User Manual

8600

100 MHz Programmable Pulse Generator

Serial Prefix: 20

Tabor Electronics Ltd.

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REVISION: D

Warranty

Tabor Electronics' products are warranted against defects in material and workmanship, when used under normal operating conditions, for a period of one year after delivery. Tabor Electronics will repair or replace without charge any product which proves defective during this period. Repair necessitated by misuse of the product is not covered by this warranty. No other warranties are expressed or implied, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Tabor Electronics is not liable for consequential damage.

REPAIR AND CALIBRATION

Prior authorization is required from Tabor Electronics before products are returned for service. All service must be performed by Tabor Electronics' factory or an authorized service center. Please contact the factory directly for repair and re-calibration:

Tabor Electronics, Ltd.
9 Hatasia Street
Tel Hanan, Israel 20302
Tel: 972-4-821-3393
Fax: 972-4-821-3388

Tabor Electronics Ltd.

REPAIR AND CALIBRATION REQUEST FORM

To allow us to better understand your repair requests, we suggest you use the following outline when calling and include a copy with your instrument to be sent to the Tabor Repair Facility.

Model_____ Serial No._____ Date_____

Company Name_____ Purchase Order #_____

Billing Address_____
City

State/Province Zip/Postal Code Country

Shipping Address_____
City

State/Province Zip/Postal Code Country

Technical Contact_____ Phone Number ( )_____
Purchasing Contact _____ Phone Number ( )_____

1. Describe, in detail, the problem and symptoms you are having. Please include all set up details, such as input/output levels, frequencies, waveform details, etc.

2. If problem is occurring when unit is in remote, please list the program strings used and the controller type.

3. Please give any additional information you feel would be beneficial in facilitating a faster repair time (i.e., modifications, etc.)

4. Is calibration data required? Yes No (please circle one)

Call before shipping
Note: We do not accept "collect" shipments.

Ship instruments to nearest support office listed on back.

Safety Precautions

The following safety precautions should be observed before using this product and associated computer. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present. This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product. Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cables, connector jacks, or test fixtures.

The American National Standard Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before touching or disconnecting the line cord. Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables and test leads for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other of the instrument parts while power is applied to the circuit under test. ALWAYS remove power from the entire test system before connecting cables or jumpers, installing or removing cards from the computer, or making internal changes, such as changing card address. Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always keep dry hands while handling the instrument. If you are using test fixtures, keep the lid closed while power is applied to the device under test. Safe operation requires that the computer lid be closed at all times during operation.

Carefully read the Safety Precautions instructions that are supplied with your computer. Instruments, cables, leads or cords should not be connected to humans. Before performing any maintenance, disconnect the line cord and all test cables. Finally, maintenance should be performed by qualified service personnel only. If you have no past experience in instrument servicing, we strongly recommend that installation and initial tests on the instrument be done by your dealer or by the factory itself.

DECLARATION OF CONFORMITY

We: Tabor Electronics Ltd.
9 Hatasia Street, Tel Hanan
ISRAEL 20302

declare, that the 100 MHz Programmable Pulse Generators

Model 8600

meet the intent of Directive 89/336/EEC for Electromagnetic Compatibility and complies with the requirements of the Low Voltage Directive 73/23/EEC. Compliance was demonstrated to the following specifications as listed in the official Journal of the European Communities:

Safety:
EN 61010-1
IEC 1010-1 (1990) + Amendment 1 (1992)

EMC:
EN 50081-1 Emissions:
EN 55022 - Radiated, Class B
EN 55022 - Conducted, Class B
EN 50082-1 Immunity:
IEC 801-2 (1991) - Electrostatic Discharge
IEC 801-3 / ENV50140 (1993) - RF Radiated
IEC 801-4 (1991) - Fast Transients

Model 8600 was tested in typical configuration.

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SECTION 1

GENERAL INFORMATION

1-1. INTRODUCTION

This manual provides operating and maintenance information for the Model 8600 Pulse Generator. Section 1 is a general description of the instrument. Sections 2 and 3 contain installation and operation instructions. IEEE programming is explained in Section 4. Maintenance and performance checks are give in section 5. The theory of operation is described in section 6. Section 7 outlines troubleshooting and adjustment procedure. Section 8 lists all replaceable parts. Section 9 contain schematic and component location diagrams.

1-2. DESCRIPTION

Model 8600 is a modern, multipurpose fully GPIB programmable dual channel 100 MHz pulse generator. Its superior performance makes it equally at home in electronic laboratories as well as design centers and automatic test systems. The instrument is capable of generating high power pulses having a typical rise times of less than 1.5 nS. It also provides a complete digital control over pulse parameters such as pulse width, pulse delay, duty cycle, high level and low level.

Parameters are displayable with 7 bright digits. The selected function is indicated by an LED. Modification of pulse parameters are digitally set over exceptionally wide ranges:

Period - set from 10 nS to 1.999 S
Amplitude - set from .5 V to 10 Vp-p within a window of +/-10 V
Pulse Width - set from 5 nS to 3.999 S
Delay - set from 0 nS to 3.999 S
Fixed Duty Cycle - set from 1 % to 95 %

When used as a bench instrument, any of 30 pre-programmed complete set-up states, stored in a non-volatile memory, can be recalled by a simple key stroke, ensuring exact duplication of previous set-ups, no matter how complex thus, saving the time which is otherwise required to set up the instrument for different tests.

Output can be selected to be continuous, gated or triggered either by an external signal or by means of front panel manual switch. An internal timer is provided to repeatedly generate an internal trigger stimulus. A burst generator provides an integer number of bursts from a minimum of 2 pulses to 65,500.

As standard, the Model 8600 is furnished with one main output channel and one auxiliary channel. The auxiliary channel, in parallel to the main output, generates a fixed voltage level of either TTL or ECL with a rise time of better than 2 nS.

An optional second channel, with its supplementary auxiliary output, is available for the Model 8600. This channel only shares a common period with the main output channel. All other parameters are independently set.

Model 8600 features a unique built-in reciprocal counter/timer which, when selected, is capable of measuring three external repetitive parameters:

Frequency - from 20 Hz to more than 150 MHz
Period Averaged - from 7 nS to 50 mS
Pulse width Averaged - from 50 nS to 1 S

The built-in counter is also used in an internal self calibration routine which corrects the basic accuracy of the VCO to better than 1 %. The self calibration routine is front panel selectable and is usable at anytime. When the Model 8600 is set to operate at its continuous mode, the internal repetition rate is periodically monitored and automatically corrected to an enhanced accuracy of 0.05% of the full scale value.

1-3. INSTRUMENT AND MANUAL IDENTIFICATION

The serial number of the instrument is located on the rear panel of the instrument. The two most significant digits identify instrument modifications. If this prefix differs from that

listed on the title page of this manual, there are differences between this manual and your instrument.

Technical corrections to this manual (if any) are listed in the back of this manual on an enclosed MANUAL CHANGES sheet.

1-4. OPTIONS

There is one option which is available for the Model 8600:

Option 1 - Channel B output amplifier option

Option 1 is field installable or may be ordered installed. Installation procedures are given in Section 6 of this manual. There are no software modifications necessary when installing this option. Model 8600 will automatically sense the presence of the installed board and will then permit accessing the parameters which are associated with the newly installed option.

1-5. SPECIFICATIONS

Instrument specifications are listed in Tables 1-1. These specifications are the limits against which the instrument is tested.

NOTE

All specifications in the following table apply with the output terminated with 50 ohms feedthrough termination and with an amplitude of 5 Vp-p. Warm-up period is 30 minimum at an ambient temperature of 25 deg C +/-5 deg C.

1-6. SAFETY CONSIDERATIONS

Model 8600 is a Safety Class 1 instrument with an exposed metal chassis that is directly connected to earth via the power supply cable and has been manufactured according to international safety standards. Before the instrument is switched on, make sure that protective earth terminal is connected to a protective earth via the power cord. Do not remove instrument covers when operating or when power cord is connected to mains.

Any adjustment, maintenance and repair of the opened instrument under voltage should be avoided as much as possible, but when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

1-7. ACCESSORIES SUPPLIED

The 8600 is supplied with ac power cord and with an instruction manual. ent tests.

Table 1-1. Model 8600 Specifications

WAVEFORMS:	Pulse, Pulse complement
OUTPUT MODES:	Single, Delayed, Double, Fixed duty cycle, Disabled
OUTPUT CHANNELS:	Two channels. Channel A standard, Channel B optional. Both channels are exactly identical in parameters and performance. Only period is common. Other parameters independently selected.

PULSE PARAMETERS (Channels A & B)

PERIOD

Range:	10.0 nS to 1.999 S
Resolution:	3 1/2 digits with exponent
Accuracy:	
Continuous:	20.0 nS to 1.999 S: +/-0.1 % of full scale value; 10.0 nS to 19.9 nS: +/-2 % of programmed value +/-.2 nS
Gated and Burst:	+/-2 % of programmed value +/-.2 nS (within 1 hour of self calibration sequence)
Duty Cycle:	1 % to 99 % (limited by 5 nS off time)
Jitter (Peak-Peak):	1 % +/-50 pS

WIDTH, DOUBLE PULSE (Measured at 50 % of amplitude)

Range:	5 nS to 79999 nS (with 1 nS increments); 80.0 uS to 4.000 S
Resolution:	5 digits maximum to 79999 nS; 4 digits maximum from 80.0 uS to 3.999 S
Accuracy:	+/-1 % of programmed value +/-2 nS
Maximum Jitter (Peak-Peak)	
Below 1 uS:	.1 % +50 pS
1 uS to 10 uS:	.05 %
Above 10 uS:	.005%

DELAY (Measured from SYNC OUT to main and auxiliary outputs at 50 % of amplitude)

Delay Range:	0 nS to 79999 nS (with 1 nS increments) 80.0 uS to 3.999 S
Resolution:	5 digits maximum to 79999 nS 4 digits maximum from 80.0 uS to 3.999 S
Accuracy:	+/-1 % of programmed value +/-2 nS
Maximum Jitter (Peak-Peak)	
Below 1 uS:	.1 % +50 pS
1 uS to 10 uS:	.05 %
Above 10 uS:	.005%

OUTPUT LEVELS

High Level Range:	-4.50 V to +5.00 V into 50 ohms; -9.0 V to +10.0 V into open circuit
Low Level Range:	-5.00 V to +4.50 V into 50 ohms; -10.0 V to +9.0 V into open circuit
Amplitude:	.5 V to 5 V into 50 ohms; 1 V to 10 V into open circuit
Resolution:	3 digits
Accuracy (1KHz):	+/-2 % of programmed value +/-2 % of amplitude +/-20 mV
Output Protection:	protected against continuous short to case ground

Table 1-1. Model 8600 Specifications (continued)

PULSE PERFORMANCE

Aberration:	Less than 5 %
Reflections:	Less than 10 %
Source Impedance:	50 ohms +/-2 %
Transition Times:	2 nS

AUXILIARY OUTPUTS

ECL/TTL OUTPUTS

Period:	Same as for main outputs
Operating Mode:	ECL or TTL output, front panel selectable
Output Impedance:	50 ohms +/-3 %
Pulse Parameters:	Shares parameters with the main output. Amplitude and transition times are fixed
Output Modes:	Shares mode with the main output
Output Level	
TTL:	0/2.5 V into 50 ohms; 0/5 V into open circuit
ECL:	-.9 V to -1.7 V into 50 ohms
Transition Times	
TTL:	4 nS
ECL:	3 nS

SYNC OUTPUT

Output Impedance:	50 ohms
Output Level:	1 V minimum into 50 ohms; 2 V minimum into open circuit
Transition Time:	1 nS typical
Duty Cycle	10 nS to 1999 nS: 50 % Above 2000 nS: Pulse width varies from 100 nS to 1 uS

TRIGGERING CHARACTERISTICS

Modes	
External Trigger:	Each input cycle generates a single output pulse.
External Burst:	As in external trigger for a programmable number of pulses.
Internal Trigger:	An internal timer repeatedly generates a single output pulse. Trigger period is adjustable
Internal Burst:	As in internal trigger for a programmable number of pulses
Gated:	External signal enables generator. First output pulse synchronous with the active slope of the gating signal. Last pulse always complete.
Manual:	Simulates an external triggering or gating signal
Manual Burst:	Simulates an external triggering signal
Burst Count Range:	Programmable from 2 to 65,500
Ext. Repetition Rate	
Triggered:	100 MHz maximum
Gated:	25 MHz maximum
Burst:	25 MHz maximum
Int. Trigger Period	
Triggered:	Continuously adjustable from 0.05 mS to 1000 S
Burst:	Continuously adjustable from 0.05 mS to 1000 S

Table 1-1. Model 8600 Specifications (continued)

Input: Via EXT FREQ / TRIG IN BNC
Input Impedance: 10 Kohms +/-5 %
Trigger Point: Adjustable from -10.0 V to +10.0 V
Trigger Sensitivity: +/-500 mVp-p
Slope: Selectable positive or negative going edge

TRIGGER MODES DELAYS (measured from trigger input to SYNC out)

Modes

Triggered:	50 nS +/-10 nS
Gated:	65 nS +/-10 nS
Burst:	65 nS +/-10 nS

FIXED DUTY CYCLE MODE

Mode:	Output pulse is automatically adjusted to the programmed duty cycle parameter. The programmed pulse width parameter is ignored
Range:	1 % to 95 %
Accuracy:	+/-3 % of the programmed value +/-2 nS

COUNTER CHARACTERISTICS

Input:	Via EXT FREQ / TRIG IN BNC
Measurement Technique:	Reciprocal counting
Gate Time:	1 S nominal
Sensitivity:	500 mV p-p
Dimension:	one digit exponent

FREQUENCY MEASUREMENT

Range:	10 Hz to more than 150 MHz
Resolution:	7 digits independent of frequency
Accuracy:	+/-0.01 % +/-1 LSD
Detectable	Pulse Width: 5 nS minimum

PERIOD AVERAGED MEASUREMENT

Range:	7 nS to 50 mS
Resolution:	7 digits independent of period
Accuracy:	+/-0.01 % +/-1 LSD

PULSE WIDTH MEASUREMENT

Range:	50 nS to 1 S
Max Repetition Rate:	10 MHz
Resolution:	$\frac{100\ nS}{F}$ where F = frequency in Hz
Accuracy:	+/-0.01 % +/-3 nS +/-1 LSD (for square shaped signals)

Table 1-1. Model 8600 Specifications (continued)

Dead time between measured pulses:	50 nS

IEEE - 488 INTERFACE

Programmable controls:	All front panel controls except POWER switch.
Subsets Implemented:	SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP2, DC1, DT1, C0
Data Output Format:	Fixed output format consisting of 10 or 14 ASCII characters plus terminators
Data Input Format:	ASCII characters lower or upper case. ASCII characters smaller than 20 HEX (32) are ignored except CR (0D HEX)
Service Request:	Selectable for illegal commands, errors, pulse error
String Termination:	Selectable CR, LF, EOI or combination of all.

Typical Programming Time (measured with Kontron GP 488 controller)

Display/Program:	2.2 mS
Display Parameter:	2.7 mS
Trigger Mode:	1.7 mS
Output Mode:	1.7 mS
Edge Mode:	1.7 mS
Auxiliary Level:	1.9 mS
Recall/Store Set-ups:	3.1 mS
Parameter Programming:	5.4 mS
Interrogate Parameter:	4.7 mS
Interrogate Counter:	6.4 mS
Interrogate Status:	9.1 mS
Reading Format:	1.7 mS
Terminator:	1.7 mS
SRQ Mask:	2.8 mS

GENERAL

Display:	7 digits 7 segment LED 14.2mm high with automatic decimal point, exponent and polarity indication
Power:	115/230 VAC +/-10 %, 48-62 Hz, 150 VA max
Stored Settings:	A non-volatile memory stores up to 30 front panel complete set-ups
Operating temperature:	0 deg C to 40 deg C ambient
Specified accuracy:	20 deg C to 30 deg C ambient
Storage temperature:	-40 deg C to +70 deg C
Humidity range:	80% R.H
Dimensions:	140 x 300 x 345 mm (H X W X L)
Weight:	approx 6 Kg

SECTION 2

INSTALLATION

2-1. INTRODUCTION

This section contains information and instructions necessary for the installation and shipping of the pulse generator - Model 8600. Details are provided for initial inspection, power connection, grounding safety requirements, installation information, and repacking instructions for storage or shipment.

2-2. UNPACKING AND INITIAL INSPECTION

Unpacking and handling of the counter requires only the normal precautions and procedures applicable to the handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to ascertain that the shipment is complete.

2-3. PERFORMANCE CHECKS

The instrument was carefully inspected for mechanical and electrical performance before shipment from the factory. It should be free of physical defects and in perfect electrical order upon receipt. Check the instrument for damage in transit and perform the electrical procedures outlined in Section 5. If there is indication of damage or deficiency, see the warranty in this manual and notify your local Tabor field engineering representative or the factory.

CAUTION

It is recommended that the operator be fully familiar with the specifications and all sections of this manual. Failure to do so may compromise the warranty and the accuracy which Tabor has engineered into your instrument.

2-4. POWER REQUIREMENTS

The pulse generator may be operated from any one of the following sources: a. 103.5 to 126.5 Volts (115 Volts nominal) b. 207 to 253 Volts (230 Volts nominal).

The instrument operates over the power mains frequency range of 48 to 63 Hz. Always verify that the operating power mains voltage is the same as that specified on the rear panel voltage selector switch.

CAUTION

Failure to switch the instrument to match the operating line voltage will damage the instrument and may void the warranty.

The Model 8600 should be operated from a power source with its neutral at or near ground (earth potential). The instrument is not intended for operation from two phases of a multiphase ac system or across the legs of a single-phase, three-wire ac power system. Crest factor (ratio of peak voltage to rms) should be typically within the range of 1.3 to 1.6 at 10% of the nominal rms mains voltage.

2-5. GROUNDING REQUIREMENTS

To insure the safety of operating personnel, the U.S. O.S.H.A. (Occupational Safety and Health) requirement and good engineering practice mandate that the instrument panel and enclosure be “earth” grounded. All Tabor instruments are provided with an Underwriters Laboratories (U.L. and V.D.E) listed three-conductor power cable, which when plugged into an appropriate power receptacle, grounds the instrument. The long offset pin on the male end of the power cable carries the ground wire to the long pin of the Euro connector (DIN standard) receptacle on the rear panel of the instrument.

To preserve the safety protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to an “earth” ground.

CAUTION

To avoid operator shock hazard do not exceed the power mains voltage frequency rating which limits the leakage current between case and power mains. Never expose the instrument to rain, excessive moisture, or condensation.

2-6. INSTALLATION AND MOUNTING

The instrument is fully solid state and dissipates only a small amount of power. No special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 50 deg C, when the relative humidity exceeds 80% or condensation appears anywhere on the instrument. Avoid operating the instrument close to strong magnetic fields which may be found near high power equipment such as motors, pumps, solenoids, or high power cables. Use care when rack mounting to locate the instrument away from sources of excessive heat or magnetic fields. Always leave 4 cm (1.5 inches) of ventilation space on all sides of the instrument.

2-7. BENCH MOUNTING

The Model 8600 is shipped with plastic feet, tilt stand in place and ready for use as a bench or portable instrument. See outline drawing Figure 2-1 for dimensions.

2-8. RACK MOUNTING

The instrument may be rack mounted in a standard 19 inch EIA rack. The instrument may be rack mounted in Rack Mount Kit option 8600-Rack

2-9. PORTABLE USE

The instrument may be used in applications requiring portability. A tilt stand consisting of two retractable legs is provided with each unit.

2-10. SHORT TERM STORAGE

If the instrument is to be stored for a short period of time (less than three months), place cardboard over the panel and cover the instrument with suitable protective covering such as a plastic bag or strong kraft paper. Place power cable and other accessories with the instrument. Store the covered voltmeter in a clean dry area that is not subject to extreme temperature variations or conditions which may cause moisture to condense on the instrument.

2-11. LONG TERM STORAGE OR REPACKAGING FOR SHIPMENT

If the instrument is to be stored for a long period or shipped, proceed as directed below. If you have any questions contact your local Tabor field engineering representative or the Tabor Service Department at the factory.

If the original Tabor supplied packaging is to be used proceed as follows:

1. If the original wrappings, packing material, and container have been saved, repack the instrument and accessories originally shipped to you. If the original container is not available, one may be purchased through the Tabor Service Department at the factory.
2. Be sure the carton is well sealed with strong tape or metal straps.
3. Mark the carton with the model number and serial number with indelible marking. If it is to be shipped, show sending address and return address on two sides of the box; cover all previous shipping labels.

If the original container is not available, proceed as follows:

1. Before packing the unit, place all accessories into a plastic bag and seal the bag.
2. For extended storage or long distance shipping only, use U.S. government packing method IIC and tape a two-unit bag of desiccant (per MIL-D-3464) on the rear cover.
3. Place a 13 cm (5 inch) by 30 cm (12 inch) piece of sturdy cardboard over the front panel for protection.
4. Place the counter into a plastic bag and seal the bag.
5. Wrap the bagged instrument and accessories in one inch thick flexible cellular plastic film cushioning material (per PPP-C-795) and place in a barrier bag (per MIL-B-131). Extract the air from bag and heat seal.
6. Place bagged instrument and accessories into a 250 mm (10 inch) x 360 mm (14 inch) x 508 mm (20 inch) fiber board box (per PPP-B-636 type CF, class WR, variety SW, grade V3C). Fill additional spaces with rubberized hair or cellular plastic cushioning material. Close box in accordance with container specifications. Seal with sturdy water resistant tape or metal straps.
7. Mark container "DELICATE INSTRUMENT", "FRAGILE", etc. Mark instrument model and serial number and date of packaging. Affix shipping labels as required or mark according to MIL-STD-129.

NOTE

If the instrument is to be shipped to Tabor for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, the symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment. ALWAYS OBTAIN A RETURN AUTHORIZATION NUMBER FROM THE FACTORY BEFORE SHIPPING THE INSTRUMENT TO TABOR.

2-12. SAFETY

Be fully acquainted and knowledgeable with all aspects of this instruction manual before using the instrument to assure operator safety and protection against personnel shock hazard.

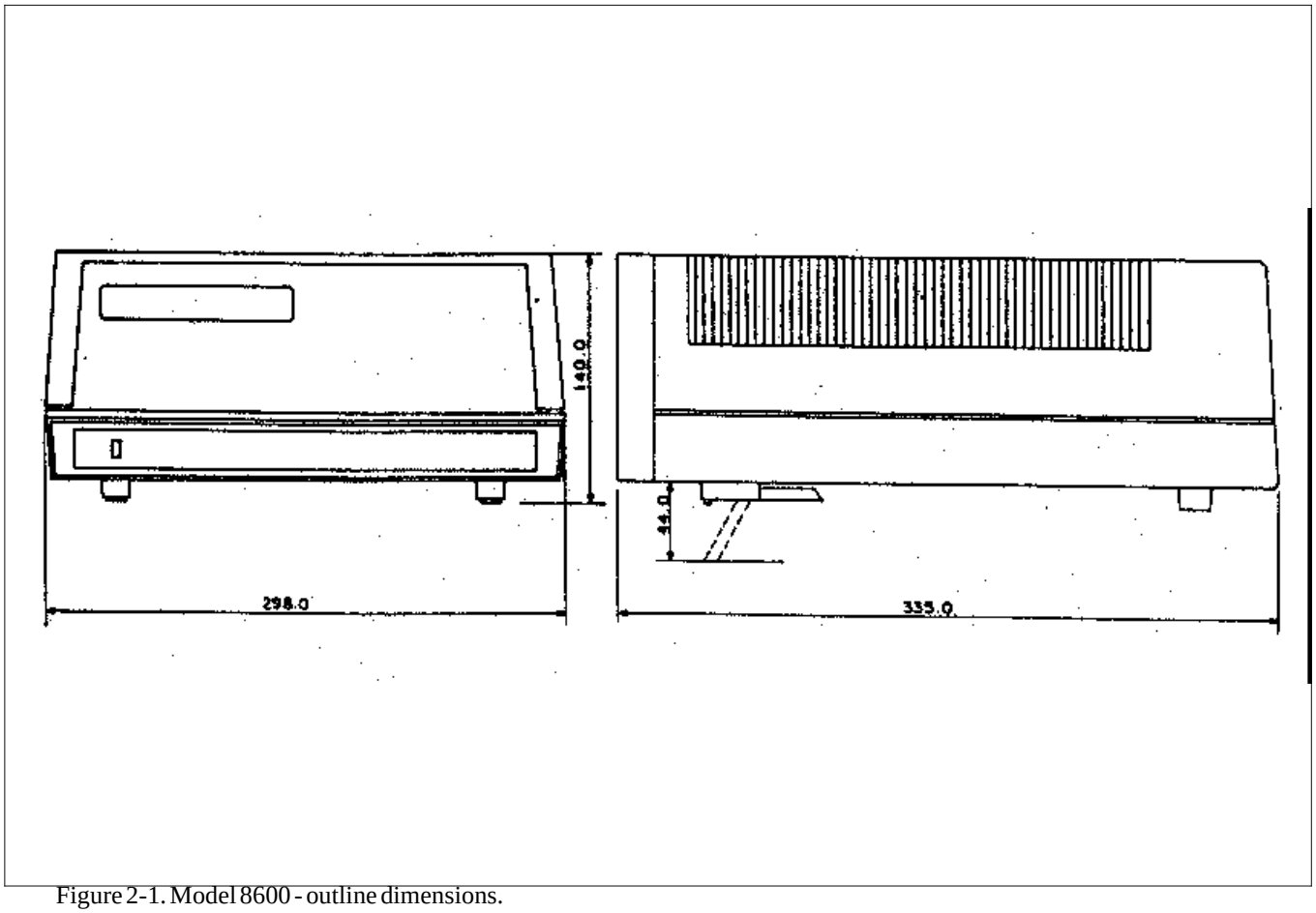

Figure 2-1. Model 8600 - outline dimensions.

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SECTION 3

OPERATING INSTRUCTIONS

3-1. INTRODUCTION

Model 8600 operation is divided into two general categories: basic bench operation, and IEEE-488 operation. Basic bench operation, which is covered in this section, explains how to use the model 8600 for generating the required pulse characteristics. IEEE programming can also be used to greatly enhance the capability of the instrument in applications such as automatic test equipment. This aspect is covered in details in Section 4.

3-2. FRONT PANEL FAMILIARIZATION

The front panel layout of the Model 8600 is shown in Figure 3-1. The front panel is generally divided into three sections: controls, connectors, display and indicators. The following paragraphs describe the purpose of each of these items in details.

3-2-1. Controls

All front panel controls except POWER are momentary contact switches. Most controls include an annunciator light for indication of the selected parameter and operating mode. Some controls do not have an annunciator light. Exercising these controls generates an immediate response on the display.

Front panel controls may be divided into functional groups: Power, Display/Modify, Trigger Mode, Ouptut and Data Entry.

1. POWER - The POWER switch controls the AC power to the instrument. Pressing and releasing the switch once turns the power on. Pressing and releasing the switch a second time turns the power off.

2. DISPLAY/MODIFY - There are four DISPLAY/MODIFY push-buttons which modify the display reading. Each time a button is depressed a different parameter is displayed. The selected parameter is indicated by an LED. The dimensions which are associated with each parameter are located below the numeric display.

The following parameters may be displayed and modified:

PERIOD - Time interval between two consecutive and unidirectional edges of the selected output pulse. Period is defined for repetitive signals only. When the generator is set to operate in triggered mode, the programmed period value has no effect on the output. In gated mode, the period defines the repetition rate within the gating signal. In burst mode, the period defines the repetition rate of the burst. The programmed period retains its value at all of the output connectors. Channels A and B share the same period.

HIGH LEVEL - The top voltage rail of the pulse at the main output connectors. Parameter is valid when the output is terminated with 50 ohms. High level may independently be adjusted for channels A and B.

LOW LEVEL - The bottom voltage rail of the pulse at the main output connectors. Parameter is valid when the output is terminated with 50 ohms. Low level may independently be selected for channels A and B.

DUTY CYCLE - Percentage ratio of positive pulse width to period. When output is in complement mode, duty cycle defines the ratio between the negative pulse width to the period. Duty cycle value may only be modified when the fixed duty cycle mode was selected otherwise Model 8600 does not permit an access to this parameter. Duty cycle may independently be selected for channels A and B.

PULSE WIDTH - In normal output mode, the pulse width specifies the positive pulse width. In complement output mode, this value relates to the negative pulse width. The specified and displayed value is that obtained at the 50% of amplitude setting. Pulse width may independently be selected for channels A and B.

DELAY - In single output mode, the delay specifies the time interval between the positive edges of the SYNC output and the main output. In double pulse output mode, the first pulse is synchronous with the SYNC OUT pulse. The selected delay then specifies the time interval between the two consecutive pulses. The specified and displayed value is that obtained at the 50% of amplitude setting. Delay may independently be selected for channels A and B.

BURST - An integer number of output pulses which follows a triggering sequence. The displayed burst value is common to both channels.

TRIGGER PERIOD - A built-in generator provides an internal triggering stimuli in such cases where an external signal is not available. The displayed value specifies the interval between consecutive triggering sequences.

TRIGGER LEVEL - Specifies a thresh-hold voltage level at the trigger input connector. Crossing this voltage level with an external signal, and with the Model 8600 set to one of the triggering modes, stimulates the generator to generate output pulses. This trigger level value also specifies the thresh-hold level for the counter input.

Table 3-2 lists the limits for each of the above parameters.

Depressing the push-button which is marked COUNTER will turn the Model 8600 into a universal counter. Frequency, Period and Pulse Width could then be measured by selecting the appropriate function.

3. TRIGGER MODE - Three push-buttons are grouped in the TRIGGER MODE section. Selection of one of the trigger modes is done by depressing one of these buttons. The selected mode is indicated by an LED. Model 8600 may be triggered from either one of the following sources:

1. External signal which may be applied to the TRIG IN connector
2. An internal - asynchronous trigger generator
3. Front panel manual push-button
4. GPIB commands (like GET)

The MANUAL trigger is active when the instrument is in one of the external trigger modes. This push-button when depressed will serve as a replacement for an external trigger source.

4. OUTPUT - There are two push-buttons in the OUTPUT group. One button selects between NORMAL and COMPLEMENT outputs and the other button selects between one of three operating modes: SINGLE, DOUBLE or DELAYED. The selected function is indicated by an LED.

5. DATA ENTRY - The DATA ENTRY group contains 16 entry push-buttons and 4 separate special function buttons. The process of entering data will be described later in this chapter.

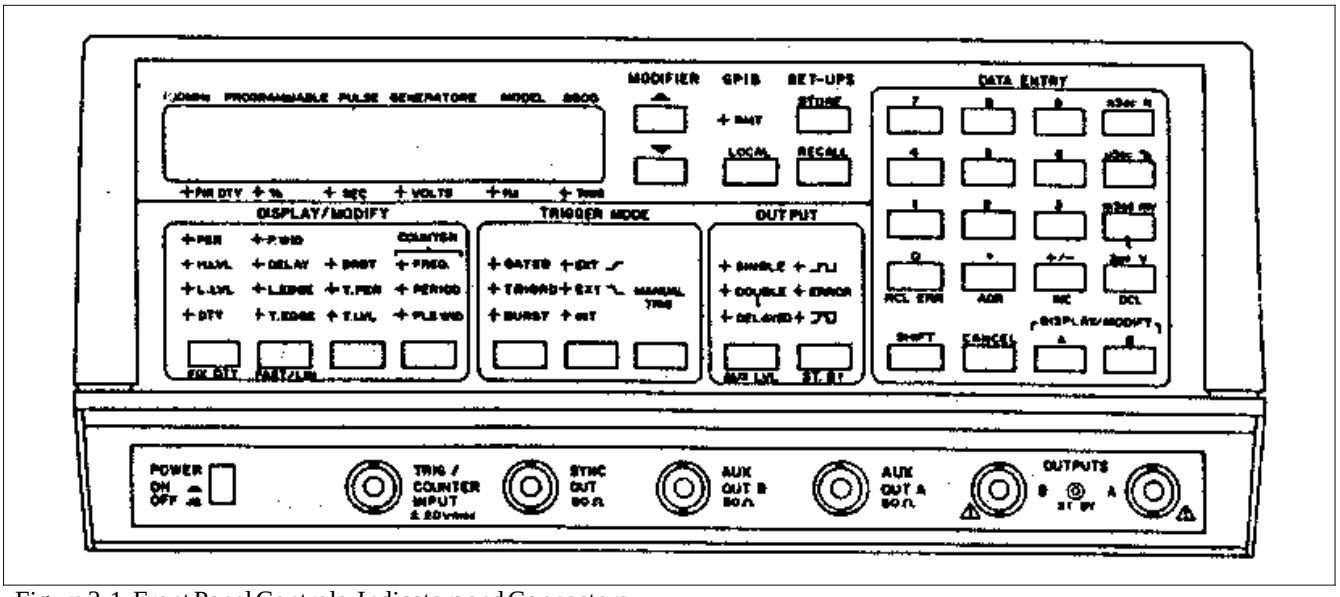

Figure 3-1. Front Panel Controls, Indicators and Connectors

SHIFT - The SHIFT button is associated with front panel 2nd functions. The 2nd functions are marked in yellow.

CANCEL - The CANCEL push-button, when depressed, terminates an incomplete data entry procedure. This button is inactive following a successful data entry procedure.

DISPLAY/MODIFY - The DISPLAY/MODIFY buttons in the DATA ENTRY group are designated as [A] and [B]. These push-buttons are inactive if Channel B (option 1) is not installed. Parameters may independently be programmed for channels A and B. Depress [A] before programming parameters for channel A. Depress [B] before programming parameters for channel B.

6. MODIFIER - The two MODIFIER push-buttons simulate a digital potentiometer. The MODIFIER operates in conjunction with the DISPLAY/MODIFY group.

7. SET-UPS - There are two push-buttons in the SET-UPS section. One is used for storing a complete front panel set-up. The other button is used for recalling a stored set-up.

8. LOCAL - The LOCAL push-button when pressed, and the instrument is in remote mode (but not in remote lockout condition LLO), restores the instrument to local operation. When the generator is in local operation mode, pressing this push-button generates no response.

3-2-2. Connectors

The connectors are used for connecting the Model 8600 to the unit under test and to and to external triggering source.

1. TRIG/COUNTER INPUT - The TRIG/COUNTER INPUT connector is used for applying an external signal to the Model 8600. When the instrument is used as a counter, the signal to be measured is applied to this input.

2. SYNC OUT - The SYNC OUT connector outputs pulses from a 50 ohms source. This output is synchronous with the main output. When the pulse generator is placed in delayed mode, the delay is measured from this output to the main output.

3. OUTPUTS A AND B - The two connectors are used as the main outputs for the pulse generator (Note that output B is optional). Outputs are driven from a 50 ohms source. Special care should be taken when these outputs are connected to the device under test because these outputs are capable of delivering up to 10 Vp-p.

4. AUX OUT A & B - The two connectors designated as AUX A and B are used as an output for an auxiliary signal. The auxiliary outputs may be set to generate TTL or ECL levels. (Note that output B is optional). Outputs are from a 50 ohms source. Period, pulse width, delay and duty cycle for the auxiliary outputs corresponds to the programmed parmeters for the main output. AUX A and AUX B are synchronous with Output A and Output B respectively.

3-2-3. Display And Indicators

1. DISPLAY - The function of the numeric display is to indicate the value of the various parameters. When the instrument set to operate in counter mode - the display indicates the result of the processed measurement. The display consists of a 7 digit mantissa and a single digit exponent. The exponent uses a leading minus indicating negative values. The sign on the exponent changes to + for zero or positive values. The display is also used for indicating information such as messages.

2. DIMENSIONS - Parameter dimensions are located below the numeric display. there are 4 indicators which, together with the exponent, are used for determining the correct value of the displayed parameter.

3. INDICATORS - 26 indicators are located on the front panel. These indicators are used as pointers to a selected parameter or modes such as gated, triggered, burst, fixed duty cycle etc. There is also a trigger indicator which illuminates whenever the pulse generator receives a legal triggering signal.

3-3. REAR PANEL FAMILIARIZATION

3-3-1. Connectors And Switches

1. AC RECEPTACLE - Power is applied through the supplied power cord to the 3-terminal AC receptacle. Note that the selected ac mains voltage is marked on the line voltage selector switch.

2. LINE SWITCH - The LINE VOLTAGE SELECTOR switch selects one of the primary voltage which are marked on both sides of the switch.

3. LINE FUSE - The line fuse provides protection for the AC power line input. For information on replacing this fuse, refer to Section 5.

4. IEEE-488 CONNECTOR - This connector is used for connection of the instrument to the IEEE-488 bus.

3-4. POWER-UP PROCEDURE

The basic procedure of powering up the Model 8600 is described below.

1. Connect the female end of the power cord to the AC mains receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

CAUTION

Be sure the power line voltage agrees with the indicated value on the rear panel of the instrument. Failure to heed this warning may result in instrument damage.

WARNING

The instrument is equipped with a 3-wire power cord designed to be used with grounded outlets. When the proper connections are made, the instrument chassis is connected to the power line ground. Failure to use a properly grounded outlet may result in personal shock hazard.

2. Turn on the mains power by pressing and releasing the POWER switch on the front panel.
3. The instrument will then begin operation by performing a display and indicator test which takes approximately one second. All front panel indicators will turn on and the display will appear as follows:

8.8.8.8.8.8.8. 8.

4. To verify that all display segments are operating, compare the instrument's display with the above during the test.
5. Following the display test, the instrument proceeds with displaying the installed options. When no option is installed, the instrument will skip this message. If option 1 (Channel B) is installed, the instrument displays the following message:

OPT-1

6. Following the option message, the instrument proceeds with displaying the previously selected GPIB primary address. The GPIB address is set by front panel programming and is stored in the non-volatile memory. For example, with the generator programmed to address 17, the display will show:

GPIB 17

7. Once the GPIB address is displayed, the instrument perform ROM and RAM tests. Successful execution of these tests is followed by a one second display of the installed software revision similar to the example below:

SoFt 1.1

8. Following these display messages, the instrument will commence its normal operating mode and begin generating pulses. Note that the instrument is equipped with a non-volatile memory. This RAM memory automatically monitors front panel traffic and retains its lastest set-up for events such as accidental power loss. In case of power loss the instrument resumes operation with its previously programmed front panel set-up.

It is possible to remove the sequence of displayed messages from the power up procedure by using a built-in shift function. Depressing [SHIFT] and then [1] in sequence writes a special code to the non-volatile memory. The next time the generator is powered up, the instrument will skip the power up procedure and will immediately commence with displaying the front panel set-up. repeating the sequence of [SHIFT] and [1] restores normal power up procedure. Special shift functions are described later in this section.

3-5. SOFTWARE RESET

One, who is not yet fully familiar with front panel operation of the Model 8600, may find himself locked in a "dead-end" situation where nothing operates the way it should. The fastest way of restoring the generator to a known state is by resetting its software. This may be done by pressing the [SHIFT] push-button and then pressing the DCL push-button (second function to the Sec/V push-button). The instrument will then be set to it's factory selected defaults. Table 3-1 summarizes these defaults.

NOTE

Software reset has no effect on stored front panel set-ups in memory locations 00 through 30. Software reset also has no effect on the programmed GPIB address.

Table 3-1. Default States After Software Reset

FUNCTION	DESCRIPTION	DEFAULT STATE
PER	Period	1.000 mS
H.LVL A,B	High Level	1.00 V
L.LVL A,B	Low Level	-1.00 V
P.WID A,B	Pulse Width	200.0 S
DELAY A,B	Delay	300.0 S
DTY A,B	Duty Cycle	50 %
BRST	Burst	2 #
T.PER	Trigger Period	1 S
T.LVL	Trigger Level	1.6 V
FIX DTY	Fixed Duty Cycle	Off
TRIGGER MODE		Continuous
OUTPUT		Single Non-inverting
ST.BY	Stand By	Off
AUX LVL	Auxiliary Level	TTL
DISPLAY/MODIFY A/B	Channel selection	A
IEEE Status		Local

3-6. DISPLAY MESSAGES

Model 8600 has several display messages which are associated with basic front panel operation. The generator also displays an error message when a front panel programming error is detected. These messages are discussed in the following. Note that the instrument has a number of additional display messages associated with IEEE-488 programming. These messages are discussed in section 4 of this manual.

3-7. ERROR INDICATION

There are several error indications which may result from incorrect front panel programming procedures. These indications are either visible (error message) or audible (audible alarm). These indications are described in the following.

Model 8600 is also capable of detecting GPIB programming errors. When such an error is detected, the controller may address the pulse generator using the serial poll command. GPIB errors are discussed in details in section 4 of this manual.

3-7-1. Audible Alarm

The audible alarm will sound when attempting an incorrect sequence of front panel programming. Error situation may occur upon various conditions. For example, it is illegal to simultaneously depress two front panel push-buttons. This operation will generate an audible alarm which will continue as long as error condition exists. There are other error conditions which may sound the alarm. These aspects are discussed in different parts of the following operating instructions.

3-7-2. Error Messages

In general, whenever a front panel or GPIB programming attempts to put the 8600 into an error condition, the 8600 responds both by front panel message and by making a Service request.

Errors are categorized in four main groups:

1. General errors
2. Limit errors
3. IEEE errors
4. Pulse setup errors

3-7-2-1. General Errors

Errors in this group are caused by improper usage of the instrument. Such errors occur while attempting to place the instrument in an illegal mode. For example, Model 8600 may not be placed in channel B display/modify mode if option 1 is not installed. In that case when the operator attempts to put the generator in [B] position, the instrument sounds an audible alarm.

Fixed Duty Cycle Error Message - The Fixed Duty Cycle Mode is a special case of the relation between the period and the pulse width. When the generator is placed in fixed duty cycle mode it is automatically restricted to a certain set of conditions which can not be modified by the operator. For example, if Model 8600 is placed in fixed duty cycle mode it will not accept a change in its OUTPUT section from SINGLE to DOUBLE pulse mode. Errors which are associated with this mode are discussed in details in paragraph 3-16.

3-7-2-2. Limit Errors

Errors in this group are caused by programming values outside the legal limits of the parameter being programmed. For example, The instrument is capable of receiving a period value of up to 1999 counts. An attempt to program a period value of 19999 counts will cause a parameter error. At this time the instrument will sound an audible alarm and the extra digit will be disregarded. Table 3-2 summarizes all front panel parameter entry limits. It is also possible to exceed the instrument's limit when parameters are being modified using the modifier push-buttons. In this case the instrument will cease modification of the display and will sound an audible alarm.

3-7-2-3. IEEE-488 Error Messages

The generator incorporates a number of display messages which are associated with errors involving GPIB interface programming. These messages are discussed in detail in Section 4 of this manual.

However, there is one message which should be explained at this point because it may interfere with front panel operation. A remote enable or a device dependent command sent to the instrument through the bus will turn the REMOTE light on. In this case, all front panel push-buttons except LOCAL are disabled. An attempt to press one of these push-buttons will cause the following message to be displayed:

PrESS LcL

This message indicates that the instrument ignores front panel programming sequence unless the [LOCAL] push-button is pressed and the REMOTE light turns off.

3-7-2-4. Pulse Set-up Errors

The pulse setup errors are inter-parameter inconsistencies errors, such as period greater than the pulse width. The pulse generator tests the programmed parameter every time a delimiter or modifier button is depressed. The instrument, if programmed so, will also respond with a service request. Programming the Model 8600 with a pulse error is possible and executable however, when pulse error is detected, the ERROR light in the OUTPUT block illuminates and an audible alarm sounds. This indicates that the signal at the output connector may appear with other parameters then those programmed. For evaluation purpose, it is then possible to recall the error status to the front panel display. The procedure of recalling the status of the pulse set-up error is given in paragraph 3-16.

Tabel 3-2. Front Panel Parameter Entry Limits

PARAMETER	LOW LIMIT	HIGH LIMIT
PER (period)	10.0 nS	1.999 S
H.LVL (high level)	-4.50 V	+5.00 V
L.LVL (low level)	-5.00 V	+4.50 V
P.WID (pulse width)	5 nS	3.999 S
DELAY (delay)	0 nS	3.999 S
DTY (duty cycle)	1 %	95 %
BRST (burst)	2 #	65,500 #
T.PER (trigger period)	0.05 mS	1000 S
T.LVL (trigger level)	-10.0 V	+10.0 V
INC (increment)	1 #	100 #
STORE (store)	00 #	30 #
RECALL (recall)	00 #	30 #
GP ADR (GPIB address)	00 #	31 #

3-8. USING THE DATA ENTRY

There are various parameters which can be modified, through front panel programming, using the data entry keys. The DATA ENTRY section includes numeric push-buttons, delimiter buttons and special function keys.

3-8-1. Special Function Keys

There are four special function keys: DISPLAY/MODIFY [A] or [B], [CANCEL] and [SHIFT]. The function of these keys is described below.

DISPLAY/MODIFY - Most parameters in the DISPLAY/MODIFY group may independently be programmed for channel A and channel B. The channel to be programmed is selected with the DISPLAY/MODIFY buttons [A] or [B]. If channel B is installed, the instrument permits selection of channel B. If channel B is not installed and [B] is depressed, the instrument sounds an audible alarm.

CANCEL - The [CANCEL] push-button is use for termination of a data entry process before a delimiter was depressed. Depressing this button during normal operation of the Model 8600 has no effect on the instrument.

SHIFT - The [SHIFT] push-button is used for selecting a secondary function. All functions which are associated with the secondary functions are printed on the front panel in yellow. There are seven functions which are accessible through the SHIFT button:

DCL	**FIX DTY**
INC	**ST. BY**
ADR	**AUX LVL**
RCL ERR	

The operation of the secondary functions is described later in this chapter. Pressing the [SHIFT] push-button causes the instrument to display the following reading:

SHIFT ?

The question mark (?) appears blinking; indicating that the instrument is ready for a consequent press of another push-button which was assigned a second function. Depressing [SHIFT] once more cancels this function. Depressing [CANCEL] has the same effect.

3-8-2. Numerals And Delimiters

There are 12 push-buttons in the DATA ENTRY group which are marked with numerals from 0 to 9, decimal point and a change sign key. There are also 4 buttons which are marked with various dimensions. Operator may select one of the following delimiters:

nSec	**N**
Sec	**%**
mSec	**mV**
Sec	**V**

These dimensions are the delimiters which terminate a successful data entry sequence. To start a data entry sequence proceed as follows:

1. Select the channel to be modified by pressing [A] or [B]. If parameters in channel B are to be modified observe that the letter b appears on the left side of the display.
2. Depress the push-button in the DISPLAY/MODIFY group until the light next to the required parameter illuminates.
3. Start the data entry procedure by depressing the numeric buttons. Observe that the exponent is replaced by a blinking question mark; indicating the a data entry sequence is in process.
4. In case of an error in the data entry sequence, depress the [CANCEL] button and restart your entry procedure.
5. Terminate the data entry sequence by depressing one of the delimiters. Observe the parameter entry limits which are given in Table 3-2. The instrument will not accept a programmed parameter outside these limits. An attempt to program more than the allowed number of digits will cause an audible alarm.

If the operator tries to program a parameter below or above the specified limits of the Model 8600, the generator will automatically place on the display the lowest or the highest limits respectively. For example, an attempt to program a pulse width value of 1 nSec will force the instrument to the low limit of 5 nSec.

3-9. USING FRONT PANEL SET-UPS

Setting-up all parameters in a versatile instrument such as the Model 8600 takes some time. The set-up time is longer when a couple of tests are involve and more than one set-up is required. Model 8600 incorporates a battery backed-up non-volatile memory that preserves stored information for a long time. The size of the non-volatile memory permits storage of up to 30 complete front panel set-ups. Front panel set-ups can be recalled one at a time. The generator also employs a special recall mode which permits automatic scrolling through the stored set-ups. Operator may select scrolling in an ascending or descending order.

3-9-1. Store Set-ups

First modify the front panel parameters as necessary to perform your tasks. Parameter modification procedure is discussed in paragraph 3-8. When all parameters are set and checked, proceed with storing this set-up as follows:

1. Depress the [STORE] pushbutton and observe that the display is modified to indicate the following:

STO ?
(? appears flashing)

This reading indicates that the instrument is ready to receive consequent information from the DATA ENTRY buttons which will identify the memory location where front panel set-up is to be stored. Set-ups may be stored in locations 00 through 30. Depressing CANCEL cancels this function and the instrument resumes normal operation.
2. Decide upon which of the memory locations is going to be used and depress the buttons in the DATA ENTRY section which are marked with the selected numbers. Remember that the generator is waiting for a two digit sequence, i.e. 02 for memory location 2.

The instrument will then display the following for one second:

STO dd

(Where dd is the selected memory location)

This display indicates that the function generator acknowledged the entered memory location. The instrument then resumes normal its operation.

3-9-2. Recall Set-ups

The model 8600 employs a non-volatile memory (RAM). The computer circuit continuously monitors front panel traffic and saves it in a special location within the RAM. This location is separate to the front panel set-ups. After turning AC MAINS off or in case of an accidental power failure, the generator will update front panel indicators with the last set-up before power shut-down.

To recall a front panel set-up proceed as follows:

1. Depress the [RECALL] push-button and observe that the display is modified to indicate the following:

RCL ?
(? appears flashing)

This reading indicates that the instrument is ready for recalling the memory location where the desired front panel set-up was stored. Depressing the RECALL button cancels this function and the instrument resumes normal operation.
2. Select the memory location from which to recall the desired set-up. You may recall set-ups from memory locations 00 through 30 by pressing the appropriate push-buttons in the DATA ENTRY section. Remember that the generator is waiting for a two digit sequence, i.e. 02 for memory location 2.

The instrument will display the following for one second:

RCL dd

(Where dd is the selected memory location)

The instrument will then recall the parameters that were previously stored in the selected memory location and will update front panel indicators with the recalled parameters.

3-9-2-1. Using The Recall Mode

The Model 8600 employs a special recall mode which permits ascending or descending scrolling through a number of set-ups by pressing either the VERNIER UP or VERNIER DOWN push-buttons respectively. This mode is especially useful for repetitive procedures such as calibration and performance tests. It is also used extensively throughout the calibration and performance verification of the Model 8600.

To set the Model 8600 for operation in the recall mode proceed as follows:

1. Depress the [SHIFT] push-button and observe that the display is modified to indicate the following:

SHIFT ?
(? appears flashing)

2. Depress the [RCL MODE] push-button (second function to [RCL]) and observe that the display is modified to indicate the following:

RCL 00

The instrument is now set to operate in its recall mode. The display is first updated with the parameters which were stored in memory number 00.
3. Use the VERNIER UP or DOWN or the Data Entry buttons for scrolling through the memory bank.
4. Depress [CANCEL] to exit this function and to return to normal display operation.

3-10. USING THE MODIFIER CONTROL

The modifier control consists of two push-buttons; one of which is marked with an arrow pointing up and the other is marked with an arrow pointing down. The arrow pointing up indicates that when this button is depressed, the display reading will increment one step. The arrow pointing down indicates that when this push-button is depressed, the display reading will decrement one step.

The modifier control, when modifying a parameter, is used similarly to a conventional potentiometer. For example; consider a period reading of 100.0 mS. Depressing the up push-button increments the reading to 100.1 mS. This example is given for an incremental step setting of 1. The incremental step may be selected for sizes other than 1. Information on how to select an incremental step is given in paragraph 3-10-1. The output then follows the new setting and the output waveform will now have a period of 100.1 mS. Similarly, decrement one step using the down push-button. Depressing the modifier push-buttons for more then 1 second causes the instrument to increment or decrement continuously.

NOTE

To prevent operator's error, the instrument has an internal audible alarm which beeps whenever a limit is reached. Table 3-2 lists these limits.

3-10-1. Changing the Magnitude of the Incremental Step

The incremental step defines the magnitude of the step which the instrument will increment or decrement when the modifier control is depressed. The incremental step size is adjustable from 1 to 100 and is individually selectable for each parameter. For example; it is possible to select an incremental step size of 100 for period setting and an incremental step of 5 for high level setting. To modify an incremental step size depress in a sequence the [SHIFT] and the [INC] (second function to +/-) push-buttons. Observe that the following reading is displayed:

Inc nnX

Where nnX may be any number from 1 to 100.

Use the DATA ENTRY push-buttons for selecting a new incremental step. Depressing the [CANCEL] button terminates this process without storing the new value. Depressing the push-button marked [N] stores the newly selected step size. Selecting a step size of more than 100 is not accepted. Depress [CANCEL] and restart the above procedure.

3-11. SELECTING THE AUXILIARY AMPLITUDE LEVEL

Parallel to the main output, Model 8600 features an auxiliary output. Voltage output level at the auxiliary output is fixed to one level. Besides that, the auxiliary output shares the same characteristics as the main output. There are two fixed levels which were assigned to the auxiliary output connector; TTL level and ECL level. Selecting one or the other is done through front panel programming. To select a level for the auxiliary output depress in sequence the [SHIFT] and the [AUX LVL] push-buttons. The display will be modified to one of the following reading:

TTL or
ECL

Use the MODIFIER push-buttons for selecting the desired auxiliary level. The level at the AUX OUT connector follows the displayed level. To terminate the selection process, depress any button on the front panel and observe that the display resumes normal readings.

3-12. SELECTING THE FIXED DUTY CYCLE MODE

Model 8600 may be programmed for different pulse width values - independent to its period setting. For example, a pulse width of 5 nS may be selected with a period of 1 S. However, some applications require that the duty cycle will be set to a fixed duty cycle ratio at all times. The instrument may be programmed for such a mode of operation. In that case, the operator is only expected to program the required duty cycle. The pulse with is then automatically adjusted by the instrument so that the duty cycle ratio remains constant. The duty cycle may be selected from a range of 1 % to 95 %. Range may almost reach 99 % by using the pulse complement function.

To select the fixed duty cycle mode, depress in sequence the [SHIFT] and the [FIX DTY] push-buttons. The FIX DTY light illuminates; indicating that the instrument is set for operation with a fixed duty cycle output. At this time, the instrument permits accessing the DTY parameter which is associated with this mode. Model 8600 when set to this mode will not permit modification of the pulse width parameter. To remove the instrument from the fixed duty cycle mode, depress in sequence the [SHIFT] and the [FIX DTY] push-buttons. The FIX DTY light turns off. The instrument now permits access and modification of the pulse width parameter.

3-13. SELECTING AN OUTPUT MODE

The Model 8600 has three output modes. Selecting one of these modes is simply a matter of depressing the push-buttons in the OUTPUT section until the light next to the desired mode illuminates. Each channel may be programmed for a different output mode. The available output modes are described in the following:

SINGLE - Normal pulse output. The leading edge is synchronous with the SYNC output signal. The delay value has no effect on this mode.

DOUBLE - A train of double pulsed output. The leading edge of the first pulse is synchronous with the SYNC output signal. The delay value specifies the time interval between the consecutive leading edges of the first two pulses.

DELAYED - Same as the SINGLE pulse mode except the leading edge is delayed from the SYNC output signal by an interval which is specified by the programmed delay value.

Each of these modes can be operated in complement operating mode.

3-13-1. Disabling The Output

The Model 8600 features a stand-by mode which disconnects the main output channels from the output connectors. The disable function is especially useful at times when the output is constantly connected to the device under test and when modifying pulse parameters may endanger this device.

To place the instrument in a stand-by mode depress in sequence the [SHIFT] and the [ST BY] push-buttons. The ST BY light next to the output connectors illuminates; indicating that the output signal is disconnected from the connectors. Note that if channel B is installed, the light indicates that this channel is disabled as well.

To resume normal operation repeat the same procedure as above. The ST BY light turns off; indicating that the output signal in now connected to the output connectors.

3-14. TRIGGERING THE PULSE GENERATOR

Selecting one of the available triggering modes is simply a matter of depressing push-buttons in the TRIGGER MODE section until the light next to the desired mode illuminates. Channels A and B share the same trigger mode. When no light in the TRIGGER MODE section is on, the pulse generator operates in its normal continuous mode. The [TRIG] light below the numeric display illuminates every time that the generator accepts a legal triggering signal either from an external source or from an internal.

Model 8600 may operate in one of the following triggering modes:

GATED - An external signal enables the generator. First output pulse is synchronous with the active slope. Last pulse is always completed.

TRIGGERED - Each input cycle, at the TRIG INPUT connector, generates a single output pulse. Output pulse is synchronous with the active slope.

BURST - Each input cycle, at the TRIG INPUT connector, generates a train of pulses. The number of pulses are pre-programmed. First output pulse is synchronous with the active slope.

The Model 8600, when set to a trigger mode, accepts various stimulants. When operating from an external source, the generator may be programmed to be triggered on a leading edge or on a trailing edge. Selecting one or the other is done by pressing the push-button in the TRIGGER MODE section until the light next to EXT / or EXT \ illuminates.

NOTE

The TRIG INPUT connector is sensitive to dc levels. If this input is left open and the trigger level was set to a negative voltage, the pulse generator may self gate.

When external source is not available, the operator has a choice of using either the MANUAL push-button or the internal trigger generator. The MANUAL button simulates an external signal. If the Model 8600 is set to GATED mode, an output signal will be available as long as the MANUAL push-button is depressed. When the generator is set to TRIGGERED or BURST mode, each time the MANUAL button is depressed an output pulse or a burst is generated. The MANUAL push-button has no effect in normal mode of operation or when the instrument is set to internal trigger mode.

To use the internal trigger generator first set the required trigger period. Place the generator in TRIGRD OR BURST mode and depress the push-button in the TRIGGER MODE group until the light next to INT illuminates.

3-15. USING THE COUNTER/TIMER

Model 8600 may be set to operate as a stand alone universal counter/timer. When the instrument is set to its counter mode, it still outputs pulses through the output channels as programmed before the counter function was selected. Note that during counter operation, period control is disabled. This means that accuracy is not controlled anymore and may change within a new accuracy limit of 5 %. To set the Model 8600 for operation in counter mode proceed as follows:

1. Select and display the trigger level (T.LVL) parameter as described in paragraph 3-8 and modify this parameter to the required value.
2. Depress the [COUNTER] push-button in the DISPLAY/MODIFY group until the light next to the desired measurement function illuminates. The instrument may be set to measure one of the following functions:

1. Frequency, from 20 Hz to 150 MHz
2. Period Averaged, from 7 nS to 50 mS
3. Pulse Width Averaged, from 50 nS to 1 S

3. Apply the signal to be measured to the TRIG / COUNTER INPUT connector. Observe that the signal is within the specified dynamic levels.

3-16. PULSE ERRORS EVALUATION

Table 3-4 lists the errors and indicates the parameters which are effected by each error. In general, errors in parameter programming, may occur at both channel A and B. Pulse programming errors which are made at channel A are reference designated from 1 through 5. Pulse programming errors which may occur at channel B are reference designated from 11 through 15.

Evaluation of the pulse setup errors requires the following procedure:

1. Depress in sequence the [SHIFT] and the [RCL ERR] push-buttons. observe that the display is modified to show the following message:

ERR dd

dd may range from 1 to 5 if an error was detected in programming channel A parameters or from 11 to 15 at channel B. If no error was detected the display will read:

ERR 0

2. The generator is capable of displaying one error at a time. To verify that all errors were noted and recorded, depress the Modifier push-buttons UP or Down to scan through the errors. Each error is indicated by a number. The interpretation of these numbers is given in the following. Errors are the same for both channels A and B. **3.** Depress [CANCEL] to resume normal operation and proceed to correct the programmed errors.

NOTE

The following abbreviations were used throughout the following error descriptions:

PER - Period of the output signal parameter
HIL - Programmed high level parameter
LOL - Programmed low level parameter
WID - Programmed pulse width parameter
DEL - Programmed delay parameter
BUR - Number of programmed burst count parameter
RPT - Period of the int. trigger generator parameter

3-16-1. Pulse Errors Interpretation

Error 1 (Error 11)

Error 1 (11) occurs when the operator attempts to program an amplitude which is larger or smaller than the specified limits. The instrument is capable of operating with an amplitude of 5 Vp-p throughout its frequency range. An error is detected when one attempts to program an amplitude level outside the following limits:

HIL - LOL >5.00 V or
HIL - LOL >500 mV

When such an error occurs the ERROR LED illuminates. The instrument retains its latest amplitude set-up. Only a legal set of parameters updates the output level at the output connector.

Error 2 (Error 12)

Error 2 (12) relates to the programmed period parameter. Error 2 can not occur when the instrument is set to operate in its external triggered mode. When the pulse generator is set to operate with a Double or Delayed output pulse mode, this error will take place under the following conditions:

DLY + PW + 5 nS >PER

When the generator is set to operate having a single pulse output (non-delayed) the value of DLY in the above formulas is set to 0.

When such an error occurs the ERROR LED illuminates. The output will follows the programmed values although the generator operates with an error. The output pulse at the output connector may look distorted

Error 3 (Error 13)

Error 3 (13) relates to the programmed delay parameter. Error 3 can only occur in double output pulse mode. It can not occur when the instrument is set to operate in either single (non-delayed) or delayed output pulse modes. this error will take place under the following conditions:

PW + 5 nS >DLY

When such an error occurs the ERROR LED illuminates. The output follows the programmed values although the generator operates with an error. The pulse output at the output connector may look distorted.

Error 4 (Error 14)

Error 4 (14) relates to the programmed internal trigger period parameter. Error 4 can only take place if the pulse generator is set to operate with its internal trigger stimuli. It can not occur under any other condition. This error is generated under the following conditions:

(BUR +1)PER >RPT

When such an error occurs the ERROR LED illuminates. The output follows the programmed values although the generator operates with an error. The pulse output at the output connector may look distorted.

Error 5 (Error 15)

Error 5 (15) relates to the fixed duty cycle operating mode and may occur only when the Model 8600 is set to operate in this mode. It can not occur under any other condition. This error will be generated when the programmed duty cycle value generates an internal pulse width outside the following limits:

PW <5 nS

When such an error occurs the ERROR LED will illuminate. The output will follow the programmed values although the generator operates with an error. The pulse output at the output connector may look distorted.

3-17. SPECIAL SHIFT FUNCTIONS

Model 8600 has a number of special shift functions which permit access to special software routines which usually are not required for normal operation of the instrument. To modify the Model 8600 for a special shift function depress the [SHIFT] push-button and then a numeric button in the data entry block. There are no special front panel markings which identify these functions. The function will be executed immediately without further front panel indications. The special shift functions are described in the following:

SHIFT 1 - Shortens the power-up procedure, as described in paragraph 3-4 by removing the messages which are associated with the options and GPIB address. Upon power-up, the instrument will skip the power-up procedure and will immediately update front panel indicators. Depressing [SHIFT] [1] again will restore the power-up procedure.

SHIFT 2 - Starts a self calibration routine. The pulse generator then measures its output period with its internal counter and updates a calibration table for the VCO (voltage controlled oscillator). Following a self calibration routine, the period accuracy of is improved to better than 1 %. The updated table is stored in the non-volatile memory and will not change unless a new calibration routine is initiated or when the RAM was replaced.

SHIFT 3 - Removes the correction factors from the above calibration table. This procedure is necessary when adjusting the Model 8600. This procedure is discussed further is Section 7 of this manual.

SHIFT 4 - Places the instrument in a special recall mode. This mode was described in paragraph 3-9-2-1. The same function can be accessed pressing [SHIFT] and then [RECALL].

SHIFT 5 - Loads the internal non-volatile RAM with factory pre-selected set-ups which may be used in conjunction with the recall mode during performance verification. More details are given in Section 7.

SHIFT 6 - Loads the internal non-volatile RAM with factory pre-selected set-ups which may be used in conjunction with the recall mode during adjustment procedure. More details are given in Section 5.

CAUTION

Shift functions 5 and 6 load the internal non-volatile memory with factory pre-selected set-ups thereby erasing the entire capacity of the stored front panel set-ups.

Before performing such an operation make sure that the set-ups which you have previously recorded are no longer required.

3-18. CHANGING GPIB ADDRESS

The GPIB address is modified using front panel programming. The non-volatile memory stores the GPIB address. A conventional address switche is not provided. Detailed instructions how to change the GPIB address are given in Section 4 of this manual.

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SECTION 4

IEEE-488 OPERATION

4-1. INTRODUCTION

The IEEE-488 GPIB (general purpose interface bus)is an instrumentation data bus with standards adopted by the IEEE (Institute of Electrical and Electronic Engineerings) and given the IEEE-488 designation. The most recent revision of bus standards was made in 1978; hence the complete description for current bus standards is the IEEE-488-1978 designation. The Model 8600 conforms to 1978 standards.

This section contains general bus information as well as detailed programming information and is divided as follows:

1. General introductory information pertaining to the IEEE-488 bus may be found primarily in paragraphs 4-2 through 4-5.
2. Information necessary to connect the Model 8600 to the bus and to change the bus address is contained in paragraphs 4-6 and 4-7.
3. Programming of the instrument with general bus command is covered in paragraph 4-8.
4. Device-dependent command programming is described in detail in paragraph 4-9. The commands outlined in this section can be considered to be the most important since they control virtually all instrument functions.
5. Additional information pertaining to front panel error messages and controller programs can be found in paragraphs 4-11-1 and 4-11-2.

4-2. BUS DESCRIPTION

the IEEE-488 bus was designed as a parallel data transfer medium to optimize data transfer without using as excessive number of bus lines. In keeping with this goal, the bus has only eight data lines which are used for both data and most commands. Five bus management lines and three handshake lines round out the complement of signal lines. Since the bus is of parallel design, all devices connected to the bus have the same information available simultaneously. Exactly what is done with the information by each device depends on many factors, including device capabilities.

A typical bus configuration for remote controlled operation is shown in Figure 4-1. The typical system will have one controller and one or more instruments to which commands are given and from which data is received. There are three categories that describe device operation. These include: controller; talker; listener.

The controller controls other devices on the bus. A talker sends data, while a listener receives data. an instrument, may be a talker only, a listener only, or both a talker and listener.

Any given system can have only one controller (control may be passed to an appropriate device through a special command). Any number of talkers or listeners may be present up to the hardware constraints of the bus. The bus is limited to 15 devices, but this number may be reduced if higher than normal data transfer rates are required or if long interconnect cables are used.

Several devices may be commanded to listen at once, but only one device may be a talker at any given time. Otherwise, communications would be scrambled much like an individual is trying to select a single conversation out of a large crowd.

Before a device can talk or listen, it must be appropriately addressed. Devices are selected on the basis of their primary address. The addressed device is sent a talk or listen command derived from its primary address. Normally, each device on the bus has a unique primary address so that each may be addressed individually. The bus also has another addressing mode called secondary addressing, but not all devices use this addressing mode.

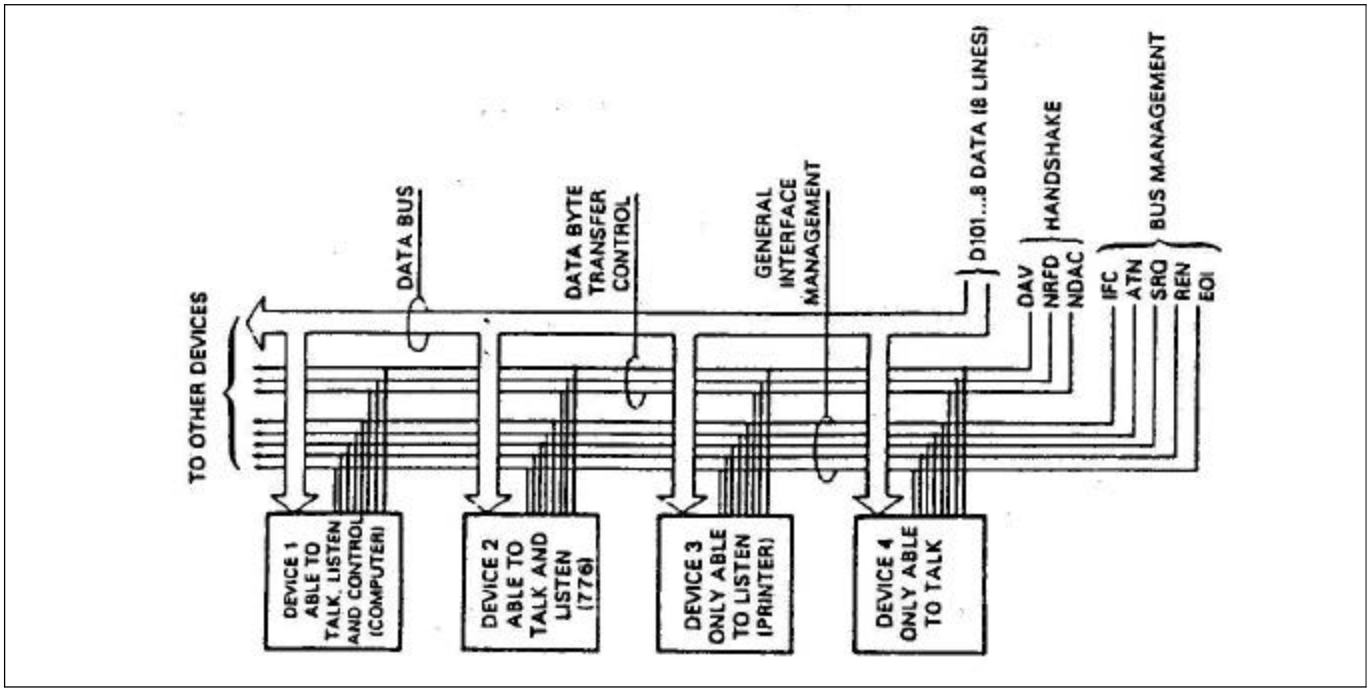

Figure 4-1. IEEE Bus Configuration

Once the device is addressed to talk or listen, appropriate bus transactions may be initiated. For example, if an instrument is addressed to talk, it will usually place its data on the bus one byte at a time. The listening device will then read this information, and the appropriate software is then be used to channel the information to the desired location.

4-3. IEEE-488 BUS LINES

The signal lines on the IEEE-488 bus are grouped into three general categories. The data lines handle bus information, while the handshake and bus management lines assure that proper data transfer and bus operation takes place. Each of the bus lines is “active low” so that approximately zero volts is a logic “one”. The following paragraphs describe the purpose of these lines, which are shown in Figure 4-1.

4-3-1. Bus Management Lines

The bus management group is made up of five signal lines that provide orderly transfer of data. These lines are used to send the uniline commands described in paragraph 4-8-1.

1. ATN (Attention) - the ATN line is one of the more important management lines. The state of the ATN line determines whether controller information on the data bus is to be considered data or a multiline command as described in paragraph 4-8-2.

2. IFC (Interface Clear) - Setting the IFC line true (low) causes the bus to go to a known state.

3. REN (Remote Enable) - Setting the REM line low sends the REM command. This sets up instruments on the bus for remote operation.

4. EOI (End Or Identify) - The EOI line is used to send the EOI command that usually terminates a multi-byte transfer sequence.

5. SRQ (Service Request) - the SRQ line is set low by a device when it requires service from the controller.

4-3-2. Handshake Lines

The bus uses three handshake lines that operate in an interlocked sequence. This method assures reliable data transfer regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the handshake lines is controlled by the data source, while the remaining two lines are controlled by accepting devices. The three bus handshake lines are:

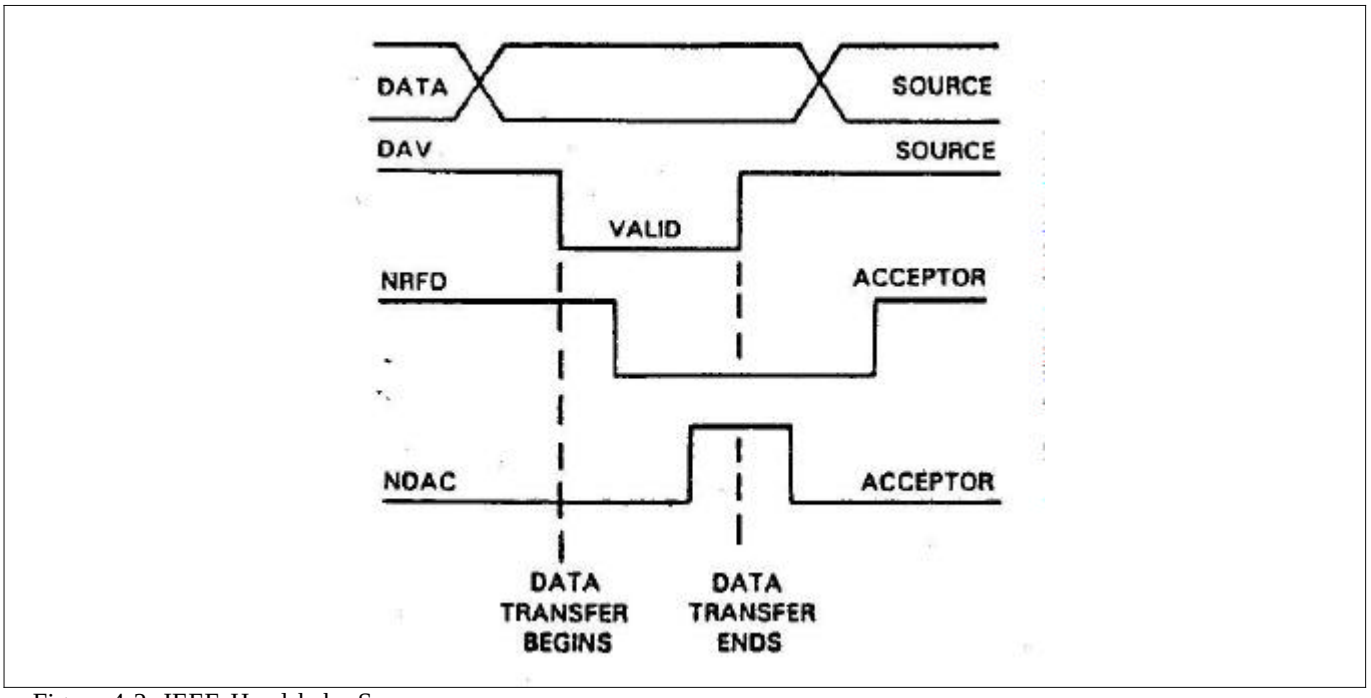

Figure 4-2. IEEE Handshake Sequence

1. DAV (Data Valid) - The source controls the state of the DAV line.

2. NRFD (Not Ready For Data) - the acceptor controls the state of the NRFD line.

3. NDAC (Not Data Accepted) - the acceptor also controls the NDAC line.

The complete handshake sequence for one data byte is shown in Figure 4-2. Once data is on the bus, the source checks to see that NRFD is high, indicating that all devices on the bus are ready for data. At the same time NDAC should be low from the previous byte transfer. If these conditions are not met, the source must then wait until the NRFD and NDAC lines have the correct status. If the source is controller, NRFD and NDAC must remain stable for at least 100ns after ATN is set low. Because of the possibility of bus hang up, some controllers have time-out routines to display error messages if the handshake sequence stops for any reason.

Once the NRFD and NDAC lines are properly set, the source sets the DAV line low, indicating that data on the bus is now valid. the NRFD line then goes low; the NDAC line goes high once all devices on the bus have accepted the data. Each device will release the NDAC line at its own rate, but the NDAC line will not go high until the slowest device has accepted the data byte.

After the NDAC line goes high, the source then sets the DAV line high to indicate that the data on the bus is no longer valid. At this point, the NDAC line returns to its low state. Finally, the NRFD line is released by each of the devices at their own rates, until the NRFD line finally goes high when the slowest device is ready, and the bus is set to repeat the sequence with the next data byte.

The sequence just described is used to transfer both data and multiline command. The state of the ATN line determines whether the data bus contains data or commands.

4-3-3. Data Lines

The IEEE-488 bus uses the eight data lines that allow data to be transmitted and received in a bit-parallel, byte-serial manner. These eight lines use the convention DI01 through DI08 instead of the more common D0 through D7 binary terminology. The data lines are bidirectional and, as with the remaining bus signal lines, low is true.

4-4. INTERFACE FUNCTION CODES

The interface function codes are part of the IEEE-488-1978 standards. These codes define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual.

Table 4-1 lists the codes for the Model 8600. The numeric value following each one or two letter code define Model 8600 capability as follows:

SH - (Source Handshake Function) - The ability for the Model 8600 to initiate the transfer of message/data on the data bus provided by the SH function.

AH - (Acceptor Handshake Function) - The ability for the Model 8600 to guarantee proper reception of message/data on the data bus provided by the AH function.

T - (Talker Function) - The ability of the Model 8600 to send device-dependent data over the bus (to another device) is provided by the T function. Model 8600 talker capabilities exist only after the instrument has been addressed to talk.

L - (Listen Function) - The ability of the Model 8600 to receive device-dependent data over the bus (from anther device) is provided by the L function. Listener function capability of the Model 8600 exist only after it has been addressed to listen.

RS - (Service Request Function) - The ability of the Model 8600 to request service from the controller is provided by the RS function.

RL - (Remote-Local Function) - The ability of the Model 8600 to be placed in remote or local modes is provided by the RL function.

PP - (parallel Poll Function) - The ability of the Model 8600 to respond to a parallel poll request from the controller is provided by the PP function.

DC - (Device Clear Function) - The ability for the Model 8600 to be cleared (initialized) is provided by the DC function.

DT - (Device Trigger Function) - The ability of the Model 8600 to have its output triggered is provided by the DT function.

Table 4-1. Model 8600 Interface Function Codes

CODE	INTERFACE FUNCTION
SH1	Source Handshake Function
AH1	Acceptor Handshake Capabilities
T6	Talker (basic talker, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service request capability
RL1	Remote/Local capability
PP2	Parallel Poll capability
DC1	Device Clear capability
DT1	Device Trigger capability
C0	No controller capability
E1	Open collector bus drivers
TE0	No Extended Talker capabilities
LE0	No Extended Listener capabilities

C - (controller Function) - The Model 8600 does not have a controller function.

TE - (Extended Talker Capabilities) - The Model 8600 does not have extended talker capabilities.

LE - (Extended Listener Function) - The Model 8600 does not have extended listener function.

4-5. SOFTWARE CONSIDERATIONS

The most sophisticated computer in the world would be useless without the necessary software. This basic requirement is also true of the IEEE-488 bus, which requires the use of handler routines as described in this paragraph.

Before a controller can be used with the IEEE-488 interface, the user must make certain that appropriate handler software is present within the controller. With the IBM PC computer, for example, the GPIB interface card must be used with an additional software which contains the necessary handler software.

Other small computers that can be used as controllers have limited IEEE command capability. The capabilities of some computers depends on the particular interface being used. Often, little software "tricks" are required to achieve the desired results.

From the preceding discussion, the message is clear: make sure the proper software is being used with the instrument. Often, the user may incorrectly suspect that

a hardware problem is causing fault, when it was the software that was causing the problem all along.

4-6. HARDWARE CONSIDERATIONS

Before the instrument can be used with the IEEE-488 bus, it must be connected to the bus with a suitable connector. Also, the primary address must be properly programmed as described in this section.

4-6-1. Typical Controlled Systems

The IEEE-488 bus is a parallel interface system. As a result, adding more devices is simply a matter of using more cables to make the desired connections. Because of this flexibility, system complexity can range from simple to extremely complex.

The simplest possible controlled system comprises a controller and one Model 8600. The controller is used to send commands to the instrument, which sends data back to the controller.

The system becomes more complex when additional instruments are added. Depending on programming, all data may be routed through the controller, or it may be transmitted directly from one instrument to another.

4-6-2. Connections

The instrument is connected to the bus through an IEEE-488 connector. This connector is designed to be stacked to allow a number of parallel connections on one instrument.

NOTES

1. To avoid possible mechanical damage, it is recommended that no more than three connectors be stacked on any one instrument. Otherwise, the resulting strain may cause internal damage to the connectors.
2. The IEEE-488 bus is limited to a maximum of 15 devices, including the controller. Also, the maximum cable length is 20 meters. Failure to observe these limits will probably result in erratic bus operation.

Custom cables may be constructed using the information in Table 4-2. Table 4-2 also lists the contact assignments for the various bus lines. Contacts 18 through 24 are return lines for the indicated signal lines, and the cable shield is connected to contact 12. Each ground line is connected to digital common in the Model 8600.

Table 4-2. IEEE Contact Designations

Contact Number	IEEE-488 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN	Management
18-24	Gnd	Ground

CAUTION

The voltage between IEEE common and ground must not exceed 0V or damage may result to your instrument.

4-7. CHANGING GPIB ADDRESS

The primary address of your instrument may be programmed to any value between 0 and 30 as long as the selected address is different from other devices addresses in the system. This may be accomplished using a front panel programming sequence. Note that the primary address of the instrument must agree with the address specified in the controller's program.

NOTE

The programmed primary address is briefly displayed during the power-up cycle of the Model 8600. It is stored in the non-volatile memory of the instrument and is retained even when power is turned off.

To check the present address, or to enter a new one, proceed as follows:

1. Press the [SHIFT] push-button once then press the [ADR] push-button. The display will be modified to display the following:

IE Adr x

Where x may be any number from 0 to 30.

2. Use the DATA ENTRY push-buttons to select a new GPIB primary address.
3. To store the newly selected primary address depress [N]. The instrument will then resume normal operation.

4-8. BUS COMMANDS

While the hardware aspect of the bus is essential, the interface would be essentially worthless without appropriate commands to control the communications between the various instruments on the bus. This paragraph briefly describes the purpose of the bus commands, which are grouped into the following three categories:

1. Uniline commands: Sent by setting the associated bus line low.
2. Multiline commands: General bus commands which are sent over the data lines with the ATN line low (true).
3. Device-dependent commands: Special commands that depend on device configuration; sent over the data lines with ATN high (false).

4-8-1. Uniline Commands

Uniline commands are sent by setting the associated bus line to low. The ATN, IFC, and REN commands are asserted only by the system controller. The SRQ command is sent by an external device. The EOI command may be sent by either the controller or an external device depending on the direction of data transfer. The following is descriptions of each command.

REN (Remote Enable) - The remote enable command is sent to the Model 8600 by the controller to set the instrument up for remote operation. Generally, this should be done before attempting to program the instrument over the bus. The Model 8600 will indicate that it is in the remote mode by illuminating its front panel REM indicator.

Table 4-3. IEEE-488 Bus Command Summary

COMMAND TYPE	COMMAND	STATE OF ATN LINE(*)	COMMENTS
Uniline	REN	X	Set up for remote operation
	EOI	X	Sent by setting EOI low
	IFC	X	Clears Interface
	ATN	Low	Defines data bus contents
	SRQ	X	Controlled by external device
Multiline Universal	LLO	Low	Locks out front panel controls
	DCL	Low	Returns device to default conditions
	SPE	Low	Enable serial polling
	SPD	Low	Disables serial polling Addressed
	SDC	Low	Returns unit to default condition
	GTL	Low	Returns to local control
	GET	Low	Triggers device for reading
Unaddress	UNL	Low	Removes all listeners from bus
	UNT	Low	Removes all talkers from bus
Device- Dependent(**)		High	Programs Model 8020 for various modes.

To place the Model 8600 in the remote mode, the controller must perform the following steps:

1. Set the REN line true.
2. Address the Model 8600 to listen.

NOTE

Setting REN true without addressing will not cause the REM indicator to turn on; however, once REN is true, the REM light will turn on the next time an address command is received.

EOI (End Or Identify) - The EOI command is used to positively identify the last byte in a multi-byte transfer sequence. This allows variable length data words to be transmitted easily.

IFC (Interface Clear) - The IFC command is sent to clear the bus and set hand shake lines to a known state. Although device configurations differ, the IFC command usually places instruments in the talk and listen idle states.

ATN (Attention) - The controller sends ATN while transmitting addresses or multiline commands. Device-dependent commands are sent with the ATN line high (false).

SRQ (Service Request) - The SRQ command is asserted by an external device when it requires service from the controller. If more than one device is present, a serial polling sequence, as described in paragraph 4-8-2, must be used to determine which has requested service.

4-8-2. Universal multiline Commands

Universal commands are multiline commands that require no addressing. All instrumentation equipped to implement the command will do so simultaneously when the command is transmitted over the bus. As with all multiline commands, the universal commands are sent over the data lines with ATN set low:

LLO (Local Lockout) - The LLO command is sent by the controller to remove the Model 8600 from the local operating mode. Once the unit receives the LLO command, all its front panel controls (except Power) will be inoperative.

NOTE

The **REN** bus line must be true before the instrument will respond to an LLO command.

To lock out the front panel controls of the Model 8600, the controller must perform the following steps:

1. Set ATN true.
2. Send the LLO command to the instrument.

DCL (Device Clear) - The DCL command may be used to clear the Model 8600, setting it to a known state. Note that all devices on the bus equipped to respond to a DCL will do so simultaneously. When the Model 8600 receives a DCL command, it will return to the default conditions listed in Table 4-4. Factory pre-selected parameters are listed in Table 3-1.

To send a DCL command the controller must perform the following steps:

1. Set ATN true.
2. Place the DCL command on the bus.

SPE (Serial Poll Enable) - The serial polling sequence is used to obtain the Model 8600 status byte. Usually, the serial polling sequence is used to determine which of several devices has requested service over the SRQ line. However, the serial polling sequence may be used at any time to obtain the status byte from the Model 8600. For more information on status byte format, refer to paragraph 4-9-20. The serial polling sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The SPE (Serial Poll Enable) command is placed on the bus by the controller.
3. The Model 8600 is addressed to talk.
4. The controller sets ATN false.
5. The Model 8600 then places its status byte on the bus to be read by the controller.
6. The controller then sets the ATN line low and places SPD (Serial Poll Disable) on the bus to end the serial polling sequence.

Steps 3 trough 5 may be repeated for other instruments on the bus by using the correct talk address for each instrument. ATN must be true when the talk address is transmitted and false when the status byte is read.

Table 4-4. Default Conditions. (Status After SDC or DCL)

MODE	DEFAULT	STATUS
Display/Program	CHA	Display/Program Channel A parameters
Display Parameter	VPER	Display period parameter
Trigger Mode	M1	Normal - continuous mode
Triggering Edge	T1	Positive edge
Output	O1	Single pulse delay off
Output Mode	C0	Complement off
Stand-By	D0	Output disable off
Duty Cycle Mode	SM0	Fixed duty cycle off
Edge Mode	W1	Fast fixed edge
Auxiliary Level	TTL	TTL at auxiliary out
Interrogate Parameter	IPER	Read-back period
Reading Format	X1	Prefix on
Terminator	Z0	CR,LF with EOI
SRQ Mask	SR0	SRQ off. no mask

SPD (Serial Poll Disable) - The SPD command is sent by the controller to remove all instrumentation on the bus from the serial poll mode.

4-8-3. Addressed Commands

Addressed commands are multiline commands that must be preceded by a listen command derived from the device's primary address before the instrument will respond. Only the addressed device will respond to each of these commands:

SDC (Selective Device Clear) - The SDC command performs essentially the same function as the DCL command except that only the addressed device will respond. This command is useful for clearing only a selected instrument instead of all devices simultaneously. Model 8600 will return to the default conditions listed in Tables 3-1 and 4-4 when responding to an SDC command.

To transmit the SDC command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 8600 to listen.
3. Place the SDC command on the data bus.

GTL (Go To Local) - The GTL command is used to remove the instrument from the remote mode of operation. Also, front panel control operation will usually be restored if the LLO command was previously sent. To send the GTL command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8600 to listen.
3. Place the GTL command on the bus.

NOTE

The GTL command does not remove the local lockout state. With the local lockout condition previously set, the GTL command will enable front panel control operation until the next time a listener address command is received. This places the Model 8600 in the local lockout state again.

GET (Group Execute Trigger) - The GET command is used to trigger or arm devices to perform a specific task depends on device configuration. Although GET is considered to be an addressed command, many devices respond to GET without being addressed. Using the GET command is only one of several methods that can be used to initiate a trigger. More detailed information on triggering can be found in Section 3 of this manual.

To send GET command over the bus, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8600 to listen.
3. Place the GET command on the data bus.

GET can also be sent without addressing by omitting step 2.

4-8-4. Unaddress Command

The two unaddress commands are used by the controller to simultaneously remove all talkers and listeners from the bus. ATN is low when these multiline commands are asserted.

UNL (Unlisten) - All listeners are removed from the bus at once when the UNL commands is placed on the bus.

UNT (Untalk) - The controller sends the UNT command to clear the bus of any talkers.

4-8-5. Device-Dependent Commands

The meaning of the device-dependent commands is determined by instrument configuration. Generally, these commands are sent as one or more ASCII characters that tell the device to perform a specific function. For example, M2 is sent to the Model 8600 to place the instrument in the trigger mode. The IEEE-488 bus treats device-dependent commands as data in providing that ATN is high (false) when the commands are transmitted.

4-9. DEVICE-DEPENDENT COMMAND PROGRAMMING

IEEE-488 device-dependent commands are sent to the Model 8600 to control various operating conditions such as display modify, trigger mode, output and parameter insertion. Each command is made up of an ASCII alpha character followed by one or more numbers designating specific parameters. For example the output waveform is programmed by sending an ASCII “O” followed by a number representing the output. The IEEE bus treats device-dependent commands as data in that ATN is high when the commands are transmitted.

A number of commands may be grouped together in one string. Each command must be separated from the preceding command by a comma “,” character (2C HEX). The Model 8600 will ignore all non-printable ASCII characters (00 HEX through 20 HEX) except the “CR” (carriage return). A command string is terminated by an ASCII “CR” (carriage return) character (0D HEX) or a uniline command “EOI” (end or identify) which tells the instrument to execute the command string. recognized as end of command string.

Programming Example:

CHA,PER10US,WID50NS,HIL2V,LOL0V

A CR or an EOI at the end of the string will set Model 8600 channel A parameters to have an output pulse with a period of 10 S, pulse width of 50 nS and an amplitude level from 0 to 2 V into 50 ohms. All other parameters remain unchanged from their previously programmed value. Note that this example does not relate to a particular controller. Other software routine commands are required for the Model 8600 to recognize this string as a device dependent command. These routines vary with each controller and should be studied separately. Other general aspects of programming the Model 8600 were discussed in paragraph 4-8.

If an illegal command or command parameter is present within a command string, the instrument will:

1. Ignore the entire string.
2. Display appropriate front panel error message.
3. Set certain bits in its status byte.
4. Generate an SRQ if programmed to do so.

These programming aspects are covered in the following.

NOTE

Before performing a programming example, it is recommended that the instrument be set to its default values by sending IFC and SDC over the bus.

In order to send a device-dependent command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8600 to listen.
3. Set ATN false.
4. Send the command string over the data bus one byte at a time.

NOTE

REN must be true when attempting to program the Model 8600.

Commands that effect the Model 8600 are listed in Table 4-5.

Table 4-5. Device-Dependent Command Summary

MODE	COMMAND	DESCRIPTION	
Display/Program	CHA	Channel A parameters	(A)
	CHB	Channel B parameters	(B)
Display Parameter	VPER	Display period	(PER)
	VHIL	Display high level	(H.LVL)
	VLOL	Display low level	(L.LVL)
	VWID	Display pulse width	(P.WID)
	VDEL	Display delay time	(DELAY)
	VDTY	Display duty cycle	(DTY)
	VBUR	Display burst number	(BRST)
	VRPT	Display trig period	(T.PER)
	VTLV	Display trigger level	(T.LVL)
	VFRQ	Display ext frequency	(FREQ)
	VPRD	Display ext period	(PERIOD)
	VPLS	Display ext pulse wid	(PLS WID)
Trigger Mode	M1	Normal	
	M2	Triggered Mode	(TRIGRD)
	M3	Gated Mode	(GATED)
	M4	Burst Mode	(BURST)
	T1	EXT trig positive edge	(EXT /)
	T2	EXT trig negative edge	(EXT \ )
	T3	Internal trig stimuli	(INT)
Output	O1	Single pulse delay off	(SINGLE)
	O2	Double pulse delay on	(DOUBLE)
	O3	Single pulse delay on	(DELAYED)
Output Mode	C0	Complement off	( )
	C1	Complement on	( )
	D0	Output disable off	(ST BY off)
	D1	Output disable on	(ST BY on)
Duty Cycle Mode	SM0	Fixed duty cycle off	(FIX DTY off)
	SM1	Fixed duty cycle on	(FIX DTY on)
Auxiliary Level	TTL	TTL at auxiliary out	(TTL)
	ECL	ECL at auxiliary out	(ECL)
Set-ups	STOnn	Store front panel set-up at nn location.	
	RCLnn	Recall set-up from nn location. nn = 00 to 30	

Table 4-5. Device-Dependent Command Summary (continued)

MODE	COMMAND	DESCRIPTION	
Parameter Programming	PER	Set period.	Delimiter=NS,US,MS,S
	HIL	Set high level.	Delimiter=MV,V
	LOL	Set low level.	Delimiter=MV,V
	WID	Set pulse width.	Delimiter=NS,US,MS,S
	DEL	Set delay.	Delimiter=NS,US,MS,S
	DTY	Set duty cycle.	Delimiter=%
	BUR	Set burst number.	Delimiter=#
	RPT	Set int trig period.	Delimiter=US,MS,S
	TLV	Set trigger level	Delimiter=MV,V
Interrogate Parameter	IPER	Read-back period	Prefix: PER
	IHIL	Read-back high level	Prefix: HIL
	ILOL	Read-back low level	Prefix: LOL
	IWID	Read-back pulse width	Prefix: WID
	IDEL	Read-back delay time	Prefix: DEL
	IDTY	Read-back duty cycle	Prefix: DTY
	IBUR	Read-back burst number	Prefix: BUR
	IRPT	Read-back trig period	Prefix: RPT
	ITLV	Read-back trigger level	Prefix: TLV
	IFRQ	Read-back ext frequency	Prefix: FRQ
	IPRD	Read-back ext period	Prefix: PRD
	IPLS	Read-back ext pulse wid	Prefix: PLS
	IERR	Read-back error status	Prefix: ERR
	ISTA	Read-back machine status A	Prefix: STA
	ISTB	Read-back machine status B	Prefix: STB
Reading Format	X0	Prefix off	
	X1	Prefix on	
Terminator	Z0	CR,LF	with EOI
	Z1	CR,LF	without EOI
	Z2	LF,CR	with EOI
	Z3	LF,CR	without EOI
	Z4	CR	with EOI
	Z5	CR	without EOI
	Z6	LF	with EOI
	Z7	LF	without EOI
	Z8	No terminator	with EOI
	Z9	No terminator	without EOI
SRQ Mask	SR0	SRQ off. no mask	
	SR1	SRQ on reading done	
	SR2	SRQ on pulse error	
	SR4	SRQ on error	

(*) String length changes to (Prefix) 14 characters (terminator)

4-9-1. Display/Program (CHA, CHB)

The display/program command selects the channel to be programmed. One of these commands should be sent once at the beginning of the string. If channel B is not installed and CHB was sent through the bus the instrument will respond with an error message. The function may be programmed by sending one of the following commands:

CHA = Program parameters which are associated with channel A

CHB = Program parameters which are associated with channel B

4-9-2. Display Parameter (Vxxx)

The display parameter command controls what the Model 8600 places on the display. There are nine parameters which are associated with the display parameter command and 3 commands which select the type of measurement made by the built-in counter. The machine status string (ISTT) contains a display parameter status; designated by the letter V. This status include a code of two ASCII characters which define the displayed parameter. This code may range from 01 to 12. (e.g code 04 corresponds to VWID in the following list). The display may be programmed using the following commands:

1. VPER = Display the period
2. VHIL = Display the high level
3. VLOL = Display the low level
4. VWID = Display the pulse width
5. VDEL = Display the delay time
6. VDTY = Display the duty cycle
7. VBUR = Display the burst number
8. VRPT = Display the trig period
9. VTLV = Display the trigger level

The display may be programmed to show counter readings using the following commands:

10. VFRQ = Display the external frequency
11. VPRD = Display the external period
12. VPLS = Display the external pulse width

4-9-3. Trigger Mode (M, T, TRG)

The trigger mode command gives the user control over the operating mode of the Model 8600. There are a number of acceptable external sources to stimulate the pulse generator. The instrument may also be set to operate in continuous mode or with an internal stimulant. Program the Model 8600 to one of the trigger modes by sending one of the following commands:

M1 = Normal continuous mode
M2 = Triggered mode
M3 = Gated mode
M4 = Burst mode

The Model 8600 may be programmed to accept either an external stimulant or an internal stimulant by sending one of the following commands:

T1 = External trigger stimulant, trigger on positive edge
T2 = External trigger stimulant, trigger on positive edge
T3 = Internal trigger stimulant, T.PER controls rate
TRG = Trigger on GPIB command

4-9-4. Output (O)

The output command gives the user control over the delay at the output and the auxiliary connectors. The output delay may be programmed by sending one of the following commands:

O1 = Single pulse - delay off
O2 = Double pulse - delay on
O3 = Single pulse - delay on

4-9-4-1. Output Mode (C, D)

The output mode command gives the user control over the condition of the pulse wave form at the output connectors. Main outputs may be enabled or disabled and set to normal or complement mode by sending one of the following commands:

C0 = Complement off
C1 = Complement on
D0 = Output disable off
D1 = Output disable on

4-9-5. Duty Cycle Mode (SM)

Duty cycle mode command gives the user control over the pulse width of the Model 8600. Pulse width may be selected by the operator or left to be automatically set, using the fixed duty cycle mode, by the instrument. The pulse generator may be programmed to turn this mode on or off using the following commands:

SM0 = Fixed duty cycle mode off
SM1 = Fixed duty cycle mode on

4-9-6. Auxiliary Level (TTL, ECL)

The auxiliary level command gives the user control over the voltage level which will be present at the auxiliary outputs. The auxiliary voltage level may be programmed by sending one of the following commands:

TTL = TTL level at the auxiliary outputs
ECL = ECL level at the auxiliary outputs

4-9-7. Set-Ups (STO, RCL)

The set-ups command gives the user control over the storage facilities of the Model 8600. The generator may store complete front panel set-ups in 31 different memory locations. These set-ups may then be recalled to the front panel using a simple bus command:

STOnn = Store front panel set-up at nn location
RCLnn = Recall front panel set-up from nn location

nn may range from 00 to 30. IFC, DCL or SDC has no effect on the stored set-ups.

4-9-8. Parameter Programming

The parameter programming command sets the Model 8600 to the various levels which are required for the unit under test. There are nine different parameters which may be modified using this command:

PER = Set the period rate
HIL = Set the high level voltage
LOL = Set the low level voltage
WID = Set the pulse width
DEL = Set the delay time
DTY = Set the fixed duty cycle
BUR = Set the burst count
RPT = Set the period of the internal trigger genertor
TLV = Set the trigger level threshold

The programming limits for each of the above parameters are listed in Table 3-2.

After DCL or SDC, the instrument will return to its factory defaults. Factory defaults are listed in Tables 3-1 and 4-4.

4-9-9. SRQ Mode (SR) and Serial Poll Status Byte Format

The SRQ command controls which of a number of conditions within the Model 8600 will cause the instrument to request service from the controller. The service request is generated by the SRQ line command. Once the SRQ is generated, the Model 8600 status byte can be checked, via serial polling, to determine if it was the Model 8600 that requested service. Other bits in the status byte could also be set depending on certain data or error conditions. The Model 8600 can be programmed to generate SRQ under one of the following conditions.

1. If a counter reading cycle has been completed.
2. If a general programming error condition has occurred.
3. If a pulse error condition has occurred.

SRQ Mask - In order to facilitate SRQ programming, the Model 8600 uses an internal mask to generate the SRQ. When a particular mask bit is set, the Model 8600 will send an SRQ when those conditions occur. Bits within the mask can be controlled by sending the ASCII letters "SR" followed by a decimal number to set the appropriate bits. Table 4-6 lists the commands to set the various mask bits, while Table 4-7 lists all legal SRQ Mask commands.

NOTE

There are 8 legal SRQ mask commands that are possible with the Model 8600. Table 4-7 lists all combinations. e.g selecting SR5, Model 8600 will request service when one of reading done or programming error occurs.

Status Byte Format: - The status byte contains information relating to data and error conditions within the instrument. Table 4-4 lists the meaning of the various bits. The status byte is obtained by using the SPE, SPD polling sequence.

The various bits in the status byte are described below:

1. Reading done - Set after completion of a measurement cycle in one of VFRQ, VPRD or VPLS modes. The reading done bit is cleared after Model 8600 was addressed to talk in one of IFRQ, IPRD or IPLS modes respectively or when a non-counter parameter was selected to be displayed.

Table 4-6. SRQ Mask Commands

Command	Sets Bit Number	Condition to Generate SRQ
SR1	B0 (LSB)	Reading done
SR2	B1	Pulse set-up error
SR4	B2	General programming error

Table 4-7. SRQ Mask Legal Commands

Bit / Command	B2 Programming Error	B1 Pulse Error	B0 (LSB) Reading Done
SR0	NO	NO	NO
SR1	NO	NO	YES
SR2	NO	YES	NO
SR3	NO	YES	YES
SR4	YES	NO	NO
SR5	YES	NO	YES
SR6	YES	YES	NO
SR7	YES	YES	YES

2. Pulse Error - Set if an inter-parameter error has been detected. This bit is cleared when the error is removed from the front panel set-up.

3. Programming Error - Set if an illegal command or an illegal parameter has been received. This bit is cleared by reading the error status string (IERR).

4. Rqs - Model 8600 will set this bit if one or more conditions for service request occur, and the SRQ mask, for at least one of these service request conditions is enabled. This bit is cleared by reading the Status Byte using the SPE, SPD polling sequence.

NOTES

1. Once the Model 8600 has generated an SRQ, its status byte should be read to clear the SRQ line. Otherwise the instrument will continuously assert the SRQ line.

2. The Model 8600 may be programmed to generate an SRQ for more than one condition simultaneously. For example, to set SRQ mask bits for an SRQ if a programming error and pulse error occurs, the following command would be sent: SR6. All possible mask combinations are listed in Table 4-7.

3. If the instrument is programmed to generate an SRQ when reading is done, it will generate the SRQ only once when the reading is complete; the SRQ may be cleared by reading the status byte. The reading done bit in the status byte may then be cleared by requesting another reading from the instrument.

4-10. READING FROM MODEL 8600

The Reading sequence is used to obtain from Model 8600, various information strings such as parameter set-ups, measurement, machine status or error status. Each information string is made up of ASCII alpha and alphanumeric characters. For more details on the information strings format refer to paragraph 4-10-1.

The reading sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The Model 8600 is addressed to talk.
3. The controller sets ATN false.

Table 4-8. Status Byte Interpretation

Bit Number	B7(MSB)	B6	B5	B4	B3	B2	B1	B0 (LSB)
Interpretation	0	rqs	0	0	0	Programming Error	Pulse Error	Reading Done

4. The instrument sends the information string over the bus one byte at a time.
5. The controller recognizes that string is terminated.
6. The controller sets the ATN line true.
7. The UNT (untalk) command is placed on the bus by the controller.

NOTE

Most controllers use the CR (Carriage Return) or LF (Line Feed) character to terminate their input sequences, but other techniques may be used as well to recognize the end of input sequence (for example the EOI line is low on the bus during the transfer of the last byte).

4-10-1. Interrogate Parameter commands (I)

The Interrogate Parameter commands allow access to information concerning present parameters or special status of the instrument. When the interrogate parameter command is given, the Model 8600 will update a special buffer with the interrogated parameter for the displayed channel. The next time that the generator is addressed to talk, it will transmit this string to the controller. For example to interrogate the pulse width for Channel B the following string should be sent to the Model 8600: CHB,IWID

The Model 8600 interrogate parameter commands include:

IPER = Interrogate period parameter
IHIL = Interrogate high level parameter
ILOL = Interrogate low level parameter
IWID = Interrogate pulse width parameter
IDEL = Interrogate delay time parameter
IDTY = Interrogate duty cycle parameter
IBUR = Interrogate burst number parameter
IRPT = Interrogate internal trigger period parameter
ITLV = Interrogate trigger level parameter

IFRQ = Interrogate external frequency
IPRD = Interrogate external period
IPLS = Interrogate external pulse width

IERR = Interrogate error status
ISTA = Interrogate machine status - channel A
ISTB = Interrogate machine status - channel B

Table 4-9 shows the general data string format for each of the first fifteen commands. Default values are shown. These defaults are generated after an SDC or DCL commands.

Table 4-10 shows the interpretation for the error status (IERR). Table 4-11 shows the machine status strings (ISTA and ISTB)

NOTE

The error status data strings (IERR) and the machine status data strings (ISTA/ISTB) have fixed length of 15 ASCII without the prefix and terminator. Counter data has a fixed length of 11 ASCII characters without the prefix and terminator. For all other data strings the length of the data string is 7 ASCII characters without the prefix and terminator. If the data string is sent with a prefix, three additional ASCII characters are included (refer to paragraph 4-10-3). If the data string is sent with one or two terminators, the length of the data string increases by one or two characters respectively.

NOTES

1. To ensure that the correct status is received, the status string should be read immediately after sending the command, to avoid having an incorrect status transmitted.

2. The status string should not be confused with the status byte. The status string contains a string of bytes pertaining to the various operating modes of the instrument. The status byte is a single byte that is read with the SPE, SPD command sequence and contains information on RSQ status.
3. Errors 1 through 5 and 11 through 15 are described in paragraph 3-16.
4. ILI error is described in paragraph 4-11-1.

4-10-2. Terminator (Z)

To allow a wide variety of controllers to be used, the terminator can be changed by sending an appropriate command over the bus. The default value is the commonly used carriage return, line feed (CR LF) sequence (mode Z0). The terminator sequence will assume this default value after receiving a DCL or SDC.

Table 4-9. Data String Format

Command	Data String Format (*)	Description	Dimensions
IPER	PER1.000US(term)	For period string	NS,US,MS,S
IHIL	HIL 1.00 V(term)	For high level string	MV,V
ILOL	LOL-1.00 V(term)	For low level string	MV,V
IWID	WID 200US(term)	For pulse width string	NS,US,MS,S
IDEL	DEL 300US(term)	For delay string	NS,US,MS,S
IDTY	DTY 50 %(term)	For duty cycle string	%
IBUR	BUR 2 #(term)	For burst number string	#
IRPT	RPT 1 S(term)	For trig period string	US,MS,S
ITLV	TLV 1.6 V(term)	For trig level string	MV,V
IFRQ	FRQ1.234567MHZ(term)	For ext frequency string	MHZ,KHZ,HZ
IPRD	PRD1.234567 US(term)	For ext period string	NS,US,MS,S
IPLS	PLS1.234567 US(term)	For ext pulse width string	NS,US,MS,S
IERR	ERR000000000000000(term)	For error status string	
ISTA	STA010111100010100(term)	For machine status string CH A	
ISTB	STB100111100010100(term)	For machine status string CH B	

(*) CR LF is normal terminator. The terminator may be changed (see paragraph 4-10-2). The prefixes are listed in Table 4-9.
(xx) depends on the installed options

The EOI line on the bus is usually set low by the device during the last byte of its data transfer sequence. In this way, the last byte is properly identified, allowing variable length data words to be transmitted. The Model 8600 will normally send EOI during the last byte of its data string or status word. The terminator and the EOI response from the Model 8600 may be sent with one of the following commands:

Z0 = CR,LF with EOI
Z1 = CR,LF without EOI
Z2 = LF,CR with EOI
Z3 = LF,CR without EOI
Z4 = CR with EOI
Z5 = CR without EOI
Z6 = LF with EOI
Z7 = LF without EOI
Z8 = No terminator with EOI
Z9 = No terminator without EOI

NOTES

1. Most controllers use the CR or LF character to terminate their input sequence. Using the NO TERMINATOR mode (Z8 or Z9) may cause the controller to hang up unless special programming is used.

Table 4-10. Error Status Word Interpretation (IERR) Following SDC or DCL

	CHANNEL A					CHANNEL B						
	ER 1	ER 2	ER 3	ER 4	ER 5	ER 11	ER 12	ER 13	ER 14	ER 15	ILI	
(ERR)	0	0	0	0	0	0	0	0	0	0	0	0000 (CR LF)

2. Some controllers may require that EOI be present at the end of the string.

4-10-3. Prefix (X)

The prefix from the data string may be suppressed using this command. When the prefix is suppressed the output data string is three byte shorter. X command parameters include:

X0 = Send data string without prefix
X1 = Send data string with prefix

4-11. FRONT PANEL ERROR MESSAGES

The process of programming the Model 8600 involves the proper use of syntax. Syntax is defined as the orderly or systematic arrangement of programming commands or languages. The Model 8600 must receive valid commands with proper syntax or it will:

1. Ignore the entire commands string in which the in valid command appears.
2. Set appropriate bits in the status byte and error word.
3. Generate an SRQ if programmed to do so.
4. Display an appropriate front panel message.

4-11-1. Illegal Instruction (ILI) Error

An Illegal Instruction error results when the Model 8600 receives an invalid command such as A0 or an invalid parameter like PER20PS. These commands are invalid because no such letter or parameter exist in the instruments programming language. When the generator receives such a command it will respond with a front panel message as follows:

ILL INS

In parallel, the ILI bit in the error status string and the B2 bit in the series poll byte will be set to 1; on the condition that the appropriate SRQ was programmed. This bit will be cleared only after the error status string (IERR) has been read.

Table 4-11. Machine Status String Interpretation (ISTA / ISTB) Following SDC or DCL

	OPT1	CHA		V	M	T	O	C	D	SM	TTL	ECL	X	Z	SR (term)
(STA)	0	1	01	1	1	1	0	0	0	1	0	1	0	0(CR LF)	
	OPT1	**CHB**		**V**	**M**	**T**	**O**	**C**	**D**	**SM**	**TTL**	**ECL**	**X**	**Z**	**SR (term)**
(STB)	1	0	01	1	1	1	0	0	0	1	0	1	0	0(CR LF)	

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SECTION 5

MAINTENANCE AND PERFORMANCE TESTS

5-1. INTRODUCTION

This section provides maintenance, service information, and performance tests for the Model 8600, the Channel B output amplifier (option 1), and the universal counter option. Fuse replacement procedure, line voltage selection and options installation procedure are also included.

WARNING

The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautinos are not observed.

5-2. LINE VOLTAGE SELECTION

The Model 8600 may be operated from either 115V or 230V nominal 50-60Hz power sources. A special transformer may be installed for 100V and 200V ranges. The instrument was shipped from the factory set for an operating voltage of 230V. To change the line voltage, proceed as follows:

WARNING

Disconnect Model 8600 from power cord and all other sources before changing the line voltage setting.

1. Using a flat-blade screwdriver, place the line voltage selection switch in the desired position. The voltages are marked on the selection switch.
2. Install a power line fuse consistent with the operating voltage. See paragraph 5-3.

CAUTION

Correct fuse type must be used to maintain proper instrument protection.

5-3. FUSE REPLACEMENT

The Model 8600 has a line fuse to protect the instrument from excessive current. This fuse may be replaced by using the procedure described in the following :

WARNING

Disconnect the instrument from the power line and from other equipment before replacing the fuse.

1. Place the end of a flat-blade screwdriver into the slot in the LINE FUSE holder on the rear panel. Push in and rotate the fuse carrier one quarter turn counterclockwise. Release the pressure on the holder and its internal spring will push the fuse and the carrier out of the holder.
2. Remove the fuse and replace it with the proper type using Table 5-1 as a guide.

CAUTION

Do not use a fuse with a rating higher than specified or instrument damage may accure. If the instrument persistently blows fuses, a problem may exist within the instrument. If so, the problem must be rectified before continuing operation.

5-4. CHANNEL B - OUTPUT AMPLIFIER OPTION, FIELD INSTALLTION (option 1)

The Channel B output amplifier option adds another output channel to the Model 8600. This output is fully synchronized to the main output - Channel A. Period and triggering modes are common. All other parameters are independently set.

Table 5-1. Line Fuse Selection

POWER LINE	VOLTAGE	FUSE TYPE
90 - 125V	0.63A, 250V	5x20 mm
195 - 250V	0.315A, 250V,	5x20 mm

Similar to Channel A, Channel B option also includes an auxiliary output which may be programmed to output a fixed level. Auxiliary voltage level is selectable between ECL and TTL.

If purchased with the Model 8600, the option will be factory installed; however the instrument may be easily upgraded in the field by installing the option as described in the following. Software modification is not required. The Model 8600 will automatically sense the impression of the installed option and will adjust the software routines accordingly.

Option 1 comprises 2 boards; designated as Pulse Width/Delay and Output Amplifier B and two coax cables with quick disconnect plugs. Model 8600 provides two empty slots which are left for the assembly of Channel B.

5-4-1. Option 1 Installation Procedure

1. Remove the top and bottom covers of the instrument as described in the disassembly instructions in paragraph 5-6.

WARNING

Disconnect the line cord and test leads from the instrument before removing the top cover.

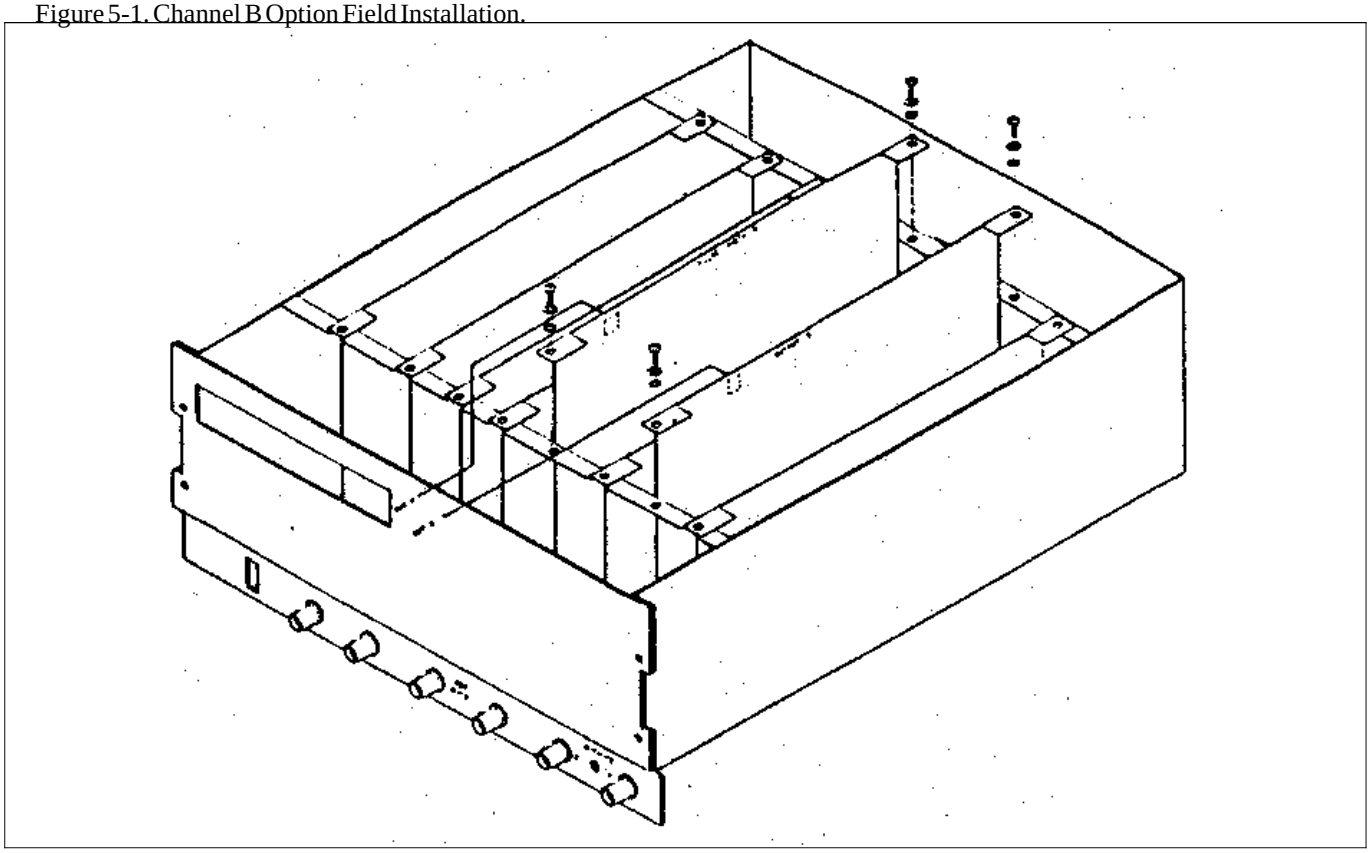
2. Idetify the empty slot for the pulse width/delay board as shown in Figure 5-1. The information is printed on the main board. Also observe that the plug in connectors, when plugged to the correct slot, fit exactly to the plugged board.
3. Slide the pulse width/delay board along the card guide. Make sure that the connectors mate exactly. Press down the plug-in board firmly until it locks into place and the metal ears rest on the top rail of the cage. Secure the board to the rail using the provided screws. 4. Use the same procedure as described before to plug in the output amplifier board.

CAUTION

Make sure that the option is plugged correctly to the main connector that is, when the option board is secured into place, no pin on the main board should by left free.

4. Solder the loose end of the shielded wire, from the pulse width/delay board to the front panel connector which is marked AUX OUT B. Solder the inner wire to the center and the outside shield to the ground lug.
5. Solder the loose end of the shielded wire, from the output amplifier B to the front panel connector which is marked OUTPUT B. Solder the inner wire to the center and the outside shield to the ground lug.
6. Replace the bottom and top covers.

Figure 5-1. Channel B Option Field Installation.



7. Turn power on and observe the power up procedure. If no other option is installed the instrument will display the following:

8600-1

This reading indicates that the instrument accepted the installed option and will now allow modification of parameters which are associated with Channel B.

5-5. DIASSEMBLY INSTRUCTIONS

If it is necessary to troubleshoot the instrument or replace a component, use the following disassembly procedure to remove the top and bottom covers:

1. Remove the two screws that secure the top cover to the rear panel.
2. Grasp the top cover at the rear and carefully lift it off the instrument. When the tabs at the front of the cover clear the front panel, the cover may be pulled completely clear.
3. Remove the eight screws that secure the bottom cover to the internal cage assembly.
4. Grasp the bottom cover and carefully lift it of the instrument.
5. When replacing the top and bottom covers, reverse the above procedure; be sure that the top cover tabs fit snugly into front panel recesses before completely installing the cover.

5-6. SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

MOS devices are designed to operate at a very high impedance levels for low power consumption. As a result, any normnal static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. When handling such devices, use precautions which are described in the following to avoid damaging them.

1. The MOS ICs should be transported and handled only in containers specially designed to prevent static build-up. Typically, these parts will be received in static-protected containers of plastic or foam. Keep these devices in their original containers until ready for installation.
2. Remove the devices from the protective containers only at a properly grounded work station. Also ground yourself with a suitable wrist strap.
3. Remove the devices only by the body; do not touch the pins.

4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table. 5. Use only anti-static type solder sucker.

6. Use only grounded soldering irons.
7. Once the device is installed on the PC board, the device is normally adequately protected, and normal handling resume.

5-7. CLEANING

Model 8600 should be cleaned as often as operating condition require. Thoroughly clean the inside and the outside of the instrument. Remove dust from inaccessible areas with low pressure compressed air or vacuum cleaner. Use alcohol applied with a cleaning brush to remove accumulation of dirt or grease from connector contacts and component terminals.

Clean the exterior of the instrument and the front panel with a mild detergent mixed with water, applying the solution with a soft, lint-free cloth.

5-8. REPAIR AND REPLACEMENT

Repair and replacement of electrical and mechanical parts must be accomplished with great care and caution. Printed circuit boards can become warped, cracked or burnt from exessive heat or mechnical stress. The following repair techniques are suggested to avoid inadverant destruction or degradation of parts and assemblies.

Use ordinary 60/40 solder and 35 to 40 watt pencil type soldering iron on the circuit board. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the circuit from the base material. Keep the soldering iron in contact with the PC board for a minimum time to avoid damage to the components or printed conductors.

To desolder components use a commercial " solder sipper ", or better, solder removing SOLDER - WICK, size **3**. Always replace a component with its exact duplicate as specified in the parts list.

5-9. PERFORMANCE CHECKS

The following performance checks verify proper operation of the instrument, and should normally be used :

a) As part of incoming inspection of instrument specifications;
b) As part of troubleshooting procedure;
c) After any repair or adjustment, before returning instrument to regular service.

Table 5-2. Required Test Equipment.

Instrument	Recommended Model	Specifications	Use (*)
Counter	Tabor 6020-1	1 Hz - 225 MHz 1PPM	P,A,
DMM	Tabor 4121	.1V- 100Vdc, 0.05%, AC rms	P,A,
Pulse Generator	Tabor 8201	0.5 S - 50 nS 0.1 %	P,A,
Synthesizer	Marconi 2019	80 KHz-1040 MHz	P,A
Oscilloscope	Tek 2465A	350 MHz bandwidth	P,A,
Distortion analyser	K-H 6900	100 Hz - 1 MHz	P,A
50 ohm feedthrough Termination	Tek 011-0049-01	50 ohm, 2W, 1%	P,A
10 MHz Standard	Oscillatec	10 MHz +/-10 E-12	P,A

(*) P= Performance Test, A= Adjustments

5-9-1. Environmental Conditions

Tests should be performed under labortory conditions having an ambient temperature of 25 +/-5 deg C and a relative humidity of less than 80 %. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

5-9-2. Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure accuracy, turn on the power to the Model 8600 and allow it to warm-up for at least 30 minutes before beginning the performance tests procedure.

5-9-3. Recommended Test Equipment

Recommended test equipment for troubleshooting, calibration and performance checking is listed in table 5-2. Test instruments other than those listed may be used only if their specifications equal or exceed the required minimal characteristics.

5-10. PERFORMANCE CHECKS PROCEDURE

Model 8600 has a special function which down-loads the required front panel set-ups for the various performance checks. To use this function depress the [SHIFT] push-button and then [5]. No readout indication will follow. The non-volatile memory is now loaded with front panel set-ups which can now be used for performance checks. The following set-ups and performance checks are identical for both channels A and B.

In the following, each procedure is associated with one memory location. Recalling a set-up will automatically update front panel parameters for the required test. No other set-up information will be given. To recall a particular set-up, use the procedure which is given in Section 3-9-2 or 3-9-2-1 of this maual.

WARNING

The memory down-load function will override any previous front panel set-ups. Before using this function be absolutely certain that information which is stored in the non-volatile memory is no longer required.

5-10-1. Period Accuracy Check

Equipment: Universal counter/timer (6020-1)

1. Connect the Channel A output connector to the counter input.
2. Set counter to period averaged measurements and 4 digits resolution and verify that counter reading is within the required results as follows:

MEASURED PERIOD	RECALL SET-UP	REQUIRED COUNTER READING
10.0 nS	00	10.0 nS +/-.40 nS
12.0 nS	01	12.0 nS +/-.44 nS
14.0 nS	02	14.0 nS +/-.48 nS
16.0 nS	03	16.0 nS +/-.52 nS
18.0 nS	04	18.0 nS +/-.56 nS
20.0 nS	05	20.0 nS +/-.60 nS
177.7 nS	06	177.7 nS +/-3.5 nS
1.777 uS	07	1.777 uS +/-35 nS
17.77 uS	08	17.77 uS +/-.35 uS
177.7 uS	09	177.7 uS +/-3.5 uS
1.777 mS	10	1.777 mS +/-35 uS
17.77 mS	11	17.77 mS +/-.35 mS
177.7 mS	12	177.7 mS +/-3.5 mS
0.900 S	13	1.900 S +/-18 mS
1.999 S	14	1.999 S +/-40 mS
199.9 nS	15	199.9 nS +/-.20 nS

5-10-2. Pulse Width Accuracy Check

Equipment: Universal counter/timer (6020-1)

1. Connect the Channel A output connector to the counter input.
2. Set counter to pulse width Averaged measurements and 4 digits resolution and verify that counter reading is within the required results as follows:

PULSE WIDTH	8600 SET-UP	READING ERROR
10 nS	06	10.0 nS +/-2.0 nS
100 nS	07	100.0 nS +/-3.0 nS
1000 nS	08	1.000 uS +/-12 nS
10000 nS	09	10.00 uS +/-100 nS
100.0 uS	10	100.0 uS +/-1.0 uS
1.000 mS	11	1.000 mS +/-10 uS
10.00 mS	12	10.00 mS +/-100 uS
100.0 mS	13	100.0 mS +/-1.0 mS
900 mS	14	900.0 mS +/-9.0 mS

3. Repeat the above checks for channel B (if installed).

5-10-3. Delay Accuracy Check

Equipment: Universal counter/timer (6020-1)

1. Connect the SYNC out connector to the counter channel A.
2. Connect the Channel A OUTPUT connector to the counter channel B.
3. Set counter to time interval A to B averaged measurements and

Verify that counter reading is within the required results as follows:

MEASURED DELAY	RECALL SET-UP	REQUIRED COUNTER READING
10 nS	06	10.0 nS +/-2.0 nS
100 nS	07	100 nS +/-3.0 nS
1000 nS	08	1.000 uS +/-12 nS
10000 nS	09	10.00 uS +/-100 nS
100.0 uS	10	100.0 uS +/-1.0 uS
1.000 mS	11	1.000 mS +/-10 uS
10.00 mS	12	10.00 mS +/-100 uS
100.0 mS	13	100.0 mS +/-1.0 mS
900 mS	14	900.0 mS +/-9.0 mS

4. Repeat the above checks for channel B (if installed).

5-10-4. Amplitude Accuracy Check

Equipment: DMM (4121)

1. Connect the Channel A output connector to the DMM input.
2. Set the DMM to ACV measurements and verify that the DMM reading is within the required results as follows:

MEASURED AMPLITUDE	RECALL SET-UP	REQUIRED DMM READING
+/-2.50 V	16	2.500 V +/-50 mV
+/-1.00 V	17	1.000 V +/-20 mV
+/-0.50 V	18	0.500 V +/-10 mV
+/-0.25 V	19	250 mV +/-5 mV

3. Repeat the above checks for Channel B (if installed).

5-10-5. Offset Accuracy Check

Equipment: DMM (4121)

1. Connect the Channel A output connector to the DMM input.
2. Set the DMM to DCV measurements and verify that the DMM reading is within the required results as follows:

MEASURED DC	RECALL SET-UP	REQUIRED DMM READING
+4.750 V	20	+4.750 V +/-0.125 V
-4.750 V	21	-4.750 V +/-0.125 V

3. Repeat the above checks for Channel B (if installed).

5-10-6. Pulse Response Check

Equipment: Sampling oscilloscope

1. Connect Channel A output to oscilloscope input.
2. Set oscilloscope for a trace of 6 vertical divisions and verify rise/fall time and aberration readings are as follows:

MEASURED TIME	RECALL SET-UP	REQUIRED TRACE
1.5 nS	22	5 nS <5 % overshoot
1.5 nS	23	5 nS <5 % overshoot
1.5 nS	24	5 nS <5 % overshoot

5-10-7 Counter Accuracy and Trigger Sensitivity Checks

Equipment: Synthesizer (2219), Pulse/Function generator (8201)

1. Connect the Synthesizer output to the TRIG/COUNTER INPUT connector. Terminate the cable with a feed through 50 ohms termination.
2. Connect the 10 MHz standard to the external reference input at the synthesizer.
3. Set synthesizer as follows:

Frequency	100 MHz
Amplitude	300 mV
Mode	External reference

4. Verify that 8600 display reading is as follows:

RECALL SET-UP	REQUIRED 8600 READING
10	100.0000 MHz +/-2 KHz

5. Remove leads from the synthesizer.
6. Set 8201 period to 10.0 uS and connect 8201 TTL output to TRIG/COUNTER INPUT connector.
7. Verify that 8600 display reading is as follows:

RECALL SET-UP	REQUIRED 8600 READING
25	10 uS +/-0.5 uS

5-10-8. Trigger Modes Operation Checks

Equipment: Pulse/Function generator (8201), oscilloscope (2345), counter (6020-1)

1. Set 8201 controls as follows:

PARAMETER	SET-UP
FREQ	1 KHz
AMPL	1 Vp-p
OUTPUT	Square wave
MODE	Normal, continuous

2. Connect the output connector from the pulse generator to the TRIG INPUT. Terminate the cable with a feed through 50 ohms termination.
3. Connect the 8600 SYNC OUT to the oscilloscopes' s external trigger.
4. Set oscilloscope to external trigger and verify that Model 8600 outputs as follows:

VERIFIED MODE	RECALL SET-UP	REQUIRED SCOPE TRACE
Gated	26	Gated signal
Triggered	27	Triggered signal
Burst	28	Bursts of 2 pulses

5. Remove all cables from the 8600.
6. Connect AUX OUT A connector to Channel B on the counter.
7. Set counter function to totalize B mode and trigger level B to 1.00 V. Reset counter.
8. Depress [MANUAL] push-button and verify that Model 8600 outputs as follows:

VERIFIED MODE	RECALL SET-UP	REQUIRED COUNTER READING
MANUAL, BURST	29	65,000 +/-0

SECTION 6

THEORY OF OPERATION

6-1. INTRODUCTION

This section contains an overall functional description of the Model 8600 as well as detailed circuit analysis of the various sections of the instrument. Information pertaining to the standard IEEE-488 interface and the various options are also included.

Information is arranged to provide a description of individual functional circuit blocks. As an aid to understanding, the descriptions are keyed to accompanying block diagrams and simplified schematics. Detailed schematics and component layout drawings are located at the end of this instruction manual.

6-2. OVERALL FUNCTIONAL DESCRIPTION

The Model 8600 is a 7 digit pulse generator with a complete digital control over all pulse parameters such as period, pulse width, delay, amplitude etc. The pulse generator utilizes a microprocessor circuit which permits high resolution and high accuracy programming of the various parameters. For example, pulse width may be programmed from 5 nS to 79.999 mS with steps of 1 nS.

Due to the complexity of the Model 8600 it was necessary to divide the instrument into functional sections and build each section on a different plug-in board. The use of the plug-in board system also simplifies troubleshooting and permits easy replacement of defective boards.

The system is constructed on a main board assembly. This board contain connectors and the necessary wires which connect between the various boards. The plug-in boards are supported by a cage. Card guides lead the boards to their matting connectors. Connectors on the plug-in boards are designed so that each board will only fit to one slot. This system simplifies board location identification.

Each board is marked with its function. The same markings are inscribed on the main board. Only two boards are interchangeable. They are: Pulse Width/Delay A and Pulse Width/Delay B. All other boards should be plugged exactly as marked on the main board.

Information is arranged to provide a description of individual plug-in board. Description includes functional circuit blocks and theory of operation. As an aid to understanding, the descriptions are keyed to accompanying block diagrams and simplified schematics. Detailed schematics and component layout drawings are located at the end of this instruction manual.

6-3. POWER SUPPLY BOARD

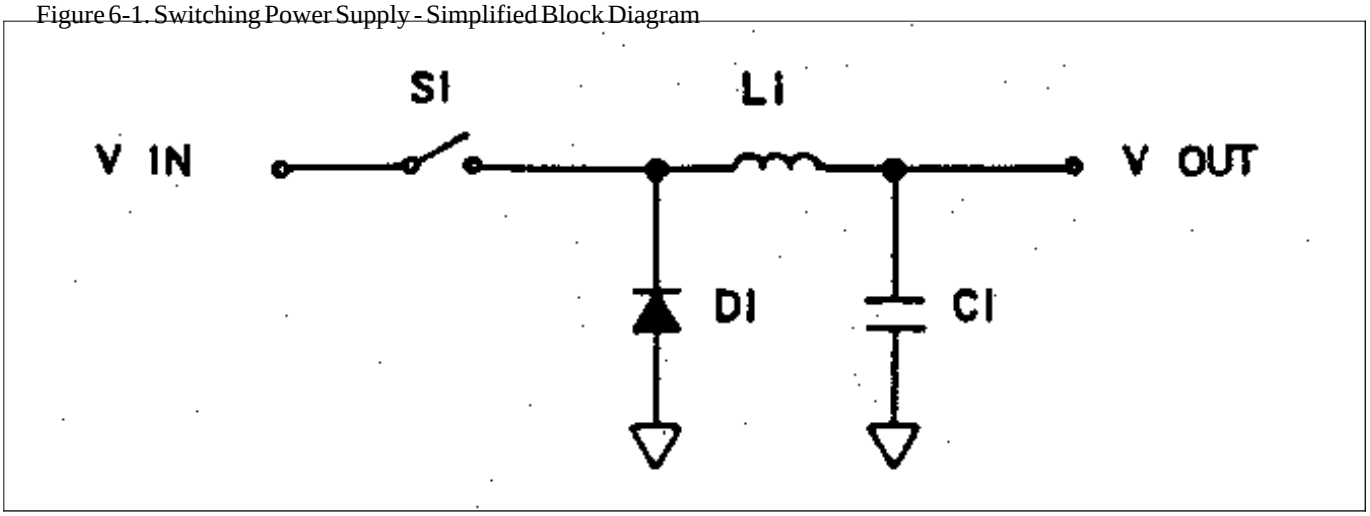
The power supply board generates the necessary voltage levels which are essential for operating the various circuits. The following paragraphs contain a description of the power supply board. Its circuit and components location drawing may be found at the end of this manual.

The power supply board generates seven different voltage levels. These are: +24 V, -24 V, +15 V, -15 V, +5 V, -5 V, and -2 V. CR1 rectify the ac voltage for U1 and U2 which generate the +24 V and -24 V respectively. U3 and U6 generate the -15 V and +15 V respectively. U5 regulates the -2 V. Its input is driven by the -5 V supply.

The +5 V and the -5 V supplies are made of a switching circuit. Figure 6-1 is a simplified block diagram describing a common switching supply circuit.

In the following block diagram, when S1 is switched on, D1 is reverse biased, allowing current from Vin to flow through L1 to the load at Vout. Switching off S1 causes the energy which is stored in L1 to drive Vout. C1 stores energy during transition times and also filters Vout. Vout is a function of the switch time off - T1 and switch time on - T2 as expressed in the following formula:

Figure 6-1. Switching Power Supply - Simplified Block Diagram



Vout = T1 x Vin / (T1 + T2)

The above theory is applied to the circuit which is used in the Model 8600. The +5 V supply is made of a switch - Q4, Q5 and their associated components. A switch controller - U7 and its associated components. A coil - L2 and a filtering capacitor C17.

U7 is a self oscillating circuit. Its output is switched on and off when the output voltage (Vout) exceeds a reference voltage which is generated internally by R21 and R22. The comparator generates the correct duty cycle which controls the output voltage as expressed in the above formula. CR6 prevents Vout from exceeding +5 V which may damage TTL devices.

Similarly, the -5 V supply is made of a switch - Q1 and Q2 and their associated components. A switch controller - U4 and its associated components. A coil - L1 and decoupling capacitor C24 and C25. Voltage reference is generated by R11 and R12.

6-4. C.P.U BOARD

The C.P.U board controls front panel traffic, generates serial information which drives the various serial to parallel converters, controls the internal 8 bit bus and its handshake commands, controls its memory bank including the non-volatile memory bank and provides the required circuits for the counter functions. The C.P.U board also contains the circuits which are necessary for the GPIB interface. The following paragraphs contain a description of the C.P.U board. Its circuit and components location drawing may be found at the end of this manual.

6-4-1. CPU Block Diagram

Circuit operation centers around the CPU unit, U4. The 8031 is an 8-bit CPU capable of directly addressing up to 64K bytes of program memory (ROM) and up to another 64K bytes of data memory (RAM). The CPU works with a 10 MHz clock which is divided internally to provide a bus operation of about 1MHz.

Software for the CPU is contained in an EPROM (Erasable Programmable Read-Only Memory). U7 is a 27256 EPROM containing 32K bytes of software. Temporary non-volatile storage is provided by U8, RAM (Random Access Memory) which can store up to 2048 bytes of information.

Interfacing between the CPU and the IEEE bus is performed by dedicated IEEE-488 bus interface IC, U14. This IC performs many bus functions automatically to minimize CPU overhead. Buffering between the 8291 IC and the IEEE bus lines is done with bus drivers U14 and U15.

Interfacing between the CPU to the keyboard and the display is performed by the Keyboard/Display interface IC - U1.

U20 is an eight bit D to A converter which generates an analog voltage for the trigger level circuit. U21 is a D to A converter which generates an analog voltage for the V.C.O circuit. U21 is buffered by U22, Q8 and their associated components.

6-4-2 Memory Mapping

The 8031 CPU is capable of directly addressing two banks of 64k (65,536) bytes memory. One bank of memory is the program memory and the second memory bank is the data memory. The selection of the banks is done internally by the CPU. Although the CPU has this large addressing capability, only a portion of the possible memory space is actually needed.

The Model 8600 uses a total of 32K of program memory stored in the 27256 EPROM U7, and a total of 1K of data memory is stored in U8 and. The 8031 CPU uses a memory-mapped I/O scheme, additional memory location must be allocated for the various I/O function. All the memory-mapped I/O functions are in the data memory space. Because of a partial decoding scheme used in this instrument, for some memory elements, a larger memory slot is allocated than the actual memory needed.

6-4-3. Address Decoding

The CPU has a total of 16 address lines which are used to locate a specific memory slot. The LOW address line (A0 to A7) are multiplexed on the address/data bus, and the ALE (address latch enable) signal is used to separate the LOW address from the address/data bus witch is done by U6 address latch. Since no memory or interface element can fully decode address locations, additional address decoding must be used.

U2 and U19 are 1-of-8 decoder. The decoders are enabled by A14 and A15. Once the decoder is selected the decoding is done by addressing lines A11, A12, A13, A14 and A15.

6-4-4. Reciprocal Counter/ Timer

The Model 8600 features a built-in universal counter/timer. This counter employs the reciprocal measurement technique which gives an outstanding resolution, in frequency measurements, throughout the specified frequency range. Although complex, this technique requires only a few integrated circuits. Model 8600 displays its counter reading with 7 digit plus exponent.

The counter comprises a highly accurate reference oscillator - U13, two counting registers - U9 (N1) and U10 (N2), synchronizer - U12 and selector U11. A fixed gate time of about 1 second is generate by the microprocessor. U9 and U10 are connected directly to the data bus. Information from these circuits are processed and converted to a frequency result.

6-4-5. Keyboard/Display Interface

The Keyboard/Display Interface IC U1 is used to control the front panel display and to find out which one of the buttons was pushed.

6-4-6. IEEE Interface

The Model 8600 has a built in IEEE-488 interface that allows the instrument to be controlled through the system controller. Commands may be given over the bus and data may be requested from the instrument as well.

The IEEE interface is made up of U14, a 8291 GPIA (General Purpose Interface Adapter), and U15 and U16, which are interface bus drivers. On the CPU side of the GPIA, data transmission is handled much like any other bus transaction. The CPU accesses the GPIA through the usual D0 through D7 data lines. Address decoding for the internal 14 registers (7 read and 7 write) is provided by the CS, WR, RD and A0, A1, A2 terminals.

The output of the 8291 IC is standard IEEE format; the eight data lines (DIO1 through DIO8) the three handshake lines (DAV, NDAC, NRFD), and the five management lines (ATN, REN, IFC, SRQ, EOI), are all active low with approximately zero volts representing a logic one. The two IEEE bus drivers, U15 and U16 are necessary to bring the drive capability of the interface up to the normal IEEE maximum 15 devices.

The GPIA simplifies CPU interfacing to the IEEE bus because many control sequences take place automatically. For example, when a write is done to the data output register, the handshake sequence is automatically performed at the proper time. Without the GPIA chip, complicated CPU routines would be required to accomplish control sequence that are performed automatically.

6-5. V.C.O BOARD

The VCO board comprises a few functional blocks which are closely related to the oscillator circuit. The main part is the voltage controlled oscillator which, under microprocessor control, generates the output repetition rate. This board also includes input amplifier for the trigger and the counter circuit, burst generator, and the necessary circuit for the various triggering options. The following paragraphs contain a description of the V.C.O board. Its circuit and components location drawing may be found at the end of this manual.

6-5-1. Control Circuit

The control circuit generates the correct digital words which are necessary to control the analog circuits. There are two control chains TTL chain - U30 through U32 and ECL chain - U33 through U36. U9b, U9c, U10b, U11a and U13d are gate selectors which select the appropriate signal to drive the trigger circuit.

6-5-2. Current Generator

The current generator provides accurate current which are necessary to drive the V.C.O circuit. The current generator comprises D/A convertor U16, reference diode CR1 U2, Q10, U36, Q1 and their associated components. Voltage is generated by the D/A convertor is accurately controlled and directly proportional to the output period. U3a, Q11, U4a, Q12, Q21 and their associated components provide a mirror multiplier and base line correction for the V.C.O and the clamp circuit.

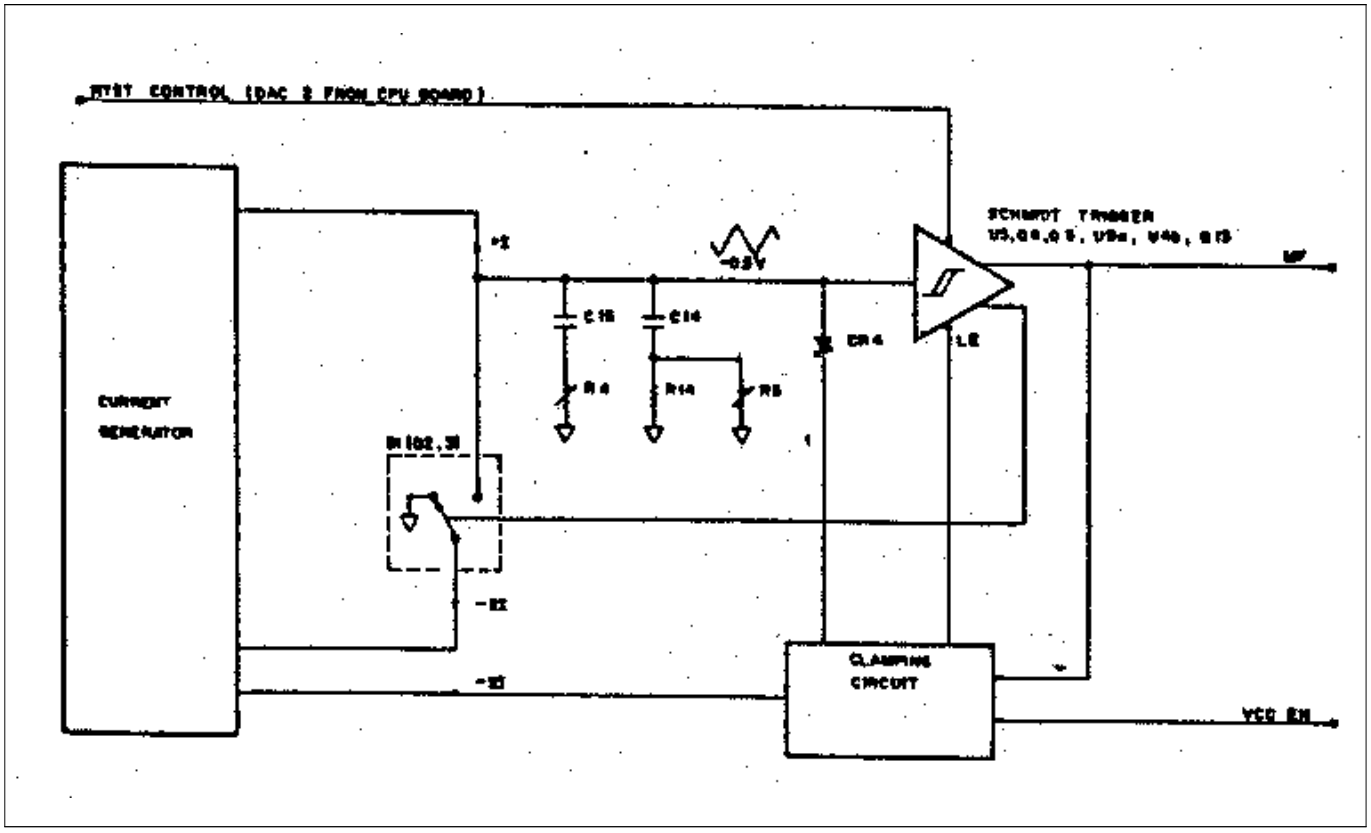
6-5-3. Current Controlled Oscillator & Clamping Circuit

The current controlled generator and the clamping circuit are described in the following simplified block diagram.

C14 is charged by a constant positive current from the current generator until the upper threshold of 0 V is reached. The shmidt trigger circuit then changes its state and negative current is now flowing from the current generator charging C14 with negative current until the negative threshold level of -0.5 V is reached. The shmidt trigger circuit then again changes state. This sequence generates oscillation of a square wave with 50 % duty cycle and having an ECL level. this oscillation is then translated to the actual output period at the output terminal. C14 is used at periods from 20 nS to 199.9 nS and C15 is used from 200 nS to 2 S. Q4 selects between these two capacitors.

The clamping circuit disables the oscillation of the V.C.O circuit at times when the instrument is set to operate at triggered gated or burst modes. The VCO enable is then set to low and Vclamp through CR4 forces the level on the timing capacitor to -0.5 V ensuring an accurate first period in gated and burst modes after the VCO EN becomes true. The base line compensation ensures a -0.5 V level at pin 4 of U5 regardless of the period setting.

Figure 6-2. C.C.O & Clamping Circuit- Simplified Block Diagram



6-5-4. Trigger/Counter Input Circuit

The trigger circuit conditions the input signal for the proceeding circuitry. The signal is routed from the input connector to the shmidt trigger amplifier - Q19,Q20, U15 and their associated components. R101, R97, C43 and C46 attenuate the input signal by 4. U29 shifts the DC level to around -1.29 V. The DAC1 circuit generates the required trigger level offset. U8b select between positive or negative slopes. U15b disables the trigger circuit when the instrument is set to operate at normal mode. 6-5-5. Gated/Burst circuit

The heart of the gated/burst circuit is U24a. The trigger signal is received from the trigger input circuit and is applied through U11b to the D input of U24a. The clock input at U24a is fed by U10a which selects between the outputs of U9c and U10b. U10a also serves as the burst clock to the burst counter chain - U23, U25, U27, U28 and their associated components. The burst stop signal drives the D input of U24a through U26. Q15 through Q18 and their associated components convert the ECL level from U8c to TTL and shapes the output for the SYNC drive at the SYNC OUT connector. U14 and delay lines DL1 through DL4 delay the SYNC out signal so that the main output and the SYNC output signals come at the same time. U6a is connected as a time stretcher which stretches the input triggering signal for the microprocessor circuit.

6-6. PULSE WIDTH/DELAY BOARD

When both channels A and B are installed, two pulse width/delay boards are installed. Both boards are exactly identical and will be referred in the following as pulse width/delay board.

The pulse width/delay board comprises pulse width generator, delay generator, programmable dividers, auxiliary output amplifier, normal/complement selector and digital control circuitry. The following paragraphs contain a description of the pulse width/delay board. Its circuit and components location drawing may be found at the end of this manual.

6-6-1. Control Circuit

The control circuit generates the correct digital words which are necessary to control the various circuits. there are two control chains TTL chain - U33 through U34 and ECL chain - U35 through U40.

6-6-2. Pulse Width Circuit

The heart of the pulse width circuit is a gateable 50 MHz oscillator - U17c and its associated components. U16b controls the start and stop sequence of U17c and later provides the signal for the auxiliary output circuit. The 50 MHz from U17c is routed to a 3 digit divide by N counter which consists of U15 and U26 through U28. The signal is then routed through U25a to a divide by 10^n range counter which is formed by U1, U11 and U23. When all the outputs from the range counter turn logical “1", U2 and U14a enable the gate U3c which in turn permits transitions from U15 to pass through the propagation delay chain - DL1 through DL6 which then provides the stop pulse for the control flip-flop - U16b. The start signal for the control flip-flop is generated by the V.C.O board.

6-6-3. Delay Circuit

The heart of the delay circuit is a gateable 50 MHz oscillator - U22c and its associated components. U21a controls the start and stop sequence of U22c. The 50 MHz from U22c is routed to a 3 digit divide by N counter which consists of U18 and U29 through U31. The signal is then routed through U25b to a divide by 10n range counter which is formed by U12, U22 and U24. When all the outputs from the range counter turn logical “1", U13 and U14b enable the gate U7c which in turn permits transitions from U18 to pass through the propagation delay chain - DL7 through DL11 which then provides the stop pulse for the control flip-flop - U21a. The start signal for the control flip-flop is generated by the V.C.O board.

6-6-4. Auxiliary Output Buffer

The auxiliary output buffer may output either a TTL level or ECL level and is being controlled by the switch - Q3 and Q6 and their associated components. The output buffer comprises Q4, Q5 and emitter followers Q7 through Q10 and their associated components.

6-7. OUTPUT AMPLIFIER - CHANNELS A&B

Output amplifier boards A and B are exactly identical. The output amplifier generates the required power for driving high frequency pulses into a impedance of 50 ohms. The output amplifier board contains: ECL Line receiver, positive and negative level shifters, positive and negative current switches, attenuator, offset generator and amplitude controller. The following paragraphs contain a description of the output amplifier board. Figure 6-3 is a simplified block diagram of the output amplifier board. Its circuit and components location drawing may be found at the end of this manual.

6-7-1. ECL Line Receiver

The ECL Line receiver transfers the signal from the pulse width/delay board to the level shifters. The ECL receiver is composed of U8 and its associated components.

6-7-2. Positive/Negative Level Shifter

The positive/negative level shifters are driven from the output of the ECL line receiver. The positive and the negative shifting circuits supply the necessary levels for the positive and negative switches respectively. U8 supplies the signal to the positive level shifter through zener diodes CR2 and CR4 to the emitter coupled transistors Q2 and Q3. The collector of Q3 is buffered by Q6 before it is applied to the positive current switch. The current into the positive level shifter is applied through R24 and R25 from the amplitude controller.

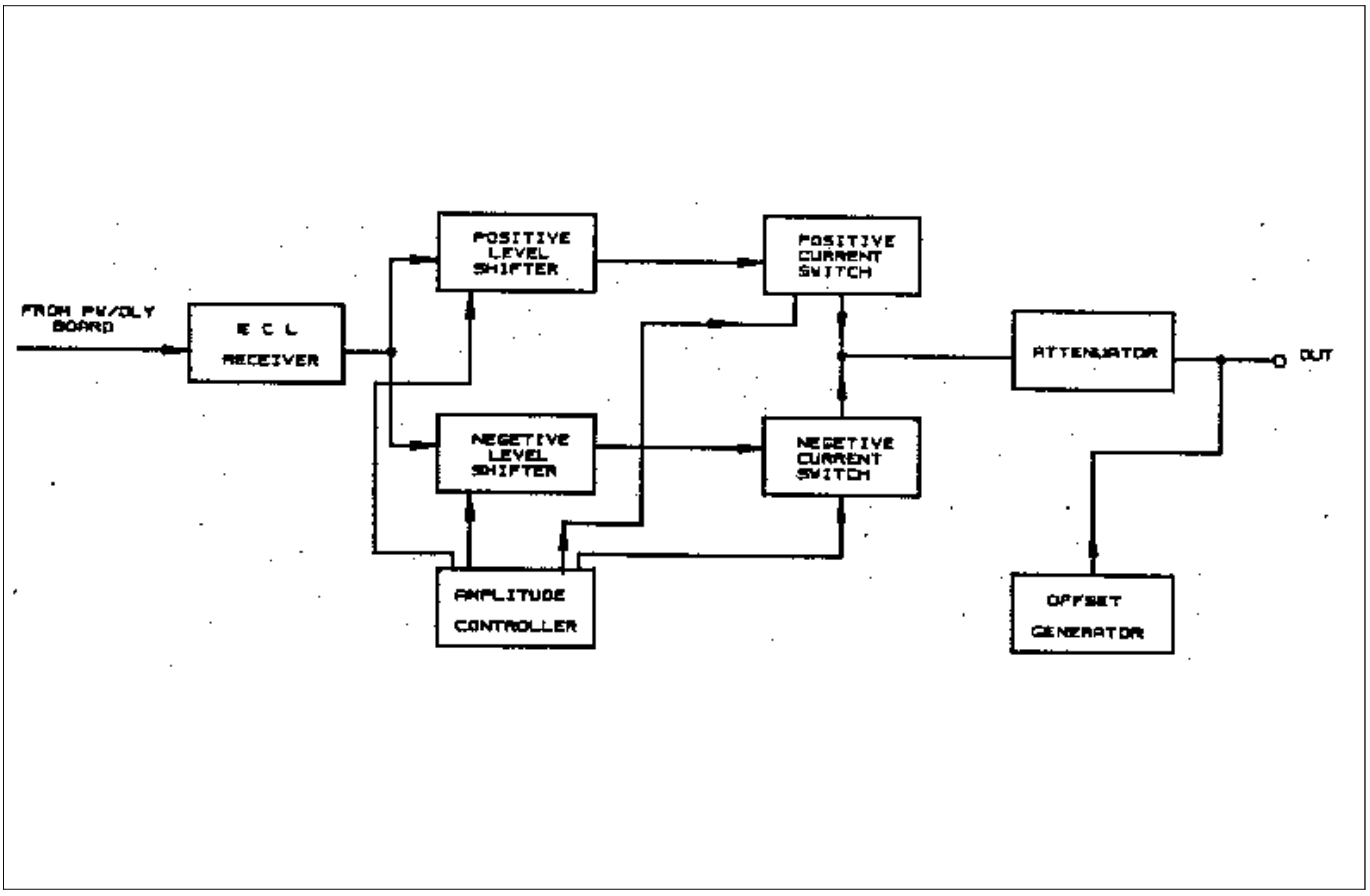
Consequently, U8 supplies the signal to the negative level shifter through zener diodes CR3 and CR5 to the emitter coupled transistors Q4 and Q5. The collector of Q5 is buffered by Q7 before it is applied to the negative current switch. The current into the negative level shifter is applied through R26 and R27 from the amplitude controller.

6-7-3. Positive/Negative Current Switches

The positive and the negative current switches switch in and out positive and negative currents. The currents are supplied from the amplitude controller circuit through L1 and L2. The magnitude of the currents through L1 and L2 are equal but opposite in direction. The current through L1 and L2 then determine the amplitude of the pulse at the output connector, not including attenuation.

The positive current switch comprises Q8, Q9 and their associated components. Consequently, the negative current switch comprises Q10, Q11 and their associated components.

Figure 6-3. Output Amplifier Simplified Block Diagram.



6-7-4. Offset Generator

The offset is generated by the D/A U5 and operational amplifiers U14 U15 and U16, Q14, Q15, Q25 and Q26 and their associated components and is applied to the power amplifier through a network made of L5, and L6 in parallel to R86. Voltage reference for the offset generator is supplied from CR1. The voltage reference is supplied to a D/A converter which is composed of U5 and operational amplifier U6a and U6b. The digital information is supplied to the D/A converter through serial to parallel converters U2 and U3.

The offset is amplified and buffered before it is applied to the output. The offset amplifier is composed of U14 through U16, Q25, Q26, Q14, Q15 and their associated components.

6-7-5. Amplitude Control

The amplitude control generates the necessary currents which in turn control the pulse amplitude at the output connector. The amplitude is digitally control by a D/A converter U4. The digital information is converted from serial information to parallel bits by U1 and U4 and is then applied to U4.

Operational amplifiers U7b, U12 and U13 and transistors Q1, Q22, Q12, Q13 and their associated components convert the signal from the D/A output to precise currents which are applied to the positive and negative switches. Q12 drives the negative current switch while Q13 drives the positive current switch.

Operational amplifiers U7a, U9, U10 and U11 and transistors Q16, Q19, Q17, Q20 and their associated components convert the signal from the D/A output to precise currents which are applied to the positive and negative level shifters. Q17 drives the negative level shifter while Q20 drives the positive level shifter. Q18 and Q21 are connected as current sources for compensation at the current switches.

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SECTION 7

ADJUSTMENTS

7-1. INTRODUCTION

This section contains information necessary to adjust the Model 8600 and the Channel B output amplifier (option 1).

WARNING

The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

7-2. ADJUSTMENTS

7-2-1. Environmental Conditions

Adjustments should be performed under laboratory conditions having an ambient temperature of 25 deg +/-5 deg C and a relative humidity of less than 70 %. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

7-2-2. Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure long-term calibration accuracy, turn on the power to the Model 8600 and allow it to warm-up for at least 30 minutes before beginning the adjustment procedure.

7-2-3. Recommended Test Equipment

Recommended test equipment for calibration is listed in Table 5-2. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

7-2-4. Adjustment Procedures

All adjustments are performed with the POWER switch ON. The top cover should be removed to allow access to test points and adjustments. Between adjustments, always leave top cover on the unit to keep internal temperature.

WARNING

Take special care to prevent contact with live circuits or power line area which could cause electrical shock resulting in serious injury or death. Use an isolated tool when making adjustments. Use plastic or nylon screw-driver when adjusting the time base trimmer as other material will cause confusion in this adjustment.

Refer to the schematic and components location drawings at the end of this manual, throughout the following adjustment procedures. Adjustment points are highlighted on the components location diagrams. Follow this procedure in the sequence indicated because some of the adjustments are interrelated and dependent on the proceeding steps.

Verify that Model 8600 is functioning according to the performance checks. Make sure that all results are within, or close to, the range of the required specifications, otherwise troubleshoot the instrument and correct the fault.

Center all trimmers and if necessary, remove selected components and clear the holes to allow a selection of new components.

Perform the following adjustment procedure. Adjustments can not be made to obtain a specific result if other problem exists within the instrument.

7-3. ADJUSTMENT PROCEDURE

Model 8600 has a special function which down-loads the required front panel set-ups for the various adjustment procedures. To use this function depress the [SHIFT] push-button and then [6]. No readout indication will follow. The non-volatile memory is now loaded with front panel set-ups which can now be used for the following adjustment procedures.

In the following, each procedure is associated with one memory location. Recalling a set-up will automatically update front panel parameters for the required procedure. No other set-up information will be given. To recall a particular set-up, use the procedure which is given in Section 3-9-2 or 3-9-2-1 of this manual.

WARNING

The memory down-load function will override previous front panel set-ups. Before using this function be absolutely certain that information which is stored in the non-volatile memory is no longer required.

7-3-1. TRIGGER INPUT SENSITIVITY ADJUSTMENT

Equipment: Pulse/Function generator (8201), Oscilloscope (2465A)

Procedure: Performed on V.C.O board assembly

1. Set 8201 controls as follows:

Output	Sinewave
Frequency	1 KHz
Amplitude	500 mVp-p
Offset	0 V
Symmetry	50 %

2. Connect the test instruments as described in Figure 7-1.
3. Recall memory, set oscilloscope and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED SCOPE READING
1	00	V.C.O R7	Rectangular wave with 50% +/-5% duty cycle

7-3-2. Trigger Input H.F Compensation Adjustment

Equipment: Pulse/Function generator (8201), Oscilloscope (2465A), 2 Extension cables, x10 Probe
Procedure: Performed on V.C.O board assembly

1. Remove the V.C.O board assembly from the cage and connect to the main board through the extension cables. Make sure that all plugs are connected correctly and no pins are left open.

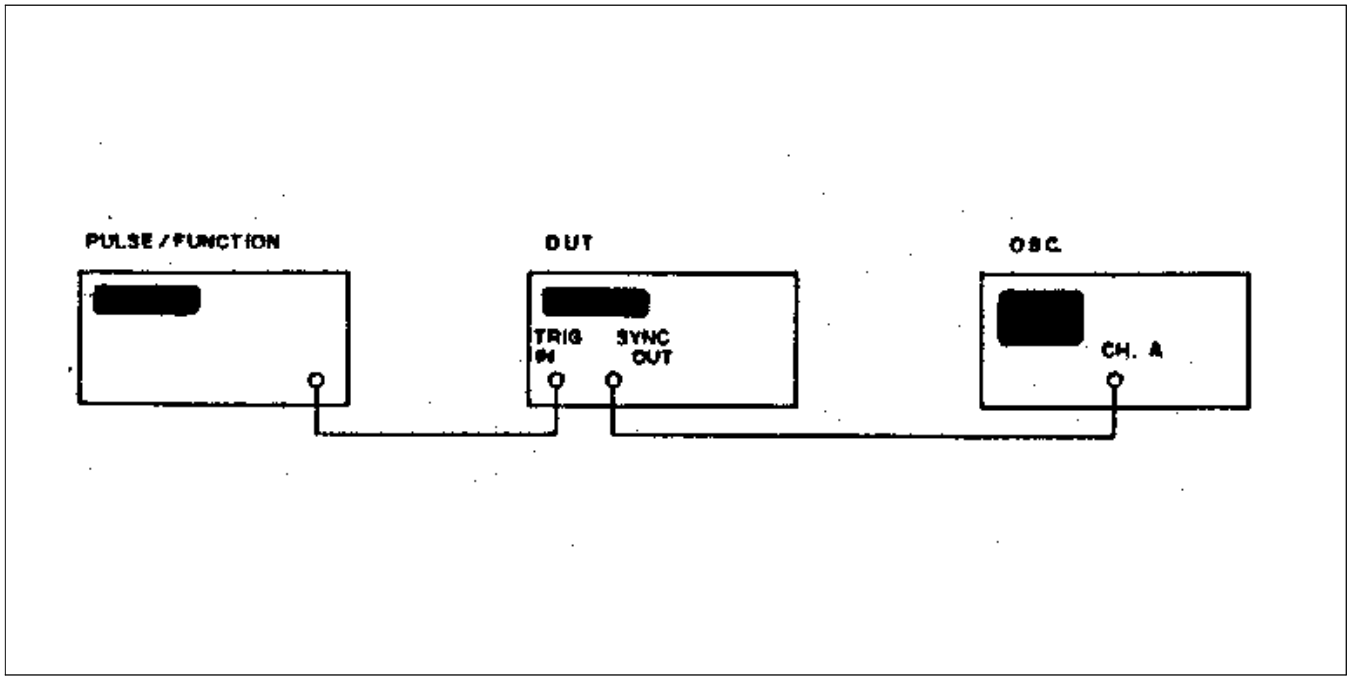

Figure 7-1. Trigger Input Sensitivity Adjustment.

2. Set 8201 controls as follows:

Output	Squarewave
Frequency	100 KHz
Amplitude	1 Vp-p
Offset	0 V
Symmetry	50 %

3. Connect the x10 probe to U15 pin 5. Connect the ground terminal to U15 pin 1.
4. Recall memory, set oscilloscope and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED SCOPE TRACE
2	00	V.C.O C46	Rectangular wave with min over/under shoots

7-3-3 Reference Oscillator Adjustment

Equipment: 10 MHz standard

Procedure: Performed on C.P.U board assembly

1. Connect the 10 MHz standard to the 8600 TRIG/COUNTER INPUT.
2. Recall memory and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED READING
3	00	C.P.U C11	10.00000MHz +/-100Hz

7-3-4. Period Adjustment

Equipment: Counter (6020)
Procedure: Performed on V.C.O board assembly

1. Rotate trimmers as follows. Leave the rest untouched:

R3	Midway
R4	Fully clockwise
R5	Fully counterclockwise

2. Connect Model 8600 output A to counter channel A input and set counter controls as follows:

Function	Period averaged
Gate time	100 mS
Trigger	level 0.00 V
Impedance	50 ohms
Displayed	digits 4

3. Recall memories and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED COUNTER READING
4	01	V.C.O R1	500.0 nS +/-2 nS
5	02	V.C.O R4	210.0 nS +/-1 nS
6		Repeat steps 4-5	
7	03	V.C.O R3	1.900 uS +/-2 nS
8		Repeat steps 4-7	
9	04	V.C.O R2	190.0 nS +/-.5 nS
10	05	V.C.O R5	30.00 nS +/-.1 nS
11		Repeat steps 9-10	

7-3-5 First Period Adjustment

Equipment: Pulse/Function generator (8201), Oscilloscope (2465A)
Procedure: Performed on V.C.O board assembly

1. Set 8201 frequency output to 100 KHz.
2. Connect the test instruments as described in Figure 7-2.
3. Recall memory, set oscilloscope to positive trigger, synchronize on Channel B and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED SCOPE TRACE
12	01	V.C.O R6	First period 500nS +/-5nS

4. Change 8201 frequency to 1 MHz
5. Recall memory, change oscilloscope setting to x10 and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED SCOPE TRACE
13	05	V.C.O C40	First period 30nS +/-1nS

7-3-6 Pulse Width Adjustment

Equipment: Counter (6020)
Procedure: Performed on Pulse Width/Delay board assembly

1. Set counter to Pulse Width Averaged measurements and connect 8600 OUTPUT A to counter. Use 50 ohms feedthrough termination at the counter input.
2. Recall memory and perform adjustments as described in the following table.

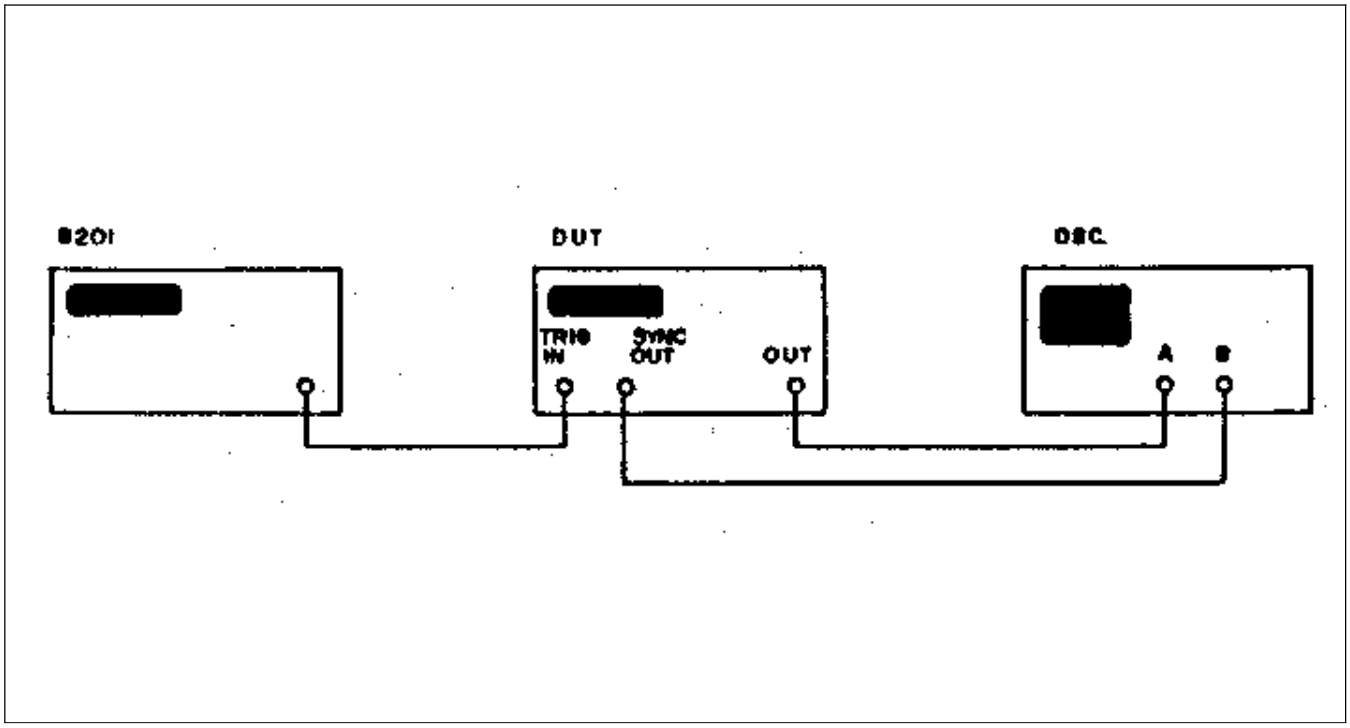

Figure 7-2. First Period Adjustment

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED COUNTER READING
14	06	P/W A C21	3.999 mS +/-10 uS

3. If Channel B (option 1) is installed, perform step 14 on pulse width/delay B board assembly.

7-3-7 Delay Adjustment

Equipment: Counter (6020)
Procedure: Performed on Pulse Width/Delay board assembly

1. Set counter to Time Interval A to B measurements.
2. Connect 8600 SYNC OUTPUT connector to Channel A on the counter. Connect 8600 OUTPUT A connector to Channel B on the counter. Use 50 ohms feedthrough termination at the counter input.
3. Recall memory and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	ADJ. READING
15	06	DLY A C25	3.999 mS +/-10 uS

3. If Channel B (option 1) is installed, perform step 15 on pulse width/delay B board assembly.

7-3-8. Amplitude Adjustment - Channels A and B

Equipment: DMM (4121), 50 ohms feedthrough terminator
Procedure: Performed on output amplifier board assembly. The same procedure is used for both channels A and B.

1. Set DMM to ACV measurement and to 20 V range.
2. Connect 8600 Channel A output to the DMM.
3. Recall memory and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED DMM READING
16	07	OUT A R6	+2.500 V +/-10 mV

7-3-9. Pulse Response Adjustment Channels A and B

Equipment: Oscilloscope (2465A), DMM, x10 attenuator (50 ohms)
Procedure: Performed on output amplifier board assembly. The same procedure is used for both channels A and B.

1. Connect 8600 OUTPUT A to oscilloscope input through a x10 attenuator and set oscilloscope input impedance to 50 ohms.
2. Set R8 and R9 at mid-position.
3. Recall memory, set oscilloscope and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED SCOPE TRACE
17	08	OUT A R9	Best pulse response
18	09	OUT A R8	Best pulse response
19	10	OUT A C37	Best pulse response

7-3-10. Output Offset Adjustment Channels A and B

Equipment: DMM, 50 ohms feedthrough termination
Procedure: Performed on Output Amplifier A board assembly. The same procedure is used for both channels A and B.

1. Set DMM to DCV function and 20 V range.
2. Connect 8600 OUTPUT A to DMM input. Terminate DMM input with a 50 ohms termination.
3. Recall memory and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED DMM READING
20	11	OUT A R7	+4.750 V +/-50 mV
21	12	OUT A R7	-4.750 V +/-50 mV

7-3-11. System Delays Adjustment

Equipment: Oscilloscope (2465A), Two identical BNC cables
Procedure: Performed on V.C.O board assembly

1. Connect the test instruments as described in Figure 7-3.
2. Set both oscilloscope inputs to 50 ohms impedance. Set oscilloscope time base to 5 nS/div. Display traces of both channels. Synchronize oscilloscope on Channel B and trigger on positive edge.
3. Recall memory, set oscilloscope and perform adjustments as described in the following table.

STEP	RECALL SET-UP	ADJ. CONTROL	REQUIRED SCOPE TRACE
22	13	V.C.O C72	Delay SYNCto OUT 0 nS +/-0.5 nS

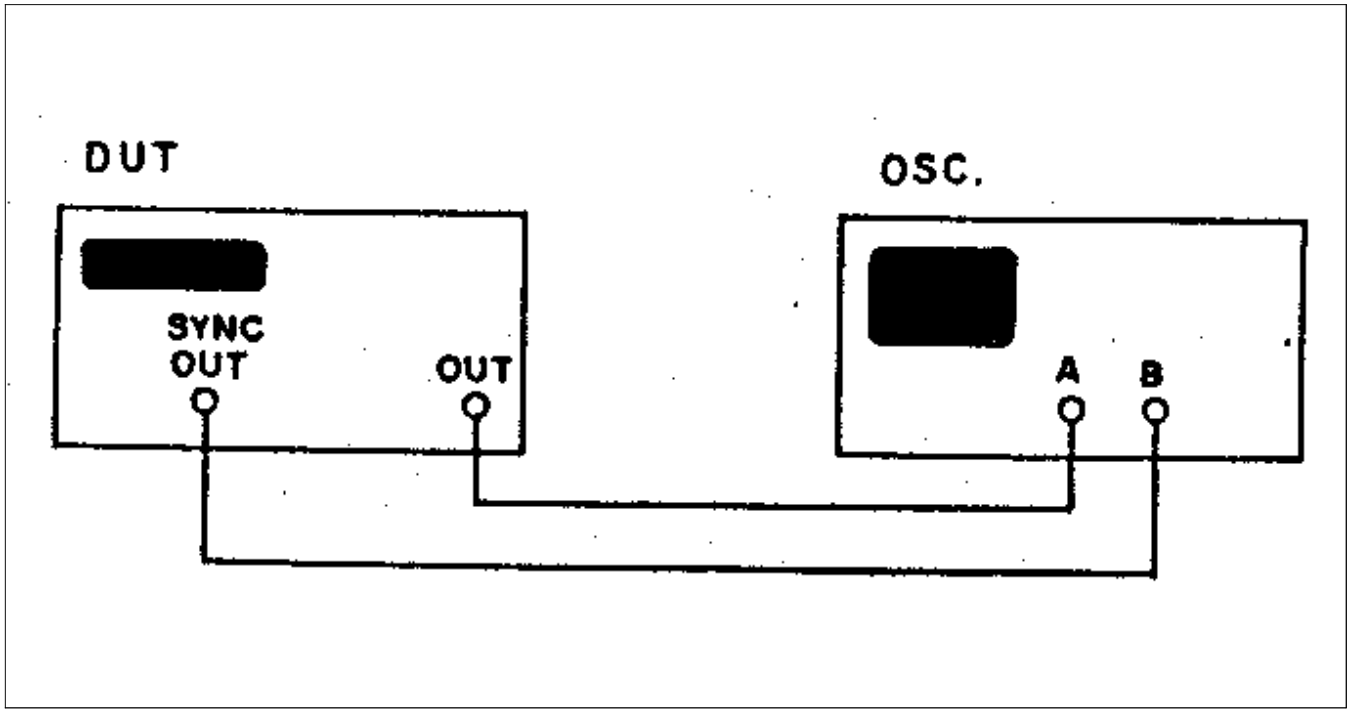

Figure 7-3. System Delays Adjustment.

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SECTION 8

PARTS LIST

8.1 GENERAL

This section contains information for ordering replacement parts. the replacement parts are available from the vendors listed or from Tabor Electronics. Mechanical parts are shown separately on Figure 8-1.

8.2 ORDERING INFORMATION

When ordering replacement parts, always include the following information:

a) Instrument Model number.
b) Instrument Serial number.
c) Tabor part number.
d) Part description.
e) Circuit designation (where applicable).

8.3 PARTS DESCRIPTION

In the following Parts List Tables, unless otherwise noted, resistors power rating is 1/4W, resistance is given in ohms, and capacitance is given in F.

Matched or selected components may only be bought from the factory. Selection guides for such components are not given anywhere in this manual.

Table 8-1. Model 8600 Parts List - Power Supply Board Assembly

REF	PART#	DESCRIPTION	REF	PART#	DESCRIPTION
R1	0101-00R5A	RES COMP .5 1W	U5	0500-53500	VOLTAGE REGULATOR LM337T
R2	0100-01210	RES COMP 120	U6	0500-52100	VOLTAGE REGULATOR MC7815CP
R3	0100-01210	RES COMP 120	U7	0500-52800	VOLTAGE REGULATOR SG3525A
R4	0100-01010	RES COMP 100			
R5	0101-01020	RES COMP 1K 1/2W	CR1	0300-50100	DIODE BRIDGE WS005
R6	0100-01030	RES COMP 10K	CR2	0300-90500	DIODE MBR 1035
R7	0100-01020	RES COMP 1K	CR3	0300-20400	DIODE 1N758A 10 V
R8	0100-05630	RES COMP 56K	CR4	0300-90400	DIODE ICTE-5
R9	0100-03020	RES COMP 3K	CR5	0300-90600	DIODE 1N5821
R10	0104-49910	RES MTF 4.99K 1%	CR6	0300-90300	DIODESA-5A
R11	0104-49910	RES MTF 4.99K 1%			
R12	0104-49910	RES MTF 4.99K 1%	C1	1534-02280	CAP ELEC 2200 35V
R13	0104-15420	RES COMP 15.4K 1%	C2	1535-02270	CAP ELEC 220 50V
R14	0100-01020	RES COMP 1K	C3	1534-02280	CAP ELEC 2200 35V
R15	0100-02210	RES COMP 220	C4	1535-02270	CAP ELEC 220 50V
R16	0100-01010	RES COMP 100	C5	1534-03380	CAP ELEC 3300 35V
R17	0100-02220	RES COMP 2.2K	C6	1534-03380	CAP ELEC 3300 35V
R18	0100-05630	RES COMP 56K	C7	1535-02270	CAP ELEC 220 50V
R19	0100-03020	RES COMP 3K	C8	1535-01081	CAP ELEC 1000 40V
R20	0104-49910	RES MTF 4.99K 1%	C9	1532-0228B	CAP ELEC 2200 16V
R21	0104-49910	RES MTF 4.99K 1%	C10	1540-01060	CAP TANT 10 25V
R22	0104-49910	RES MTF 4.99K 1%	C11	1500-02030	CAP CER 20n 20% 50V
R23	0104-49910	RES MTF 4.99K 1%	C12	1500-01040	CAP CER .1 -20+80% 50V
R24	0100-02210	RES COMP 220	C13	1534-03380	CAP ELEC 3300 35V
R25	0101-01R0A	RES COMP 1 1w	C14	1534-03380	CAP ELEC 3300 35V
			C15	1535-02270	CAP ELEC 220 50V
U1	0500-52600	VOLTAGE REGULATOR MC7824CP	C16	1535-01081	CAP ELEC 1000 40V
U2	0500-52700	VOLTAGE REGULATOR MC7924CP	C17	1532-0228B	CAP ELEC 2200 16V
U3	0500-52500	VOLTAGE REGULATOR MC7915CP	C19	1500-02030	CAP CER 20n 20% 50V
U4	0500-52800	VOLTAGE REGULATOR SG3525A	C20	1500-01040	CAP CER .1 -20+80% 50V

Table 8-1. Model 8600 Parts List - Power Supply Assembly (continued)

REF	PART#	DESCRIPTION	REF	PART#	DESCRIPTION
C21	1533-01070	CAP ELEC 100 25V	F1	1100-12900	FUSE 1.6A FAST BLOW
Q1	0500-53800	TSTR D44H5	F2	1100-11300	FUSE 0.5A FAST BLOW
Q4	0500-53900	TSTR D45H5	L1	2500-02800	COIL 200u
Q2	0400-40100	TSTR 2N2219A	L2	2500-02850	COIL 1m
Q3	0400-01340	TSTR 2N3906A	J1	3000-30520	CON FEMALE 2x8
Q5	0400-01340	TSTR 2N3906A	J2	3000-30520	CON FEMALE 2x8

Table 8-2. Model 8600 Parts List - C.P.U Board Assembly

REF	PART#	DESCRIPTION	REF	PART#	DESCRIPTION
U1	0500-20700	P8279	R3	0100-01520	RES COMP 1.5K
U2	0510-02700	74LS138	R4	0100-01010	RES COMP 100
U3	0520-07300	74HC4049	R6	0100-01020	RES COMP 1K
U4	0500-21410	P8031	R7	0100-01020	RES COMP 1K
U5	0520-07100	74HCT4040	R8	0100-08210	RES COMP 820
U6	0510-03650	74LS373	R9	0100-08210	RES COMP 820
U7	0500-21240	27256-250nSEC	R10	0100-08210	RES COMP 820
U8	0500-11160	MK48ZO2B	R11	0100-01020	RES COMP 1K
U9	0550-00200	32BIT COUNTER LS 7060	R12	0100-01020	RES COMP 1K
U10	0550-00200	32BIT COUNTER LS 7060	R13	0100-01020	RES COMP 1K
U11	0500-12750	74F158	R14	0100-01020	RES COMP 1K
U12	0500-12600	74F74	R15	0104-15020	RES MF 15K 1%
U13	0800-70000	OSCILLATOR 10MHZ 10PPM	R16	0203-0103A	10K TRIM
U14	0500-21300	P8291A	R18	0104-63410	RES MF 6.34K 1%
U15	0500-21520	BUFFER DS75161N	R19	0100-01020	RES COMP 1K
U16	0500-21510	BUFFER DS75160N	R20	0104-75010	RES MF 7.5K 1%
U17	0500-11600	BUFFER 9668	R21	0104-75010	RES MF 7.5K 1%
U18	0520-07300	74HC4049	R22	0100-08210	RES COMP 820
U19	0510-02700	74LS138	R23	0100-01020	RES COMP 1K
U20	0560-00500	D/A CONV AD558KD			
U21	0560-00500	D/A CONV AD558KD	C1	1500-01040	CAP CER .1 -20+80% 50V
U22	0500-56500	LM1458N	C2	1500-01040	CAP CER .1 -20+80% 50V
			C3	1540-03350	CAP TANT 3.3 25V
Y1	0800-30000	CRYSTAL 10MHZ C.T.S	C4	1500-01040	CAP CER .1 -20+80% 50V
SP1	0900-01900	BEEPER AT-02	C5	1500-01040	CAP CER .1 -20+80% 50V
L1	0600-03310	COIL 330 UH 2500-04 DEL.	C6	1500-01040	CAP CER .1 -20+80% 50V
LK1	3000-40610	CON JUMPER	C7	1500-01040	CAP CER .1 -20+80% 50V
LK1A	3000-30200	CON 75160-315	C8	1500-01040	CAP CER .1 -20+80% 50V
			C9	1500-01040	CAP CER .1 -20+80% 50V
RN1	0109-01500	RES NET MDP-16-03-150G	C10	1500-01040	CAP CER .1 -20+80% 50V
			C12	SELECTED	
Q1	0400-01810	TSTR 2N4401	C13	1500-01040	CAP CER .1 -20+80% 50V
Q2	0400-01200	TSTR 2N3904A	C14	1500-01040	CAP CER .1 -20+80% 50V
Q3	0400-01200	TSTR 2N3904A	C15	1500-01040	CAP CER .1 -20+80% 50V
Q4	0400-01200	TSTR 2N3904A	C16	1500-01040	CAP CER .1 -20+80% 50V
Q5	0400-01340	TSTR 2N3906A	C17	1531-04770	CAP ELEC 470 6V
Q6	0400-01340	TSTR 2N3906A	C18	1500-01040	CAP CER .1 -20+80% 50V
Q7	0400-01340	TSTR 2N3906A	C19	1500-01040	CAP CER .1 -20+80% 50V
Q8	0400-01340	TSTR 2N3906A	C21	1500-01040	CAP CER .1 -20+80% 50V
Q9	0400-01340	TSTR 2N3906A	C11	1550-0180A	CAP VAR 5-18P NPO
CR1	0300-00400	DIODE 14151	J1	3000-30520	CON FEMALE 2X8
CR2	0300-21100	DIODE REF 1825A	J2	3000-30520	CON FEMALE 2X8
			J3	3000-30260	CON MALE 2X10
R1	0100-03320	RES COMP 3.3K	J4	3000-30270	CON MALE 2X12
R2	0100-01030	RES COMP 10K			

Table 8-3. Model 8600 Parts List - V.C.O Board Assembly (continued)

REF	PART#	DESCRIPTION
U1	0500-90900	ANALOG SW DG211CJ
U2	0500-53400	OP AMP LN308A
U3	0500-56500	DUAL OP AMP LM1458N
U4	0500-56500	DUAL OP AMP LM1458N
U5	0500-60600	AD9685BD
U6	0500-40920	ECL TO TTL MC10125P
U7	0500-40930	ECL DIVIDER MC10138P
U8	0500-40950	ECL XOR/XNOR MC10107P
U9	0500-40900	ECL NOR 10102
U10	0500-45100	ECL OR/NOR GATE MC10H105P
U11	0500-40900	ECL NOR 10102
U12	0500-40910	ECL OR/NOR GATE MC10105P
U13	0500-40900	ECL NOR 10102
U14	0500-40900	ECL NOR 10102
U15	0500-41100	LINE REC 10216
U16	0560-00800	D/A CONVERTOR AD7541AJN
U17	0510-04900	74LS490
U18	0510-04900	74LS490
U19	0510-02650	74LS133
U20	0510-04900	74LS490
U21	0510-01100	74LS74
U22	0510-00100	74LS00
U23	0500-45600	ECL 10HO16
U24	0500-41200	ECL FLIP-FLOP 10131
U25	0500-45600	ECL 10HO16
U26	0500-40850	ECL 10109
U27	0500-45600	ECL 10HO16
U28	0500-45600	ECL 10HO16
U29	0500-56500	DUAL OP AMP LM1458N
U30	0540-01100	SHIFT REGISTER CD4094B
U31	0540-01100	SHIFT REGISTER CD4094B
U32	0540-01100	SHIFT REGISTER CD4094B
U33	0540-01100	SHIFT REGISTER CD4094B
U34	0540-01100	SHIFT REGISTER CD4094B
U35	0540-01100	SHIFT REGISTER CD4094B
U36	0540-01100	SHIFT REGISTER CD4094B
Q1	0400-40800	TSTR 2N4959
Q2	0400-40600	TSTR MRF 904
Q3	0400-40600	TSTR MRF 904
Q4	0400-00700	TSTR BFY 90
Q5	0400-00700	TSTR 2N5179
Q6	0400-00700	TSTR 2N5179
Q7	0400-00700	TSTR 2N5179
Q8	0400-40600	TSTR MRF 904
Q9	0400-40600	TSTR MRF 904
Q10	0400-01200	TSTR 2N3904A
Q11	0400-01340	TSTR 2N3906A
Q12	0400-00700	TSTR 2N5179
Q13	0400-00700	TSTR 2N5179
Q14	0400-01200	TSTR 2N3904A
Q15	0400-00700	TSTR 2N5179
Q16	0400-00700	TSTR 2N5179
Q17	0400-00750	TSTR 2N5771
Q18	0400-00750	TSTR 2N5771
Q19	0400-01200	TSTR 2N3904A
Q20	0400-01340	TSTR 2N3906A
Q21	0400-00700	TSTR 2N5179

REF	PART#	DESCRIPTION
CR1	0300-21100	DIODE REF 1N825A
CR2	0300-20900	DIODE ZENER 1N749A
CR3	0300-20900	DIODE ZENER 1N749A
CR4	0300-10300	DIODE 5082-2835
L1	0600-03330	COIL 3.3 1537-24
L2	0600-03330	COIL 3.3 1537-24
L3	0600-0R100	0.1m
L7	4200-00000	BEAD
R1	0203-0502A	RES VAR 5K 3386W
R2	0203-0502A	RES VAR 5K 3386W
R3	0203-0103A	RES VAR 10K 3386F
R4	0203-0100A	RES VAR 10 3386W
R5	0203-0202A	RES VAR 2K 3386W
R6	0203-0102A	RES VAR 1K 3386W
R7	0203-0103A	RES VAR 10K 3386F
R8	0104-20040	RES MTF 2M 1%
R9	0100-01510	RES COMP 150
R10	0104-40200	RES MTF 402 1%
R11	0100-02230	RES COMP 22K
R12	0100-01020	RES COMP 1K
R13	0102-05610	RES COM 560 1/8W
R14	0102-05600	RES COMP 56 1/8W
R15	0104-49R90	RES MTF 49.9 1%
R16	0104-4R020	RES MTF 4.02 1%
R17	0104-14010	RES MTF 1.4K 1%
R18	0104-10020	RES MTF 10K 1%
R19	0100-02710	RES COMP 270
R20	0100-03300	RES COMP 33
R21	0100-02710	RES COMP 270
R22	0100-03300	RES COMP 33
R23	0102-03900	RES COMP 39 1/8W
R24	0102-02210	RES COMP 220 1/8W
R25	0100-03300	RES COMP 33
R26	0100-03300	RES COMP 33
R27	0102-05600	RES COMP 56 1/8W
R28	0100-03310	RES COMP 330
R29	0100-03310	RES COMP 330
R30	0104-20010	RES MTF 2K 1%
R31	0104-11500	RES MTF 115 1%
R32	0100-07510	RES COMP 750
R33	0104-33210	RES MTF 3.32K 1%
R34	0104-18210	RES COMP 1.82K 1%
R35	0104-18210	RES COMP 1.82K 1%
R36	0100-01010	RES COMP 100
R37	0104-20000	RES MTF 200 1%
R38	0104-10020	RES MTF 10K 1%
R39	0104-49900	RES MTF 499 1%
R40	0104-49910	RES MTF 4.99K 1%
R41	0102-01010	RES COMP 100 1/8W
R42	0100-01010	RES COMP 100
R43	0104-17410	RES MTF 1.74K 1%
R44	0104-26100	RES MTF 261 1%
R45	0104-20000	RES MTF 200 1%
R46	0100-03300	RES COMP 33
R47	0104-49900	RES MTF 499 1%
R48	0104-49900	RES MTF 499 1%
R49	0100-03300	RES COMP 33
R50	0100-05610	RES COMP 560

Table 8-3. Model 8600 Parts List - V.C.O Board Assembly (continued)

REF	PART#	DESCRIPTION
R51	0100-05610	RES COMP 560
R52	0100-07510	RES COMP 750
R53	0100-01020	RES COMP 1K
R54	0100-03310	RES COMP 330
R55	0100-03310	RES COMP 330
R56	0100-09100	RES COMP 91
R57	0100-01040	RES COMP 100K
R58	0100-05610	RES COMP 560
R60	0100-03310	RES COMP 330
R61	0100-01010	RES COMP 100
R62	0100-05610	RES COMP 560
R63	0100-05610	RES COMP 560
R65	0100-03310	RES COMP 330
R66	0100-03310	RES COMP 330
R67	0100-05610	RES COMP 560
R68	0100-03310	RES COMP 330
R69	0100-09100	RES COMP 91
R70	0100-03300	RES COMP 33
R71	0100-05610	RES COMP 560
R72	0100-02010	RES COMP 200
R73	0100-03300	RES COMP 33
R74	0100-09100	RES COMP 91
R75	0100-09100	RES COMP 91
R76	0104-10000	RES MTF 100 1%
R77	0104-10000	RES MTF 100 1%
R78	0100-01010	RES COMP 100
R79	0100-08200	RES COMP 82
R80	0100-08200	RES COMP 82
R81	0100-01010	RES COMP 100
R82	0100-03310	RES COMP 330
R83	0100-09100	RES COMP 91
R84	0100-01010	RES COMP 100
R85	0100-05610	RES COMP 560
R86	0100-09100	RES COMP 91
R87	0100-09100	RES COMP 91
R88	0100-09100	RES COMP 91
R89	0100-09100	RES COMP 91
R90	0100-09100	RES COMP 91
R91	0100-09100	RES COMP 91
R92	0100-09100	RES COMP 91
R93	0100-05610	RES COMP 560
R94	0100-03310	RES COMP 330
R95	0100-01020	RES COMP 1K
R96	0100-03910	RES COMP 390
R97	0104-47010	RES MTF 4.7K 1%
R98	0100-03310	RES COMP 330
R99	0100-03310	RES COMP 330
R100	0100-03310	RES COMP 330
R101	0104-15020	RES MTF 15K 1%
R102	0104-19620	RES MTF 19.6K 1%
R103	0104-18230	RES MTF 182K 1%
R104	0104-60410	RES MTF 6.04K 1%
R105	0104-30100	RES MTF 301 1%
R106	0104-10020	RES MTF 10K 1%
R107	0104-10020	RES MTF 10K 1%
R108	0104-40200	RES MTF 402 1%
R109	0104-18210	RES COMP 1.82K 1%
R110	0104-33220	RES MTF 33.2K 1%
R111	0100-03310	RES COMP 330
R112	0100-03310	RES COMP 330
R113	0100-09100	RES COMP 91
R114	0100-03310	RES COMP 330
R115	0100-05610	RES COMP 560
R116	0100-05610	RES COMP 560
R117	0100-03310	RES COMP 330
R118	0100-05610	RES COMP 560
R119	0100-09100	RES COMP 91
R120	0100-09100	RES COMP 91
R121	0100-03310	RES COMP 330
R122	0100-05120	RES COMP 5.1K
R200	0104-15020	RES MTF 15K 1%
R201	0100-01010	RES COMP 100
R202	0100-08200	RES COMP 82
R203	0100-02020	RES COMP 2K
C1	1500-03300	CAP CER 33 P 20% 50V
C2	1500-01040	CAP CER .1 -20+80% 50V
C3	1500-01040	CAP CER .1 -20+80% 50V
C4	1500-01040	CAP CER .1 -20+80% 50V
C5	1500-01010	CAP CER 100 P 20% 50V
C6	1500-01040	CAP CER .1 -20+80% 50V
C7	1500-01040	CAP CER .1 -20+80% 50V
C9	1500-01040	CAP CER .1 -20+80% 50V
C11	1500-01040	CAP CER .1 -20+80% 50V
C13	1500-01040	CAP CER .1 -20+80% 50V
C14	1510-08200	CAP MICA 82P 10% 500V
C15	1510-08210	CAP MICA 820 P 10% 300V
C16	1560-01040	CAP CHIP .1 50V
C17	1560-01040	CAP CHIP .1 50V
C18	1500-01040	CAP CER .1 -20+80% 50V
C19	1500-01040	CAP CER .1 -20+80% 50V
C20	1500-01040	CAP CER .1 -20+80% 50V
C21	1500-01040	CAP CER .1 -20+80% 50V
C25	1500-01040	CAP CER .1 -20+80% 50V
C26	1500-01030	CAP CER 10n 20% 50V
C27	1500-01040	CAP CER .1 -20+80% 50V
C28	1500-01040	CAP CER .1 -20+80% 50V
C29	1500-01040	CAP CER .1 -20+80% 50V
C30	1500-01040	CAP CER .1 -20+80% 50V
C31	1500-01040	CAP CER .1 -20+80% 50V
C32	1500-01040	CAP CER .1 -20+80% 50V
C33	1500-01040	CAP CER .1 -20+80% 50V
C34	1500-01040	CAP CER .1 -20+80% 50V
C35	1500-01040	CAP CER .1 -20+80% 50V
C36	1500-01040	CAP CER .1 -20+80% 50V
C22	1500-01040	CAP CER .1 -20+80% 50V
C23	1500-01040	CAP CER .1 -20+80% 50V
C37	1500-01040	CAP CER .1 -20+80% 50V
C38	1500-01040	CAP CER .1 -20+80% 50V
C39	1500-01040	CAP CER .1 -20+80% 50V
C40	SELECTED	
C41	1500-01040	CAP CER .1 -20+80% 50V
C42	1500-01040	CAP CER .1 -20+80% 50V
C43	1500-04R70	CAP CER 4.7P 20% 50V
C44	1500-01040	CAP CER .1 -20+80% 50V
C45	1500-01040	CAP CER .1 -20+80% 50V
C46	1550-02000	CAP VAR 5-40P
C47	1500-01040	CAP CER .1 -20+80% 50V
C48	1500-01040	CAP CER .1 -20+80% 50V

Table 8-3. Model 8600 Parts List - V.C.O Board Assembly (continued)

REF	PART#	DESCRIPTION
C49	1500-01040	CAP CER .1 -20+80% 50V
C50	1500-01040	CAP CER .1 -20+80% 50V
C51	1500-01040	CAP CER .1 -20+80% 50V
C52	1500-01010	CAP CER 100 P 20% 50V
C53	1500-01040	CAP CER .1 -20+80% 50V
C54	1500-01040	CAP CER .1 -20+80% 50V
C55	1500-01040	CAP CER .1 -20+80% 50V
C56	1500-01040	CAP CER .1 -20+80% 50V
C57	1500-01040	CAP CER .1 -20+80% 50V
C58	1500-01040	CAP CER .1 -20+80% 50V
C59	1500-01040	CAP CER .1 -20+80% 50V
C60	1500-01040	CAP CER .1 -20+80% 50V
C61	1533-01070	CAP ELEC 100 25V
C62	1533-01070	CAP ELEC 100 25V
C63	1534-01070	CAP ELEC 100 40V
C64	1534-01070	CAP ELEC 100 0V
C65	1532-0107P	CAP ELEC 100 16V
C66	1532-0107P	CAP ELEC 100 16V
C67	1532-0107P	CAP ELEC 100 16V
C68	1500-04R70	CAP CER 4.7 P 20% 50V
C69	SELECTED	
C70	1500-05600	CAP CER 56P 20% 50V
C71	1500-01020	CAP CER 1n 20% 50V
C72	SELECTED	
C73	SELECTED	
J1	3000-30520	CON FEMALE 2X8-8200
J2	3000-30520	CON FEMALE 2X8-8200
J3	3000-16000	CON RF MALE JACKSON
J4	3000-16000	CON RF MALE JACKSON
DL1	0600-10500	DLY LINE 10nS
DL2	0600-10400	DLY LINE 8nS
DL3	0600-10400	DLY LINE 8nS
DL4	0600-10500	DLY LINE 10nS
J3A	3000-17000	CON RF FEMALE JACKSON

Table 8-4. Model 8600 Parts List - Pulse Width/Delay (A and B) Board Assembly

REF	PART#	DESCRIPTION
U1	0510-04900	74LS490
U2	0510-02650	74LS133
U3	0500-45000	ECL NOR MC10H102P
U4	0500-45000	ECL NOR MC10H102P
U5	0500-45100	ECL OR/NOR GATE MC10H105P
U6	0500-45000	ECL NOR MC10H102P
U7	0500-45000	ECL NOR MC10H102P
U8	0500-45000	ECL NOR MC10H102P
U9	0500-45100	ECL OR/NDR GATE MC10H105P
U10	0500-45000	ECL NOR MC10H102P
U11	0510-04900	74LS490
U12	0510-04900	74LS490
U13	0510-02650	74LS133
U14	0500-40860 ECL	10124
U15	0500-45500 ECL	10H109
U16	0500-45300 ECL	FLIP-FLOP MC10H131P
U17	0500-45100 ECL	OR/NOR GATE MC10H105P
U18	0500-45500 ECL	10H109
U19	0500-45300 ECL	FLIP-FLOP MC10H131P
U20	0500-45100 ECL	OR/NOR GATE MC10H105P
U21	0500-45300 ECL	FLIP-FLOP MC10H131P
U22	0510-04900	74LS490
U23	0500-20350	74S196
U24	0500-20350	74S196
U25	0500-40920	ECL TO TTL MC10125P
U26	0500-40970	MC10136P
U27	0500-40970	MC10136P
U28	0500-40970	MC10136P
U29	0500-40970	MC10136P
U30	0500-40970	MC10136P
U31	0500-40970	MC10136P
U32	0500-45100	ECL OR/NOR GATE MC10H105P
U33	0540-01100	SHIFT REGISTER CD4094B
U34	0540-01100	SHIFT REGISTER CD4094B
U35	0540-01100	SHIFT REGISTER CD4094B
U36	0540-01100	SHIFT REGISTER CD4094B
U37	0540-01100	SHIFT REGISTER CD4094B
U38	0540-01100	SHIFT REGISTER CD4094B
U39	0540-01100	SHIFT REGISTER CD4094B
U40	0540-01100	SHIFT REGISTER CD4094B
U41	0500-40950	ECL XOR/XNOR MC10107P
Q1	0400-01340	TSTR 2N3906A
Q2	0400-01340	TSTR 2N3906A
Q3	0400-02500	TSTR J109
Q4	0400-20050	TSTR BFW30
Q5	0400-20050	TSTR BFW30
Q6	0400-01200	TSTR 2N3904A
Q7	0400-00100	TSTR 2N3640
Q8	0400-00200	TSTR 2N3646
Q9	0400-01610	TSTR 2N3866A
Q10	0400-00800	TSTR 2N5160A
R1	0102-05610	RES COMP 560 1/8W
R2	0102-09100	RES COMP 91 1/8W
R3	0102-09100	RES COMP 91 1/8W
R4	0102-09100	RES COMP 91 1/8W
R5	0102-09100	RES COMP 91 1/8W
R6	0102-09100	RES COMP 91 1/8W
R7	0102-09100	RES COMP 91 1/8W
R8	0102-05610	RES COM 560 1/8W
R11	0102-03310	RES MTF 330 1/8W
R12	0102-05610	RES COM 560 1/8W
R13	0102-09100	RES COMP 91 1/8W
R14	0102-09100	RES COMP 91 1/8W
R15	0102-09100	RES COMP 91 1/8W
R16	0102-09100	RES COMP 91 1/8W
R17	0102-09100	RES COMP 91 1/8W
R18	0102-05610	RES COM 560 1/8W
R19	0102-03310	RES MTF 330 1/8W

Table 8-4. Model 8600 Parts List - Pulse Width/Delay (A and B) Board Assembly (continued)

REF	PART#	DESCRIPTION
R20	0102-09100	RES COMP 91 1/8W
R21	0102-05610	RES COM 560 1/8W
R22	0102-05610	RES COM 560 1/8W
R23	0102-05610	RES COM 560 1/8W
R24	0102-05610	RES COM 560 1/8W
R25	0102-05610	RES COM 560 1/8W
R26	0102-09100	RES COMP 91 1/8W
R28	0102-03310	RES MTF 330 1/8W
R29	0102-05610	RES COM 560 1/8W
R30	0100-09100	RES COMP 91
R31	0102-05610	RES COM 560 1/8W
R32	0102-05610	RES COM 560 1/8W
R33	0102-05610	RES COM 560 1/8W
R35	0102-03310	RES MTF 330 1/8W
R36	0102-09100	RES COMP 91 1/8W
R37	0102-05610	RES COM 560 1/8W
R38	0102-09100	RES COMP 91 1/8W
R39	0102-05610	RES COM 560 1/8W
R40	0102-05610	RES COM 560 1/8W
R41	0102-03310	RES MTF 330 1/8W
R42	0100-01020	RES COMP 1K
R43	0100-01020	RES COMP 1K
R44	0102-05610	RES COM 560 1/8W
R45	0102-05610	RES COM 560 1/8W
R46	0102-03310	RES MTF 330 1/8W
R47	0102-05610	RES COM 560 1/8W
R48	0102-05610	RES COM 560 1/8W
R49	0100-03310	RES COMP 330
R50	0102-05610	RES COM 560 1/8W
R51	0102-05610	RES COM 560 1/8W
R52	0102-05610	RES COM 560 1/8W
R53	0102-05610	RES COM 560 1/8W
R54	0102-05610	RES COM 560 1/8W
R55	0102-03310	RES MTF 330 1/8W
R56	0102-03310	RES MTF 330 1/8W
R57	0102-09100	RES COMP 91 1/8W
R58	0100-01810	RES COMP 180
R59	0102-09100	RES COMP 91 1/8W
R60	0102-05610	RES COM 560 1/8W
R61	0100-02220	RES COMP 2.2K
R62	0100-01810	RES COMP 180
R63	0100-05610	RES COMP 560
R64	0100-05610	RES COMP 560
R65	0100-01030	RES COMP 10K
R66	0100-01030	RES COMP 10K
R67	0100-01530	RES COMP 15K
R68	0100-01030	RES COMP 10K
R69	0100-02040	RES COM 200K
R70	0100-01820	RES COMP 1.8K
R71	0100-02200	RES COMP 22
R72	0100-02200	RES COMP 22
R73	0100-01010	RES COMP 100
R74	0104-71R5A	RES MTF 71.5 1% 1/2W
R75	0100-02210	RES COMP 220
R76	0104-16500	RES MTF 165 1%
R77	0100-01520	RES COMP 1.5K
R78	0100-01520	RES COMP 1.5K
R79	0100-01520	RES COMP 1.5K
R80	0100-01520	RES COMP 1.5K
R81	0100-03300	RES COMP 33

REF	PART#	DESCRIPTION
R82	0100-03300	RES COMP 33
R83	0104-5R620	RES MTF 5.62K 1%
R84	0104-5R620	RES MTF 5.62K 1%
R85	0100-03910	RES COMP 390
R86	0100-05610	RES COMP 560
R87	0100-03910	RES COMP 390
R88	0100-05610	RES COMP 560
R89	0104-43R20	RES MTF 43.2 1%
R90	0100-02220	RES COMP 2.2K
R91	0100-03910	RES COMP 390
R92	0100-05610	RES COMP 560
R93	0100-09100	RES COMP 91
R94	0100-08200	RES COMP 82
C1	1500-01040	CAP CER .1 -20+80% 50V
C2	1500-01040	CAP CER .1 -20+80% 50V
C3	1500-01040	CAP CER .1 -20+80% 50V
C4	1500-01040	CAP CER .1 -20+80% 50V
C5	1500-01040	CAP CER .1 -20+80% 50V
C6	1500-01040	CAP CER .1 -20+80% 50V
C7	1500-01040	CAP CER .1 -20+80% 50V
C8	1500-01040	CAP CER .1 -20+80% 50V
C9	1500-01040	CAP CER .1 -20+80% 50V
C10	1500-01040	CAP CER .1 -20+80% 50V
C11	1500-01040	CAP CER .1 -20+80% 50V
C12	1500-01040	CAP CER .1 -20+80% 50V
C13	1500-01040	CAP CER .1 -20+80% 50V
C14	1500-01040	CAP CER .1 -20+80% 50V
C15	1500-01040	CAP CER .1 -20+80% 50V
C16	1500-01040	CAP CER .1 -20+80% 50V
C17	1500-01040	CAP CER .1 -20+80% 50V
C18	1500-01040	CAP CER .1 -20+80% 50V
C19	1500-01040	CAP CER .1 -20+80% 50V
C20	1500-02700	CAP CER 27P 20% 63V
C21	1550-02700	CAP VAR 3.5-20P 5MM
C22	1500-01040	CAP CER .1 -20+80% 50V
C23	1500-01040	CAP CER .1 -20+80% 50V
C24	1500-02700	CAP CER 27P 20% 63V
C25	1550-02700	CAP VAR 3.5-20P 5MM
C26	1500-01040	CAP CER .1 -20+80% 50V
C27	1500-01040	CAP CER .1 -20+80% 50V
C28	1500-01040	CAP CER .1 -20+80% 50V
C29	1500-01040	CAP CER .1 -20+80% 50V
C30	1500-01040	CAP CER .1 -20+80% 50V
C31	1500-01040	CAP CER .1 -20+80% 50V
C32	1500-01040	CAP CER .1 -20+80% 50V
C33	1500-01040	CAP CER .1 -20+80% 50V
C34	1500-01040	CAP CER .1 -20+80% 50V
C35	1500-01040	CAP CER .1 -20+80% 50V
C36	1500-01040	CAP CER .1 -20+80% 50V
C37	1500-01500	CAP CER 15 P 20% 50V
C38	1533-01070	CAP ELEC 100 25V
C39	1533-01070	CAP ELEC 100 25V
C40	1533-01070	CAP ELEC 100 25V
C41	1533-01070	CAP ELEC 100 25V
C42	1500-01040	CAP CER .1 -20+80% 50V
C44	1500-01040	CAP CER .1 -20+80% 50V
C46	1500-01040	CAP CER .1 -20+80% 50V
C47	1500-01040	CAP CER .1 -20+80% 50V
C48	1510-06R20	CAP MICA 6.2P 10% 500V

Table 8-4. Model 8600 Parts List - Pulse Width/Delay (A and B) Board Assembly (continued)

REF	PART#	DESCRIPTION
C49	1500-01040	CAP CER .1 -20+80% 50V
C50	1500-01040	CAP CER .1 -20+80% 50V
C51	1500-01040	CAP CER .1 -20+80% 50V
C52	1500-01040	CAP CER .1 -20+80% 50V
C53	1500-01800	CAP CER 18P
C56	1500-01000	CAP CER 10P 20% 50V
C57	1500-01000	CAP CER 10P 20% 50V
C58	1500-01000	CAP CER 10P 20% 50V
C60	1500-01000	CAP CER 10P 20% 50V
C61	1500-01000	CAP CER 10P 20% 50V
C62	1500-01000	CAP CER 10P 20% 50V
C65	1500-01040	CAP CER .1 -20+80% 50V
DL1	0600-10100	DLY LINE 1nSEC
DL2	0600-10200	DLY LINE 2nSEC
DL3	0600-10300	DLY LINE 4nSEC
DL4	0600-10400	DLY LINE 8nSEC
DL5	0600-10400	DLY LINE 8nSEC
DL6	0600-10000	DLY LINE 7nSEC
DL7	0600-10100	DLY LINE 1nSEC
DL8	0600-10200	DLY LINE 2nSEC
DL9	0600-10300	DLY LINE 4nSEC
DL10	0600-10400	DLY LINE 8nSEC
DL11	0600-10000	DLY LINE 7nSEC
DL12	0600-10400	DLY LINE 8nSEC
DL13	0600-10300	DLY LINE 4nSEC
DL14	0600-10400	DLY LINE 8nSEC
DL15	0600-10400	DLY LINE 8nSEC
DL16	0600-10000	DLY LINE 7nSEC
DL18	0600-10500	DLY LINE 10NSEC
DL19	0600-10400	DLY LINE 8nSEC
J1	3000-30520	CON FEMALE 2 x 8
J2	3000-30520	CON FEMALE 2 x 8
J3	3000-16000	CON RF MALE
J3A	3000-17000	CON RF FEMALE

Table 8-5. Model 8600 Parts List - Output Amplifier (A and B) Board Assembly

REF	PART#	DESCRIPTION
C1	1533-01070	CAP ELEC 100 25V
C2	1533-01070	CAP ELEC 100 25V
C3	1533-01070	CAP ELEC 100 25V
C4	1533-01070	CAP ELEC 100 25V
C5	1533-01070	CAP ELEC 100 25V
C6	1533-01070	CAP ELEC 100 25V
C7	1500-01040	CAP CER .1 -20+80% 50V
C8	1500-01040	CAP CER .1 -20+80% 50V
C9	1500-01040	CAP CER .1 -20+80% 50V
C10	1500-01040	CAP CER .1 -20+80% 50V
C11	1500-01040	CAP CER .1 -20+80% 50V
C12	1500-01040	CAP CER .1 -20+80% 50V
C13	1500-01040	CAP CER .1 -20+80% 50V
C14	1500-01040	CAP CER .1 -20+80% 50V
C15	1500-01040	CAP CER .1 -20+80% 50V
C16	1540-0106A	CAP TANT 10 35V
C17	1500-01040	CAP CER .1 -20+80% 50V
C18	1500-01040	CAP CER .1 -20+80% 50V
C19	1500-01040	CAP CER .1 -20+80% 50V
C20	1540-0106A	CAP TANT 10 35V
C21	1540-0106A	CAP TANT 10 35V
C23	1500-01040	CAP CER .1 -20+80% 50V
C24	1500-01040	CAP CER .1 -20+80% 50V
C25	1540-0106A	CAP TANT 10 35V
C26	1500-01030	CAP CER 10n 20% 50V
C27	1500-01030	CAP CER 10n 20% 50V
C28	1560-01040	CAP CHIP .1 50V
C29	1560-01040	CAP CHIP .1 50V
C30	1500-01030	CAP CER 10n 20% 50V
C31	1500-01040	CAP CER .1 -20+80% 50V
C32	1500-01040	CAP CER .1 -20+80% 50V
C33	1500-01040	CAP CER .1 -20+80% 50V
C34	1500-01040	CAP CER .1 -20+80% 50V
C35	1500-01030	CAP CER 10n 20% 50V
C36	1500-01030	CAP CER 10n 20% 50V
CR1	0300-21100	DIODE REF 1N825A
CR2	0300-20200	DIODE ZENER 1N753A
CR3	0300-20110	DIODE ZENER 1N747A
CR4	0300-20200	DIODE ZENER 1N753A
CR5	0300-20110	DIODE ZENER 1N747A
CR6	0300-20800	DIODE ZENER 1N750A
CR7	0300-20800	DIODE ZENER 1N750A
CR8	0300-20400	DIODE ZENER 1N758A
CR9	0300-20400	DIODE ZENER 1N758A
CR10	0300-00400	DIODE 1N4151
CR11	0300-00400	DIODE 1N4151
J1	3000-16000	CON RF MALE JACKSON
K1	0900-00700	RELAY RZ-1
K2	0900-00700	RELAY RZ-1
L1	4200-00000	FERRITE BEAD 24 57-1355
L2	4200-00000	FERRITE BEAD 24 57-1355
L3	4200-00000	FERRITE BEAD 24 57-1355
L4	4200-00000	FERRITE BEAD 24 57-1355
L5	4200-00000	FERRITE BEAD 24 57-1355
L6	0600-03310	COIL 330uH 2500-04
L7	4200-00000	FERRITE BEAD 24 57-1355
Q1	0400-01200	TSTR 2N3904A
Q2	0400-00710	TSTR BFY-90
Q3	0400-00710	TSTR BFY-90
Q4	0400-00750	TSTR 2N5771
Q5	0400-00750	TSTR 2N5771
Q6	0400-50100	TSTR 2N4260
Q7	0400-20050	TSTR BFW30
Q8	0400-20400	TSTR NE 90115D
Q9	0400-20400	TSTR NE 90115D
Q10	0400-50000	TSTR 2N 5109
Q11	0400-50000	TSTR 2N 5109

Table 8-5. Model 8600 Parts List - Output Amplifier (A and B) Board Assembly (continued)

REF	PART#	DESCRIPTION
Q12	0400-40100	TSTR 2N2219A
Q13	0400-01500	TSTR 2N2905A
Q14	0400-01500	TSTR 2N2905A
Q15	0400-40100	TSTR 2N2219A
Q16	0400-01200	TSTR 2N3904A
Q17	0400-01200	TSTR 2N3904A
Q18	0400-01200	TSTR 2N3904A
Q19	0400-01340	TSTR 2N3906A
Q20	0400-01340	TSTR 2N3906A
Q21	0400-01340	TSTR 2N3906A
Q22	0400-01340	TSTR 2N3906A
Q23	0400-00750	TSTR 2N5771
Q24	0400-00200	TSTR 2N3646
Q25	0400-01340	TSTR 2N3906A
Q26	0400-01200	TSTR 2N3904A
Q27	0400-01200	TSTR 2N3904A
Q28	0400-01200	TSTR 2N3904A
R1	0104-49910	RES MTF 4.99K 1%
R2	0104-24920	RES MTF 24.9K 1%
R3	0100-01020	RES COMP 1K
R4	0104-24920	RES MTF 24.9K 1%
R5	0104-24920	RES MTF 24.9K 1%
R6	0203-0202A	RES VAR 2K 3386W
R7	0203-0202A	RES VAR 2K 3386W
R8	0203-0104A	RES VAR 100K 3386W
R9	0203-0104A	RES VAR 100K 3386W
R10	0104-10010	RES MTF 1K 1%
R11	0104-10020	RES MTF 10K 1%
R12	0104-10020	RES MTF 10K 1%
R13	0100-01310	RES COMP 130
R14	0100-08200	RES COMP 825 1%
R15	0100-05110	RES COMP 510
R16	0102-03300	RES COMP 33 1/8W
R17	0102-03300	RES COMP 33 1/8W
R18	0100-01020	RES COMP 1K
R19	0100-05110	RES COMP 510
R20	0100-05100	RES COMP 515 1%
R21	0104-71R50	RES MTF 71.5 1%
R22	0100-05100	RES COMP 515 1%
R23	0104-71R50	RES MTF 71.5 1%
R24	0100-02210	RES COMP 220
R25	0100-01810	RES COMP 180
R26	0100-02210	RES COMP 220
R27	0100-01810	RES COMP 180
R28	0100-01020	RES COMP 1K
R29	0100-05110	RES COMP 510
R30	0104-20000	RES MTF 200 1%
R31	0104-20000	RES MTF 200 1%
R32	0104-20000	RES MTF 200 1%
R33	0104-20000	RES MTF 200 1%
R34	0102-01000	RES COMP 10 1/8W
R35	0102-01000	RES COMP 10 1/8W
R36	0100-01000	RES COMP 10
R37	0100-01000	RES COMP 10
R38	0104-20000	RES MTF 200 1%
R39	0104-20000	RES MTF 200 1%
R40	0104-71R50	RES MTF 71.5 %
R41	0104-20000	RES MTF 200 1%
R42	0104-20000	RES MTF 200 1%
R43	0104-71R50	RES MTF 71.5 %

REF	PART#	DESCRIPTION
R44	0100-08210	RES COMP 820
R45	0100-08210	RES COMP 820
R46	0104-68120	RES MTF 68.1K 1%
R47	0104-18230	RES MTF 182K1%
R48	0104-56220	RES MTF 56.2K 1%
R49	0104-51110	RES MTF 5.11K 1%
R50	0104-56210	RES MTF 56.2K 1%
R51	0100-05120	RES MTF 5.11K 1%
R52	0104-2000A	RES MTF 200 1% 1/2W
R53	0104-40200	RES MTF 402 1%
R54	0104-49910	RES MTF 4.99K 1%
R55	0104-49910	RES MTF 4.99K 1%
R56	0100-05120	RES COMP 5.1K
R57	0104-2000A	RES MTF 200 1% 1/2W
R59	0104-56200	RES MTF 562 1%
R60	0104-10010	RES MTF 1K 1%
R61	0100-01030	RES COMP 10K
R62	0104-10R0A	RES MTF 10 1% 1/2W
R63	0100-01010	RES COMP 100
R64	0104-10010	RES MTF 1K 1%
R65	0100-01030	RES COMP 10K
R66	0104-10R0A	RES MTF 10 1% 1/2W
R67	0100-01010	RES COMP 100
R68	0104-10010	RES MTF 1K 1%
R69	0100-01030	RES COMP 10K
R70	0100-01020	RES COMP 1K
R71	0104-10R0A	RES MTF 10 1% 1/2W
R72	0100-01010	RES COMP 100
R73	0100-01010	RES COMP 100
R74	0100-01030	RES COMP 10K
R75	0100-01020	RES COMP 1K
R76	0104-10R0A	RES MTF 10 1% 1/2W
R77	0104-10010	RES MTF 1K 1%
R78	0100-05620	RES COMP 5.6K
R79	0100-05620	RES COMP 5.6K
R80	0104-30110	RES MTF 3.01K 1%
R81	0104-1000B	RES MTF 100 1% 1W
R82	0104-1000B	RES MTF 100 1% 1W
R83	0104-96R5A	RES MTF 96.5 1% 1W
R84	0104-71R5A	RES MTF 71.5 1/2W 1%
R85	0104-96R5A	RES MTF 96.5 1% 1W
R86	0100-03920	RES COMP 3.9K
U1	0540-01100	SHIFT REGISTER CD4094B
U2	0540-01100	SHIFT REGISTER CD4094B
U3	0540-01100	SHIFT REGISTER CD4094B
U4	0560-00700	10 BIT D/A AD7533JN
U5	0560-00700	10 BIT D/A AD7533JN
U6	0500-56500	DUAL OP AMP LM1458N
U7	0500-56500	DUAL OP AMP LM1458N
U8	0500-45200	LINE RECEIVER MC10H116P
U9	0500-56000	OP AMP LF13741
U10	0500-56500	DUAL OP AMP LM1458N
U11	0500-56500	DUAL OP AMP LM1458N
U12	0500-56500	DUAL OP AMP LM1458N
U13	0500-56500	DUAL OP AMP LM1458N
U14	0500-56310	OP AMP LM741C
U15	0500-56310	OP AMP LM741C
U16	0500-56310	OP AMP LM741C

Table 8-6. Model 8600 Parts List - Front Panel Board Assembly

REF	PART#	DESCRIPTION
U1	0510-02700	IC 74LS138
U2	0510-02700	IC 74LS138
U3	0510-02700	IC 74LS138
Q1	0400-01800	TSTR 2N4403
Q2	0400-01800	TSTR 2N4403
Q3	0400-01800	TSTR 2N4403
Q4	0400-01800	TSTR 2N4403
Q5	0400-01800	TSTR 2N4403
Q6	0400-01800	TSTR 2N4403
Q7	0400-01800	TSTR 2N4403
Q8	0400-01800	TSTR 2N4403
Q9	0400-01800	TSTR 2N4403
Q10	0400-01800	TSTR 2N4403
Q11	0400-01800	TSTR 2N4403
Q12	0400-01800	TSTR 2N4403
Q13	0400-01800	TSTR 2N4403
C1	1533-01070	CAP ELECT 100 25V
DS1 to DS7	1200-10800	7 SIGMENT DISPLAY HDSP 5501
DS8	1200-10100	LED HDSP 7507 +/-1
DS9	1200-10200	LED HDSP 7501 7 SEG
DS10	1000-00300	LED 3MM RED 5082-4480
DS11	1000-00700	LED RED MV 57124-18
DS12	1000-00700	LED RED MV 57124-18
DS13	1000-00700	LED RED MV 57124-18
DS14	1000-00300	LED 3MM RED 5082-4480
DS15	1000-00700	LED RED MV 57124-18
DS16	1000-00700	LED RED MV 57124-18
DS17	1000-00700	LED RED MV 57124-18
DS18	1000-00700	LED RED MV 57124-18
DS19	1000-00300	LED 3MM RED 5082-4480
DS20	1000-00700	LED RED MV 57124-18
DS21	1000-00700	LED RED MV 57124-18
DS22	1000-00700	LED RED MV 57124-18
DS23	1000-00300	LED 3MM RED 5082-4480
DS24	1000-00700	LED RED MV 57124-18
DS25	1000-00700	LED RED MV 57124-18
DS26	1000-00700	LED RED MV 57124-18
DS27	1000-00300	LED 3MM RED 5082-4480
DS28	1000-00700	LED RED MV 57124-18
DS29	1000-00700	LED RED MV 57124-18
DS30	1000-00700	LED RED MV 57124-18
DS31	1000-00300	LED 3MM RED 5082-4480
DS32	1000-00700	LED RED MV 57124-18
DS33	1000-00700	LED RED MV 57124-18
DS34	1000-00700	LED RED MV 57124-18
DS35	1000-00700	LED RED MV 57124-18
DS36	1000-00700	LED RED MV 57124-18
DS37	1000-00700	LED RED MV 57124-18
DS38	1000-00700	LED RED MV 57124-18
DS39	1000-00700	LED RED MV 57124-18
DS40	1000-00700	LED RED MV 57124-18
DS41	1000-00700	LED RED MV 57124-18
DS42	1000-00700	LED RED MV 57124-18
DS43	1000-00300	LED 3MM RED 5082-4480
S1- to S33	2000-61600	SW PUSH BUTTON
R1-	0100-02210	RES COMP 220
R13	0100-02210	RES COMP 220
R14	0100-02700	RES COMP 27
R15	0100-03300	RES COMP 33
J1	3000-40150	CON 20 PIN MALE
J1A	3000-40700	CON 20 PIN FEMALE

SECTION 9

SCHEMATIC DRAWINGS

List Of Figures

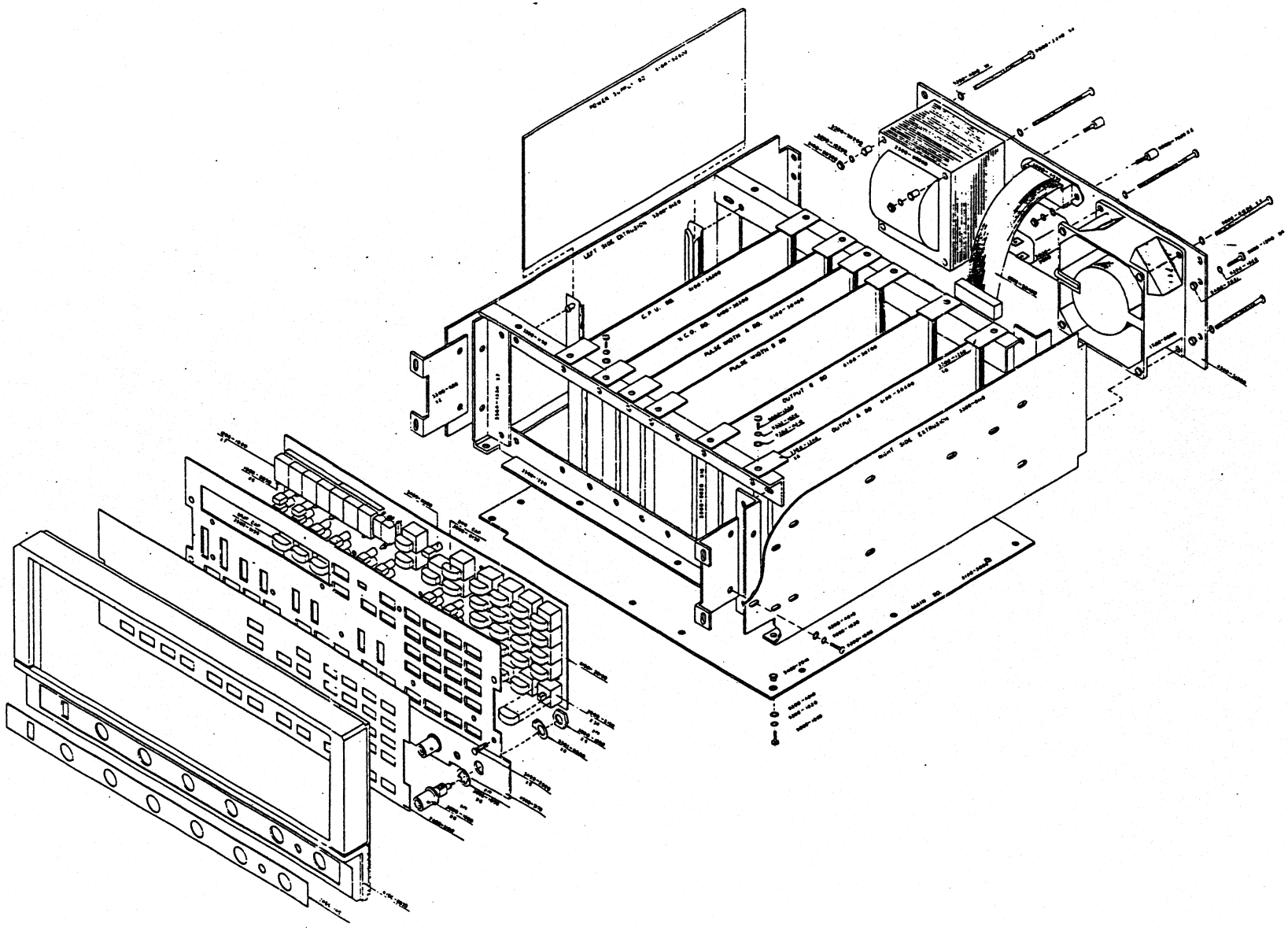
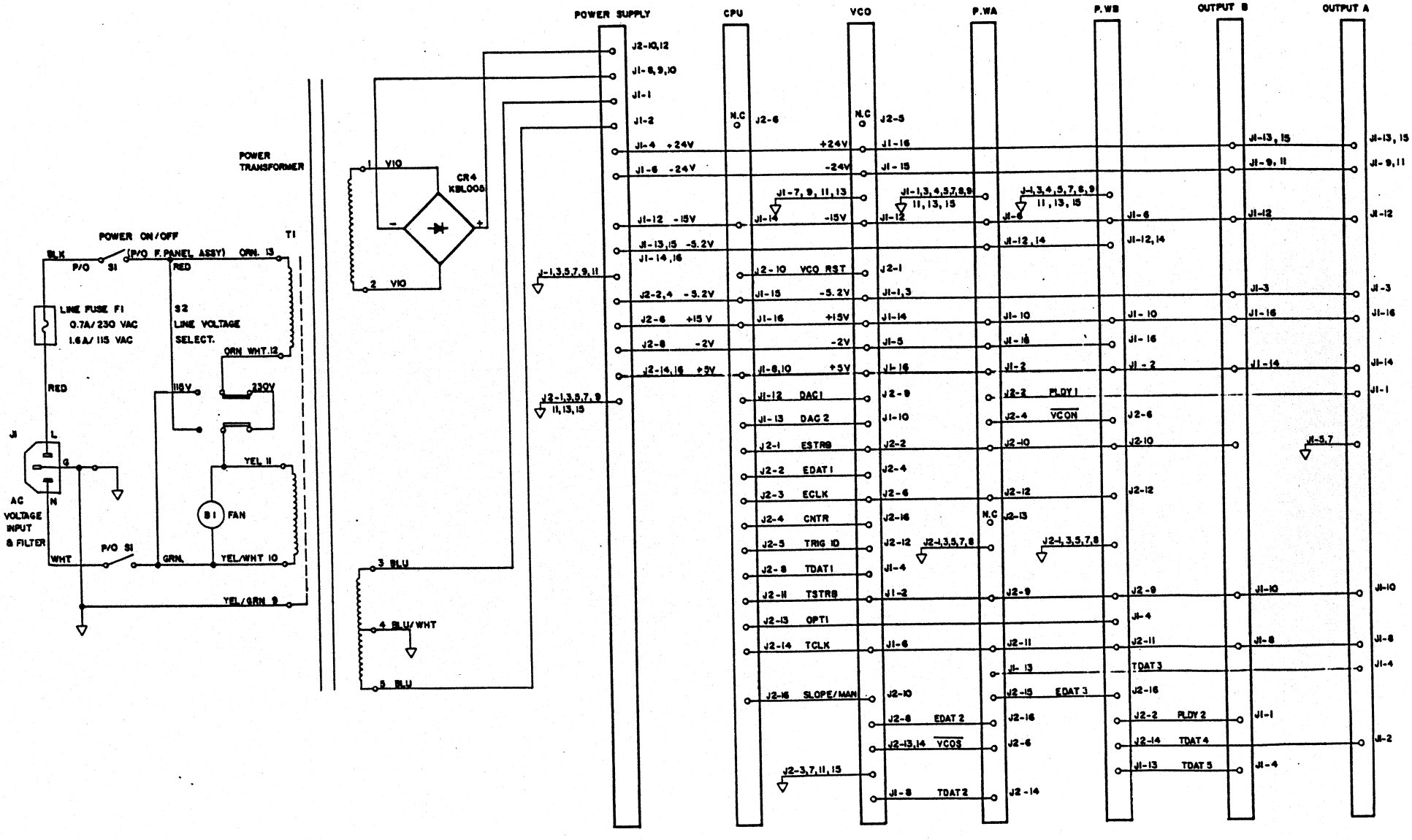
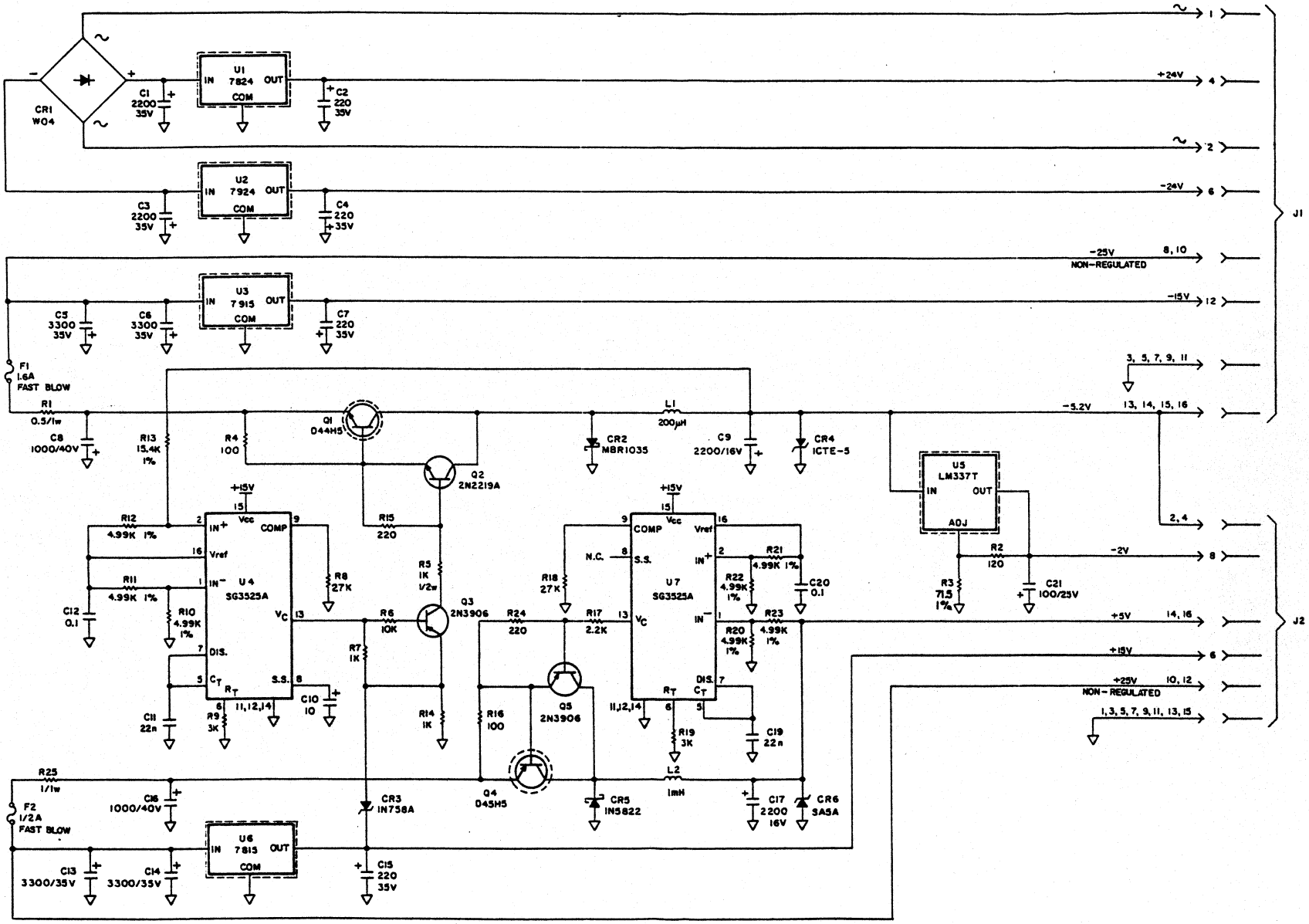


Figure 8-1. Model 8600 - Exploded View

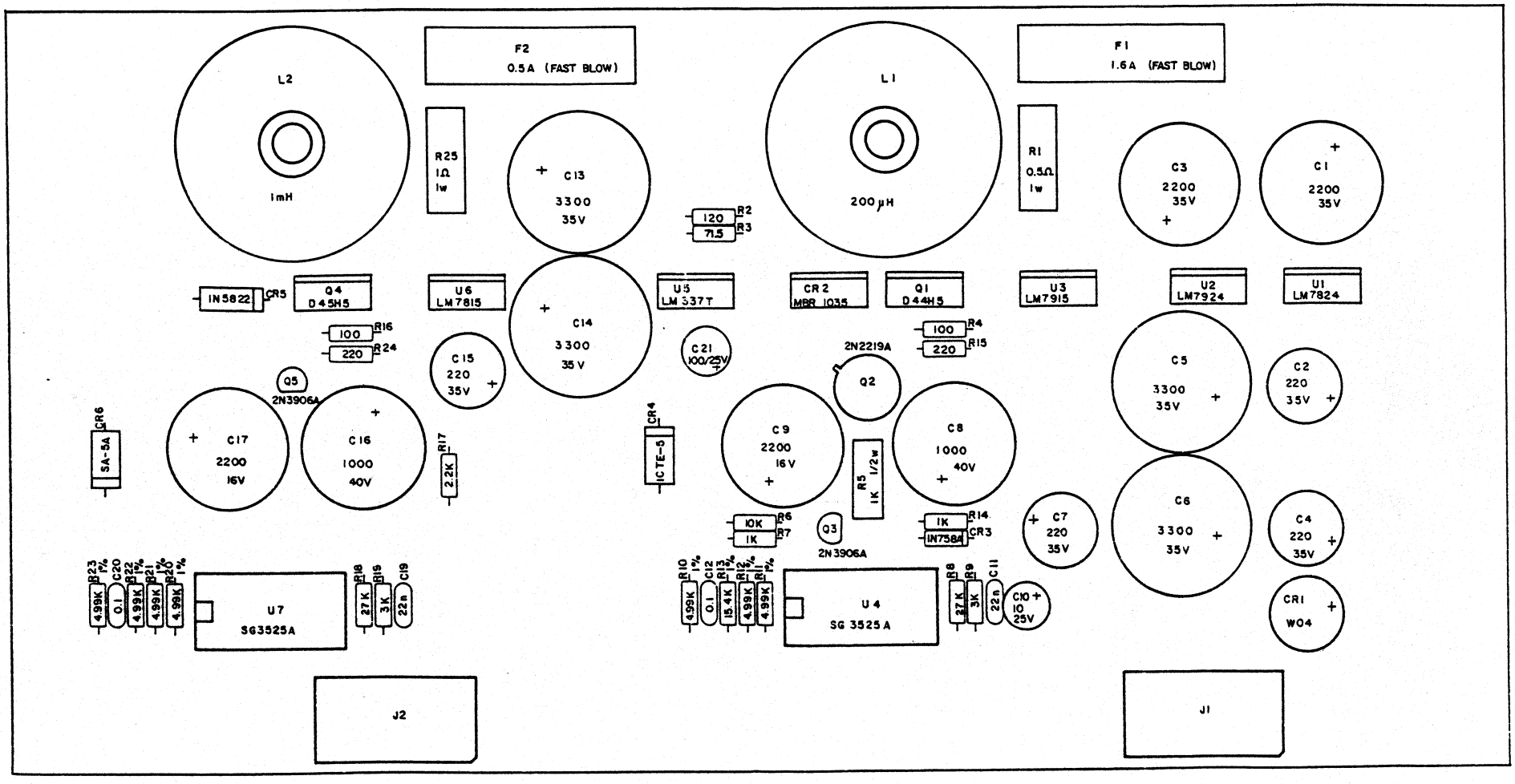


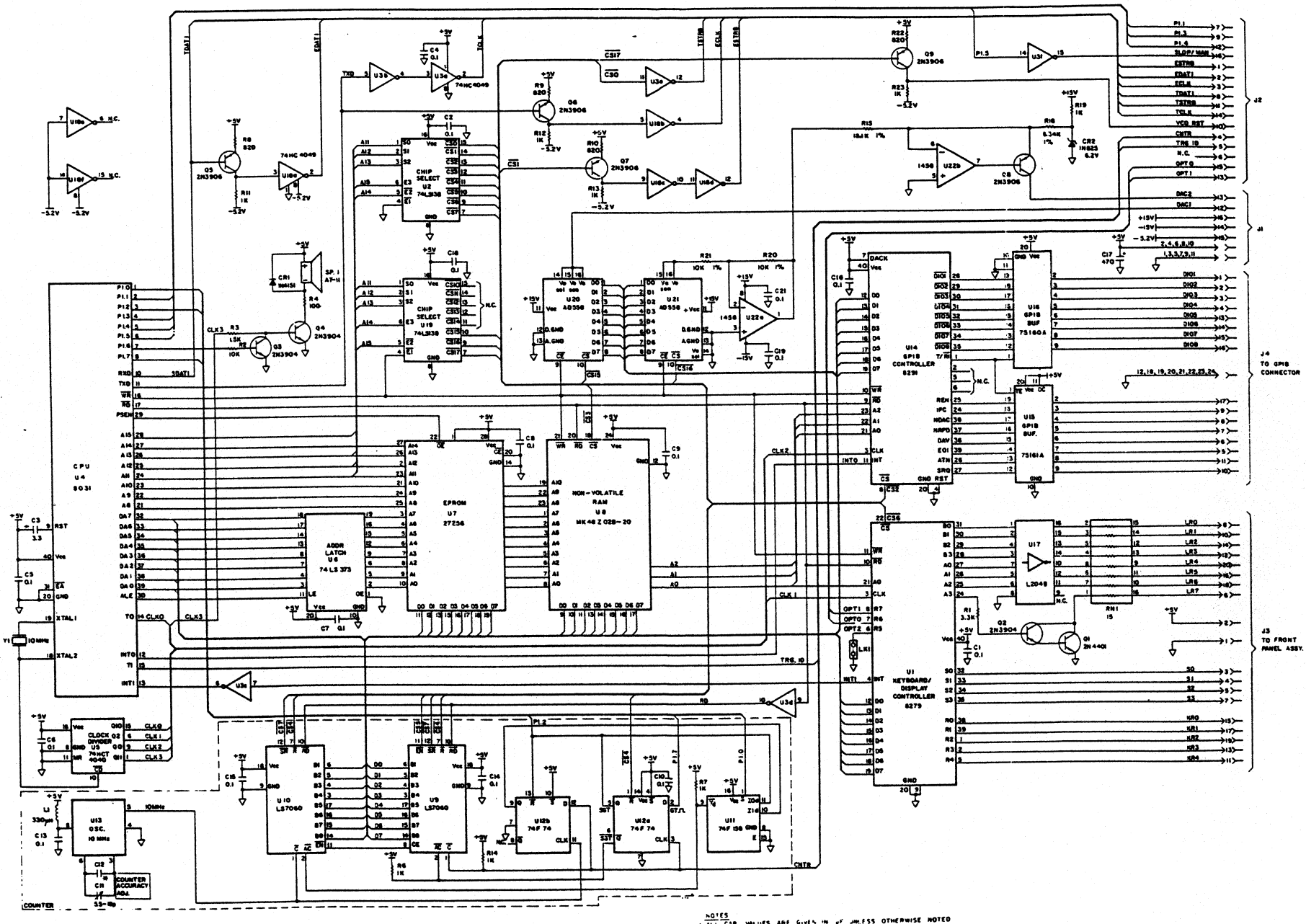
9-1 Main Board - Inter-Connection Diagram



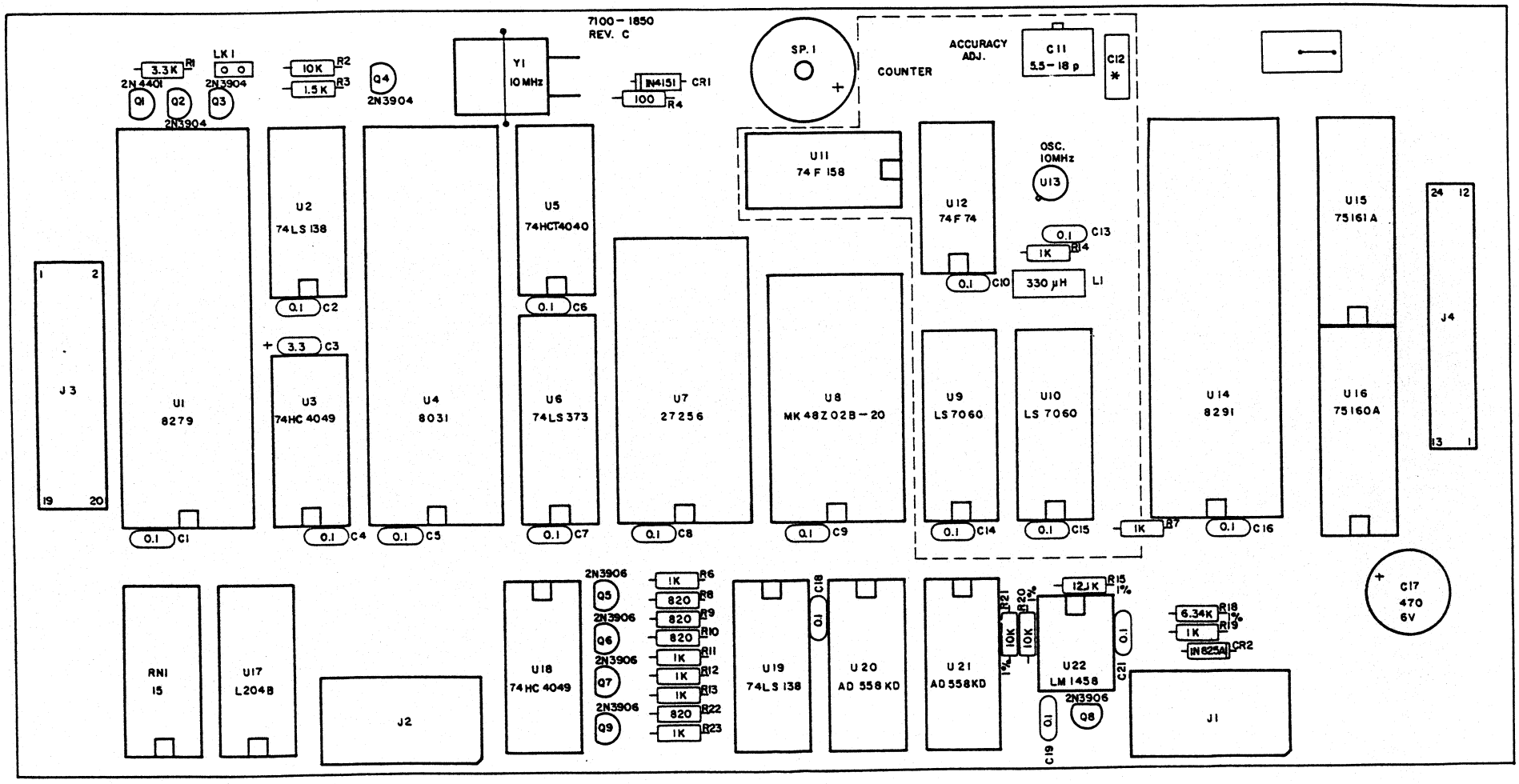
NOTES
1 ALL CAP VALUES ARE GIVEN IN µF UNLESS OTHERWISE NOTED.
2 ALL RES VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3 * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.

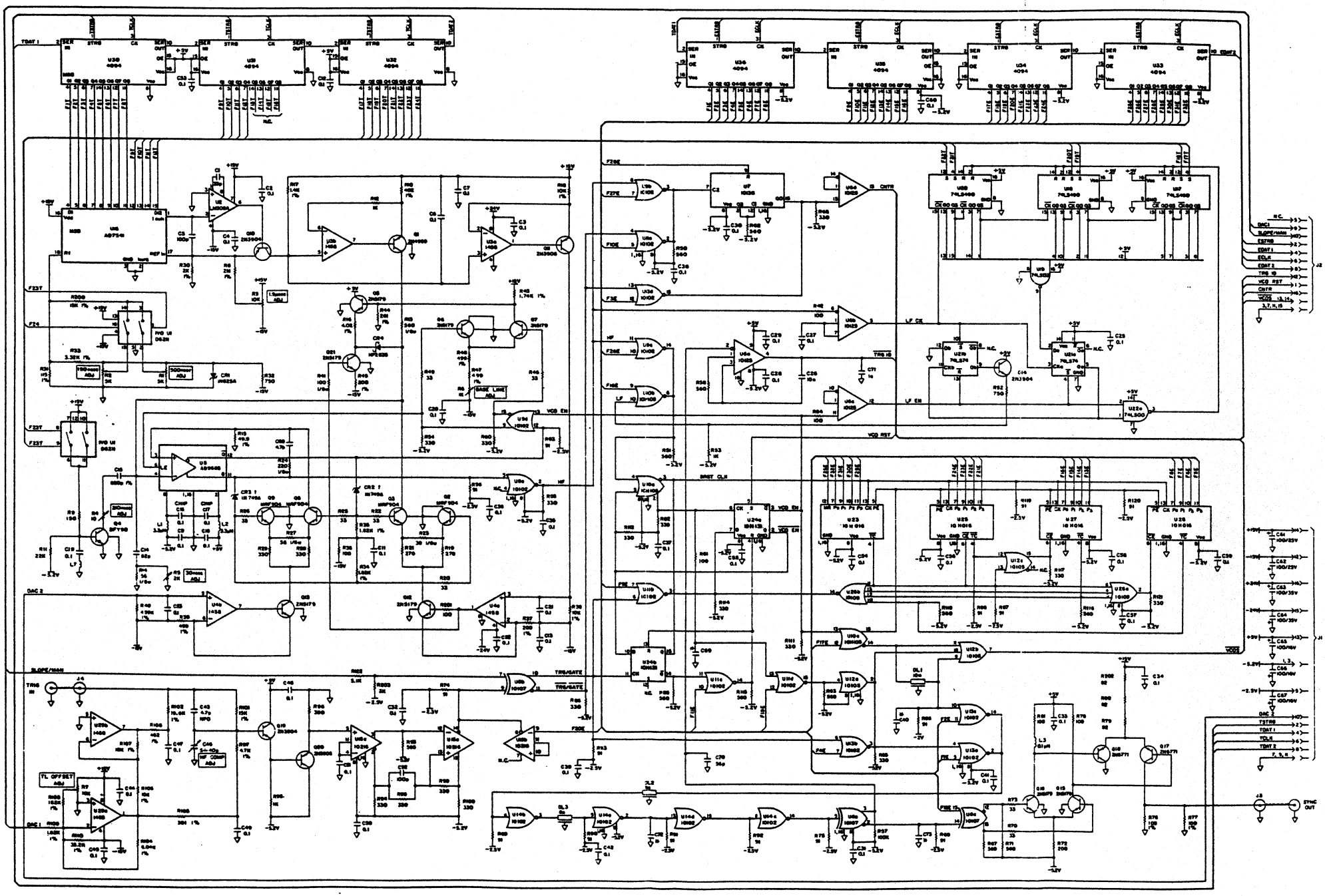
9-2 Power Supply Board - Schematic Drawing

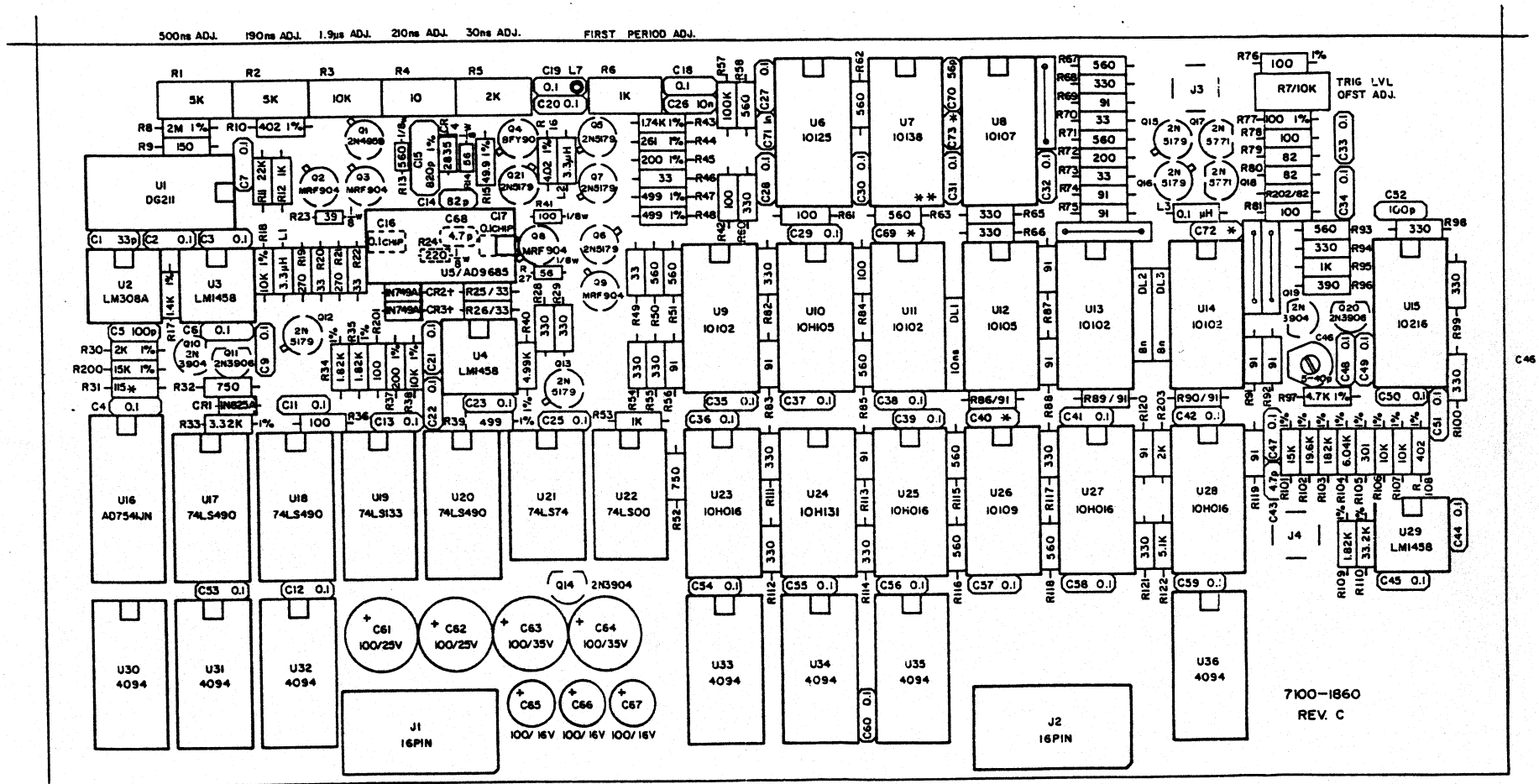

L2
1mH
F2
0.5A (FAST BLOW)
R25
1Ω
1w
C13
3300
35V
L1
200µH
F1
1.6A (FAST BLOW)
R1
0.5Ω
1w
C3
2200
35V
C1
2200
35V
120
71.5
R2
R3
IN5822
CR5
Q4
D45H5
U6
LM7815
C14
3300
35V
U5
LM337T
CR2
MBR 1035
Q1
D44H5
U3
LM7915
U2
LM7924
U1
LM7824
100
220
R16
R24
C15
220
35V
C21
100/25V
2N2219A
100
220
R4
R15
Q5
2N3906A
Q2
C5
3300
35V
C2
220
35V
SA-5A
CR6
C17
2200
16V
C16
1000
40V
R17
2.2K
ICTE-5
CR4
C9
2200
16V
R5
1K 1/2w
C8
1000
40V
10K
1K
R6
R7
Q3
2N3906A
1K
IN758A
R14
CR3
C7
220
35V
C6
3300
35V
C4
220
35V
R23
4.99K
1%
C20
0.1
R22
4.99K
1%
R21
4.99K
1%
R20
4.99K
1%
U7
SG3525A
R18
27K
R19
3K
C19
22n
R10
4.99K
1%
C12
0.1
R13
15.4K
1%
R12
4.99K
1%
R11
4.99K
1%
U4
SG 3525A
R8
27K
R9
3K
C11
22n
C10+
10
25V
CR1
W04
J2
J1



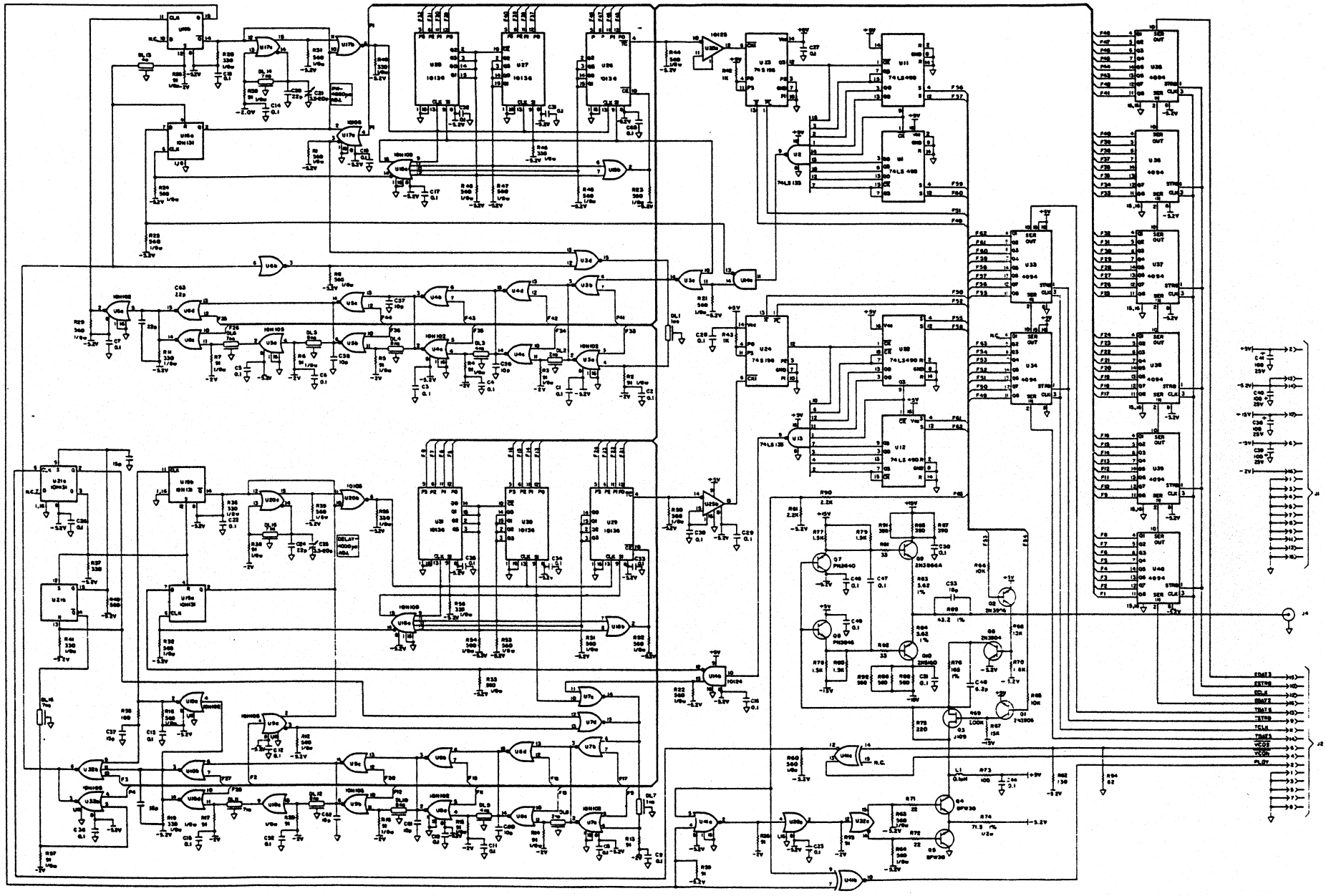
9-4 C.P.U Board - Schematic Drawing


7100 - 1850
REV. C
LK1
3.3K R1
2N4401 Q1
Q2 2N3904
Q3 2N3904
10K R2
1.5K R3
Q4 2N3904
Y1 10 MHz
1N4151 CR1
100 R4
SP. 1
COUNTER
ACCURACY ADJ.
C11 5.5 - 18 p
C12 *
U11 74 F 158
U12 74F 74
OSC. 10MHz U13
0.1 C13
1K R14
0.1 C10
330 µH L1
U15 75161A
U16 75160A
J4
24 12
13 1
J3
1 2
19 20
U1 8279
U2 74LS 138
U3 74HC 4049
U4 8031
U5 74HCT4040
U6 74LS 373
U7 27256
U8 MK48Z02B-20
U9 LS 7060
U10 LS 7060
U14 8291
0.1 C1
0.1 C2
3.3 C3
0.1 C4
0.1 C5
0.1 C6
0.1 C7
0.1 C8
0.1 C9
0.1 C14
0.1 C15
1K R7
0.1 C16
C17 470 6V
RN1 15
U17 L204B
J2
U18 74HC 4049
2N3906 Q5
2N3906 Q6
2N3906 Q7
2N3906 Q9
1K R6
820 R8
820 R9
820 R10
1K R11
1K R12
1K R13
820 R22
1K R23
U19 74LS 138
C18 0.1
U20 AD 558 KD
U21 AD 558KD
12.1K R15 1%
10K R21 1%
10K R20 1%
U22 LM 1458
C21 0.1
2N3906 Q8
C19 0.1
6.34K R18 1%
1K R19 1%
IN825A CR2
J1

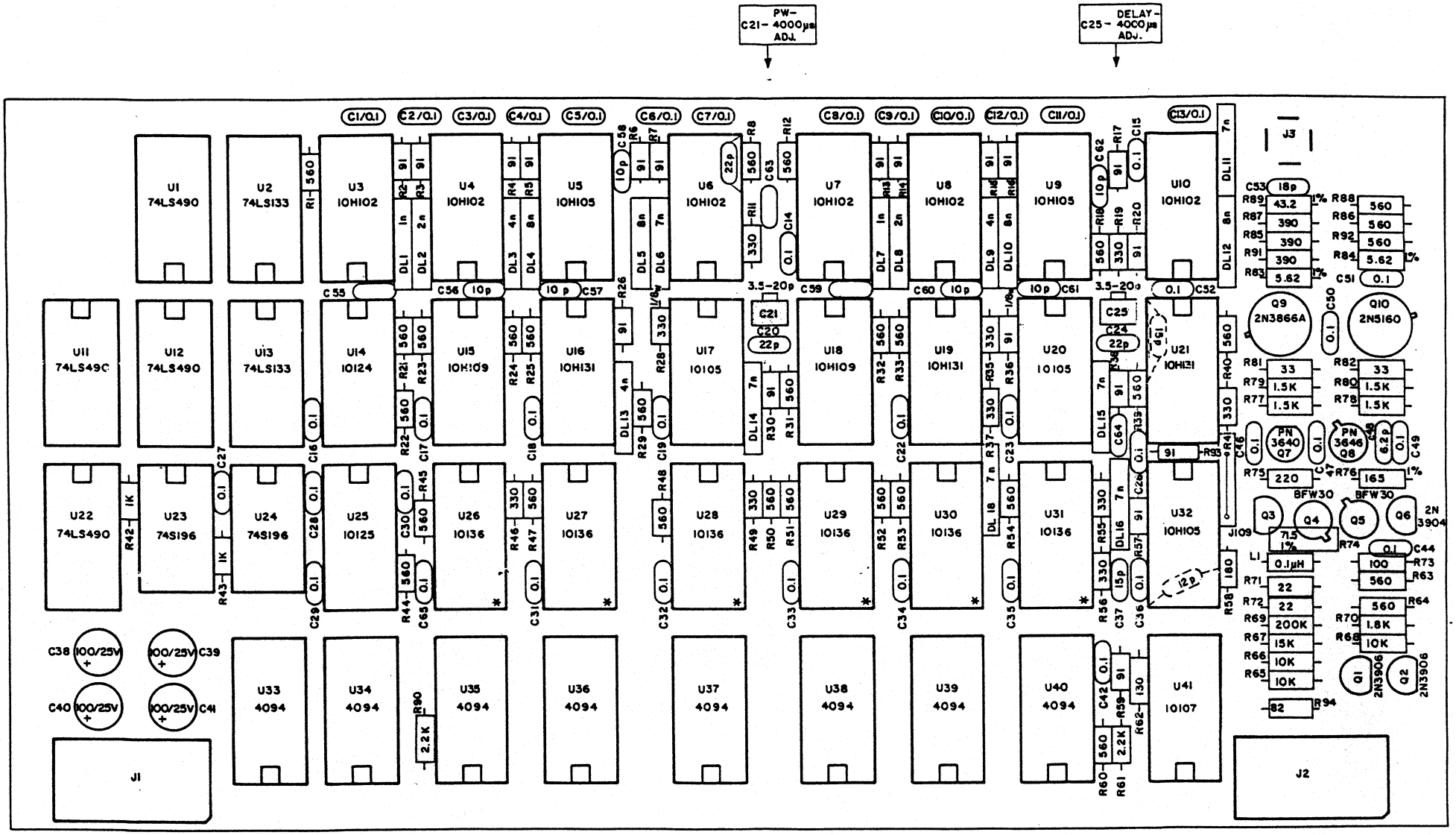




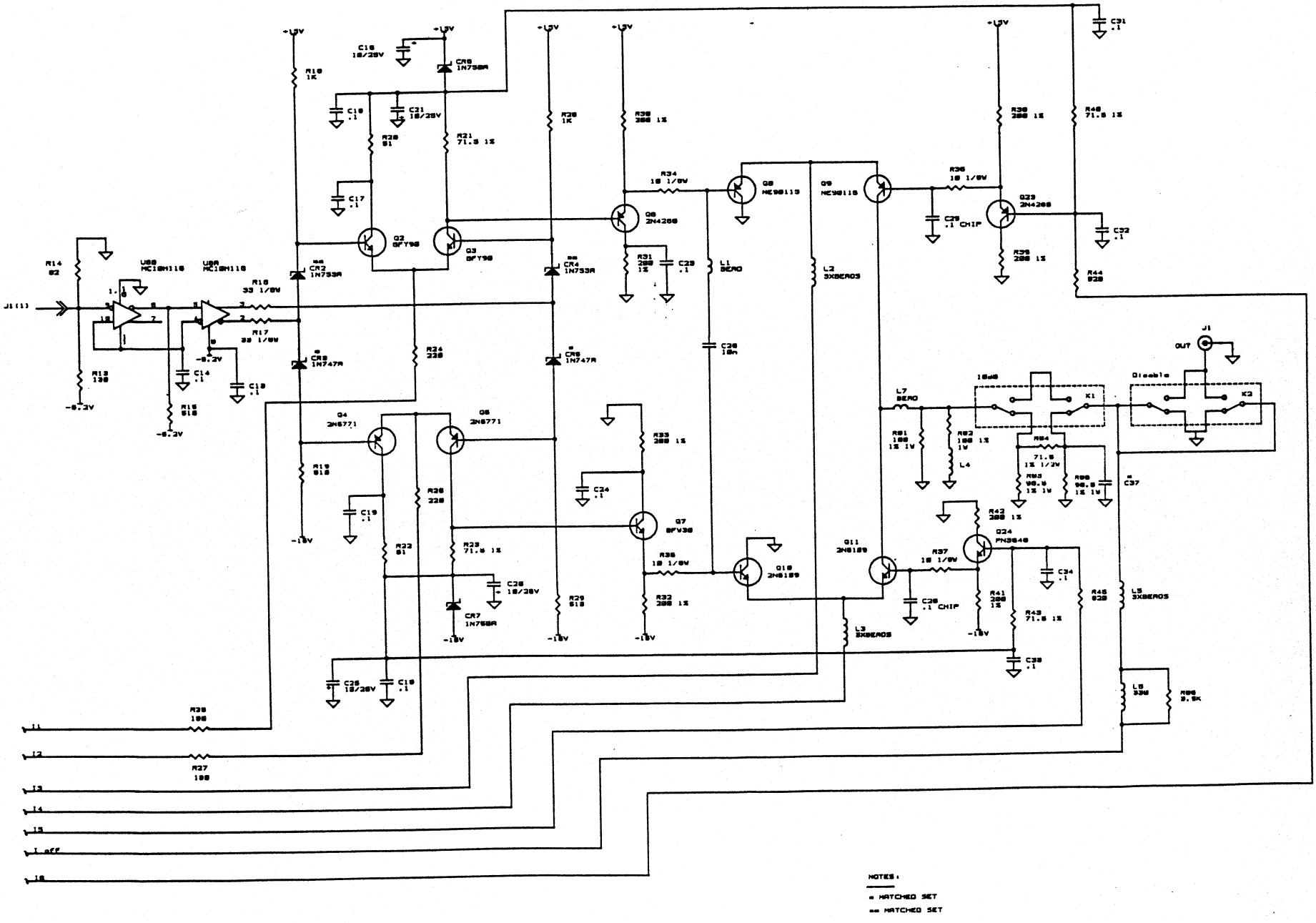
NOTES:
1. ALL CAP. VALUES ARE GIVEN IN µF UNLESS OTHERWISE NOTED.
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.
4. † DENOTES MATCHED PAIR.
5. ** HEAT SINK.



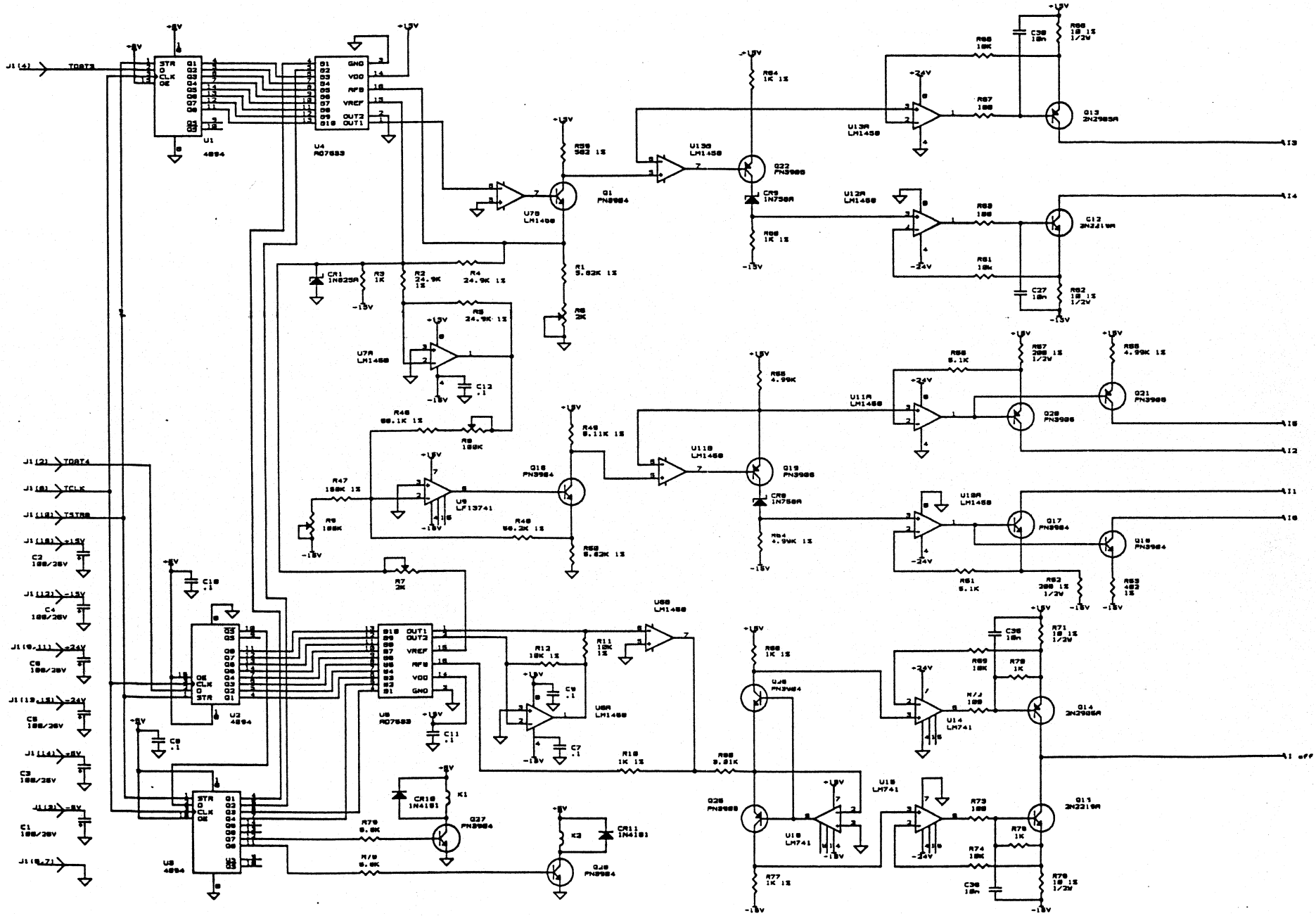
9-8 Pulse Width/Delay Board - Schematic Drawing



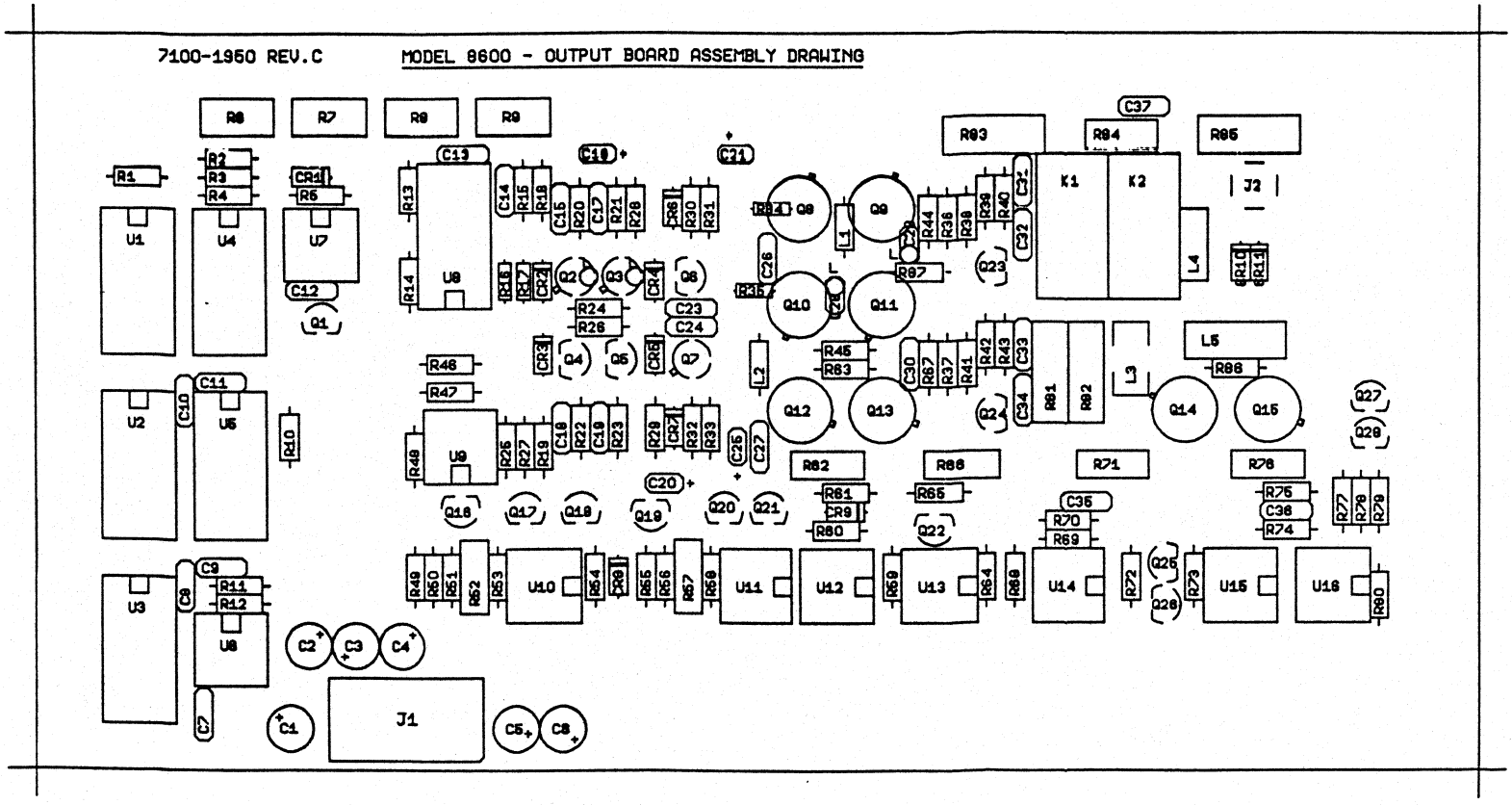
NOTES:
1. ALL CAP. VALUES ARE GIVEN IN µF UNLESS OTHERWISE NOTED.
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES HEAT SINK.



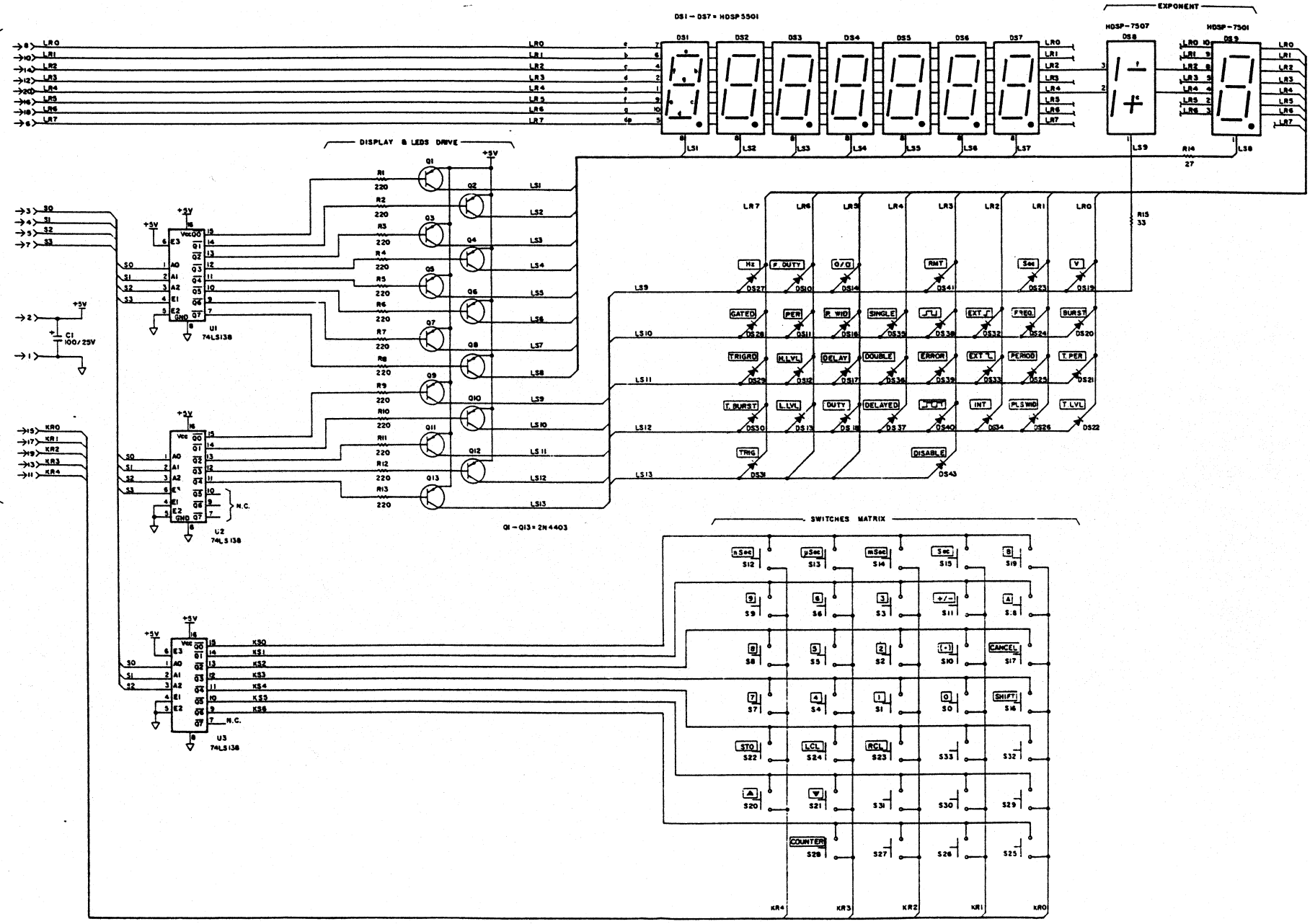
9-10 Output Amplifier Board Part 1 - Schematic Drawing



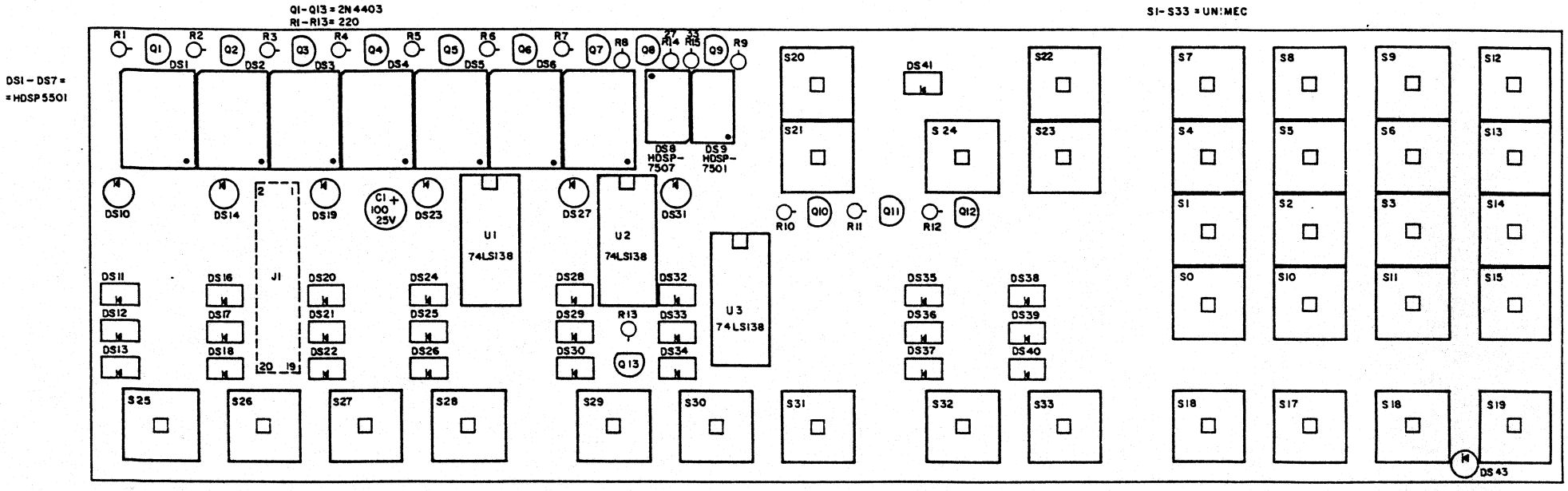
9-11 Output Amplifier Board Part 2 - Schematic Drawing



9-12 Output Amplifier Board - Assembly Drawing



9-13 Display Board - Schematic Drawing


Q1-Q13 = 2N4403
R1-R13 = 220
S1-S33 = UNIMEC
DS1 - DS7 =
= HDSP5501
R1
Q1
R2
Q2
R3
Q3
R4
Q4
R5
Q5
R6
Q6
R7
Q7
R8
Q8
R14
R15
Q9
R9
DS1
DS2
DS3
DS4
DS5
DS6
DS8 HDSP-7507
DS9 HDSP-7501
S20
S21
DS41
S22
S23
S24
S7
S8
S9
S12
S4
S5
S6
S13
S1
S2
S3
S14
S0
S10
S11
S15
DS10
DS14
DS19
C1 + 100 25V
DS23
U1 74LS138
DS27
U2 74LS138
DS31
U3 74LS138
R10
Q10
R11
Q11
R12
Q12
DS11
DS12
DS13
DS16
DS17
DS18
J1
2
1
20
19
DS20
DS21
DS22
DS24
DS25
DS26
DS28
DS29
DS30
R13
Q13
DS32
DS33
DS34
DS35
DS36
DS37
DS38
DS39
DS40
S25
S26
S27
S28
S29
S30
S31
S32
S33
S18
S17
S16
S19
DS43