at the AOUTP Pin and AOUTN Pin of the MSM7564-01.

• List of MCU (MSM66507) Port Assignments

Port Number	I/O	Active Level	Signal Name	Function
P0.0 to P0.7	Input/ output		AD0 to AD7	Address bus (low order) and data bus.

Port Number	I/O	Active Level	Signal Name	Function
P1.0 to P1.7	Output		A8 to A15	Address bus (high order)

Port Number	I/O	Active Level	Signal Name	Function
P2.0	Output	H	RLY1	For dial relay control signal.
P2.1	Output	H	RLY2	For line connection relay control signal.
P2.2	Output	L	CI	Calling indicator
P2.3	Input	L	DTR	Data Terminal Ready
P2.4	Output	L	DSR	Data Set Ready
P2.5	Output	L	DCD	Data Carrier Detect signal.
P2.6	Output	L	CTS	Clear to Send.
P2.7	Input		SW1	For SW1 signal input.

Port Number	I/O	Active Level	Signal Name	Function
P3.0	Input		SW2	For SW2 signal input.
P3.1	Input	L	$\overline{\text{RII}}$	For the incoming call signal input from the NCU circuit (Note1).
P3.2	Output	L	$\overline{\text{SPK}}$	For speaker control signal.
P3.3	Input		SW3	For SW3 signal input.
P3.4	Input		SD	For transmission data (connect to P6.6)
P3.5	Input	L	RTS	Request to send.
P3.6	Input		RT	Reception timing clock input (from the MSM7564-01).
P3.7	Input		ST2	Transmission timing clock input (from the MSM7564-01).

Port Number	I/O	Active Level	Signal Name	Function
P4.0	Output		CE1	MSM7564-01 select signal.
P4.1	Input		SW4	For SW4 signal input.
P4.2	Input		SW5	For SW5 signal input.
P4.3	Input		SW6	For SW6 signal input.
P4.4	Output	H	MR	For the modem ready indicator signal.
P4.5	Output	H	HS	For the high-speed indicator signal.
P4.6	Output	H	EC	For the error correction mode indicator signal.
P4.7	Output	H	AA	For the auto answer indicator signal.

Port Number	I/O	Active Level	Signal Name	Function
P5.0	Output		CS	For non-volatile memory control signal (Note2)
P5.1	Output		CLK	For non-volatile memory control signal (Note2)
P5.2	Output		DI	For non-volatile memory control signal (Note2)

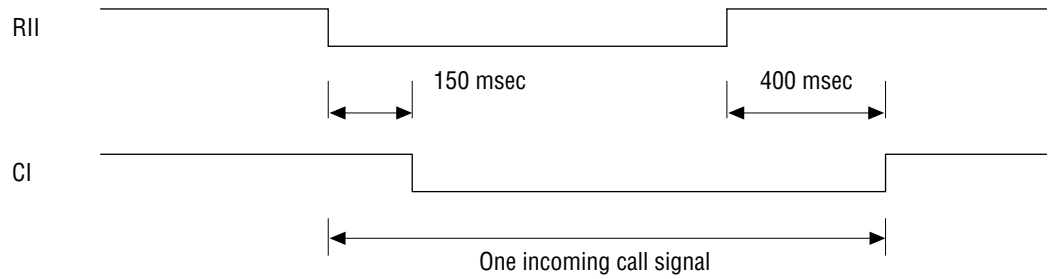
Port Number	I/O	Active Level	Signal Name	Function
P6.0	Input		RBTM	Reception modulation timing signal from the MSM7564-01.
P6.1	Input	L	STSCHG	STSCHG signal (from the MSM7564-01).
P6.2	Input		TxD	Reception data from the MSM7564-01.
P6.3	Output		RxD	Transmission data to the MSM7564-01.
P6.4	Input		RT	Reception timing clock input (from the MSM7564-01).
P6.5	Input		ST2	Transmission timing clock input (from the MSM7564-01).
P6.6	Input		SD	For transmission data. (connect to P34)
P6.7	Output		RD	For reception data.

Port Number	I/O	Active Level	Signal Name	Function
P7.0	Output	L	$\overline{WR}$	External memory write signal.
P7.1	Output	L	$\overline{RD}$	External memory read signal.
P7.2	Input		SW7	For SW7 signal input.
P7.3	Output		MCK	Clock signal to the MSM7564-01. (3.888MHz)
P7.4	Input		SW8	For SW8 signal input.
P7.5	Input		SW9	For SW9 signal input.
P7.6	Input		R/B	For non-volatile memory control signal (Note2)
P7.7	Input		DO	For non-volatile memory control signal (Note2)

• Other MCU Signals

Pin Name	I/O	Pin Processing
$\overline{EA}$	Input	Connect to +5 V.
NMI	Input	Connect to digital ground.
$\overline{OE}$	Input	Connect to digital ground.
PSEN	Output	Not used (open pin).
ALE	Output	Connect to the MSM7564-01 ALE pin.
$\overline{RES}$	Input	Connect to system reset signal.

Note1: If a signal is input to RII under the conditions below, this chip set recognizes it as one incoming call signal.



Note2: Each pin assignment to nonvolatile memory type to be used is indicated below.

Port Number	SW9 (7.5)=0		SW9 (7.5)=1
	AT59C22 equivalent	No non volatile memory	X24C02 equivalent
P5.2	DI	connect to P7.7	connect to ground
P7.7	DO	connect to P5.2	open
P5.0	CS	open	CSL
P7.6	R/B	connect to P5.1	open
P5.1	CLK	connect to P7.6	SDA

•When SW9=0, "No nonvolatile memory'' is automatically identified during initial processing
•If no nonvolatile memory is used,
(1) The chip-set is factory shipped after hardware or software is reset.
(2) The following commands are invalidated: &w, &z, dial storing s (store dial)

COMMAND SPECIFICATIONS

- AT Commands
  AT commands are explained in Appendix A.
  Industry standard AT commands are supported.

- EIA/TIA-578 (Class 1) Fax Commands
  EIA/TIA-578 fax commands are explained in Appendix B.
  In order to perform facsimile communication, fax commands stipulated by EIA/TIA-578 (Class 1) are supported.

- S-Registers
  S-registers are explained in Appendix C.

- Command Mode and Data Mode
  Supplementary explanations of the command mode and data mode are recorded in Appendix D.

- Loopback Tests and Self Diagnostic
  Supplementary explanations of the loopback tests and self diagnostic are recorded in Appendix E.

Appendix A
AT Commands

OVERVIEW

AT commands begin with <AT> or <at>. The <character string> up to the carriage return is interpreted as commands, which are executed sequentially. The result code is returned to the DTE.

AT	Command character string	CR	LF

However, the A, D, Dc, On, Zn, Ax, &Tn and &Zn commands must be placed last in the command string. Even if a command is entered afterwards, any characters up to the return code are ignored. The maximum length of the command character string is 40 characters (spaces <20h> are ignored).
Only the backspace function (code can be changed) is valid for deleting an input character.
<CR> is the carriage return code (code can be changed).
<LF> is the line feed code (can be omitted; code can be changed).
Both upper and lower case alpha characters used in commands are recognized, but At or aT are not recognized.
When inputting commands, communication with the DTE is handled in asynchronous mode.
When AT (at) is input, the terminal speed and character format are automatically determined.

TERMINAL SPEED AND CHARACTER FORMAT

When the DCE is in the asynchronous command mode, the communication mode with the DTE is as shown below:

- Terminal speed: 300 bps, 1,200 bps, 2,400 bps, 4,800 bps, 7,200 bps, 9,600 bps, 12,000 bps, 14,400 bps, 19,200 bps, 28,800 bps, 38,400 bps, 57,600 bps

- Character format

Start bit	Data bit	Parity bit	Stop bit	Character length
1	7	Odd/even	1	10
1	7	None	2	10
1	7	Mark/space	1	10
1	8	None	1	10

LIST OF AT COMMANDS

Command	Function	Initial Value	Remarks
A/	Re-execute the immediately preceding command.		Same
A	Connect the modem to the line in the answer mode.		
Bn	Selection of ITU-T standard and BELL standard: n = 0: Modem function operates in accordance with the ITU-T standard. n = 1: Modem function operates in accordance with the Bell standard.	0	
D	Force operation into originate mode.		

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
Dc	The modem dials and operates in the originate mode. Dial Characters Pulse: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, (A, B, C, D, ∗, # are ignored) Tone: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, ∗, # Control Characters @ Detect silence If during the time set in the S7 register, a continuous 5-second interval of silence is detected after the ring tone, and dial string processing is not detected after that (@), a "BUSY" is returned if the call progress tone is a busy tone, and a "NO ANSWER". ! Flash The modem goes off hook for 0.5 seconds. , Pause Dialing pauses for the time set in the S8 register. ; After dialing is completed, return to command mode without disconnecting the line L Redial the last dialed telephone number If there is an L in the dial string, the last dialed dial string (telephone number) is substituted for the L and dialed. P Temporarily sets the subsequent dial string to the pulse dial format R Reverse After dialing is completed, the modem starts communication in the answer mode. An interval from after dialing until sending the answer tone can be set by inserting a pause (,) before the reverse (R). If there is an R in the dial string, subsequent chara Sn Dials the telephone number, specified by registration number n, which was stored in nonvolatile memory by the &Zn command. The value for n is specified by 0 to 3 (if there is no specification, it is interpreted as n = 0). If there is an Sn in the dial string and the character after S is 0 to 3, the dial string (telephone number) of the specified registration number is substituted for Sn and dialed. If the character after S is outside of the characters 0 to 3, or if there is T Temporarily sets the subsequent dial string to the tone dial format.		c is the dial string. The dial string comprises a combination of dial characters and control characters. The maximum number of characters is 40 (D + 39). However, if L or Sn are used, a dial string of greater than 40 characters is possible. L and Sn can store up to 63 and 33 characters, respectively. L is ignored if the telephone numbers are not in memory, such as after a reset or power ON. Sn is ignored if the telephone number is not registered in the registration number of the nonvolatile memory specified by n. If there is an L or Sn in the dial string, the dial string stored in memory is displayed when that L or Sn is executed (however, this is dependent on the Qn command).

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
Dc	W Detect a dial tone Regardless of the ATXn command entered, if a dial tone is detected during the time set in the S7 register, the next dial string is processed. If a dial tone is not detected, a "NO DIALTONE" is returned. J When MNP Class 10 is enabled, the starting communication carrier speed for the handshaking is performed at 1,200 bps (V.22). [Equivalent to AT∗H1 command.] K When MNP Class 10 is enabled, the transmission level during communication is changed temporarily according to the line conditions. [Equivalent to the AT)M1 command] (Characters other than those above are completely ignored.)		J and K are ignored if MNP Class 10 is disabled (AT-N1).

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
En	Selects whether to echo when in the command mode. n = 0 The command input characters are not echoed. n = 1 The command input characters are echoed.	1	
Hn	Controls the connection to the line. n = 0 Set the line OFF (on hook) n = 1 Set the line ON (off hook)		
In	dentification of the DCE. n = 0 Display the product code (14400) n = 1 Display the ROM checksum. n = 2 Perform a ROM check sum and display OK or ERROR. n = 19 Display the ROM version. <CR><LF>MSC2121A Vx.xx MMM.YYYY<CR><LF> <CR><LF>Copyright (C) 1995 Oki Electric Industry Co., Ltd.<CR><LF>		
Mn	Controls operation of the monitor speaker. n = 0 The speaker is always OFF n = 1 The speaker is ON from the connection to the line (off hook) until handshaking is completed. n = 2 The speaker is always ON. n = 3 The speaker is ON only during handshaking.	1	
Nn	Selects the automatic fallback function for the modem-modem communication carrier speed. The maximum communication speed is determined by the S37 register. n = 0 Disables the automatic fallback function n = 1 Enables the automatic fallback function If the automatic fallback function is enabled, the modem automatically falls back to the communication carrier speed of the remote modem when handshaking and retraining. However, if connected in the direct mode, automatic fallback is not performed when retraining regardless of the setting.	1	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
On	Return from the on-line command mode to the data mode. n = 0 Switch from the on-line command mode to the data mode. n = 1 When switching from the on-line command mode to the data mode, execute the retraining sequence. If this command is issued from the command state after going off hook (not yet connected to the remote modem), the DCE tests the connection in the mode specified when on hook (D, A, DxxxR commands).		
P	Sets dialing to the pulse dial method.		Factory setting is pulse dial.
Qn	Selects whether to send the result code. n = 0 Send a result code. n = 1 Do not send a result code.	0	
Sr	Sets the pointer value for the S-register to the value r.		Refer to Appendix C.
Sr?	Returns the contents of the S-register indicated by r.		
Sr=d	Sets the contents of the S-register indicated by r to the value d.		
=d	Sets the contents of the S-register indicated by the current pointer value to the value d.		
?	Returns the contents of the S-register indicated by the current pointer value.		
T	Sets the dialing mode to tone dialing.		Factory setting is pulse dial.
Vn	Type of result code. n = 0 Short form result code (numeric). n = 1 Long form result code (character string/word).	1	Refer to the section on result codes.

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
Wn	Selects the connect result code. n = 0 DTE-DCE terminal speed CONNECT xxxx However, when in the direct mode or terminal speed variable mode (AT \ J1), the communication carrier speed is displayed after the CONNECT display. n = 1 Carrier speed CARRIER xxxx Protocol PROTOCOL : xxxx Data compression COMPRESSION : xxxx DTE-DCE terminal speed CONNECT xxxx n = 2 Communication carrier speed CARRIER xxxx n = 3 DTE-DCE terminal speed CONNECT xxxx/REL Displays the DTE-DCE speed and error correction connection. In the normal mode and direct mode, only CONNECT xxxx is displayed. In the terminal speed variable mode (AT \ J1), the communication carrier speed is displayed after CONNECT. Communication carrier speed: 300, 1200, 2400, 4800, 7200, 9600, 12000, 14400 Protocol LAPM, ALT, NONE Data compression V. 42bis, class5, NONE DTE-DCE terminal speed: 300, 1200, 2400, 4800, 7200 9600, 12000, 14400, 19200 28800, 38400, 57600	0	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
Xn	Selects extended result codes. n = 0 Return basic result codes (result code numbers: 0 to 4, 8). The dial tone and busy tone are not detected and the only connect result code is CONNECT. n = 1 Return basic + extended result codes (result code numbers: 0 to n = 2 5, 8 to 80). The dial tone and busy tone are not detected. n = 3 Return basic + extended result codes (result code numbers: 0 to n = 4 6, 8 to 80). The busy tone is not detected. Return basic + extended result codes (result code numbers: 0 to 5, 7 to 80). The dial tone is not detected. Return basic + extended result codes (result code numbers: all numbers). A dial tone is detected by a continuous signal longer than 100 ms within 5 seconds after going off hook. The second dial tone is detected by a continuous signal longer than 100 ms starting from after dialing is completed (starting point of W) and during the time set n the S7 register. After the detection of a busy tone, if the tone signal turns ON and OFF every 500 ms ±150 ms continuously for 3 seconds, it is judged to be BUSY.	4	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
Yn	Selects the call abort function. n = 0 Disables the call abort function. n = 1 Enables the call abort function. Call Abort Function If an ON → OFF change is detected in the DTR (ER) signal when an ATH (ATH0) command is received from the DTE, or when an AT&D2 command is set, the following operation is performed: If the modem is in the direct mode with the communication carrier speed at 2,400 bps or lower, a 4-second long space is transmitted to the remote modem, and the line is dropped (invalid when in a mode other than the direct mode). If the communication carrier speed is 4,800 bps or greater, a call abort signal is sent to the remote modem and the line is dropped. If the modem is in the direct mode and the communication carrier speed is 2,400 bps or below, the line is dropped if a long space of 1.6 seconds or greater is received from the remote modem (invalid when in a mode other than the direct mode). If the communication carrier speed is 4,800 bps or greater, the line is dropped, regardless of this setting, if a call abort signal is received from the remote modem.	0	
Zn	Initializes the DCE the same as when turning on the power supply. n = 0 Initializes the DCE with the contents of profile number 0 in n = 1 nonvolatile memory. Initializes the DCE with the contents of profile number 1 in nonvolatile memory.		
&Cn	Controls the DCD (CD) signal n = 0 The DCD (CD) signal is always ON. n = 1 The DCD (CD) signal is ON or OFF according to whether a carrier is detected.	0	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
&Dn	Controls the DCE by the state of the DTR (ER) signal. n = 0 Ignore the DTR (ER) signal (DTR (ER) signal is considered to be always ON). n = 1 When in the data mode, the modem switches to the on-line command mode when the DTR (ER) signal changes from ON to OFF. n = 2 When in the data mode, the modem disconnects the line and switches to the command mode when the DTR (ER) signal changes from ON to OFF. Further, the modem does not auto answer when the DTR (ER) signal is OFF. n = 3 When in the data mode, the DCE is initialized (the same as when turning the power ON) when the DTR (ER) signal changes from ON to OFF.	0	
&F	Initializes the S-registers and commands to the factory set values.		
&Gn	Controls the guard tone. n = 0 No guard tone. n = 1 There is a 550 Hz guard tone. n = 2 There is a 1,800 Hz guard tone.	0	
&Ln	Type of line format used. n = 0 A general telephone switched line is used. n = 1 A dedicated line is used. The handshake uses only a retraining sequence, and the modem starts sending a carrier signal at the target speed one second after going off hook, regardless of whether the modem is in originate or answer mode.	0	
&Mn	Sets the data communication mode. n = 0 Asynchronous communication mode. n = 1 Synchronous mode 1 n = 2 Synchronous mode 2 n = 3 Synchronous mode 3	0	This has a higher priority than the AT\Nn command.
&Pn	Selects the mode of the pulse dial. n = 0 10 pps (39%) USA specification n = 1 10 pps (33%) UK and Japan specifications n = 2 20 pps (33%) Japan specification	1	
&Rn	Controls the CTS (CS) signal. n = 0 When in the data mode, data is output with the delay set in register S26 when an RTS is input. n = 1 The RTS signal is ignored.	0	Synchronous.
&Sn	Controls the DSR signal. n = 0 The DSR (DR) signal is always ON. n = 1 The DSR (DR) signal is sent in accordance with the ITU-T recommendation for each modem function.	0	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
&Tn	Selects the loopback test mode. n = 0 Terminates the loopback test mode. n = 1 The DCE loops back the data from the DTE between the modulator unit and the demodulator unit and sends it to the DTE. (Local Analog Loopback test: LAL) n = 3 The DCE loops back the data received from the remote modem and transmits the data to the remote modem. (Local Digital Loopback test: LDL) n = 4 The DCE receives data from the remote modem. When a remote digital loopback (RDL) ID signal is received, a verification signal is sent to the remote modem. Afterwards, the data received from the remote modem is looped back by the digital unit and transmitted to the remote modem. When a terminate signal is received from the remote modem, the remote digital loopback test (RDL) is terminated. n = 5 Even if the remote digital loopback test (RDL) ID signal is received from the remote modem, the DCE ignores it and does not transmit a verification signal to the remote modem. n = 6 The DCE transmits the remote digital loopback test (RDL) ID signal to the remote modem. Upon reception of the verification signal from the remote modem, the DCE starts the test. If a verification test is not received from the remote modem, ERROR is displayed and the test is stopped. (Remote Digital Loopback test: RDL) n = 7 The DCE transmits the remote digital loopback test (RDL) ID signal to the remote modem. Upon receiving a verification signal from the remote modem, the DCE transmits specific data in the DCE itself to the remote modem, and the data is looped back by the remote modem. The received specific data is verified, and the errors are counted. When the test is terminated, the error count is displayed. If the verification signal is not received from the remote modem, display ERROR and stop the test. (RDL with self) n = 8 Specific data from the DCE itself is looped back between the modulator unit and demodulator unit. The specific data is verified and the errors are counted. When the test is terminated, the error count is displayed. (LAL with self)	0, 4	Valid only in direct mode.

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
&Un	Controls the enabling of trellis coding for ITU-T V.32bis at a 9,600 bps communication carrier speed. n = 0 Trellis coding enabled. n = 1 Trellis coding disabled.	0	
&V	Displays the current state of the DCE settings. Displays the current command setting, the S-registers (user, profiles 0, 1) registered in nonvolatile memory, and the transmission level.		Refer to the section on display formats.

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
&Wn	Writes the current contents of the specified S-register to nonvolatile memory. n = 0 n = 0 Writes to user profile number 0. n = 1 n = 1 Writes to user profile number 1.		Object S-register numbers: 0, 6 to 10, 12, 14, 18, 21 to 23, 25 to 27, 34 to 48, 40 to 46, 48
&Xn	Selects the communication clock used in the synchronous mode. n = 0 Use ST2 from the modem. n = 1 Use ST1 from the terminal. n = 2 Use the receive clock RT from the modem.	0	Synchronous
&Yn	Selects the user profile number in nonvolatile memory used for the default settings when turning the power ON. n = 0 When turning the power ON, initialize with the profile number 0. n = 1 When turning the power ON, initialize with the profile number 1.	0	
&Zn = c	Writes the character string (c) after the equal sign, as a telephone number, to the nonvolatile memory registration number specified by n. n = 0 Write to nonvolatile memory number 0. n = 1 Write to nonvolatile memory number 1. n = 2 Write to nonvolatile memory number 2. n = 3 Write to nonvolatile memory number 3. The character string c is a maximum of 33 characters. If it is 34 characters or greater, the characters up to the 33rd character are written to nonvolatile memory, and the 34th and beyond are ignored. If c is omitted, the contents of the specified registration number in nonvolatile memory is cleared.	(clear)	The telephone number c conforms to the Dc command.
¥An	Selects the maximum block size in MNP reliable mode. n = 0 The maximum block size is 64 bytes. n = 1 The maximum block size is 128 bytes. n = 2 The maximum block size is 192 bytes. n = 3 The maximum block size is 256 bytes.	3	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
¥Bn	Sends a break signal to the remote modem. n = 0 Transmits a 300 ms break signal (long space). n = 1 to 9 Transmits an n × 100 ms break signal (long space). When in the data mode of the normal or reliable modes, this functions as a command which transmits a break to the remote modem. If in the data mode of the direct mode, an ERROR is returned. Note: The default value of this command is 0. Values set subsequently are stored in internal memory, but are not included in the S-registers and are not stored in nonvolatile memory. Therefore, the following explanations are for a break transmission by means of \Bn. However, even if a break signal is received directly from the DTE, the \Bn value at that time is used. Normal Mode A break (space) signal is sent to the line for an interval set by n on the transmit side. The receive side receives the break signal and the modem sends a break signal to the DTE for a fixed time of 300 ms. V.42/V.42bis Modes The break information is delivered in accordance with the break processing (\Kn) and break length (\Bn) on the transmit side. The break processing is executed on the receive side according to the frame received from the remote modem. The break signal to the DTE is sent in accordance with the break length information of the frame from the remote modem (100 to 900 ms). MNP4/MNP5 Modes When transmitting, only the break processing mode (\K) is delivered. When receiving, break processing is performed according to the information from the remote modem. The break signal to the DTE is fixed at 300 ms.		Valid only when in normal mode and reliable mode.

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
¥Cn	Selects the automatic determination in auto reliable mode. n = 0 The receive data is not buffered. If there is no reliable request n = 1 even after 8 seconds have elapsed, the modem connects in n = 2 normal mode. Two-hundred bytes or 8 seconds of receive data is buffered. If a reliable request is received during that time, the data in the buffer is discarded and the modem connects in reliable mode. If a reliable request is not received, the modem connects in normal mode and sends the data in the buffer to the DTE. The receive data is not buffered. If an auto reliable fallback character is received, or if there is no reliable request even after 8 seconds have elapsed, the modem connects in normal mode.	0	Valid only in the answer mode when the AT\N3 or AT\N7 command (auto reliable mode) is set.
¥F	Displays all telephone numbers registered in nonvolatile memory and the last dialed telephone number.		Refer to the section on display formats.
¥Gn	Sets the flow control with the remote modem. n = 0 No flow control. n = 1 Flow control based on XON/XOFF codes.	0	Valid only when in normal mode.

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
¥Jn	Sets the DTE-DCE terminal speed. n = 0 The DTE-DCE terminal speed is fixed. When in the command n = 1 mode, the speed is in accordance with the terminal speed. Follows the communication carrier speed at the time when the connection is completed. The DTE needs to reset the terminal speed according to the "CONNECT xxxx" speed displayed.	0	Valid only in the normal mode and reliable mode.
¥Kn	Sets the processing of the break signal. • If a break signal (long space) is received from the DTE: a: In the data mode state of the normal/reliable mode n = 4 The modem switches to the on-line command state without transmitting a break signal to the remote modem. n = 5 The modem transmits a break signal after transmitting he data remaining in the transmit buffer to the remote modem (nondestructive, nonexpedited). b: In the on-line command mode state of the normal/reliable mode (includes break processing based on the AT\Bn command from the DTE). n = 4, 5 The modem transmits the break information after transmitting the data remaining in the transmit buffer to the remote modem (nondestructive, nonexpedited). After processing the break signal, the modem remains in the on-line command mode state. c: Data mode state of direct mode. n = 4 The modem immediately transmits a break signal to the remote modem and switches to the on-line command mode state. n = 5 The modem immediately transmits a break signal to the remote modem and remains in the data mode. Break signals from the DTE are ignored in the on-line command state when in the direct mode. • If a break signal (long space) is received from the remote modem while in the data mode of the normal mode: n = 4, 5 The modem transmits a break signal (long space) after sending the data remaining in the receive buffer to the DTE (nondestructive, nonexpedited).	5	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
¥Kn	Even if a break signal (long space) is received from the remote modem while in the on-line mode, it is ignored. • If a frame for a break signal is received from the remote modem while in the data mode of the reliable mode, processing is performed according to the commands in that frame. If a frame for a break signal is received from the remote modem while in the on-line command mode, it is processed when the modem returns to the data mode state. • If a break signal (long space) is received from the remote modem while in the data mode of the direct mode, the break signal (long space) is sent, as is, to the DTE. Even if a break signal (long space) is received from the remote modem while in the on-line command mode, it is ignored.	5	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
¥Nn	Sets the operation of the modem. n = 0 Modem operates in normal mode (with buffering). V.42 and MNP are not used. n = 1 Modem operates in direct mode (without buffering). V.42 and MNP are not used. The DTE needs to reset the terminal speed according to the speed displayed in "CONNECT xxxx." n = 2 Modem operates in V.42/MNP reliable mode. The modem tries to connect using V.42 and MNP, in that order. If it cannot connect, it drops the line. n = 3 Modem operates in V.42/MNP auto reliable mode. The modem tries to connect using V.42 and MNP, in that order. If it cannot connect, the modem connects in direct mode if the \J1 command is set. Otherwise, it connects in normal mode. n = 4 The modem operates in V.42 reliable mode. If it cannot connect in V.42, it drops the line. n = 5 The modem operates in V.42 reliable mode without using the detection phase. If it cannot connect in V.42, it drops the line. n = 6 The modem operates in MNP reliable mode. If it cannot connect in MNP, it drops the line. n = 7 The modem operates in MNP auto reliable mode. The modem tries to connect in MNP. If it cannot connect, it connects in direct mode if the \J1 command is set. Otherwise, it connects in normal mode.	3	
¥Qn	Selects the DTE-DCE flow control. n = 0 No flow control. n = 1 Bidirectional flow control based on XON/XOFF codes. n = 2 Unidirectional flow control from the DCE side based on the CTS (CS) signal line. n = 3 Bidirectional flow control based on the CTS (CS) signal line and RTS (RS) signal line.	2	Invalid when in direct mode.
¥Sn	Displays the current DCE settings. n = 0 Display first screen. n = 1 Display second screen.		Refer to the section on display formats.
¥Tn	Sets the inactivity timer when in reliable mode. n = 1 to 90 (min); n = 0 indicates no timer function. If, for the above time setting, no transmit data is input from the local DTE and there is also no receive data from the remote modem, the line is dropped.	0	

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
¥Xn	Sets the transparency of the XON/XOFF codes from the DTE. n = 0 The XON/XOFF codes from the DTE are not transmitted to the n = 1 remote modem. The XON/XOFF codes from the DTE are transmitted to the remote modem.	0	Valid when AT\Q1 is set in normal mode.
%Ac	Sets the MNP fallback character. c = 0 to 127 Set by a decimal ASCII code.	0	Used when setting AT\C2 in MNP mode.
%Cn	Sets whether data is compressed. n = 0 Data is not compressed. n = 1 Data is compressed by V.42bis or MNP Class 5.	1	
%En	Sets whether auto retraining is performed. n = 0 No auto retraining. n = 1 Auto retraining.	1	
%R	Displays the current contents of all S-registers.		Refer to the section on display formats.

Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
–Nn	Sets whether MNP Class 10 is enabled. n = 0 MNP Class 10 is enabled. The settings of the -Kn, ∗Hn, and) n = 1 Mn commands become enabled. MNP Class 10 is disabled. The settings of the -Kn, ∗Hn, and) Mn commands are ignored and treated as -K0, ∗H0 and)M0.	1	
–Kn	Sets whether extended MNP service is enabled. n = 0 Extended MNP service disabled. n = 1 Extended MNP service enabled. The originate-side modem monitors the MNP detection pattern (MDP) in the V.42 detection phase. The answer-side modem transmits the MDP after ODP detection, thus making MNP protocol negotiation possible. Further, the V.42bis compression function can be used in the MNP connection state.	0	
∗Hn	Selects the communication carrier speed when handshaking. n = 0 Connects at the communication carrier speed set in the DCE n = 1 and performs protocol negotiation. First connects at a communication carrier speed of 1,200 bps (V.22) when handshaking, and performs protocol negotiation. If the line conditions are judged to be good by the DCE itself, the communication carrier speed is changed to 2,400 bps (V.22bis). If the line conditions are still good, the communication carrier speed is changed to 4,800 bps (V.32bis). In the same manner, the communication carrier speed is changed to 7,200 bps (V.32bis), 9,600 bps (V.32bis), 12,000 bps (V.32bis) and 14,400 bps (V.32bis). Data communication is started. (Initial Speed-up Shift Function)	0	

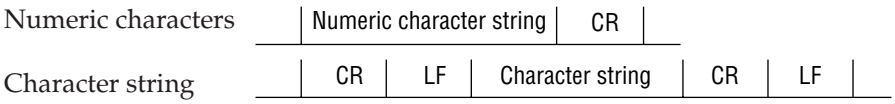
Note: If n is omitted, it is interpreted as n = 0.

Command	Function	Initial Value	Remarks
)Mn	Sets the variation of the transmission level during communication. n = 0 DCE does not change the transmission level during communication. n = 1 DCE changes the transmission level during communication according to the line conditions. If the DCE is used in a mobile telephone, etc., the demodulation state information of the remote modem is received and, based on that information, the transmission level is changed to one most suitable for the remote modem.	0	

Note: If n is omitted, it is interpreted as n = 0.

RESULT CODES

When the DCE is in asynchronous command mode result codes are returned to the DTE as commands are executed. There are two types of result codes which can be selected by the Vn command. Further, the Qn command selects whether to return result codes.
The following shows the format of the two types of result codes.



LIST OF RESULT CODES

Numeric Character	Character String (Word)	Meaning
0	OK	Commands are executed normally; modem returns to command mode state.
1	CONNECT	Connection is established; modem switches from command mode to data mode.
2	RING	Ring signal detected.
3	NO CARRIER	Carrier not detected; carrier dropped.
4	ERROR	Command abnormal; there is an error in the command parameter.
5	CONNECT 1200	The connection is established at a DTE - DCE terminal speed of 1,200 bps.
6	NO DIALTONE	Dial tone not detected.
7	BUSY	Busy signal detected; dial oscillation spacing is inadequate.
8	NO ANSWER	Silence state not detected by the @ parameter.
10	CONNECT 2400	Connection established at a DTE-DCE terminal speed of 2,400 bps.
11	CONNECT 4800	Connection established at a DTE-DCE terminal speed of 4,800 bps
12	CONNECT 7200	Connection established at a DTE-DCE terminal speed of 7,200 bps
13	CONNECT 9600	Connection established at a DTE-DCE terminal speed of 9,600 bps
14	CONNECT 12000	Connection established at a DTE-DCE terminal speed of 12,000 bps
15	CONNECT 14400	Connection established at a DTE-DCE terminal speed of 14,400 bps
16	CONNECT 19200	Connection established at a DTE-DCE terminal speed of 19,200 bps
17	CONNECT 28800	Connection established at a DTE-DCE terminal speed of 28,800 bps
18	CONNECT 38400	Connection established at a DTE-DCE terminal speed of 38,400 bps
19	CONNECT 57600	Connection established at a DTE-DCE terminal speed of 57,600 bps
22	CONNECT 1200/REL	Connection established at a DTE-DCE terminal speed of 1,200 bps (with error correction)
23	CONNECT 2400/REL	Connection established at a DTE-DCE terminal speed of 2,400 bps (with error correction)
24	CONNECT 4800/REL	Connection established at a DTE-DCE terminal speed of 4,800 bps (with error correction)
25	CONNECT 7200/REL	Connection established at a DTE-DCE terminal speed of 7,200 bps (with error correction)
26	CONNECT 9600/REL	Connection established at a DTE-DCE terminal speed of 9,600 bps (with error correction)
27	CONNECT 12000/REL	Connection established at a DTE-DCE terminal speed of 12,000 bps (with error correction)
28	CONNECT 14400/REL	Connection established at a DTE-DCE terminal speed of 14,400 bps (with error correction)
29	CONNECT 19200/REL	Connection established at a DTE-DCE terminal speed of 19,200 bps (with error correction)

22-32 Error Correction Mode

*: The speed display xxxx of "CONNECT xxxx" and "CARRIER xxxx," "PROTOCOL: xxxx" and "COMPRESSION: xxxx" are determined by the Xn and Wn commands.

Numeric Character	Character String (Word)	Meaning
30	CONNECT 28800/REL	Connection established at a DTE-DCE terminal speed of 28,800 bps (with error correction)
31	CONNECT 38400/REL	Connection established at a DTE-DCE terminal speed of 38,400 bps (with error correction)
32	CONNECT 57600/REL	Connection established at a DTE-DCE terminal speed of 57,600 bps (with error correction)
40	CARRIER 300	Connection established at a communication carrier speed of 300 baud. (V.21/Bell 103J)
42	CARRIER 1200	Connection established at a communication carrier speed of 1,200 baud. (V.22/Bell 212A)
43	CARRIER 2400	Connection established at a communication carrier speed of 2,400 baud. (V.22bis)
44	CARRIER 4800	Connection established at a communication carrier speed of 48,00 baud. (V.32)
45	CARRIER 7200	Connection established at a communication carrier speed of 7,200 baud. (V.32bis)
46	CARRIER 9600	Connection established at a communication carrier speed of 9,600 baud. (V.32/V.32bis)
47	CARRIER 12000	Connection established at a communication carrier speed of 12,000 baud. (V.32bis)
48	CARRIER 14400	Connection established at a communication carrier speed of 14,400 baud. (V.32bis)
66	COMPRESSION : class 5	The Class 5 MNP standard is used for data compression.
67	COMPRESSION : V.42bis	The V.42bis ITU-T standard is used for data compression.
69	COMPRESSION : NONE	Data compression not used.
76	PROTOCOL : NONE	Error correction protocol not used.
77	PROTOCOL : LAPM	The V.42 LAP-M ITU-T standard is used for the error correction protocol.
80	PROTOCOL : ALT	The Class 4 MNP standard is used for the error correction protocol.
82	PROTOCOL : ALT+CELLULAR	The Class 10 MNP standard is used for the communication protocol. The Class 4 MNP standard is used for the error correction protocol.

*: The speed display xxxx of "CONNECT xxxx" and "CARRIER xxxx," "PROTOCOL: xxxx" and "COMPRESSION: xxxx" are determined by the Xn and Wn commands.

DISPLAY FORMAT

• The following is displayed by executing the AT&V command.

```
   DTE SPEED & CHARACTER FORMAT : 9600 bps 8bit Non-Parity 1Stop-bit
   ACTIVE- :    B0 E1 M1 N1 Q0 V1 W0 X4 &C0 &D0 &G0 &L0 &M0 &P1 &S0 &T4 &U0 &Y0
   PROFILE      %C1 %E1 \A3 \C0 \G0 \J0 \K5 \N3 \Q2 \X0 -N1 -K0 *H0 )M0
                S00 = 000 S01 = 000 S02 = 043 S03 = 013 S04 = 010 S05 = 008 S06 = 004 S07 = 050
                S08 = 002 S09 = 006 S10 = 014 S12 = 050 S14 = 170 S18 = 000 S21 = 004 S22 = 244
                S23 = 059 S25 = 005 S26 = 001 S27 = 000 S36 = 007 S37 = 000 S38 = 020 S39 = 064
                S40 = 055 S41 = 153 S42 = 024 S43 = 000 S44 = 000 S46 = 136 S48 = 007 S49 = 000
   STORED- :    B0 E1 M1 N1 Q0 V1 W0 X4 &C0 &D0 &G0 &L0 &M0 &P1 &S0 &T4 &U0
   PROFILE      %C1 %E1 \A3 \C0 \G0 \J0 \K5 \N3 \Q2 \X0 -N1 -K0 *H0 )M0
   No.0         S00 = 000 S06 = 004 S07 = 050 S08 = 002 S09 = 006 S10 = 014 S12 = 050 S14 = 170
                S18 = 000 S21 = 004 S22 = 244 S23 = 059 S25 = 005 S26 = 001 S27 = 000 S36 = 007
                S38 = 020 S39 = 064 S40 = 055 S41 = 153 S42 = 024 S43 = 000 S44 = 000 S46 = 002
                S48 = 007 S49 = 000
   STORED- :    B0 E1 M1 N1 Q0 V1 W0 X4 &C0 &D0 &G0 &L0 &M0 &P1 &S0 &T4 &U0
   PROFILE      %C1 %E1 \A3 \C0 \G0 \J0 \K5 \N3 \Q2 \X0 -N1 -K0 *H0 )M0
   No.1         S00 = 000 S06 = 004 S07 = 050 S08 = 002 S09 = 006 S10 = 014 S12 = 050 S14 = 170
                S18 = 000 S21 = 004 S22 = 244 S23 = 059 S25 = 005 S26 = 001 S27 = 000 S36 = 007
                S38 = 020 S39 = 064 S40 = 055 S41 = 153 S42 = 024 S43 = 000 S44 = 000 S46 = 002
                S48 = 007 S49 = 000
   LEVEL   :    TX CARRIER = -15dBm
   REMAIN  :    PRODUCTION = MSC2121A
                VER = 1.00
OK
```

• The following is displayed by executing the AT\F command.

```
   STORED DIAL (&Z0) = 03-1234-5678
   STORED DIAL (&Z1) =
   STORED DIAL (&Z2) =
   STORED DIAL (&Z3) =

              LAST DIAL =
OK
```

• The following is displayed by executing the AT%R command.

```
   REG  DEC  HEX    REG  DEC  HEX    REG  DEC  HEX    REG  DEC  HEX    REG  DEC  HEX
   S00  000  00H    S00  014  0EH    S20  ---  ---    S30  ---  ---    S40  055  37H
   S01  000  00H    S11  ---  ---    S21  004  04H    S31  ---  ---    S41  153  99H
   S02  043  2BH    S12  050  32H    S22  244  F4H    S32  ---  ---    S42  024  18H
   S03  013  0DH    S13  ---  ---    S23  059  3BH    S33  ---  ---    S43  000  00H
   S04  010  0AH    S14  170  AAH    S24  ---  ---    S34  015  0FH    S44  000  00H
   S05  008  08H    S15  ---  ---    S25  005  05H    S35  009  09H    S45  000  00H
   S06  004  04H    S16  000  00H    S26  001  01H    S36  007  07H    S46  002  02H
   S07  050  32H    S17  ---  ---    S27  000  00H    S37  000  00H    S47  ---  ---
   S08  002  02H    S18  000  00H    S28  ---  ---    S38  020  14H    S48  007  07H
   S09  006  06H    S19  ---  ---    S29  ---  ---    S39  064  40H    S49  000  00H
OK
```

• The following is displayed by executing the AT\Sn command.

Display of the first screen [AT\S or AT\S0]

```
    DTE Speed           9600
    DCE Speed           Off-line
    DCE Type            DATA            AT+FCLASS=0
    Modem Type          ITU-T           ATB0
    Line Mode           GSTN            AT&L0
    Auto Answer         Off             S0=000
    Dial Mode           Pulse           ATP
    Dial Speed          33% 10PPS       AT&P1
    Command Echo        On              ATE1
    Result Code         On              ATV1
    Extended CONNECT                    ATW0
    Extended Result                     ATX4
    Speaker Control                     ATM1
    DCD Control                         AT&C0
    DTR Control                         AT&D0
    DSR Control                         AT&S0
OK
```

Display of the second screen [AT\S1]

```
    Modem Mode          Auto V. 42/MNP  AT\N3
    DTE Speed Adjust    Off             AT\J0
    Block Size          256             AT\A3
    Break Control                       AT\K5
    Break length                        AT\B003
    Auto Buffer                         AT\C0
    Fall-Back Code                      AT%A000
    Flow (DTE-DCE)      CTS             AT\Q2
    Flow (DCE-DCE)      Off             AT\G0
    Pass Xon/Xoff       Off             AT\X0
    Watch timer         Off             AT\T000
    Data Compression    On              AT%C1
    V. 32bis trellis    On              AT&U0
    Cellular            Off             AT-N1
OK
```

S-REGISTER SETTINGS

The S-register can display and change the register contents by means of the following command examples:

Example 1	ATS0 = 4:	Sets the S0 register to 4.
Example 2	ATS0:	Stores 0 in the register pointer.
	AT = 4:	Sets 4 to the register specified at the register pointer (S0).
Example 3	ATS0?:	Displays the contents of the S0 register.
Example 4	AT?:	Displays the current value of the register pointer stored in memory.

Note: If AT = ? is executed, the register number, pointed to by the register pointer currently stored in memory, is set to 0, and that set value (0) is displayed.

MNP CLASS 10 OPERATION

The MNP Class 10 protocol has four main functions for performing modem communication in a state which is best suited to the line conditions.

- Initial Speed-up Shift Function
  This function is enabled by setting the AT∗H1 command.
  If AT∗H0 is set, the modem performs handshaking with the remote modem at the communication carrier speed set in the DCE, and then performs protocol negotiation.
  If AT∗H1 is set, hand shaking is performed with the remote modem at a communication carrier speed of 1,200 bps (V.22), since this speed performs well even if line noise is present and improves the probability of connecting properly even with poor line conditions. The modem performs protocol negotiation. Afterwards, both modems judge the line condition by means of the reception condition.
  If the line conditions are judged to be unsuitable when the communication carrier speed is at 2,400 bps (V.22bis), the modem starts data communication as is, at a communication carrier speed of 1,200 bps.
  If the line conditions are satisfactory, the communication carrier speed is shifted upwards to 2,400 bps and both modems judge the line conditions by means of the reception condition.
  If the line conditions are judged to be unsuitable when the communication carrier speed is at 4,800 bps (V.32bis), the modem starts data communication as is, at a communication carrier speed of 2,400 bps.
  If the line conditions are satisfactory, the communication carrier speed is shifted upwards to 4,800 bps and both modems judge the line conditions by means of the reception condition.
  The above operation is performed for 4,800 bps (V.32bis), 9,600 bps (V.32bis), 12,000 bps (V.32bis) and 14,400 bps (V.32bis), and data communication is performed at the highest communication carrier speed suited to the current line conditions.

- Robust Auto Reliable Function
  The DCE performs the following processing during protocol negotiation in order to raise the protocol connectivity as much as possible, even if the line conditions are poor.

  a) If in originate mode:
     * If there is no response from the remote modem to a link request frame sent, the DCE retransmits the link request frame a maximum of 15 times at 2 second intervals.
     * The link verification frame is transmitted twice during negotiation.
     * The link disconnect frame is transmitted twice in order to refuse the link establishment.

  b) If in answer mode:
     * If even one SYN code is detected in the data received from the remote modem, the link establishment timer is increased to 30 seconds.
     * The link disconnect frame is transmitted twice in order to refuse the link establishment.

• Aggressive Adaptive Packet Size Function

If a data error is generated in a frame due to line noise, etc. during data communication, the DCE reduces the frame size (shortens the frame transmission time) and holds the qualitative drop in the transmission throughput to a minimum by actively changing the frame size. Thus, data communication is performed in a state best suited to the given line conditions.

The DCE monitors the frequency with which data errors are generated and executes this function in cases such as when the line conditions change gradually.

• Dynamic Speed Shift Function

During the protocol negotiation, the DCE learns which modem standards the remote modem supports, and freely changes to those modem standards during data communication.

The DCE monitors the frequency with which data errors are generated and executes this function in cases such as when the line conditions change suddenly.

For example, if a sudden line degradation is detected during data communication at a communication carrier speed of 14,400 bps (V.32bis), the DCE requests a change to a communication carrier speed of 12,000 bps (V.32bis), thus rapidly dealing with the poor line condition.

Further, conversely, if an improvement in the line condition is detected during data communication at a communication carrier speed of 12,000 bps, the DCE requests to the remote modem a return to a communication carrier speed of 14,400 bps, thus raising the qualitative transmission throughput.

Appendix B
EIA/TIA-578 (Class 1) Facsimile Commands

OVERVIEW

The EIA/TIA-578 (Class 1) fax commands are added to the AT command set, and begin with <AT> or <at>, the same as for AT commands. The <character string> up to the carriage return is interpreted as commands and executed. The result code is returned to the DTE.
If multiple commands are sent in the same character string, commands are separated by a colon ":" (3Bh).
To switch the modem from the data modem to the Class 1 fax mode, the AT+FCLASS=1 command is executed. To return to the data modem, the AT+FCLASS=0 command must be executed.
The command structure and result codes conform to the AT command set. When inputting commands, communication with the DTE is handled in asynchronous mode, the same as for AT commands. When AT (at) is input, the DTE-DCE terminal speed and character format are automatically determined.
To execute Class 1 fax communication, application software (G3 fax communication software) is used which conforms to the EIA/TIA-578 (Class 1) fax command standards.

DTE-DCE TERMINAL SPEED AND CHARACTER FORMAT

The DTE-DCE terminal speed and character format are the same as for AT commands when in the EIA/TIA-578 command mode. However, to execute fax communication, the DTE-DCE terminal speed must be 19,200 bps or greater, and the character format must have 1 start bit, 8 data bits, no parity, 1 stop bit and a character length of 10.

LIST OF EIA/TIA-578 (CLASS 1) FAX COMMANDS

Command	Function	Initial Value	Remarks
+ FCLASS = ?	Returns all service classes supported by the DCE. Parameter: <0, 1> 0 = Data communication 1 = Fax communication (Class 1 fax commands)		
+ FCLASS?	Returns the service class currently set in the DCE. 0 = Data communication. 1 = Fax communication (Class 1 fax commands).		
+ FCLASS = n	Switches the DCE to the specified service class. n = 0 Data communication. n = 1 Fax communication (Class 1 fax commands).	0	

Note: If n and t are not specified, it results in an error.

Command	Function	Initial Value	Remarks
+FTS=t	Stops transmission and returns the OK result code after the specified time. Specified time = t x 10 ms; t = 0 to 255		
+FRS=t	Detects a continuous silence for the specified time and returns the OK result code. Specified time = t x 10 ms; t = 0 to 255		
+FTM=m	Transmits fax data by the modulation method specified by m.		*1
+FTM=?	Returns all fax data modulation methods supported by the DCE. Parameter: <24, 48, 72, 73, 74, 96, 97, 98, 121, 122, 145, 146>		
+FRM=m	Receives the fax data by the demodulation method specified by m.		*1
+FRM=?	Returns all fax data demodulation methods supported by the DCE. Parameter: <24, 48, 72, 73, 74, 96, 97, 98, 121, 122, 145, 146>		
+FTH=m	Transmits the HDLC format by the modulation method specified by m.		*1
+FTH=?	Returns all HDLC format modulation methods supported by the DCE. Parameter: <3, 24, 48, 72, 73, 74, 96, 97, 98, 121, 122, 145, 146>		
+FRH=m	Receives HDLC format by the demodulation method specified by m.		*1
+FRH=?	Returns all HDLC format demodulation methods supported by the DCE. Parameter: <3, 24, 48, 72, 73, 74, 96, 97, 98, 121, 122, 145, 146>		
+FLO=?	Returns all DTE-DCE flow control methods, when in fax communication mode, supported by the DCE. Parameter: <0, 1> 0 = Bidirectional flow control based on XON/XOFF codes. 1 = Bidirectional flow control based on the CTS (CS) signal line and RTS (RS) signal line.		
+FLO?	Returns the DTE-DCE flow control method, when in fax communication mode, currently set by the DCE. 0 = Bidirectional flow control based on XON/XOFF codes. 1 = Bidirectional flow control based on the CTS (CS) signal line and RTS (RS) signal line.		
+FLO=n	Sets the DTE-DCE flow control methods, when in fax communication mode, in the DCE. 0 = Bidirectional flow control based on XON/XOFF codes. 1 = Bidirectional flow control based on the CTS (CS) signal line and RTS (RS) signal line.	0	

*1: Refer to the "Specification of the Modulation/Demodulation Method" section regarding the setting of the modulation/demodulation method.

Note: If n and m are not specified, it results in an error.

Command	Function	Initial Value	Remarks
A	Connects the DCE to the line in the fax receive mode. The CED signal transmission and the +FTH=3 command are automatically added to the A command of the AT command.		
Dc	Dials and performs fax transmission. The CNG signal transmission and the +FRH=3 command are automatically added to the Dc command of the AT command.		
H	Disconnects the telephone line (goes on hook). If this command is executed during transmission/reception, the telephone line is disconnected (goes on hook) after stopping that transmission/reception.		

Note: If n and m are not specified, it results in an error.

SPECIFICATION OF MODULATION/DEMODULATION METHOD

The m which specifies the modulation/demodulation method in the +FTM=m, +FRM=m, +FTH=m, +FRH=m commands must be specified using the codes indicated in the table below. Further, if m is set to a question mark "?" (e.g., +FTH=?), the modem returns the codes of all supported modulation/demodulation methods to the DTE.

• List of modulation/demodulation methods used by EIA/TIA-578 (Class 1) fax commands.

Code	Moduration/ Demoduration on Method	Communication Speed	Required Conditions
3	V.21 ch.2	300 bps	It is essential to specify by the +FTH and +FRH commands.
24	V.27 ter	2400 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
48	V.27 ter	4800 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
72	V.29	7200 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
73	V.17	7200 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
74	V.17 w/st	7200 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
96	V.29	9600 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
97	V.17	9600 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
98	V.17 w/st	9600 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
121	V.17	12000 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
122	V.17 w/st	12000 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
145	V.17	14400 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.
146	V.17 w/st	14400 bps	Specify by the +FTM, +FRM, +FTH and +FRH commands.

RESULT CODES

The result codes to the EIA/TIA-578 (Class 1) commands operate under the same conditions as those for the result codes of the AT commands.
However, "NO CARRIER" (numeric character 3) does not mean that the modem changes to the on hook state.

Numeric Character	Character String (Word)	Meaning
0	OK	The command executed normally and the modem returns to the command mode state.
1	CONNECT	The modem entered the data transmission state. Data input/output is performed.
2	RING	A ring signal was detected.
3	NO CARRIER	A receive carrier was not detected. Or, since the receive carrier stopped, data reception ends. However, this does not mean that the modem has changed to the on hook state.
4	ERROR	The command is abnormal or there is an error in the command parameters. Or, the command ended abnormally. The modem returns to the command mode state. There is an abnormality in the HDLC frame. Or, data is not input from the DTE during transmission even after 5 seconds have elapsed.
6	NO DIALTONE	A dial tone was not detected.
7	BUSY	A busy tone was detected. The dial interval is insufficient.
+F4	+FCERROR	A signal was received other than one specified by the AT+FRM=x or AT+FRH=x command.

FAX COMMUNICATION PROTOCOL

If executing facsimile communication using EIA/TIA-578 (Class 1) fax commands, the DTE side must be responsible for creating and managing the modulation/demodulation method, HDLC frame configuration, various signal procedures, methods, various signal times and intervals as stipulated in ITU-T Recommendation T.30 which is the facsimile communication protocol.
This is the same for message data: the DTE must be responsible for creating and decoding the message data in the format stipulated by ITU-T Recommendation T.4 (MH, MR conversion) or T.6 (MMR conversion).

HDLC FRAME DATA

The +FTH=m command performs the following processing on the HDLC frame data input from the DTE, and transmits the data to the remote fax by the specified modulation method.

Recognize the <DLE><ETX> codes as the end of data input.
Replace the <DLE><DLE> codes with one <DLE> code.
Delete the <DLE> code and the next character.
Perform the frame check sequence and add the 2-byte FCS.
Insert the HDLC zero bit.
Continuously transmit the HDLC flag.

The +FRH=m command performs the following processing on the HDLC frame data received from the remote fax by the specified modulation method.

Delete the HDLC flag.
Delete the HDLC zero bit.
Perform the frame check sequence and verify the 2-byte FCS.
However, the 2-byte FCS is not deleted.
Replace each <DLE> code with <DLE><DLE> codes.
Add the <DLE><ETX> codes as an end of data transmission.

MESSAGE DATA

The +FTH=m command performs the following processing on the message data input from the DTE, and transmits the data to the remote modem by the specified modulation method.

Recognize the <DLE><ETX> codes as the end of data input.
Replace the <DLE><DLE> codes with one <DLE> code.
Delete the <DLE> code and the next character.

The +FRH=m command performs the following processing on the message data received from the remote fax by the specified modulation method, and sends the data to the DTE.

Replace each <DLE> code with <DLE><DLE> codes.
Add the <DLE><ETX> codes as an end of data transmission.

Note: The following recommendations, at a minimum, must be understood and followed if using the EIA/TIA-578 (Class 1) fax commands.

ITU-T T.4	Standardization of group 3 facsimile apparatus for document transmission.
ITU-T T.6	Facsimile coding schemes and coding control functions for group 4 facsimile apparatus.
ITU-T T.30	Procedures for document facsimile transmission in the general switched telephone network.
EIA/TIA-578	Service Class 1 Asynchronous Facsimile DCE Control Standard.

Appendix C
S-Registers

OVERVIEW

In this modem, the memory referenced as a variable or state (status), used for the main environment settings known as the S-registers, is arranged in RAM.
When the power is turned on, only the S-registers marked with an asterisk "*" on the List of S-Registers are copied from non-volatile memory to the relevant S-registers, making it possible to automatically set the environment.
Further, the contents and initial value of each S-register are recorded in the List of S-registers and Bit-mapped S-Registers.

LIST OF S-REGISTERS

Registers marked with an asterisk "*" are stored in non-volatile memory.
Set values with input ranges outside of 0 to 255 are forced to the maximum/minimum value when set.
The functioning and operation of the modem cannot be guaranteed if S-registers other than the ones listed below are written to or read from.

S-Register No.	Range	Unit	Initial Value	Function
*S0	0 to 255	Count	0	Number of ring signals for the auto answer mode; 0 = auto answer OFF.
S1	0 to 255	Count	0	Number of ring signals received.
S2	0 to 127	ASCII	43	Escape sequence code.
S3	0 to 127	ASCII	13	Carriage return code.
S4	0 to 127	ASCII	10	Line feed code.
S5	0 to 32, 127	ASCII	8	Back space code.
*S6	4 to 20	Seconds	4	Pause time from off hook until the start of dialing.
*S7	1 to 50	Seconds	50	Allowable time until connection is established.
*S8	0 to 255	Seconds	2	Pause time of comma (,) when dialing
*S9	1 to 255	1/10 Second	6	Carrier detect time.
*S10	1 to 255	1/10 Second	14	Carrier loss detect time; 255 does not automatically go on hook.
*S14	—	—	170	Bit-mapped option register.
S16	—	—	0	Bit-mapped option register.
*S18	0 to 255	Seconds	0	Timer for testing.
*S21	—	—	4	Bit-mapped option register.
*S22	—	—	244	Bit-mapped option register.
*S23	—	—	63	Bit-mapped option register.
*S25	0 to 255	1/100 Second	5	Minimum time of DTR(ER) OFF detection.
*S26	0 to 255	1/100 Second	1	Delay time from RTS to CTS.
*S27	—	—	0	Bit-mapped option register.
*S34	0 to 5	dB	5	Attenuation level of the data carrier output.
*S35	0 to 5	dB	3	Attenuation level of the DTMF (tone) output.
*S36	0 to 7	—	7	Fallback option selection.
*S37	0 to 11	—	0	Maximum DCE line speed setting: 0 = based on the S23 and S45 registers.
*S38	0 to 255	Seconds	20	Time until line disconnect: 255 = line does not disconnect.
*S39	—	—	64	Bit-mapped option register.
*S40	—	—	55	Bit-mapped option register.
*S41	—	—	153	Bit-mapped option register.
*S42	—	—	24	Bit-mapped option register.
*S43	0 to 127	ASCII	0	Fallback character in the auto reliable mode.
*S44	0 to 90	Minutes	0	Inactivity timer of the \Tn command: 0 = no timer function.
*S45	0 to 32	—	32	Display of DTE-DCE terminal speed: Enabled when S23.3-1 = 7.
*S46	0 to 138	—	2	Protocol and data compression specification: Enabled when S48 = 0.
*S48	0, 7, 128	—	7	Protocol negotiation specification.
*S49	—	—	0	Bit-mapped option register.

General S-Registers

Register No.	Function
S0 Default: 0 Profile: Yes	• Specifies the number of ring signals to be received when auto answering. • Specify in the range of 0 to 255 (Units: Number of rings). • 0 specifies no auto answer. • 1 to 255 specifies the number of ring signals received until the start of auto answer.
S1 Default: 0 Profile: No	• Counts the number of ring signals received when there is an incoming call. • This register clears 8 seconds after the ring signals stop.
S2 Default: 43 Profile: No	• Specifies the escape sequence code character. • Specify in the range of 0 to 127 in ASCII code (decimal). • The default "43" displays a "+" code.
S3 Default: 13 Profile: No	• Specifies the carriage return code character. • The specified character is used in commands and result codes. • Specify in the range of 0 to 127 in ASCII code (decimal). • Uses the default <CR> code (ASCII 13).
S4 Default: 10 Profile: No	• Specifies the line feed code character. • The specified character is used in commands and result codes. • Specify in the range of 0 to 127 in ASCII code (decimal). • Uses the default <LF> code (ASCII 10).
S5 Default: 8 Profile: No	• Specifies the backspace code character. • The specified character is used in commands. • Specify in the range of 0 to 32, 127 in ASCII code (decimal). • Uses the default <BS> code (ASCII 8).
S6 Default: 4 Profile: Yes	• Sets the pause time from off hook to the start of dialing. • Specify in the range of 4 to 20 (Units: Seconds). • Used when dial tone detection is not performed during dialing.
S7 Default: 50 Profile: Yes	• Specifies the maximum time until a carrier signal is detected. • Disconnects the line if a carrier signal is not detected within the specified time. • In originate mode: the time from the end of dialing until carrier signal detection. In answer mode: the time from off hook until carrier signal detection. • Specify in the range of 1 to 50 (Units: Seconds).
S8 Default: 2 Profile: Yes	• Specifies the pause time of the dial control character (comma ",") used in the ATD command. • Specify in the range of 0 to 255 (Units: Seconds). • No pause when set to 0.
S9 Default: 6 Profile: Yes	• Specifies the carrier signal detection time. • If the carrier signal duration is shorter than the specified time, it is not detected. • Specify in the range of 1 to 255 (Units: 1/10 second).
S10 Default: 14 Profile: Yes	• Specifies the carrier signal loss detection time. • If a carrier signal loss longer than the specified time is detected, the line is automatically disconnected. • If 255 is specified, automatic line disconnect is not performed. Therefore, the DTE must go on hook at the DTR(ER) signal or by the H command. • Specify in the range of 1 to 255 (Units: 1/10 second).

Register No.	Function
S18 Default: 0 Profile: Yes	• Specifies the measurement time of the loopback test. • Specify in the range of 0 to 255 (Units: Seconds).
S25 Default: 5 Profile: Yes	• Specifies the timespan to detect that DTR(ER) is OFF. • Specify in the range of 0 to 255 (Units: 1/100 second).
S26 Default: 1 Profile: Yes	• The delay time until the CTS (CS) signal is turned ON when the RTS(RS)signal changes from ON to OFF. • Specify in the range of 0 to 255 (Units: 1/100 second).
S34 Default: 5 Profile: Yes	• Sets the attenuation level for the data carrier output line. • Specify in the range of 0 to 5 (Units: dB).
S35 Default: 3 Profile: Yes	• Sets the attenuation level for the DTMF (tone) output line. • Specify in the range of 0 to 5 (Units: dB).
S36 Default: 7 Profile: Yes	• Specifies the fallback options. • This register operates when the S48 register is 128, and the V.42 link could not be connected. • If an invalid value is specified, the value itself is accepted, but actual operation takes place as though the default was input. • Specify in the range of 0 to 7. 0: DCE disconnects the line. 1: DCE establishes a direct mode connection. 2: Reserved. 3: DCE establishes a normal mode connection. 4: The DCE tries to make an MNP link connection. If the connection fails, the line is disconnected. 5: The DCE tries to make an MNP link connection. If the connection fails, then a connection is established in direct mode. 6: Reserved. 7: The DCE tries to make an MNP link connection. If the connection fails, then a connection is established in normal mode.

Register No.	Function
S37 Default: 0 Profile: Yes	• Specifies the maximum communication carrier speed of the DCE. • When S40.5 = 0, tries to connect to the remote modem at the specified communication carrier speed. When S40.5 = 1, tries to connect with the remote modem at a high communication carrier speed which is supported by both modems, but not exceeding the range of the specified communication carrier speed. • If an invalid value is specified, the value itself is accepted, but actual operation takes place as though the default was input. • Specify in the range of 0 to 13. 0: Communication carrier speed is specified according to the local DTE terminal speed. Based on bits 3, 2, 1 of the S23 register and the S45 register: S23 bits: b3 b2 b1 0 0 0 V.21 or Bell 103J 300 bps 0 1 0 V.22 or Bell 212A 1200 bps 0 1 1 V.22bis or Bell 224 2400 bps 1 0 0 V.32 4800 bps 1 0 1 V.32 or V.32bis 7200 bps 1 1 1 and S45 = 8, V.32bis 9600 bps 1 1 1 and S45 = 16, V.32bis 12000 bps 1 1 1 and S45 = 17 or greater, V.32bis 14400 bps 1: V.21 300 bps 2: V.21 or Bell 103J 300 bps 3: V.21 or Bell 103J 300 bps 5: V.22 or Bell 212A 1200 bps 6: V.22bis or Bell 224 2400 bps 7: V.32 4800 bps 8: V.32bis 7200 bps 9: V.32 or V.32bis 9600 bps 10: V.32bis 12000 bps 11: V.32bis 14400 bps
S38 Default: 20 Profile: Yes	• Specifies the time until the line is disconnected. • When in error correction mode if a disconnect command is received, or the DTR(ER) goes from ON to OFF, or data appears in the buffer, the DCE will lose its data, or it will wait the specified amount of time, disconnect the line and discard the data. • If a value from 0 to 254 is specified, waits the specified amount of time before disconnecting the line, or sends all data. • If a value of 255 is specified, the line is not disconnected until all the data is sent. • Specify in the range of 0 to 255 (Units: Seconds).
S43 Default: 0 Profile: Yes	• Specifies the fallback character used in the auto reliable mode. • Specify by the AT%Ac command. • Specify in the range of 0 to 127 ASCII code (decimal).

Register No.	Function
S44 Default: 0 Profile: Yes	• Sets the inactivity timer. • If 0 is specified the timer does not function. • When connecting in reliable mode, if there is no data transmission or reception even if a time longer than the specified time has elapsed, the line is disconnected. • Set by the AT\Tn command. • Specify in the range of 0 to 90 (Units: minutes).
S45 Default: 32 Profile: Yes	• Displays the DTE-DCE terminal speed. • Set by automatic recognition of "AT" or "SET." • When bits 1 to 3 of the S23 register are all "1," this register is enabled, and the DTE-DCE terminal speed is displayed. • Displayed by a numeric value in the range of 0 to 32. 0 Terminal speed is indicated by bits 1 to 3 of the S23 register. 8: 7,200 bps 16: 12,000 bps 17: 14,400 bps 19: 19,200 bps 23: 28,800 bps 27: 38,400 bps 32: 57,600 bps
S46 Default: 2 Profile: Yes	• Specifies the communication protocol and data compression when the S48 register is specified as "0." • If an invalid value is specified, the value itself is accepted, but actual operation takes place as though the default was input. • Displayed by a numeric value in the range of 0 to 138. 0: Only normal mode connection. 1: Only MNP Class 3, 4 connection. 2: Only LAPM or V.42bis connection. 3: Only MNP Class 5 connection. 136: Only LAPM connection. 138: Only V.42bis connection.
S48 Default: 7 Profile: Yes	• Sets the negotiation of the communication protocol with the remote modem. • For negotiation with the remote modem, this register is referred to with maximum priority, and the communication protocol of the link connection is determined based on this register. • Specify as 0, 7 or 128. 0: Communication protocol of the link connection is determined by the S46 register. 7: Communication protocol of the link connection is determined by the AT\Nn command. 128: Communication protocol of the link connection is determined by the AT\Nn command. However, if the link connection fails with V.42, the modem operates according to the S36 register.

Bit-mapped S-Registers

Register No.	Bit Position	Bit State	Function	Relevant Commands
S14 Default: 170 Profile: Yes	0		Reserved (bit state is "0").	
	1	0	• No echo back when in command mode.	E0
		* 1	• Echo back when in command mode.	E1
	2	* 0	• Result codes.	Q0
		1	• No result codes.	Q1
	3	0	• Digit form result code (numeric).	V0
		* 1	• Word form result code (character string).	V1
	4	* 0	• Pulse dialing speed 10 pps.	&P0, &P1
		1	• Pulse dialing speed 20 pps.	&P2
	5	0	• Sets tone dialing as the default.	T
		* 1	• Sets pulse dialing as the default.	P
	6		Reserved (bit state is "0").	
	7	0	• Answer mode.	A
		* 1	• Originate mode.	D
S16 Default: 0 Profile: No	0	* 0	• Local analog loopback test (LAL) disabled.	&T0
		1	• Local analog loopback test (LAL) enabled.	&T1
	1		Reserved (bit state is "0").	
	2	* 0	• Local digital loopback test (LDL) disabled.	&T0
		1	• Local digital loopback test (LDL) enabled.	&T3
	3	* 0	• The RDLB from the remote modem stops.	(&T4)
		1	• The RDLB from the remote modem is in operation.	
	4	* 0	• Remote digital loopback test (RDL) disabled.	&T0
		1	• Remote digital loopback test (RDL) enabled.	&T6
	5	* 0	• RDL disabled by the self diagnostic.	&T0
		1	• RDL enabled by the self diagnostic.	&T7
	6	* 0	• LAL disabled by the self diagnostic.	&T0
		1	• LAL enabled by the self diagnostic.	&T8
	7		Reserved (bit state is "0").	
S21 Default: 4 Profile: Yes	0		Reserved (bit state is "0").	
	1		Reserved (bit state is "0").	
	2	0	• Responds to the RTS(RS) and controls the CTS(CS).	&R0
		* 1	• Ignores the RTS(RS).	
	4, 3	* 0, 0	• Ignores the DTR(ER).	&D0
		0, 1	• Returns to the command mode by DTR(ER) ON → OFF.	&D1
		1, 0	• Disconnects the line by DTR(ER) ON → OFF.	&D2
		1, 1	• Initializes by DTR(ER) ON → OFF.	&D3
	5	* 0	• The DCD(CD) is always ON.	&C0
		1	• The DCD(CD) depends on the presence of the receive carrier.	&C1
	6	* 0	• The DSR(DR) is always ON.	&S0
		1	• The DSR(DR) follows the various ITU-T recommendations.	&S1
	7	* 0	• Line does not disconnect by a break signal.	Y0
		1	• Line disconnects by a break signal.	Y1

Register No.	Bit Position	Bit State	Function	Relevant Commands
S22 Default: 244 Profile: Yes	0		Reserved (bit state is "0").	
	1		Reserved (bit state is "0").	
	3, 2	0, 0	• Monitor speaker is always OFF.	M0
		* 0, 1	• Monitor speaker is ON until a carrier signal is detected.	M1
		1, 0	• Monitor speaker is always ON.	M2
		1, 1	• Monitor speaker is ON only during handshake.	M3
	6, 5, 4	0, 0, 0	• Returns a basic result code.	X0
		0, 0, 1	Reserved.	
		0, 1, 0	Reserved.	
		0, 1, 1	Reserved.	
		1, 0, 0	• Returns a basic + extended (no busy or dial detection).	X1
		1, 0, 1	• Returns a basic + extended (no busy tone detection).	X2
		1, 1, 0	• Returns a basic + extended (no dial tone detection).	X3
		* 1, 1, 1	• Returns a basic + extended (all functions are enabled).	X4
	7	0	• Uses pulse dialing with make/break ratio of 39%.	&P0
		* 1	• Uses pulse dialing with make/break ratio of 33%.	&P1, &P2
S22 Default: 244 Profile: Yes	0	0	• Refuses remote digital loopback test.	&T5
		* 1	• Permits remote digital loopback test.	&T4
	3, 2, 1	0, 0, 0	• Local DTE terminal speed: 0 ~ 300 bps.	
		0, 0, 1	Reserved.	
		0, 1, 0	• Local DTE terminal speed: 1,200 bps.	
		0, 1, 1	• Local DTE terminal speed: 2,400 bps.	
		1, 0, 0	• Local DTE terminal speed: 4,800 bps.	
		1, 0, 1	• Local DTE terminal speed: 9,600 bps.	
		1, 1, 0	Reserved.	
		* 1, 1, 1	• Local DTE terminal speed is displayed by the S45 register.	
	5, 4	0, 0	• Even parity.	
		0, 1	• Space parity.	
		1, 0	• Odd parity.	
		* 1, 1	• Mark or no-parity.	
	7, 6	* 0, 0	• No guard tone	&G0
		0, 1	• 550 Hz guard tone.	&G1
		1, 0	• 1,800 Hz guard tone.	&G2
		1, 1	Reserved.	

Register No.	Bit Position	Bit State	Function	Relevant Commands
S27 Default: 0 Profile: Yes	1, 0	* 0, 0	• Specifies the asynchronous mode	&M0
		0, 1	• Specifies synchronous mode 1.	&M1
		1, 0	• Specifies synchronous mode 2.	&M2
		1, 1	• Specifies synchronous mode 3.	&M3
	2	* 0	• Specifies general public switched line.	&L0
		1	• Specifies dedicated line.	&L1
	3		Reserved (bit state is "0").	
	5, 4	0, 0	• ST2 clock setting.	&X0
		0, 1	• ST1 clock setting.	&X1
		1, 0	• RT clock setting.	&X2
		1, 1	• Not used.	
	6	* 0	• Modem operation based on ITU-T recommendations.	B0
		1	• Modem operation based on BELL standards.	B1
	7		Reserved (bit state is "0").	
S39 Default: 64 Profile: Yes	2, 1, 0		Reserved (bit state is "000").	
	3	* 0	• Extended MNP is disabled.	–K0
		1	• Extended MNP is enabled.	–K1
	4	* 0	• Connects at the specified communication carrier speed.	∗H0
		1	• Connects at a communication carrier speed of 1,200 bps (V.22).	∗H1
	5	* 0	• Does not change transmission level during communication.	)M0
		1	• Changes transmission level during communication.	)M1
	6	0	• MNP 10 protocol is enabled.	–N0
		* 1	• MNP 10 protocol is disabled.	–N1
	7		Reserved (bit state is "0").	

Register No.	Bit Position	Bit State	Function	Relevant Commands
S40 Default: 55 Profile: Yes	1, 0	0, 0	• Uses normal mode.	\N0
		0, 1	• Uses direct mode.	\N1
		1, 0	• Uses reliable mode.	\N2, 4 to 6
		* 1, 1	• Uses auto reliable mode.	\N3, \N7
	4, 3, 2	0, ×, ×	Reserved.	
		1, 0, 0	• Uses break mode 4.	\K4
		* 1, 0, 1	• Uses break mode 5.	\K5
		1, 1, ×	Reserved.	
	5	0	• Inhibits auto fallback function.	N0
		* 1	• Enables auto fallback function.	N1
	7, 6	* 0, 0	• Reports terminal speed.	W0
		0, 1	• Reports communication carrier speed, protocol data compression and terminal speed.	W1
		1, 0	• Reports communication carrier speed.	W2
		1, 1	• Report appends to the terminal carrier speed whether there is error correction (/REL).	W3
S41 Default: 153 Profile: Yes	0	0	• No auto retrain.	%E0
		* 1	• Auto retrain.	%E1
	1	* 0	• Does not perform flow control between the modem and the remote modem.	\G0
		1	• Performs flow control based on XON/XOFF codes.	\G1
	2	* 0	• Does not send XON/XOFF codes to the remote modem.	\X0
		1	• Sends XON/XOFF codes to the remote modem (transparent).	\X1
	4, 3	0, 0	• Maximum block length is 64 bytes.	\A0
		0, 1	• Maximum block length is 128 bytes.	\A1
		1, 0	• Maximum block length is 192 bytes.	\A2
		* 1, 1	• Maximum block length is 256 bytes.	\A3
	6, 5	* 0, 0	• No buffering.	\C0
		0, 1	• Buffers until an SYN or ODP is received, until 200 characters are received, or until 8 seconds of reception.	\C1
		1, 0	• Received data is discarded until the auto reliable fallback character is received, or until a maximum of 8 seconds of reception.	\C2
		1, 1	Reserved.	
	7	0	• No data compression.	%C0
		* 1	• Data compression.	%C1

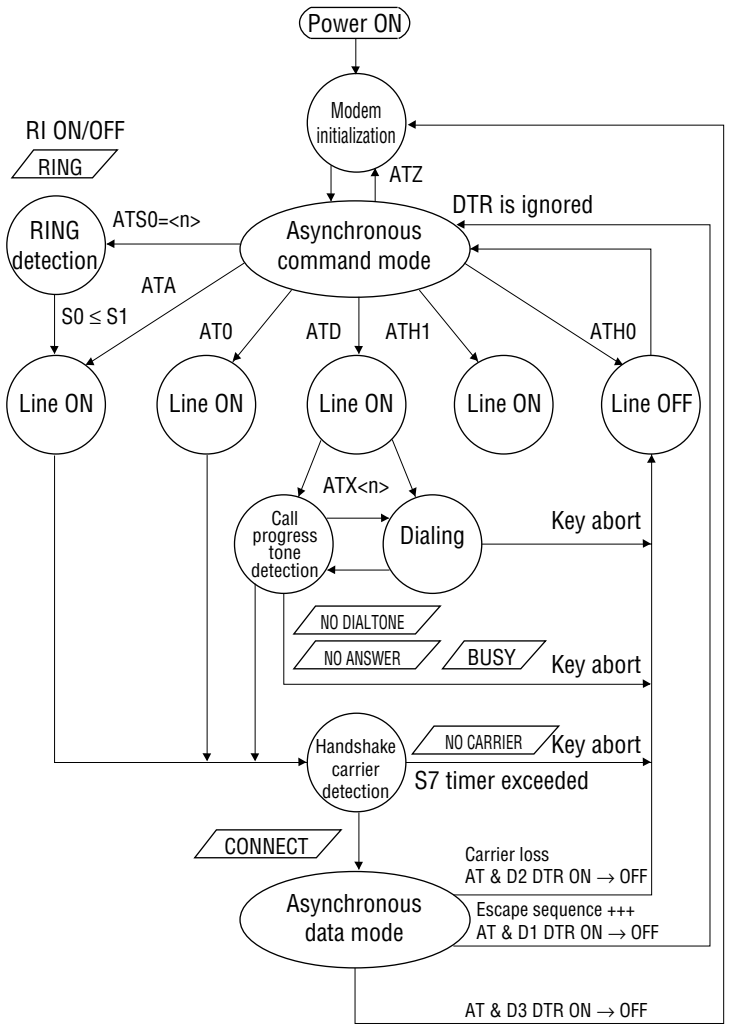
Register No.	Bit Position	Bit State	Function	Relevant Commands
S42 Default: 24 Profile: Yes Bits 3 and 2 are only valid when in data modem mode. Bits 5 and 4 are only valid in facsimile DCE mode.	0	* 0	• V.32bis at 9,600 bps; trellis coding.	&U0
		1	• V.32bis at 9,600 bps; no trellis coding.	&U1
	1		Reserved.	
			Reserved.	
	3, 2	0, 0	• No flow control between the DTE and the modem.	\Q0
		0, 1	• Flow control based on XON/XOFF codes.	\Q1
		* 1, 0	• Flow control based on the CTS(CS) signal of the modem.	\Q2
		1, 1	• Flow control based on the CTS(CS)/RTS(RS) signals.	\Q3
	5, 4	0, 0	Reserved.	
		* 0, 1	• Flow control based on XON/XOFF codes.	+FLO=0
		1, 0	• Flow control based on the CTS(CS)/RTS(RS) signals.	+FLO=1
		1, 1	Reserved.	
	6	0	Reserved (bit state is "0").	
	7	* 0	• Terminal speed during communication is the same as during commands.	\J0
		1	• Terminal speed during communication matches the carrier speed.	\J1
S49 Default: 0 Profile: Yes (Bits 7 and 6 cannot be written to a profile.)	2, 1, 0	* 0, 0, 0	• Data modem using asynchronous AT commands.	+FCLASS=0
		0, 0, 1	• Facsimile DCE using Class 1 fax commands.	+FCLASS=1
		0, 1, 0	Reserved.	
		0, 1, 1	Reserved.	
		1, 0, 0	Reserved.	
		1, 0, 1	Reserved.	
		1, 1, 0	Reserved.	
		1, 1, 1	Reserved.	
	3		Reserved (bit state is "0").	
	4		Reserved (bit state is "0").	
	5		Reserved (bit state is "0").	
	7, 6	* 0, 0	• FAX/DATA automatic switching disabled.	+FAA=0
		0, 1	• FAX/DATA automatic switching enabled.	+FAA=1
		1, 0	Reserved.	
		1, 1	Reserved.	

Appendix D
Command Mode and Data Mode

OVERVIEW

The modem has two general states: command mode and data mode.
Since the command mode performs asynchronous communication with the terminal, it is more accurately called the asynchronous command mode. The data mode refers to the state in which the modem connects the line to the remote equipment and in which data can be transmitted/received.

ASYNCHRONOUS MODE



• Originate Mode
The modem dials by the ATD (ds) command. If there is a response from the remote equipment and the modem connects successfully, the CONNECT result code is returned indicating that the modem has switched to the data mode.
• Answer Mode
To set the auto answer mode, enter a command such as ATS0=2. With this command, the modem will auto answer if 2 rings are received. To set the manual answer mode, enter the ATS0=0 command. After verifying the ring, enter the ATA command to answer the call.
If the modem connects with the remote equipment, a CONNECT result code is returned indicating that the modem has switched to the data mode.
• Switch From Data Mode to Command Mode
If DTR ON→OFF is detected by & D1 mode, the OK result is returned indicating that the modem has returned to the command mode. At this point, commands can be used freely with the modem still connected to the line.
• Switch From Command Mode to Data Mode
By inputting the ATO command, the CONNECT result code is returned indicating that the modem has switched to the data mode again.
• Drop the Line Connection (ATH0 command)
Normally, the ATH0 command is input in the state where the modem has switched to the command mode. The line is turned OFF and the OK result code is returned.
At this point, the remote side detects the carrier loss, turns the line OFF and returns the NO CARRIER result code. At this point, some garbage characters may accompany the signal and change to a result code.
If both sides input the ATY1 command to each other beforehand, the line disconnect operates by sending a break signal. The remote side can thus drop the line normally with an OK result code.
• Drop the Line Connection (DTR)
If the AT&D2 command is set, the line is disconnected if the DTR makes a transition from ON to OFF, and the modem returns to the command mode.
• DTR Function
By entering the AT&D<n> command, the modem performs the functions shown in the figure at left.

SYNCHRONOUS MODE

This modem can utilize the synchronous mode in addition to the asynchronous mode.
There are three types of synchronous modes which are called synchronous mode 1, synchronous mode 2 and synchronous mode 3. The synchronous mode is basically controlled by changes in the DTR state of the DTE. However, only synchronous mode 1 uses the asynchronous command mode up until the line is connected. After the line is connected, the modem switches to the synchronous mode. This mode is therefore called the synchronous/asynchronous mode.
In synchronous modes 2 and 3, the command mode functions are enabled if the line is not connected when DTR is in the OFF state.
Note: If synchronous mode 2 or 3 is already set, take care that the power ON sequence is correct and that the connection cable is not unplugged. When the modem power is turned ON, this mode is entered and changes in the DTR are detected. If, at this time, the DTR transitions from OFF to ON, originate operation begins. Generally, the modem is powered ON after the DTE is set up.

DTEs such as asynchronous type data terminals, personal computers, etc., can use the three synchronous modes. However, they must have a synchronous communication function for after the line is connected.
Synchronous modes 2 and 3 can use synchronous type DTEs.

RS-232C related commands which do not function in the synchronous mode are AT&C<n>, AT&D<n> and AT&S<n>. The AT&R<n> command functions only in synchronous mode.
The time set in S25 is in units of seconds if the DTR state is detected immediately after the line is connected in synchronous mode 1. Otherwise, S25 is used as the delay time for detecting the change in DTR from ON to OFF, and the unit is 1/100 second.
The time set in S26 is the delay time from RTS ON until CTS ON. S26 functions if AT&R0 is set.
The result of the line connection in synchronous mode depends on changes in the DSR, DCD and CTS signals. Synchronous mode communication is possible when all three of these signals are in the ON state.
Further, the AT&X<n> command is set beforehand to select which signal is used for each transmission clock.
The setup of each mode is set by the AT&M<n> command.

Overview of Synchronous Mode 1 (SYNC/ASYNC mode)

Connections are made in the same manner as the asynchronous mode, for both originate and answer modes.
A result code is also returned when making a connection (CONNECT xxxx, NO CARRIER, RING).
The conditions for dropping the line are if DTR changes from ON to OFF, or if the carrier is not detected for longer than S10.

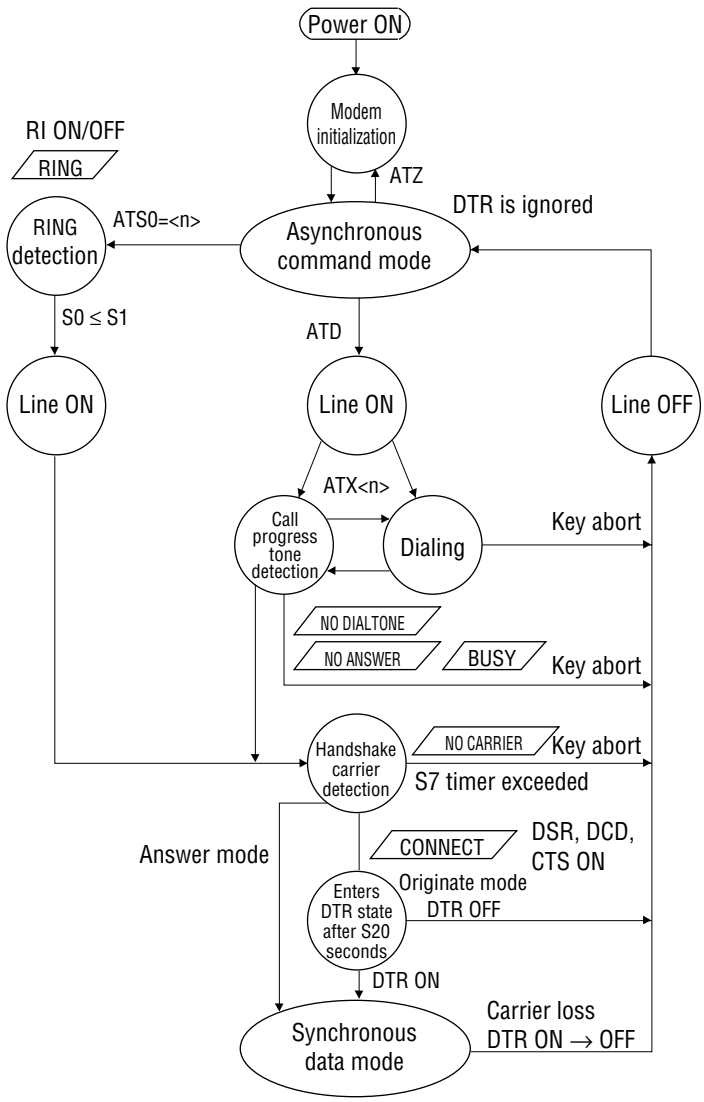
Overview of Synchronous Mode 2

When the DTR changes from OFF to ON, the modem dials the telephone number in nonvolatile memory.
Answering is similar to the asynchronous mode, but is also related to DTR. Namely, if DTR is left in the ON state, the modem auto answers if S0 is not 0 and the ring count S0 = S1.
The result codes and key abort do not function. (For convenience, the DTE is assumed to be an asynchronous type if the AT00V1 state is set; the result codes will then function.)
The conditions for dropping the line are the same as for synchronous mode 1.

Overview of Synchronous Mode 3

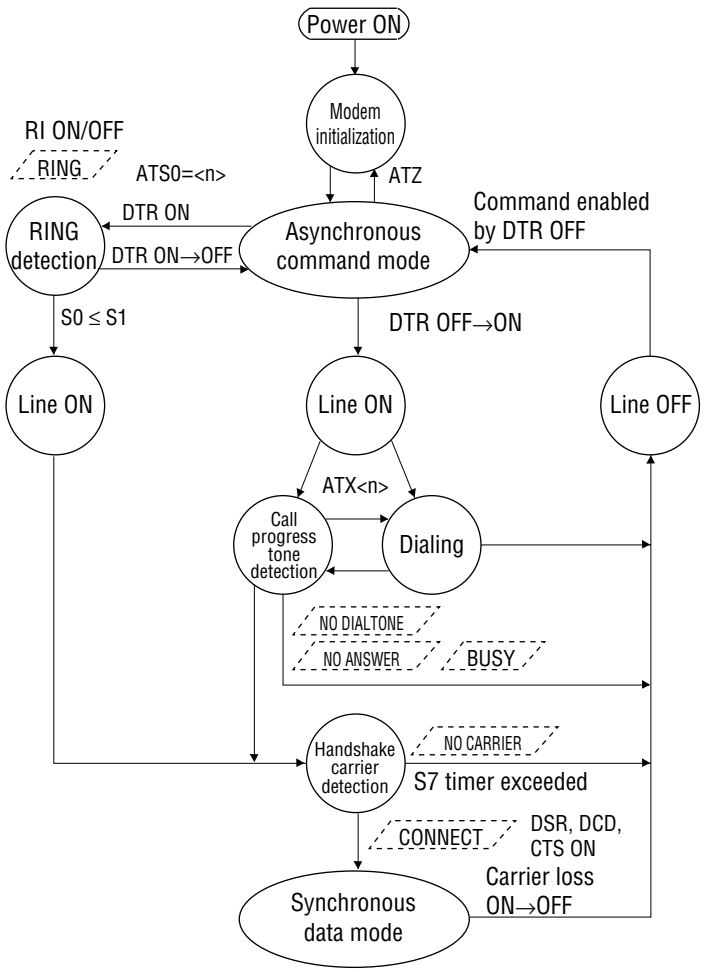
Dialing is performed by an auxiliary telephone instrument and the connection is made when DTR changes from OFF to ON. Other aspects are the same as for synchronous mode 2.

SYNCHRONOUS MODE 1



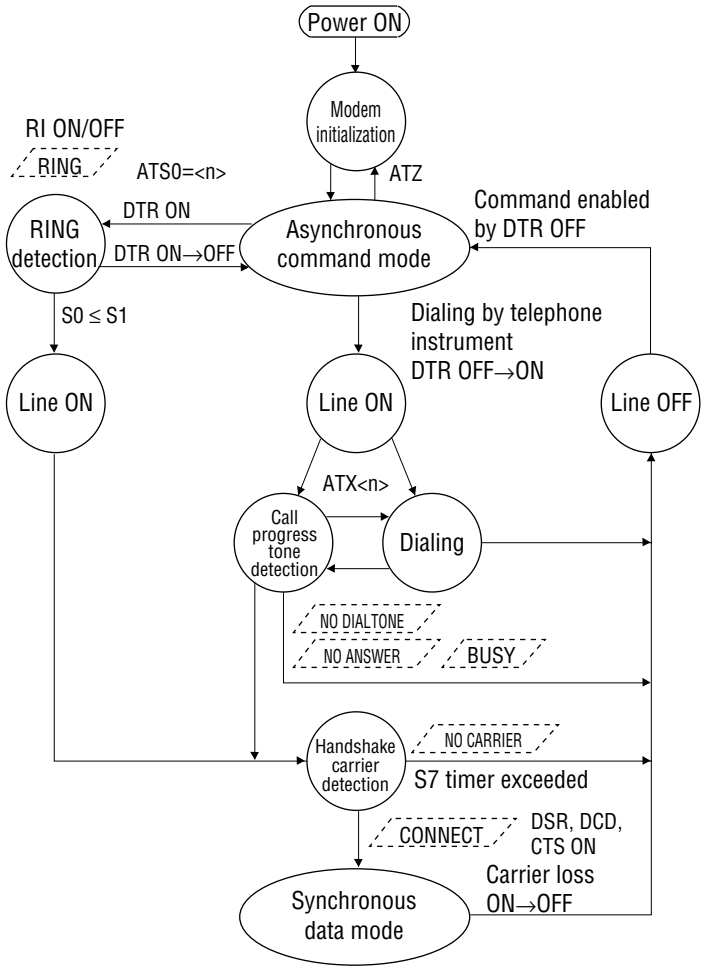
• Setup
Synchronous mode 1 is set by the AT&M1 command, and appropriate settings are made with the ATX<n> and ATQ<n> commands according to the intended purpose. With ATQ1, result codes are returned but communication is completely in asynchronous mode. Set the S25 register to a value suitable for the following purposes (factory setting is 5 seconds).
If switching from the asynchronous mode to the synchronous mode is performed on the application side, the DTR may momentarily turn OFF. However, in order not to recognize this change as signal to drop the line, the DTR state is inspected S25 seconds after the connection is completed.
The DTR is ignored in the asynchronous command mode state. However, since the ON/OFF changes of the DTR affect the connection, the DTR is generally set to the ON state ahead of time when making a connection.
• Originate Mode
The number is dialed by the ATD<ds> or ATDS command. The modem switches to the synchronous mode upon completing the connection to the remote modem. However, the DTR state is inspected after the time set in S25 has elapsed. If the state is OFF, the line is dropped and the modem returns to the asynchronous command mode.
• Answer Mode
If <n> in the ATS0=<n> command is not 0, and the modem receives <n> rings, the modem will auto answer the call. The modem switches to the synchronous data mode when the connection with the remote modem is completed (there is no S25 function).
• Drop the Line
If the carrier is not detected for the time set in S10 (factory setting: 1.4 seconds), or if the modem detects a DTR change from ON to OFF, the modem drops the line and returns to the asynchronous command mode.
If S10 = 255, the line is not dropped due to a carrier loss. At this point, the carrier state can be monitored by the CD LED. Further, a change in the DTR from ON to OFF is not recognized for the time set in S25 (factory setting: 100 seconds).
• Drop the Connection State [TN: "Drop" should probably be "Observe"]
If the modem is in the ATX4, ATQ0 or ATV1 state, result codes such as RING, BUSY, NO DIALTONE, CONNECT 1200, CONNECT 2400 and NO CARRIER are returned in the asynchronous mode.
DSR turns ON upon receiving an answer tone from the remote modem.DCD turns ON when the data carrier is detected. The CD LED also turns ON.
The CTS turns ON if the RTS of the DTE is ON. The operation of RTS and CTS is related to the AT&R<n> command. If n = 0,
the CTS turns ON with a delay of time as set in S26 (factory setting: 100 seconds) after RTS turns ON.
If n = 1, the CTS is always ON during synchronous data mode, regardless of RTS.
DSR, DCD and CTS are all ON in states where synchronous communication is possible.

SYNCHRONOUS MODE 2



• Setup
Synchronous mode 2 is set by the AT&M2 command. The telephone number of the remote modem is written to nonvolatile memory by the AT&Z<ds> command.
If this mode is always used, store the current settings in nonvolatile memory by the AT<...Q1E0>&W command ("..." is the required command string).
By storing the current settings, the S registers are automatically set to the values stored in nonvolatile memory the next time power is turned ON, thus setting this mode.
To change the settings or test using new ones, set the DTR to the OFF state and use the asynchronous command mode to make the changes.
With ATQ0E1, the result codes are returned and the commands are echoed back.
Further, if setting the modem as mentioned above, the result code notations in the figure to the left will differ from the normal codes.
• Originate Mode
This mode dials the stored telephone number when the DTR changes from OFF to ON.
At this point, the line noise can be heard on the monitor speaker if the ATL2M1 command is set.
If the line does not connect normally, the line is turned OFF and the modem returns to the asynchronous state.
• Answer Mode
The modem is set to the auto answer mode by the ATS0=<n> command. When DTR is ON, the modem starts auto answer when the ring count reaches n (S0 = S1). If S0 > S1, DTR turns OFF and the modem stops auto answering 8 seconds after the last ring. Conversely, if a ring is received even if DTR is turned OFF, the modem auto answers if DTR is turned ON again within 8 seconds. After this interval is exceeded, turning DTR ON starts the originate mode.
• Drop the Line
Same as for synchronous mode 1.
• Observe the Connection State
Same as for synchronous mode 1.

SYNCHRONOUS MODE 3



• Setup
Synchronous mode 3 is set by the AT&M3 command. If this mode is always used, store the current settings in nonvolatile memory by the AT<...Q1E0>&W command ("..." is the required command string).
By storing the current settings, the S registers are automatically set to the values stored in nonvolatile memory the next time power is turned ON, thus setting this mode.
To change the settings or test using new ones, set the DTR to the OFF state and use the asynchronous command mode to make the changes.
With ATQ0E1, the result codes are returned and the commands are echoed back.
Further, if setting the modem as mentioned above, the result code notations in the figure to the left will differ from the normal codes.

• Originate Mode
The DTR is turned OFF beforehand. Dial the remote modem using an auxiliary telephone instrument.
The connection will start when the DTR changes from OFF to ON.
At this point, the line noise can be heard on the monitor speaker if the ATL2M1 command is set.
If the line does not connect normally, the line is turned OFF and the modem returns to the asynchronous state.

• Answer Mode
Same as for synchronous mode 1.

• Drop the Line
Same as for synchronous mode 1.

• Observe the Connection State
Same as for synchronous mode 1.

DEDICATED LINE MODE

In addition to data communication using general telephone lines, this modem has the following data communication functions for dual-line dedicated lines.
By selecting the dedicated line mode with the AT&L1 command, the modem has the same functions as the general telephone line mode except that the operation for originating and answering calls is different.
However, since there is no automatic speed response (fallback) function when answering, set both modems to the same speed before making connection.

Asynchronous Mode and Synchronous Mode 1

Select the dedicated line mode by the AT&L1 command.
The connection is made by the originating side inputting the ATD command and the answering side inputting the ATA command at about the same time.

Synchronous Modes 2, 3

Select the dedicated line mode by the AT&L1 command.
The originating side sets the S0 register to 0.
The answering side sets the S0 to a value other than 0.
Connection is made by setting DTR from OFF to ON at about the same time.

Appendix E
Loopback Tests and Self Diagnostic

OVERVIEW

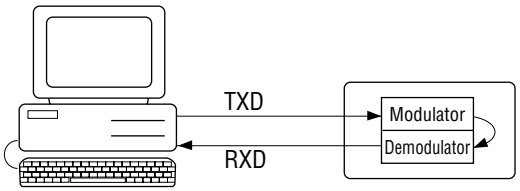
As stated previously in the section on command explanations, there are five types of test functions which can be performed. Further, by using a test timer, testing can be performed for arbitrarily times.
The purpose of the tests is to check whether transmitted data is looping back normally. The results can be used as a diagnostic tool.

Test Preparation

First check that the terminal and modem and the telephone lines are connected properly, finish setting up the equipment, and then turn the power on. If using a personal computer as a terminal, perform the required preparation (communication speed, formatting, etc.).
First, input the ATZ command. "ATZ" should echo back on the terminal screen, and the result code "OK" should be displayed. The terminal and modem are now in a normal state. If they are not in this state, check the connections and settings again.
When any of the test modes are executing, the MR-LED display flickers in approximately 1 second intervals.

Local Analog Loopback Test (&T1)

This test can test the line from the terminal to the internal modem.



Reference Example (1): If a test timer is not used.

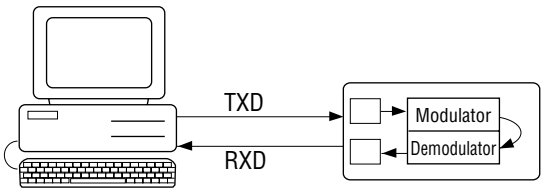
Terminal	ATS18 = 0&T1	Begin test.
	OKI ELECTRIC COMPANY	Input freely and it will be echoed back, as is.
	+++	Escape sequence.
Modem	OK	Returns to command mode.
Terminal	AT&T0	Input test end command.
Modem	OK	Test ends.

Reference Example (2): If a test timer is used.

Terminal	ATS18 = 50&T1	Set the test timer to 50 seconds and begin the test.
	OKI ELECTRIC COMPANY	Input freely and it will be echoed back, as is.
		(In this interval, 50 seconds elapse.)
Modem	OK	Test ends.

Local Analog Loopback Self-Test (&T8)

This test is not input from the terminal. A 1:1, 0/1 alternating pattern is automatically input to the TXD inside the modem, and the errors are counted by the receiver unit. If an error is generated, it is counted. (If a command is input during the test, the test is temporarily interrupted until processing is completed.)



Reference Example (1): If a test timer is not used and no errors occur.

Terminal	ATS18 = 0&T8	Begin test.
		(During this time, pause only for an appropriate interval.)
	AT&T0	Test ends.
Modem	000	There were 0 errors.
	OK	

Reference Example (2): If a test timer is not used and 7 errors occur.

Terminal	ATS18 = 0&T8	Begin test.
		(During this time, pause only for an appropriate interval.)
	AT&T0	Test ends.
Modem	007	There were 7 errors.
	OK	

Reference Example (3): If a test timer is used and no errors occur.

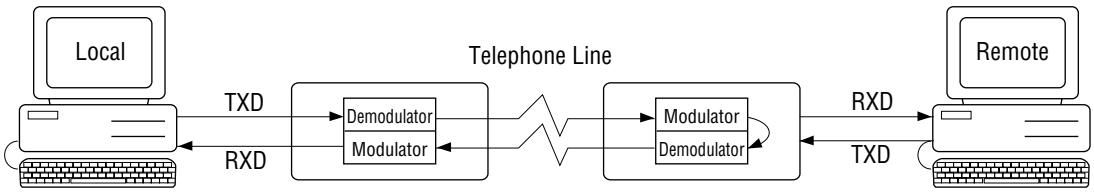
Terminal	ATS18 = 10&T8	Set the test timer to 10 seconds and begin the test.
		(In this interval, 10 seconds elapse.)
Modem	000	There were 0 errors.
	OK	

Reference Example (4): If a test timer is used and 7 errors occur.

Terminal	ATS18 = 10&T8	Set the test timer to 10 seconds and begin the test.
		(In this interval, 10 seconds elapse.)
Modem	007	There were 7 errors.
	OK	

Remote Digital Loopback Test (&T6)

If the remote modem is the same type as the main unit, a remote digital loopback test can be performed with the local modem. (This function is not available at 300 bps.)



As preparation for this test, match up the communication modes for both the local and remote modems. (The communication speed should either be 1200 or 2400 bps.)
Input AT&T4 at the remote side, so that there will be a response to the remote digital loopback test request. (The AT&T5 command, conversely, is the setting for no response to the request.)
This test is performed in the connected state (on-line), so the usual method is to connect the line.
After the test, the modem can return to the on-line data mode by the AT0 command.
The explanations in the following reference examples start from after the modem goes on-line.

Reference Example (1): If a test timer is not used.

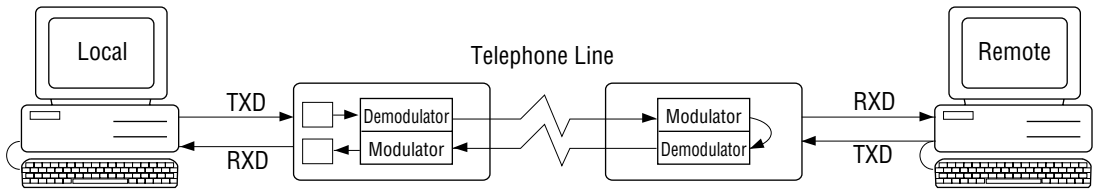
Terminal	+++	Escape sequence.
	OK	Changes to command mode.
	ATS18 = 0&T6	Begin test.
	OKI ELECTRIC	Enter arbitrary characters freely and those characters will be
	COMPANY	echoed back, as is.
	+++	Escape sequence.
Modem	OK	Changes to command mode.
Terminal	AT&T0	Input test end command.
Modem	OK	Test ends.

Reference Example (2): If a test timer is used

Terminal	+++	Escape sequence.
	OK	Changes to command mode.
	ATS18 = 30&T6	Set test timer to 30 seconds and begin test.
	OKI ELECTRIC	Enter arbitrary characters freely and those characters will be
	COMPANY	echoed back, as is.
		(In this interval, 30 seconds elapse.)
Modem	OK	Test ends.

Remote Digital Loopback Self-Test (&T7)

This test differs from the remote digital loopback test only on the point that the modem internal data is used, the same as for the local analog loopback self test, instead of using the terminal input data. Perform test preparation in the same manner.
(If a command is input during the test, the test is temporarily interrupted until processing is completed.)



Reference Example (1): If a test timer is not used and no errors occur.

Terminal	+++	Escape sequence.
Modem	OK	Changes to command mode.
Terminal	ATS18 = 0&T7	Set test timer to 0 and begin test.
		(Pause for an appropriate interval.)
	AT&T0	Input test end command.
Modem	000	No errors.
	OK	Test ends.

Reference Example (2): If a test timer is not used and 7 errors occur.

Terminal	+++	Escape sequence.
Modem	OK	Changes to command mode.
Terminal	ATS18 = 0&T7	Set test timer to 0 and begin test.
		(Pause for an appropriate interval.)
	AT&T0	Input test end command.
Modem	007	7 errors occur.
	OK	Test ends.

Reference Example (3): If a test timer is used and no errors occur.

Terminal	+++	Escape sequence.
Modem	OK	Changes to command mode.
Terminal	ATS18 = 30&T7	Set test timer to 30 seconds and begin test.
		(In this interval, 30 seconds elapse.)
Modem	000	No errors.
	OK	Test ends.

Reference Example (4): If a test timer is not used and 7 errors occur.

Terminal	+++	Escape sequence.
Modem	OK	Changes to command mode.
Terminal	ATS18 = 30&T7	Set test timer to 30 seconds and begin test.
		(In this interval, 30 seconds elapse.)
Modem	007	7 errors occur.
	OK	Test ends.

The Remote Digital Loopback Test and The Remote Side State During Self-Testing

For both test modes, input the AT&T4 command on the remote side beforehand, as it must be set to respond to the request. It can be known via the S-register (16) bit 3 if this test is being performed on the remote side.

Reference Example (Remote Side)

Terminal	+++	Escape sequence.
Modem	OK	Changes to command mode.
Terminal	ATS167	
Modem	008	Since bit 3 of S16 is ON, the modem knows that testing is taking place on the local side.
	OK	

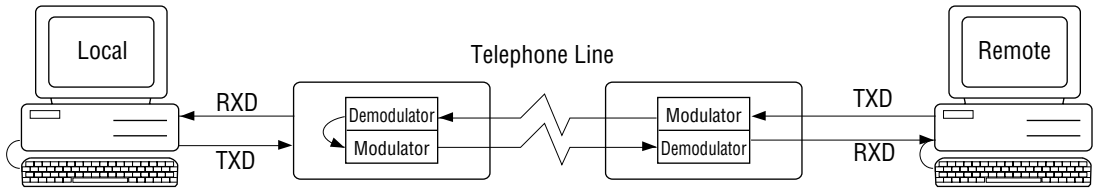
Reference example of the AT&T5 command input on the remote side, with testing on the local side.

Terminal	+++	Escape sequence.
Modem	OK	Changes to command mode.
Terminal	AT&T6	Remote digital loopback test begins.
		(The time set in S7 elapses.)
Modem	NO CARRIER	Connection failure.
	OK	

If, for causes outside of this test, a loop is not configured, a result code (NO CARRIER) is returned to the modem.

Local Digital Loopback Test (&T3)

In this test, data transmitted from the remote modem is digitally looped back in the local modem, and returned to the remote modem.
Perform the same preparation for this test as for the remote digital loopback test.



Reference Example: (In this case, the test type can also be used. However, it is not practical, since input for the test is done at the remote side. The general method is not to use a test timer, but to perform the test by making telephone contact.)

Terminal	+++	Escape sequence.
Modem	OK	Changes to command mode.
Terminal	ATS18 = 0&T8	Set test timer to 0 and begin test.
Modem	OK	Enters loopback.
		(In this interval, the characters entered at the remote terminal are echoed back to the local display.)
Terminal	AT&T0	Input test end command.
Modem	OK	Test ends.
	(If AT0 is input, the modem returns to the on-line data mode.)	

&T4 and &T5 Commands

The &T4 command sets the response to the request from the remote modem for a remote digital loopback test.
The &T5 command sets the opposite.

Appendix F
Application Circuit Diagrams

CIRCUIT DIAGRAMS

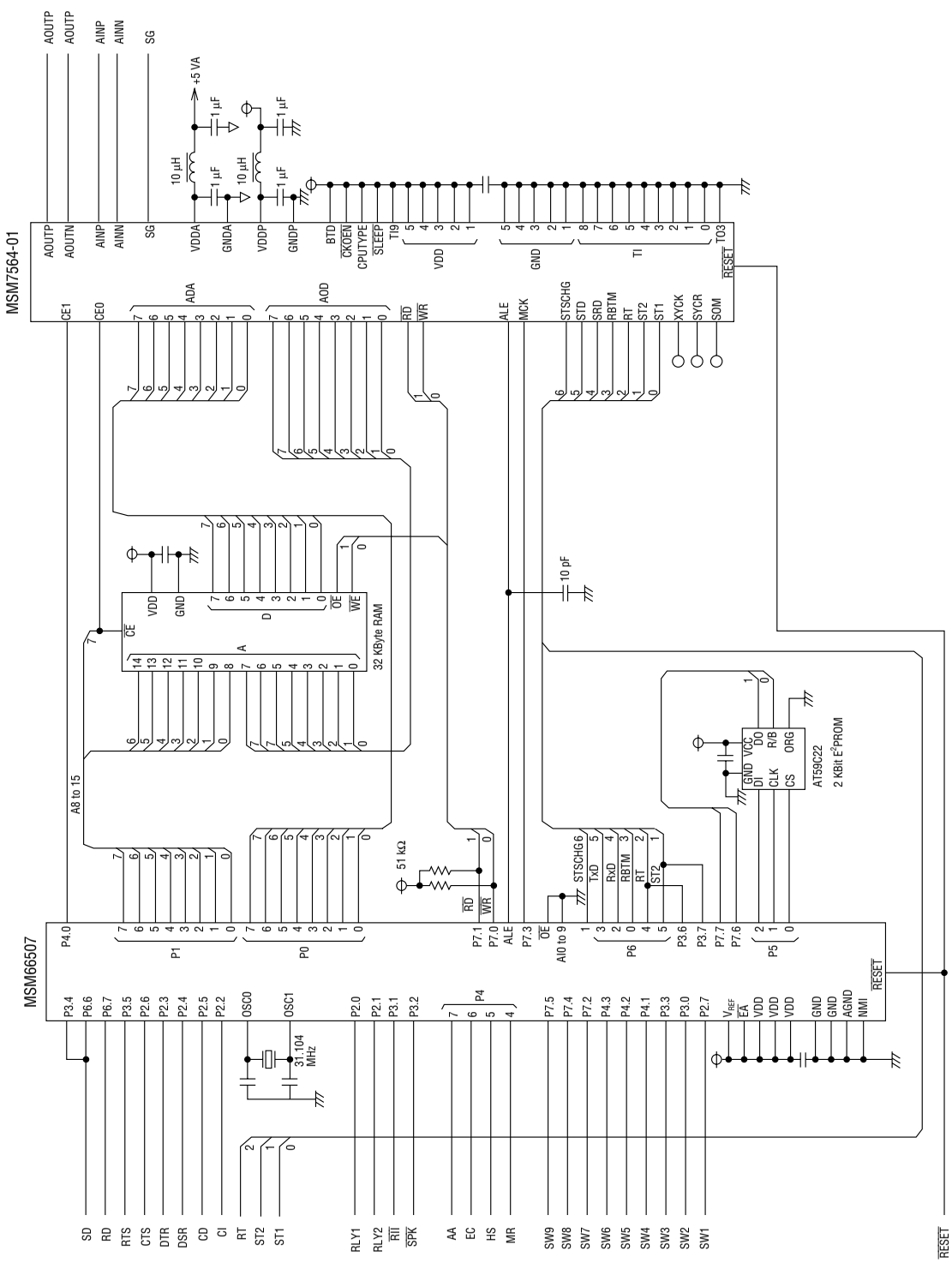
Application Circuit Diagram 1

This application circuit diagram is for an MSC2121A modem chip set.
The IC pin numbers vary according to the IC package used. Please refer to the individual IC data sheets.

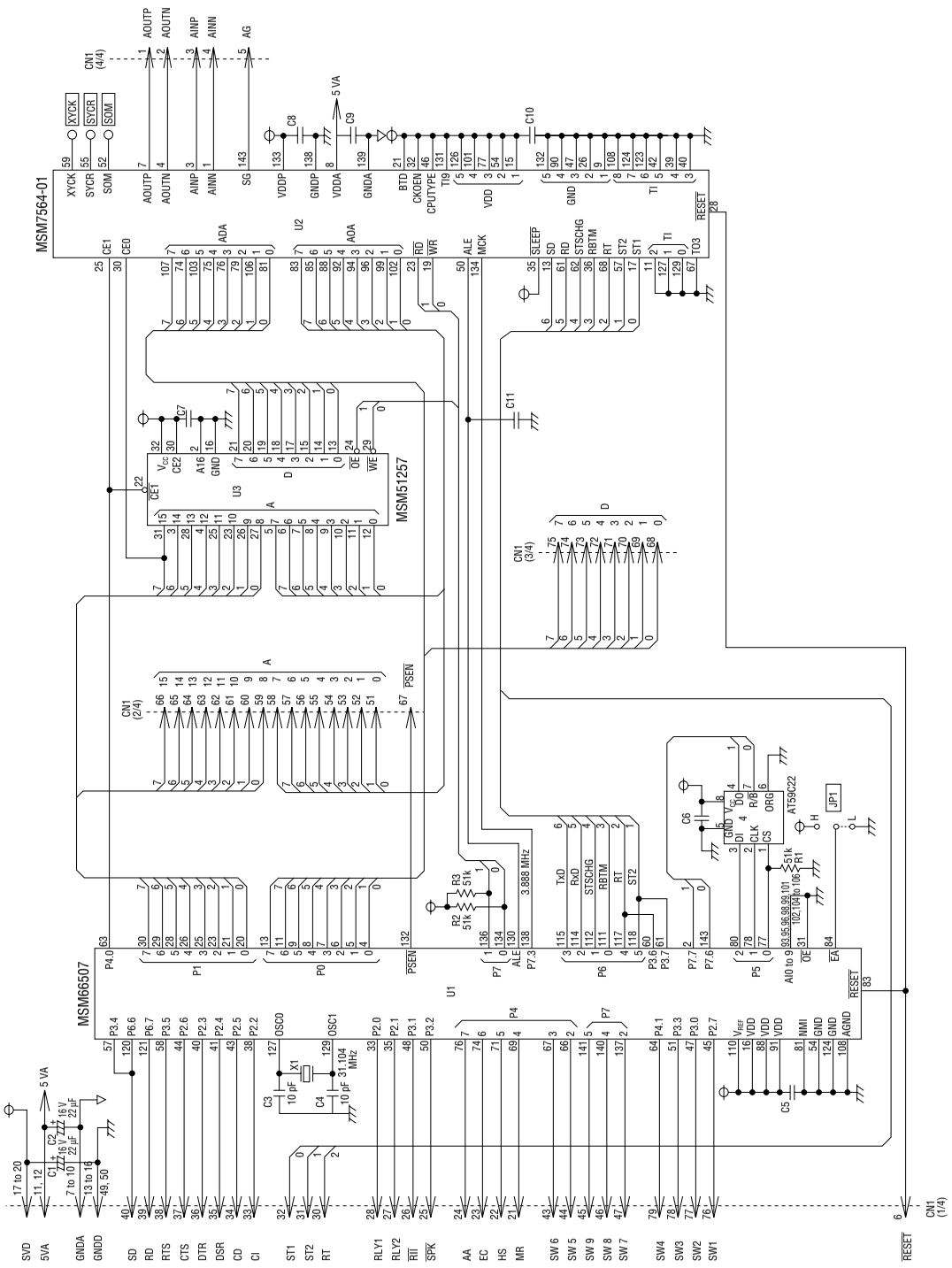
Application Circuit Diagram 2

This application circuit diagram is for an MSC2121A modem chip set evaluation board.

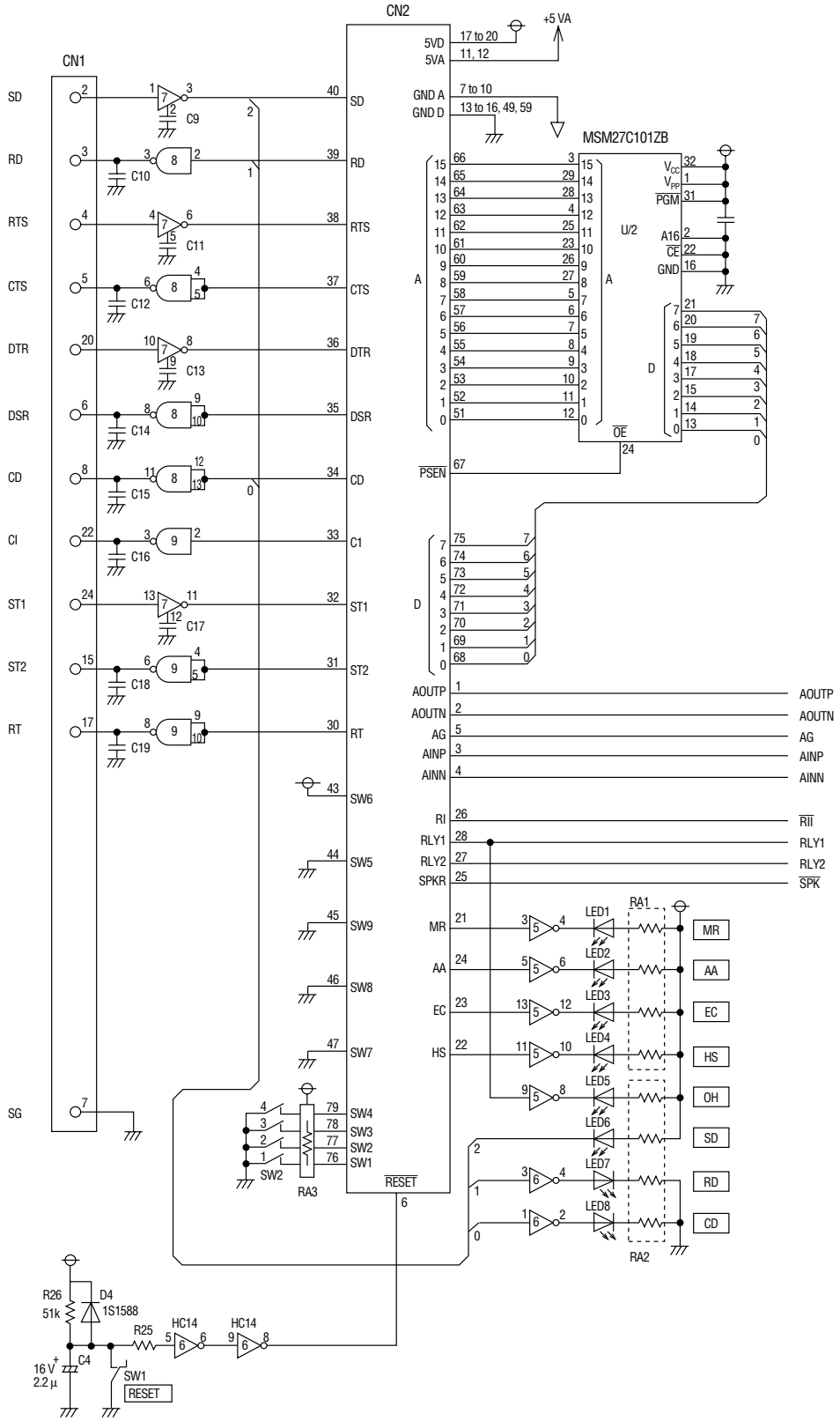
* The evaluation board has onboard EPROM for the microcomputer program, but this is not needed in the actual chip set since it is built into the microcomputer.
* The evaluation board is for evaluating the modem chip set.
* Do not use on actual lines. (JATE approval in Japan not obtained.)
* These circuit diagrams are evaluation board circuit diagrams. Performance other than the function checks and performance evaluation of the modem chip set is not guaranteed.



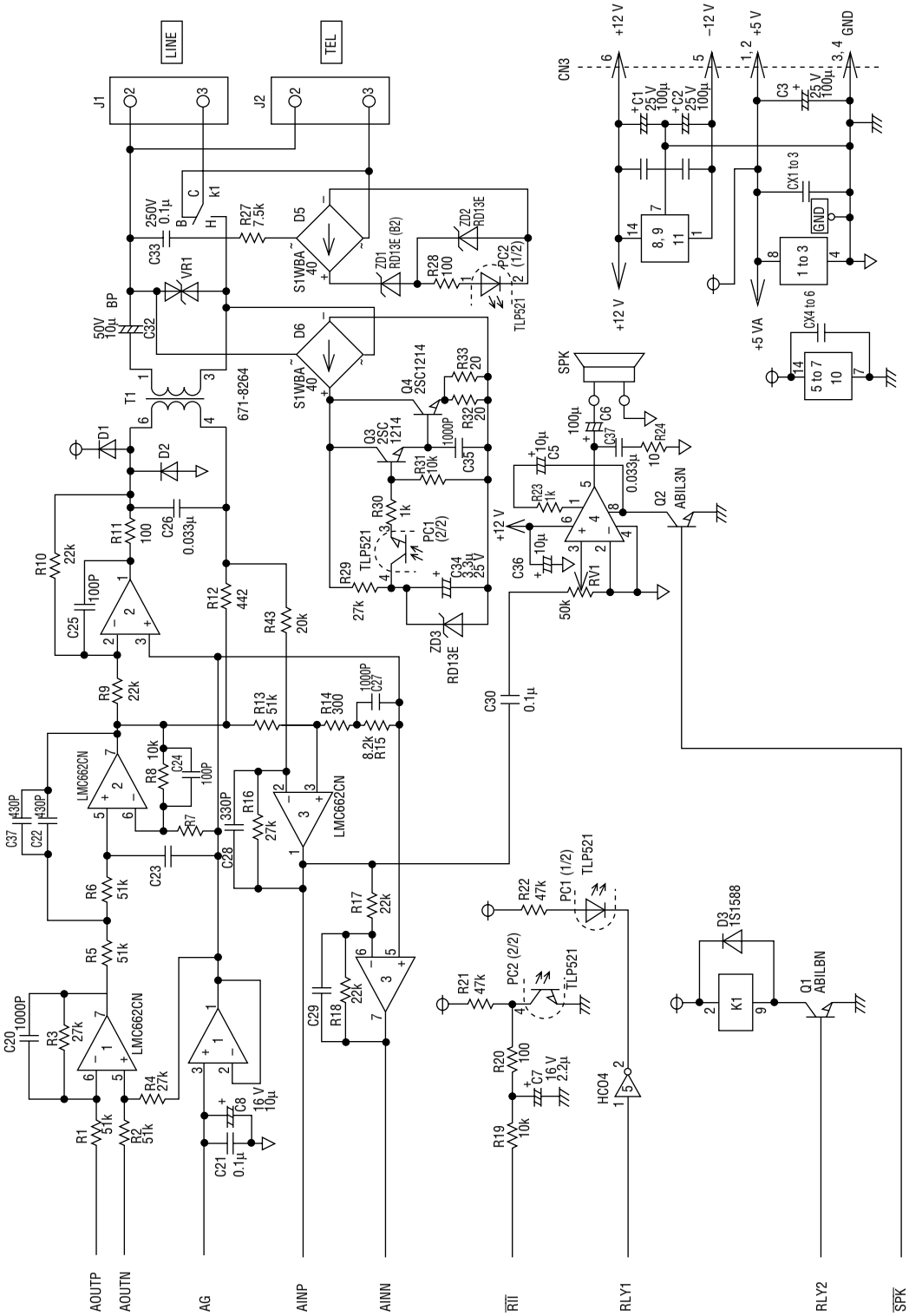
MSC2121A Application Circuit Diagram 1



Application Circuit Diagram 2 (1/3)



Application Circuit Diagram 2 (2/3)



Application Circuit Diagram 2 (3/3)

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Printed in Japan

Preliminary

OKI Semiconductor

MSM7564-01

A Single Chip 14.4 kbps Data & Fax Modem

GENERAL DESCRIPTION

The MSM7564-01 is a highly integrated single-chip modem IC which provides the functions needed to construct 14.4 kbps full-duplex and half-duplex modems. This device is compliant with the following data communication formats : ITU-T Recommendation V.32bis, V.32, V.22bis, V.21 and Bell standard Bell 212A and Bell103 modes, and facsimile communication formats : ITU-T Recommendation V.17, V29, V.27ter, V.21 ch2.

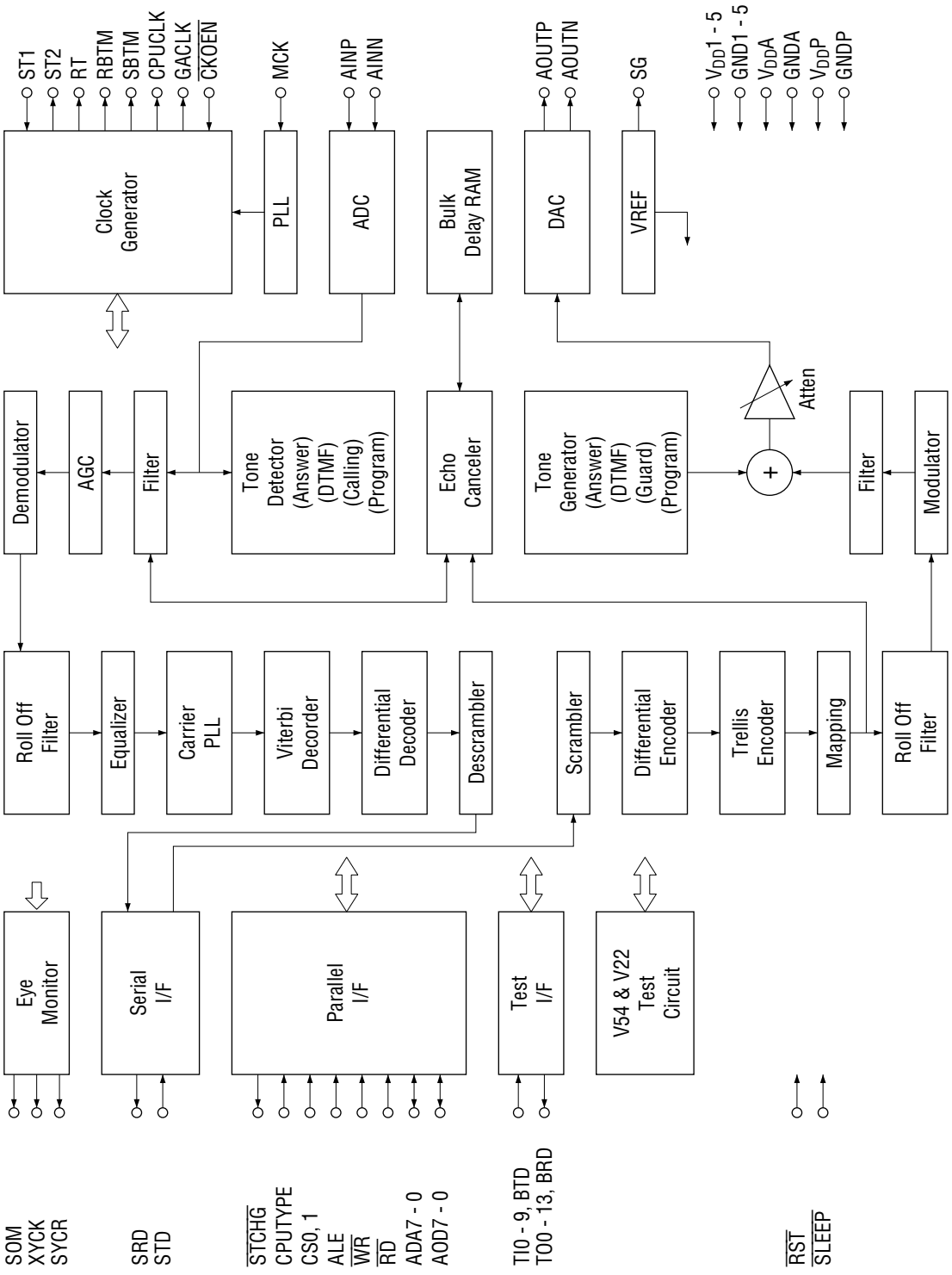
This device contains fundamental functions : high speed DSP, analog front end, and digital logic circuit. It also provides additional circuits such as test functions, synchronous-asynchronous conversion circuit, DTMF generator/detector, programmable tone generator/detector, voice output function and sleep mode. The MSM7564-01 is designed to provide a microprocessor peripheral to interface with popular single-chip microprocessors for the control of modem functions through its 8-bit multiplexed address/data bus.

FEATURES

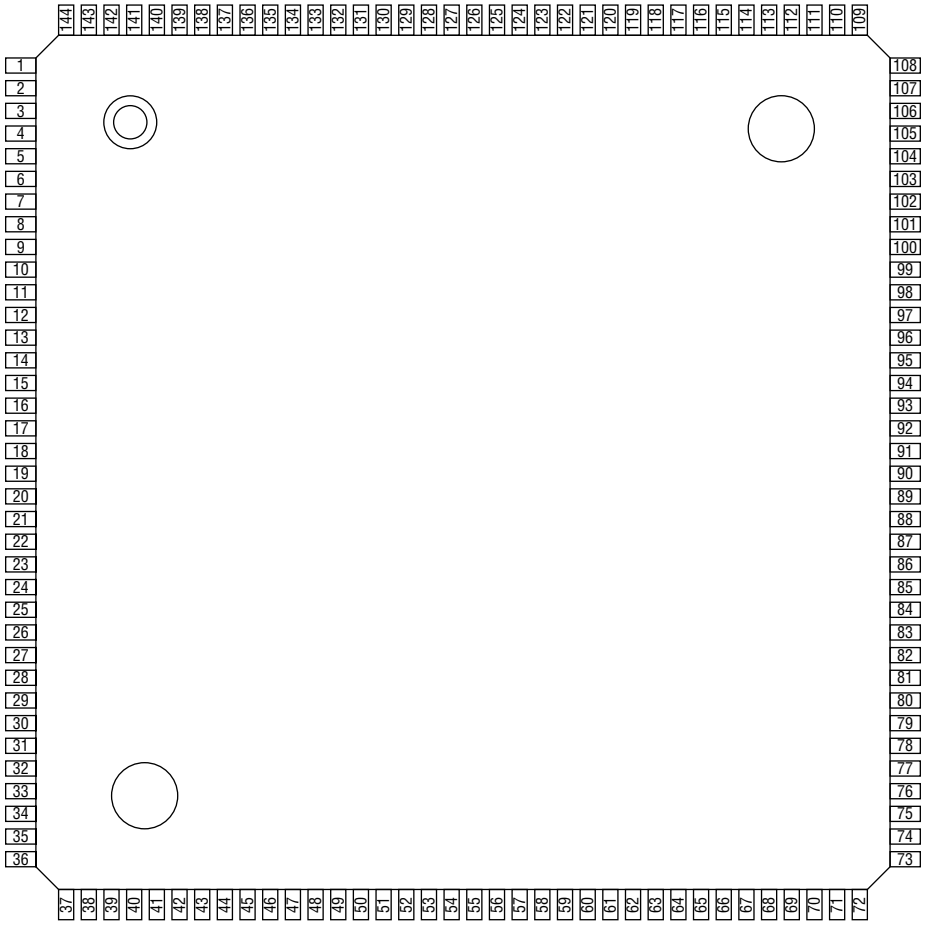
- Data mode : ITU-T Recommendation V.32bis, V.32, V.22bis, V.22, V.21
  Bell standard Bell 212A, Bell103
- Fax mode : ITU-T Recommendation V.17, V.29, V.27ter, V.21 ch2
- Synchronous/Asynchronous conversion
- Scrambler/Descrambler
- DTMF, answer tone, and guard tone generator
- Programmable transmit attenuation (15 dB, 1 dB steps)
- Call progress, answer tone, DTMF, and carrier detector
- Receiving signal quality monitor
- Independent adaptive line equalization for transmit and receive
- Carrier detection level selectable (4 steps)
- Echo canceler
- Jitter canceler
- Programmable tone generator/detector
- Voice output function
- Test mode : Local analog loop (internal/external)
  Remote digital loop
  511PN pattern generator for error test
  1:1 pattern generator for error test
  Error counter
- Sleep mode
- Single +5 V DC supply
- CMOS technology for low power consumption
  Operation mode : 500 mW Typ. @ +5 V
  Sleep mode : < 10 mW @ +5 V
- Package options:

144-pin plastic TQFP	(TQFP144-P-2020-K)	(Product name : MSM7564-01GS-K)
84-pin plastic QFJ	(QFJ84-P-S115)	(Product name : MSM7564-01JS)

BLOCK DIAGRAM



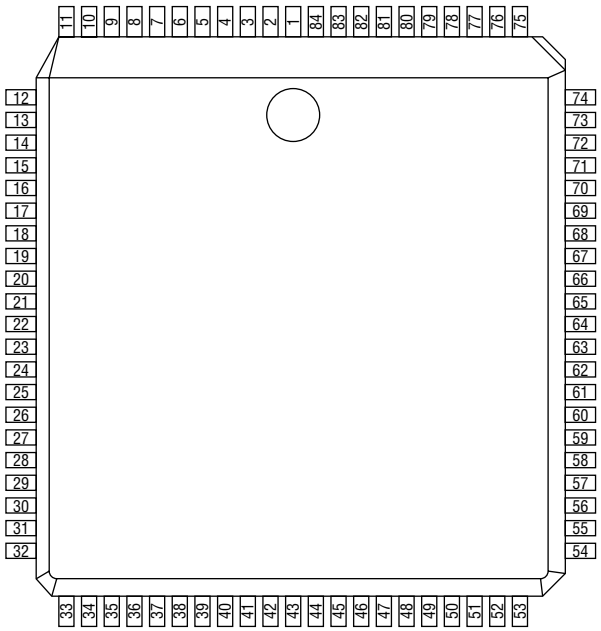
PIN CONFIGURATION (TOP VIEW)



144-Pin Plastic TQFP

Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
1	AINN	37	NC	73	TO1	109	NC
2	NC	38	NC	74	ADA6	110	TO10
3	AINP	39	TI4	75	ADA4	111	TO6
4	AOUTN	40	TI3	76	ADA3	112	NC
5	NC	41	NC	77	$V_{DD}3$	113	TO13
6	NC	42	TI5	78	NC	114	TO12
7	AOUTP	43	NC	79	ADA2	115	NC
8	$V_{DD}A$	44	TO4	80	NC	116	TO11
9	GND1	45	NC	81	ADA0	117	TO7
10	NC	46	CPUTYPE	82	NC	118	NC
11	TI2	47	GND3	83	AOD7	119	TO9
12	NC	48	NC	84	NC	120	NC
13	STD	49	BRD	85	AOD6	121	TO8
14	NC	50	ALE	86	NC	122	NC
15	$V_{DD}1$	51	NC	87	NC	123	TI6
16	NC	52	SOM	88	AOD5	124	TI7
17	ST1	53	NC	89	NC	125	NC
18	NC	54	$V_{DD}2$	90	GND4	126	$V_{DD}5$
19	$\overline{WR}$	55	SYCR	91	NC	127	TI1
20	NC	56	NC	92	AOD4	128	NC
21	BTD	57	ST2	93	NC	129	TI0
22	NC	58	NC	94	AOD3	130	NC
23	$\overline{RD}$	59	XYCK	95	NC	131	TI9
24	NC	60	NC	96	AOD2	132	GND5
25	CS1	61	SRD	97	NC	133	$V_{DD}P$
26	GND2	62	$\overline{STCHG}$	98	NC	134	MCK
27	NC	63	NC	99	AOD1	135	NC
28	$\overline{RST}$	64	TO2	100	NC	136	NC
29	NC	65	NC	101	$V_{DD}4$	137	TO5
30	CS0	66	TO0	102	AOD0	138	GNDP
31	NC	67	TO3	103	ADA5	139	GNDA
32	$\overline{CKOEN}$	68	RT	104	NC	140	NC
33	NC	69	NC	105	NC	141	NC
34	SBTM	70	CPUCLK	106	ADA1	142	NC
35	$\overline{SLEEP}$	71	GACLK	107	ADA7	143	SG
36	RBTM	72	NC	108	TI8	144	NC

NC : No connect pin



84-Pin Plastic QFJ

Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
1	GND4	22	$V_{DD}5$	43	$\overline{WR}$	64	SYCR
2	AOD4	23	TI1	44	BTD	65	ST2
3	AOD3	24	TI0	45	$\overline{RD}$	66	XYCK
4	AOD2	25	TI9	46	CS1	67	SRD
5	AOD1	26	GND5	47	GND2	68	$\overline{STCHG}$
6	$V_{DD}4$	27	$V_{DD}P$	48	$\overline{RST}$	69	TO2
7	AOD0	28	MCK	49	CS0	70	TO0
8	ADA5	29	TO5	50	$\overline{CKOEN}$	71	TO3
9	ADA1	30	GNDP	51	SBTM	72	RT
10	ADA7	31	GNDA	52	$\overline{SLEEP}$	73	CPUCLK
11	TI8	32	SG	53	RBTM	74	GACLK
12	TO10	33	AINN	54	TI4	75	TO1
13	TO6	34	AINP	55	TI3	76	ADA6
14	TO13	35	AOUTN	56	TI5	77	ADA4
15	TO12	36	AOUTP	57	TO4	78	ADA3
16	TO11	37	$V_{DD}A$	58	CPUTYPE	79	$V_{DD}3$
17	TO7	38	GND1	59	GND3	80	ADA2
18	TO9	39	TI2	60	BRD	81	ADA0
19	TO8	40	STD	61	ALE	82	AOD7
20	TI6	41	$V_{DD}1$	62	SOM	83	AOD6
21	TI7	42	ST1	63	$V_{DD}2$	84	AOD5

PIN DESCRIPTIONS

System and Clock

Symbol	Type	Description
MCK	I	Master Clock Input Frequency of 3.888 MHz ±100 ppm, with a duty ratio of between 45 and 55%.
$\overline{RST}$	I	Reset Input '0' : reset state, '1' : normal operation
$\overline{SLEEP}$	I	Sleep Input '0' : sleep state, '1' : normal operation
$\overline{CKOEN}$	I	Clock Output Enable '0' : CPUCLK and GACLK pins are enabled to output. (Internal PLL operates normally in sleep state.) '1' : CPUCLK and GACLK pins are disabled to output. (Internal PLL turns to be power down in sleep state.)
CPUCLK	O	CPU Clock Output CPUCLK outputs a 15.552 MHz clock for external CPU.
GACLK	O	Gate Array Clock Output GACLK outputs a 13.824 MHz clock for external gate array.

Modem Digital Interface

Symbol	Type	Description
ST1	I	External Transmit Clock Input An external transmit clock provided to input to ST1. The clock frequency of 300 to 14400 Hz is supplied by the local DTE.
ST2	O	Internal Transmit Clock Output ST2 outputs the transmitting data clock of between 300 and 14400 Hz selected by modem mode.
RT	O	Internal Receive Clock Output RT outputs the receiving data clock of between 300 and 14400 Hz selected by modem mode.
STD	I	Transmit Data Serial Input STD inputs the transmit serial data synchronized with either internal timing selected by modem mode or ST1 / ST2.
SRD	O	Received Data Serial Output SRD outputs the received serial data synchronized with either internal timing selected by modem mode or RT.

CPU Interfaces

Symbol	Type	Description
CPUTYPE	I	CPU Type Select CPUTYPE selects CPU bus type of ADA7 - 0 and AOD7 - 0. '1' : 80 mode (multiplexed address and data bus for Intel-compatible) '0' : 68 mode (separated address and data bus for Motorola-compatible)
$\overline{\text{STCHG}}$	O	Status Change Output When interface memory registers (0C, 0D, 1E, 1F) change, STCHG is set to "0". When the registers are read by external CPU, this pin is set to '1'.
CS0, 1	I	Chip Select Input 0 and 1 When CS0 and CS1 are set to '1', this chip is selected for microprocessor operation.
ALE	I	Address Latch Enable Input ALE allows the microprocessor to latch the address bus (ADA7 - 0) when CPUTYPE is 80 mode. Address bus is latched at the falling edge of ALE.
$\overline{\text{RD}}$	I	Read Enable $\overline{\text{RD}}$ is active LOW and is used to read from internal memory register via 8-bit address data input/output pins selected by CPUTYPE pin. CS0 and CS1 must be high.
$\overline{\text{WR}}$	I	Write Enable $\overline{\text{WR}}$ is active Low and is used to write the data at the rising edge via data input/output pins selected by CPUTYPE pin into internal memory registers. CS0 and CS1 must be high.
ADA7 - 0	I/O	8 bit Address and Data Bus 1 8 lines provide 2 modes of bus type which are selected by CPUTYPE pin. AD7 to 0 are controlled by ALE, $\overline{\text{RD}}$ and $\overline{\text{WR}}$. 80 mode : (I/O) address input and data input/output 68 mode : (I) address input
AOD7 - 0	I/O	8 bit Address and Data Bus 2 8 lines provide 2 modes of bus type which are selected by CPUTYPE pin. AD7 to 0 are controlled by ALE, $\overline{\text{RD}}$ and $\overline{\text{WR}}$. 80 mode : (O) address output (outputs latched address by ALE) 68 mode : (I/O) address input/output

Other Interfaces

Symbol	Type	Description
RBTM	O	Receive Baud Rate Timing Clock Output RBTM outputs receive baud rate timing clock of between 600 and 2400 Hz selected by modem mode.
SBTM	O	Transmit Baud Rate Timing Clock Output RBTM outputs transmit baud rate timing clock of between 600 and 2400 Hz selected by modem mode.
SOM	O	Serial Eye Pattern X/Y Output SOM outputs serial pattern containing two 16 bit words (X, Y references), synchronized with the falling edge of XYCK.
XYCK	O	Serial Eye Pattern Clock Output XYCK outputs a 1152 Hz clock for SOM timing.
SYCR	O	Serial Eye Pattern Timing Output SYCR outputs synchronous timing for SOM output. SYCR outputs two clocks of SOM clocks.

Test Interface

Symbol	Type	Description
TI0	I	TEST PIN. Connect to ground.
TI1	I	TEST PIN. Connect to ground.
TI2 - 4	I	TEST PIN. Connect to ground.
TI5, 6	I	TEST PIN. Connect to ground.
TI7	I	TEST PIN. Connect to ground.
TI8	I	TEST PIN. Connect to ground.
TI9	I	TEST PIN. Connect to V_{DD}.
BTD	I	TEST PIN. Connect to V_{DD}.
TO0	I/O	TEST PIN. Leave "OPEN".
TO1	I/O	TEST PIN. Leave "OPEN".
TO2	I/O	TEST PIN. Leave "OPEN".
TO3	I/O	TEST PIN. Connect to ground.
TO4	I/O	TEST PIN. Leave "OPEN".
TO5	O	TEST PIN. Leave "OPEN".
TO6 - 13	I/O	TEST PIN. Leave "OPEN".
BRD	O	TEST PIN. Leave "OPEN".

Analog Interface

Symbol	Type	Description
AINP	I	Analog Input (positive)
AINN	I	Analog Input (negative)
AOUTP	O	Analog Output (positive) AOUTP is in high impedance state when $\overline{\text{CKOEN}}$ is '1' state and in sleep mode.
AOUTN	O	Analog Output (negative) AOUTN is in high impedance state when $\overline{\text{CKOEN}}$ is in '1' state and in sleep mode.
SG	O	Signal Ground for Analog The SG level is about +2.4 V. Connect bypass capacitor between SG and GNDA when $\overline{\text{CKOEN}}$ is in '1' state and in sleep mode.

Power Supply

Symbol	Type	Description
V_{DD}1 - 5	I	Digital V_{DD}.
GND1 - 5	I	Digital Ground.
V_{DD}P	I	PLL V_{DD}.
GNDP	I	PLL Ground.
V_{DD}A	I	Analog V_{DD}.
GNDA	I	Analog Ground.

FUNCTIONAL DESCRIPTION

Modem Mode

MSM7564 conforms to ITU-T Recommendation and Bell standard as follows.

Modem Mode	Data Rate (bps)	Modulation	Carrier Frequency (Hz)	Baud Rate	Synchronous/ Asynchronous	Note
V.17	14400	TCM	1800	2400	sync	
V.17	12000	TCM	1800	2400	sync	
V.17	9600	TCM	1800	2400	sync	
V.17	7200	TCM	1800	2400	sync	
V.32bis	14400	TCM	1800	2400	sync/async	
V.32bis	12000	TCM	1800	2400	sync/async	
V.32bis	9600	TCM	1800	2400	sync/async	
V.32bis	7200	TCM	1800	2400	sync/async	
V.32	9600	QAM	1800	2400	sync/async	
V.32	4800	QAM	1800	2400	sync/async	
V.29	9600	QAM	1700	2400	sync	
V.29	7200	QAM	1700	2400	sync	
V.29	4800	PSK	1700	2400	sync	
V.27ter	4800	PSK	1800	1600	sync	Backward Channel ON/OFF
V.27ter	2400	PSK	1800	1200	sync	Backward Channel ON/OFF
V.22bis	2400	QAM	1200/2400	600	sync/async	
V.22	1200	PSK	1200/2400	600	sync/async	
Bell212A	1200	PSK	1200/2400	600	sync/async	
V.21	300	FSK	1080/1750	300	async	
V.21ch2	300	FSK	1080/1750	300	sync	
Bell103	300	FSK	1170/2125	300	async	

Serial Interface

MSM7564 provides a one channel serial interface, including synchronous-asynchronous and asynchronous-synchronous converters. Select synchronous or asynchronous. In synchronous mode, the transmit data is synchronized with the clock provided from this chip or DTE. Serial transmit data to STD pin is latched with the rising edge of ST1 or ST2, and receive data on SRD is output synchronously with the falling edge of RT. This chip also includes a scrambler and descrambler.

Parallel Interface

MSM7564 contains twenty 8-bit registers (location from addresses 00H through 0FH and 1C through 1F), which are used to control this chip and to detect various signals. Connect this chip to either multiplexed address and data bus such as Intel-compatible (80 mode) or separate address and data bus such as Motorola-compatible (68 mode).

Transmit and Receive Level

Analog input and output are differential amplifiers, and are $\pm 1.2\ V_{O\text{-}P}$ peak signals. The level of the transmit line signal is –10 dBm. The modem can provide 15 dB programmable transmit attenuation with 1 dB steps controlled by the TXLEV bit in located 0BH register. Receive signal level is from –10 dBm to –43 dBm. Carrier detection level can be selected from 4 levels (–43, –33, –26, –16 dBm) by the CDLEV bit located in register 0BH. An amplitude equalizer in transmitter and receiver can be individually controlled by RAEQL and SAEQL bits in register 07H.

DTMF Tone, Answer Tone, and Guard Tone Generators

The modem can generate 16 types of DTMF tones using the PBANSEL bit located in register 05H. It also generates answer tone and guard tone.

Various Detection Circuits

The internal detection circuit monitors carrier, call progress tone, answer tone, DTMF tone, and other receive signals needed for each modem mode, and stores them in the corresponding bits of each of the following registers : 0C, 0D, 1C, and 1D. Classification of detected tones is controlled by DETMODE bit in register 08H. If the contents of registers 0C, 0D, 1C, and 1D change, the interruption signal (STCHG) for controlling microprocessor is generated.

Programmable Tone Generator and Detector

The transmission of programmable tone 1 and tone 2 is available and is controlled by PTONE1 and PTONE2 bits in 05H register. To use this function, the initial download of frequency and gain is needed. This modem can output 16 kinds of frequency selected by PBANSEL bit of register 05H (composition of two tones is also available.). PTONE1 and PTONE2 are the same frequency and only the gain is variable. Each bit of D7, D6, D3, D2, D1, and D0 in register 0C can be used for programmable tone detecting by rewriting a coefficient of internal filter at the initial download.

Received Signal Quality Monitor

The modem indicates a state of received signal quality using the SQD bit of register 0D. If this bit changes, an interrupt signal (STCHG) for controlling the microprocessor is generated. Furthermore, it can read the bit error rate and receive level (stored in internal RAM) required for MNP class 10.

Echo Canceler

The modem has internal RAM for bulk delay and can cope with delays of up to 1.2 s for far-end echo.

Voice Output Function

The voice output is enabled by setting MODEMSET bit of register 06 to voice mode. In this case, voice data of 7.2 kHz sampling of 8 bits must be written in 00, 01, and 02 registers with the rising edge of RBTM (2.4 kHz).

Test Mode

The modem performs the internal local analog loop testing by the LALTST bit of register 07H. It also performs external local analog loop testing by the LALTST bit of register 07H and by connecting transmit analog output and receive analog input. Remote digital loop is available by the LOOP2 bit of register 1EH.
It can output a 511PN pattern and 1 to 1 pattern for error test controlling PN511 and ERR11 bits of register 1EH.
Error counts can be read controlling ERRCNT bit of register 1DH.

Sleep Mode

The modem supports a sleep function by controlling $\overline{\text{SLEEP}}$ bit of register 04H and $\overline{\text{SLEEP}}$ pin. It provides two modes of sleep1 (clock generator is inactive at $\overline{\text{CKOEN}}$ = '1') and sleep2 (clock generator is active at $\overline{\text{CKOEN}}$ = '0') controlled by $\overline{\text{CKOEN}}$ pin. Cancellation of sleep mode is controlled by SOFTRST bit of register 04H and $\overline{\text{RST}}$ pin.

Control register

The modem contains twenty 8-bit registers for control and signal detection monitoring. These registers are assigned by the address (ADA7-0 or AOD7-0) as shown in the following table.

• Table of control register

REG (H)	D7	D6	D5	D4	D3	D2	D1	D0
1F W	SB1DEN	RDZ	SDZ	SDA	WSIZE		EXTEND	ASYN
1E W	TXCLK		ERR11	PN511	SB11	PN1	PN0	LOOP2
1D R	DON'T CARE	BRKDET	ERRCNT			SB11DET	PN1DET	PN0DET
1C R	DON'T CARE	DON'T CARE	DON'T CARE	DON'T CARE	USB124D	USB112D	SB124D	SB112D
0F W	write "0"							
0E R	DON'T CARE						DCD	CTS
VOICE	PBTONE NO							
0D R	DON'T CARE	DSPRST	PBDET	TRN	FCD	SQD	EED	RATED
0C R V32	1650	1300	CPGDET	ANSDET	2250USB1	3000 AC	1800 AA	600 AC
V22ORG	2225	1100			2250USB1	2700 S1	2400 S1	2100 S1
V22ANS	980	1100			1270USB1	1500 S1	1200 S1	900 S1
V21ORG	1650	1300			2250USB1	3000 AC	1800 AA	600 AC
V21ANS	980	1300			2250USB1	3000 AC	1800 AA	600 AC
Bell103ORG	2225	1300			2250USB1	3000 AC	1800 AA	600 AC
Bell103ANS	1270	1300			2250USB1	3000 AC	1800 AA	600 AC
V17, V21ch2	1650	1300			1750	3000 AC	1800 AA	600 AC
V29	1650	1300			1750	2900	1700	500
V27	1650	1300			1750	2600	1800	1000
VOICE	1100	1300			2250USB1	3000 AC	1800 AA	600 AC
0B W	AGCRST	AGCH	TXLEV				CDLEV	
0A W	ILDCNT	DSPST	write "0"	write "0"	STRN	BRTS	EPT	RTS
09 W V32	EB1	RATES	TRN	ECTRN	SS	XCHG	AACC	ACCA
V22	write "0"	write "0"	write "0"	SB124	SB112	USB124	USB112	S1
VOICE	write "0"	VSMODE			write "0"			
08 W	DETMODE		AQID	TIMC	TANI	JHOLD	EHOLD	TAPH
07 W	LALTST		GTS	GTE	RAEQL	SAEQL	ORGANS	V32DATA
VOICE	write "0"			VEN	RAEQL	SAEQL	ORGANS	write "0"
06 W	MODEMSET							
05 W	PBANSEL				SFIL	PBANS	PTONE2	PTONE1
04 W	write "0"	NEGO	STUP	AUTO	EQLST	SLEEP	SOFTRST	RAMRDWR

• Table of control register (Continued)

REG (H)	D7	D6	D5	D4	D3	D2	D1	D0
03 R/W	DRAMDH (F-8)							
VOICE	write "0"			VSEN	write "0"	write "0"	VIOF	write "0"
02 R/W	DRAMDL (7-0)							
VOICE	VDATA3RD							
01 R/W	DRAMAH (F-8)							
VOICE	VDATA2ND							
00 R/W	DRAMAL(7-0)							
VOICE	VDATA1ST							

Notes: 1. W:Write Only, R: Read Only, R/W: Read/Write.
2. Deal with the following modes due to MODEMSET bit of 06H register and ORGANS bit of 07H register.
V32: V.32bis & V.32, V22: V.22bis & V.22, V21: V.21, V17: V.17, V21ch2: V.21ch2, V29: V.29, V23: V.23, V27: V.27ter, VOICE: Voice mode, ORG: Originate, ANS: Answer

Control register functional summary

REG (H)	BIT	SYMBOL	FUNCTION
00 R/W	7-0	DRAMAL (7-0)	Specify low-order 8-bit (bit7 - 0) of the address to access an internal RAM.
01 R/W	7-0	DRAMAH (F-8)	Specify high-order 8 bits (bit15 - 8) of the address to access an internal RAM.
02 R/W	7-0	DRAMDL (7-0)	Store low-order 8 bits of the data to access an internal RAM.
03 R/W	7-0	DRAMDH (F-8)	Store high-order 8 bits of the data to access an internal RAM.
00 R/W (VOICE)	7-0	VDATA1ST	Voice output 1st data
01R/W (VOICE)	7-0	VDATA2ND	Voice output 2nd data
02 R/W (VOICE)	7-0	VDATA3RD	Voice output 3rd data
03 R/W	1	VIOF	Input/output flag of voice data output
(VOICE)	4	VSEN	Enables voice data output.
04 W	0	RAMRDWR	When internal RAM is accessed, selects read or write.
	1	SOFTRST	Soft reset
	2	SLEEP	Sleep
	3	EQLST	Controls adaptive equalizer.
	4	AUTO	Specifies control method of adaptive equalizer.
	5	STUP	Start-up control
	6	NEGO	Auto negotiation control
05 W	0	PTONE1	Programmable tone control 1
	1	PTONE2	Programmable tone control 2
	2	PBANS	PB tone and answer tone control
	3	SFIL	Transmission filter control
	7-4	PBANSEL	Selects PB tone and answer tone.
06 W	7-0	MODEMSET	Modem mode setting.
07 W	0	V32DATA	Selects V.32bis and V.32 operating mode.
	1	ORGANS	Sets originate mode and answer mode.
	2	SAEQL	Sets adaptive equalization for transmit.
	3	RAEQL	Sets adaptive equalization for receive.
	4	GTE	Sets guard tone generator.
	5	GTS	Sets guard tone frequency.
	7-6	LALTST	Local analog loop back test control
07 W	1	ORGANS	Sets originate mode and answer mode.
(VOICE)	2	SAEQL	Sets transmit amplitude equalizer.
	3	RAEQL	Sets receive amplitude equalizer.
	4	VEN	Enables voice output.

Control register functional summary (Continued)

REG (H)	BIT	SYMBOL	FUNCTION
08 W	0	TAPH	Holds automatic equalizer, jitter canceler, and carrier PLL.
	1	EHOLD	Holds automatic equalizer and jitter canceler.
	2	JHOLD	Holds jitter canceler.
	3	TANI	Uses automatic equalizer of unit taps.
	4	TIMC	A pass through timing PLL
	5	AQID	Clears automatic equalizer, jitter canceler, and carrier PLL.
	7-6	DETMODE	Sets tone detection mode.
09 W (V22)	0	S1	Transmits S1 signal.
	1	USB112	Transmits unscrambled binary 1 at 1200 bps.
	2	USB124	Transmits unscrambled binary 1 at 2400 bps.
	3	SB112	Transmits scrambled binary 1 at 1200 bps.
	4	SB124	Transmits scrambled binary 1 at 2400 bps.
09 W (V32)	0	ACCA	Transmits signals AC and CA.
	1	AACC	Transmits signals AA and CC.
	2	XCHG	Selects signals AA and CC. Exchage command of AA/CC
	3	SS	Transmits signal S.
	4	ECTRN	Transmits echo canceler training signal.
	5	TRN	Transmits consecutive signals S, $\overline{S}$, and TRN.
	6	RATES	Transmits signals R1 to R3.
	7	EB1	Transmits consecutive signals E and B1
09 W (VOICE)	6-4	VSMODE	Controls coding method at voice output.
0A W	0	RTS	Request of transmission.
	1	EPT	Transmits echo protector tone.
	2	BRTS	Sets RTS of backward channel.
	3	STRN	Selects short or long training.
	6	DSPST	DSP start
	7	ILDCNT	Initial load control
0B W	1-0	CDLEV	Carrier Detect Threshold Level select.
	5-2	TXLEV	Set programmable attenuator for transmission.
	6	AGCH	AGC hold
	7	AGCRST	AGC reset
0C W (V32)	0	600 AC	Detects signal AC of 600 Hz.
	1	1800 AA	Detects signal AA of 1800 Hz.
	2	3000 AC	Detects signal AC of 3000 Hz.
	3	2250USB1	Detects unscrambled binary 1 at 2250 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	1650	Detects signal of 1650 Hz.

Control register functional summary (Continued)

REG (H)	BIT	SYMBOL	FUNCTION
0C W	0	2100 S1	Detects signal S1 of 2100 Hz.
(V22ORG)	1	2400 S1	Detects signal S1 of 2400 Hz.
	2	2700 S1	Detects signal S1 of 2700 Hz.
	3	2250USB1	Detects unscrambled binary 1 at 2250 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1100	Detects signal of 1100 Hz.
	7	2225	Detects signal of 2225 Hz.
0C W	0	900 S1	Detects signal S1 of 900 Hz.
(V22ANS)	1	1200 S1	Detects signal S1 of 1200 Hz.
	2	1500 S1	Detects signal S1 of 1500 Hz.
	3	1270USB1	Detects unscrambled binary 1 at 1270 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1100	Detects signal of 1100 Hz.
	7	980	Detects signal of 980 Hz.
0C W	0	600 AC	Detects signal AC of 600 Hz.
(V21ORG)	1	1800 AA	Detects signal AA of 1800 Hz.
	2	3000 AC	Detects signal AC of 3000 Hz.
	3	2250USB1	Detects unscrambled binary 1 at 2250 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	1650	Detects signal of 1650 Hz.
0C W	0	600 AC	Detects signal AC of 600 Hz.
(V21ANS)	1	1800 AA	Detects signal AA of 1800 Hz.
	2	3000 AC	Detects signal AC of 3000 Hz.
	3	2250USB1	Detects unscrambled binary 1 at 2250 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	980	Detects signal of 980 Hz.
0C W	0	600 AC	Detects signal AC of 600 Hz.
(Bell 103 ORG)	1	1800 AA	Detects signal AA of 1800 Hz.
	2	3000 AC	Detects signal AC of 3000 Hz.
	3	2250USB1	Detects unscrambled binary 1 at 2250 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	2225	Detects signal of 2225 Hz.

Control register functional summary (Continued)

REG (H)	BIT	SYMBOL	FUNCTION
0C W	0	600 AC	Detects signal AC of 600 Hz.
(Bell 103 ANS)	1	1800 AA	Detects signal AA of 1800 Hz.
	2	3000 AC	Detects signal AC of 3000 Hz.
	3	2250USB1	Detects unscrambled binary 1 at 2250 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	1270	Detects signal of 1270 Hz.
0C W	0	600 AC	Detects signal AC of 600 Hz.
(V17, V21ch2)	1	1800 AA	Detects signal AA of 1800 Hz.
	2	3000 AC	Detects signal AC of 3000 Hz.
	3	1750	Detects signal of 1750 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	1650	Detects signal of 1650 Hz.
0C R	0	500	Detects signal of 500 Hz.
(V29)	1	1700	Detects signal of 1750 Hz.
	2	2900	Detects signal of 2900 Hz.
	3	1750	Detects signal of 1750 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	1650	Detects signal of 1650 Hz.
0C R	0	1000	Detects signal of 1000 Hz.
(V27)	1	1800	Detects signal of 1800 Hz.
	2	2600	Detects signal of 2600 Hz.
	3	1750	Detects signal of 1750 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	1650	Detects signal of 1650 Hz.
0C W	0	600 AC	Detects signal AC of 600 Hz.
(VOICE)	1	1800 AA	Detects signal AA of 1800 Hz.
	2	3000 AC	Detects signal AC of 3000 Hz.
	3	2250USB1	Detects unscrambled binary 1 at 2250 Hz.
	4	ANSDET	Detects answer tone.
	5	CPGDET	Detects call progress tone.
	6	1300	Detects signal of 1300 Hz.
	7	1100	Detects signal of 1100 Hz.

Control register functional summary (Continued)

REG (H)	BIT	SYMBOL	FUNCTION
0D R	0	RATED	Detects rate signal.
	1	EED	Detects end signal.
	2	SQD	Indicates a state of received signal quality.
	3	FCD	Detects fast carrier.
	4	TRN	Indicates a state of training.
	5	PBDET	Detects PB tone.
	6	DSPRST	DSP reset
0E R	0	CTS	Ready for sending.
	1	DCD	Detects carrier
0E R (VOICE)	0	PBTONE NO	PB tone number
1C R	0	SB112D	Detects scrambled binary 1 at 1200 bps.
	1	SB124D	Detects scrambled binary 1 at 2400 bps.
	2	USB112D	Detects unscrambled binary 1 at 1200 bps.
	3	USB124D	Detects unscrambled binary 1 at 2400 bps.
1D R	0	PN0DET	Detects preparatory signal.
	1	PN1DET	Detects answer / termination signal.
	2	SB11DET	Detects SB11
	5-3	ERRCNT	Error Count
	6	BRKDET	Detects break signal.
1E W	0	LOOP2	Controls Loop2 test.
	1	PN0	Transmits preparatory signal.
	2	PN1	Transmits answer /termination signal.
	3	SB11	Transmits SB11
	4	PN511	Transmits signal 511PN for error test.
	5	ERR11	Transmits 1 to 1 signal for error test.
	7-6	TXCLK	Sets transmitter signal element timing.
1F W	0	ASYN	Selects synchronous or asynchronous.
	1	EXTEND	Sets extended asynchronous mode.
	3-2	WSIZE	Sets a character size for synchronous to asynchronous converter.
	4	SDA	Transmitted data clamped to A
	5	SDZ	Transmitted data clamped to Z
	6	RDZ	Received data clamped to Z
	7	SB1DEN	Controls detection of scrambled binary 1.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Power Supply Voltage	V_{DD}	–0.3 to V_{DD} + 0.3	V
Analog Input Voltage	V_{AIN}	–0.3 to V_{DD} + 0.3	V
Digital Input Voltage	V_{DIN}	–0.3 to V_{DD} + 0.3	V
Digital Output Voltage	V_{OUT}	–0.3 to V_{DD} + 0.3	V
Storage Temperature	T_{STG}	–55 to + 150	°C

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power Supply Voltage	V_{DD}	4.75	5.00	5.25	V
Operating Temperature	T_{op}	–20	—	70	°C

RECOMMENDED OPERATING CONDITIONS (ANALOG)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Impedance	R_{AI}	50	—	—	kΩ
Output Load Impedance	R_{AOL}	20	—	—	kΩ
Output Load Capacitance	C_{AOL}	—	—	100	pF
Analog Input Amplitude	V_{AIN}	—	—	V_{SG}	V_{PP}
SG Output Voltage	V_{SG}	2.35	2.40	2.45	V

ELECTRICAL CHARACTERISTICS

DC Characteristics

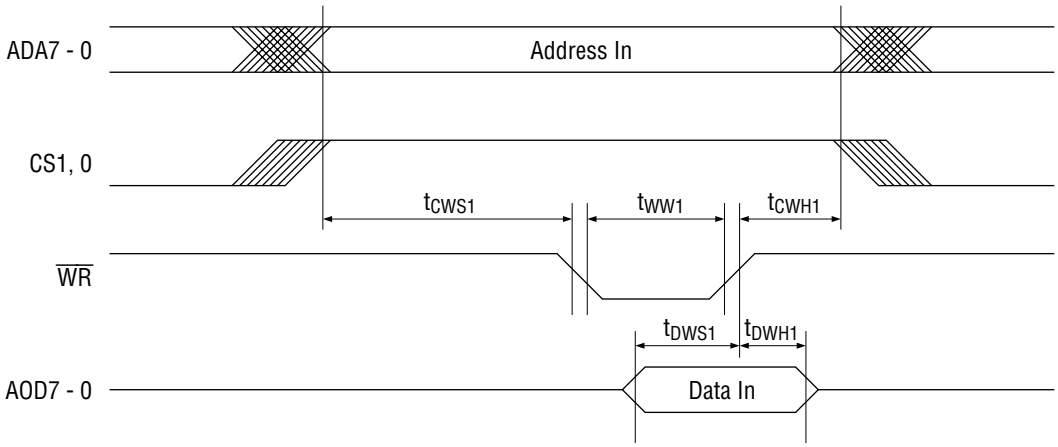
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Input Leakage Current	I_{LI}	V_{IN} = V_{DD}/0 V	–10	—	10	µA
Output Leakage Current	I_{LO}	V_{IN} = V_{DD}/0 V	–10	—	10	µA
High-level Input Voltage *1	V_{IH}	—	4.0	—	V_{DD} + 0.3	V
High-level Input Voltage *2	V_{IH}	—	2.4	—	V_{DD} + 0.3	V
Low-level Input Voltage *1	V_{IL}	—	–0.3	—	0.8	V
Low-level Input Voltage *2	V_{IL}	—	–0.3	—	0.8	V
High-level Output Voltage *1	V_{OH}	I_{OH} = –400 µA	4.2	—	—	V
High-level Output Voltage *2	V_{OH}	I_{OH} = –200 µA	4.2	—	—	V
Low-level Output Voltage *1	V_{OL}	I_{OL} = 3.2 mA	—	—	0.4	V
Low-level Output Voltage *2	V_{OL}	I_{OL} = 1.6 mA	—	—	0.4	V
Stand-by Current 1 (Sleep Mode)	I_{DDS1}	clock generator inactive state ($\overline{CKOEN}$ = 1)	—	—	2	mA
Stand-by Current 2 (Sleep Mode)	I_{DDS2}	clock generator active state ($\overline{CKOEN}$ = 0)	—	35	—	mA
Average Power Supply Current (Operating)	I_{DDO}	MCK = 3.888 MHz	—	100	—	mA

Notes: *1: Applied to RST, SLEEP pins.
*2: Applied to input pins except those of *1.
*3: Applied to ADA7 - 0 and AOD7 - 0 pins.
*4: Applied to output pins except those of *3.

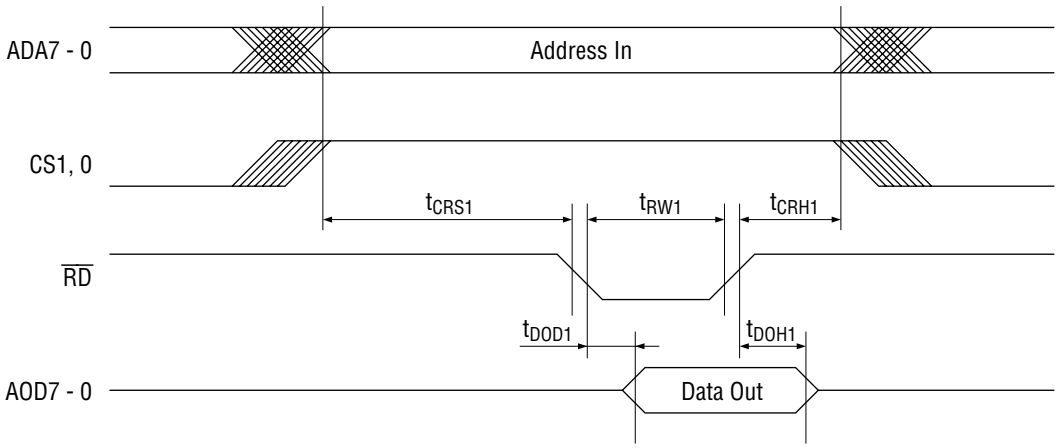
AC Characteristics (CPU Interface : 68 mode)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Address and Chip Select Setup Time (to $\overline{WR}$ Negative Edge)	t_{CWS1}	30	—	—	ns
Address and Chip Select Setup Time (to $\overline{WR}$ Positive Edge)	t_{CWH1}	15	—	—	ns
$\overline{WR}$ Pulse Width	t_{WW1}	45	—	—	ns
Data-in Setup Time	t_{DWS1}	30	—	—	ns
Data-in Hold Time	t_{DWH1}	15	—	—	ns
Address and Chip Select Setup Time (to $\overline{WR}$ Negative Edge)	t_{CRS1}	30	—	—	ns
Address and Chip Select Setup Time (to $\overline{RD}$ Positive Edge)	t_{CRH1}	15	—	—	ns
$\overline{RD}$ Pulse Width	t_{RW1}	45	—	—	ns
Data-out Delay Time (to $\overline{RD}$ Negative Edge)	t_{DOD1}	—	—	40	ns
Data-out Hold Time (to $\overline{RD}$ Positive Edge)	t_{DOH1}	0	—	—	ns

Write timing



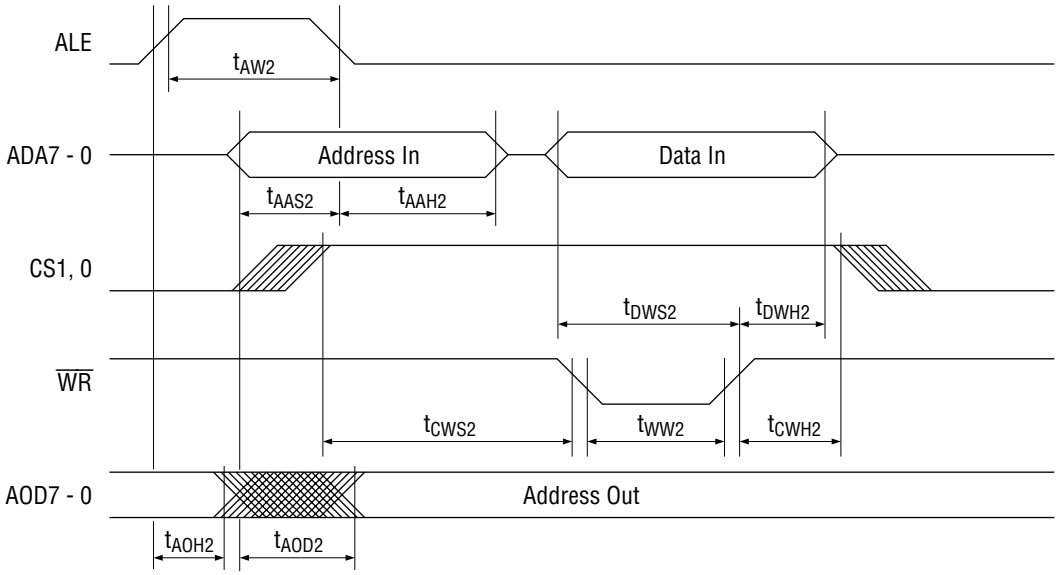
Read timing



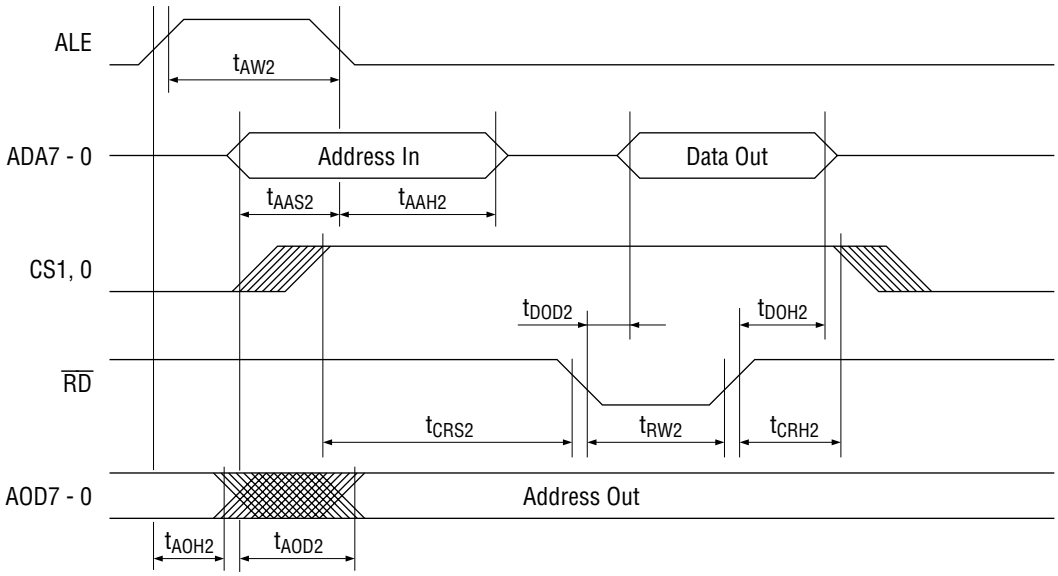
AC Characteristics (CPU Interface : 80 mode)

Parameter	Symbol	Min.	Typ.	Max.	Unit
ALE Pulse Width	t_{AW2}	30	—	—	ns
Address-in Setup Time	t_{AAS2}	30	—	—	ns
Address-in Hold Time	t_{AAH2}	15	—	—	ns
Chip Select Setup Time (to $\overline{WR}$ Negative Edge)	t_{CWS2}	30	—	—	ns
Chip Select Hold Time (to $\overline{WR}$ Positive Edge)	t_{CWH2}	15	—	—	ns
$\overline{WR}$ Pulse Width	t_{WW2}	45	—	—	ns
Data-in Setup Time	t_{DWS2}	30	—	—	ns
Data-in Hold Time	t_{DWH2}	15	—	—	ns
Address-out Hold Time	t_{AOH2}	0	—	—	ns
Address-out Delay Time	t_{AOD2}	—	—	40	ns
Chip Select Setup Time (to $\overline{RD}$ Negative Edge)	t_{CRS2}	30	—	—	ns
Chip Select Hold Time (to $\overline{RD}$ Positive Edge)	t_{CRH2}	15	—	—	ns
$\overline{RD}$ Pulse Width	t_{RW2}	45	—	—	ns
Data-out Delay Time (to $\overline{RD}$ Negative Edge)	t_{DOD2}	—	—	40	ns
Data-out Hold Time (to $\overline{RD}$ Positive Edge)	t_{DOH2}	0	—	—	ns

Write timing



Read timing



Analog Transmit Characteristics

Parameter		Symbol	Min.	Typ.	Max.	Unit	Note
Transmit Carrier	Output level (at TXLEV = 00)	TSFL	–11.5	–10	–8.5	dBm	
	Transmit signal to noise ratio	TSSN	—	65	—	dB	–10 dBm output
DTMF Tone	Frequency tolerance	TSDF	F – 10	F	F + 10	Hz	F = 1209, 1336, 1477, 1633, 697, 770, 852, 941 Hz
	Transmit level (at TXLEV = 00)	TSDLH	–7	–5.5	–4	dBm	High channel
		TSDLL	–8.5	–7	–5.5	dBm	Low channel
Answer Tone	Frequency tolerance	TSAF	F – 10	F	F + 10	Hz	F = 2100, 2225 Hz
	Transmit level (at TXLEV = 00)	TSAL	–11.5	–10	–8.5	dBm	

Analog Receive Characteristics

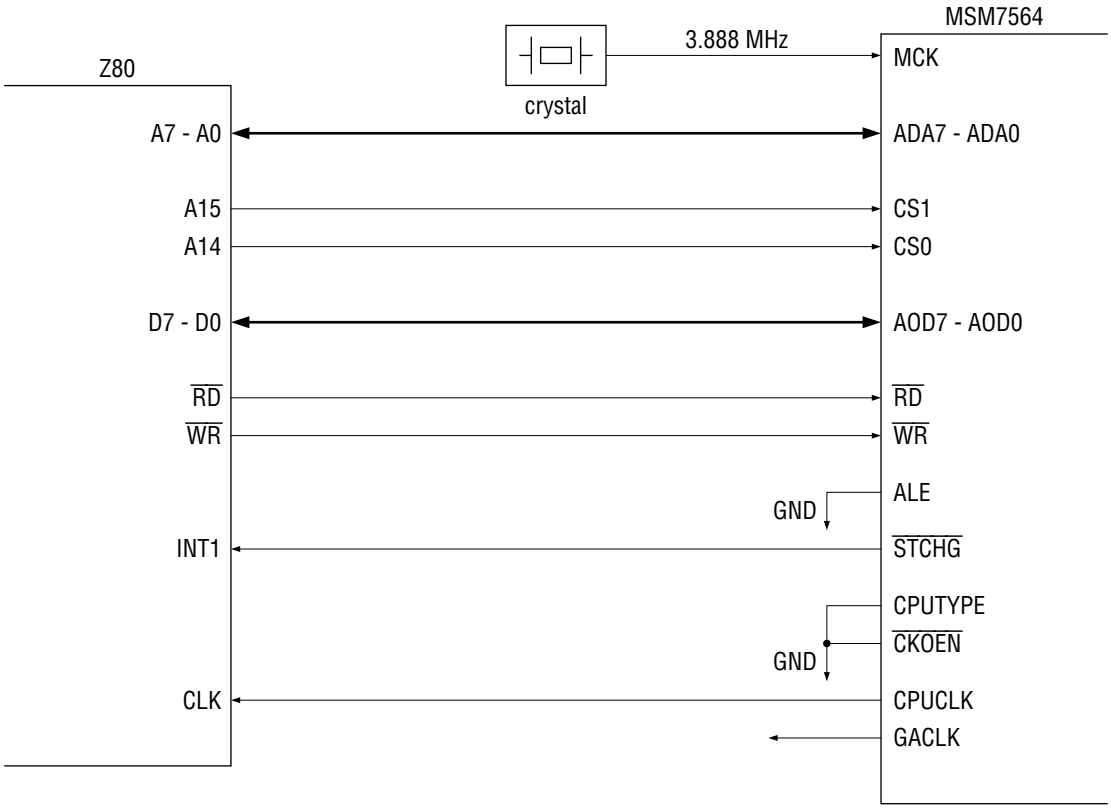
Parameter		Symbol	Min.	Typ.	Max.	Unit	Note
Receive Carrier	Input level	TRFL	–43	—	–10	dBm	
	Receive signal to noise ratio	TRSN	—	45	—	dB	–40 dBm input
Carrier Detector	Detect level	CDDL	–48	—	–43	dBm	
	Delay time	t_{CDD}	—	25	—	ms	
	Hold time	t_{CDH}	—	15	—	ms	
Answer Tone	Detect level	ATDL	–43	—	—	dBm	2100 Hz / 2225 Hz
	Delay time	t_{ATD}	—	25	—	ms	
	Hold time	t_{ATH}	—	25	—	ms	
Call Progress Tone	Detect level	CTDL	–43	—	—	dBm	350 to 620 Hz band
	Delay time	t_{CTD}	—	50	—	ms	
Other Tone	Detect level	OTDL	–43	—	—	dBm	ex. DTMF tone

Note: A unit (dBm) to signal power level is 600 Ω termination. 0 dBm is equal to 0.775 Vrms.

APPLICATION CIRCUITS

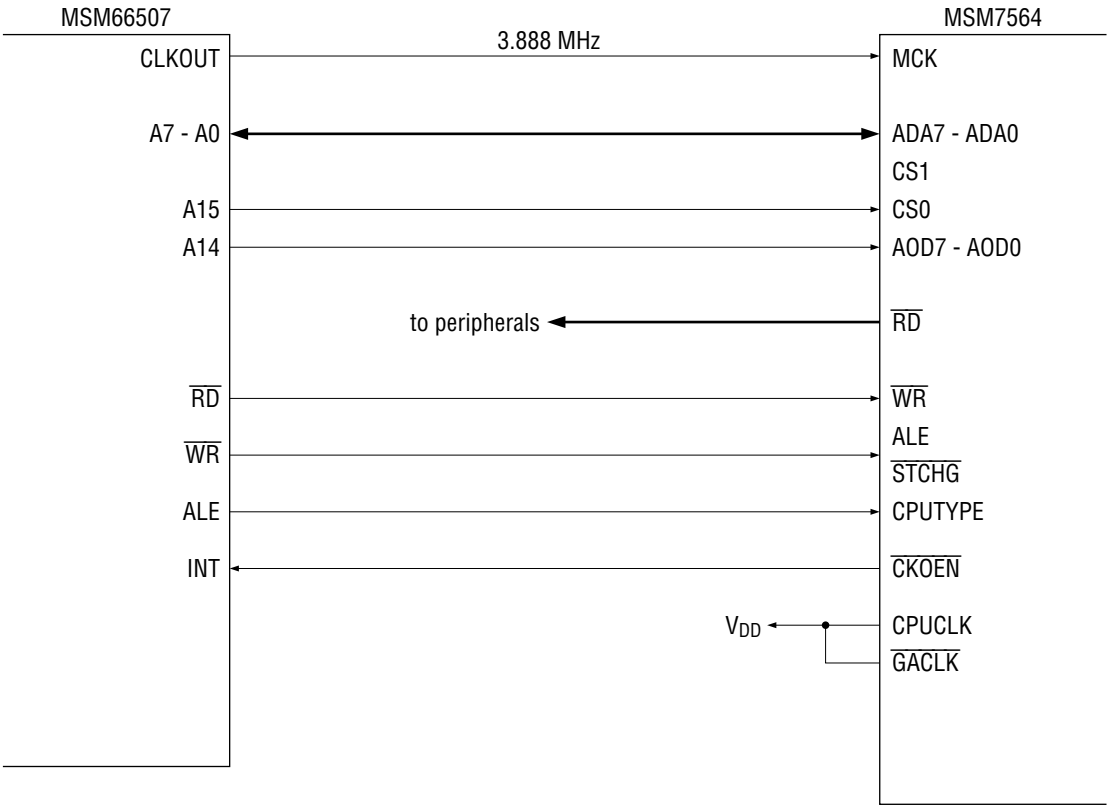
CPU Interface1

The modem supports an interface to connect directly to separate address-data bus such as a Motorola-compatible CPU (68 mode : ex. Z80). The master clock (3.888 MHz) is assumed to be supplied from an external crystal. The clock for Z80 or gate array clock generated in this device is sent from CPUCLK and GACLK pins. The outline of connection is as follows.



CPU Interface 2

The modem supports an interface to connect directly to a multiplexed address-data bus such as an Intel-compatible CPU (80 mode : ex. MSM66507). The master clock (3.888 MHz) is assumed to be supplied from clock out pin of an external CPU. Internal address latch and address output pins for peripherals are also provided. The outline of connection is as follows.



Analog Interface