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Final Report

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Operator's Manual for Waveform Generator Model RPG-6236-A

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16. Abstract

The waveform generator, described in this manual, provides a reference signal standard for use in testing the performance of crash test data acquisition systems. During the test, the waveform generator provides the signal inputs to the data acquisition system under test. The signals recorded by the data acquisition system are processed by a general purpose digital computer to yield the performance characteristics of the data acquisition system tested. This operators manual provides instructions for use of the waveform generator.

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PREFACE

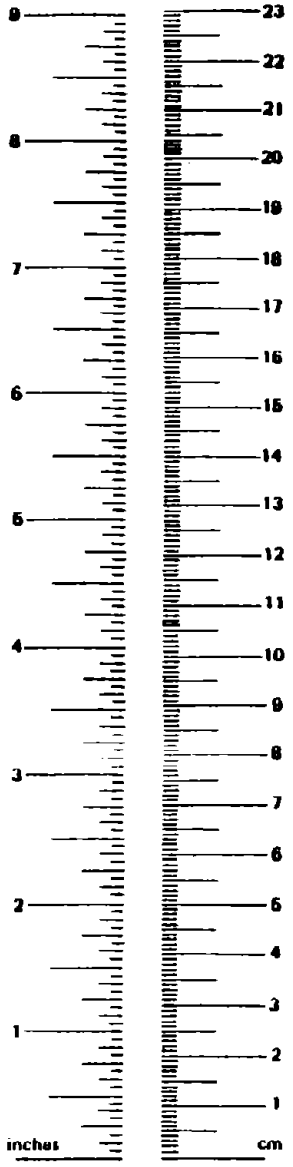
The waveform generator, described herein, has been developed for the National Highway Traffic Safety Administration (NHTSA) by MGA Research Corporation. The waveform generator provides standard signals for testing the performance characteristics of data acquisition channels at the facilities of NHTSA crash test contractors. Initial development of the waveform generator was carried out under the Test-Site Instrumentation Study (Contract No. DOT-HS-8-01936, Task Order No. 3). Modifications were subsequently made under Phase II (Contract No. DTNH22-82-C-07041) and Phase III (Contract No. DTRS-57-84-C-00003, Task Order Nos. 3, 3A, 8, 8A, and Purchase Order No. DTRS-57-86-P-81655) of the study. This report contains the operating instructions for use of the waveform generator.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

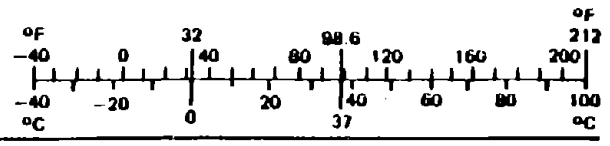
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286, Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. GENERAL INSTRUCTION

An overall view of the waveform generator instrument is shown in Figure 1-1, which also identifies the location of the data output connectors, the instrument control switches and light indicators. To use the instrument, it is first necessary to connect up to 16 channels to the data recording system input. These output connectors are located on the side of the instrument. (See output connectors pin assignment for more detail.) After the output lines are properly connected, the instrument power can be turned on. **To function correctly durimg the self-test, before the instrument power is turned on, set the transducer type switch to piezo resistive and the calibration mode switch to manual negative. These settings are only necessary while the instrument is going through the self-test.**

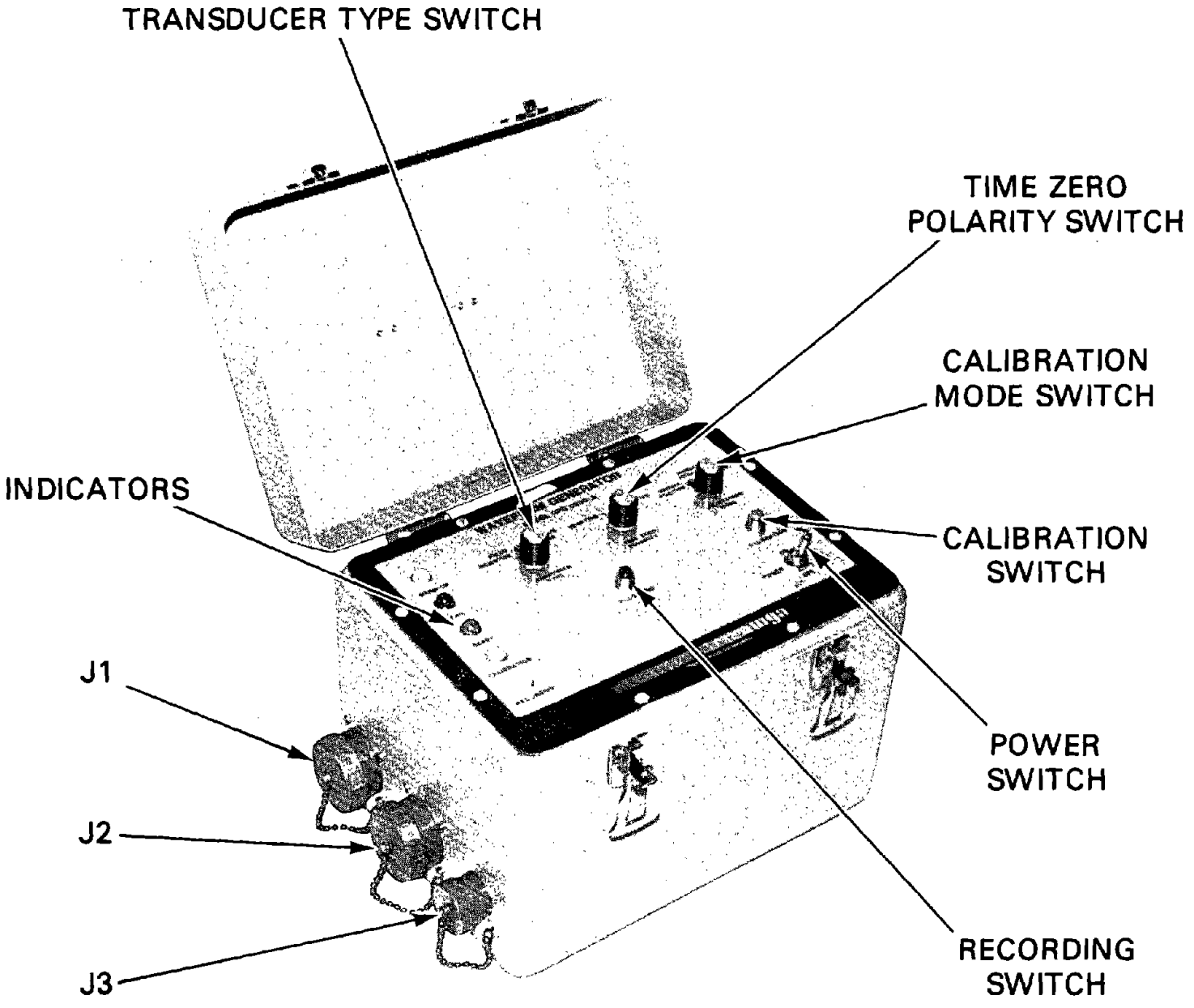


Figure 1-1 GENERAL OVERVIEW OF THE WAVEFORM GENERATOR INSTRUMENT

2. POWER REQUIREMENTS

The instrument operates on 120 volts A.C., 60 Hz,and it requires a current of 1 amp. To minimize the potential for output noise contamination due to power line ground loops, it is recommended that the A.C. power source for the instrument be connected to the same power circuit that supplies power to the data acquisition and recording system. Turning on the power switch on the instrument activates the internal electronics.

3. SELF-TEST

The waveform generator instrument performs three internal tests to ensure the proper operation during recording sequence. These tests are performed every time the instrument goes through power on. As mentioned in Section 1, to function correctly during the self test, before the instrument power is turned on:

1. The transducer type switch must be set to piezo resistive position.

2. The calibration mode switch must be set to manual negative position.

When the instrument power is first turned on, all panel indicator lamps light up for 12 seconds to test the lights. The instrument then goes through a built-in time delay of one minute to allow for the stabilization of the electronics. During the one minute, the "warm-up" light is on. After the one minute warm-up, an internal self-test is performed on the instrument electronics.

The self-test consists of three internal checks:

1. A test of the data clock and associated interrupt bus operation

2. A test of the amplitude linearity of the output data

3. Verification of the data contents stored in the waveform memory chips

If these checks are completed successfully, the instrument will be in to a ready mode. This is displayed by the panel indicator (Ready Light).

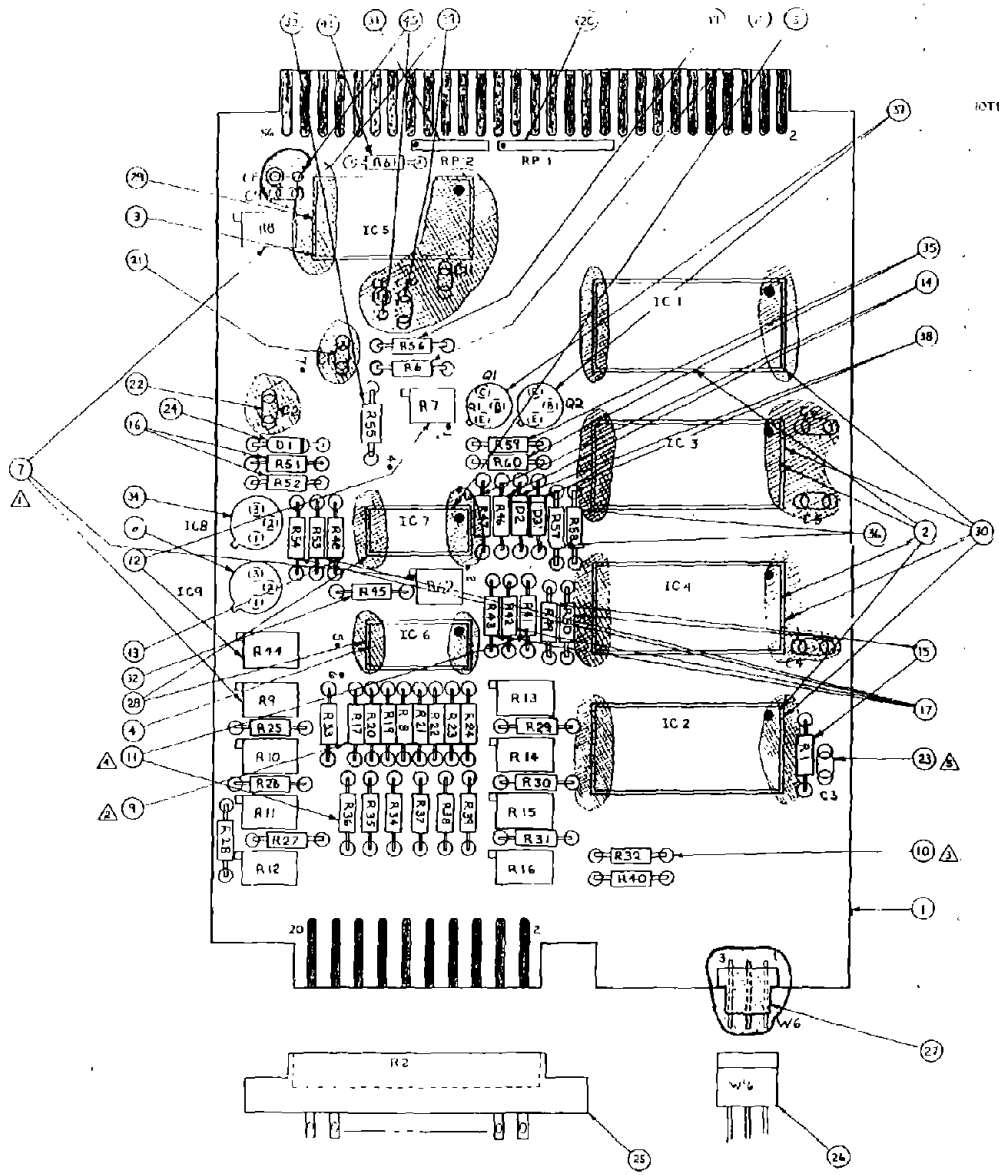
If the system fails the self-test, the **FAIL** indicator and a combination of other indicators flashes this condition and the instrument is interlocked to prevent data recording. Momentarily turning off the input power resets the unit and initiates another warm-up and self-test sequence. If the system continues to fail the self-test, a problem exists in the instrument, and repair is required. To identify the cause of the failure, the **FAIL** indicator and different combinations of the other indicators flash to signal each failure. These combinations are as follows:

1. **FAIL** and **RECORDING** indicators flash for fault in data clock or interrupt bus operation.

2. **FAIL** and **CALIBRATION** indicators flash for inaccuracy in amplitude linearity of the output data.

3. **FAIL, READY, RECORDING; FAIL, READY, WARM-UP**; or **FAIL, READY, CALIBRATION** indicators flash for inaccuracy in the content of EPROM's IC (test waveforms data stored in EPROM) for first sequence of waveforms. These ICs are located on EPROM Board 1 and are listed in IC1, IC2, IC3, IC4 on the layout diagram (Figure 3-1 presents a layout of EPROM boards).

4. **FAIL, READY, CALIBRATION, WARM-UP; FAIL, READY, CALIBRATION, RECORDING**; or all indicators flash for inaccuracy in content of EPROM's IC for second sequence of waveforms. These ICs are located on EPROM Board 2 and are listed as IC1, IC2, IC3, IC4 on the layout diagram.



NOTES:

1. 4 REQ'D R8-R16
2. 8 REQ'D R17-R24
3. 8 REQ'D R25-R32
4. 9 REQ'D R33-R41
5. 4 REQ'D C3-C6,C11
6. SHADED AREAS ARE TO BE COVERED WITH SILICONE

⚠ ALL POTENTIOMETER ADJUSTMENT SCREWS SHOULD HAVE LOCTITE APPLIED TO THEM.

REF NO	NO. REQ'D	REF DESIGN.	MANUFACTURER	DESCRIPTION	PART NO.
41	1	R61		1.4 K RESISTOR	RN55D 2201 F
40	2	C7,8	SPRAGUE	1 uFd TANTALUM CAP	150D105X9020A
39	3	C9,10	CENTRALAB	.01 uFd CERAMIC CAP	CK15C103K
38	2	D2,D3	Radio Shack	DIODE	1N914
37	2	Q1,Q2	MOTORALO	NPN TRANSISTOR	2N2222
36	2	R57,R58		1K RESISTOR	RN55D1001F
35	2	R59,R60		1K Ω RESISTOR	" 1001F
34	1	IC 8	ANALOG DEVICES	VOLTAGE REGULATOR	AD581
33	1	R55		750 Ω RESISTOR	RN55D 7500F
32	1	R45		8K "	RN55D 8001F
31	1	RP 2	BOURNS	6 PIN 2.8K RESISTOR PACK	4306R-101-222
30	4		T.I	28 PIN SOCKET	TIC932802
29	1		"	24 " "	TIC932402
28	2		"	14 " "	TIC931402
27	1	W6	MOLEX	3 PIN CONNECTOR	22-05-3031
26	1	W6'	"	3 PIN MATE CONNECTOR	22-01-2037
25	1	P2	WINCHESTER	EDGE CONNECTOR	HCA10
24	1	D1	MOTOROLLA	ZENER DIODE 2.4 V	1N4370
23	5	C3-C6,11	CENTRALAB	.1 uFd CAPACITOR	CZ20C104M
22	1	C2	MALLARY	4.7 uFd "	47SK035NLF
21	1	C1	ARCO	150 pFd "	DM5FA151J
20	2	RP1	BOURNS	2.2K RESISTOR PACK	4310-101-222
19	1	R56		200K RESISTOR	RN55D 2003F
18					
17	4	R42,43,53,54		100 K "	" 1003F
16	2	R51,R52		100 Ω "	" 1000F
15	3	R1,49-50		10 K "	" 1002F
14	2	R46,R47		30.1K "	" 3012F
13	1	R48		20K "	" 2002F
12	2	R7,R44	BURNS	100K TRIMPOT	3299 x 100K
11	9	R33-R41		348 Ω RESISTOR	RN55D 3480F
10	8	R25-R32		16.2 K "	" 1622F
9	8	R17-R24		16.9 K "	" 1692F
8	1	R6		2M "	MF55D
7	10	R5,R9-R16,R62	BURNS	2K TRIMPOT	3299 x 2K
6	1	IC 9	NATIONAL	VOLTAGE REGULATOR	LH007-2H
5	1	IC 7	"	" COMPARTOR	LM339AN
4	1	IC 6	ANLOG DEVICES	INSTRUMATION AMP	521JD
3	1	IC 5	DATEL INTERSIL	DAC	DAC-HK-12BMC
2	4	IC1-IC4	INTEL	EPROM (8K x 8)	INTEL 2764
1	1			.062" THICK GLASS EPOXY	

PARTS LIST

IC1	LOW 1	LOW 3
IC2	HIGH 1	HIGH 3
IC3	LOW 2	LOW 4
IC4	HIGH 2	HIGH 4
IC	BOARD 1	BOARD 2
NO	PROGRAM NO	

EPROM PLACEMENT

2-1
8-1-84

Figure 3-1 LAYOUT OF EPROM BOARDS

4. FRONT PANEL CONTROL

There are five light indicators. The functions of these indicators are:

- Warm-up - This light indicates that the instrument is going through a warm-up delay to allow the electronic components to become stable.

- Ready - This light will be on when the instrument passes the self-test successfully and is ready to produce the waveform or calibration signal outputs.

- Fail - This light indicates a failure occurred during the self-test operation.

- Recording - This light indicates that the instrument is producing test waveform outputs.

- Calibration - This light indicates that the instrument is producing calibration signals.

There are three rotary switches. The function of these switches are as follows:

- Transducer Control - This switch controls the voltage level of the output. The strain gage setting produces a level of -10 MV to +10 MV output. The piezo resistive setting produces a level of -100 MV to +100 MV.

- Time Zero Contol - This switch controls the polarity of the time zero signal generated by the instrument.

- Calibration Control - This switch controls the type of calibration control and also the level of the calibration output. By placing this switch in the MANUAL POSITIVE (MANUAL NEGATIVE) position, the instrument generates a positive voltage (negative voltage) when the calibration switch is pressed. By placing the switch in the REMOTE position, a remote TTL signal (0 to .75 volts as TTL "0", 2.4 to 5 volts as TTL "1") controls the polarity of the calibration voltage. A "0" TTL signal (0 to .75 volts) causes the instrument to generate positive voltage when the calibration switch is pressed. A "1" TTL signal (2.4 to 5.0 volts) causes the instrument to generate a negative voltage when the calibration switch is pressed.

There are two momentary switches. The function of these switches are:

- Recording - This switch initiates the generation of test data for a recording sequence. Test waveforms are produced on 18 data channels.

- Calibration - This switch initiates the generation of calibration voltages on all 18 data channels.

5. OUTPUT CHANNELS

The waveform generator instrument generates the test waveforms on 18 data channels in two different sequences. In addition to these data channels, the instrument generates two types of time synchronization signals. These data output channels are located on J1 and J2 connectors. The two time synchronization channels are located on J3 connector (for more detail on these connectors see output connectors pin assignment).

Figure 5-1 presents a sketch of the sequence of the test waveforms and time synchronization outputs. Channels 1, 2, 3, 4, 9, 10, 11 and 12 contain the first group of test waveforms. These channels are located on the J1 connector. Channels 5, 6, 7, 8, 13, 14, 15 and 16 are located on the J2 connector. Channels 1 to 16 are low level channels (-100 to +100 MV; -10 to +10 MV). Channel 17 (18) generates the first (second) group of test waveforms. Channel 17 and 18 are located on the J3 connector and these two channels are high level channels (-5.0 to +5.0 volts; -.5 to +.5 volts). This output signal arrangement is illustrated graphically in Figure 7-1.

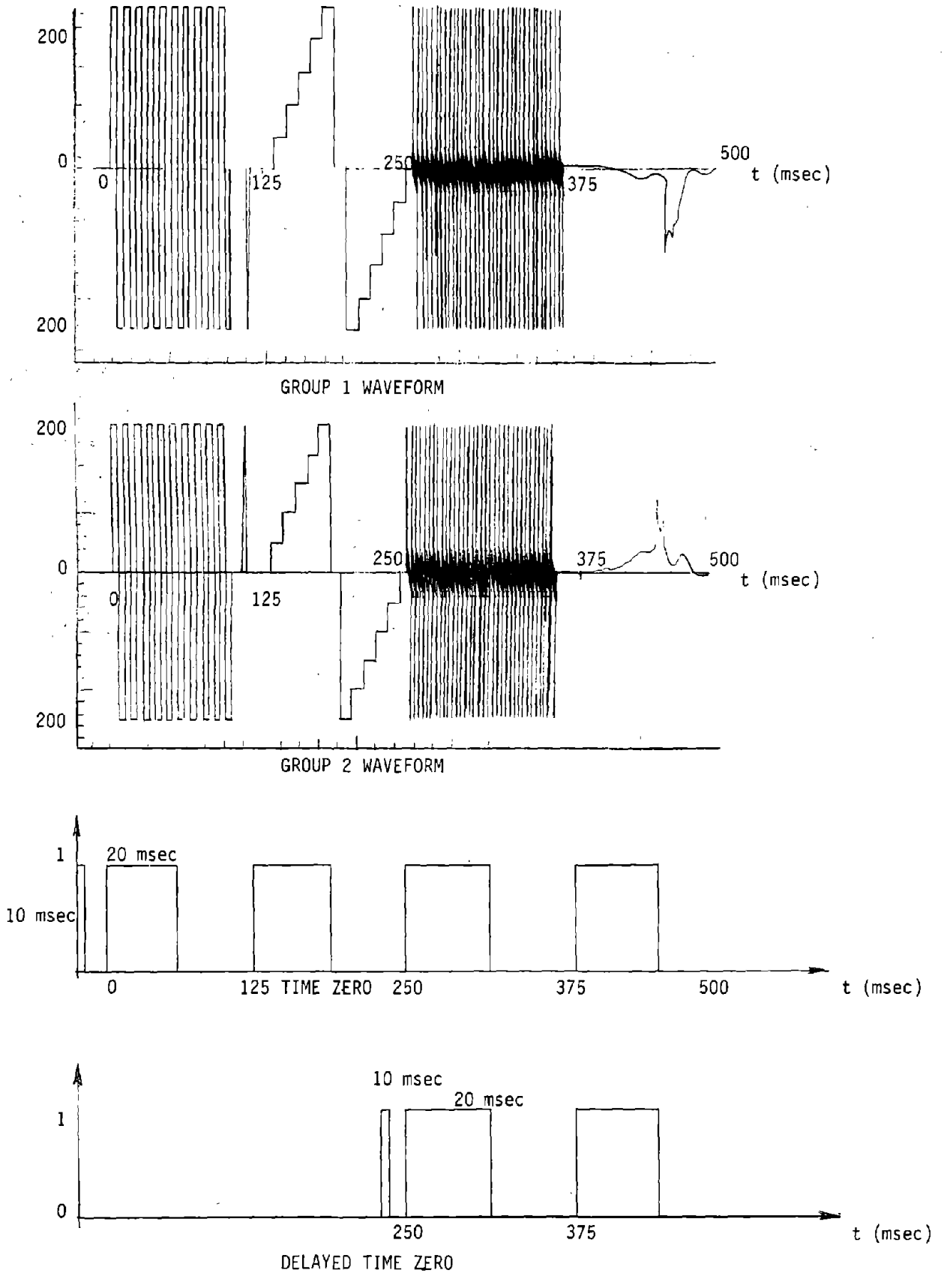


Figure 5-1 WAVEFORMS TIME HISTORY

6. REMOTE CONTROL CAPABILITY

The waveform generator instrument is capable of being controlled by a remote computer. The remote computer shall be capable of producing TTL compatible signals. The remote control can initiate the self-test operation as well as the calibration or recording sequences. To initiate a calibration or a recording sequence a "1" level TTL signal is required (2.4 to 5.0 volt is TTL "1"). For remote calibration control please see the calibration control switch explanation in Section 4. The remote control signals should be connected to designated pins on J3 connector.

7. OUTPUT CONNECTOR PIN ASSIGNMENT

The waveform generator low level output signals are terminated on the two large connectors on the side of the instrument (see Figure 1-1). Channels 1, 2, 3, 4, 9, 10, 11 and 12 terminate on connector J1, and channels 5, 6, 7, 8, 13, 14, 15 and 16 terminate on connector J2. The wiring for connectors J1 and J2 is identical and the channel assignment on individual connector pins is identified in Figure 7-1.

As noted in Figure 7-1, each data channel output terminates on two connector pins: signal high (positive) on one pin and signal low (negative) on the other pin. It is recommended that a two wire shielded cable be used to connect to each output channel with the shield floating at the waveform generator and terminated at the signal conditioning end.

If it is desirable to terminate the shield at the waveform generator, pins J, E or F on the J3 connector can be used for this purpose. These pins are ground (see Figure 7-1 pin assignment on J3).

Also identified in Figure 7-1 is the wiring configuration for the two high level output signals and the time synchronization output channels. The outputs for these signals are on the small ten pin connector on the side of the box identified as J3 (see Figure 7-1). The mating cable connectors to the waveform generator instrument are as follows:

Connector	Connector Type
J1	MS-3106-A-28-16P
J2	MS-3106-A-28-16P
J3	MS-3106-A-18-1P

Connector	Pin	Signal
J1/J2	A	Cha 1 (-)/Cha 5 (-)
J1/J2	B	Cha 1 (+)/Cha 5 (+)
J1/J2	C	Cha 2 (-)/Cha 6 (-)
J1/J2	M	Cha 2 (+)/Cha 6 (+)
J1/J2	L	Cha 3 (-)/Cha 7 (-)
J1/J2	T	Cha 3 (+)/Cha 7 (+)
J1/J2	N	Cha 4 (-)/Cha 8 (-)
J1/J2	U	Cha 4 (+)/Cha 8 (+)
J1/J2	V	Cha 9 (-)/Cha 13 (-)
J1/J2	S	Cha 9 (+)/Cha 13 (+)
J1/J2	D	Cha 10 (-)/Cha 14 (-)
J1/J2	P	Cha 10 (+)/Cha 14 (+)
J1/J2	Q	Cha 11 (-)/Cha 15 (-)
J1/J2	R	Cha 11 (+)/Cha 15 (+)
J1/J2	E	Cha 12 (-)/Cha 16 (-)
J1/J2	F	Cha 12 (+)/Cha 16 (+)
J3	A	Time Zero
J3	B	Remote Calibration Polarity Control
J3	C	Remote Calibration Initiation
J3	D	Remote Recording Initiation
J3	E	Ground
J3	F	Ground
J3	G	Time Zero Delayed
J3	H	High Level Group 1
J3	I	High Level Group 2
J3	J	Ground

Figure 7-1 OUTPUT CONNECTOR PIN ASSIGNMENT

8. RECORDING REQUIREMENTS

This section of the manual provides instructions in using the waveform generator to record test data. When the instrument is first received, it should be removed from its shipping container and inspected for possible shipping damage. Each container includes a waveform generator, an operator's manual, three connectors that mate to the connectors on the instrument, and an AC line power cord. Note that the shipping container and the foam packing have been designed for proper shipping of the instrument and should be retained in dry storage for future use. The instrument should not be shipped in an alternative container without prior approval from an appropriate government representative.

Before operating the instrument, the operator's manual should be reviewed and the operator should familiarize himself with the location, function and purpose of the various lights, switches, and wiring attachment points on the unit. An overall layout of these items is presented in Figure 1-1. The AC line power input is on the side opposite the J1, J2 and J3 data output connectors.

The input power to the instrument is 110 VAC or 220 VAC at 60 Hertz. All units are labeled as to the proper input voltage. Place the instrument on a suitable test table and check that the main power switch is off; then plug the power cord into a grounded electrical power source of proper voltage. All units for North American use are wired for 110 VAC input power.

Initial checkout tests can be performed with no attachments to the J1, J2, and J3 connectors. Before turning on the power, set the transducer type switch to piezo-resistive and the calibration mode switch to manual negative. This assures a successful self-test if the instrument is operating correctly. Next, turn on the power and observe that all lights come on for a lamp check test period of about 12 seconds.

After a one minute time delay during which internal self tests are being performed, the ready light should light. This indicates that all aspects of the instrument are operating correctly. Turning the power switch off and then on again will repeat this cycle. Once the operator has verified that the instrument is operating correctly, he can assemble his external wiring to allow signals from the instrument to be injected into a data recording system. The instrument should be turned off while these external wiring connections are being made.

The waveform generator instrument produces three types of signals. One consists of low level waveforms that simulate either strain gage or piezo-resistive type sensor outputs. These signals are available on connectors J1 and J2 providing a total of 16 data output channels.

All low level calibration signals are derived from either group 1 waveforms or group 2 waveforms as shown in Figure 5-1. Channels 1, 2, 3 and 4 on connector J1 contain group 1 waveforms. Channels 5, 6, 7 and 8 contain group 2 waveforms; consequently, there are eight outputs on connector J1 consisting of four of each group of waveforms. Connector J2 is wired identically to J1 and provides eight additional output data channels. Note that the signal output on a given pair of terminals on J1 and J2 are identical.

The J3 connector contains the two remaining types of signals produced by the instrument. A high level signal is produced on J3 for the group 1 and the group 2 type waveforms. The high level outputs are produced with respect to a common ground (pin E, F or J on connector J3).

Time synchronization pulses are also available on the J3 connector. These time waveforms are used in the processing software to separate the recorded data into individual waveforms.

The waveform generator is capable of generating four different types of time synchronization outputs. These are:

1. Time Zero

2. Inverted Time Zero

3. Delayed Time Zero

4. Inverted Delayed Time Zero

During each recording sequence, it is necessary to record one of the above time synchronization output signals along with the data channel outputs. During the processing of the recorded data, the recorded time synchronization data is used to separate the sequence of the waveforms from each channel into individual waveforms. Note that the delayed time zero is provided for those data acquisition systems which are not capable of recording the full sequence of waveforms. As it can be seen from Figure 5-1, if the delayed time zero output is used to trigger the data acquisition systems, only the last two waveforms will be recorded, and this will reduce the recording duration from 500 to 250 msec.

The "time zero" waveform contains rising edges at 0, 125, 250, and 375 milliseconds. The "time zero" waveform is a standard 5 VDC logic signal and each pulse is about 62.5 milliseconds in duration. The "time zero" waveform also contains a pre-trigger pulse that occurs 30 milliseconds before the first time pulse and is 10 milliseconds long. The "delayed time zero" waveform is similar, but the first time edge occurs at 250 milliseconds.

To test a data recording system, the operator must record one low level signal on each of his data recording channels. It is also necessary to simultaneously record the "time zero" or "delayed time zero" signal. The high level group 1 and 2 waveforms on connector J3 can be monitored on an oscilloscope during setup and checkout.

The data waveforms are 500 milliseconds in duration consisting of two 250 millisecond blocks. If the facility recording system can record 500 milliseconds of data in a continuous block, the complete waveform can be recorded in one pass; if not, the recording process can be broken down into two blocks.

On the first pass, the "time zero" channel is recorded to capture the first 250 milliseconds of data. On the second pass, the "delayed time zero" signal is used to record the second 250 millisecond block of data. The pre-trigger pulse is present on both timing waveforms to allow pre-trigger starting of a digitizing system.

As an example of a typical calibration process, assume a facility has 50 data channels to calibrate; also, assume that the facility uses Endevco type accelerometers. First, cables should be assembled to allow signals from the J1 and J2 connectors to be be applied to the facility instrumentation amplifiers. Cables should also be assembled to connect the high level group 1 and 2 outputs on connector J3 to an oscilloscope. Further, cables should be wired to connect the appropriate time channel to an input channel on the facility data recording system.

With the waveform generator instrument turned on and with all data channels connected, check that the facility instrumentation amplifier outputs are near zero. Set the generator to piezo-resistive and the calibration mode switch to manual positive.

Now depress the calibration push button switch and check that the gains of the facility instrumentation amplifiers are correct to avoid channel saturation. Next, select manual negative and again check the amplifier output levels for saturation.

This process simulates the maximum positive and negative signal levels that the instrument will produce and checks the balance and gain settings of the data recording amplifiers. In the calibrate mode the generator

simulates a signal level of +200 Gs and -200 Gs. When the calibrate push button switch is not depressed, the output signal levels represent 0 Gs.

After the first 16 data channels and the "time zero" recording channel are confirmed to be operating correctly, actual data recording can begin. To record data it is necessary to first record calibration levels and then test waveforms.

Calibration levels are recorded by turning on the facility recording system and recording about one second of manual positive calibrate levels.

Following the calibrate level recording, the generator "record" switch is depressed to produce and record data on the first 16 data channels plus a time reference channel. Test data available for the first 16 data channels will then consist of the zero and calibrate levels followed by the waveform signals on 16 data channels and time reference pulses on the time reference channel. This process is then repeated until both calibrate signals and data signals are recorded for all data channels to be tested.

In generating data tapes for the recorded data, the recorded test waveforms should be scaled based on the recorded calibrate signals. The signal level change between the calibrate zero level and the positive calibrate level should be considered to be 200 Gs. This level change should then be used to scale the test waveforms into Gs. It is important to also digitize the "time zero" waveform on the data tape for each group of data channels. The amplitude assigned to the "time zero" channel is arbitrary.

On creating test and instrumentation information headers for the data tapes, use the following codes:

TSTTYP	=	SWG	Signal waveform generator test of the data acquisition system
SENTYP	=	LL	for low level signal (strain gage)
		HL	for high level signal (piezo-resistive)
		ET	for event time indicators (code already exists)

SENLOC	=	01	channel 1 of signal waveform generator
		02	channel 2 of signal waveform generator
		16	channel 16 of signal waveform generator
		H1	high level signal of group 1 waveform
		H2	high level signal of group 2 waveform
		E1	event time indicator (time zero)
		E2	event time indicator (delayed time zero)
SENATT	=	CH01	channel 1 of data acquisition system
		CH02	channel 2 of data acquisition system
		CHNN	channel NN of data acquisition system
AXIS	=	XG	for group 1 waveform (channels 1, 2, 3, 4 and 9, 10, 11, 12 of the SWG)
AXIS	=	ZG	for group 2 waveform (channels 5, 6, 7, 8 and 13, 14, 15, 16 of the SWG)

INSMAN = In the lines that correspond to the time reference channels, identify the polarity of the "time zero" (time reference) signal that was recorded, and whether "delayed time zero" was used.

INSCOM = Commentary field
Identify the run number, amplifier tape recorder, tape recorder channel number and umbilical pair; or anything necessary to uniquely identify the system. There are only 70 characters available. Do the best that you can!

APPENDIX A

SCHEMATIC AND ASSEMBLY LAYOUT

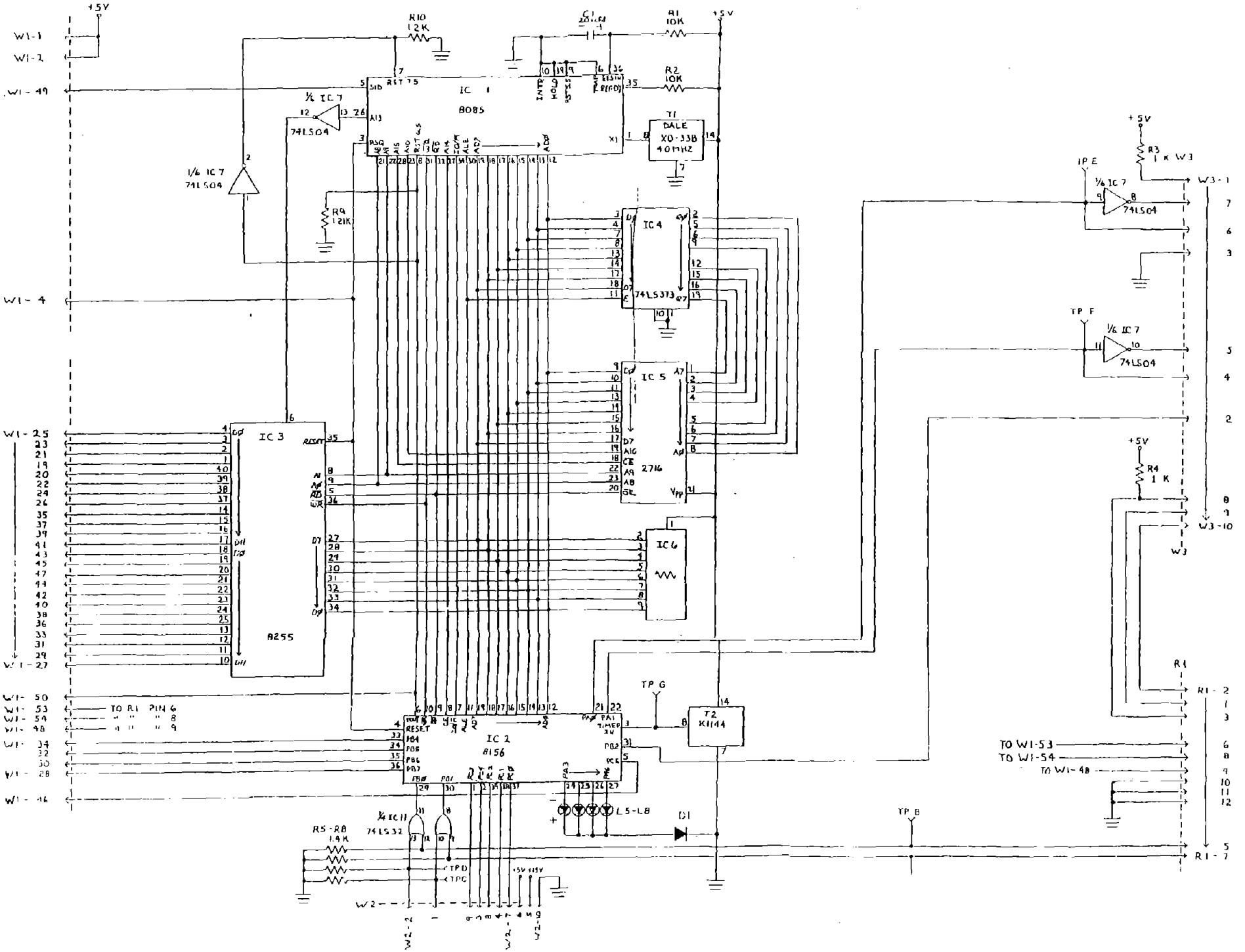


Figure A-1 SCHEMATIC OF CPU BOARD

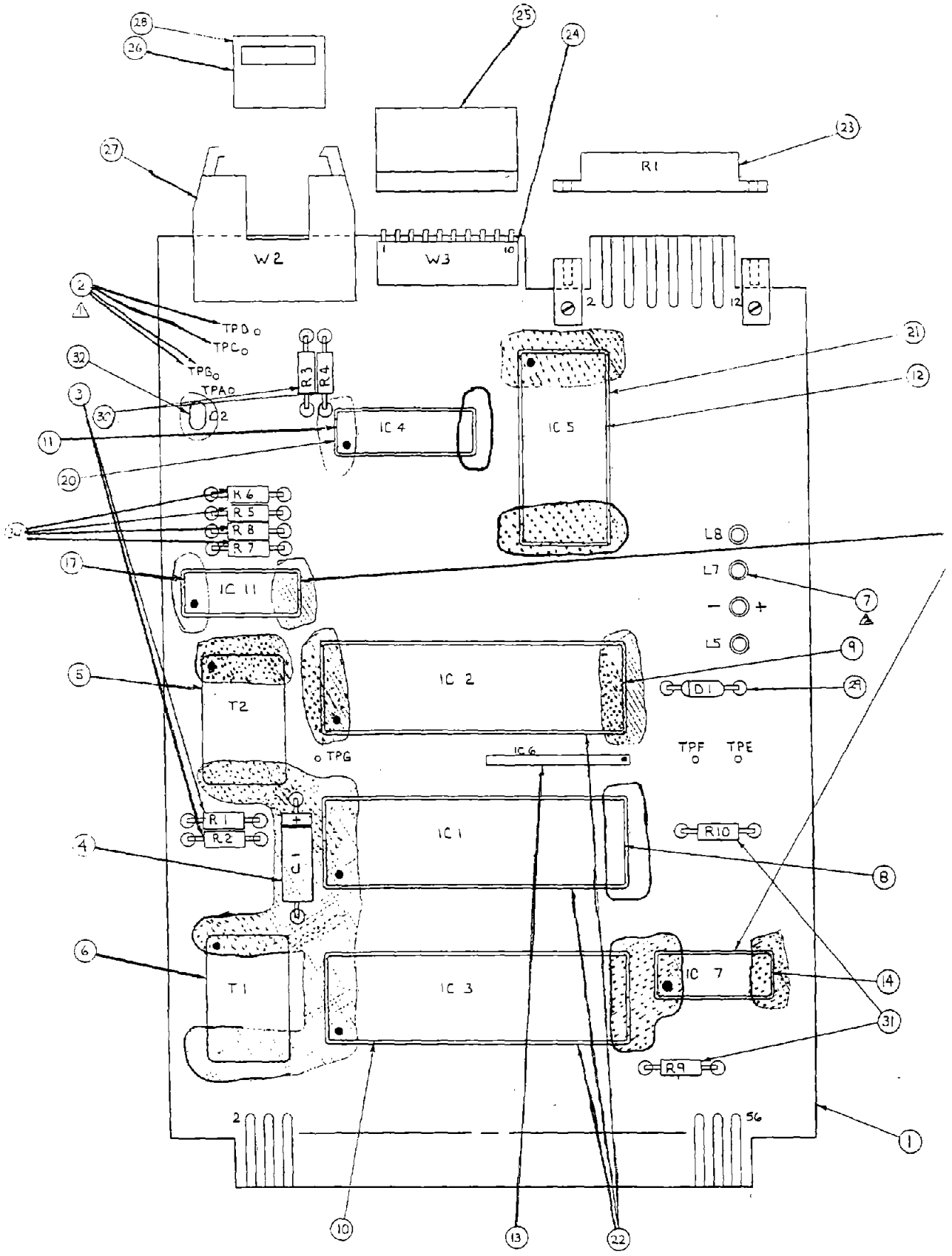
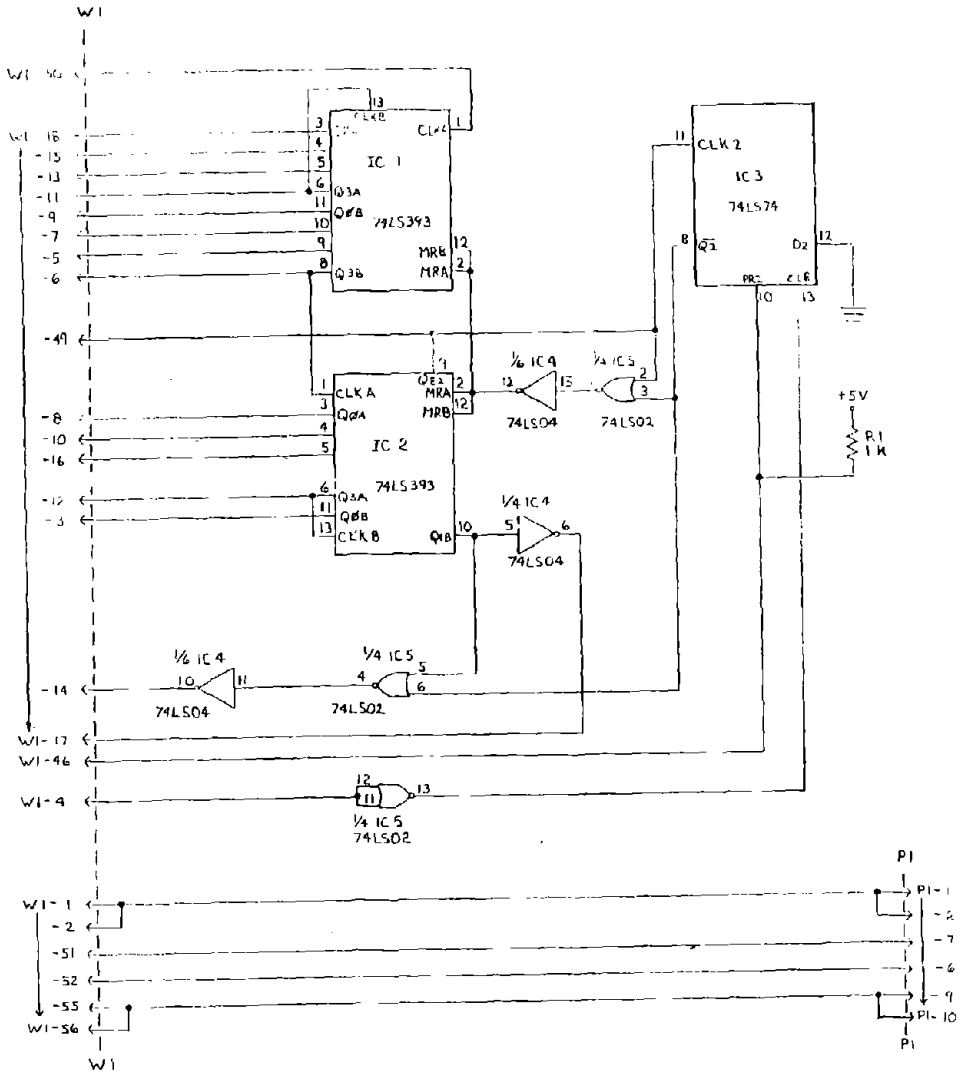


Figure A-2 LAYOUT OF CPU BOARD

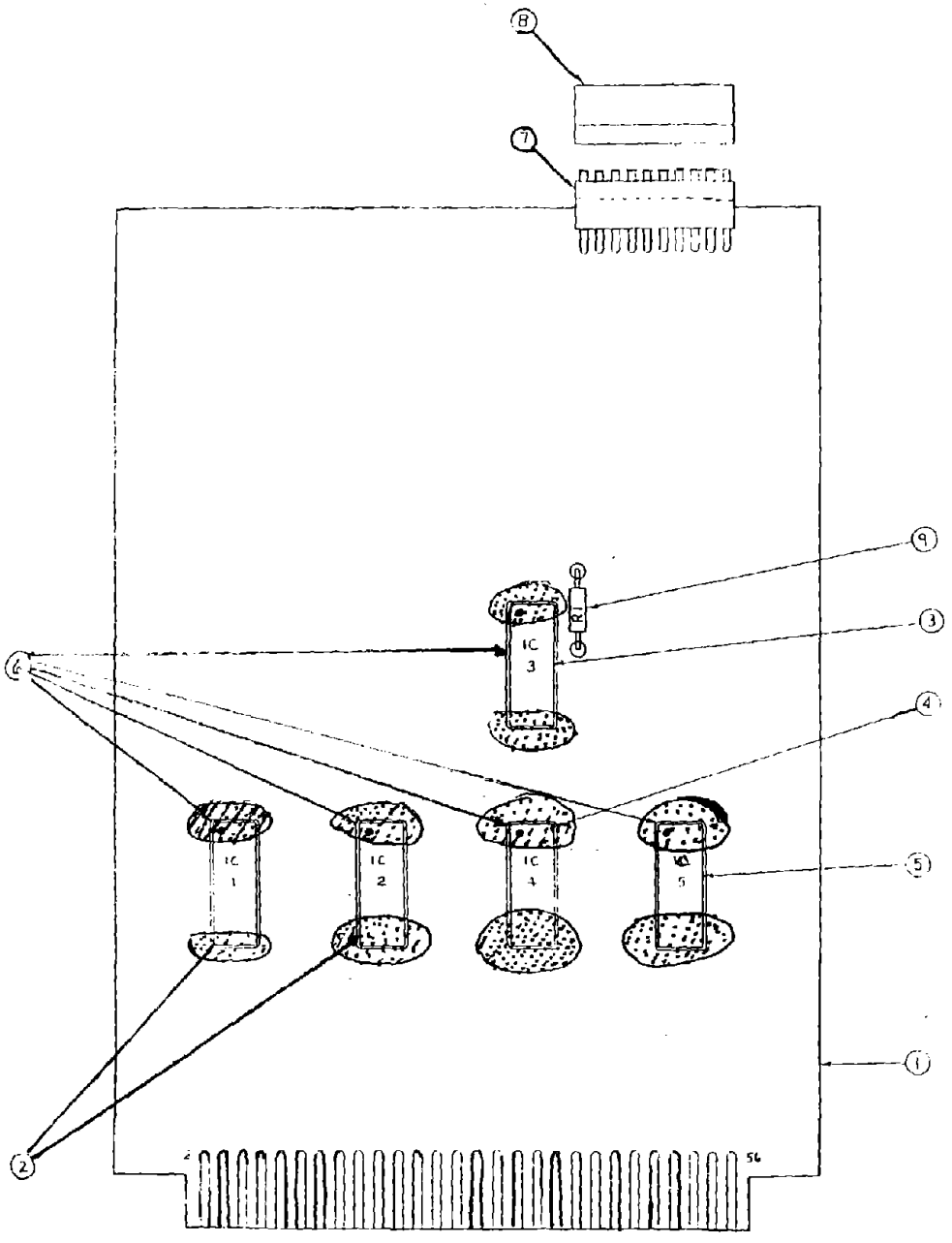
56 CONTACT CONNECTOR		
W1- 1		+5V
2		"
3		A'12
4		RESET
5		A'6
6		A'7
7		A'5
8		A'8
9		A'4
10		A'9
11		A'3
12		A'11
13		A'2
14		CSØ
15		A'1
16		A'10
17		CS1
18		A'Ø
19		D'3
20		D'4
21		'2
22		'5
23		'1
24		'6
25		'Ø
26		'7
27		"11
28		PB7
29		"10
30		PB6
31		"9
32		PB5
33		"8
34		PB4
35		'8
36		"7
37		'9
38		"6
39		"10
40		"5
41		'11
42		"4
43		"Ø
44		"3
45		"1
46		PC5
47		"2
48		ANALOG GND
49		SLO
50		TIMER OUT
51		+15V
52		-15V
53		H L V EB3
54		" EB2
55		GND
W1-56		"

POWER CONNECTOR		
P -1		+5V
-6		-15V
-7		GND
-10		GND
-2		+5V



POWER & GND CHART		
	+5V	GND
IC 1	14	7
2	14	7
3	14	7,12
4	14	7
5	14	7

Figure A-3 SCHEMATIC OF TIMING BOARD



A SHADED AREAS ARE TO BE COVERED WITH SILICONE

REF NO	NO REQD	REF DESIG	DESCRIPTION	MANUFACTURER	PART NO
9	1	R1	1K RESISTOR		RN55D 1001F
8	1	—	10 PIN PLUG	MOLEX	22-01-3101
7	1	P1	10 PIN RECEPTALE	"	22-01-2107
6	5	—	14 PIN SOCKET	TI	C93402
5	1	IC 5	NOR GATE	NATIONAL	74LS02
4	1	IC 4	INVERTER GATE	"	74LS04
3	1	IC 3	FLIP-FLOP	"	74LS 74
2	2	IC1, IC2	COUNTER	"	74LS393
1			062 THICK GLASS EPOXY		

PART LIST

Figure A-4 LAYOUT OF TIMING BOARD

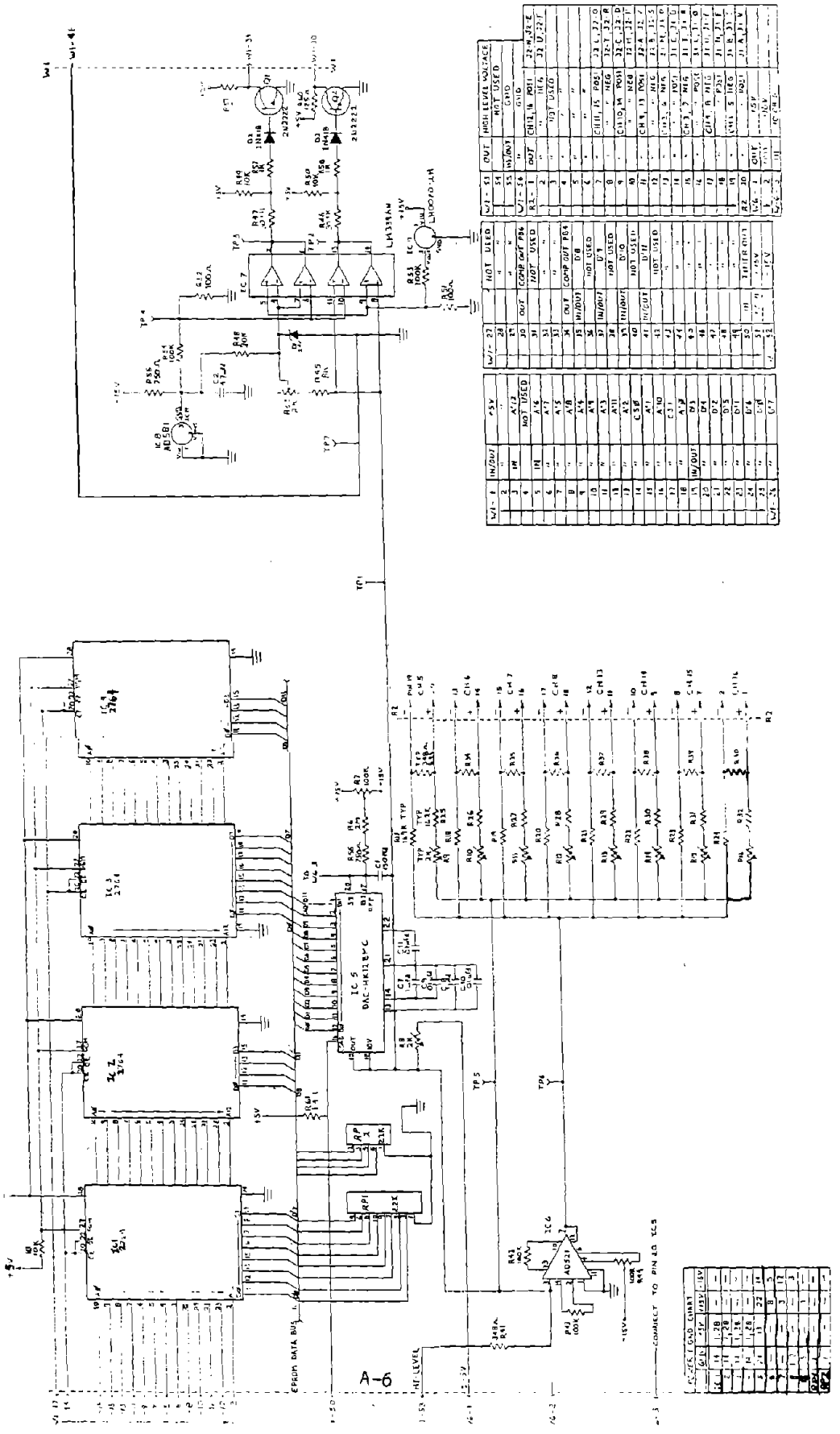
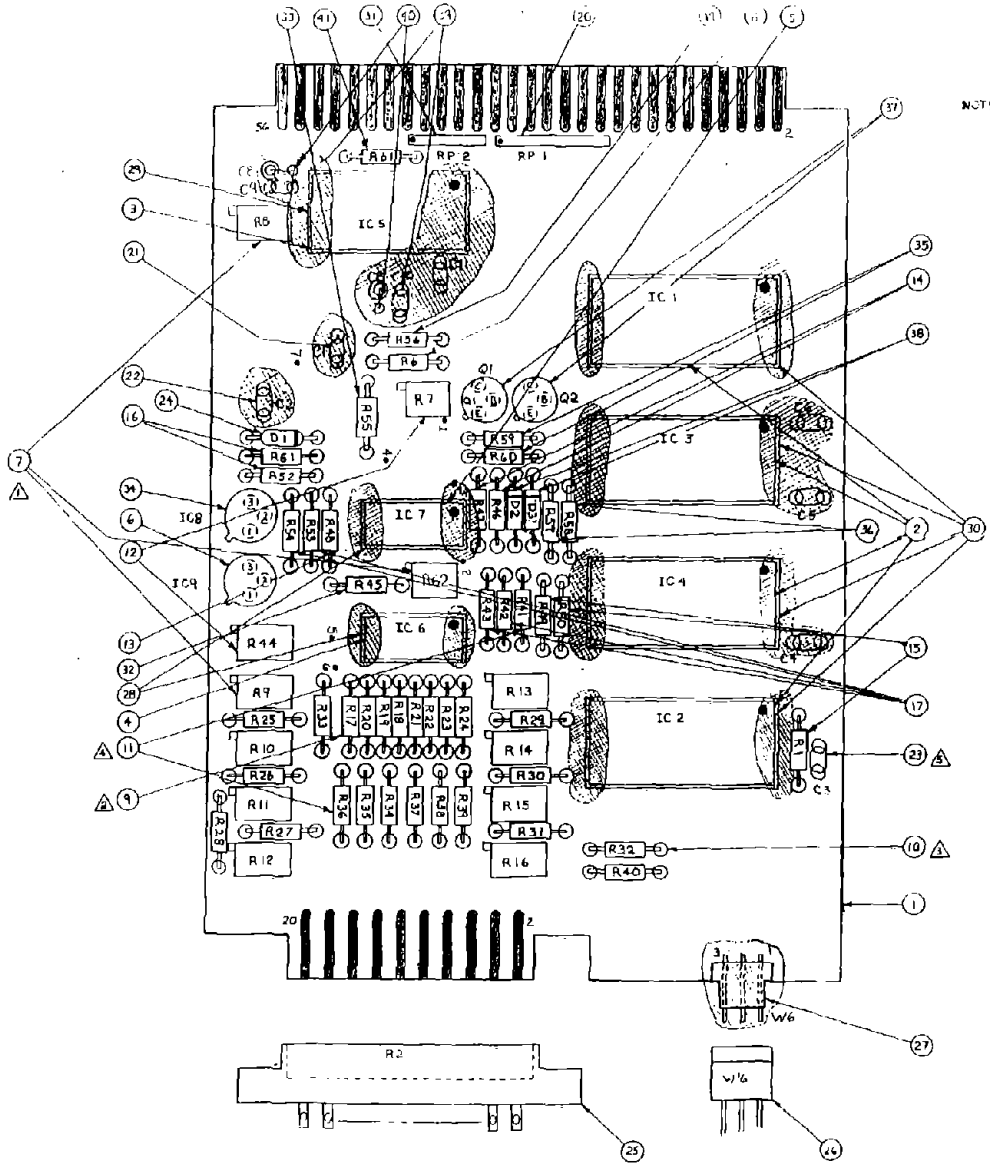


Figure A-5 SCHEMATIC OF EPROM BOARD



NOTES:

1. 9 REQ'D R8 - R16
2. 8 REQ'D R17 - R24
3. 8 REQ'D R25 - R32
4. 9 REQ'D R33 - R41
5. 4 REQ'D C3 - C6, C11
6. ALL POTENTIOMETER ADJUSTMENT SCREWS SHOULD HAVE LOCTITE APPLIED TO THEM
7. SHADED AREAS ARE TO BE COVERED WITH SILICONE

REF NO	NO. REQ'D	REF. DESIGN	MANUFACTURER	DESCRIPTION	PART NO.
41	1	R61		1.4K RESISTOR	RN55D 2201F
40	2	C7,8	SPRAGUE	1 μfd TANTALUM CAP	150D155X1020A
39	3	C9,10	CENTRALAB	.01 μfd CERAMIC CAP	CK15C103K
38	2	D2, D3	Radio Shack	DIODE	1N914
37	2	Q1, Q2	MOTORALA	NPN TRANSISTOR	2N2222
36	2	R57, R58		1K RESISTOR	RN55D1001F
35	2	R59, R60		1K Ω RESISTOR	" 1001F
34	1	IC 8	ANALOG DEVICES	VOLTAGE REGULATOR	AD581
33	1	R55		750 Ω RESISTOR	RN55D 7500F
32	1	R45		8K "	RN55D 8001F
31	1	RP 2	BOURNS	6 PIN 2.8K RESISTOR PACK	4306R-101-222
30	4		T.I	28 PIN SOCKET	TIC932802
29	1		"	24 " "	TIC932402
28	2		"	14 " "	TIC931402
27	1	W6	MOLEX	3 PIN CONNECTOR	22-05-3031
26	1	W6'	"	3 PIN MATE CONNECTOR	22-01-2037
25	1	R2	WINCHESTER	EDGE CONNECTOR	HCA10
24	1	D1	MOTOROLLA	ZENER DIODE 2.4 V	1N4370
23	5	C3-C6,11	CENTRALAB	.1 μfd CAPACITOR	CZ20C104M
22	1	C2	MALLARY	4.7 μfd "	475K03SNLF
21	1	C1	ARCO	150 pfd "	DM5FA151J
20	2	RP1	BOURNS	2.2K RESISTOR PACK	4310 101-222
19	1	R56		200K RESISTOR	RN55D 2003F
18					
17	4	R42,43,53,54		100 K "	" 1003F
16	2	R51,R52		100 Ω "	" 1000F
15	3	R1,49-50		10 K "	" 1002F
14	2	R46, R47		30.1K "	" 3012F
13	1	R48		20K "	" 2002F
12	2	R7, R44	BURNS	100K TRIMPOT	3299 x 100K
11	9	R33 - R41		348 Ω RESISTOR	RN55D 3480F
10	8	R25 - R32		16.2 K "	" 1622F
9	8	R17 - R24		16.9 K "	" 1692F
8	1	R6		2M "	MF55D
7	10	R8, R9-R15, R62	BURNS	2K TRIMPOT	3299 - 2K
6	1	IC 9	NATIONAL	VOLTAGE REGULATOR	LH0071-2H
5	1	IC 7	"	" COMPARTOR	LM339AN
4	1	IC 6	ANLOG DEVICES	INSTRUMATION AMP	521JD
3	1	IC 5	DATEL INTERSIL	DAC	DAC-HK-12BMV
2	4	IC1 - IC4	INTEL	EPROM (8K x 8)	INTEL 2764
1	1			.062" THICK GLASS EPOXY	

PARTS LIST

IC1	LOW 2	LOW 3
IC2	HIGH 1	HIGH 2
IC3	LOW	LOW 4
IC4	HIGH 2	HIGH 4

IC NO	BOARD 1 PROGRAM NO	BOARD 2 PROGRAM NO

EPROM PLACEMENT

2.1
8-1-84

Figure A-6 LAYOUT OF EPROM BOARD

APPENDIX B

WAVEFORM GENERATOR INPUT POWER

The waveform generator power supply is designed to operate at power line frequencies from 47 to 63 Hz. and for a broad range of input voltages. The proper wiring of the power supply input transformer primary winding for specific input voltage levels is described here.

The primary winding on the power supply has five voltage taps. The five wire input provides four voltage ranges: 100/120/220/230-240 **, + 10% - 13%.

Table B-1 identifies the proper jumpering requirements for the individual input voltage levels.

Table B-1 JUMPERING REQUIREMENTS FOR INDIVIDUAL INPUT VOLTAGE LEVELS

AC Input 47-63 Hz.

For Use At	100 VAC	120 VAC	220 VAC	230/240 VAC
Jumper	1 & 3 2 & 4	1 & 3 2 & 4	2 & 3	2 & 3
Apply AC	1 & 5	1 & 4	1 & 5	1 & 4

** Tolerance for 230 VAC operation is + 15%, - 10%

A jumpering example for 100/120 VAC operation is presented in Figure B-1.

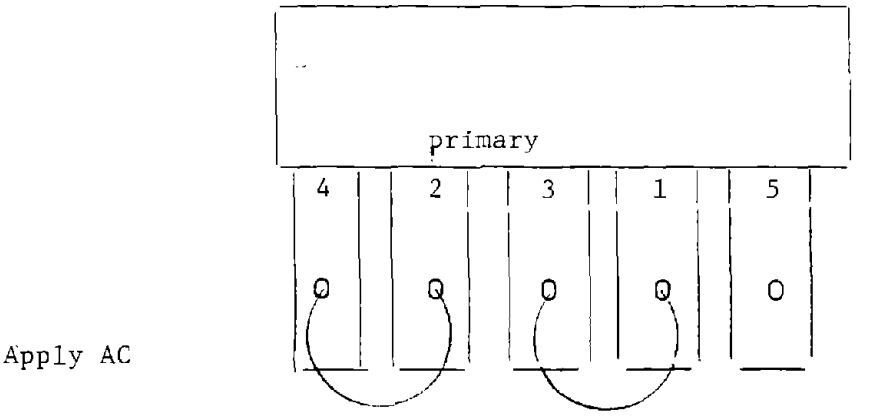


Figure B-1 JUMPERING EXAMPLE FOR 100/120 VAC OPERATION