

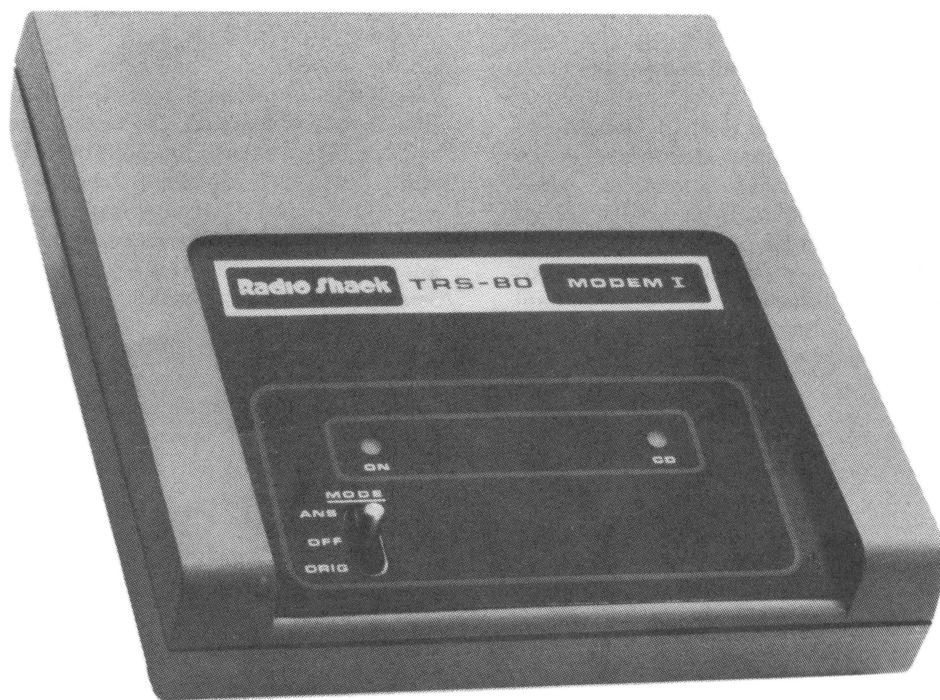
Radio Shack®

Service Manual

26-1172

TRS-80^{T.M.} **MODEM I**

CATALOG NUMBER: 26-1172



CUSTOM MANUFACTURED IN USA BY RADIO SHACK, A DIVISION OF TANDY CORP.

SPECIFICATIONS

Receive Frequencies:

- A. ANSWER – Mark 1270 Hz; Space 1070 Hz
- B. ORIGINATE – Mark 2225 Hz; Space 2025 Hz

Transmit Frequencies:

- A. ANSWER – Mark 2225 Hz; Space 2025 Hz
- B. ORIGINATE – Mark 1270 Hz; Space 1070 Hz

Transmit Power:

– 10 dBm, ± 1 dB

Receive Sensitivity:

–45 dBm

Baud Rate:

0 – 300

Electrical Requirements:

15VAC at 300mA supplied by UL listed AC Adapter

Size:

6.5'' x 7.7'' x 2'' (16.5mm x 19.05mm x 5.08 mm)

MODEM I

I. INTRODUCTION

The TRS-80 Modem I is a device which allows two computer terminals to communicate via standard telephone lines. The functional blocks of the unit are listed below: (Refer to the Block Diagram, Figure 1.)

- A. Power Supply
- B. Telephone Line Interface
- C. Receive Filter
- D. Limiter
- E. Carrier Detection
- F. Modem (Modulator/demodulator)
- G. Transmit Filter
- H. Data I/O Drivers and Receivers

II. THEORY OF OPERATION

(Refer to the Schematic Diagram, Figure 5)

A. Power Supply

Power for the Modem is derived from a low-voltage AC adapter whose output is 15VAC. This AC voltage is half-wave rectified by CR2 and CR3 and filtered by C9 and C14 to provide the unregulated DC voltages. The +12V is provided by a three-terminal regulator (U1). The -12V is provided by a zener regulator which consists of R3, CR1 and CR4. The +5V is provided by a three-Terminal regulator (U9) which receives it's input from the +12 V regulated supply.

B. Telephone Line Interface

The telephone line must be matched to the Modem circuitry. The matching "hybrid" consists of a 600:600 ohm transformer (T1) with a tapped secondary. A balancing network (R37 and C16) is employed to isolate the transmitted tones (T1, pin 8) from the received tones (T1, pin 5) and termination is provided for the secondary (R26 and R28). To protect the Modem I from voltage spikes on the telephone line, a 22V MOV (metal-oxide-varistor), ZN1 is located across the primary.

C. Receive Filter

The receive filter (U6a, U6b, and U2b) removes all undesirable frequencies from the incoming signal. The filter is a 6-pole Chebyshev with 1 dB of ripple in the pass band. The filter characteristics are switchable for answer and originate modes: In the originate mode, the center frequency is approximately 2100 Hz; in the answer mode, the center frequency is approximately 1170 Hz. (See Table 1.) The bandwidth of the filter in either case is approximately 300 Hz. Preceding the receive filter is an amplifier (U2a) which has some filtering to remove the 1 MHz clock noise generated by the crystal. Filter output is fed to the carrier detection and limiting circuitry.

D. Limiting and Carrier Detection

The Modem IC (U4) requires a 50%, $\pm 4\%$ square-wave signal as receive data input. This is accomplished via the high-speed comparator (U5). The sine-wave tones from the receive filter are AC coupled by C23 to the inverting input of the comparator to remove DC offset. The comparator toggles on successive zero-crossings of the input signal. The limiter has an open-collector output which is wire- ANDed with the output of the carrier detection circuit. This allows input to the Modem IC only while a valid carrier is being received.

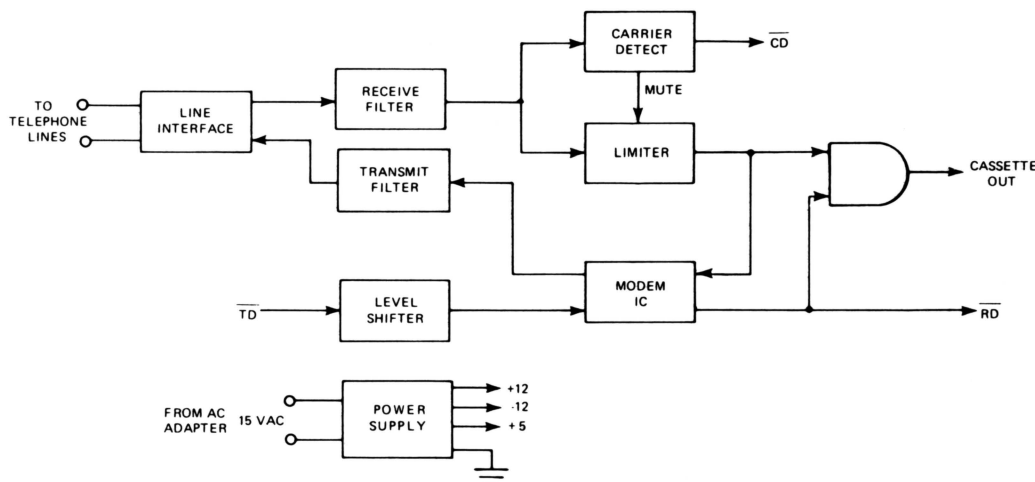


Figure 1. Block Diagram

Carrier detection is accomplished via an active rectifier (U3) and comparator (U8a and U8b). One section of the comparator (U8b) is connected to the MODE switch (S1) to compensate for gain mismatch between the answer and originate filters. The tone from the filter is half-wave rectified by U3a, U3b, CR7 and CR8, and filtered by C30. It is then compared to the threshold. When the level at the minus (–) input exceeds the level at the plus (+) input, the output is pulled low. This turns off transistor Q8 and allows the limiter to pass tones to the Modem IC.

E. Modem (Modulator/Demodulator) Circuitry

The modulation and demodulation of the FSK data is done internally by the Modem IC (U4). This is a CMOS IC which is clocked by the 1.0 MHz crystal (Y1). The Modem IC generates a particular frequency, depending on the MODE switch setting and the input data. The Modem IC also detects the square-wave signal from the limiter and generates logical highs and lows for transmission to the computer.

F. Transmit Filter

The transmit filter (U3b) removes the higher harmonics from the "sine-waves" generated by the Modem IC which prevents "singing" or feedback between the transmit and receive filters. The telephone "hybrid" transformer also acts as a filter for the transmitted tones. The transmit power is set by potentiometer R1 on the output of the transmit filter. Adjust the output for 0.2V RMS with a 600 ohm resistor across the tip and ring of the transformer primary (J4, pin 3 to J4, pin 4).

G. Data I/O Drivers and Receivers

Communication to and from the computer is usually in RS-232-C format. The Modem I incorporates the drivers and receivers necessary to implement this function. The drivers (U7) accept TTL inputs (from 0 to 5V) and produce RS-232-C compatible outputs ($\pm 12V$). The capacitor on the data output line (C28) is used to limit the rise and fall times of the digital data. The receiver (U8c) accepts RS-232-C compatible data and produces a TTL output.

The threshold of the receiver is changed from 3V to 0.6V via diode CR10 and the Normal/Cassette switch (S2). This allows the cassette data from the TRS-80 computer to drive the Modem. Cassette data to the TRS-80 is generated by the comparator (U8d) and the driver (U7). The comparator forms an inverter for the normal RS-232-C data which is ANDed with the limiter output to produce tone bursts. The resistor at the output of the driver limits the voltage swing to the cassette port by forming a divider with the internal 220 ohm resistor termination in the TRS-80 computer.

III. TROUBLESHOOTING HINTS

(Refer to the Waveform Chart, Figure 2)

The waveform shown on line A of the chart is typical of the output of U4. It is a digitally produced sine-wave that can have a frequency of 1070 Hz or 1270 Hz when in the originate mode and a frequency of 2025 Hz or 2225 Hz when in the answer mode. This depends upon the state of the data coming from the CPU at pin 11. (Refer to Table 1).

Line B shows the result of the transmit filter on the digitally produced sine-wave. The transmit level was adjusted to – 10dB, measured at the telephone line with a 600 ohm resistor across the tip and ring of the transformer primary (J4, pin 3 to J4, pin 4).

The waveform from the "hybrid" transformer has many harmonics summed into it. The signal is first amplified by U2a and then goes to the receive filter which removes these undesirable frequencies.

The waveform shown in line C is typical of incoming FSK data. There are three voltage measurements to be taken: (1) at the input of the amplifier, (2) at the output of the amplifier and (3) at the output of the first stage of filtering. These amplitudes are typical with the input level shown. *ref to TABLE 1*

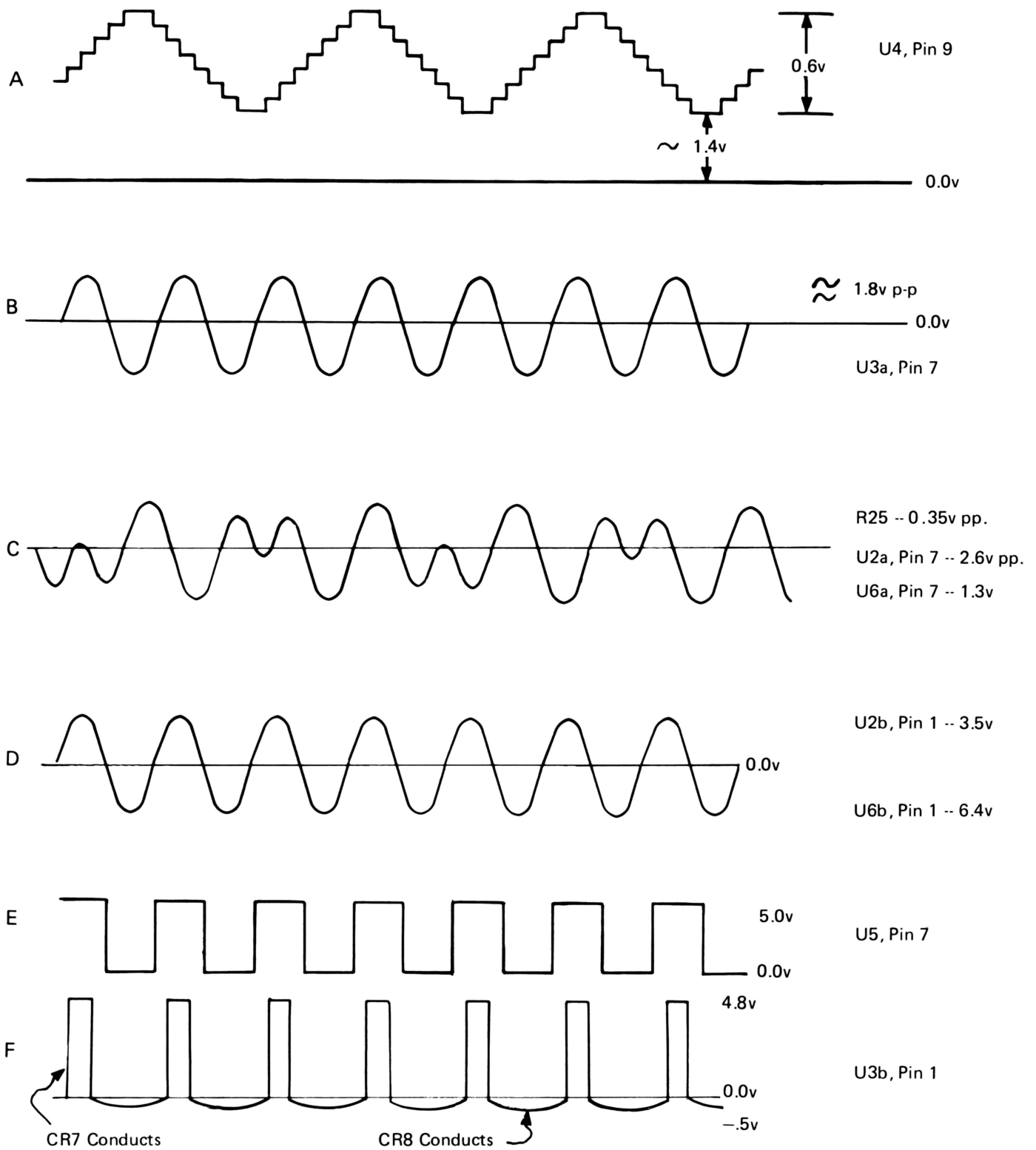
The last two stages of the filter have the harmonics filtered out of the input waveform and the voltage levels are shown on line D.

Line E shows the limited action produced by U5. ~~This is the carrier detect (CD) signal that is fed into U7 and the RS-232-C control line.~~ The action of the half-wave rectifier is shown in line F. Notice that when CR7 conducts, the input signal is amplified and squared off at the top. When CR8 conducts, it bypasses the gain resistor (R16) and produces almost a half-volt swing at the output.

The rectified waveform is filtered by C30, producing a voltage at pin 4 of U8. The output of U8 goes low when the voltage exceeds the threshold set by comparator U8b and resistors R50, R59 and R60. This is the carrier detect (CD) signal that is fed into U7 and the RS-232-C control line. This turns on the LED and removes Q8's shorting action from the limiter output.

FILTER STAGE	CENTER FREQ. O/A	$\frac{Q}{O/A}$	$\frac{GAIN}{O/A}$
1	994/1880	9.75/12.7	4.5/4.5
2	1170/2110	5.5/8.3	4.5/4.5
3	1362/2350	9.3/11.8	4.5/4.5

Table 1



NOTE: Phase Reference Between Waves Not Shown.

Figure 2. Waveform Chart

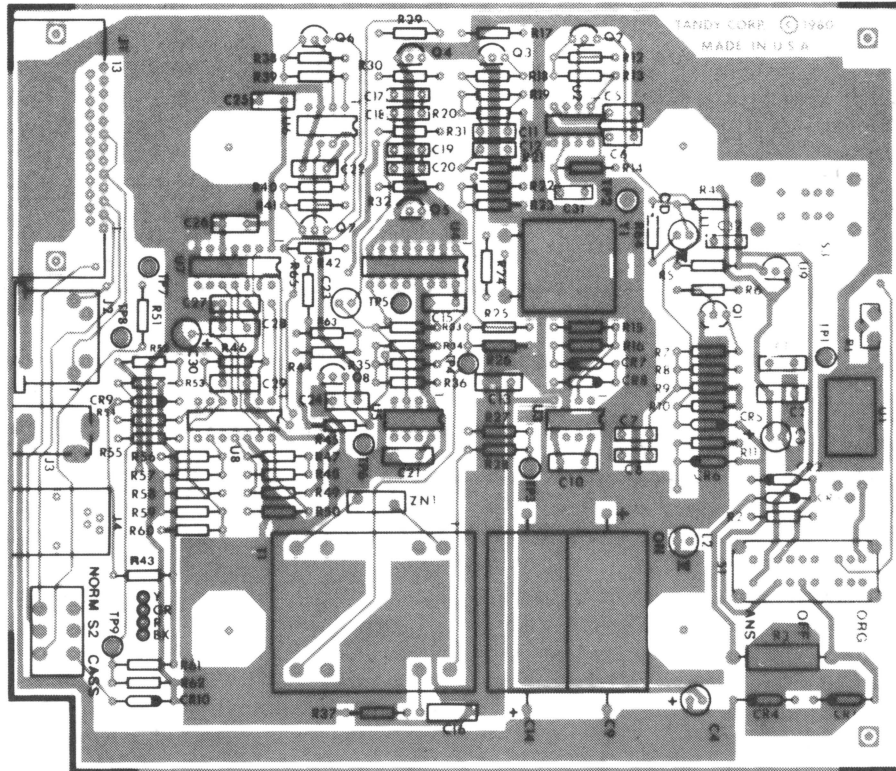


Figure 3. P.C. Board (Top View)

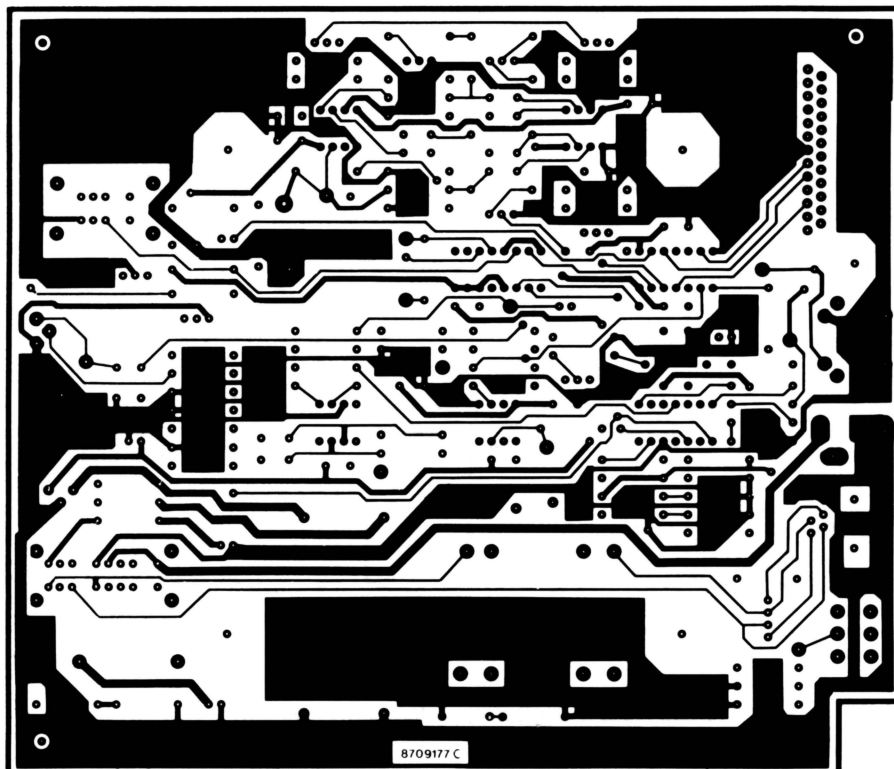


Figure 4. P.C. Board (Bottom View)

MODEM I PARTS LIST

Symbol	Description	Manufacturer's Parts List	Radio Shack Parts List
	P.C. Board	8894204	AX8758
CAPACITORS			
C1	0.1 μ F, 50V, Ceramic, Z5U	8384104	ACC104QJAP
C2	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C3	10 μ F, 25V, Electrolytic, Radial	8326102	ACC106QFAP
C4	10 μ F, 25V, Electrolytic, Radial	8326102	ACC106QFAP
C5	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C6	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C7	0.0047 μ F, 100V, 1%	8392475	ACC472QJCP
C8	0.0047 μ F, 100V, 1%	8392475	ACC472QJCP
C9	1000 μ F, 50V, Electrolytic, Axial	8318104	ACC108QFAP
C10	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C11	0.0047 μ F, 100V, 1%	8392475	ACC472QJCP
C12	0.0047 μ F, 100V, 1%	8392475	ACC472QJCP
C13	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C14	1000 μ F, 50V, Electrolytic	8318104	ACC108QFAP
C15	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C16	0.047 μ F, 100V, 10%	8353476	ACC473QLGP
C17	0.0047 μ F, 100V, 1%	8392475	ACC472QJCP
C20	0.0047 μ F, 100V, 1%	8392475	ACC472QJCP
C21	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C22	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C23	1.0 μ F, 50V, Non-Polarized, Electrolytic	8395114	ACC105MJAP
C24	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C27	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C28	330pF, 50V, Ceramic Disc	8301333	ACC331MJCP
C29	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
C30	3.3 μ F, 50V, Electrolytic	8325334	ACC335MJAP
C31	68pF, 50V, Ceramic Disc	8300684	ACC680QJCP
C32	0.01 μ F, 50V, Ceramic, Z5U	8383104	ACF2130
CONNECTORS			
J1	RS-232, Right Angle	8519109	AJ6983
J2	4-pin, DIN	8519094	AJ6904
J3	Miniature Jack, 1/8"	8519111	AJ7014
J4	Modular Phone Jack	8519108	AJ7013
CRYSTAL			
Y1	1.000MHz, 500 ohm	8409012	AMX2939
DIODES			
CR1	1N4735, Zener, 1W, 5%, 6.2V	8150735	ADX0214
CR2	1N4002	8150002	ADX1148
CR3	1N4002	8150002	ADX1148
CR4	1N4735, Zener, 1W, 5%, 6.2V	8150735	ADX0214
CR5	1N4148	8150148	ADX1152
CR10	1N4148	8150148	ADX1152

MODEM I **PARTS LIST (Cont'd)**

Symbol	Description	Manufacturer's Parts List	Radio Shack Parts List
INTEGRATED CIRCUITS			
U1	MC78M12, Regulator, +12V, 500mA	8050812	AMX4577
U2	MC4558, Wideband Op Amp	8050558	AMX4695
U3	MC4558, Wideband Op Amp	8050558	AMX4695
U4	MC14412AFP, CMOS, MODEM	8030412	AMX4697
U5	MLM311P1, Comparator	8050311	AMX4327
U6	MC4558, Wideband OP Amp	8050558	AMX4695
U7	75488, RS-232 Driver	8050188	AMX3867
U8	LM339, Quad Comparator	8050339	AMX4200
U9	LM78L05ACP, Regulator	8052805	AMX4713
RESISTORS			
R1	Trim Pot, 10K, 20%	8279310	AP7167
R2	620 ohms, 1/4W, 5%	8207162	AN0181EEC
R3	180 ohms, 1W, 5%	8247118	AN0144EGC
R4	240 ohms, 1/4W, 5%	8207124	AN0151EEC
R5	1.0K, 1/4W, 5%	8207210	AN0196EEC
R6	9.1K, 1/4W, 5%	8207291	AN0276EEC
R7	2.26K, 1/4W, 1%	8200222	AN0217BEE
R8	8.06K, 1/4W, 1%	8200280	AN0601BEE
R9	13.7K, 1/4W, 1%	8200314	AN0620BGE
R10	100K, 1/4W, 5%	8207410	AN0371EEC
R11	10K, 1/4W, 5%	8207310	AN0281EEC
R12	32.4K, 1/4W, 1%	8200332	AN0590BEE
R13	287K, 1/4W, 1%	8200428	AN0610BEE
R14	360K, 1/4W, 5%	8207436	AN0412EEC
R15	10K, 1/4W, 5%	8207310	AN0281EEC
R16	39K, 1/4W, 5%	8207339	AN0330EEC
R17	4.7K, 1/4W, 5%	8207247	AN0247EEC
R18	1.3K, 1/4W, 1%	8200213	AN0202BEE
R19	52.3K, 1/4W, 1%	8200352	AN0613BEE
R20	1.18K, 1/4W, 1%	8200212	AN0617BEE
R21	2.74K, 1/4W, 1%	8200227	AN0619BEE
R22	73.2K, 1/4W, 1%	8200373	AN0612BEE
R23	1.65K, 1/4W, 1%	8200216	AN0218BEE
R24	15Meg, 1/4W, 5%	8207615	AN0486EEC
R25	27K, 1/4W, 5%	8207327	AN0316EEC
R26	620 ohms, 1/4W, 5%	8207162	AN0181EEC
R27	165K, 1/4W, 1%	8200417	AN0611BEE
R28	620 ohms, 1/4W, 5%	8207162	AN0181EEC
R29	4.7K, 1/4W, 5%	8207247	AN0247EEC
R30	806 ohms, 1/4W, 1%	8200180	AN0557BEE
R31	33.2K, 1/4W, 1%	8200333	AN0622BEE
R32	806 ohms, 1/4W, 1%	8200180	AN0557BEE
R33	1.0K, 1/4W, 5%	8207210	AN0196EEC
R34	1.0K, 1/4W, 5%	8207210	AN0196EEC
R35	1Meg, 1/4W, 5%	8207510	AN0445EEC
R36	1.0K, 1/4W, 5%	8207210	AN0196EEC
R37	910 ohms, 1/4W, 5%	8207191	AN0192EEC

MODEM I **PARTS LIST (Cont'd)**

Symbol	Description	Manufacturer's Parts List	Radio Shack Parts List
RESISTORS (Cont'd)			
R38	107K, 1/4W, 1%	8200411	AN0237BEE
R39	422K, 1/4W, 1%	8200442	AN0419BEE
R40	590 ohms, 1/4W, 1%	8200459	AN0615BEE
R41	118K, 1/4W, 1%	8200412	AN0374BEE
R42	4.7K, 1/4W, 5%	8207247	AN0247EEC
R43	16K, 1/4W, 5%	8207316	AN0554EEC
R44	4.7K, 1/4W, 5%	8207247	AN0247EEC
R45	2K, 1/4W, 5%	8207220	AN0213EEC
R46	2.4Meg, 1/4W, 5%	8207524	AN0616EEC
R47	2.4Meg, 1/4W, 5%	8207524	AN0616EEC
R48	1.0K, 1/4W, 5%	8207210	AN0196EEC
R49	9.1K, 1/4W, 5%	8207291	AN0276EEC
R50	1.1K, 1/4W, 5% 1.8K, 1/4W, 5%	8207211 8207218	AN0198EEC
R51	820 ohms, 1/4W, 5%	8207182	AN0187EEC
R52	10K, 1/4W, 5%	8207310	AN0281EEC
R53	390K, 1/4W, 5%	8207439	AN0414EEC
R54	1.0K, 1/4W, 5%	8207210	AN0196EEC
R55	10K, 1/4W, 5%	8207310	AN0281EEC
R56	9.1K, 1/4W, 5%	8207291	AN0276EEC
R58	9.1K, 1/4W, 5%	8207291	AN0276EEC
R59	820 ohms, 1/4W, 5% 1.5, 1/4W, 5%	8207182 8207215	AN0187EEC
R60	9.1K, 1/4W, 5%	8207291	AN0276EEC
R61	30K, 1/4W, 5%	8207330	AN0321EEC
R62	11K, 1/4W, 5%	8207311	AN0285EEC
R63	1.1K, 1/4W, 5%	8207211	AN0198EEC
R64	820 ohms, 1/4W, 5%	8207182	AN0187EEC
R65	1.0K, 1/4W, 5%	8207210	AN0196EEC
SWITCHES			
S1	4P3T, Toggle	8489037	AS9156
S2	DPDT, Slide	8489035	AS9158
TRANSFORMER			
T1	Hybrid, 600:600	8790024	ATA0883
TRANSISTORS			
Q1	MPS3904, NPN	8110904	AMX3583
Q2	2N5638, FET, N-Channel	8120638	AMX4714
Q3	MPS3904, NPN	8110904	AMX3583
Q5	MPS3904, NPN	8110904	AMX3583
Q6	2N5638, FET, N-Channel	8120638	AMX4714
Q7	2N5638, FET, N-Channel	8120638	AMX4714
Q8	MPS3904, NPN	8110904	AMX3583

**MODEM I
PARTS LIST (Cont'd)**

Symbol	Description	Manufacturer's Part Number	Radio Shack Part Number
MISCELLANEOUS			
L1	Light Emitting Diode	8469008	AL1279
	LED Spacer	8589049	AHC0666
L2	Light Emitting Diode	8469008	AL1279
	LED Spacer	8589049	AHC0666
TP1	Staking Pin	8529014	AHB9682
TP9	Staking Pin	8529014	AHB9682
ZN1	Transient Suppressor, 22V	8190022	ATA0886
	Case Top	8719134	AZ6039
	Case Bottom	8719135	AZ6040
	AC Adapter	8790026	AW2667
	Telephone Line Cord	8709171	AW2668
	Socket, 16-pin DIP	8509003	AJ6581
	Foot, Rubber (4)	8589023	AF0332
	Screw, Plastite, 4-40 x 1/4" (2)	8569032	AHD1541
	Screw, Plastite, 4-40 x 3/8" (2)	8569102	
	Screw, Machine, 4-40 x 3/8"	8569002	AHD2249
	Screw, Plastite, 6-32 x 1/2" (4)	8569087	AHD1355
	Nut, Keps, #4	8052805	AMX4713
	Label, Logo, Mylar	8789406	AHC0667
	Label, FCC	8789407	

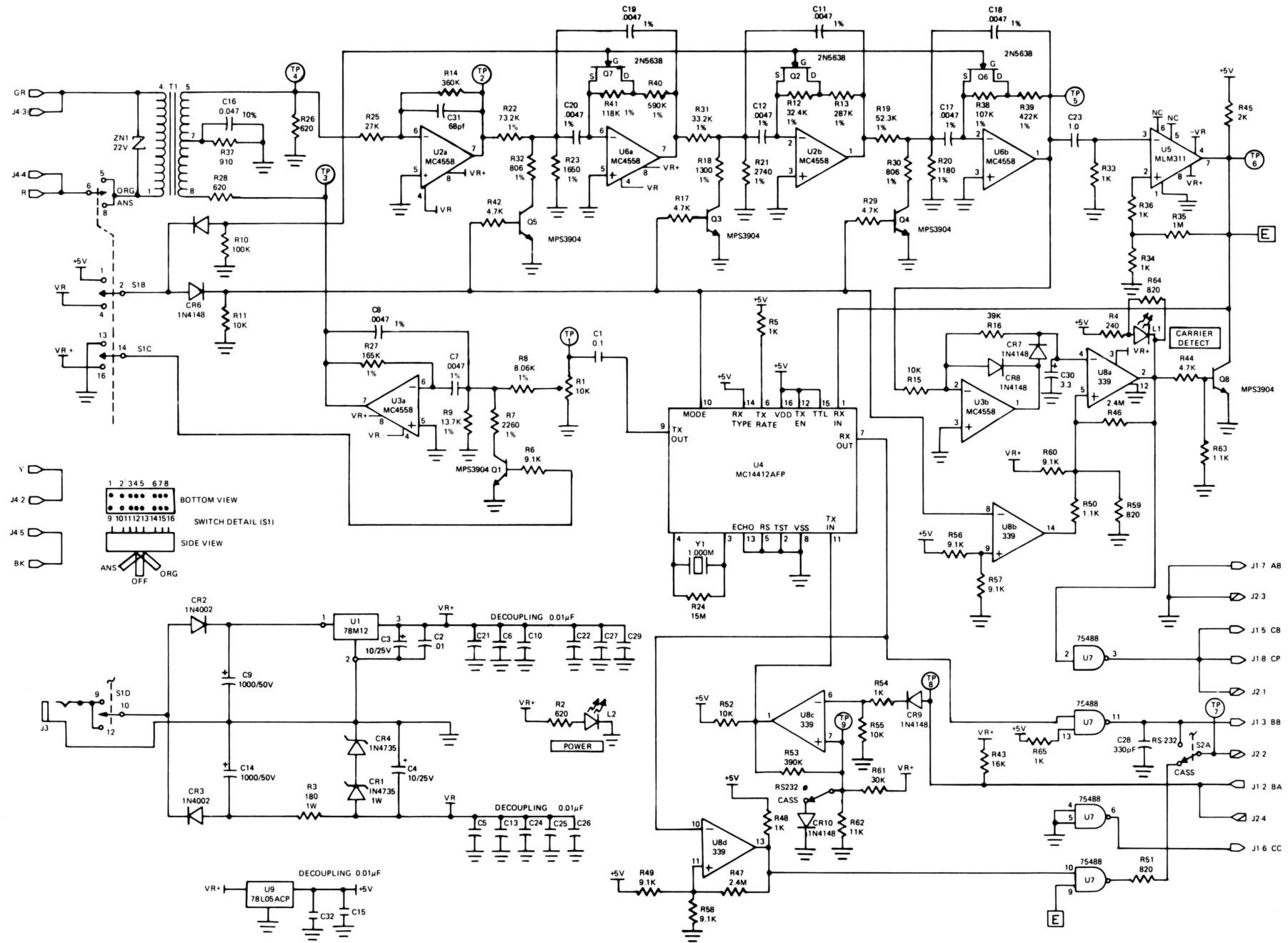


Figure 5. Schematic Diagram

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