MODEL 2510
DC RANGE CALIBRATOR
INSTRUCTION MANUAL

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation and maintenance of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instruments. Boonton Electronics assumes no liability for the customer's failure to comply with these requirements.

THE INSTRUMENT MUST BE GROUNDED.
To minimize shock hazard the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three conductor, three prong a.c. power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to a two-contact adapter with the (green) grounding wire firmly connected to an electrical ground at the power outlet.

DO NOT OPERATE THE INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE.
Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.
Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions dangerous voltages may exist even though the power cable was removed; therefore, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.
Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.
Do not install substitute parts or perform any unauthorized modification of the instrument. Return the instrument to Boonton Electronics for repair to ensure that the safety features are maintained.

SAFETY SYMBOLS.

This safety requirement symbol (located on the rear panel) has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, Paragraph 5.3, which directs that an instrument be so labeled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available, and that the switch on the rear panel is set to the applicable operating voltage.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

WARNING

The WARNING sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

Indicates dangerous voltages.

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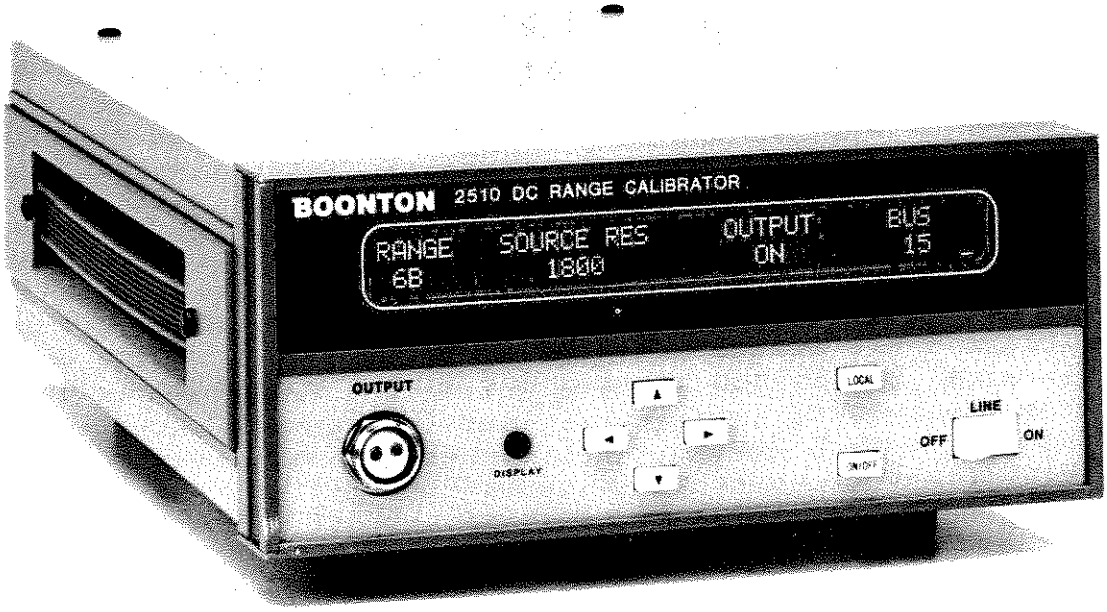

Figure 1-1. 2510 Photo

SECTION 1
GENERAL INFORMATION

1-1. INTRODUCTION. This manual provides information on specifications, installation, operating instructions, applications, theory of operation, maintenance (including performance verification), parts list, and schematics for the 2510 DC Range Calibrator. Refer to **Figures 1-1 and 1-2.**

1-2. DESCRIPTION. The Model 2510 is a DC source with eight levels and three impedances that simulate Boonton sensors. The 2510 is used to calibrate all Boonton RF Power meters and RF Voltmeters such as the 4200, 4300, 4210, 42B/BD/C/CD, 9200/B, 92BD, and 92EA. These meters, although RF meters, require DC calibration of the "box" (main instrument) independently of the sensor so that all "boxes" are identical at the sensor output port, which is DC. This means that all boxes are interchangeable, without the requirement for AC calibration when swapped.

The output of the 2510 is differential with a special Boonton connector that matches the Boonton power meter and voltmeter cable system. A special double shielded differential cable is used for interconnections.

The 2510 is GPIB bus programmable with all functions available on the bus except the power switch.

The 2510 is suitable for performance verification of Boonton meters (main instrument less sensor), and for troubleshooting, by isolating the problem to the sensor or the main instrument.

1-3. ACCESSORIES. The Boonton sensor cables are available as accessories as listed in **Table 1-1.**

TABLE 1-1
ACCESSORY CABLES

Cable	Length (ft.)
41-2A/10	10
41-2A/20	20
41-2A/50	50
41-2A/100	100

1-4. OPTIONS. Option -01 is the high temperature display, for operation from 0 to 55 degrees C (see specifications).

1-5. SPECIFICATIONS. The performance specifications for the 2520 are listed in **Table 1-2.**

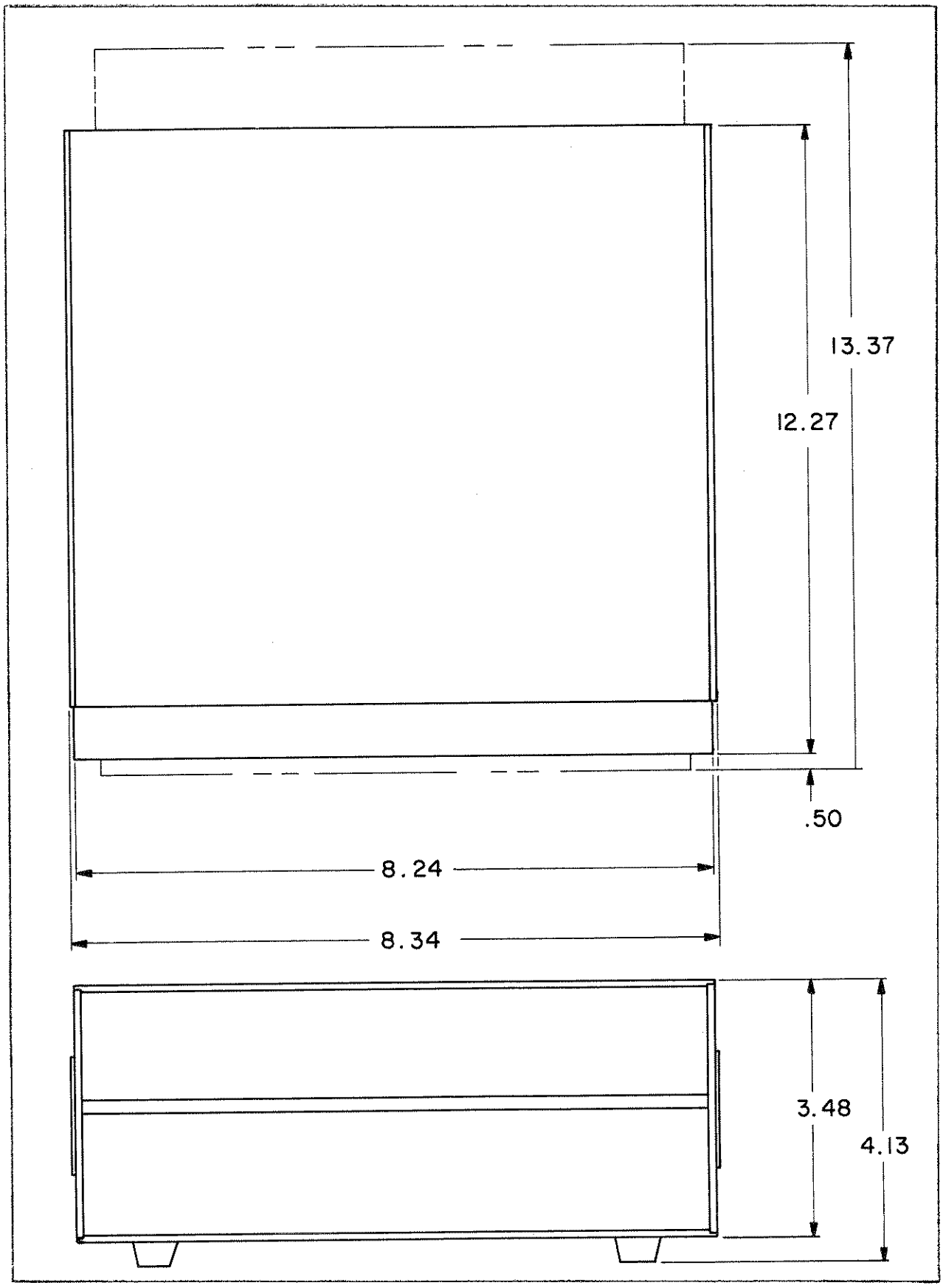

Figure 1-2. Outline Dimensions

TABLE 1-2. SPECIFICATIONS

Output Levels:	9, 90, 900 uV, 9, 90, 900 mV, 1.8 V, 4.5 V. Voltages are differential, end to end, center tapped to ground, with no load.
Output Impedance:	Selectable as "Low" (900 to 1800 ohms, range dependent), 300K, and 500K ohms +/- 1 %.
Output Level Accuracy (23 +/-5 degrees C, 1 year accuracy, after 5 min. warmup:	+/- 0.15 %. Add 0.2 % for 0 to 18 degrees C and 28 to 55 degrees C.
Aging:	120 ppm (0.012 %) per year max.
Settling Time:	100 mS to settling within spec
Display:	40 x 2 LCD, backlit with an EL panel, shows range (1 through 6B), output enabled condition, impedance setting, and bus address
Bus :	GPIB standard. Implements SH1, AH1, T6, L4, RL1, SR1, DT1, and DC1.
Input Power:	100, 120, 220, 240 VAC +/-10%, 50 to 400 Hz, <24 VA
Operating Temperature:	0 to 50 Degrees C, standard. 0 to 55 Degrees C with extended temperature display option.
Storage Temperature:	-20 to 70 Degrees C, standard; -40 to 90 Degrees C with extended temperature display option.
Dimensions:	3.5" H x 8.24 W x 12.375 D (8.9 cm x 20.0 x 31.4)
Weight:	7.0 lbs (3.2 kg)

SECTION 2
INSTALLATION

2-1. INTRODUCTION. This section contains instructions for the unpacking and repacking of the Model 2510, and for doing a preliminary checkout of the instrument.

2-2. UNPACKING. The 2510 is shipped complete and is ready to use upon receipt. Unpack the instrument from it's shipping container and inspect it for damage that may have occurred during shipment. See **Figure 2-1.**

NOTE

Save the packing material and container for possible use in reshipment of the instrument.

2-3. MOUNTING. For bench mounting, choose a clean, sturdy, uncluttered mounting surface. For rack mounting, an accessory kit is available for mounting either one instrument or two similar instruments side by side, (P/N 95401501B).

2-4. POWER REQUIREMENTS. The 2510 has a tapped power transformer and two line voltage selection switches which permit operation from 100, 120, 220, or 240 VAC single phase, +/- 10%, from 50 to 400 Hz. Power consumption is approximately 20 VA.

CAUTION

Always make certain that the line voltage selection switches are set to the correct position most nearly corresponding to the voltage of the available AC power source, and that a fuse of the correct rating is installed in the fuse holder before connecting the 2510 to any power source.

The correct fuse is shown in **Table 2-1.**

TABLE 2-1. FUSE RATINGS

VOLTAGE	FUSE
100/120	0.3 A
220/240	0.2 A

2-5. CABLE CONNECTIONS. The DC output is on the front panel, using a Boonton female sensor connector, and the GPIB bus connector is on the rear panel. There is also a Control output on the rear panel, for controlling external devices such as relays under GPIB command. Refer to Section 3 for details on the connections.

2-6. PRELIMINARY CHECKOUT. The preliminary checkout ensures that the 2510 is functioning to a fair degree of confidence. For a full performance checkout, refer to "Performance Verification" in Section 6-100.

CAUTION

The line voltage selector switches must be set to the proper positions before conducting this test. Refer to Section **2-4** and to the rear panel.

The procedure for checkout is as follows :

1. Set the voltage selector switches on the rear panel for the proper voltage, and connect the instrument to the AC line and power up.

2. Connect the DC output of the 2510 to a general purpose DC multimeter using a 2 conductor shielded cable with a Boonton sensor connector on one end and a dual banana plug on the other. A Boonton 41-2A cable may be used to make this. Alternatively, hold the multimeter probes on the 2510 DC output connector.

3. Press the "On/Off" key once to enable the output, and verify that the indication on the display shows that the output is enabled.

4. Using the left and right arrow keys, position the cursor under the "Impedance" field, and then using the down arrow key, set the impedance to 1800 ohms.

5. Using the left and right arrow keys, position the cursor under the range indication (1 through 6B).

6. Using the up and down arrow keys, set the 2510 to the ranges listed in **Table 2-1** and check for the voltages listed in the table. Note: The limits listed in the table assume a voltmeter accuracy of .05 %, and assume that this test is done at 18 to 28 degrees C.

TABLE 2-1. DC OUTPUT VOLTAGES

Range	Level
2	898 - 902 uV
3	8.98 - 9.02 mV
4	89.8 - 90.2 mV
5	898 - 902 mV
6A	1.796 - 1.804 V
6B	4.490 - 4.510 V

See the Specifications for operation outside this range. Ranges 1 and 0 can be checked only with a nanovoltmeter such as the Kiethley 181. See Section **6-100**, Performance Tests, for this procedure.

7. Set the unit to range 5, and connect a 500K ohm 1% load resistor across the output, in parallel with the voltmeter. Position the cursor under the "Impedance" Field and set the impedance to 500K ohms. The voltage should read 430 to 470 mV. Now set the impedance to 300K ohms. The voltage should be 320 to 360 mV.

8. Connect the GPIB connector on the rear panel to a controller and run a test program, following the program instructions.

This completes the checkout of the instrument.

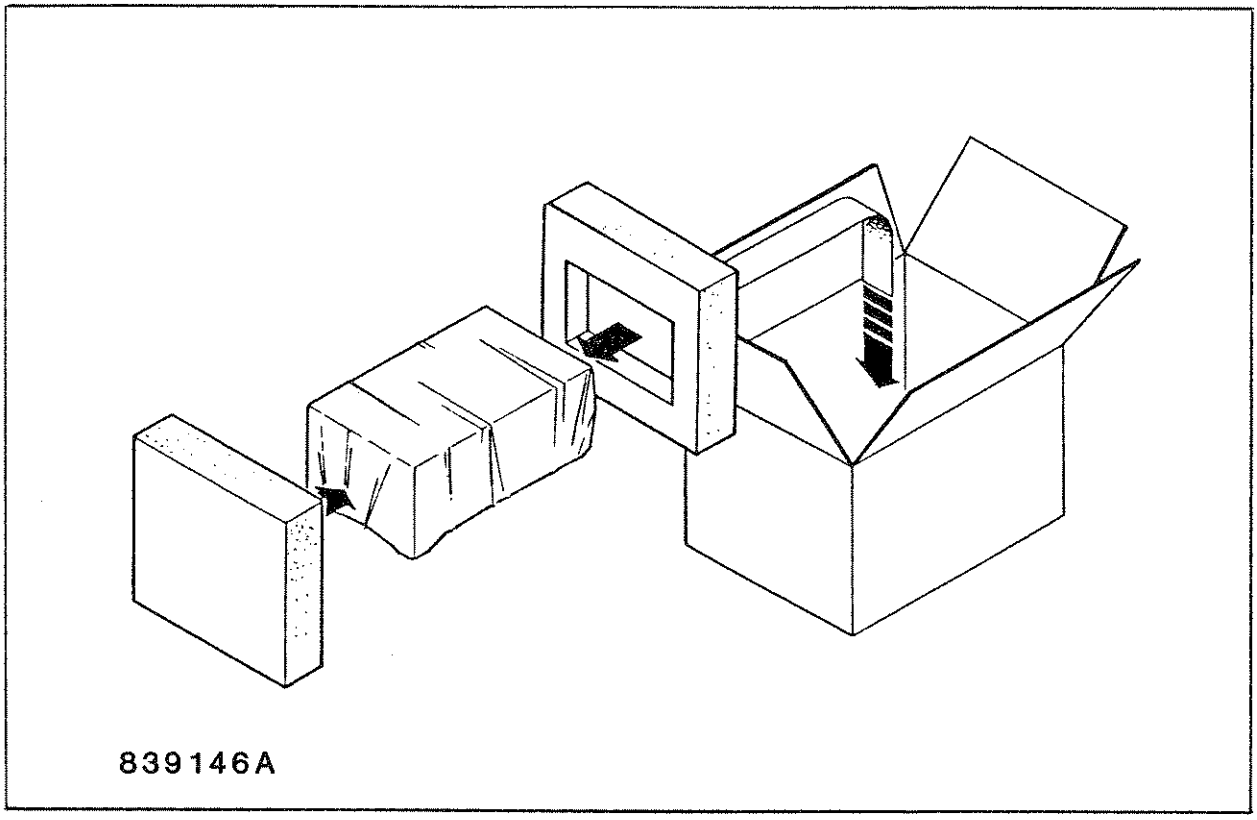

Figure 2-1. Packing and Unpacking Diagram

SECTION 3
OPERATION

3-1. INTRODUCTION. Section 3 contains information on the operating controls, indicators, and connectors, and operating instructions for the 2510. This section is broken down into two subsections :

1. Local Operation (3-3).
2. Remote (GPIB) operation (3-100).

3-2. OPERATING CONTROLS, INDICATORS, AND CONNECTIONS. The controls, indicators, and connections are listed in **Table 3-1,** and are shown in **Figures 3-1 and 3-2.**

TABLE 3-1. CONTROLS, INDICATORS, AND CONNECTIONS

Control/ Indicator/ Connector	Figure and Index No.	Function
Line On/Off	3-1, 1	Switches the AC Power on and off.
Display	3-1, 2	Controls the vertical viewing angle.
Up Arrow Key	3-1, 3	Modifies the selected parameter in an increasing direction.
Down Arrow Key	3-1, 4	Modifies the selected parameter in a decreasing direction.
Left Arrow Key	3-1, 5	Positions the cursor under a selected parameter.
Right Arrow Key	3-1, 6	Positions the cursor under a selected parameter.
Local Key	3-1, 7	Returns the operation from Bus to the front panel. Also used in some of the calibration modes.
On/Off Key	3-1, 8	Enables and disables the DC output without disturbing the range or impedance.
Output Connector	3-1, 9	The DC output, 9 uV to 4.5 VDC.

continued on next page

TABLE 3-1 Continued.

Control/ Indicator/ Connector	Figure and Index No.	Function
Display	3-1,10	Display
Fuseholder	3-2, 1	AC power line fuse.
AC Connector	3-2, 2	AC power line input.
Line Voltage Selector Switches	3-2, 3	Changes the transformer taps to select the line voltage.
IEEE-488 Bus Connector	3-2, 4	Remote programming GPIB bus.
Bit Switch	3-2, 5	Sets the Bus address, terminating characters, and SRQ enabled. See **Table 3-3.**
Control Out BNC	3-2, 6	Set to logic level high when a Bus command "C1" is sent, and low when "C0" is sent. Used for controlling a switch matrix or accessory.

3-3. OPERATING INSTRUCTIONS: LOCAL OPERATION.

1. Initialization. Set the line voltage selector switches on the rear panel according to the labels for the proper line voltage. Connect the power cord to the power input connector. The rear panel Bit switch settings are used only for bus operation; see **Table 3-3** as required. Turn on the unit from the front panel. Refer to **Figure 1-1** for a typical display.

2. Adjusting the Display. Using a small screwdriver, adjust the "Display" potentiometer on the front panel for the best contrast at the given viewing angle. The pot adjusts the up/down viewing angle. The side to side viewing angle is fixed.

3. Setting the Range. To set the range, use the left and right arrow keys to position the cursor under the "Range" heading on the display, and press the up and down arrow keys until the proper range from 1 to 6B is shown.

4. Toggling the Output On and Off. The DC output alternately changes between on and off, while keeping the range and impedance constant, by pressing the "On/Off" key.

5. Setting the Output Impedance. The output impedance of the 2510 is adjustable to approximate the output im-

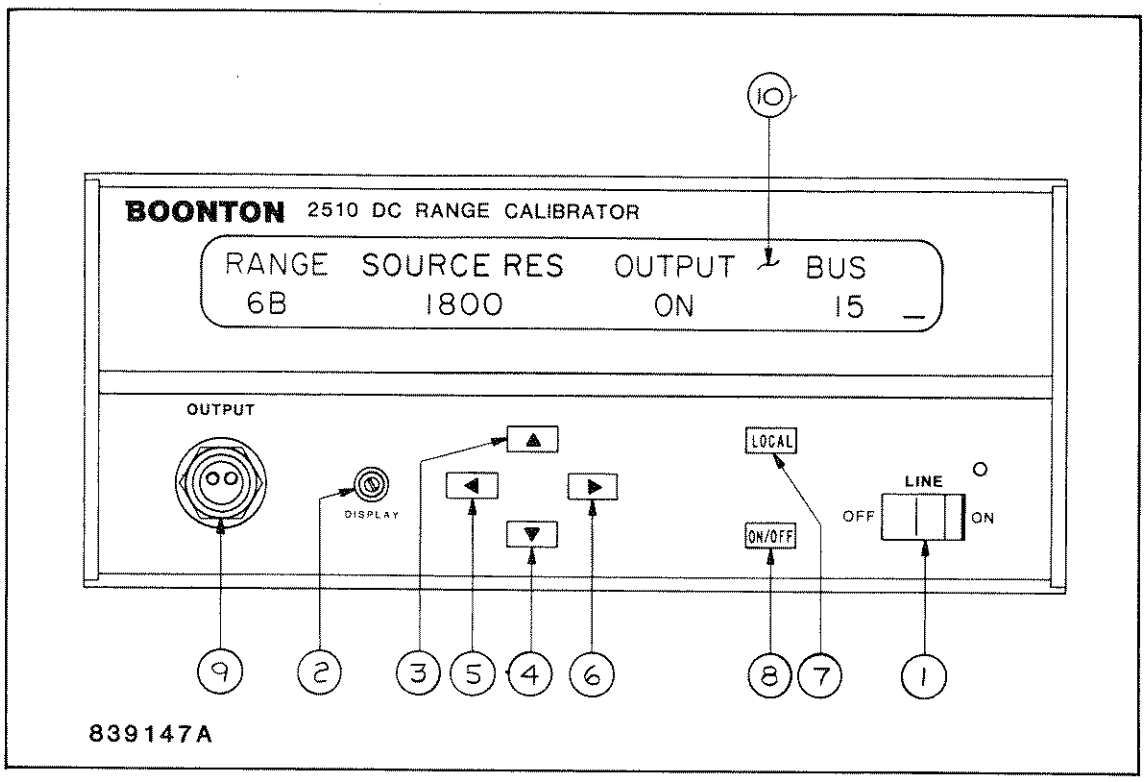

Figure 3-1. Front Panel

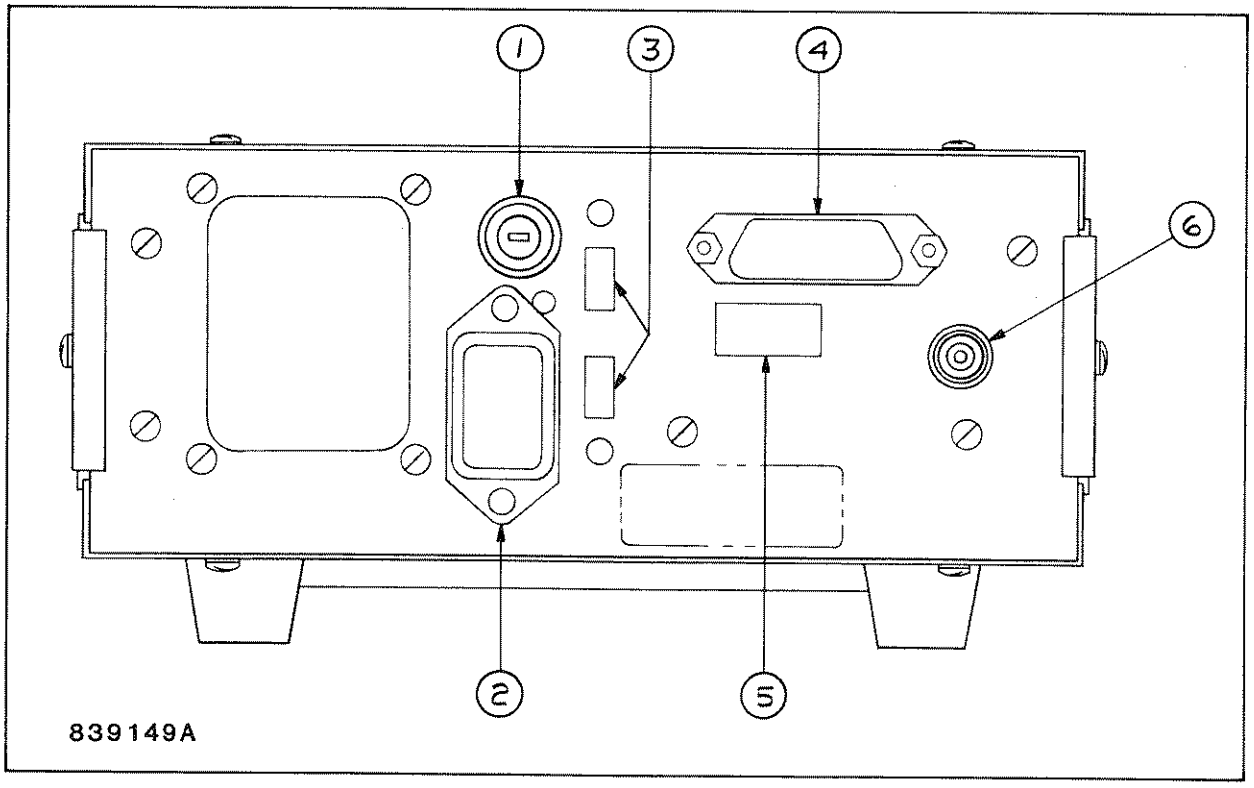

Figure 3-2. Rear Panel

pedance of Boonton power sensors and voltmeter probes. Thermal units are low impedance (a few hundred ohms) and diode units are generally about 300K to 500K ohms. The 2510 impedance does not need to match the sensor exactly. The particular Boonton meter to be used has it's calibration defined at one of the three selectable impedances of the 2510. See the meter's recommendations for the impedance setting.

To set the impedance, position the cursor under the "Impedance" field using the left and right arrow keys, and use the up and down arrow keys to adjust.

SECTION 3-100.
REMOTE (GPIB) OPERATION.

3-101. Introduction. The remote operation of the 2510 is accomplished through an IEEE-488-1978 Interface. The IEEE-488 is a hardware standard which describes the communication and handshaking across the 8 bit parallel bus between a controller and up to 15 instruments. Refer to "IEEE Standard Digital Interface for Programmable Instrumentation", published by IEEE.

The 2510 interfaces to the IEEE bus through a TI9914A bus interface IC and tristate buffers. No DMA operations are supported. The general capabilities of the 2510 are listed below. **Table 3-2** lists specific IEEE interface functions that are handled. Parallel Poll (PP) is not supported.

Features:

* Talk/Listen capability

* SRQ (Service Request)

* Serial Poll capability with masking

* All front panel operations supported on the bus, except power on/off.

* Talk Error mode

* Selectable output terminators

* Free format number handler

3-102. Local and Remote Operation. The Local mode is the front panel operation of the instrument. The local mode is the power on condition of the instrument and the remote condition becomes active only when the instrument is addressed by the controller. Once in the remote mode, there are three ways to return to local mode: 1) The controller issues a GTL command (go to local); 2) Power is removed from the instrument, and 3) The operator presses the Local key. This third method is disabled by issuing a local lockout command (LLO). In the remote mode, all key closures except the Local key are ignored. When in the remote mode, the message REM appears in the lower right corner of the display.

TABLE 3-2. GPIB CAPABILITIES

SH1	Source Handshake
AH1	Acceptor Handshake
T6	Basic Talker
L4	Basic Listener
RL1	Remote Local
SR1	Service Request (see par. **3-109**)
DC1	Device Clear (see par. **3-108**)
DT1	Device Trigger (see par. **3-110**)

3-103. Setting the Bus Address. The bus address is set from the rear panel Bit switch, and is viewed on the display. The unit reads the Bit switch on power up only.

3-104. Terminating Characters. To inform the instrument that a complete message has been sent, the last character must be followed by a terminator. The termination can be done either by asserting the EOI line on the

bus or by sending an in-line terminating character, or both.

The terminating character is selectable from the rear panel Bit switch as CR, LF, or CRLF. When neither positions 2 or 3 are set to 1, EOI is used as a terminator. The Bit switch settings are determined by **Table 3-3.**

3-105. Listen Operation. The instrument may be addressed as a listener without regard for remote or local mode. When the listener state is set by the controller, the instrument will receive bytes over the bus and place them into it's input buffer and the LSN message will appear in the lower right corner of the display. Only one message can be put into the buffer at a time; a second cannot be sent until the instrument is done processing the previous message.

3-106. Talk Operation. Only one instrument on the bus is allowed to talk at once, while many may be set up to listen. The instrument is set up to allow a talk message with a format as follows:

Example: 3,1,0,2
Format: R,I,A,E
where:

R = Range from 0 to 7, corresponding to actual range 0 to 6B.

I = Impedance (0 = 1800, 1 = 300K, and 2 = 500K ohms).

A = Output enabled condition (1 = on).

E = an error number, see below.

TABLE 3-3. REAR PANEL BIT SWITCH

Position	1	0
1	SRQ Enabled	SRQ Disabled
2	LF used as terminator	LF not used as terminator (can be used with position 3)
3	CR used as terminator	CR not used as terminator (can be used with position 2)
4	Bus address MSB	
5	Bus address	
6	Bus address	
7	Bus address	
8	Bus address LSB	

3-107. Error Messages.

The error messages are "2", which is a function error such as an improper bus mnemonic, and "16", which is a number entry error such as a level that is out of range. A decimal 64 is added to these numbers with bit 6 of the serial poll byte, resulting in "66" and "80". Once polled, this bit is reset to zero.

3-108. Device Clear. The 2510 responds to the Device Clear (DC1) command by turning the output off and setting the range to 0. The impedance is set to 500K ohms. The IFC command (Interface Clear) performs the same function.

3-109. Service Request and Serial Poll. The 2510 will output a service request (SRQ) when an error is encountered, if the Bit switch is set up to make SRQ active. The possible errors are listed in **Section 3-106, Talk Operation.**

Refer to the **Table 3-3,** Rear Panel Bit Switch, for setting up the SRQ mask bit. When the controller receives an SRQ, the 2510 may be polled serially to determine the source of the SRQ (which instrument). Bit 6 of the status byte indicates the SRQ condition. Serially polling the 2510 will reset the error condition.

3-110. Device Trigger. When the 2510 is triggered via this command, it will enable the output and go to the range that was previously set. It functions the same as the "ON" command. The GET command (Group Execute Trigger) will also perform this function.

3-111. Bus Commands. The bus commands specific to the 2510 are listed in **Table 3-4.**

TABLE 3-4. BUS COMMANDS.

Command	Function
Rx	Sets the range where "x" is the range as follows: 0, 1, 2, 3, 4, 5, A, and B. Ranges A and B correspond to ranges 6A and 6B in Boonton literature. The output is not activated with this command.
X0	Sets the output impedance to 1800 ohms.
X1	Sets the output impedance to 300K ohms.
X2	Sets the output impedance to 500K ohms.
OF	Turns output off. The range and impedance settings are not reset with this command.
ON	Turns the output on, to the range that was previously loaded with the Rx command.

continued on next page

TABLE 3-4. Continued

C0	Sets the Control output to logic zero. Used for switch matricies or other accessories.
C1	Sets the Control output to logic 1.
T0	Disables the trigger mode (the 2510 will not respond to a trigger).
T1	Enables the trigger mode. Reset when powered down.
B0	Blanks the display, for security purposes.
B1	Enables the display. See B0.

SECTION 5
THEORY

5-1. INTRODUCTION. This section contains circuit descriptions and software functions, and block diagrams for the 2510. Refer to the overall block diagram, **Figure 5-1,** which is described below.

5-2. BLOCK DIAGRAM DESCRIPTION. The 2510 is basically a differential voltage reference. In **Figure 5-1,** a precision 5V reference is used to generate 5.000 VDC. Following this, a unity gain inverting amplifier generates a mirror image of the this (-5V). These two lines feed a voltage divider bank with selectable taps. The selecting switches are reed relays which are controlled from the microprocessor. Refer to **Table 5-2** for the status of the lines for each range.

The voltage divider feeds two selectable series resistors, which are terminated with two 900 ohm resistors. Finally, series resistors are added to bring the output impedance to the proper level.

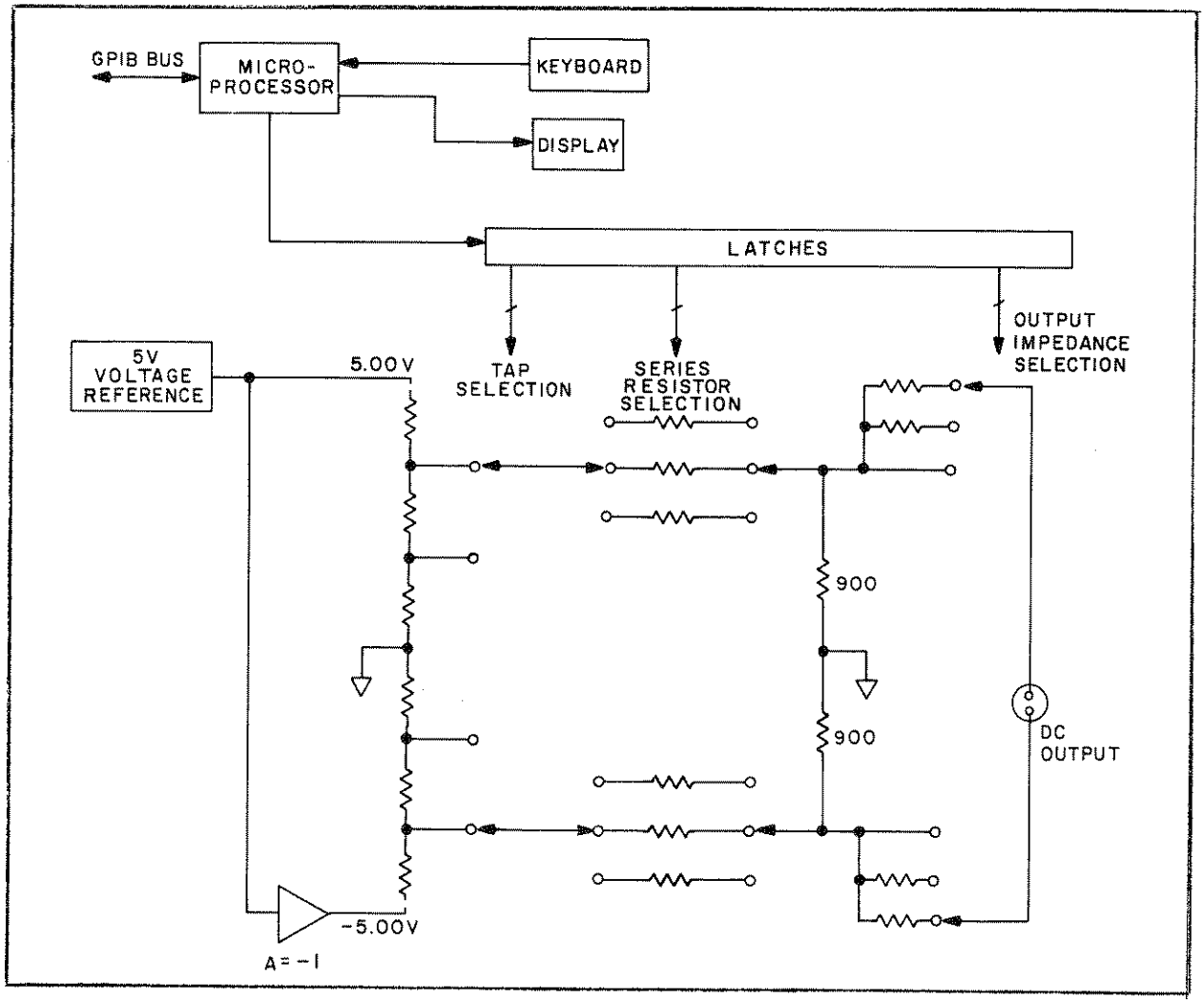

Figure 5-1. Overall Block Diagram

The microprocessor reads the keyboard, stores temporary data in registers or RAM as required, and generates the relay drive signals.

The GPIB bus is controlled with a dedicated I/C, in addition to the microprocessor itself. The display is sent ASCII information and control bytes from the microprocessor. The keyboard is a simple hardware scan.

5-3. CONTROL BOARD DESCRIPTION.

1. General. Refer to the Control board schematic in Section 7 and to the Control board block diagram, **Figure 5-2.** Microprocessor U4 operates on stored instructions from PROM U6. Both of the memories U6 and U9 operate on the common data, address, and control bus. The control bus consists of the read and write lines, and the chip selects. The data bus is bidirectional, and all "talk" devices are tri-stated (open) unless addressed to output data, so that only one device talks at a time. The Z80 controls the address and control lines at all times.

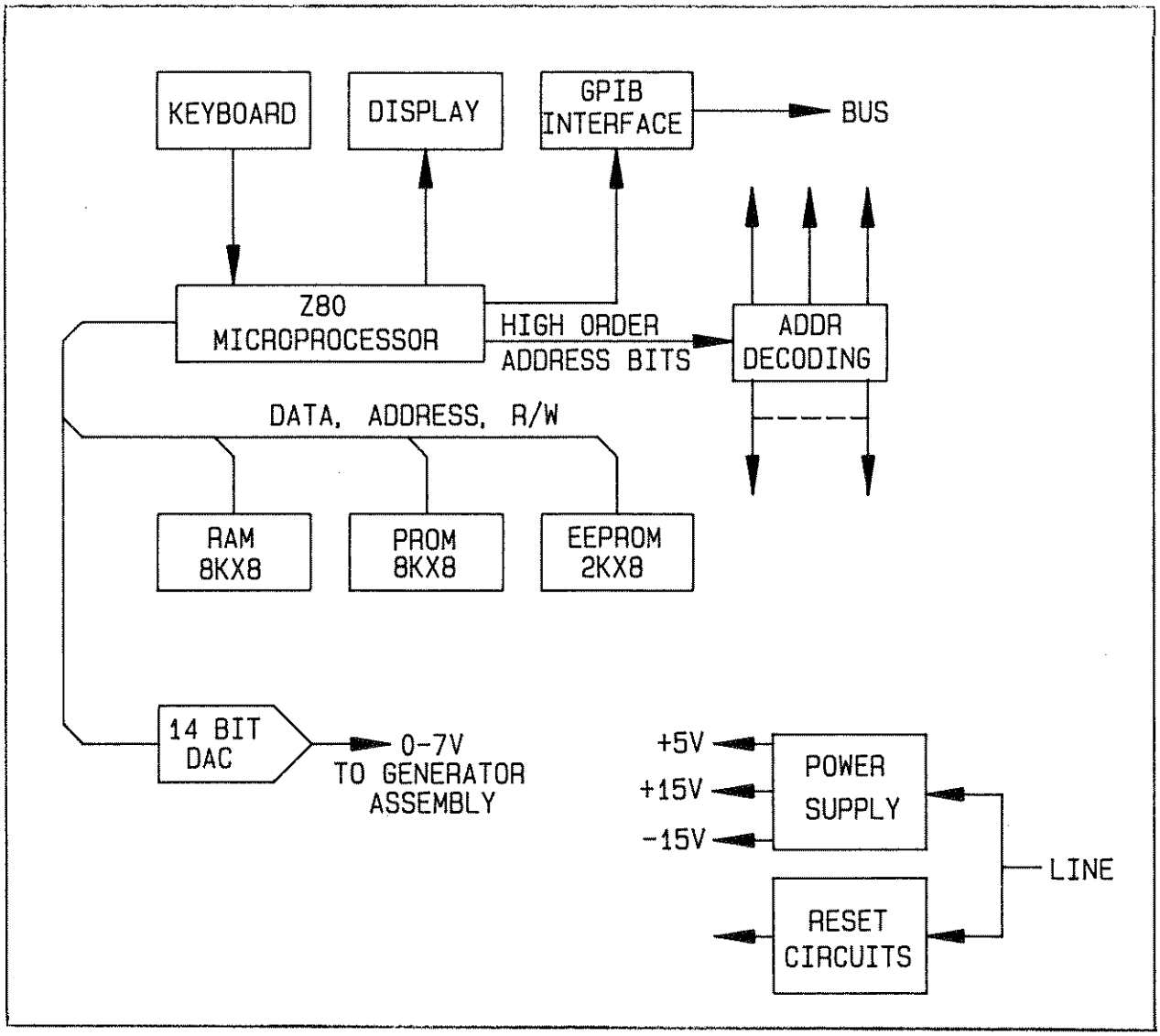

Figure 5-2. Control Board Block Diagram

2. RAM. The RAM U9 is used for temporary storage of variables and program data. This data is not retained on power down; the instrument always starts at the default settings of Range 0, impedance set at 500K ohms, and output off.

3. Decoding. Address bits A13 and A14 break the address map into three major sections, RAM, PROM, and miscellaneous. The miscellaneous section is further segregated by A10, A11, and A12 into 1K blocks (400 hex) which select the display, the DAC, etc. as shown in **Table 5-1.** Most of these 1K blocks is wasted, only one or two bytes per block being used, for simplicity of decoding. For the display, which has two "registers" (data and control byte), the LSB's of the address do the final decoding to one exact address in the device itself, although intensive decoding is not used (that is, not all of the 14 address bits are used to select a given device).

Table 5-1. Memory Map.

Address (Hex)	Function
0000-1FFF	PROM
2000-BFFF	RAM
4000-5FFF	not used
6000-63FF	KEYBOARD
6400	REAR SWITCH
6800	INTERNAL SW
6C00	LATCH 1
7000	LATCH 2
7400	GPIB
7801	not used
7802	not used
7803	not used
7C00	DISPLAY CNTL
7C01	DISPLAY DATA

4. Keyboard Circuits. The keys are scanned by the Z80 with U28. When the nonlatching buffer U28 is active (closed), the status of each key switch is put on the data bus.

5. Display. The display is sent characters in ASCII in a similar way to a data terminal. The Z80 sends control characters at power up to set the display up for certain modes such a non-blinking cursor, shifting or nonshifting mode, etc. The Nand and And gates that precede the display convert the Read and Write lines to a single "Read/Write" line and delay the enable line so that the data is settled before the display latches it.

Also supplied to the display is a control voltage that controls the vertical viewing angle and the contrast. The display is a self contained non-repairable unit.

6. GPIB Circuits. The General Purpose Interface Bus is controlled by U15 which handles most of the protocol between the bus and the Z80. It serves as a one character buffer. When a character is received on the bus, U15 interrupts the Z80 and the Z80 fetches it. The hardware lines such as SRQ, IFC, and ATN are all handled by U15. U16 and U17 are buffers.

7. Power On Reset Circuits. The requirement for the reset signal is that it comes up some time after the power supply has stabilized, and that in the event of a short power glitch, it goes low immediately, before the +5V begins to droop, and stays low for a short period after the glitch has gone away. These aspects of the reset line assure that the microprocessor is operating only when the +5V

is fully stabilized. The microprocessor can respond to a reset by shutting itself down in an orderly manner in a few microseconds, while the electrolytic capacitors in the power supply are still holding charge.

Comparator U24B monitors the unregulated +5V, which is about +8V with ripple. When this line drops to about 8V, the regulator U22 can no longer guarantee 5V at it's output, and at this point U24B drops low. U25 is an open collector output which discharges C23 rapidly through 100 ohms. U24A and U25E then go low. The microprocessor takes a few microseconds to complete it's current operation, while the electrolytic capacitors are decaying. On power up, C23 has to charge through 47.5 K ohms, providing a time delay of about one half of a second.

8. Relay Drive. U2, U3, and U8 read the Bit switches and control the relays. U2 and U3 are actually not latches but tristated buffers. The relay control lines going to the Output Board are set according to levels shown in **Table 5-2.** In the table, "HI" refers to the relay open condition. Not shown in the table are K1, which is simply the output enable, and the three relays that control the output impedance. The status of these drive lines are evident from inspection of the schematic.

TABLE 5-2. RELAY LINE CONTROL

Range	K2	K3	K4	K5	K6	K7	K8	K9	K10
0	LO	HI	HI	HI	LO	HI	HI	HI	HI
1	HI	LO	HI	HI	LO	HI	HI	HI	HI
2	HI	HI	LO	HI	LO	HI	HI	HI	HI
3	HI	HI	HI	LO	LO	HI	HI	HI	HI
4	HI	HI	HI	LO	HI	LO	HI	HI	HI
5	HI	HI	HI	LO	HI	HI	LO	HI	HI
6A	HI	HI	HI	LO	HI	HI	HI	LO	HI
6B	HI	HI	HI	LO	HI	HI	HI	HI	LO

SECTION 6
MAINTENANCE

6-1. INTRODUCTION. This section contains the following items related to maintenance: safety requirements, test equipment, cleaning procedures, inspection procedures, removal and replacement of module procedures, and also three major subsections:

6-100. PERFORMANCE VERIFICATION
6-200. ADJUSTMENTS (CALIBRATION)
6-300. TROUBLESHOOTING

6-2. SAFETY REQUIREMENTS. Although this instrument has been designed in accordance with international safety standards, general safety precautions must be observed during all phases of operation, service, and repair of the instrument. Failure to comply with the precautions listed in the Safety Summary located at the beginning of this manual or with the specific warnings given throughout this manual could result in serious injury or death. Service and adjustments should be performed only by qualified service personnel.

6-3. TEST EQUIPMENT. The test equipment required for the performance tests, adjustments, and troubleshooting is listed in **Table 6-1.**

6-4. CLEANING PROCEDURE. Painted surfaces can be cleaned with a commercial spray type window cleaner or with a mild soap and water solution. Or, use isopropyl alcohol or kelite reduced by water 20:1.

CAUTION
Avoid the use of chemical cleaning agents which might damage the plastics used in the instrument.

6-5. REMOVAL AND REPLACEMENT OF BOARDS AND ASSEMBLIES.

1. Instrument Covers. Disconnect the power cord and all cables. Remove the screws on the top and bottom of the instrument at the rear. Slide the cover(s) off toward the rear of the unit.

2. Control Board. With the top cover removed, remove the ribbon cables that go to the display and keyboard, and remove the multiwire connector that goes to the Output board. Remove the two connectors at the front of the unit that go to the inverter assembly and to the pilot LED. Also remove the five pin connector that comes from the transformer, and the 24 pin GPIB cable.

Remove the right side panel and the two screws that hold the heat sink assembly to the side frame. Remove the rest of the screws that secure the Control board, and remove the board.

3. Keyboard. Remove the bottom cover. Turn the unit upside down and remove the bottom trim strip at the front of the unit. Tilt the lower section of the front panel away and remove the keyboard (the ribbon cable can remain attached). Remove the screws that secure the keyboard and remove the ribbon cable that goes to the Control board.

TABLE 6-1. MAINTENANCE TEST EQUIPMENT

Equipment	Pertinent Specifications	Suggested Model
Nanovoltmeter	Can read 9 uV to an accuracy of +/- 1uV	Kiethley 181
DMM	150 VAC	Kiethley 179
Oscilloscope	10 MHz, 5 mV/ div	Tek 475 with 10X probe
Variac	0 to 120% of nominal line voltage	
Bus Controller	IEEE Interface	HP85A/B
Test Cable #1	Kiethley Model 1506 cable/connector mated to one half of a Boonton 41-2A cable. See text for substitutes.	
Test Cable #2	Boonton 41-2A cable modified with a dual banana plug on one end.	
Load	500K ohm 1% resistor on a dual banana plug	

4. Output Board. Remove the top and bottom covers, and with the unit upside down, unplug the multiconductor cables that go from the Control board to the Output board. Unsolder the cable that goes to the output connector. Remove the screws that secure the Output board and remove the board.

5. Display. Remove the top cover and the trim strip at the front of the unit. Tilt the upper section of the front panel away and unplug the ribbon cable that goes to the display, at either end as desired. Unsolder the two wires at the right of the display. (If desired, the inverter can be removed also with the display; this will eliminate the need to unsolder. To do this, remove the 2 screws that secure the inverter and unplug it from the Control board. Remove the screws that secure the display and remove it).

6-6. INSPECTION. If an equipment malfunction occurs, perform a visual inspection of the 2510. Inspect for signs of damage caused by excessive shock, vibration, or overheating, such as broken wires, loose hardware, loose electrical connections, electrical shorts, or accumulations of dirt and foreign matter. Correct any problems discovered, and do the Performance Verification tests in Section 6-100. If a malfunction persists or the instrument fails

any of the performance tests, refer to the Adjustments Section, 6-200. If the instrument cannot be adjusted, refer to the Troubleshooting Section, 6-300.

SECTION 6-100
PERFORMANCE TESTS

6-101. INTRODUCTION. The performance tests should be performed about every 12 months or after the instrument has been repaired. These tests may also be performed when the 2510 is received to verify instrument performance. Refer to **Table 6-1** and the text below for a list of the equipment required. The procedure is listed below.

6-102. VERIFICATION PROCEDURE.

1. Set the voltage selector switches on the rear panel for the proper voltage, and connect the instrument to the AC line and power up.

2. Connect the DC output to a Kiethley 181 nanovoltmeter or equivalent using a custom shielded cable (Test cable #1 in **Table 6-1**) made from a Kiethley 1506 cable with a Boonton sensor connector attached to one end (obtained from a Boonton 41-2A cable). Observe shielding when making up the cable.

NOTE

A general purpose DVM with good resolution may be used for verification, but not on the lower ranges. The 2510 output on range 0 is 9 uV. If another meter is substituted in the tests below, increase the test limits as required for that meter.

3. Press the "On/Off" key once on the 2510 to enable the output, and verify that the indication on the display shows that the output is enabled.

4. Using the left and right arrow keys, position the cursor under the "Impedance" field, and then using the down arrow key, set the impedance to 1800 ohms.

5. Using the left and right arrow keys, position the cursor under the range indication (1 through 6B).

6. Using the up and down arrow keys, set the 2510 to the ranges listed in **Table 6-101** and check for the voltages listed in the table. On the lower ranges, the nanovoltmeter must be zeroed occasionally with the 2510 output disabled. Note: The tests below assume that this test is done at 18 to 28 degrees C. See the Specifications for operation outside this range.

TABLE 6-101. DC OUTPUT VOLTAGES

Range	Level	
0	8.0 - 10.0	uVDC
1	89.0 - 91.0	uV
2	898 - 902	uV
3	8.985 - 9.015	mV
4	89.85 - 90.15	mV
5	898.5 - 901.5	mV
6A	1.797 - 1.803	V
6B	4.493 - 4.507	V

7. Set the 2510 to range 5, and connect it to the nanovoltmeter or a standard DVM using Test Cable #2 in the Equipment list (**Table 6-1**). This is a cable that is made from a Boonton 41-2A cable modified on one end

with a dual banana plug. This cable is double shielded, although for this test a standard 2 conductor cable with a single shield will suffice, since it is run at a high level. Then connect a 500K ohm 1% load resistor across the voltmeter, in parallel with the 2510, mounted on a banana plug.

8. Position the cursor under the "Impedance" Field and set the impedance to 500K ohms. The voltage should read 430 to 470 mV. Now set the impedance to 300K ohms. The voltage should be ~~320 to 360 mV.~~ see 33K1-4-1825-1 540 to 580 mV.

9. Connect the GPIB connector on the rear panel to a controller and run a test program, following the program instructions.

This completes the checkout of the instrument.

SECTION 6-200
ADJUSTMENTS

6-201. INTRODUCTION. The adjustments listed here are to be used for periodic maintenance (every 12 months typically), or on a unit which has been repaired. Repairs on the Control board will not affect the DC output calibration, but if circuits in the power up reset area of the control board are repaired, the trip voltage adjustment (R13) should be adjusted.

If any of the RF relays have been replaced in the Generator assembly, they need to be "burned in" by cycling. This is done by setting the internal Bit switch on the Control board to the positions in **Table 6-201** and turning the power on. The relays will cycle every few seconds, accumulating 20,000 counts in 16 hours. This is sufficient to "wear in" the contacts. The contacts are rated for more than one million counts. Return the Bit switch to the positions shown in **Table 6-202.**

6-202. POWER UP RESET ADJUSTMENT. Connect the 2510 to the AC line through a variac. Monitor Control board **TP4** (regulated 5 V) and **U24 pin 10** (Reset) on a scope. With the scope set to 5 mS per division, drop the variac down from the nominal AC voltage to the point where the regulated 5 V just begins to drop out. Now increase the AC line voltage by 10 V if operating from 120 volts and by 20 V if operating from 220/240 V. Now set the pot **R13** so that the reset line is just at the point of not going low (to where it is stable).

TABLE 6-201. INTERNAL BIT SWITCH SETTING FOR BURN IN

Position	Setting
1	Closed
2	Closed
3	Closed
4	Closed
5	Open
6	Closed
7	Closed
8	Closed

Increase the line voltage to 105 V or 210 V as appropriate, depending on how the line voltage selector switches are set up, and verify that the 2510 is functioning with a stable display. Then power down and remove the variac from the line.

6-203. OUTPUT LEVEL CALIBRATION.

1. With the 2520 upside down and the bottom cover removed, connect a general purpose DVM or the Kiethley 181 nanovoltmeter to TP2 on the Output board (negative lead) and to TP1 (positive lead). Adjust R2 on the Output board for an indication of 4.999 to 5.001 VDC.

2. Move the DVM positive lead to TP3 and adjust R5 on the Output
board for -4.999 to -5.001 VDC.

3. Perform the tests shown in **Section 6-100,** Performance Verification, to assure that the voltage dividers and relays

operate properly, and that the output impedance selection is functioning.

TABLE 6-202. INTERNAL BIT SWITCH SETTING FOR NORMAL OPERATION

Position	Setting
1	Closed
2	Closed
3	Closed
4	Closed
5	Closed
6	Closed
7	Open
8	Closed

SECTION 6-300
TROUBLESHOOTING

6-301. GENERAL. An instrument malfunction will generally be evident from the front panel or the output level. Or, the unit may not be able to be calibrated. If either of these conditions are present, refer to the theory of operation, Section 5, and to the troubleshooting steps below. After an instrument is repaired, the adjustments (calibration) should be done as listed in Section **6-200**, or the performance tests as listed in Section **6-100**, or both.

Some of the Control board repairs that are strictly digital in nature will not affect the calibration.

6-302. ACCESS TO BOARDS AND ASSEMBLIES. Refer to Section **6-5** for instructions on removal and replacement of boards and assemblies.

6-303. TROUBLESHOOTING. Refer to **Table 6-301** and proceed to the appropriate section according to the malfunction.

6-304. POWER SUPPLY. The power supply consists of the bridge rectifiers and the three regulators, and the power up reset circuit. The power up circuit generates a reset pulse that goes high a half second or so after the application of power; if this does not go high the instrument will appear dead. Refer to the paragraphs below.

1. Basic Power Supply. First check the fuse and check that the line voltage selector switch is in the proper position for the line voltage that is being used. If the fuse keeps blowing, the bridge rectifier(s) are probably shorted. Replace as required.

TABLE 6-301. TROUBLESHOOTING

Malfunction	Refer to
Display dark and no DC output	6-304, Power supply
Display active and functional; no output or wrong output; one or more ranges bad	6-305, Isolation to Assy
Output controllable but display is out	6-306, Control Board
Bus not working	6-306, Control Board
Output board known to be non-operative	6-307, Output Board

Also, the regulators may be shorted.

If the fuse and the line selector switch appear OK, apply power and measure the DC voltages (+5, +15, -15) at TP4, TP1, and TP3 respectively. If any are faulty, unplug the cable that goes to the Output board and to the display. If the suspect voltage comes up, refer to the troubleshooting section for that item that was removed. If it doesn't, measure the DC voltages at the electrolytic capacitors C7, C5, and C6. There should be about 9 VDC on C7, and +/-22 VDC on the others, with many volts of ripple. The best way to measure these is with a scope. If any of these voltages is not correct, check the transformer secondaries for AC voltage. Replace the transformer as required, or check the line voltage selector switch wiring and related circuitry for broken wires.

If a given regulator has input but no output, that line may be shorted through some component in the unit. If replacing the regulator does not help, this is probably the case. One of the suspect parts could be the filter capacitors. Replace the component(s) as required.

2. Power Up Reset Circuit. Assuming at this point that the three power supplies check out OK, look at pin 10 of U25. This is the reset pulse. This should go high one half second after power is applied, and stay high. If it doesn't, look at pins 2 and 13 of U24, the comparator. These should do the same, with perhaps faster timing and not so clean waveforms. Also, U25 pin 4 should do the same. If not, replace U24 or U25 as required. Finally, check U24 pin 10 for about 2.7 VDC.

6-305. ISOLATION TO ASSEMBLY. With this test, it can be determined with reasonable accuracy if the problem is on the Control board or in the Output board. This is done by monitoring the control signals that go the the Output board. Refer to the Theory of Operation for a description of the control signals, and to **Table 5-2.**

Set the 2510 to ranges 0 through 6B, and check the control lines (roughly TTL levels) going into the Output board according to that **Table 5-2.** These points may be checked either on the Control board or at the Output board. If any of these are not correct, disconnect the Output board and check again. If they are still not correct, the Control board is at fault; go to **Section 6-306,** Control board. If the voltages are correct only with the Output board disconnected, there is a short in the harness or in the Output board. Check the wiring and refer to the Output board troubleshooting section.

If the control lines appear OK, but the output is bad, the problem lies with the Output board. Proceed to that troubleshooting section. If these lines are not OK, troubleshoot the Control board.

6-306. CONTROL BOARD TROUBLESHOOTING. Refer to Section 5, Theory of Operation and to the Control board schematic. The first things to check are the clock and the power up reset. Check for 2 MHz at pin 6 of the Z80 (U4), and check for a logic high at pin 26. If these are OK, check for activity on all the data and address lines on the Z80. All

lines should have some activity; even very short pulses are to be considered valid. If all the data lines are "dead", the microprocessor may be at fault.

Since the RAM and PROM are intimately tied in to the Z80, a failure of one of these components would in general cause the Z80 to appear nonfunctional. The easiest way to check these components is by replacement. The PROM is of course replaceable only by the Boonton equivalent since it is a programmed part.

If the failure can be identified with a particular section such as the display, look for activity on data lines in that particular area. Generally, failures will be manifested as nonactivity. A gross malfunction in the 2510 may be due to failed decoder IC's U11 and U12 since they control all the other chip selects in the unit. This can be checked by looking for activity on all the output lines of those IC's.

6-307. OUTPUT BOARD TROUBLESHOOTING. Check for +5.000 VDC at TP1, using TP2 for a ground. If this is not within one millivolt and cannot be adjusted, replace U1 or R1 or R2 as required. Since the -5V is generated from the +5V, this must be checked first.

If the +5V at TP1 is not correct, it may be due to one or more relays being closed that should not be. For example, if K5 and K2 are closed, U1 will be trying to drive 10 ohms (R10 and R11). In normal operation, these two relays will never be closed at once. The most likely cause of a relay being inadvertently closed is a shorted driver IC. Check the input and output voltages of the suspected driver gate; they should always be the same. (Either both high TTL or low TTL). The relays close when the gate outputs are low.

Then check for -5V at TP3 and replace U2 as required. Again, relays that are inadvertently closed may cause the -5V to be incorrect.
If a given range is bad, check all the relay drive lines at the relays according to **Table 5-2,** and replace suspected drivers. If the drive is OK, short the relays that are supposed to be closed with a clip lead; if the output goes to normal, the relay is not closing properly. Replace as required.

SECTION 7 - PARTS LIST

7-101. INTRODUCTION. Table 7-1 lists the part manufacturers Federal Supply Codes, and Table 7-2 lists all the replaceable parts in the 2510. Non-replaceable parts are parts such as screws and sheet metal parts. Contact Boonton for information on securing these parts.

TABLE 7-1. MANUFACTURER'S FEDERAL SUPPLY CODE NUMBERS

Number	Name	Number	Name
00241	Fenwal Electronics	31313	Components Corp.
01121	Allen Bradley	31918	ITT Schadow, Inc.
01247	Sprague Electric Company	32575	AMP
01295	Texas Instruments	32897	Erie
02660	Amphenol	32997	Bourns, Inc., Trimpot Div.
02735	RCA Solid State Division	33297	NEC
03888	Pyrofilm (KDI)	33883	RMC
04713	Motorola Semiconductor	34335	Advanced Micro Devices
04901	Boonton Electronics	51640	Analog Devices, Inc.
06383	Panduit Corp.	52464	OKI
06776	Robinson Nugent, Inc.	54420	Dage — MTI
07263	Fairchild Semiconductor	54426	Buss Fuses
07326	Fairchild Semiconductor	54473	Panasonic
13812	Dialco Div. of Amperex	56289	Sprague Electric Company
14655	Cornell-Dubilier	56708	Zilog, Inc.
17801	Panel Corp. (Schurter)	57582	Kahgan Electronics Corp.
19701	Mepco Electra	61637	Kemet-Union Carbide
20307	Arco — Micronics	71450	CTS Corp.
24226	Gowanda Electronics	73138	Beckman Instr., Helipot Div.
27014	National Semiconductor	81073	Grayhill
27264	Molex, Inc.	91293	Johanson
27735	F-Dyne Electronics	91506	Augat
27777	Varo Semiconductor	98291	Sealectro Corp.
28480	Hewlett-Packard Corp.	99942	Centralab
		S4217	United Chemicon, Inc.

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FRAME ASSY 2510

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A1(1)	CHASSIS UNIT 2510/2520/4220	04901	60474900B	1	60474900B
A2(9)	POWER SWITCH FINAL ASSY	04901	04311703A	1	04311703A
A4(8)	INVERTER ASSY (EL)	04901	04313300A	1	04313300A
A5(5)	DISPLAY ASSEMBLY LCD	04901	04312100B	1	04312100B
A3(13)	PWA 2510 CONTROL DC CALIBRATOR	04901	02510200A	1	02510200A
A7(12)	PWA 2510 KEYBOARD	04901	02510000A	1	02510000A
U6	PROM 2510/20 A3 U6 CONTROL	04901	53447300A	1	53447300A
W2	CABLE FLAT ASSY	04901	57222801A	1	57222801A
W3	CABLE ASSEMBLY	04901	57123100A	1	57123100A
W4	CABLE FLAT ASSY	04901	57222704A	1	57222704A
W5	(G) CABLE UNIT 16 PIN	04901	92004600B	1	92004600B
DS1	LED YELLOW DIFF 5082-4684	28480	HLMP-1401	1	536034000
J13(11)	CONNECTOR HOUSING 4 PIN	27264	03-06-2043	1	477306000
R1	RES MF 267 OHM 1% 1/4W	19701	5043ED267R0F	1	341241000
S1	SWITCH ROCKER DPDT	13812	572-2121-0103-010	1	465286000
W29	CABLE ASSEMBLY 2 CONNECTOR	04901	57222907A	1	57222907A
W31	CABLE ASSEMBLY 2 CONNECTOR	04901	57222903A	1	57222903A
A5(1)	DISPLAY LCD DOT MAT STD TEMP	62483	LM24E2C40CTW	1	55500002A
MP1(4)	EL LAMP (SPARE FOR 555000XX*)	62483	ELS4000	1	55500021A
LC1	LINE CORD	UNION	568106000	1	568106000
F1	FUSE 0.3 AMP 250V MDL	54426	MDL 0.3	1	545507000
J12	CONN COAX BNC	54420	UG-625/U	1	479123000
P5	CONNECTOR 5 CIRCUIT	06383	CE156F24-5-C	1	479394000
T1	TRANSFORMER POWER	04901	44609100A	1	44609100A
W1	CABLE ASSY FLAT (GPIB)	04901	57223001A	1	57223001A
W7	CABLE ASSEMBLY 2 CONNECTOR	04901	57222908A	1	57222908A
XF1A(2)	FUSE HOLDER	SCHURT	FEU031.1673	1	482117000
XF1B(4)	FUSE CARRIER GRAY 1/4 x 1-1/4	SCHURT	FEK031.1666	1	482114000
J1	CONNECTOR LINE CORD	82389	EAC309	1	477281000
S1	SWITCH DUAL SLIDE DPDT-DPDT	82389	47206LFR	1	465279000

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PWA 2510 KEYBOARD

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
J1	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
MP1(2)	BUTTON MARKED "LOCAL"	04901	77553716B	1	77553716B
MP2(3)	BUTTON MARKED "ON/OFF"	04901	77553712B	1	77553712B
MP3(4)	BUTTON MARKED "RIGHT ARROW"	04901	77553736B	1	77553736B
MP4(5)	BUTTON MARKED "UP ARROW"	04901	77553737B	1	77553737B
R1	RES VAR 25K 10% 0.5W	73138	72PR25K	1	311400000
S1-6	SWITCH PUSHBUTTON SPST	31918	210272	6	465230000

PWA 2510 CONTROL DC CALIBRATOR

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1	CAP MICA 430pF 1% 500V	14655	CD15FD431F03	1	200037000
C2-3	CAP MICA 100pF 5% 500V	14655	CM05FD101J03	2	200001000
C5-6	CAP EL 2200uF -10%+50% 35V	57582	KSMM-2200-35	2	283351000
C7	CAP EL 4700uF -10%+50% 16V	S4217	SM-25-VB-100-M	1	283352000
C9-11	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	3	283334000
C12-19	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	8	224268000
C22	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C23	CAP EL 10uF 20% 25V	S4217	SM-25-VB-10-M	1	283336000
C24	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C25	CAP EL 10uF 20% 25V	S4217	SM-25-VB-10-M	1	283336000
CR1	DIODE BRIDGE KBP-02	15281	KBP02	1	532013000
CR2	DIODE BRIDGE VS-248 6A 200 PIV	27777	VS-248	1	532014000
CR3-5	DIODE SIG 1N4001	04713	1N4001	3	530151000
CR7	DIODE ZENER 1N52318 5.1V 5%	04713	1N5231BSZ	1	530169000
J1	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
J3	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
J4	SOCKET IC 24 PIN	06776	ICN-246-S4-G	1	473043000
J5	HEADER 5 PIN STRAIGHT	06383	MPSS156-5-D	1	477345000
J7-9	CONN M 02 CIR .1 SP PLZ STRAIT	06383	MPSS100-2-A	3	47740702A
J10	HEADER 5 PIN STRAIGHT	06383	MPSS156-5-D	1	477345000
J11	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
L1	INDUCTOR 15uH 10%	24226	10M152K	1	400373000
R1	RES MF 332 OHM 1% 1/4W	19701	5043ED332R0F	1	341250000
R2-3	RES NTWK 10K 2% 1.5W 10-SIP	71450	750-101-R10K	2	345038000
R4	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	1	341365000
R6	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	1	341365000
R7	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R9	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R10-11	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	2	341400000
R12	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R13	RES VAR 1K 10% 0.5W	73138	72PR1K	1	311316000
R14	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R15	RES MF 47.5K 1% 1/4W	19701	5043ED47K50F	1	341465000
R16	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R17-18	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	2	341365000
R19	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R20	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	1	341365000
R21	RES NTWK 10K 2% 1.5W 10-SIP	71450	750-101-R10K	1	345038000
S1	SWITCH PIANO 8PST DIP	LAMB	BT-8-2	1	46529908A
S2	SWITCH ROCKER 8PST DIP	81073	76SB08	1	465225000
U1	IC 7404 HEX INVERTER	01295	SN7404N	1	534042000
U2-3	IC 74HCT541 OCTAL BUFFER	01295	74HCT541N	2	534383000
U4	IC Z80C CPU CMOS	TOSHIB	TMPZ84C00AP	1	53440900A
U5	IC 74LS02 2 INPT POS NOR	01295	SN74LS02N	1	534154000
U7-8	IC 74HCT373 OCTAL LATCH	02735	CD74HCT373E	2	534417000
U9	IC 5564 8Kx8 RAM CMOS 28 DIP	TOSHIB	TC5564PL-15	1	534403000
U11	IC 74HCT139 DUAL DEMUX	02735	CD74HCT139E	1	53444208A
U12	IC 74HCT138 1 OF 8 DECODER	ZYTREX	ZX74HCT138-2N	1	534375000
U13	IC 74LS00 2 INP POS NAND	01295	SN74LS00N	1	534167000
U14	IC 74LS08 QUAD 2 INPUT AND	18324	SN74LS08N	1	534156000
U15	IC 9914ANL IEEE BUS PROCESSOR	01295	TMS9914ANL	1	534288000
U16	IC 75160 IEEE BUS TRANSCEIVER	01295	SN75160BN	1	534286000
U17	IC 75161 IEEE BUS TRANSCEIVER	01295	SN75161BN	1	534287000
U20	IC UA7815 REGULATOR	07263	uA7815	1	535056000
U21	IC UA7915UC REGULATOR	07263	uA7915UC	1	535103000
U22	IC UA7805UC VOLT REG	07263	uA7805UC	1	53511700A
U25	IC 7407 HEX BUFFER	01295	SN7407N	1	534066000
U26	IC 74HCT541 OCTAL BUFFER	01295	74HCT541N	1	534383000
U27	IC 79L05 VOLT REG	04713	MC79L05ACP	1	535090000
XU1	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU2-3	SOCKET IC 20 PIN	06776	ICN-203-S3-G	2	473065000
XU4	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU5	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU6	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU7-8	SOCKET IC 20 PIN	06776	ICN-203-S3-G	2	473065000
XU9	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000

02510200A PWA 2510 CONTROL DC CALIBRATOR
MODEL: 2510

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
XU11-12	SOCKET IC 16 PIN	06776	ICN-163-S3-G	2	473042000
XU13-14	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU15	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU16-17	SOCKET IC 20 PIN	06776	ICN-203-S3-G	2	473065000
XU18	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU19	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU23	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU24-25	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU26	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000

02510100A PWA 2510 DC OUTPUT
MODEL: 2510

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1-3	CAP EL 10uF 20% 25V	54217	SM-25-VB-10-M	3	283336000
J1	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
J2	HEADER 5 PIN STRAIGHT	06383	MPSS156-5-0	1	477345000
K1-13	RELAY REED DPST NO 5V 14 DIP	95348	832A-2	13	47105502A
R1	RES MF 301K 1% 1/4W	19701	5043ED301K0F	1	341546000
R2	RES VAR 10K 10% 0.5W	73138	72PR10K	1	311328000
R3	RES MF 24.3K 1% 1/4W	19701	5043ED24K30F	1	341437000
R4	RES MF 49.9K 1% 1/4W	19701	5043ED49K90F	1	341467000
R5	RES VAR 1K 10% 0.5W	73138	72PR1K	1	311316000
R6	RES MF 49.9K 1% 1/4W	19701	5043ED49K90F	1	341467000
R7	RES WW 9.0K 0.005% 0.175W	GEN. R	8E16-A-9K	1	314271000
R8	RES WW 900 OHM 0.01% 0.175W	GEN. R	8E16-A-900	1	314204000
R9	RES WW 90 OH 0.01% 0.175W	GEN. R	8E16-A-90	1	314040000
R10-11	RES WW 10 OHM 0.01% 0.175W	GEN. R	8E16-A-10	2	314027000
R12	RES WW 90 OH 0.01% 0.175W	GEN. R	8E16-A-90	1	314040000
R13	RES WW 900 OHM 0.01% 0.175W	GEN. R	8E16-A-900	1	314204000
R14	RES WW 9.0K 0.005% 0.175W	GEN. R	8E16-A-9K	1	314271000
R15	RES WW 999.1K 0.005% 0.175W	GEN. R	8E24-A-999.1K	1	314593000
R16	RES WW 99.1K 0.005% 0.175W	GEN. R	8E16-A-99.1K	1	314473000
R17	RES WW 9.1K 0.005% 0.175W	GEN. R	8E16-A-9.1K	1	314272000
R18	RES WW 4.1K 0.005% 0.175W	GEN. R	8E16-A-4.1K	1	314258000
R19	RES WW 1.1K 0.005% 0.175W	GEN. R	8E16-A-1.1K	1	314256000
R20-21	RES WW 900 OHM 0.01% 0.175W	GEN. R	8E16-A-900	2	314204000
R22	RES WW 1.1K 0.005% 0.175W	GEN. R	8E16-A-1.1K	1	314256000
R23	RES WW 4.1K 0.005% 0.175W	GEN. R	8E16-A-4.1K	1	314258000
R24	RES WW 9.1K 0.005% 0.175W	GEN. R	8E16-A-9.1K	1	314272000
R25	RES WW 99.1K 0.005% 0.175W	GEN. R	8E16-A-99.1K	1	314473000
R26	RES WW 999.1K 0.005% 0.175W	GEN. R	8E24-A-999.1K	1	314593000
R27	RES MF 249K 1% 1/4W	19701	5043ED249K0F	1	341538000
R28-29	RES MF 150K 1% 1/4W	19701	5043ED150K0F	2	341517000
R30	RES MF 249K 1% 1/4W	19701	5043ED249K0F	1	341538000
R31-32	RES NTWK 10K 2% 1.5W 10-SIP	71450	750-101-R10K	2	345038000
U1	IC AD584JHV VOLTAGE REGULATOR	51640	AD584JH	1	535123000
U2	IC 356P OP AMP	04713	LF356N	1	535040000
U3-5	IC 7407 HEX BUFFER	01295	SN7407N	3	534066000
XU1-2	SOCKET IC 8 PIN	06776	ICN-083-S3-G	2	473041000
XU3-5	SOCKET IC 14 PIN	06776	ICN-143-S3-G	3	473019000

SECTION 8
SCHEMATICS AND COMPONENT LOCATION DIAGRAMS

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8-2.	Control Component Location Diagram	02510200A	8-4
8-3.	Control Board Schematic Sht 1	83150102A	8-5
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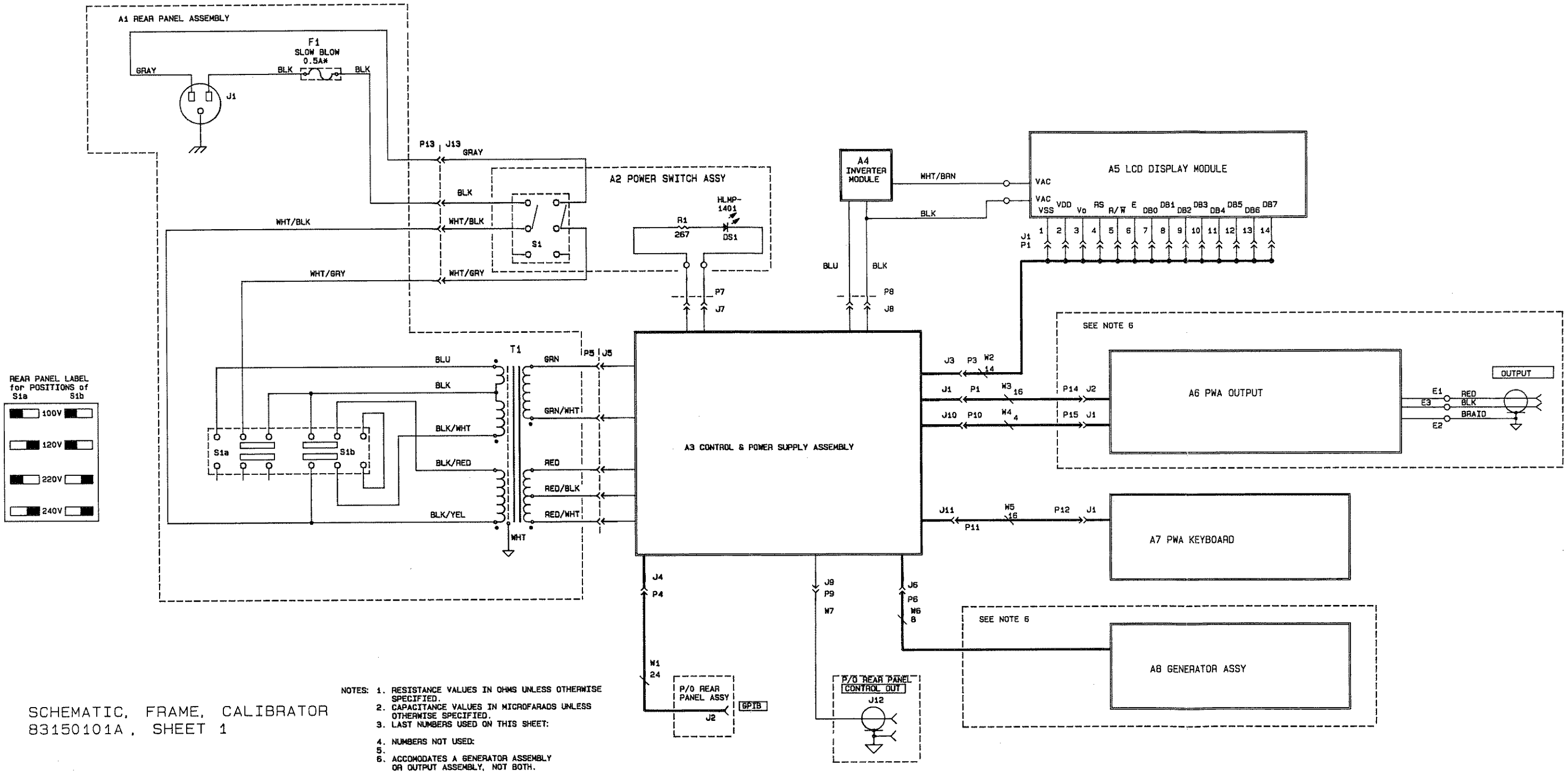
8-9.	Output Board Schematic	83150104A	8-11



SCHEMATIC, FRAME, CALIBRATOR
83150101A , SHEET 1

NOTES:
1. RESISTANCE VALUES IN OHMS UNLESS OTHERWISE SPECIFIED.
2. CAPACITANCE VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
3. LAST NUMBERS USED ON THIS SHEET:
4. NUMBERS NOT USED:
5.
6. ACCOMODATES A GENERATOR ASSEMBLY OR OUTPUT ASSEMBLY, NOT BOTH.

Figure 8-1. Frame Schematic

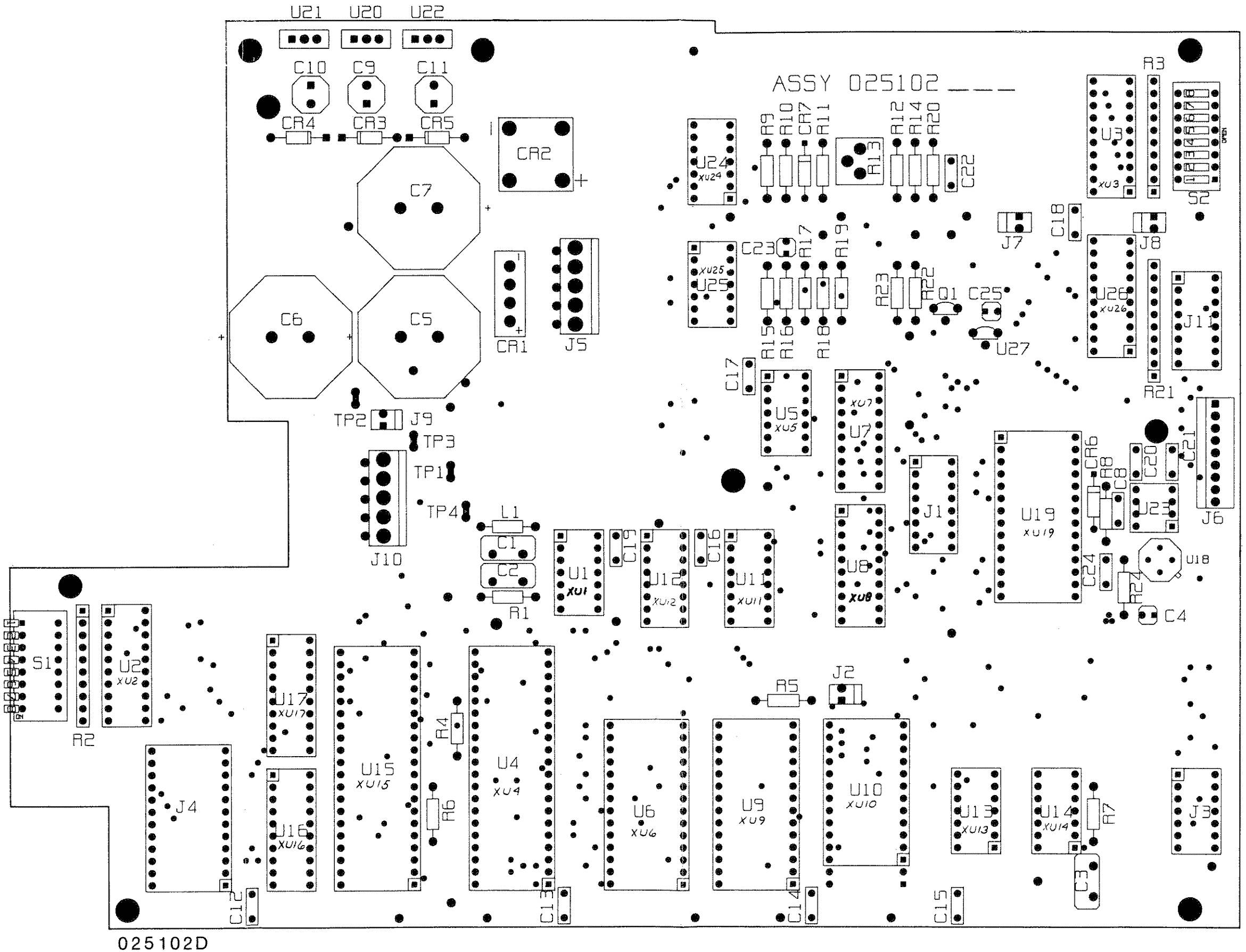


Figure 8-2. Control Component Location Diagram

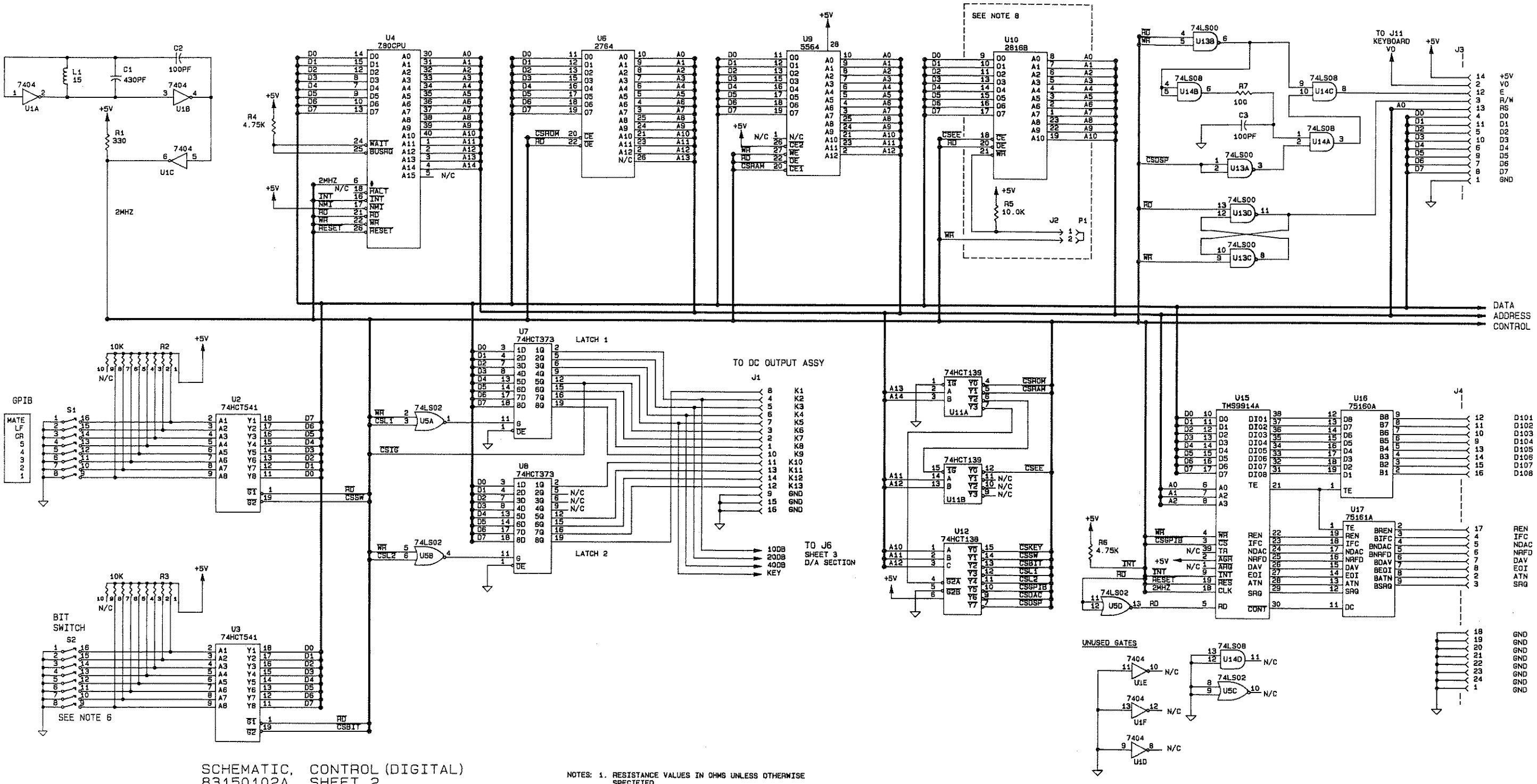


Figure 8-3. Control Board Schematic Sht 1

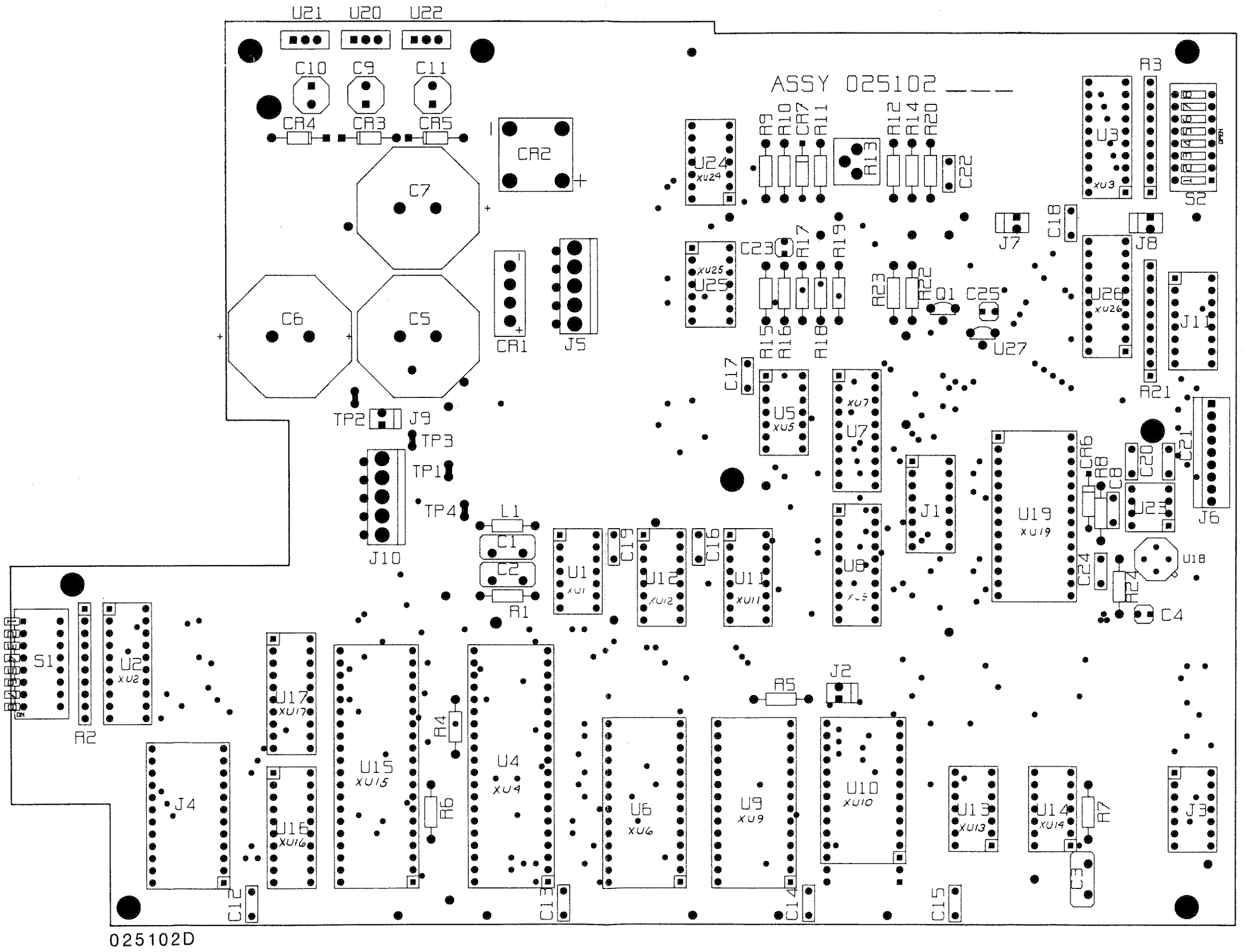
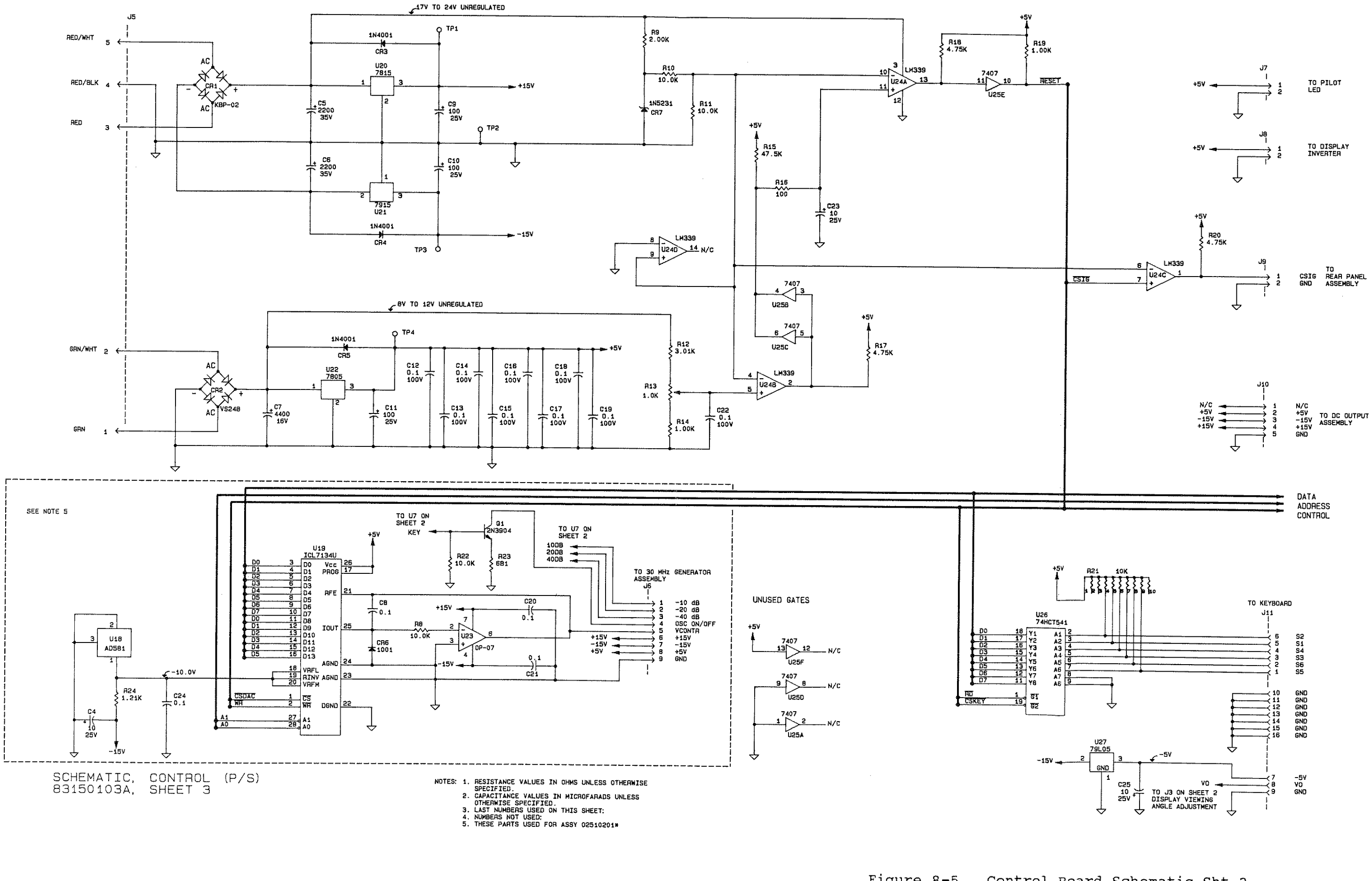


Figure 8-4. Control Component Location Diagram



SCHEMATIC, CONTROL (P/S)
83150103A, SHEET 3

NOTES:
1. RESISTANCE VALUES IN OHMS UNLESS OTHERWISE SPECIFIED.
2. CAPACITANCE VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
3. LAST NUMBERS USED ON THIS SHEET:
4. NUMBERS NOT USED:
5. THESE PARTS USED FOR ASSY 02510201#

Figure 8-5. Control Board Schematic Sht 2

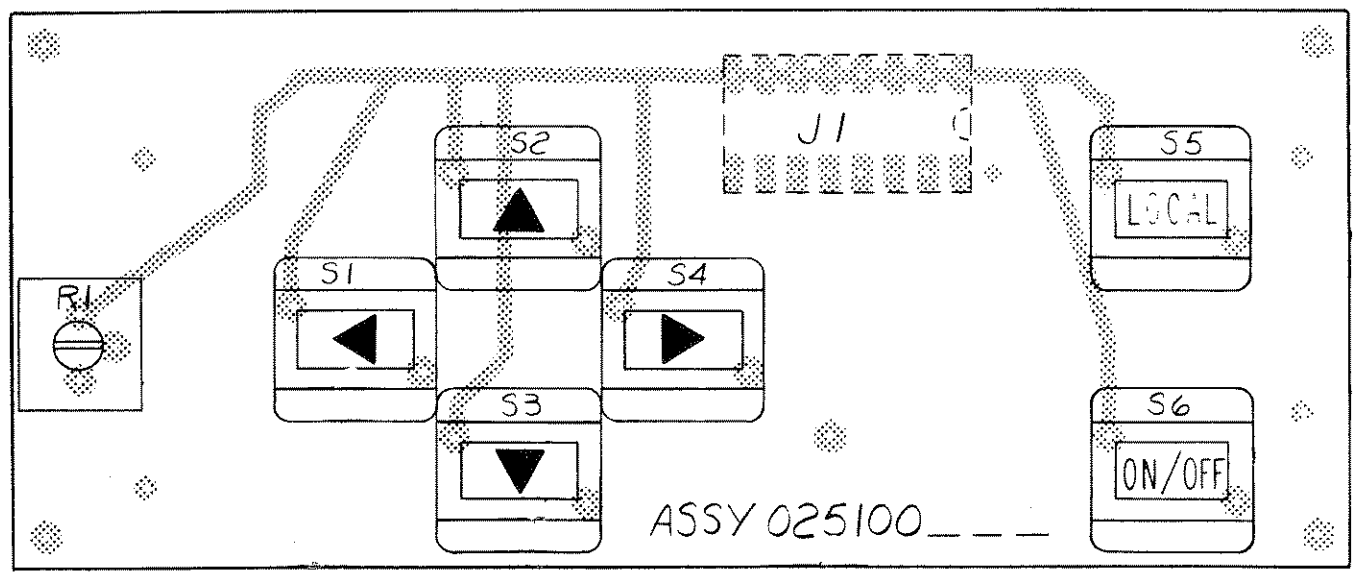
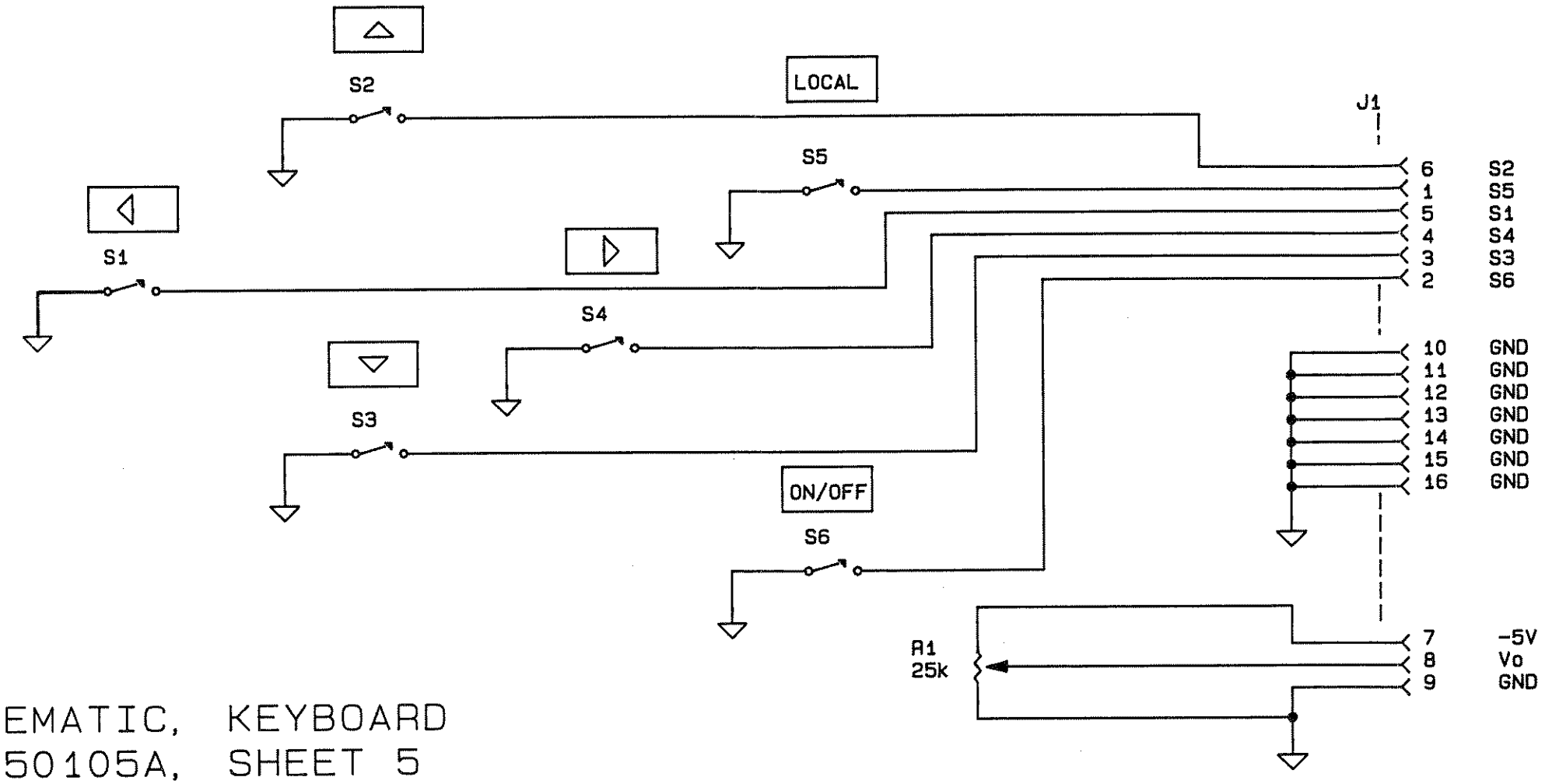


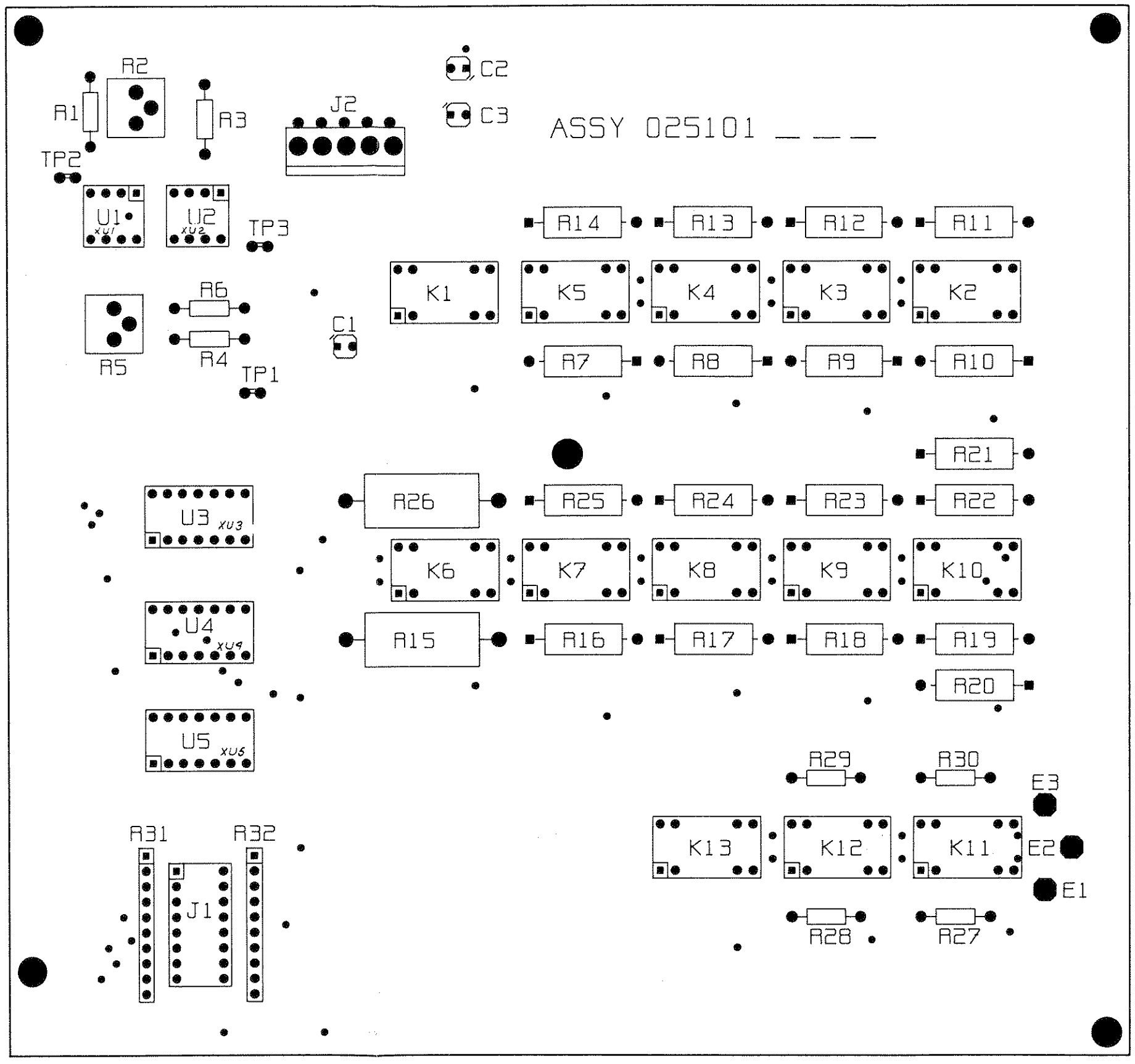
Figure 8-6. Keyboard Component Location Diagram



SCHEMATIC, KEYBOARD
83150105A, SHEET 5

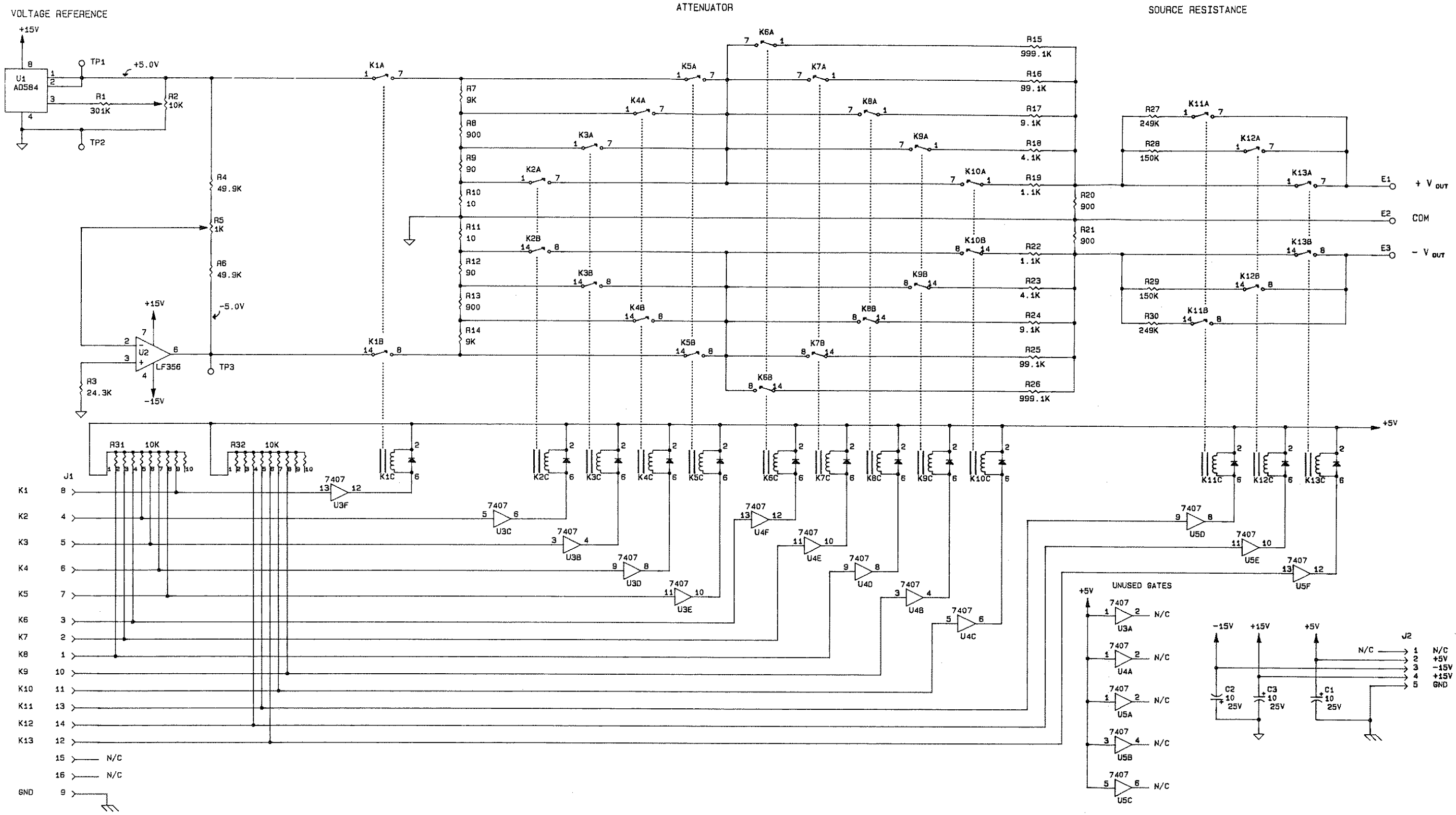
NOTES: 1. RESISTANCE VALUES IN OHMS UNLESS OTHERWISE SPECIFIED.
2. CAPACITANCE VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
3. LAST NUMBERS USED ON THIS SHEET: J1, R1, S6
4. NUMBERS NOT USED:
5. BOX DENOTES EXTERNAL MARKING. ☐

Figure 8-7. Keyboard Schematic



025101B

Figure 8-8. Output Board Component Location Diagram



SCHEMATIC, OUTPUT 2510
83150104A, SHEET 4

NOTES:
1. RESISTANCE VALUES IN OHMS.
2. CAPACITANCE VALUES IN μF.
3. LAST NUMBERS USED; C3, J2, K13, R32, TP3, U5.
4. NUMBERS NOT USED; ---
5.
6.
7.

Figure 8-9. Output Board Schematic

T.O. 33K1-4-1825-1

TECHNICAL MANUAL

CALIBRATION PROCEDURE

FOR

DC RANGE CALIBRATOR

2510

(BOONTON)

This publication replaces T.O. 33K1-4-1825-1 dated 15 January 1995.

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30 APRIL 1998

DC RANGE CALIBRATOR

2510

(BOONTON)

1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
DC Output Level	Range: 0.0 to 9.0, 90.0, and 900.0 µV, 9.0, 90.0, and 900.0 mV, 1.8, and 4.5 V Accuracy: 0.0 to 9.0 µV range, ±(0.15% + 2 µV); all others, ±(0.15% + 1 µV)	Measured with a Nanovoltmeter
Output Impedance	Range: Low (900 to 1800 Ω), 300 kΩ, and 500 Ω Accuracy: ±1.0%	Voltage is measured with a Nanovoltmeter when the TI Impedance is set to each of the ranges

2 EQUIPMENT REQUIREMENTS:

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.1 NANOVOLTMETER	Range: 9.0 µV to 4.8 VDC Accuracy: ±0.0375%	Keithley 181	As Avail
2.2 RESISTOR	Range: 500 kΩ Accuracy: ±1.0%	Local Purchase	

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with entire procedure before beginning calibration process.

WARNING

Unless otherwise designated, and prior to beginning the Calibration Process, ensure that all test equipment voltage and/or current outputs are set to zero (0) or turned off, where applicable. Ensure that all equipment switches are set to the proper position before making connections or applying power.

3.2 Set the TI Voltage Selector (rear panel) for the proper voltage. Connect the TI and all test equipment to the appropriate power source, set the POWER switches to ON and allow a 30 minute warm-up period.

4 CALIBRATION PROCESS:

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met, before proceeding.

4.1 DC OUTPUT LEVEL CALIBRATION:

4.1.1 Press the TI RF ON/OFF key to disable the OUTPUT. Connect the TI OUTPUT connector to the Nanovoltmeter mV INPUT using appropriate cables, observe polarity. Press Nanovoltmeter 2 mV Range and Zero buttons.

4.1.2 Press the TI RF ON/OFF key to enable the OUTPUT.

4.1.3 Press the TI ← or → keys to position the cursor under the IMPEDANCE field on the TI display.

4.1.4 Press the TI ↑ or ↓ keys to set the TI Impedance to 1800 Ω.

4.1.5 Press the TI ← or → keys to position the cursor under the RANGE field on the TI display.

4.1.6 Press the TI ↑ or ↓ keys to set the TI to the first range listed in the Range column of Table 2.

NOTE

The Nanovoltmeter must be zeroed occasionally while set to the lower ranges with the TI OUTPUT off.

4.1.7 Set the Nanovoltmeter to the appropriate range. The Nanovoltmeter must indicate between the values listed in the corresponding Limits column of Table 2.

Table 2.

TI Range	Limits (VDC)
0	7 to 11 μ
1	88.9 to 91.1 μ
2	898 to 902 μ
3	8.985 to 9.015 m
4	89.86 to 90.14 m
5	898.6 to 901.4 m
6A	1.797 to 1.803
6B	4.493 to 4.507

4.1.8 Repeat steps 4.1.6 and 4.1.7 for the remaining ranges listed in Table 2. (Connect the TI to the Nanovoltmeter V INPUT connector when checking Ranges 5, 6A, and 6B.)

4.1.9 Press the TI RF ON/OFF key to set the OUTPUT to OFF.

4.2 OUTPUT IMPEDANCE CALIBRATION:

4.2.1 Connect the TI OUTPUT connector through appropriate cables and adapters to the Nanovoltmeter V INPUT connector. Connect the 500 kΩ Resistor across the Nanovoltmeter HI and LO connectors.

4.2.2 Set the TI Range to 5, Impedance to 500 kΩ and press the ON/OFF key to enable the TI OUTPUT.

4.2.3 Set the Nanovoltmeter to the appropriate range. The Nanovoltmeter must indicate between 430.0 to 470.0 mV DC.

4.2.4 Set the TI Impedance to 300 kΩ.

4.2.5 The Nanovoltmeter must indicate between 540.0 to 580.0 mV DC.

4.2.6 Press the TI RF ON/OFF key to set the OUTPUT to OFF, disconnect and secure all equipment.

CALIBRATION PERFORMANCE TABLE

Not Required