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9161-002-037-NA ISSUE 3 November 1990

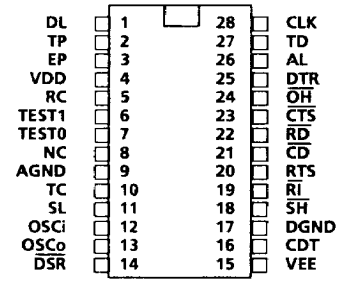
Features

- Single chip 300 bps, full duplex, asynchronous FSK modem
- Bell 103/113 and CCITT V.21 selectable
- Auto answer/originate operating modes
- Manual mode
- Phase continuous transmit carrier switching
- Digital and analog loopback modes
- CCITT V.25 tone generation
- UART clock output
- Passthru mode for protocol independence
- No external filtering required
- DTE Interface - Functionally: RS-232C Compatible (CCITT V.24)
  Electrically: TTL level Compatible

Applications

- Stand alone RS-232C interface modem
- Add on modem for personal computers and microprocessor systems

Pin Connections



Ordering Information 0°C to 70°C

MT3530BE Plastic DIP

Description

The MT3530 is a ISO²-CMOS single chip full duplex FSK modem. It is intended for use in Bell 103/113 and CCITT V.21 type applications. The MT3530 features on-chip transmit and receive filters; answer/originate mode selection; RS-232C control interface; digital and analog Loopback test modes; and generation of both 4.8 kHz UART clock and V.25 Answer Tone. The device uses a 3.579545 MHz NTSC color T.V. crystal.

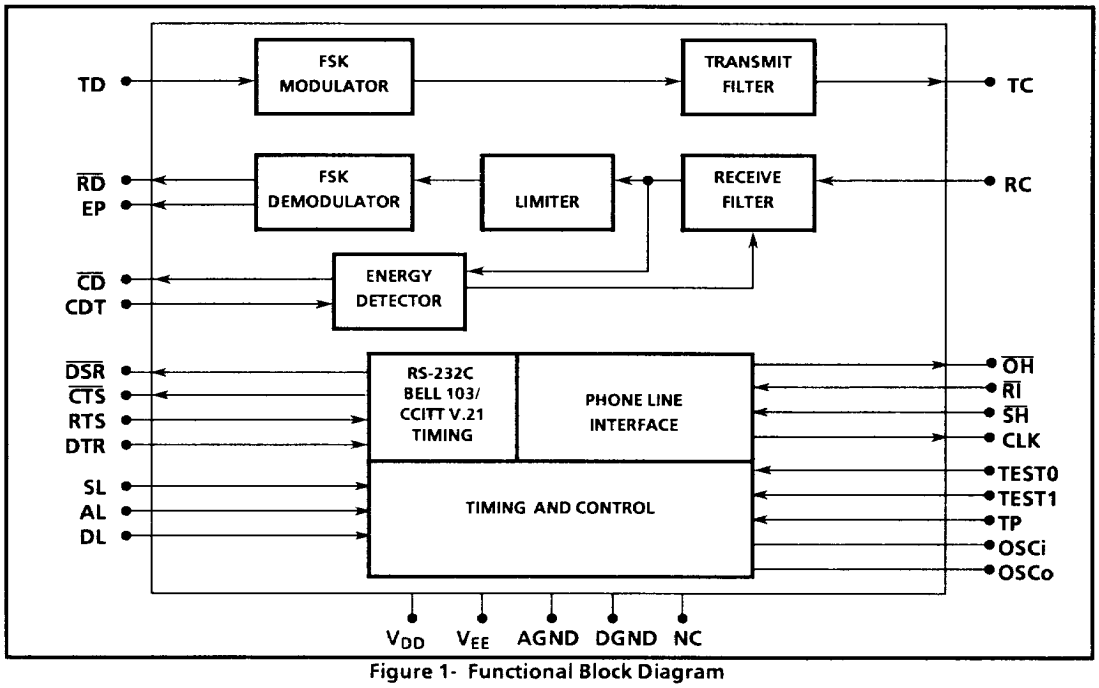


Figure 1- Functional Block Diagram

Absolute Maximum Ratings*

	Parameter	Symbol	Min	Max	Units
1	DC Supply Voltage	V_{DD}-V_{EE}		+12.0	V
2	Storage Temperature Range	T_{STG}	−65	+150	°C
3	Input Voltage, All Pins	V_{IN}	V_{EE}−0.3	V_{DD}+0.3	V

*Exceeding these values may cause permanent damage. Functional operation under these conditions is not implied.

D.C. Electrical Operating Conditions - T_O = 0°C to + 70°C.

	Characteristics	Sym	Min	Typ‡	Max	Units	Test Conditions
1	Positive Supply Voltage	V_{DD}	+4.75	+5.0	+5.25	V	DGND = AGND = 0 Volt
2	Negative Supply Voltage	V_{EE}	−4.75	−5.0	−5.25	V	DGND = AGND = 0 Volt
3	Power Consumption	P_C		110	200	mW	V_{DD}=5.0 V; V_{EE}=−5.0 V

‡ Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

Recommended Operating Conditions - Voltages are with respect to ground unless otherwise stated.

		Parameter	Sym	Min	Typ‡	Max	Units	Test Conditions
1	I	Positive Supply Voltage	V_{DD}		+5		V	DGND=AGND=0 Volt
2	N	Negative Supply Voltage	V_{EE}		−5		V	DGND=AGND=0 Volt
3	P	Oscillator Clock Frequency	fosc		3.579545		MHz	
4	U	Oscillator Frequency Tolerance	Δfosc		±0.02		%	
5	T S	Operating Temperature Range	T_O	0		70	°C	

‡ Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

Analog Signal Parameters T_O = 0°C to +70°C, ±5 Vdc, fosc = 3.579545 MHz.

	Parameter	Sym	Min	Typ‡	Max	Units	Test Conditions
1	Oscillator Clock Frequency Oscillator Frequency Tolerance Transmit Frequency Tolerance	fosc Δfosc Δft		3.579545 ±0.02 ±1.2	 ±3	MHz % Hz	
2	Transmit 2nd Harmonic Attenuation with respect to carrier level	T_{HD}		50		dB	
3	Transmit Output Level	T_{OUT}	−9	−8	−7	dBm	Load 10 kΩ 25 pF Max.
4	Carrier Input Range		−50		0	dBm	CDT open
5	Dynamic Range	DNR		50		dB	CDT open
6	Carrier Detect: On Level Off Level On/Off level Hysterisis	CD_{ON} CD_{OFF} CD_H	 −50 2.5	−43 −48 5	−41	dBm dBm dB	
7	Bit Jitter Bit Bias (Mark and Space) Bias Distortion			100 1 3		µs % %	Input = −30dBm

‡ Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

DC Electrical Characteristics - V_{DD} = 5 ± 5% Vdc, V_{EE} = −5 ± 5% Vdc, AGND=DGND=0V, T_O = 0°C to 70°C.

		Characteristics	Sym	Min	Typ‡	Max	Units	Test Conditions
1	INPUTS	CMOS Inputs Voltage High	V_{IH}	3			V	Note 1
		Voltage Low	V_{IL}			−3	V	
2		TTL Inputs Voltage High	V_{IH}	2			V	Note 2
		Voltage Low	VIL			0.8	V	
3		Input Resistance	R_{IN}	8			MΩ	All Inputs
4		Input Capacitance	C_{IN}			15	pF	All Inputs
1	OUTPUTS	LSTTL Outputs						Note 3
		Voltage High	V_{OH}	2.4			V	
		Voltage Low	V_{OL}			0.4	V	I_{OL} = 0.4mA
2		TTL Output						Note 4
		Voltage High	V_{OH}	2.4			V	
		Voltage Low	V_{OL}			0.4	V	I_{OL} = 1.6mA

‡ Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

Modem Timing† Parameter for CCITT V.21 Operating Mode. See Figures 2 and 4a.

		Parameter	Sym	Min	Typ‡	Max	Units	Test Conditions
1	ORIG	Answer Detect	t_{AD}	332	450	564	ms	Note 5
2		Receive Carrier Low	t_{RCL}	172	205	236	ms	Note 5
3		Transmit Carrier	t_{TXC}	592	632	688	ms	Note 5
4		Receive Carrier to $\overline{CD}$ Delay	t_{RCD}	20	50	80	ms	Note 5
5		$\overline{CD}$ to Off-Hook Delay	t_{COH}	180	200	232	ms	Note 5
1	ANS	Billing Delay	t_{BD}	2.0	2.1	2.3	s	Note 5
2		Answer Tone	t_{AT}		3.4		s	Note 5
3		Transmit Carrier Delay	t_{TCD}		80		ms	Note 5
4		Clear-To-Send	t_{CTS}	332	450	564	ms	Note 5

† Timing is over recommended temperature & power supply voltages.
‡ Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

Modem Timing† Parameters for Bell 103 Operating Mode. See Figures 3 and 4a.

		Characteristics	Sym	Min	Typ‡	Max	Units	Test Conditions
1	ORIG	Receive Dial Tone	t_{DT}	70			ms	Note 5
2		Answer Tone Detect	t_{ATD}	100	120	200	ms	Note 5
3		Receive Carrier Low	t_{RCL}	172	200	236	ms	Note 5
4		Transmit Carrier	t_{TXC}	592	632	688	ms	Note 5
5		Receive Carrier to $\overline{CD}$ Delay	t_{RCD}	10	20	32	ms	Note 5
6		$\overline{CD}$ to Off-Hook Delay	t_{COH}	180	200	232	ms	Note 5
1	ANS	Billing Delay	t_{BD}	2.0	2.1	2.2	s	Note 5
2		Clear-To-Send Low	t_{CTS}	100	120	200	ms	Note 5

† Timing is over recommended temperature & power supply voltages
‡ Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

Note 1. Include $\overline{SH}$, $\overline{RI}$, TEST0, TEST1
Note 2. Include RTS, TD, DTR, AL, DL, SL
Note 3. Include $\overline{OH}$, $\overline{CLK}$, $\overline{CD}$, $\overline{DSR}$
Note 4. Include $\overline{RD}$, $\overline{CTS}$
Note 5. Test conducted using Passthru mode

Modem Timing† Parameters for Bell 103/CCITT V.21. See Figures 2, 3, 4b & 5.

		Characteristics	Sym	Min	Typ‡	Max	Units	Test Conditions
1	ORIG	Data Terminal Low	t_{DTL}	15			ms	Note 5
2	ORIG	Request to Send On Delay	t_{RTS}	1			ms	Note 5
3	ORIG	Switch Hook Low	t_{SHL}	54			ms	
1	ANS	Ring Indicator to $\overline{OH}$ Delay	t_{RIO}		80		ms	Note 5
2	ANS	Data Terminal Low to $\overline{OH}$ Delay	t_{TOH}		10		ms	Note 5
3	ANS	Switch Hook to Off Hook Delay	t_{SOH}		40		ms	Note 5
4	ANS	Ring Indicator Low	t_{RIL}	107			ms	

† Timing is over recommended temperature & power supply voltages.

‡ Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

Note 5: Test conducted using Passthru Mode.

Pin Name	Pin No.	Input	Output	Voltage Level Low	Voltage Level High	Logic Family	I_{OL} mA
$\overline{SH}$	18	X		−3	+3	CMOS	
$\overline{RI}$	19	X		−3	+3	CMOS	
TEST0	7	X		−3	+3	CMOS	
TEST1	6	X		−3	+3	CMOS	
$\overline{OH}$	24		X	+0.4	+2.4	LSTTL	0.4
CLK	28		X	+0.4	+2.4	LSTTL	0.4
$\overline{CD}$	21		X	+0.4	+2.4	LSTTL	0.4
$\overline{RD}$	22		X	+0.4	+2.4	TTL	1.6
$\overline{CTS}$	23		X	+0.4	+2.4	TTL	1.6
$\overline{DSR}$	14		X	+0.4	+2.4	LSTTL	0.4
RTS	20	X		+0.8	+2.0	TTL	
TD	27	X		+0.8	+2.0	TTL	
DTR	25	X		+0.8	+2.0	TTL	
AL	26	X		+0.8	+2.0	TTL	
DL	1	X		+0.8	+2.0	TTL	
SL	11	X		+0.8	+2.0	TTL	

Table 1 - Signal Input and Output Compatibility

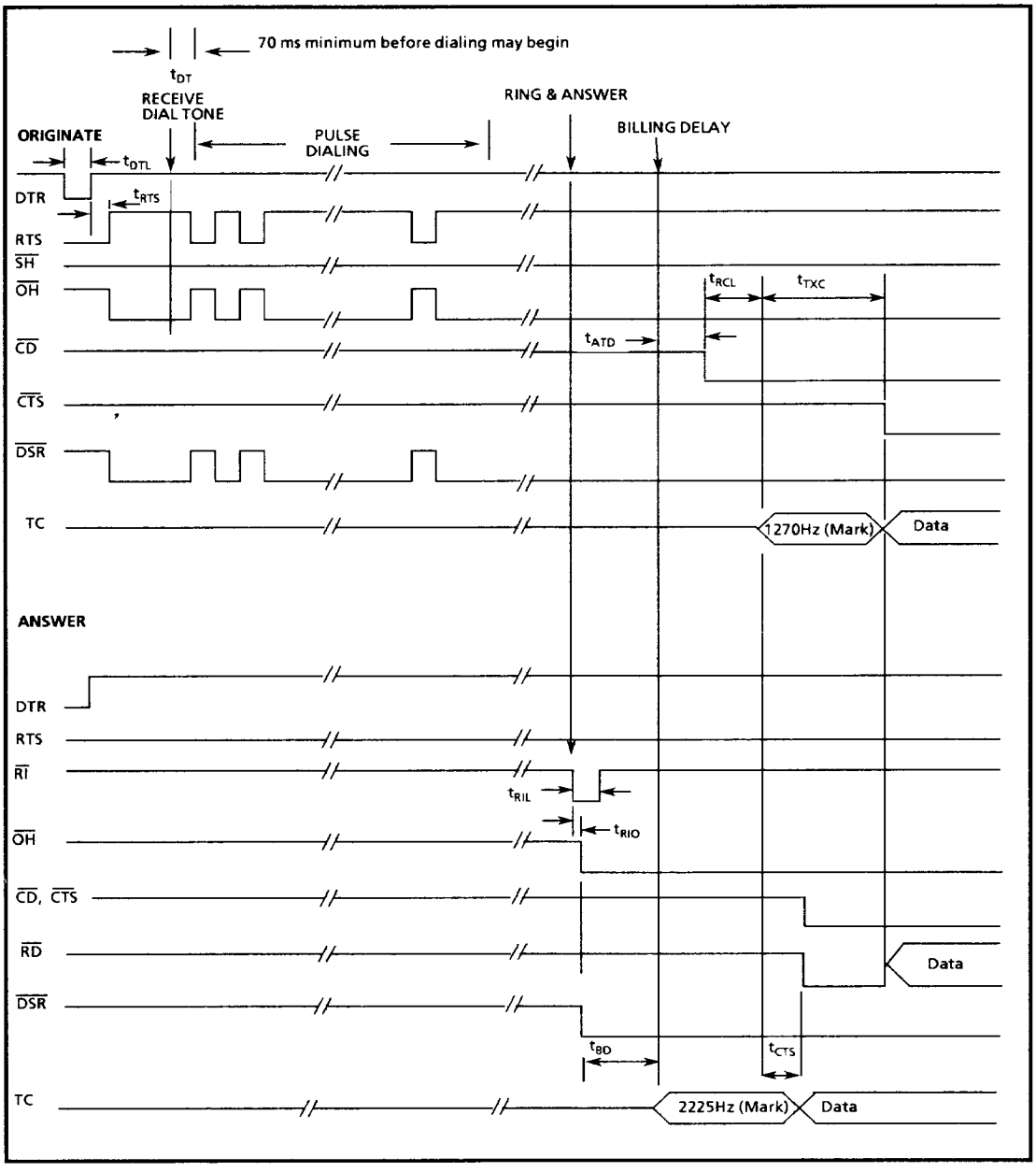


Figure 2 - MT3530 Modem Timing Chart for Bell 103 Operating Mode

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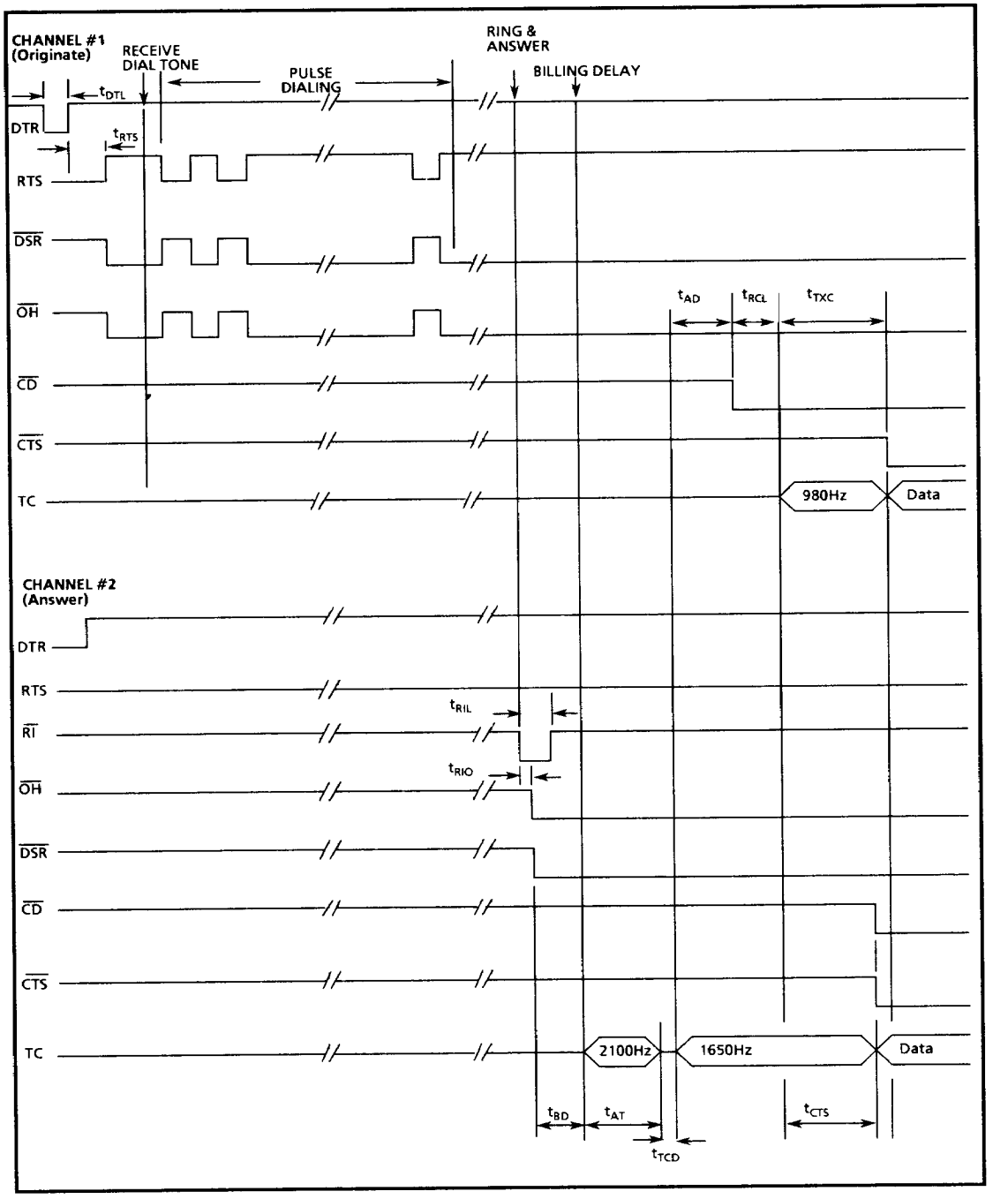

Figure 3 - MT3530 Modem Timing Chart for CCITT V.21 Operating Mode

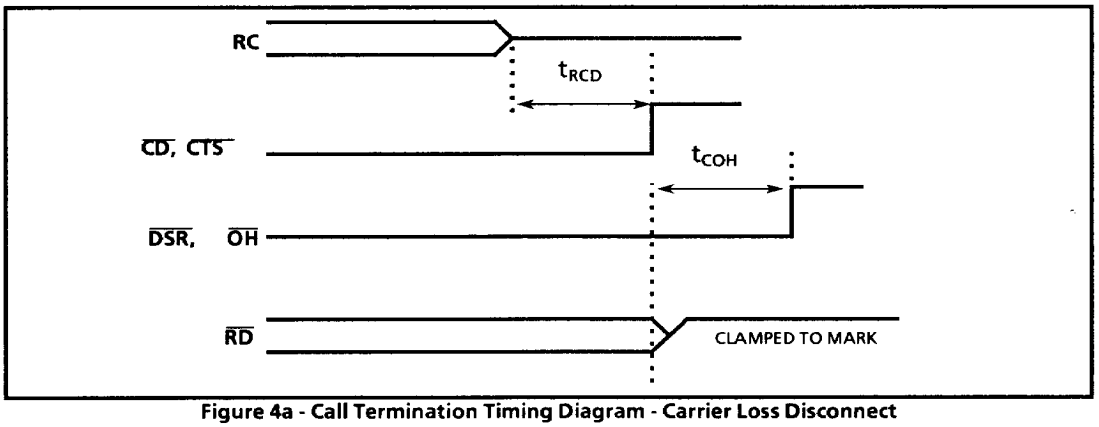

Figure 4a - Call Termination Timing Diagram - Carrier Loss Disconnect

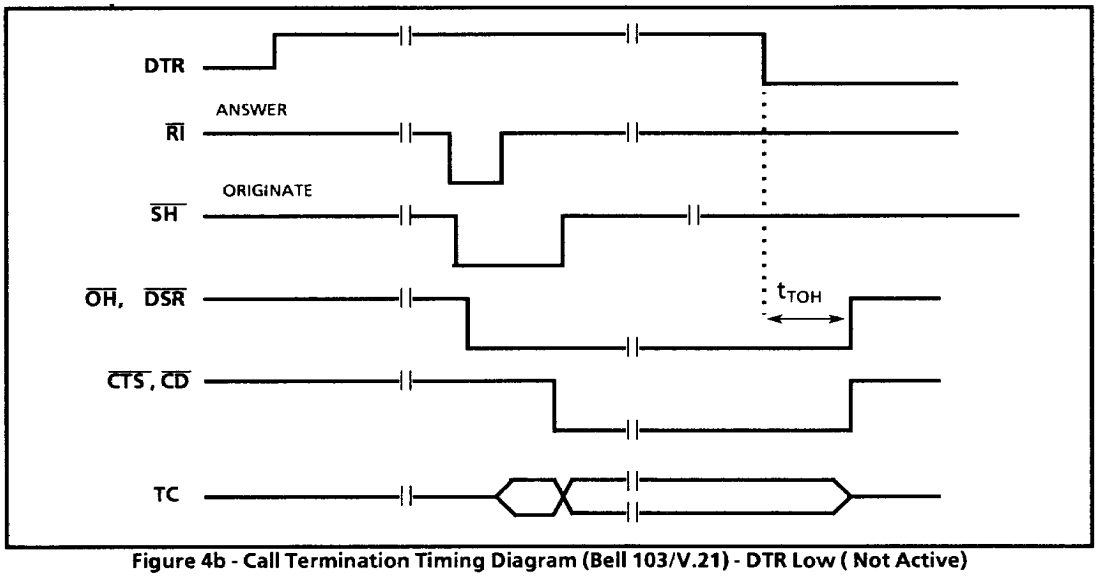

Figure 4b - Call Termination Timing Diagram (Bell 103/V.21) - DTR Low (Not Active)

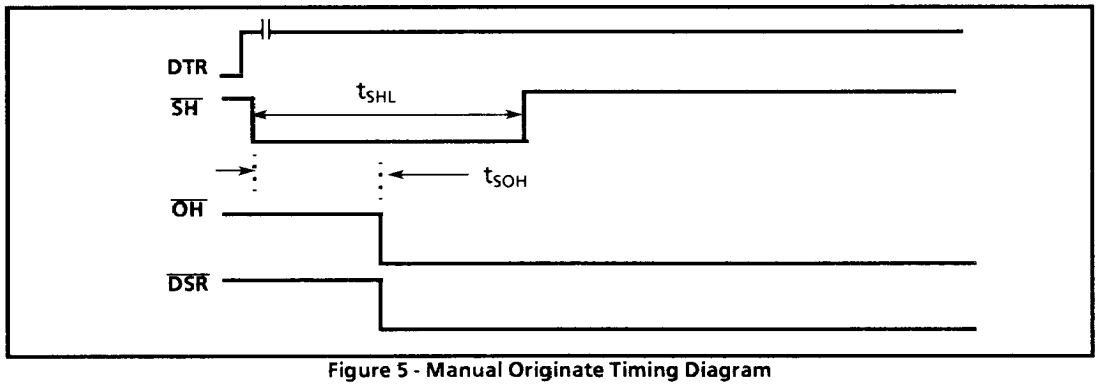

Figure 5 - Manual Originate Timing Diagram

Pin Description

Pin #	Name	Description
1	DL	**Digital Loopback** (TTL Input) - A High level on this input causes the device to enter the Digital Loopback mode. In this mode, the received data from the remote end is internally looped back to TD and $\overline{DSR}$ is forced High to signal to the DTE that the modem is not ready for transmission. The received data is not available on $\overline{RD}$ pin during the DL mode.
2	TP	**Test Point** - Test pin must be connected to either V_{EE} or V_{DD} for normal operations.
3	EP	**Eye Pattern** - Output (analog) of the demodulator prior to slicing. Do not load.
4	V_{DD}	Positive power pin (+5 V).
5	RC	**Receive Carrier** - This analog input is the data carrier received by the Data Access Arrangement from the line. The modem demodulates this signal to generate the receive data bits.
6 7	TEST1 TEST0	These are test inputs and must be tied to V_{EE} for normal applications. See Table 3 under Passthru mode.
8	NC	**No Connect**
9	AGND	**Analog Ground** - (0 Volt).
10	TC	**Transmit Carrier** - This analog output is the modulated transmit data carrier. Its frequency depends upon whether the modem is in the Answer or Originate mode and if a Mark or Space condition is being sent (Table 2).
11	SL	**Select** - A High on this input selects the CCITT V.21 data transmission format. Applying a Low selects the Bell 103 data transmission format.
12	OSCi	**Oscillator Input** - A 3.579545 MHz crystal can be connected between OSCi and OSCo. All internal clock signals are derived from this time base. Additional 20 pF caps to V_{EE} from each pin are required. An external clock signal may instead be applied at the OSCi input.
13	OSCo	**Oscillator Output** -This is not connected when external clock is applied at at the OSCi input.
14	$\overline{DSR}$	**Data Set Ready** - This output, when Low, indicates to the data terminal that the modem is ready to transmit data.
15	V_{EE}	Negative power input pin (−5 V).
16	CDT	**Carrier Detect Threshold** - Applying a variable voltage between 0 and −5 V_{DC} at this input pin allows control of the receiver carrier detection threshold. This will override the internally determined threshold. If CDT is set to a voltage between +1.5 V and +2.0 V the AGC will be disabled during the test modes of pins 6 and 7.
17	DGND	**Digital Ground** - (0 Volt).
18	$\overline{SH}$	**Switch-Hook** - This input is used to manually place the device in the Originate mode. The device will make the $\overline{OH}$ output Low and start the Originate sequence if $\overline{SH}$ is Low and DTR is High. This can be a level or a momentary low going pulse input (min. 54 ms). A pulse duration of less than 27 ms will not be detected. $\overline{RI}$ should be High if $\overline{SH}$ is to be exercised. Once $\overline{RI}$ has been activated then RTS has no effect.
19	$\overline{RI}$	**Ring Indicator** - This input when High permits auto answer capability. The Data Access Arrangement should apply a Low level to $\overline{RI}$ when a ringing signal is detected. The level should be Low for at least 107 ms. The input can remain Low until reset by DTR or loss of carrier. Similarly, in Manual mode, the Answer Mode is entered by applying a Low to this input, unless RTS is High.

Pin Description (continued)

Pin #	Name	Description
20	RTS	**Request To Send** - This controls data transmission from the modulator. A High on this input with the DTR input High (in the On condition) causes the device to enter the Originate mode. $\overline{OH}$ will go Low to seize the phone line. Auto dialing can be performed by turning the RTS input High and Low to effect dial pulsing. This input must remain High for the duration of data transmission. (Auto and manual answer will not function if RTS is High.)
21	$\overline{CD}$	**Carrier Detect** - The output goes Low (On) to indicate that the receive data carrier has been received. It goes High (Off) if the received data carrier falls below the carrier detection threshold.
22	$\overline{RD}$	**Received Data** - The device presents data bits demodulated from the received data carrier at this output. This output is forced High if DTR is Low or Carrier Detect is High (Off).
23	$\overline{CTS}$	**Clear To Send** - This output goes Low at the completion of the handshaking sequence and goes High when the modem disconnects. It is always High if the device is in the Digital Loopback mode. Data to be transmitted should not be applied at the TD input until this output goes Low (active).
24	$\overline{OH}$	**Off-Hook** - This output goes to Low when either the RTS or $\overline{SH}$ input is active in the Originate mode and when a valid ring signal is detected on the $\overline{RI}$ input in the Answer mode.This output is High if DTR is Low or if the disconnect sequence has been completed.
25	DTR	**Data Terminal Ready** - A High on this input enables all the other inputs and outputs and must be present before the device will enter the data mode either manually or automatically. The device will enter an irreversible disconnect sequence if the input goes Low for more than 14 ms during a data call. A pulse duration of less than 6 ms will not be detected.
26	AL	**Analog Loopback**- This input allows the data terminal to make the telephone line busy (Off-Hook) and implement the Analog Loopback mode. A High at this input while DTR is High causes the device to make the OH output Low and to enter the Analog Loopback mode. The receive filter center frequency is switched to correspond to the transmit filter center frequency and the transmit data carrier output is internally connected to the receive data carrier input, as well as being available at TC.
27	TD	**Transmit Data** - Data bits to be transmitted are presented to this input serially by the data terminal. A High is considered a binary '1' or Mark and a Low is considered a binary '0' or Space. The data terminal should hold this input in the Mark state when data is not being transmitted. During handshaking this input is ignored.
28	CLK	**Clock** - A 4.8 kHz LSTTL compatible squarewave output is provided for supplying the 16 times clock signal required by a UART for 300 bps data rate. This output facilitates the integration of the modem function in the data terminal.

Introduction

The MT3530 is a low-speed full duplex modem designed for use in stand-alone modem applications and applications in which the modem function is designed directly into the Data Terminal Equipment (DTE). The MT3530 contains on-chip FSK modulator and demodulator, transmit and receive filters and a supervisory control section. The modem can be used in many different modes. These include Answer/Originate modes, automatic/manual modes, automatic abort, automatic disconnect and Passthru.

Functional Description

Figure 1 illustrates the functionality of the MT3530 modem. The modulator section converts input serial digital data into a squarewave of the frequency corresponding to the Mark/Space being sent. The transmit filter outputs a Frequency Shift Keying signal at the TC (Transmit Carrier) output. The frequency of the FSK signal corresponds to the fundamental frequency of the square wave at the input of the filter. The incoming analog signal from the telephone network is bandlimited (filtered) and limited (amplified/clipped) prior to the demodulator carrier input to remove adjacent channel interference and system noise. The output at the receive data pin is a digital logic "1" or "0". The supervisory control and timing section contains the necessary logic to provide initial inter-modem handshaking as well as operational protocol, such as automatic Answer, Originate only and automatic disconnect. Two diagnostic modes, analog and Digital Loopbacks, allow for system tests. In addition, Passthru mode is available whereby the protocol handshake is disabled. The modem I.C. may be operated in Bell 103/113 or CCITT V.21 type applications. The select (SL) pin defines the operating mode. See Table 2.

Operation of MT3530 Modem Chip

A. Bell 103/113

Answer Mode

In the answer mode the MT3530 is idle waiting for an incoming call. As long as DTR is High, when a Low from the ring detector is presented to $\overline{RI}$ the MT3530 sets $\overline{OH}$ and $\overline{DSR}$ Low. This enables the hook-switch relay. This connects the modem to the phone line in the Answer mode. The MT3530 waits 2.0 s (min.), then sends carrier at 2225 Hz (Mark) to the originating modem. When the originating modem returns with 1270 Hz (Mark) the carrier detect circuits turns on within 120 ms and sets $\overline{CD}$ and $\overline{CTS}$ Low, indicating the handshaking sequence is completed. Data can now be sent and received.

Originate Mode

In the Originate mode a call is initiated, if DTR is High, by applying a High to the RTS input in auto mode or a negative pulse or Low to $\overline{SH}$ in manual mode. This will cause $\overline{OH}$ to go Low pulling in the hook-switch relay to connect the telephone line, and putting the MT3530 in the Originate mode.

After a suitable time, or when dial tone is detected, RTS can be pulsed Low/High to provide dial pulses. (N.B., $\overline{OH}$ only follows RTS. The proper timing for dialing must come from the terminal on the RTS line.) The $\overline{OH}$ will go Low and High, pulsing the line with desired digits. When the answering modem comes on line it will wait 2.0 s minimum ("billing delay") and then send the 2225 Hz Answer Tone. 120 ms later the $\overline{CD}$ output goes Low indicating received carrier. 200 ms later it will respond with 592 ms (min.) of 1270 Hz carrier. At the end of that time $\overline{CTS}$ (Clear-to-Send) will go Low indicating to the terminal side that the communications link has been established.

SL (Select)	Mode	Transmit Frequency (Hz)*		Receive Frequency (Hz)*	
		Mark	Space	Mark	Space
0	Bell 103 Originate Bell 103 Answer	1270 2225	1070 2025	2225 1270	2025 1070
1	CCITT V.21 Channel 1 (Originate) CCITT V.21 Channel 2 (Answer)	980 1650	1180 1850	1650 980	1850 1180
	CCITT V.25 Answer Tone	2100			

Table 2 - Bell 103/CCITT V.21 Operating Modes

Space = Binary 0, Mark = Binary 1, Crystal Frequency = 3.579545 MHz, *Frequency drift = ±3 Hz

Abort Mode

There is an automatic abort feature in the MT3530 to avoid tying up a system should there be difficulty in establishing the link. If no carrier is detected within 14 seconds after the device has been put into the Answer or Originate mode it will abort the call by setting High $\overline{OH}$ and disconnecting the telephone line. $\overline{DSR}$ will, also, go High. This abort time can be extended by pulsing RTS Low for 1 ms minimum before the 14 seconds have elapsed. This will reset the abort timer. If it does time out DTR will need to be pulsed High to reset the MT3530. After Abort mode it resorts to Originate mode.

Shutdown Mode

Should the received carrier fall below −50 dBm during data exchange for more than 190 ms the MT3530 will terminate the call and go on-hook, disconnecting the telephone line. (See Figure 4a.)

Manual Operation

The MT3530 can be operated manually as well as automatically. To put it in the Answer mode apply a negative pulse (−5V) on $\overline{RI}$ of greater than 107 ms. If $\overline{RI}$ is tied Low then the device will go into the Answer mode whenever DTR is set High.

Similarly, to put it into the Originate mode, $\overline{SH}$ can be pulled Low for more than 54 ms. By tying $\overline{SH}$ Low, the MT3530 will go into the Originate mode whenever DTR is set High.

Passthru Mode

With the control of "TEST0" and "TEST1" pins the MT3530 can be put into the Passthru mode. See Table 3 for setup. In this mode the modem stands idle in the Originate mode and the transmit and receive functions become independent of each other. In this mode the timing and handshake protocol can be suspended, depending on the status of DTR.

With DTR set Low, the transmit and receive functions become independent of the timing and handshake protocol. All the events on Switch-Hook, Ring Indicator and Request-To-Send input pins are ignored.

With DTR High, Answer or Originate mode is selected in the same manner as in the normal mode. The transmit and receive functions are dependent on the timing and handshake protocol. Carrier Detect operates as in the normal mode. Auto Shutdown applies but Auto Abort does not apply. After call termination the modem is placed in the Originate mode.

TEST0 PIN 7	TEST1 PIN 6	MT3530 STATUS	H = + 5 V (V_{DD}) L = − 5 V (V_{EE})
L	L	Normal	
H	L	Passthru	

Table 3 - Passthru Mode Control Inputs

B. CCITT V.21 Mode

The MT3530 will perform the same operations described above in the CCITT V.21 mode if the SL pin is tied High. The basic principle is the same but the frequencies and the timings are switched to conform to V.21 specifications. See the timing charts (Figures 3 and 4) and Table 2 for additional details. When in V.21 mode the V.25 Answer Tone of 2100 Hz will be generated upon answering.

External Clock Requirements

To use an external 3.579545 MHz clock a TTL level, 50 % duty cycle, squarewave can be applied to pin 12, OSCi, through a 0.1 μF capacitor.

Diagnostic Modes

The MT3530 has two diagnostic modes available to the operator. By putting the AL pin High while DTR is High, the device enters the Analog Loopback Mode. $\overline{OH}$ goes Low to busy out the phone line.

The receive filter center frequency moves to the transmit center frequency and TC signal is internally connected to the RC input. The transmit signal also remains available on the TC pin. Thus, any digital input at TD is coded and sent out via TC, and at the same time back through the analog input, decoded, and out on the $\overline{RD}$ pin.

By putting the DL pin High the MT3530 enters Digital Loopback mode. In this mode any data received from the remote end of the telephone line is retransmitted back to its source and $\overline{DSR}$ is forced High. Note that the digital data is not available at the $\overline{RD}$ output in this mode. See Table 4.

Test Mode	Status Lines†						
	DTR	RTS	$\overline{DSR}$	$\overline{OH}$	$\overline{CTS}$	$\overline{CD}$	$\overline{RD}$
AL	H	H	L	L	L	L	L
DL	H	H	H	L	H	H	H

Table 4 - Control Status During Diagnostic Modes

† (L = Low, H = High)

Application

Two typical MT3530 system configurations are illustrated. Figure 6 shows a stand-alone RS-232 interface modem to be used as a peripheral accessory to a communications terminal or computer.

Figure 7 shows an add-on modem for building into a computer and connecting to the internal parallel bus structure. The ACIA or UART does the parallel-to-serial and serial-to-parallel conversion required.

Both configurations are intended for direct connection to the telephone line. This requires meeting FCC Part 68 for network protection.

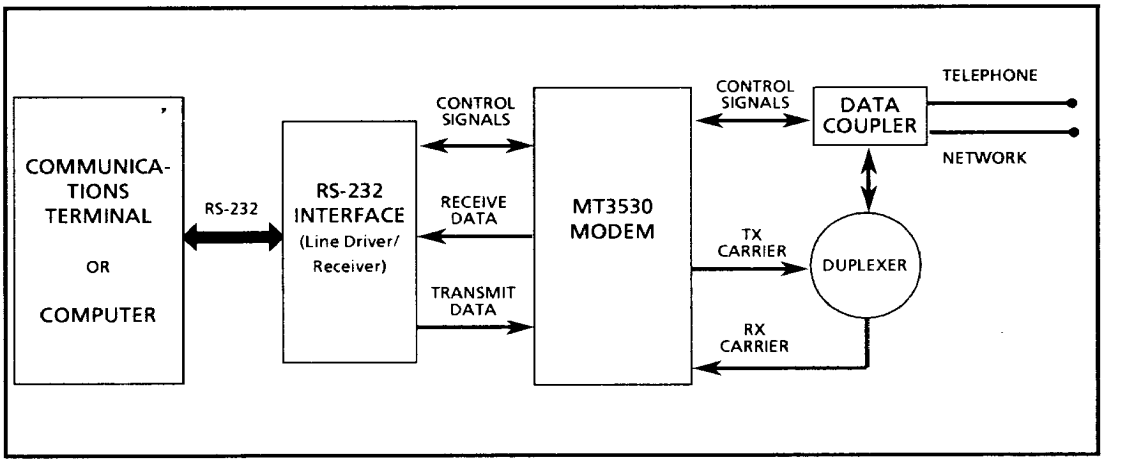

Figure 6 - Serial Interface System Configuration for MT3530

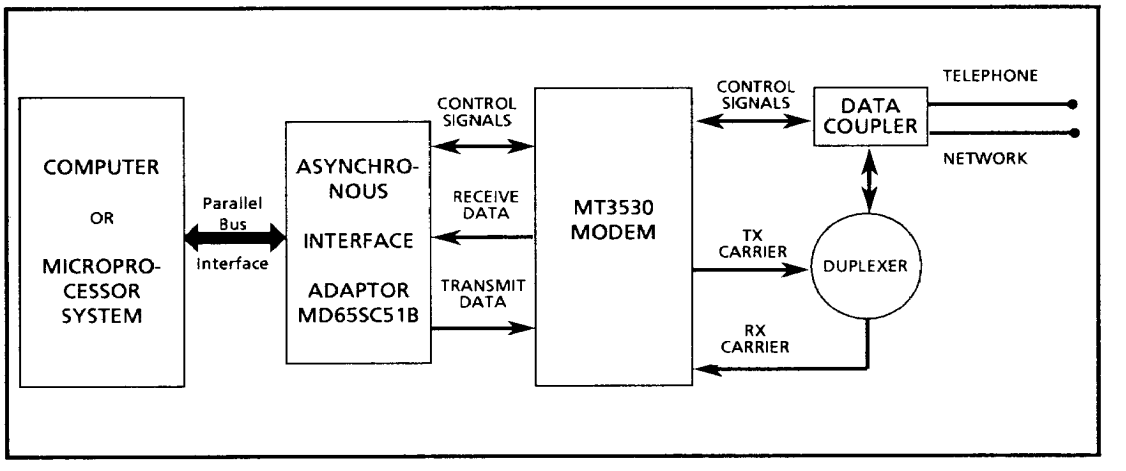

Figure 7 - Parallel Interface System Configuration for MT3530