INSTRUCTION MANUAL

MODEL 1110
PROGRAMMABLE
AUDIO OSCILLATOR

BOONTON
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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 instrument. 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 quailfied 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 insturment. 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 and 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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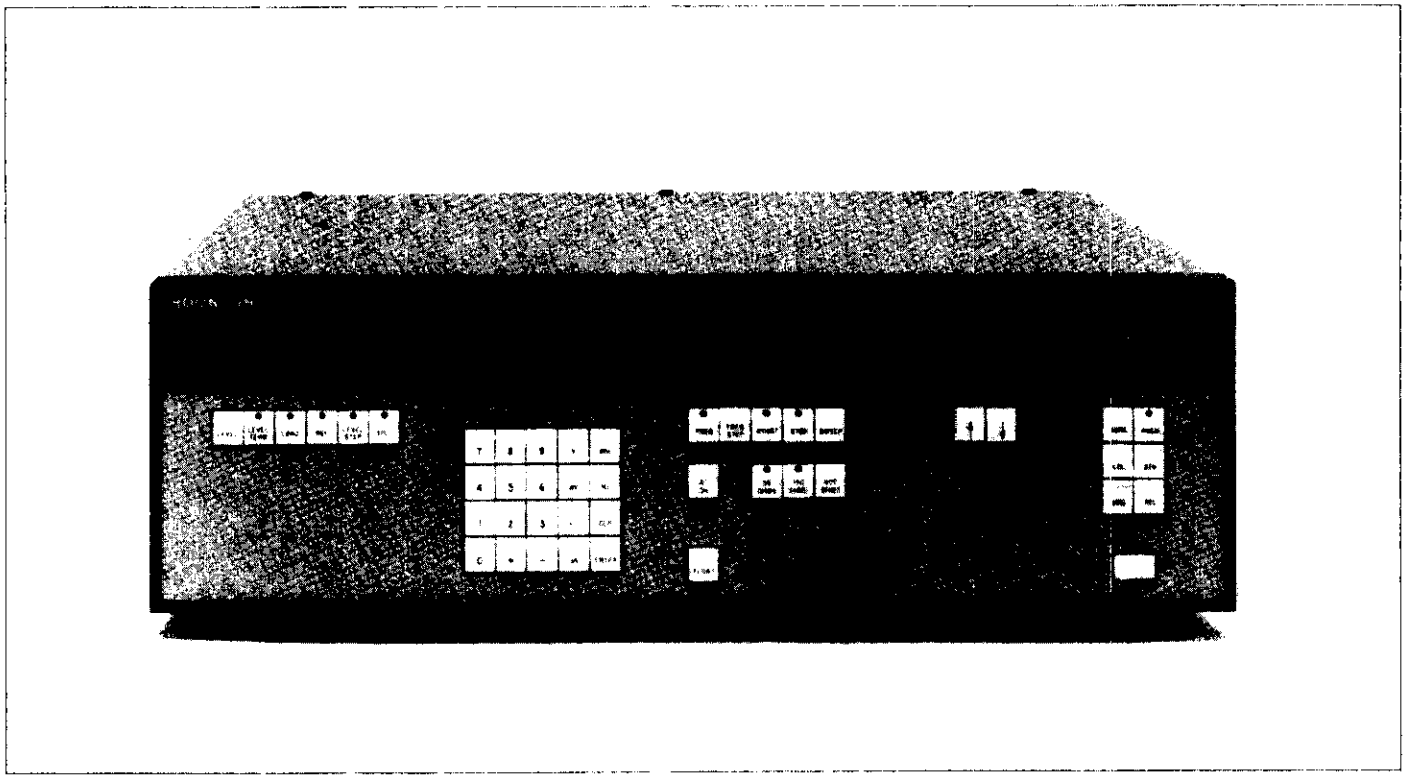


MODEL 1110 AUDIO OSCILLATOR

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This instruction manual provides installation, operation and maintenace instructions, parts list and schematics for the Model 1110 Audio Oscillator.

1-3. DESCRIPTION.

1-4. The Model 1110 is a versatile, precision, solid-state instrument with features and performance characteristics especially suited to laboratory and industrial applications. Human engineering considerations have been emphasized in both the mechanical and electrical design of the Model 1110. The result is an audio oscillator that is easy and convenient to use. Among the outstanding features are:

a. **Versatile Performance.** Advanced generation techniques enable the Model 1110 to provide accurate, low distortion signals. Demanding applications are satisfied by the high output power capability, wide frequency range and selectable output impedance.

b. **Separate Displays of All Major Functions.** The Model 1110 has 3 separate display windows to simultaneously present amplitude, frequency and program number or bus address information. Continuous display of IEEE-488 bus status is also presented.

c. **Ultra-low Distortion .** The mark of quality for any audio oscillator is spectral purity. The total harmonic distortion of the Model 1110 is specified as less than 0.01 % with typical performance an order of magnitude better than specified.

d. **Versatile Output.** The Model 1110 features wide control over its output configurations. Source impedance can be set to 50, 150, or 600 ohms in either a floating or single-ended configuration. All source impedances are available at the same set of output connectors, eliminating the need to multiplex separate 50 ohm and high impedance outputs.

e. **Sweep Operation.** Frequency or level can be swept in user-selected linear or logarithmic steps over any portion of the range. Rear panel X axis and PEN outputs are provided for plotter application.

f. **Instrument Setup Memory.** Up to 99 front panel setups containing all data required to configure the instrument to a previous operating mode can be stored in non-volatile memory for future recall. The last valid instrument setup before power interruption is also saved automatically and restored when power is resumed.

g. **IEEE-488 Interface Bus.** All instrument functions are programmable except bus address. Annunciators to the left of the BUS/PRGM display window show the status of bus activity. The 1110 is designed to interface easily with controllers currently in use. A versatile free-form number entry system is used so that the 1110 will accept any conceivable valid number string. Triggering may be performed in immediate or wait modes. There are six talk modes which can be addressed in either the remote or local state. The 1110 also provides a choice of several end-of-string terminators. Service-request (SRQ) can be asserted on errors or using the front panel SRQ key and the LCL/INIT key will force return to local control when using the bus as long as a lockout message has not been sent.

1-5. ACCESSORIES.

1-6. The following accessories are supplied with the instrument:

AC power cord
Spare output fuses

The following accessories are available:

950044	Rack mounting hardware
950043	Chassis slide kit
95401801A	Single binding post to BNC (M) adapter
95401901A	BNC (F) to phono plug
95402001A	Phono jack to BNC (M)
95402104A	Two conductor shielded balanced line, 36"
95402201A	XLR connector to three banana plugs

1-7. OPTIONS.

1-8. The following option is available:

-01 Rear panel output connectors

1-9. SPECIFICATIONS.

1-10. Performance specifications for the Model 1110 Audio Oscillator are listed in Table 1-1.

TABLE 1-1. PERFORMANCE SPECIFICATIONS.

SOURCE SPECIFICATIONS

Frequency

Range: 10 Hz to 150 kHz
Resolution:
0.001 Hz; 10.000 to 199.999 Hz
0.01 Hz; 200.00 to 1999.99 Hz
0.1 Hz; 2.0000 to 19.9999 kHz
1.0 Hz; 20.000 to 150.000 kHz
Accuracy: 10 ppm + 1 count

Timebase

Type: 10 MHz TCXO
Accuracy: +- 1 ppm/yr

Level

Range: 0.01 mV to 16.000 V rms, open circuit
Full Scale Ranges:
16.000 V, 3.000 V, 300.0 mV, 30.00 mV
Accuracy (settings from 0.60 mV to 16.000 V):
+- 0.5 % of setting + 0.05 % of range;
10 Hz to 50 kHz
+- 1.0 % of setting + 0.05 % of range;
50 kHz to 100 kHz
+- 1.5 % of setting + 0.1 % of range;
100 kHz to 150 kHz

Flatness, ref 1 kHz (0.30 mV to 8 V into 50 ohms):
+- 0.5 %; 10 Hz to 50 kHz
+- 1.0 %; 10 Hz to 100 kHz
+- 1.5 %; 10 Hz to 150 kHz

Output

Impedance:
50 ohms +- 2 %
150 ohms +- 1 %
600 ohms +- 1 %
Distortion and Noise (the greater of):
0.01 % (-80 dB) or 10 uV;
10 Hz to 20 kHz, 80 kHz bandwidth
0.02 % (-74 dB) or 20 uV;
20 to 50 kHz, 220 kHz bandwidth
0.056 % (-65 dB) or 50 uV;
50 to 100 kHz, 500 kHz bandwidth
0.1 % (-60 dB) or 50 uV;
100 to 150 kHz, 500 kHz bandwidth
Output Power (50 ohm source):
31.07 dBm (8.00 V) into 50 ohm load
29.82 dBm (12.00 V) into 150 ohm load
25.60 dBm (14.76 V) into 600 ohm load

SUPPLEMENTAL INFORMATION

General Information

Power Requirements:
100, 120, 220, 240 volts AC, 50 to 400 Hz, 60 VA
Operating Temperature:
0 to 55 degrees centigrade
Dimensions:
17.75 inches (45.1 cm) wide, 5.85 inches (14.9 cm) high, 18 inches (45.8 cm) deep
Weight: 25 lbs (11.3 kg)
Accessories Included:
Spare output fuses and AC power cord

Accessories Available:
950044 Rack mounting hardware
950043 Chassis slide kit
954018 Single binding post to BNC (M)
954019 BNC (F) to phono plug
954020 Phono jack to BNC (M)
954021 Two conductor shielded balanced line, 36 "
954022 XLR Audio connector to three banana plugs
Options:
-01 Rear panel output

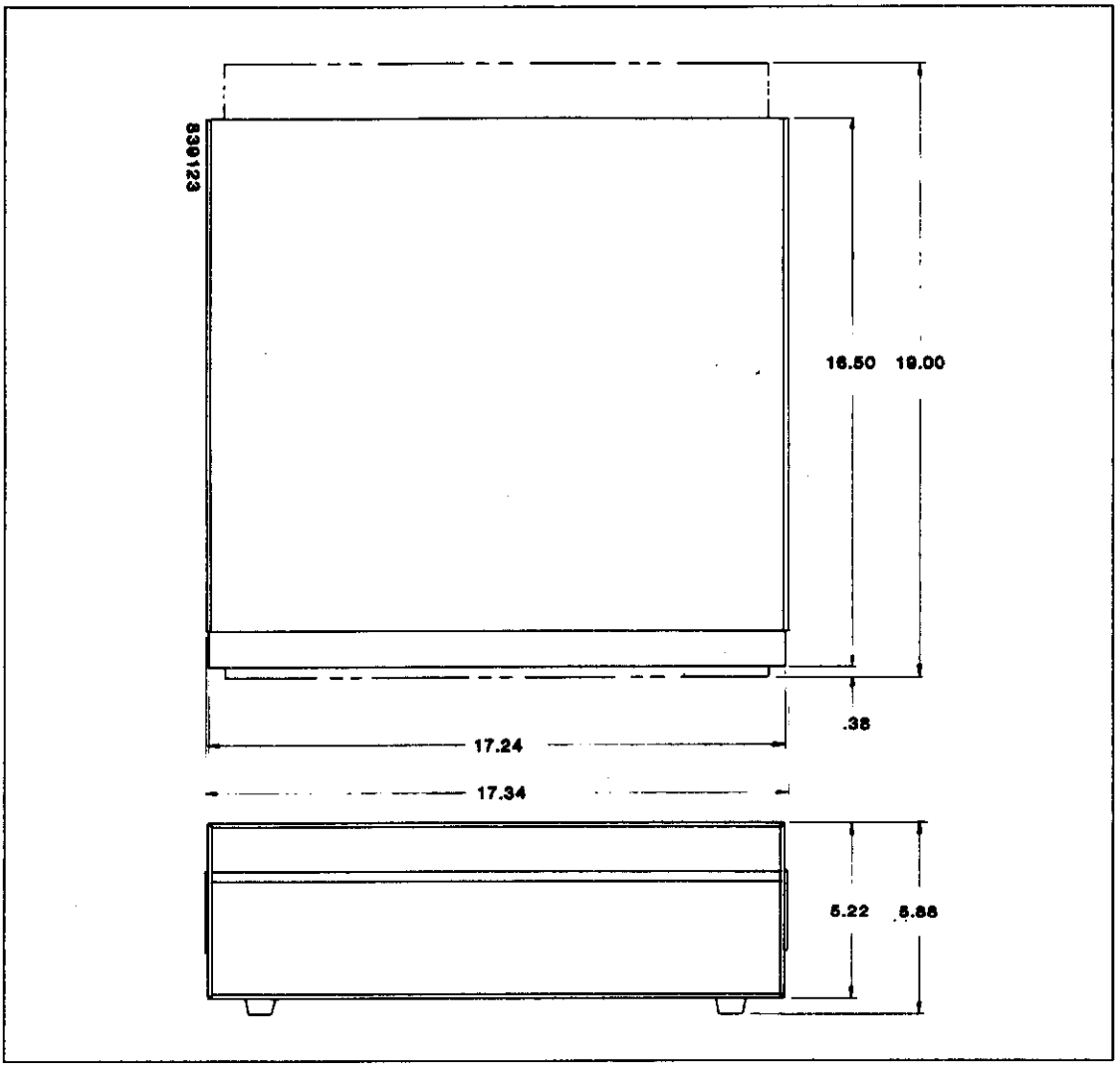


Figure 1-1. Outline Dimensions.

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains the unpacking, mounting, power requirements, cable connections, and preliminary check-out instructions for the Model 1110 Audio Oscillator.

2-3. UNPACKING.

2-4. The instrument is shipped complete and is ready to use upon receipt. Unpack the instrument from its shipping container and inspect for damage that may have occurred during shipment. Refer to Figure 2-1.

NOTE

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

2-5. MOUNTING.

2-6. For bench mounting choose a clean, sturdy, uncluttered mounting surface. For rack mounting, an accessory kit is available which provides mounting ears. The rack mounting kit contains the required hardware and instructions.

2-7. POWER REQUIREMENTS.

2-8. The instrument has a tapped power transformer and two line voltage selection switches which permit operation form 100, 120, 220, or 240 volt +- 10 %, 50 to 400 Hz, single phase AC power sources.

CAUTION

Always make certain that the line voltage selection switches are set to the correct positions corresponding to the voltage of the AC power source, and that a fuse of the correct rating is installed before connecting the instrument to any AC power source.

Line Voltage Select Chart

VAC +-10%	100 120	220 240	50 to 400 Hz
Fuse	3/4 ATD	3/8 ATD	60 VA

2-9. Set the rear panel line voltage selector switches to the appropriate positions as indicated in the Line Voltage Select Chart and check that the line fuse is correct for the selected power source.

2-10. CABLE CONNECTIONS.

2-11. Front panel connector:

OUTPUT. Source output HIGH and LOW BNC type connectors and chassis ground allow connection to external devices and components. The output impedance is selected by the keys marked 50 OHMS, 150 OHMS and 600 OHMS located above the connectors. The LOW terminal is connected to chassis ground in the non-floating mode.

2-12. Rear panel connectors:

SYNC. The SYNC BNC type output connector provides a TTL compatible output relative to the frequency of the source output sine wave.

X CLK. The X CLK BNC type input connector provides a means of connecting an external 10 MHz counter reference. The external reference is automatically selected when a TTL level signal is present.

X AXIS. The X AXIS BNC type output connector provides a 0 to 5 volt d. c. level relative to the sweep frequency or level in the sweep mode. The output impedance is 1000 ohms.

PEN. The PEN BNC type output connector provides a TTL compatible signal to control the pen of an external recorder.

2-13. PRELIMINARY CHECK.

2-14. The preliminary check verifies that the Model 1110 is operational and should be performed before the instrument is placed into use. To perform the preliminary check, set the front panel LINE switch to ON. Wait several seconds then depress the LCL/INIT key. The FREQUENCY display will contain the instrument firmware number and the other displays will contain dashes for a period of about two seconds. The FREQUENCY display will then contain 1000.00 kHz with the KYBD legend illuminated the LEVEL display will contain 0.00 mV and the BUS/PRGM display will contain 99. The initialize sequence executes the oscillator frequency self-

check and resets all functions and operating modes of the Model 1110 to the initialized values and conditions listed in Table 2-1. If a hardware fault is evident in the oscillator frequency generation circuits, an error code (30-35) will be displayed.

2-15. Program location 99 is a recall-only location which contains the initialize values. The operating conditions at the time the instrument power is interrupted are maintained in non-volatile memory and restored when power to the Model 1110 is resumed.

TABLE 2-1. INITIAL CONDITIONS.

Level Group:	Frequency Group:	Bus/Prgm Group:
Level function enabled Level set to 0.00 mV Level Terminated calculated at 0.00 mV Load set to 0.600 k ohms Relative reference set to 0.00 dB Level Step set to 0.00 mV Special functions 0, 10, 55, 63 and 80 are selected	KYBD legend illuminated Frequency function enabled Frequency set to 1000.00 Hz Frequency Step set to 0.00 Hz Start set to 20.000 Hz Stop set to 20.000 kHz Sweep mode disabled Output disabled 600 ohm output impedance enabled Float disabled	Address function is unchanged Program function is set to 99 Service-Request is cleared Bus status is unchanged

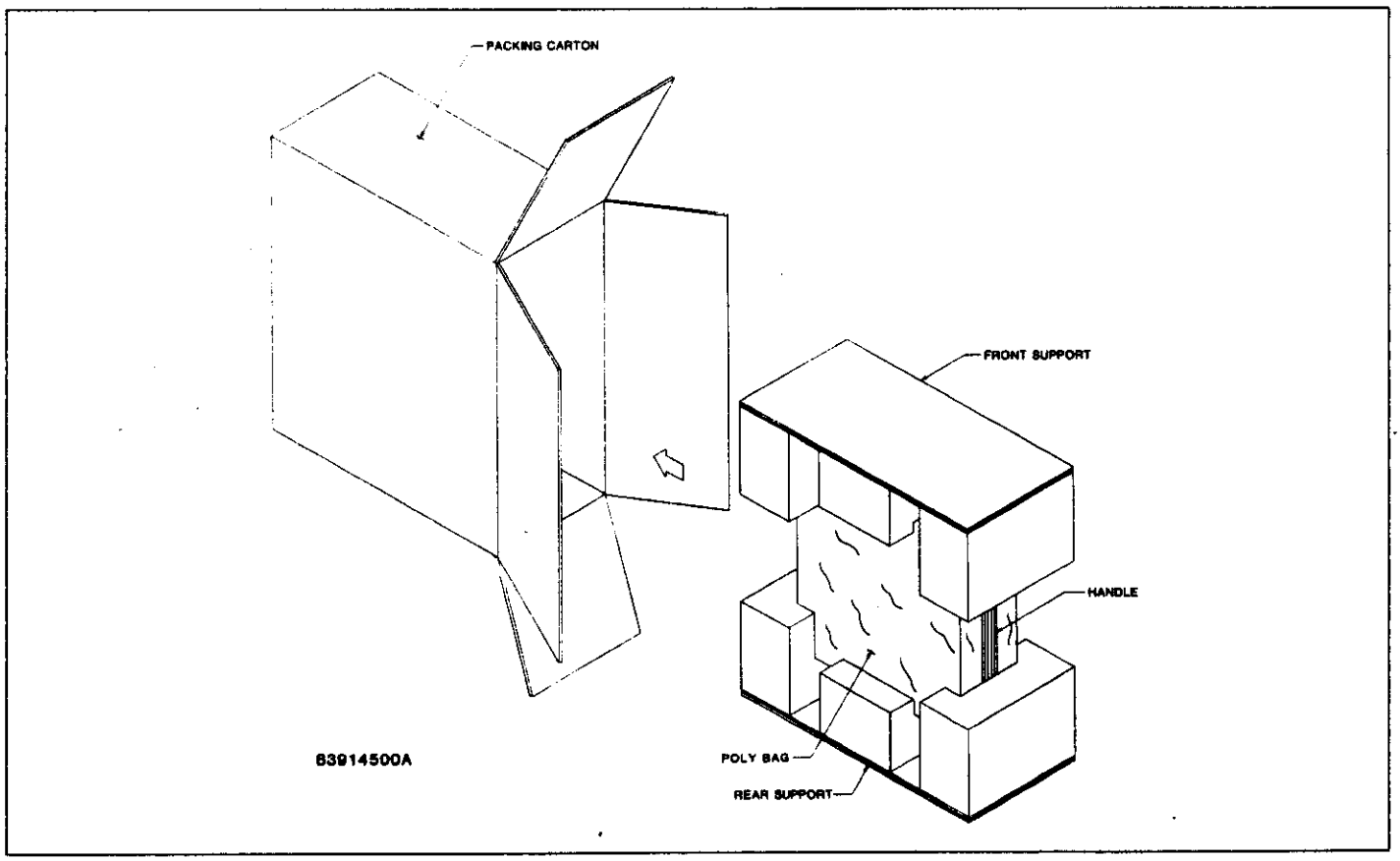


Figure 2-1. Packing and Unpacking Diagram.

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. This section contains the operating instructions for the Model 1110 Audio Oscillator.

3-3. OPERATING CONTROLS, INDICATORS AND CONNECTIONS.

3-4. The controls, indicators and connectors used during the operation of the instrument are listed in Table 3-1 and shown in Figures 3-1 and 3-2.

3-5. OPERATING INSTRUCTIONS.

3-6. The operating instructions for the Model 1110 are divided into sections of Initial Conditions, Local Operation and Remote Operation.

3-7. INITIAL CONDITIONS.

3-8. Initialize the instrument as follows:

a. Connect the power cord to the instrument and to the desired power source. Refer to paragraph 2-7 for proper power application.

b. Set the front panel power switch to ON.

c. Depress the LCL/INIT key.

d. The FREQUENCY display will contain the instrument firmware identification number and the other displays will contain dashes for a period of about two seconds. After the initialization sequence is complete, the Model 1110 will be set to the conditions listed in Table 2-1.

3-9. LOCAL OPERATION.

3-10. Function Selection. The DATA ENTRY keypad is common to all functions of the Model 1110. The KYBD legend determines the active display window to which the DATA ENTRY keypad is dedicated at any given time. To select a function simply depress the function key desired. The results will be the LED of the function key will be illuminated, the current value of the selected function will be displayed in the window above the key, and the KYBD legend will be illuminated in the display window. The DATA ENTRY keypad is dedicated to the selected function and any unit selection or number entry will appear in the active display window.

3-11. Data Entry Operation. Once a function has been selected, new values may be entered with the DATA ENTRY keypad. To enter data simply depress the desired digit keys followed by the appropriate unit key or ENTER key. During digit selection a (') mark will appear in the display to the left of the first digit selected to indicate the number in the display is in the process of being entered. No action is taken until the unit or ENTER key is depressed. The unit keys can also be used aside from number entry to select display modes. For example, to change the level displayed in mV to logarithmic units in dBV, simply select the LEVEL key and depress the dB key in the DATA ENTRY keypad. The display program will calculate and display the logarithmic value. The ENTER key serves a dual function as a dimensionless unit key for SPCL, ADRS, and PRGM number entry and also as a default unit terminator of V, Hz, and ohms for functions where more than one unit can be selected.

3-12. Many of the Model 1110 functions have multiple display and entry modes. Listed in table 3-2, Function Display And Data Entry Units, are the display legends which can be active for each function along with the unit keys in the DATA ENTRY keypad which select the available display modes. Argument entry ranges for all the Model 1110 functions are described in Table 3-3, Valid Function Argument Range. Number entry out of range of the selected functions will result in an error displayed in the FREQUENCY display window. Errors can be cleared by depressing any key. If at any time prior to entry a wrong digit is entered, depress the CLR key to clear and restore the previous display.

3-13. Audio Oscillator General Description. The Model 1110 contains a variable frequency, low distortion audio oscillator and a precision programmable amplifier/attenuator. The oscillator frequency tuning uses a frequency lock technique under microprocessor control to yield high accuracy and resolution. The output level can be varied in very fine increments over a wide range of levels. Levels can be set in either linear or logarithmic units to accommodate existing test procedures and applications. The oscillator incorporates a user configurable sweep mode which can be programmed to sweep frequency or level in logarithmic or linear increments.

3-14. Oscillator Output Description. The output configuration of the Model 1110 can be selected for single-ended

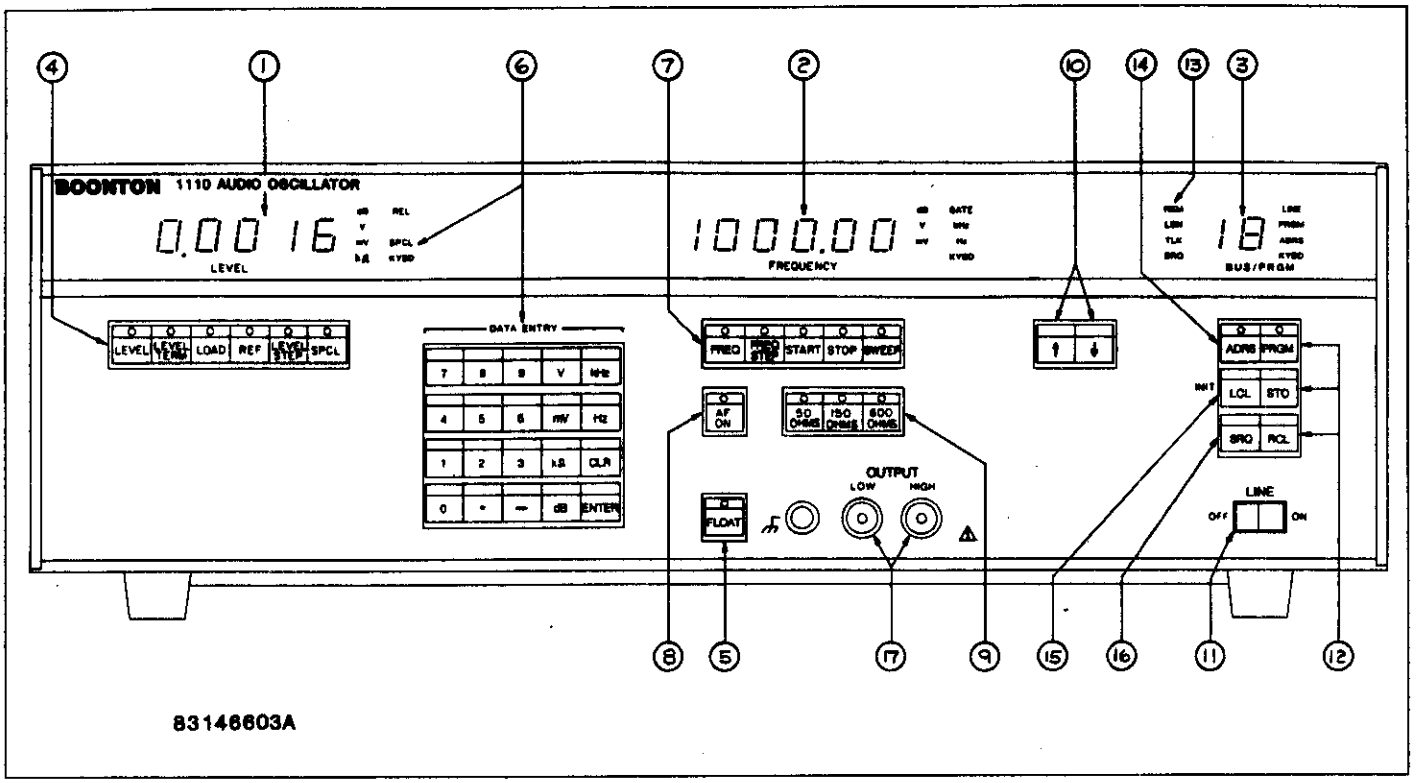


Figure 3-1. Model 1110, Front View.

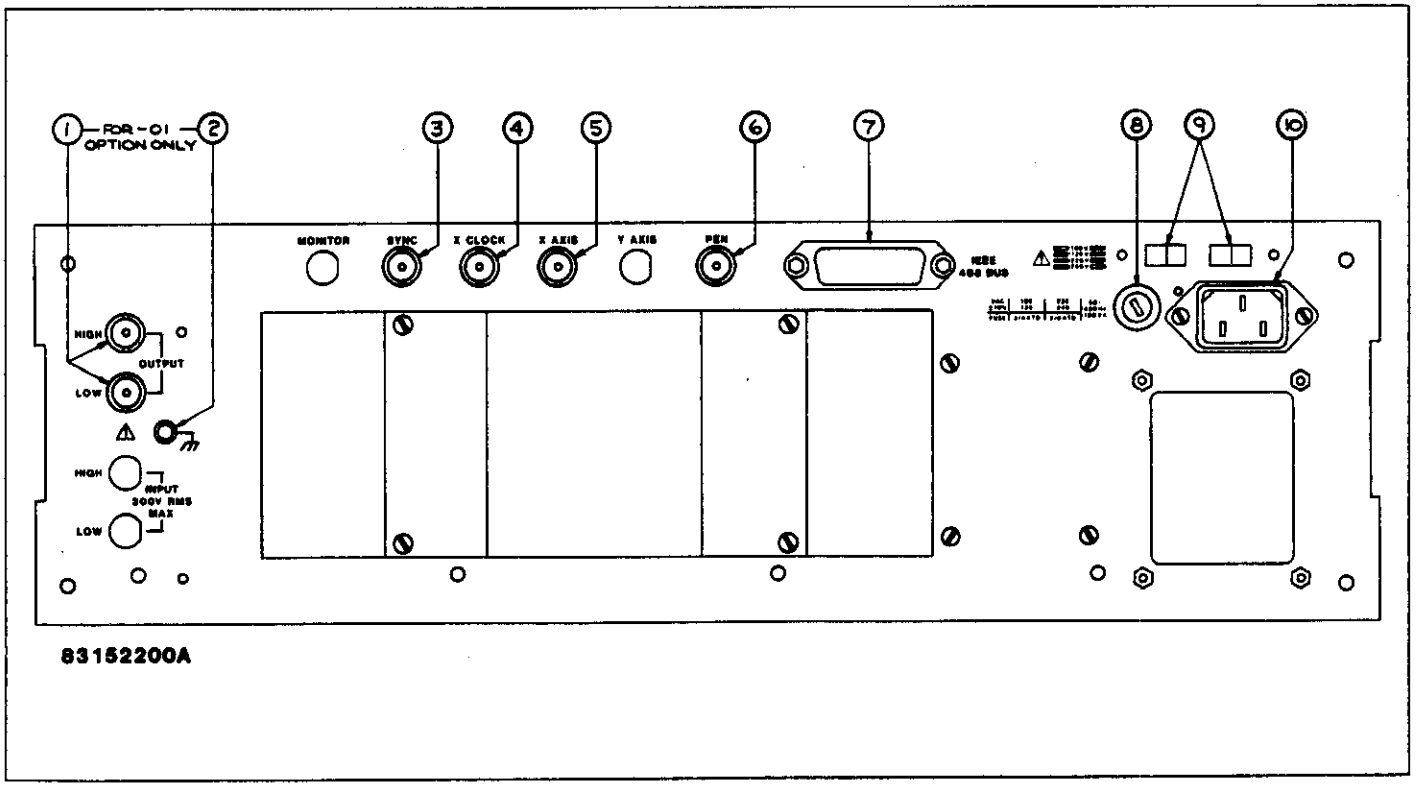


Figure 3-2. Model 1110, Rear View.

TABLE 3-1. CONTROLS, INDICATORS AND CONNECTORS.

Control, Indicator, or Connector	Figure and Index No.	Function
LEVEL display	3-1, 1	Displays open circuit level, terminated level, load impedance, relative reference value, level step size and special function code. (6 digit LED display)
FREQUENCY display	3-1, 2	Displays frequency value, sweep start value, sweep stop value, and frequency step size. Alternately displays error codes and messages. (8 digit LED display)
BUS/PRGM display	3-1, 3	Displays current program number or IEEE-488 bus address. (2 digit LED display)
LEVEL keys	3-1, 4	Selects the following active level functions.
LEVEL key		Displayed in mV, V, dBV or dBm.
LEVEL TERM key		Displayed in mV, V, dBV or dBm.
LOAD key		Displayed in k ohms.
REF key		Displayed in dB.
LEVEL STEP key		Displayed in mV, V or dB.
SPCL key		Allows alteration to the normal analyzer modes of of operation such as: frequency lock disable, range hold, sweep rate and resolution, and special modes for testing, troubleshooting.
FLOAT key	3-1, 5	Selects floating or single-ended output connection.
DATA ENTRY keypad	3-1, 6	Used with the function keys to enter data into the active display designated by the KYBD annunciator.
FREQUENCY keys	3-1, 7	Selects the following active frequency functions.
FREQ key		Displayed in Hz or kHz.
SWEEP key		Initiates sweep mode and indicates sweep in progress.
START key		Frequency values are displayed in Hz or kHz and level values are displayed in mV, V, dBV or dBm.
STOP key		Frequency values are displayed in Hz or kHz and level values are displayed in mV, V, dBV or dBm.
FREQ STEP key		Displayed in Hz or kHz.

TABLE 3-1. CONTROLS, INDICATORS AND CONNECTORS CONTINUED.

Control, Indicator, or Connector	Figure and Index No.	Function
AF ON key	3-1, 8	Selects and deselects the output.
Impedance keys	3-1, 9	Allows selection of the source output impedance.
Step keys	3-1, 10	Increments and decrements the active frequency or level value by the frequency step and level step sizes and single steps the program location function.
LINE switch	3-1, 11	Switches the instrument AC power on or off.
PROGRAM keys	3-1, 12	Selects the following program functions.
PRGM key		Allows display and entry of the store/recall program location.
STO key		Stores the instrument setup at the current program location.
RCL key		Recalls the instrument setup at the current program location.
Bus status	3-1, 13	Displays the current IEEE-488 bus status; REM (remote enabled), LSN (listener addressed), TLK (talker active), and SRQ (service request).
ADRS key	3-1, 14	Allows display and entry of IEEE-488 bus address.
LCL/INIT key	3-1, 15	Causes the instrument to "go-to-local" when remote enabled otherwise executes the initialize sequence.
SRQ key	3-1, 16	Sets the IEEE-488 bus SRQ line true.
OUTPUT connectors	3-1, 17	LOW and HIGH. Used to apply the signal to external devices and components. The LOW terminal is connected to chassis ground in the non-floating mode.

or balanced/floating operation using the FLOAT key. The 50 OHMS, 150 OHMS and 600 OHMS keys select the source output impedance and the output can be enabled or squelched using the front panel AF ON key. When the output is squelched, the output attenuation is set to maximum while the source impedance and float configuration remain connected.

3-15. Frequency Display and Selection. To select the Frequency function simply depress the FREQ key. The key's LED and the KYBD legend will be illuminated and the FREQUENCY display window will contain the current frequency setting. Once the function is selected a new frequency may be entered using the DATA ENTRY keypad. Display units can be selected by depressing either the Hz or kHz keys.

3-16. Frequency Lock Mode Description. The Model 1110 Audio Oscillator achieves high frequency accuracy and resolution through the use of a frequency lock technique. The design of the Model 1110 enables internal measurement of the oscillator frequency. During initialization after power is applied or when the LCL/INIT key is depressed, the oscil-

TABLE 3-1. CONTROLS, INDICATORS AND CONNECTORS CONTINUED.

Control, Indicator, or Connector	Figure and Index No.	Function
OUTPUT connectors	3-2, 1	Rear panel output connectors which replace the front panel input connectors.
Ground connector.	3-2, 2	Chassis ground connector.
SYNC connector	3-2, 3	Provides a TTL compatible output relative to the frequency of the sine wave output.
X CLK connector	3-2, 4	Provides a TTL compatible input for an external 10 MHz timebase reference. Automatic switching to external reference when present.
X AXIS connector	3-2, 5	Provides a 0 to 5 volt d. c. level in the sweep mode to control the X axis of an external recorder.
PEN connector	3-2, 6	Provides a TTL compatible output to control the pen of an external recorder.
IEEE-488 connector	3-2, 7	Provides a means for connecting the standard IEEE-488 bus interface cable.
Fuse holder	3-2, 8	AC line fuse holder.
Line voltage selector switches	3-2, 9	Selects the desired operating voltage.
AC connector	3-2, 10	AC power connector.

lator is sequenced through its five frequency bands and specific frequencies settings are verified for accuracy. Tuning errors are stored by the control program in internal memory as calibration factors. If the oscillator fails to function on any of the frequency bands, an error (30-34) will be displayed as an indication of a hardware fault requiring service.

3-17. When a frequency setting is entered the oscillator is coarse tuned to the setting by the control program. Thereafter, the internal frequency of the oscillator is measured and fine adjustments are made by the control program to tune the oscillator to within tolerance. Special function 16 disables the frequency lock mode to enable faster frequency settability and sweep rates where the full frequency accuracy of the oscillator is not required.

3-18. Level Display And Selection. To select the Level function simply depress the LEVEL key. The key's LED and the KYBD legend will be illuminated and the LEVEL display window will contain the current level setting. Once the function is selected a new level may be entered using the DATA ENTRY keypad. The level function allows display and selection of the open-circuit output level. When a level is selected, the programmable amplifier/attenuator is configured by the microprocessor circuits to one of the ranges listed in Table 3-4. Special function 18 disables the automatic range selection and holds the range that is active at the time the special function is enabled. When the range-hold mode is active, new levels may be entered from 0 V up to the maximum value for the selected range. This mode provides the ability to generate levels over a wide dynamic range without the delay and transients associated with range to range tran-

sitions. The LEVEL function can be incremented or decremented by the value in the LEVEL STEP function and can also be displayed as a relative value using the REF function.

3-19. **Terminated Level Display and Selection.** To select the Terminated Level function simply depress the LEVEL TERM key. The key's LED and the KYBD legend will be illuminated and the LEVEL display window will contain the current level setting. Once the function is selected a new level may be entered using the DATA ENTRY keypad. The LEVEL TERM function operates the same as the LEVEL function except that the value entered and displayed in mV, V or dBV units is the amplitude at the load instead of the open-circuit amplitude. The value is calculated based on the open-circuit amplitude and the source and load impedances. Alternate selection of the AF ON, 50 OHMS, 150 OHMS, or 600 OHMS keys will update the displayed value to the extent that the terminated voltage is changed. The LEVEL TERM function can be incremented or decremented by the value in the LEVEL STEP function and can also be displayed as a relative value using the REF function.

3-20. **Load Display and Selection.** To select the Load function simply depress the LOAD key. The key's LED and the KYBD legend will be illuminated and the LEVEL display window will contain the current load impedance setting. Once the function is selected a new value may be entered using the DATA ENTRY keypad. The LOAD function enables the entry of the external load impedance used to calculate the LEVEL TERM value. Refer to paragraph 3-19. The load value may only be displayed in k ohm units but may be entered with the DATA ENTRY keypad in k ohms or ohms using the respective k ohm or ENTER keys.

3-21. **Reference Display and Selection.** Amplitude values for the LEVEL, LEVEL TERM, START and STOP functions may be displayed as relative values. In some applications external amplifiers or attenuators may be required to provide signal levels outside the operating range of the Audio Oscillator. The reference mode scales the display of the Model 1110 to account for the change in signal level. Entering a value other than 0.00 dB in the REF function enables the reference mode. The REL annunciator remains

TABLE 3-2. FUNCTION DISPLAY AND DATA ENTRY UNITS.

Function	Display Legends	Unit Keys	Default Units (ENTER Key)
LEVEL GROUP:			
LEVEL	mV V dBV dBm	mV V dB	V
LEVEL TERM	mV V dBV dBm	mV V dB	V
LOAD	k ohms	k ohms	ohms
REF	dB	dB	dB
SPCL	SPCL	ENTER	dimensionless
FREQUENCY GROUP:			
FREQ	Hz kHz	Hz kHz	Hz
START	Hz kHz mV V dBV dBm	Hz kHz mV V dB	Hz
STOP	Hz kHz mV V dBV dBm	Hz kHz mV V dB	Hz
FREQ STEP	Hz kHz	Hz kHz	Hz
BUS/PRGM GROUP:			
ADRS	ADRS	ENTER	dimensionless
PRGM	PRGM	ENTER	dimensionless

illuminated when amplitudes are displayed indicating the value displayed is relative. Entering 0.00 dB as a reference extinguishes the annunciator and returns the display to normal.

3-22. Amplitude Display Units. Amplitude values for the LEVEL, LEVEL TERM, START and STOP functions may be displayed in linear units of mV or V or as a logarithmic value in units of dBV or dBm. Display units can be selected by depressing either the mV, V, or dB keys. Special functions 80 through 86 and 89 select the logarithmic display mode where 80, dBV, is the default selection. The dBV display mode converts the linear voltage display (open-circuit or terminated) to a logarithmic value relative to 1.000 V rms. When a dBm mode is selected, the actual power into the load is calculated and displayed based on the open-circuit level and source and load impedance settings.

TABLE 3-3. VALID FUNCTION ARGUMENT RANGE.

Function	Argument Range	Entry Action	Error No.
LEVEL GROUP:			
LEVEL[1]	0 mV to 16 V -120 to 24.08 dBV	Open circuit output level (lin) Open circuit output level (log)	03 03
LEVEL TERM[1,2]	variable	Terminated output level	13
LOAD	0.1 ohm to 1000 k ohms	Load termination value	14
REF	-40 to 40 dB	Relative reference	15
LEVEL STEP	0 mV to 16 V 0 to 120 dB	level increment (lin) level increment (log)	04 04
SPCL	See TABLE 3-5	See TABLE 3-5	05
FREQUENCY GROUP:			
FREQ	10 Hz to 150 kHz	Source Frequency	01
START[1]	10 Hz to 150 kHz 0 mV to 16 V -120 to 24.08 dBV	Sweep start frequency Sweep start level (lin) Sweep start level (log)	06 06 06
STOP[1]	10 Hz to 150 kHz 0 mV to 16 V -120 to 24.08 dBV	Sweep stop frequency Sweep stop level (lin) Sweep stop level (log)	07 07 07
FREQ STEP	0 Hz to 150 kHz	Frequency increment	02
BUS/PRGM GROUP:			
ADRS	0 to 30	IEEE-488 Bus Address	10
PRGM	0 to 99	Store/Recall Location	11

NOTE 1 Amplitude values can be entered and displayed in dBm units and/or as relative values. The allowable argument range for dBm values varies based on the source and load impedance settings and is limited by the open-circuit voltage range. The allowable argument range for relative values varies based on the REF function value.

NOTE 2 Allowable argument range for Terminated Level values varies based on source and load impedance settings and is limited by the open-circuit voltage range.

3-23. Step Size and Step Key Operation. The keys marked with up and down arrows are used to increment and decrement function values in the active window designated by the KYBD legend. If an arrow key is constantly depressed, the stepping will repeat. Functions which can be stepped are PRGM, FREQ, START, STOP, LEVEL, and LEVEL TERM. Stepping any other function has no effect.

3-24. Increment/Decrement Program Number. The Program number can be stepped in single increments. A special Auto-recall function is provided which automatically executes the recall operation after the program location function has been incremented or decremented with the step keys. This function allows rapid recall of sequential program setups by using a single key or bus mnemonic. The auto-recall function can be enabled or disabled using the internal option switch A4S1-5 or special functions 7 and 8.

3-25. Increment/Decrement Frequency Values. Frequency values in the FREQ, START, and STOP functions can be stepped by the value in the FREQ STEP function. Available Frequency step sizes are listed in Table 3-3. The Frequency step size also functions as the step size for the linear frequency sweep mode.

3-26. Increment/Decrement Level Values. Amplitude values in the LEVEL, LEVEL TERM, START, and STOP functions can be stepped by the value in the LEVEL STEP function. Level step sizes can be linear or logarithmic values. Available Level step sizes are listed in Table 3-3. The Level step size also functions as the step size for the linear and logarithmic level sweep modes.

3-27. Sweep Mode General Description. The Model 1110 provides a user programmable sweep capability which simplifies time consuming measurements such as flatness, gain and compression/expansion linearity. In the sweep mode the Model 1110 is used as the stimulus and can be configured to sweep frequency or level in linear or logarithmic steps. The Model 1110 provides the X axis and pen control signals for an external plotter/recorder.

3-28. SWEEP Key Description. The SWEEP key is an alternate action key which initiates and terminates the sweep. The key's LED indicates a sweep is in progress and will be illuminated for the period of one sweep.

3-29. START Key Description. The START key allows entry of either the frequency or level start value. The start value defines the origin of the X axis which corresponds to 0 volts at the X AXIS output connector. When the START key is depressed the FREQUENCY display will contain the start value and 0 volts is presented at the X AXIS output connector as an aid in setting the offset adjustment on most X-Y plotters. The start value can be either a frequency, open-circuit level or a relative level.

3-30. STOP Key Description. The STOP key allows entry of either the frequency or level stop value. The stop value defines the end of the X axis which corresponds to 5 volts at the X AXIS output connector. When the STOP key is depressed the FREQUENCY display will contain the stop value and 5 volts is presented at the X AXIS output connector as an aid in setting the sensitivity adjustment on most X-Y plotters. The stop value can be either a frequency, open-circuit level or a relative level.

3-31. X AXIS Output Description. The X AXIS output of the Model 1110 is the scaled result of the sweep frequency or level relative to the start and stop values. The Model 1110 can be swept in level or frequency with 4096 points of resolution on the X axis. Selection of a level or frequency sweep is determined by the type of start and stop values entered: start and stop level entries designate a level sweep and start and stop frequency entries designate a frequency sweep.

3-32. PEN Output Description. The Model 1110 generates a TTL compatible pen control output for use with a plotter/recorder. The active state of the PEN output is selected using option switch A4S1-3 or special functions 5 and 6.

3-33. Using The Sweep Mode. When the SWEEP key is depressed the start value is transferred to the LEVEL or FREQ function, and the function is activated. When the sweep is in progress the X AXIS output will produce an incrementing voltage between 0 and 5 volts. The start and stop values must be compatible in level or frequency units or an error will be displayed when the SWEEP key is depressed. When the sweep sequence is initiated the X axis information is presented at the rear panel X AXIS output and after an approximate 1 sec delay the PEN output is set true. When the sweep is terminated the PEN output is immediately set false. The PEN output can be set independent of any sweep operation using the PU and PD bus mnemonics.

3-34. The sweep mode will be terminated if any number entry is attempted, any function is selected other than the functions displayed at the start of the sweep sequence, or either the SWEEP key or the LCL/INIT key is depressed. Selecting source impedance, floating mode, and display units will not terminate the sweep mode. If a sweep has been terminated, it can be resumed by selecting the appropriate LEVEL or FREQ function and depressing the SWEEP key. The sweep will be activated and will resume from the displayed value until the stop value is reached.

3-35. Generating Frequency Sweeps. The Model 1110 can generate user configurable frequency sweep sequences up to the entire frequency range of the oscillator in logarith-

TABLE 3-4. OUTPUT LEVEL RANGES.

Level Ranges:	Resolution:
16.000 to 3.005 V	5.0 mV
3.000 to 0.301 V	1.0 mV
300.0 to 30.1 mV	0.1 mV
30.00 to 0.00 mV	0.01 mV

mic or linear increments. The range of the sweep is defined by the start and stop values which can be in ascending or descending order. Logarithmic frequency increments are selected using special function 51 through 59 and vary from 16 to 4096 steps. Linear frequency increments are selected using special function 50 and the FREQ STEP function defines the increment value. Linear sweep step sizes which exceed the X axis resolution limit of 4096 steps are allowed, however, the X AXIS output voltage will dwell at the same level for more than one frequency increment.

3-36. **Generating Level Sweeps.** The Model 1110 can generate user configurable level sweep sequences up to the entire level range of the oscillator in logarithmic or linear increments. The range of the sweep is defined by the start and stop values which can be in ascending or descending order. Logarithmic and linear level increments are selected using the LEVEL STEP function. Special functions 50 through 59 have no effect on level sweep. A logarithmic level sweep is defined by a level step value expressed in dB units and a linear level sweep is defined by a level step value expressed in mV or V units. Level sweep step sizes which exceed the X axis resolution limit of 4096 steps are allowed, however, the X AXIS output voltage will dwell at the same level for more than one level increment.

3-37. **Program Store And Recall Description.** The entire status of the Model 1110, including all functions, entered values and display modes, can be saved in a program location of non-volatile memory for recall at a later time. Up to 99 such programs (0-98) can be stored and recalled.

3-38. **Store Operation.** To save the complete front-panel setup in the program memory, first set all the desired instrument operating parameters to be stored. Next depress the PRGM key and enter the desired program location with the DATA ENTRY keypad and the ENTER key. Finally, depress the STO key to save the complete instrument status in program memory. Below is a list of all the parameters which are retained in program memory.

1. All entered values of all functions.
2. All source impedance and floating settings.
3. All display modes and selected display units.
4. All special functions settings

3-39. **Recall Operation.** To recall the front-panel setup in the program memory, depress the PRGM key and enter the desired program location with the DATA ENTRY keypad and the ENTER key. After the memory location has been selected, depress the RCL key. Program location 99 is a recall-only location that restores the initialize parameters in the same manner as the LCL/INIT key. Any panel setting may be changed after recalling a program location.

3-40. **Program Memory Initialization.** In normal use the internal memory is never erased, new programs are simply written over the old ones. It is necessary, however, to erase the program memory after a new firmware revision has been installed or after the CPU circuit board has been serviced. Entering special function 25 will erase the entire program memory. Attempting to recall an erased program will result in Error 11 being displayed. Special function 25 can be disabled using the internal option switch A4S1-4.

3-41. **Special Function Description.** The Model 1110 provides special modes of operation for specific application situations. Special function modes shown in Table 3-5 can be selected using the SPCL key and the DATA ENTRY keypad.

3-42. **Option Switch Functions.** Codes 1 through 8 supersede current settings of the internal Option switch, A4S1. The option switch settings are restored on power-up, by executing special function 0, or by depressing the LCL/INIT key.

3-43. **Mode Alteration Functions.** Codes 16 and 18 alter the normal operation of the Model 1110. When selected, the SPCL legend in the LEVEL display window will remain illuminated as an indication of the special operating mode regardless of the function displayed.

3-44. The unlock frequency function, 16, is provided to speed repetitive frequency setting. In normal operation a variable period of 20 to 200 mS is required to measure the actual oscillator frequency, calculate the frequency deviation and apply fine tune correction. Inhibiting the frequency lock operation results in faster frequency settability at the cost of frequency accuracy. The unlock mode is cleared by entering special function 10 or initializing the instrument.

3-45. The range-hold function, 18, is provided to hold specific output level ranges. Available level ranges and

resolution are listed in Table 3-4. Range-hold mode is cleared by entering special function 10 or initializing the instrument.

3-46. Initialization And Test Functions. Codes 25, 30 and 31 are used for memory initialization, testing and troubleshooting of the Model 1110. These functions can be disabled using Option switch A4S1-4 to prevent accidental use resulting in possible loss of current memory data.

3-47. Frequency Sweep Resolution Functions. Codes 50 through 59 allow selection of linear or logarithmic frequency sweep modes and logarithmic sweep resolution. The default mode after initialization is code 55.

3-48. Sweep Rate Functions. Codes 60 through 69 allow selection of the time delay for each sweep step. The delay may be selected in 500 mS increments form 0 to 4.5 seconds. The default mode after initialization is code 63.

3-49. Source Impedance Selection Functions. Codes 75 through 77 are used as an alternate mode for selection of the source output impedance. These functions perform the same action as the front panel 50 OHMS, 150 OHMS and 600 OHMS keys. The default mode after initialization is 600 ohms, code 77.

3-50. dBV/dBm Display Mode Functions. Codes 80 through 86 and 89 are used to select the reference used to calculate the logarithmic display value (dBV or dBm). All logarithmic levels will be displayed in the form selected. When any of codes 81 through 86 are selected, the the LOAD function value will automatically be set to the respective load impedance. Code 89, however, calculates the dBm reference (1mW) relative to the current LOAD function value. Code 80 has no effect on the LOAD function value. The default mode after initialization is dBV, code 80.

3-51. Option Switch, A4S1, Operation. Several of the Model 1110 operating features are internally programmable by setting bit switch A4S1. Gaining access to the switch requires that the cover be removed. Some of the option switch functions can be altered using the special functions 1 through 8. The option switch consists of eight separate switches which change the operating conditions of the Model 1110. Table 3-6 list the individual switches and their function.

3-52. Positions 1 and 2 of A4S1 are used for end-of-string (EOS) control for the IEEE-488 bus. End-or-Identify (EOI) is always recognized and asserted in addition to the EOS characters selected. Position 3 determines the pen-up active state of the PEN output on the rear panel. Position 4 is available to restrict the use of special functions 25, 30 and 31. These special functions are associated with initialization and repair of the instrument. Position 5 determines the operation of the IEEE-488 SRQ function. When enabled the SRQ line will be set true if the SRQ key is depressed or if the instrument is in the remote condition and an error is generated. Position 6 determines the auto-recall function. Normally the REC key must be depressed in order to recall any program location. When enabled the auto-recall function automatically performs the REC function when using the step keys to increment or decrement the PRGM function. However, entering a program location directly using the DATA ENTRY keypad requires that the REC key be depressed to execute the recall function. Positions 7 and 8 are used for test modes. When the lamp test is selected the display LEDs, display legends, and key LEDs with the exception of the LEVEL and FREQUENCY function keys will be constantly illuminated. The remaining function keys will be illuminated in sequence.

3-53. Error Codes. Error codes and descriptions for the Model 1110 are listed in Table 3-7. The error codes will appear in the FREQUENCY display window and will be returned by the talk-status (TS) IEEE-488 bus function if executed. The SRQ status byte will consist of the error code expressed in excess sixty-four. The status code 64 decimal means the SRQ was activated by the front panel SRQ key rather than an error.

3-54. REMOTE OPERATION.

3-55. Any front-panel operation of the instrument with the exception of the POWER ON/OFF switch and the ADRS function can be remotely controlled under direction of an IEEE-488 interface controller.

3-56. Setting the Bus Address. To set the IEEE-488 bus address (MLTA), depress the ADRS key, enter the address number by means of the DATA ENTRY keypad and use the ENTER key to complete the entry. The address may be any decimal number from 0 to 30, inclusive. A secondary address is not implemented.

3-57. Entering the Remote Mode. The instrument is put in the remote mode by addressing it as a listener with remote enable (REN) true. In the remote state the keyboard is disabled, except for the LCL/INIT key and the POWER ON/OFF switch, and the REM status annunciator is illuminated.

3-58. Returning to Local Mode. The instrument may be returned to the local mode as follows:

a. The LCL/INIT key is depressed, provided local lockout (LLO) is not active.

b. The go-to-local (GTL) bus command is sent.

c. Remote enable (REN) is set false.

TABLE 3-5. SPECIAL FUNCTIONS.

Option Switch A4S1 Functions:

		Listen:	Talk:
0	Restores settings of internal option switch		
1	EOS Character:	LF or CR LF	CR LF
2	EOS Character:	CR	CR LF
3	EOS Character:	CR	CR
4	EOS Character:	CR	CR
5	Pen-up is active high		
6	Pen-up is active low		
7	Disable program auto-recall		
8	Enable program auto-recall		

Mode Alteration Functions:

10	Clear functions 16 and 18
16	Unlock frequency
18	Hold output level range

Initialization And Test Functions:

	(These functions can be disabled using option switch A4S1-4)
25	Erase all program memory locations
30	Dac test mode
31	Counter plug-in board test mode

Frequency Sweep Resolution Functions:

50	Linear frequency sweep (frequency step value determines resolution)
51	16 step logarithmic sweep
52	32 step logarithmic sweep
53	64 step logarithmic sweep
54	128 step logarithmic sweep
55	256 step logarithmic sweep
56	512 step logarithmic sweep
57	1024 step logarithmic sweep
58	2048 step logarithmic sweep
59	4096 step logarithmic sweep

Sweep Rate Functions:

60	Rapid Sweep
61	0.5 Sec/step
62	1.0 Sec/step
63	1.5 Sec/step
64	2.0 Sec/step
65	2.5 Sec/step
66	3.0 Sec/step
67	3.5 Sec/step
68	4.0 Sec/step
69	4.5 Sec/step

Source Output Impedance Selection Functions:

75	50 ohm output impedance
76	150 ohm output impedance
77	600 ohm output impedance

dBV/dBm Display Mode Selection Functions:

80	dBV display reference: 1.000 V
81	dBm display reference: 1 mW, 50 ohms
82	dBm display reference: 1 mW, 75 ohms
83	dBm display reference: 1 mW, 150 ohms
84	dBm display reference: 1 mW, 300 ohms
85	dBm display reference: 1 mW, 600 ohms
86	dBm display reference: 1 mW, 900 ohms
89	dBm display reference: 1 mW into the impedance specified by LOAD function

NOTE

The instrument must be placed in the remote mode for it to store and respond to data messages.

3-59. Triggered Operation. In the remote mode the instrument can be operated in the immediate mode (mnemonic IM), or in the wait-for-trigger mode (WT). The immediate mode is the default condition and results in the immediate response to mnemonic commands and settings. The wait-for-trigger mode causes the execution of commands and settings to be deferred until a trigger is received. This aids in synchronizing the instrument's state changes to other system components. The wait-for-trigger mode is set when the WT mnemonic is encountered in the input string. From that point on execution is delayed. No change will occur until one of the following events is encountered:

a. "Group-execute-trigger" (GET) is received.

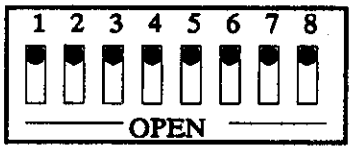
b. The mnemonic TR (trigger) is interpreted.

c. Any mnemonic following IM (immediate) is interpreted.

NOTE

Event (c), above, or go-to-local terminates the wait-

TABLE 3-6. OPTION SWITCH A4S1.

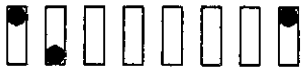


Factory settings.

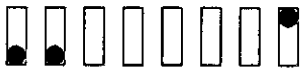
EOS Character Selection:

Listen: LF or CR LF Talk: CR LF

Listen: CR Talk: CR LF



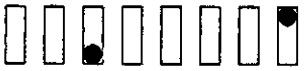
Listen: CR Talk: CR



Listen: CR Talk: LF

Pen Status Control:

Pen-up is active low



Pen-up is active high

SPCL Function Disable:

Enable SPCL Functions 25, 30 and 31

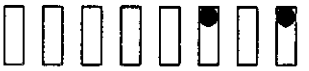
Disable SPCL Functions 25, 30 and 31

Auto Recall Enable:

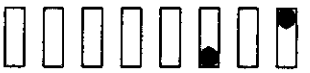
Disable Program Auto-recall

Enable Program Auto-recall

SRQ Enable:

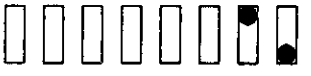


Disable SRQ



Enable SRQ

Test Mode Enable:



Lamp Test

Reference Test

TABLE 3-7. ERROR CODES.

Error Code	Description
01	Illegal source frequency entry
02	Illegal frequency step size entry
03	Illegal source level entry
04	Illegal level step size entry
05	Illegal special function entry
06	Illegal start frequency or level entry
07	Illegal stop frequency or level entry
10	Bus address entry out of range
11	Store/Recall error: attempting to recall an erased location or Store in read-only location No. 99
13	Illegal level terminated entry
14	Illegal load entry
15	Illegal reference entry
20	Illegal units for active function
21	Buffer overflow: too many key entries for display or IEEE-488 buffer overflow
22	IEEE-488 bus error: non existent mnemonic
23	IEEE-488 bus error: illegal Learn string format
24	IEEE-488 bus error: illegal Burst string format
25	Sweep errpr: Start and stop units are not compatible
26	Sweep error: Start and stop values are equal.
30-35	Hardware error: Frequency lock

for-trigger mode and restores the immediate mode. The wait-for-trigger mode is not active in local operation.

3-60. **Talk Operation.** The instrument may be addressed as a talker without regard for remote/local mode. When the talker state is set by the bus controller, the instrument sends a character string which is determined by the current talk mode. One of six different talk modes is selected by sending the appropriate mnemonic with the Model 1110 addressed as a listener. The selected mode will remain in effect until changed.

3-61. **Talk Status (TS) Mode.** In the TS mode the error code status of the instrument is returned as a number. Normal status returns a 0 code otherwise the error number is returned. The TS mode will automatically clear the error after the status is reported. The TS mode is the default talk mode after initialization of the instrument.

3-62. **Talk Value (TV) Mode.** In the TV mode The argument of the active function designated by the KYBD annunciator is returned as a number. All values returned are in basic units such as: Hz, V, ohms, dB, etc.

3-63. **Talk Program (TP) Mode.** In the TP mode a 6 digit number is returned that uniquely identifies the firmware.

3-64. **Talk Function (TF) Mode.** In the TF mode a variable length string of ASCII characters will be returned which identifies the state of all active functions. The bit assignments are arranged to allow for string or byte oriented decoding. The various characters are listed in Table 3-9.

3-65. **Talk Learn (TL) Mode.** In the TL mode a compressed parameter string of 143 ASCII characters, the last of which is an ASCII ($), is returned. This string can be sent back to the instrument at any time to restore the exact state of all functions and settings which defined it, but it must be sent as a complete string without alteration. When the ($) character is encountered in the input buffer, the learn mode is automatically activated. While this form provides a compact and fast method to save and restore all settings, it bypasses much of the error control and must be used with caution.

3-66. Talk Burst (TB) Mode. In the TB mode a compressed parameter string of 21 ASCII characters, the last of which is an ASCII (&), is returned. Like the Learn string, this string can be sent back to the instrument at any time to restore the exact state of the level and frequency settings which defined it, but it must be sent as a complete string without alteration. While this form provides a compact and fast method to save and restore frequency and amplitude setting to create sweep or tone burst sequences, it bypasses update of the display and much of the error control and must be used with caution. To prevent the display from giving false indications the display may be blanked using the (BL) command.

3-67. End-Of-String (EOS) Control. The instrument provides several end-of-string options to accommodate a wide variety of controllers. The instrument always terminates on EOI (end-or-identify) true and always sends EOI true with the last character of every string. In addition, CR, LF, or CRLF may be used. The use of CR and LF is selected by option switch A4S1-1 and 2 and special functions 1 through 4. Detection of EOI is not affected by A4S1 switch settings.

3-68. Using "Service Request" (SRQ). The instrument may be configured to set SRQ true when it is in the remote mode and an error occurs. This is enabled by setting the op-

TABLE 3-8. IEEE-488 BUS MNEMONICS.

Level Function Group:

SL	Source Level
LT	Level terminated
LD	Load
RF	Reference
LZ	Level step size
SP	Special function

Frequency Function Group:

SF	Source Frequency
XL	Start
XR	Stop
FZ	Frequency step size

Program Function Group:

PG	Program location
RE	Recall program
ST	Store program

Sweep Control Group:

SW	Sweep mode
SG	Signal generator mode
PU	Pen-up
PD	Pen-down

Units Group:

HZ	Hertz
KH	Kilohertz
VO	Volt
MV	Millivolt
KO	Kilohm
DB	Decibel

Output Control Group:

ON	Enable AF output
OF	Disable AF output
Z0	50 ohm output impedance
Z1	150 ohm output impedance
Z2	600 ohm output impedance
SS	Single-ended source output
FS	Floating source output

Talk Mode Group:

TS	Talk status
TV	Talk value
TF	Talk function
TL	Talk learn string
TB	Talk burst string
TP	Talk program revision

Trigger Group:

IM	Immediate mode
WT	Wait-for-trigger mode
TR	Trigger

Display Mode Group:

BL	Blank display
UD	Update display

Error and SRQ Group:

CH	Frequency self-check
CL	Clear error
EI	Enable SRQ interrupt
DI	Disable SRQ interrupt

TABLE 3-9. TALK FUNCTION (TF) DECODING.

Talk Function String Format: 99,999,AAAAAAAAAAAAA

Active Function Assignments:

1	FREQ
2	FREQ STEP
3	LEVEL
4	LEVEL STEP
5	SPCL
6	START
7	STOP
10	ADRS
11	PRGM
13	LEVEL TERM
14	LOAD
15	REF

Option Switch Bit Assignments:

[8]MSB	A4S1-8	Reserved
[7]	A4S1-7	Reserved
[6]	A4S1-6	Enable SRQ
[5]	A4S1-5	Enable program auto-recall
[4]	A4S1-1	End-of-String Character Select
[3]	A4S1-2	End-of-String Character Select
[2]	A4S1-3	Pen-up active high
[1]LSB	A4S1-4	Disable Special Functions 25 and 30

Alternate Operating Modes:

Z0	50 ohm output impedance
Z1	150 ohm output impedance
Z2	600 ohm output impedance
ON	AF output enabled
FS	Float source
SW	Sweep mode
XC	External counter reference
UL	Unlock frequency mode
RH	Range hold mode

tion switch A4S1-6 to the open position. The bus controller must be programmed to respond to SRQ true. In the usual case, the controller then executes a serial poll to determine which device caused SRQ to be true. If the instrument is the requesting device, it will respond to the serial poll with a single byte which expresses the error code number in excess sixty-four. The serial poll will clear the SRQ line automatically. In small systems only one instrument may be capable of using SRQ. In this situation there is no need to execute a serial poll since the identity of the requesting device is known. The error code may be obtained directly form the talk status (TS) mode. The SRQ line can then be cleared by sending the clear (CL) command.

3-69. **Bus Command Responses.** IEEE-488 bus commands are sent by the controller to all devices on the bus (Universal Command Group) or to addressed devices only (Addressed Command Group). The response of the instrument is listed in Table 3-10.

TABLE 3-10. BUS COMMAND RESPONSES.

Commands	Instrument Response
Universal Command Group:	
Device Clear (DCL)	Clear errors
Local Lockout (LLO)	Disable LCL/INIT key
Serial Poll Enable (SPE)	Sets talk mode for poll response
Serial Poll Disable (SPD)	Restores talk mode before poll
Addressed Command Group:	
Selective Device Clear (SDC)	Same as device clear (DCL)
Go to Local (GTL)	Sets LOCAL mode
Group Execute Trigger (GET)	Triggers a measurement
All Others:	Ignored

3-70. **Program Function Mnemonics.** Each front panel key is assigned a program mnemonic. Programming the mnemonic, followed by unit values, if appropriate, is analogous to manual front-panel operation. In addition, other program mnemonics are used for functions that are applicable only in remote operation. Table 3-8 lists all the program function mnemonics.

3-71. **Number Formatting.** Number formatting rules are as follows:

a. Fixed or floating formats are accepted.

b. The optional + or - sign may precede the mantissa and/or the exponent.

c. The optional radix point may appear at any position within the mantissa. A radix point in the exponent is ignored.

d. The optional "E" for exponent may be upper or lower case.

e. ASCII characters having hexadecimal values of 0 to 23 and 26 to 2C are ignored.

3-72. **Data String Format.** Data string formats are as follows:

a. The programming sequence is in natural order, that is, a function mnemonic is sent first followed by the argument, if appropriate.

b. ASCII characters having hexadecimal values of 0 to 23 and 26 to 2C are ignored. The ASCII ($) and (&), hexadecimal 24 and 25, are reserved. Lower case letters are automatically changed to upper case.

c. A primary function mnemonic sent without a following argument will make the specified function active.

d. The data string may not exceed 150 characters and may be terminated with LF, CR, and/or EOI.

e. Interpretation of the data string does not begin until termination occurs.

f. If units are unspecified for any argument, default units are automatically appended. The functions SPCL and PRGM always use default units.

g. If a unit mnemonic is sent without a corresponding argument, the display will reflect the change provided that the units are appropriate for the active function and the display can accommodate the rescaled number.

3-73. **Data String Errors.** Errors are detected during interpretation. The occurrence of an error will display the error code if the display is enabled, and will set SRQ true, if enabled. The error and SRQ can be cleared by a serial poll, a status request (TS), or a clear error instruction (CL). All errors cause previous valid parameters to be restored. No new input can be processed until an existing error is cleared.

3-74. **Data String Examples.** The following are examples of typical programming strings in HP BASIC:

```
OUTPUT 715; "SP16SF1234.56HZ"
```

```
OUTPUT 715; "Z1FSSL2VO"

OUTPUT 715; "PG1RE"

OUTPUT 715; "LD.05KO"
```

3-75. Store and Recall Operation. Store and Recall operation may be used to advantage with a bus controller. The instrument provides either temporary or long-term storage for control strings. This can be used to minimize bus traffic by storing several control setups at initialization and recalling them when needed with a simple string statements, such as:

```
OUTPUT 715; "PG23RE"
```

Since few controllers have power fail protection, the data in the instrument's non-volatile memory is the more secure.

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The Model 1110 is a versatile, solid-state, microprocessor controlled, audio oscillator that covers the frequency range of 10 Hz to 150 kHz. The instrument contains a programmable audio source with simultaneous display of frequency and level settings. Function parameters can be keyed in through a front panel keyboard or with remote programming using the IEEE-488 interface. Selected modes and values are displayed on an alphanumeric display and LED indicators. Input commands are processed by the internal microprocessor and control signals are developed to configure the internal circuits in accordance with the commands. The use of the microprocessor also enables the storage of up to 99 complete sets of instrument setup data. Commonly used setups can be entered into non-volatile memory either through the keyboard or through the IEEE-488 interface; thereafter, the instrument can be set to any desired set of conditions in memory by keying in the code number assigned to the desired setup in storage.

4-3. FUNCTIONAL BLOCK DIAGRAM.

4-4. Control of the instrument operation is exercised by a microprocessor that executes a fixed program resident in read-only-memory (ROM). Timing of the microprocessor operations is controlled by a 5 MHz clock. A random-access-memory (RAM) provides storage capability for microprocessor data. To insure retention of data in storage, the non-volatile RAM is powered from an internal 3 volt lithium battery. The main power supply develops the operating power required by the instrument.

4-5. The microprocessor communicates with the internal circuits through a data bus and an address bus. Command information is entered into the microprocessor through the front panel keyboard or an IEEE-488 interface. DIP switches are provided for option and test purposes. Input data selection is displayed by means of a digital readout and LED indicators. The microprocessor stores and processes input data, and generates data and address information to cause execution of command functions.

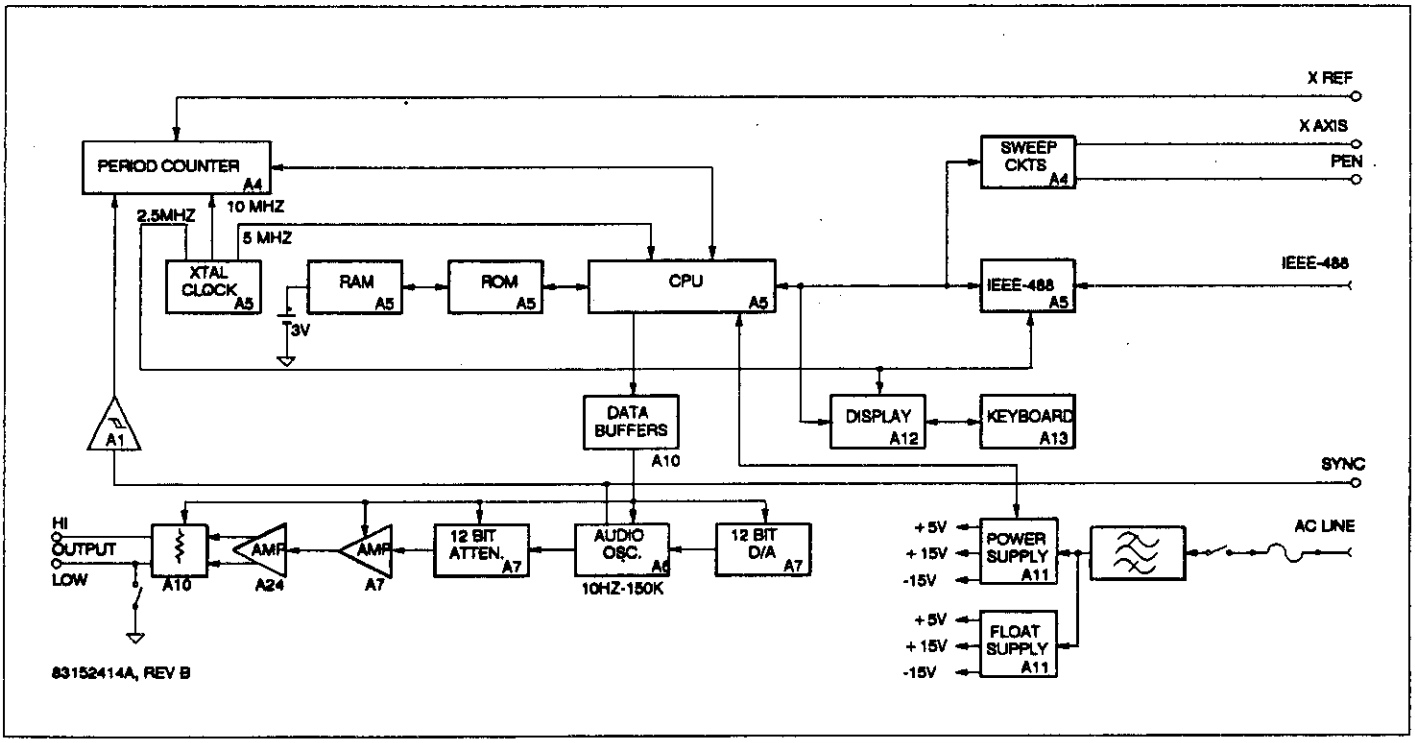


Figure 4-1. Functional Block Diagram.

4-6. The audio output signal is generated by a low distortion oscillator design which tunes from 10 Hz to 150 kHz. Microprocessor controlled coarse and fine tuning precisely sets and maintains the source frequency. A peak detecting sampler is used in the automatic level control circuits (ALC) to maintain a constant amplitude at all frequency settings.

4-7. The output of the oscillator is applied to a programmable attenuator which adjusts output level in 1 mV increments over a 0.001 to 3.000 volt range. The attenuator output is amplified and attenuated further to provide a total level range of 0.01 mV to 16.000 volts open circuit. A class A power amplifier is used to convert the single-ended source to a differential output with a 50 ohm impedance. The oscillator, output attenuator and power amplifier are isolated from the chassis by an optically coupled digital interface and a floating power supply to enable the source to operate in a floating configuration. Output impedance selections of 150 and 600 ohms are achieved by inserting 100 and 450 ohm resistors in series with the 50 ohm output.

4-8. The period counter circuits enable the measurement of the source frequency. The actual source frequency is measured to enable fine tuning of the oscillator by the microprocessor as part of a frequency lock loop.

4-9. The power supply circuits convert the incoming line voltage into regulated DC operating voltages to power the instrument circuitry.

4-10. DETAILED CIRCUIT DESCRIPTION.

4-11. A11 Power Supply Circuits. The power supply provides the main power for the logic and analog circuits. Refer to Figure 4-2.

4-12. Line power is connected to transformers T1 and T2 via line filter FL1, fuse F1, and line voltage selector switch S2. Fl1 keeps internally generated RF signals from appearing on the power connecting cable thus preventing unwanted electromagnetic radiation. Line switch S2 alters the connections to the primaries of T1 and T2 allowing the Model 1110 to operate from line voltages of 100 to 240 volts. The dual power supplies provide fixed and floating sources of +5, +15 and -15 volts. The fixed and floating supplies are essentially identical; therefore, only one will be described in detail.

4-13. One of the two secondary windings on T1 is connected through full-wave bridge CR1 to regulator U4. This regulator generates a +5 volt regulated voltage for logic circuits. Capacitor C5 provides the essential energy storage which reduces the ripple voltage at the input of U4. C15 provides local bypassing of the regulator circuits and diodes CR5 and CR10 protect the integrated regulator from reverse power.

4-14. The other secondary winding of T1 is connected through full-wave bridge CR4 to regulators U8 and U10. These regulators are enclosed in feedback loops to improve regulation and increase the operating voltages from 5 to 15 volts. Capacitors C13 and C15 reduce input ripple voltage and CR14, CR16, CR19, and CR24 provide reverse voltage protection. Reference U12 provides the voltage reference for the power supply. Precision resistors R10a, b, and e configure U9a for a gain of +1.5. This converts the +10.00 volt output of U12 to +15.00 volts. R10f and d configure U9b for a gain of -1 which inverts the +15.00 volt supply to -15.00 volts. Zener diodes CR17 and CR18 are required to insure proper startup of the supply, and are normally reverse biased when the supplies are operation properly. C31 and C32 provide local bypassing to maintain loop stability as the supply loading changes.

4-15. An additional 5 volt regulator, U1, supplies power to the power-fail circuits. The operating voltage for U1 is the +5 volt supply input voltage which is about 9 volts at nominal line. Capacitor C23 insures that the output of U1 will be maintained as long as possible when line voltage is removed. The power-fail circuit operates to properly isolate the random access memory from logic circuitry when the line voltage drops or the instrument is switched off. Comparator U2a monitors the unregulated voltage which supplies the 5 volt logic supplies. Resistors R1 and R2 divide the power-fail circuit supply by two as a reference for U2a. If the power line voltage drops to about -11 % of nominal, U2a switches, pulling line SNMI low. This activates the power-fail sequence which interrupts the microprocessor and isolates the random access memory. U2b buffers the SNMI signal and drives a delay network, R8 and C26. When the open-collector output of U2b goes low, C26 is discharged quickly. This output is buffered by U2c to drive the PRST line which resets the CPU circuitry. When the output of U2b switches off, the PRST signal is delayed by the time required to charge C26 to one half of the power-fail supply voltage. This prevents multiple CPU resets as the supply voltage decays toward zero.

4-16. A10 Motherboard Circuits. The motherboard circuitry provides the main interconnect for the operating circuits of the Model 1110. The motherboard circuits include the connectors for the plug-in boards, the power supply connectors and instrument data and address buffers for the source and output analog sections. The motherboard circuits also contain the source output attenuators and impedance selection circuits.

4-17. Address decoding on the counter plug-in board generates the Master Source Enable (MSE) signal which enables address decoder U3 and tri-state buffer U18. MSE is only active during instrument data write cycles to the source and output circuits and inhibits RF generated noise caused by the many data transfers between the CPU and counter plug-in boards. Additionally, the source interface is optical-

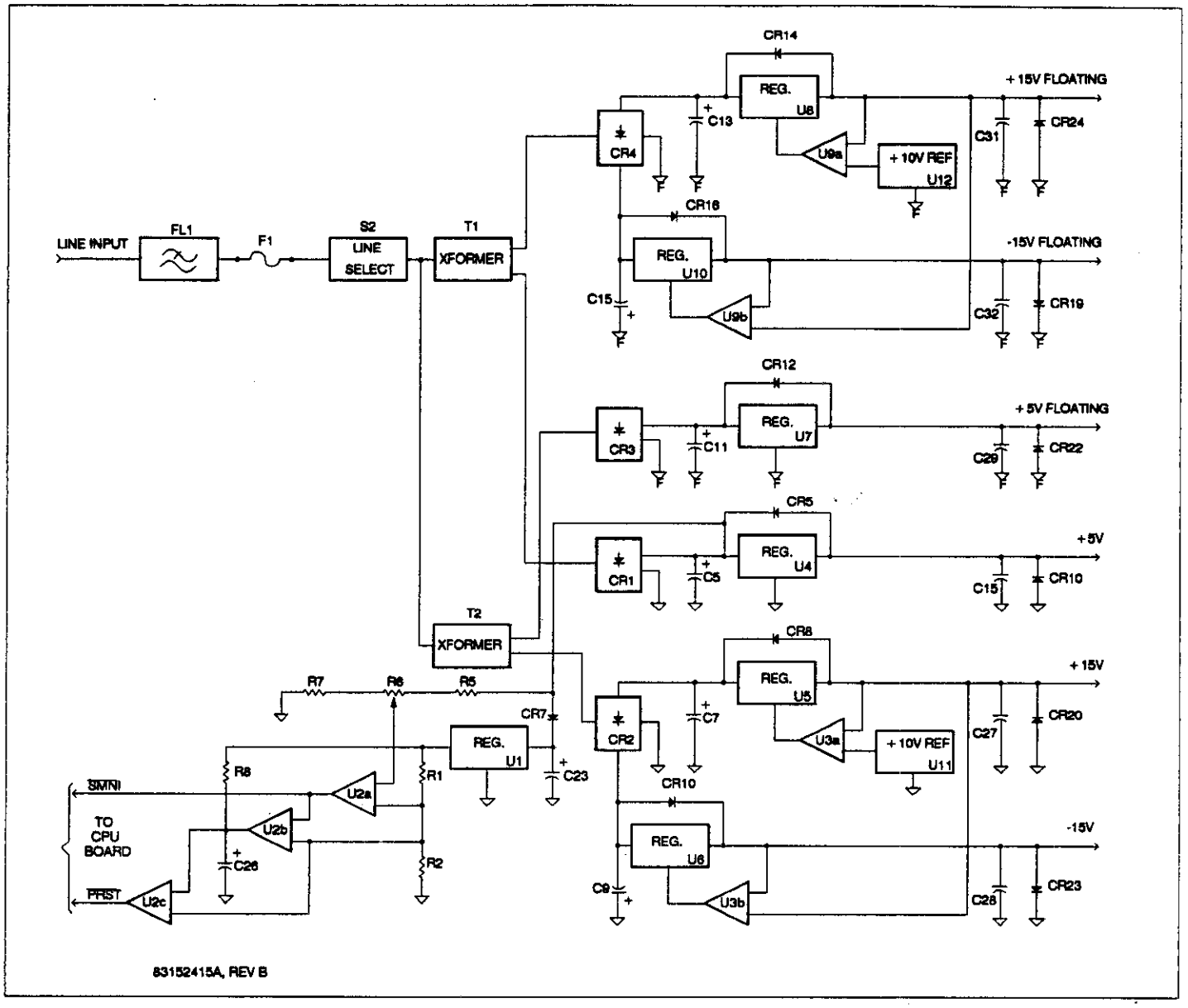


Figure 4-2. Power Supply Circuits Block Diagram.

ly coupled using U5 through U17 to allow the source oscillator circuits to operate while isolated from the chassis. Optical coupler U4 conveys the sync square wave from the source board back to the counter circuit board for measurement (TP1). The rear panel SYNC output signal is buffered by Q1 and associated circuitry

4-18. The parallel combination of R26 and R29 from the 50 ohm output impedance of the power amplifier. A 14 dB attenuator (/5) is formed by R12, R14 and K1. Relay K1 engages the attenuator for output level settings of 3.000 volts and below. A 20 dB attenuator (/10) is formed by R15, R17 and K2 (TP3). Relay K2 engages the attenuator for output level settings of 300.0 mV and below. The 150 ohm output impedance is configured by adding R18, 100 ohms, in series with the 50 ohm output using K3. The 600 ohm output impedance is configured by adding R22, 450 ohms, in series with the 150 ohm output using K4. Float relay K5 connects the LOW output terminal (TP4) to chassis ground through fuse F2 in the non-floating mode while fuse F1 protects the source circuits HI output (TP5) from reverse power. During power-up Q8 disables the +15 volt supply to relays K1 through K5 for approximately 1 second to provide time for the C.P.U to initialize the source circuits.

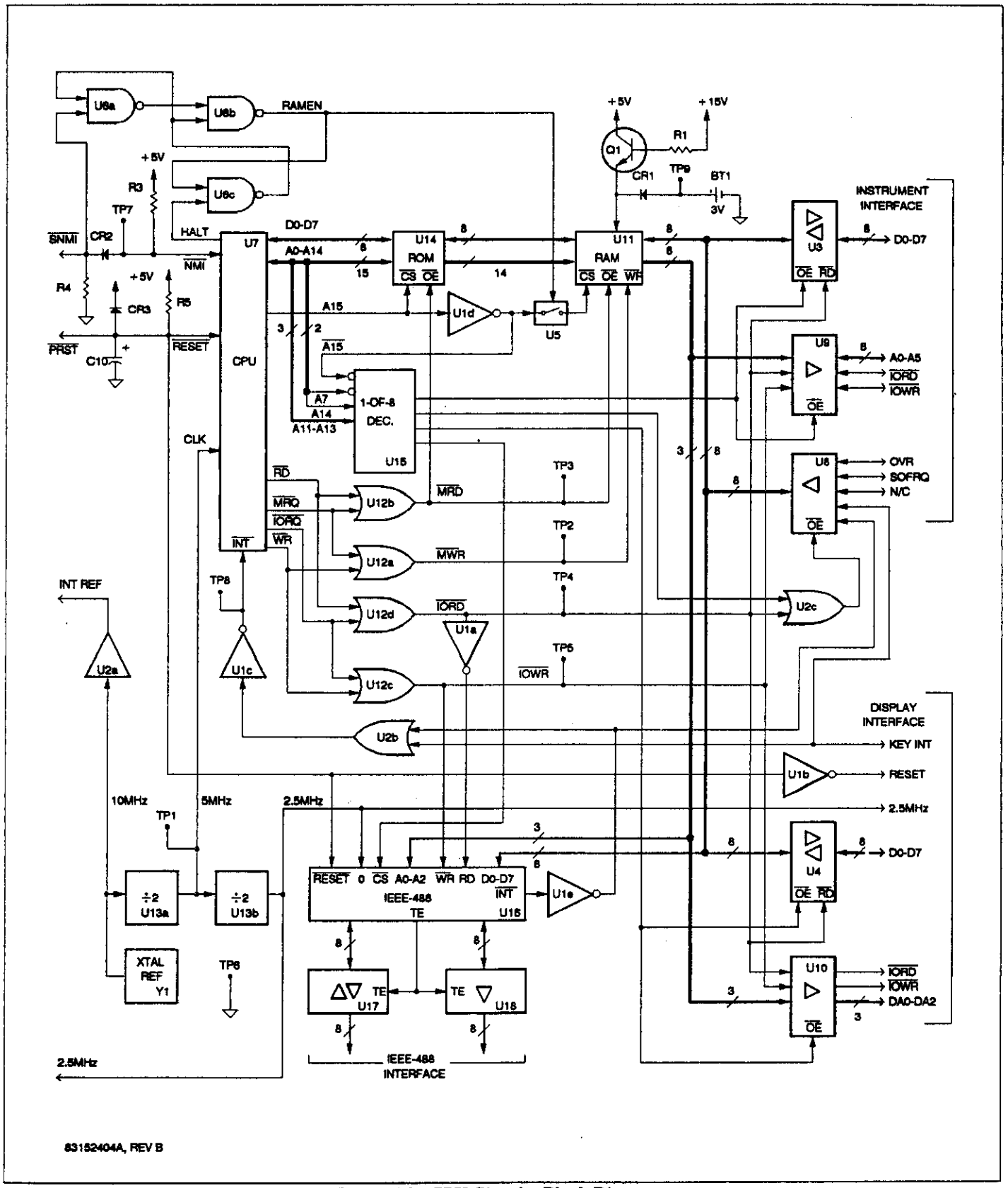


Figure 4-3. CPU Circuits Block Diagram.

4-19. A5 CPU Circuits. The CPU circuits are the central control circuits of the instrument. They receive input commands and data form the front panel keyboard or an IEEE-488 interface and configure the internal circuits of the instrument in accordance with the input commands and data. Storage facilities for up to 99 complete front panel setups are also provided. Refer to figure 4-3.

4-20. The Z-80 CPU, U7, executes a control program resident in read-only memory, (ROM) U14. Program variables and front panel setups are stored in random-access memory, (RAM) U11. Local communications on the CPU board are via the high-speed data bus D0 through D7 and address bus A0 through A15. Memory address space partitioning is divided equally between RAM and ROM and is accomplished through inverter U1d. All other instrument peripherals are partitioned in the I/O address space which is accomplished with decoder U15. U12a, b, c, and d generate memory read and write signals and I/O read and write signals for qualifying data transfers between memory or I/O peripherals and the CPU (TP2-TP5).

4-21. The RAM is powered from a non-volatile power supply consisting of Q1, CR1 and BT1 (TP9). If a power fault occurs, circuits in the power supply activate the SNMI line which in turn activates the NMI processor interrupt line (TP7). This causes the processor to stop the control program and execute a HALT instruction which sets the HALT pin low. This inhibits further write cycles to the RAM by setting a latch formed by U6c and d which disconnects the chip select (CS) line to the RAM using analog switch U5. Signal PRST is also set low shortly after SNMI is activated, causing the CPU to be reset to the program start. When proper operating voltage is restored, the SNMI line returns high releasing NMI and restoring the RAM CS connection. During the power down interval the RAM is powered by BT1 (TP9).

4-22. Microprocessor timing is controlled by a 5 MHz clock (TP1) which is derived from a 10 MHz TCXO, Y1, and flip-flop divider U13a. The clock signal is further divided by U13b to 2.5 MHz which is used by the IEEE-488 microcontroller, U16, and by the display circuits. The 10 MHz TCXO output is also buffered through U2a and is used for the internal timebase reference for the frequency counter circuits.

4-23. All IEEE-488 interface operations are conducted by U16 in conjunction with the microprocessor interrupt routines. These routines move data into and out of memory buffers as required in response to bus commands. U17 and U18 are buffer circuits which connect U16 to the IEEE-488 bus via J20. These buffers meet the electrical requirements of the IEEE-488.

4-24. Interrupt oriented control enables the CPU and control program to respond quickly to peripheral activity. When bus activity occurs, U16 sets the INT line (TP8) via U1e, U2b and U1c. When a display/keyboard interrupt occurs the KEY INT line sets the microprocessor interrupt line through U2b and U1c. The microprocessor determines the source of the interrupt by reading the interrupt status buffer, U8, and services the requesting peripheral device.

4-25. The instrument bus interface adapter consists of U3, U9, R8, and R9. These tri-state buffers are normally in the high-impedance mode during all memory transfers and I/O data transfers occurring between the CPU and the display/keyboard circuits or the IEEE-488 interface.

4-26. The display/keyboard bus interface adapter consists of U4 and U10. These tri-state buffers are only active during display/keyboard circuit transactions.

4-27. A12 Display And A13 Keyboard Circuits. The display and keyboard circuits provide the operator interface to the Model 1110 circuits. Key closures are detected and sent to the microprocessor which interprets and modifies the display LEDs appropriately. The software configurable display/keyboard microcontroller, U4, is programmed to operate 16 display digits. All of the seven segment displays are connected to a common cathode driver bus which is generated by U4 and buffered through U1 and current limiting resistors R1a through h. The LED anodes are individually connected to a one-of-sixteen decoder consisting of U5 and U6 and buffers U2 and U3. All segment decoding is done by the microprocessor so that no additional decoders are required.

4-28. All of the alphanumeric annunciators are static and latched by octal latches U8, U9 and U10. Resistors R4, R5 and R6 limit the current through the LEDs. Decoding for these latches is accomplished by U7.

4-29. The key LEDs are all static and latched by octal latches U12, U14 and U16. In addition some LEDs on the keyboard are decoded further by one-of-eight decoders U18 and U19. Resistors R7 through R10 limit the current through the keyboard LEDs.

4-30. Keyswitch decoding is accomplished by scanning the keyboard and detecting key closures. Microcontroller U4 controls the scanning of the keyboard through decoder U17 which generates the column strobes C0 through C7. Any key closure will convey the column strobe to one of eight row lines, R0 through R7, which are monitored by U4. Multiple key closures and key debouncing are handled by U4. When a keyswitch closures occurs a microprocessor interrupts is generated and processed as described in the CPU board section.

4-31. A4 Frequency Counter Circuits. The counter circuits provide the frequency measurement functions of the Model 1110. Additionally, the sweep output circuits, and the

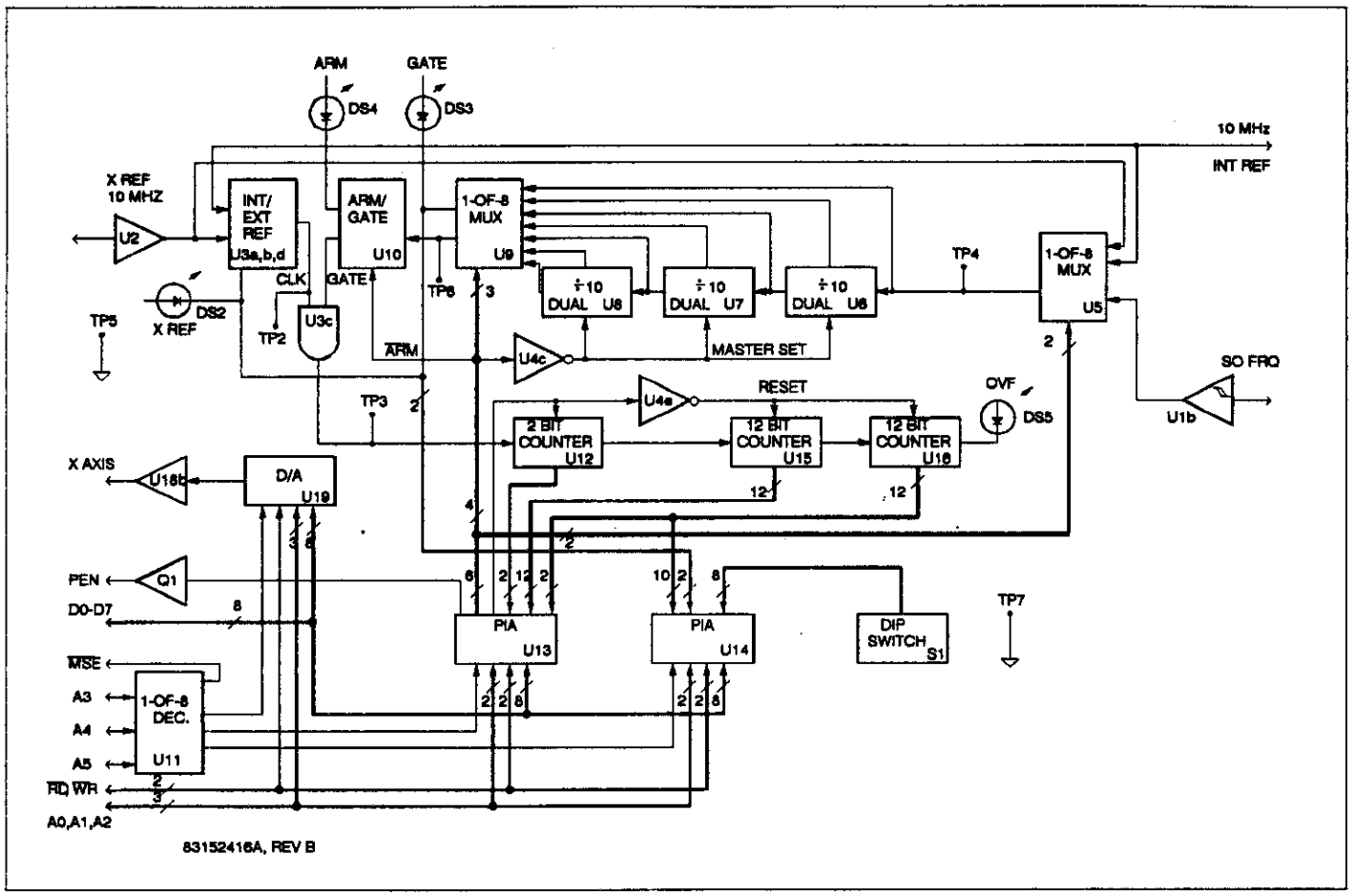


Figure 4-4. Frequency Counter Circuits Block Diagram.

option switch are located on the counter plug-in board. Refer to Figure 4-4.

4-32. The 10 MHz internal frequency reference from the CPU board is connected to gate U3d. The other input of U3d is a signal derived from the external reference input. If an external reference signal is present, pin 6 of U2a will be a TTL compatible signal at the external reference frequency rate. The signal is inverted by U2b and detected by CR3, C25 and R4. When a signal is present the input of inverter U2c will be a TTL low level which is the control to automatically switch to the external reference using U2d, U3a, U3b, and U3d. The output of U3b (TP2) is the reference frequency for the counter circuits derived from either the internal or external source. DS2 will be illuminated when the external reference is active.

4-33. The source frequency line SOFRQ is generated on the source plug-in board and is applied to hysteresis amplifier U1a and associated components. U1b acts as a buffer between the analog and digital sections of the instrument and is insensitive to the noise which is present between the analog and digital grounds. The output of U1b is applied to the input multiplexer, U5, of the counter. U5 selects one of three inputs; source frequency, external reference, and internal reference, based on the state of control lines S0 and S1. The output of U5 (TP4) is applied to a chain of dual decade dividers, U6, U7 and U8. These dividers are used for period selections and divide the selected input by factors of 1 to 1000000 in decade increments. All the divider output are presented to a second multiplexer, U9, which selects one of the six period divisions based on control lines T0, T1 and T2.

4-34. Dual flip-flop, U10, controls the arm and gate intervals. The output of U9 (TP6) is inverted by U4b and applied to the clock input of U10a. The arm interval synchronizes the counter circuits to begin the gate interval on the next rising edge of the measurement signal. The ARM line is set low to clear flip-flop U10a. and, after being inverted by U4c, is applied to the master set (MS) lines of U6, U7 and U8. The MS sets all the divider output high which prepares the dividers to all start at count 0 with the next falling edge of the measurement signal. The rising edge of the ARM line clocks U10b, sets the U10b pin 9 high and illuminates DS4. When the fall-

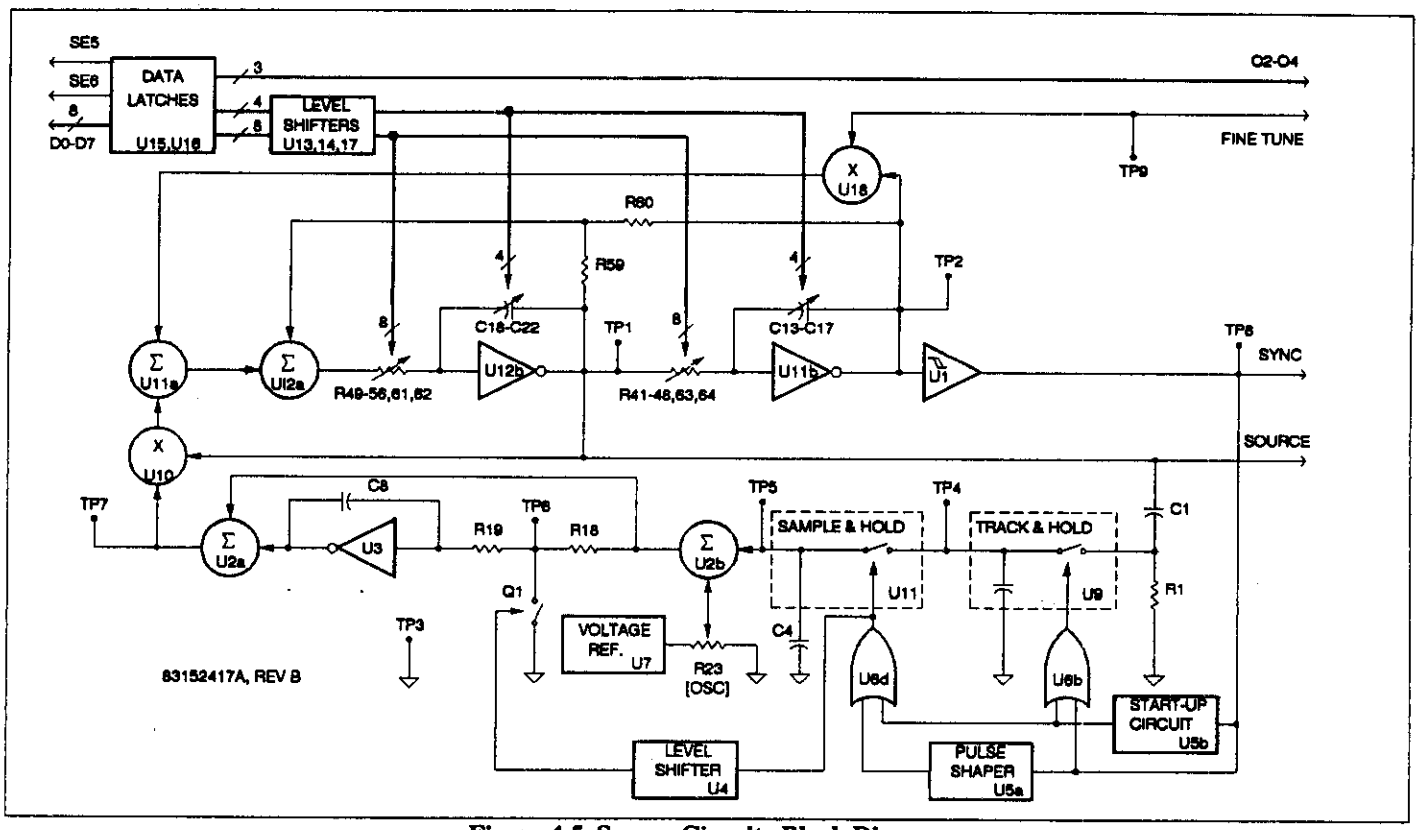


Figure 4-5. Source Circuits Block Diagram.

ing edge of the measurement signal occurs, U10a is clocked and the gate interval begins when U10a pin 5 goes high. Simultaneously U10a pin 6 goes low which illuminates DS3 and clears the arm latch U10b. When U10b is cleared, DS4 is extinguished and U10b pin 9 is set low. The gate interval continues until U10a pin 5 is clocked low by the next rising edge at U10a pin 3. Gate U4a detects the end of the arm and gate intervals and indicates to the CPU that the count is complete. The counter will hold the count until the next arm interval is initiated. The output of U10a pin 5 goes to gate U3c which allows the reference to pass to the counter accumulator during the gate interval (TP3).

4-35. The gated reference is applied to to a 26 bit accumulator consisting of U12, U15 and U16. The accumulators cleared by a TTL low level from U13 pin 11. By detecting the most significant bit of the accumulator, U4d will prevent the accumulator from overflowing and illuminate DS5. The accumulator is read by the CPU through I/O devices U13-14.

4-36. The option dip switch is connected to one port of I/O device U14 along with lines indicating external reference control and gate status. The sweep output circuits generate the X AXIS and PEN outputs. Buffer Q1 generates the PEN output under command by the CPU through I/O device U13 pin 10. Reverse power protection is provided by R12, CR4 and CR5. The X AXIS output is generated by 12 bit digital-to-analog converter (D/A), U19, and associated voltage amplifier U18a. The -5 volt reference voltage for the D/A converter is zener regulated from the -15 volt supply by R24 and CR14 and filtered by C13. Reverse power protection is provided by R25, CR6 and CR7.

4-37. Address decoder U11 decodes the chip select lines for I/O devices U13 and U14 and D/A converter U19. MSE, the master source enable command used on the mother board, is also generated by U11.

4-38. A6 Source Circuits. The source oscillator is a digitally tuned, automatically leveled state-variable oscillator. The source circuits generate a sinusoidal audio waveform at a constant amplitude over a frequency range of 10 Hz to 150 kHz. Refer to Figure 4-5.

4-39. The source oscillator consists of a state-variable oscillator and a automatic level control (ALC) loop. In operation the oscillator is coarse tuned to the selected frequency and then the actual frequency is measured by the counter circuits and fine adjustments are made by the control program to achieve an accurate frequency.

4-40. Coarse frequency tuning is achieved by adjusting the time constant of the two integrators. The individual integrators are identical, so only one will be described in detail. The output from summing amplifier U12a is applied to a series of eight resistors. The values of these resistors, R49 through R56, are chosen in a binary series to operate as a discrete 8 bit D/A converter. These resistors are selected for frequency tuning within a selected frequency band by FET switches Q18 through Q25. Capacitors C18 through C22 are selected by FET switches Q14 through Q17 for integrator tuning over five frequency bands. Integrating amplifier U12b completes the integrator (TP1). Coarse tuning of the oscillator is provided by the selection of resistor and capacitor combinations by the control program. Data from the control program is latched in data latches U15 and U16. The 12 comparators contained in U13, U14, and U17 and associated pull-up resistors R61, R62, and R63 act as level translators to convey the latched TTL data to gate drive levels necessary to operate the FET switches.

4-41. The oscillator output is generated at the output of integrating amplifier U12b (TP1). A limiter circuit formed by CR9 through CR14 and R38 through R40 prevent overload transients in the output which may occur during frequency transitions.

4-42. The leveling and fine tuning of the oscillator is controlled by adjusting the in-phase and quadrature components of the source signal at the output of U12b. The ALC circuits sample the positive peak of the sine wave and compare the peak level to a voltage reference. The difference is sampled by an error integrator and applied to gain control circuits which work to reduce leveling errors by adjusting the feedback of the in-phase component.

4-43. A quadrature detector is formed by U1 and associated components. The output of U1 is a TTL compatible square wave used in the ALC loop to detect the peak of the source output waveform. The output of U1 is buffered by gate U6a and is used to generate the rear panel SYNC output (TP8). The SOFRQ output is also applied to the counter circuits to enable internal measurement of the actual source frequency.

4-44. The source output signal is AC coupled by C1 and R1 and applied to a track-and-hold circuit, U9. The quadrature detector generates the track and hold control signal which tracks the rise of the sinusoid and holds the peak value for 180 degrees. The output of U9 (TP4) is sampled by U10 immediately following the start of the hold period. The hold period of U9 effectively extends the peak of the sinusoid to eliminate sampling aperture errors. The 30 uS sampler aperture is determined by one-shot U5a and timing network C6 and R16. The output of U10 (TP5) is a DC level equal to the positive peak amplitude of the source output signal. Voltage reference U7 generates +5 volts which is applied to a voltage divider network formed by R5, R23, and R12. Oscillator calibration adjustment R23 allows fine adjustment of the source output level. The output of U10 is subtracted from the calibration reference by amplifier U2b and associated components forming an error voltage. Error integrator U3 is enabled by shunt chopper Q1 (TP6) during the 30 uS sampling period. A level translator circuit consisting of U4 and associated components convert the TTL sampling signal to gate drive levels to control FET Q1. The output of the error integrator, U3, is amplified by U2a and applied to four-quadrant multiplier U10 to complete the ALC control loop. One-shot U5b and timing network R17 and C7 forms a start-up circuit which triggers after a 200 mS absence of the quadrature signal. When U5b triggers, U9 and U10 are set in track and sample modes to guarantee oscillation when the power is first applied and when there is no quadrature signal.

4-45. The fine tune and ALC error voltages are applied to four-quadrant multipliers U10 and U18. The current outputs through pin 4 of each multiplier is summed together and amplified by U11a. The output of U11a is the product of the ALC error and fine tune voltages and the in-phase (TP1) and quadrature (TP2) signals which are summed back into the oscillator through U12a. The ALC control loop can be disabled to aid in troubleshooting the oscillator circuits by removing U10. In this design The ALC control loop operates to reduce oscillation, therefore, removing U10 causes the oscillator level to increase to the limit set by the limiter circuits controlling U12b. The oscillator and ALC circuits can then be investigated individually.

4-46. **A7 Output Circuits.** The output circuits consist of the differential power output amplifier (located on the rear panel heat sink), the variable gain and attenuation to cover a level range of 0.01 mV to 16 volts, and the programmable DC voltage used to fine tune the frequency of the source circuits. Refer to Figure 4-6.

4-47. The source oscillator output is applied to resistors R13 through R32. The values of these resistors are chosen in a binary series to operate as a discrete 12 bit D/A converter. These resisters are selected for level increments within the 16 volt, 3 volt, 300 mV or 30 mV level ranges by FET switches Q3 through Q14. The three most significant bits are trimmed for maximum accuracy by resistor R15, R17, and R21. Data from the control program is latched in data latches U4 and U5. The 14 comparators contained in U6 through U9 and associated pull-up resistors R4, R5, and R6 act as level translators to convey the latched TTL data to gate drive levels necessary to operate the FET switches. Amplifier U10 is a summing amplifier which combines the currents from the selected bits in the discrete 12 bit D/A converter. Analog switch U11 and resistors R9 and R36 form a programmable attenuator with selections of 0 dB, -20 dB and OFF. The -20 dB range is enabled for signal levels of 30.00 mV and below. In the signal-to-noise measurement mode, U11 is configured to squelch the source output during the noise measurement

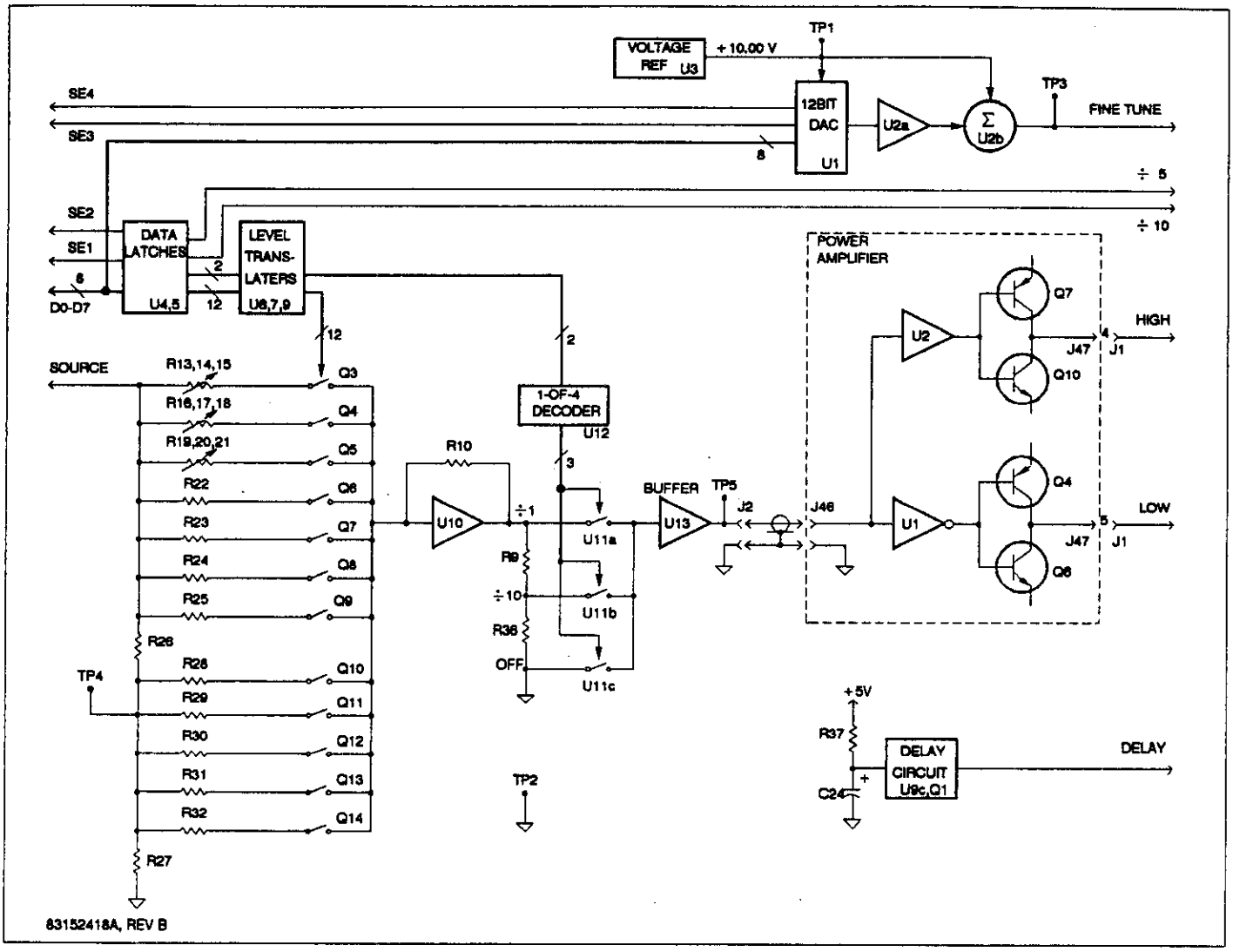


Figure 4-6. Output Circuits Block Diagram.

interval.

4-48. The output amplifier is formed by rear panel assembly A24. The single-ended signal is applied to amplifiers U1 and U2 to form a differential HI and LOW output. The LOW amplifier formed by U1, Q4, Q6 and associated circuitry is configured as an inverting amplifier while U2, Q7, Q10 and associated circuitry is non inverting and drives the HI output. The power transistors Q4, Q6, Q7, and Q10 are current boosters to supply current into impedances as low as 50 ohms.

4-49. The fine tune voltage is generated by 12 bit D/A converter U1. A 10 volt reference for the D/A converter (TP1) is provided by U3. Amplifier U2a provides a 0 to -10 volt output from the D/A converter while U2b and resistors R1, R2, and R3 generate a -6.7 to +13.4 volt output range to tune the source oscillator (TP3).

4-50. A power-on delay circuit is formed by R37, C24 and U9c. The one second delay provides time for the CPU to initialize the source circuits. When power is applied, C24 charges through R37 to +5 volts. Comparator U9c detects at the +1.8 volt level and turns Q1 on. The emitter of Q1 drives Q8 on the mother board supplying +15 volts to relays K1 through K5.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This sections contains the safety requirements, required test equipment, and procedures for cleaning, removal and replacement, inspection, performance test, and adjustment for the Model 1110 Audio Oscillator.

5-3. SAFETY REQUIREMENTS.

5-4. 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 at the front of this manual or with specific warnings given throughout this manual could result in serious injury or death. Service and adjustments should be performed only by qualified service personnel.

5-5. REQUIRED TEST EQUIPMENT.

5-6. Test equipment required for the performance tests, adjustments and troubleshooting is listed in Table 5-1. Any equipment that satisfies the critical specifications in the table may be substituted for the recommended models. However, the performance tests are based on the assumption that the recommended test equipment is used.

5-7. CLEANING PROCEDURE.

5-8. Painted surfaces can be cleaned with a commercial, spray-type window cleaner or with a mild soap and water solution.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in the instrument. Recommended cleaning agents are isopropyl alcohol, a solution of 1 part kelite and 20 parts water, or a solution of 1 % mild detergent and 99 % water.

5-9. REMOVAL AND REPLACEMENT.

5-10. **Instrument covers.** Remove the instrument covers as follows:

a. Disconnect the power cord and all signal cables from the instrument.

b. Remove the three screws located at the rear of the cover and slowly lift the cover up and to the rear.

c. Turn the unit over and remove the bottom cover in the same manner as the top cover was removed.

d. To replace the covers reverse the removal procedure.

5-11. **Display/Keyboard Access.** To gain access to the display and keyboard proceed as follows:

a. Remove the instrument covers as described in paragraph 5-10.

b. Remove the three screws that hold the top trim extrusion and remove the trim strip.

CAUTION

When removing the display window be careful not to scratch the inner surface of the window.

c. Remove the plastic display window.

d. Turn the instrument over and remove the three screws that hold the bottom trim extrusion and remove the trim strip.

e. Tilt the bottom of the front panel away from the instrument until all switches are clear. Pull the front panel up to clear the center trim extrusion for access.

f. To replace the display/keyboard reverse the removal procedure.

5-12. **Plug-in Circuit Boards.** Remove the plug-in circuit boards as follows:

a. Remove the instrument covers as described in paragraph 5-10.

b. Grasp the circuit board extractors, pull up, and slide the circuit board up and out of the instrument.

c. To replace the circuit board reverse the removal procedure.

TABLE 5-1. RECOMMENDED TEST EQUIPMENT.

INSTRUMENT	CRITICAL SPECIFICATIONS	USAGE		MODEL
		PERFORMANCE EVALUUATION	ADJUSTMENT	
AC/DC Calibrator	**Frequency Range:** 10 Hz to 200 kHz **Level Range:** 1mV to 300 V **Flatness:** + - 0.3 %; 10 - 30 Hz + - 0.25 %; 30 Hz - 200 kHz **AC Accuracy:** + - 0.1 %; 50 Hz - 50 kHz **DC Accuracy:** + - 0.05 %	X	X	**Fluke Model 5100B-03**
Frequency Counter	**Frequency Range:** 10 Hz to 200 kHz **Accuracy:** 0.1 ppm	X		**HP Model 5345A**
Distortion Analyzer	**Frequency Range:** 10 Hz to 140 kHz **Level Range:** 10 mV to 16 V **Residual Distortion:** .01 %; 10 Hz to 20 kHz .02 %; 20 KHz to 50 kHz .056 %; 50 kHz to 100 kHz .1 %; 100 kHz to 140 kHz	X		**BEC Model 1130 or 1120**
Digital Multimeter	**AC Accuracy:** + -1.0 % **Resolution:** 1 uV; 0 to 200 mV 10 uV; 200 to 2000 mV 100 uV; 2.0 to 20.0 V		X	**Fluke Model 8840A-09**
Frequency Standard	**Frequency:** 10 MHz **Level:** TTL compatible **Accuracy:** 0.1 ppm		X	**House Standard**
Variac/Line Monitor	**20 % variation about 100, 120 or 240 volts**		X	**Powerstat Model 3PN116B**
Balanced Cable	**Two conductor shielded balanced line**	X	X	**BEC 954021**
Adapters (4 req.)	**Single binding post to BNC (M)**	X	X	**BEC 954018**
50 ohm resistor **150 ohm resistor** **600 ohm resistor**	**50 ohms, + - 0.1 %, 2 watt, T2** **150 ohms, + - 0.1 %, 1 watt, T2** **600 ohms, + - 0.1 %, 1 watt, T2**	X X X		**KDI PME 75** **Dale CMF 70** **Dale CMF 70**

5-13. Firmware Integrated Circuit. Remove the EPROM as follows:

a. Remove the instrument top cover as described in paragraph 5-10.

b. Remove the CPU board (green extractors). Refer to paragraph 5-12. Place the board on a flat, non-conductive working surface with the components up.

CAUTION

When removing and replacing an integrated circuit (IC) note the mark or notch used for pin number identification.

c. Locate EPROM A6U14. Remove the IC with a straight pull away from the board.

d. Install the replacement IC and replace the circuit board.

WARNING

There are voltages at various points in the instrument which can, if contacted, cause personal injury. Observe all safety precautions. Service and adjustments should be performed by trained service personnel only.

e. Connect power to the instrument and set the LINE ON/OFF switch to ON.

f. Depress the LCL/INIT key to initialize the instrument. The new firmware number will appear in the FREQUENCY display for a few seconds before the instrument resumes normal operation.

g. Set the LINE ON/OFF switch to OFF, disconnect all power to the instrument and replace the instrument top cover.

5-14. Component Removal. Most components are readily accessible for inspection and replacement when the instrument covers are removed. Solid-state circuit components, mounted on plug-in circuit boards, are used throughout the instrument. Standard printed circuit board maintenance techniques are required for removal and replacement of parts. Excessive heat must be avoided; a low wattage soldering iron and suitable heat sinks should be used for all soldering and unsoldering operations.

5-15. INSPECTION.

5-16. If an equipment malfunction occurs, perform a visual inspection of the instrument. Inspect for signs of damage caused by excessive shock, vibration, or overheating, such as broken wires, loose hardware and parts, loose electrical connections, or accumulations of dirt and other foreign matter. Correct any problems discovered, then perform the performance tests to verify that the instrument is operational. If a malfunction persists or the instrument fails any of the performance tests, refer to the adjustment procedure. After the instrument has been adjusted, perform the performance tests again to verify instrument operation.

5-17. PERFORMANCE TESTS.

5-18. The performance tests should be performed about every 12 months or after the instrument has been repaired. The performance tests may also be performed when the instrument is first received to verify instrument performance.

5-19. Frequency Accuracy. Depress the LCL/INIT key on the Model 1110 to initialize the instrument. Connect the SYNC output on the rear panel of the oscillator to the Frequency Counter CHANNEL A input and set the Frequency Counter controls as follows:

FUNCTION	**FREQ A**
GATE TIME	**10 Sec**
DISPLAY POSITION	**AUTO**
LEVEL	**PRESET**
SLOPE	**+**
ATTEN	**1 MEG, X1**
AC/DC	**AC**
CHECK/COM/SEP	**SEP**

5-20. For each test frequency listed in table 5-2 set the Model 1110 to the test frequency, verify the frequency accuracy and record the result, pass or fail, in Table 5-2.

5-21. Output Impedance Accuracy. Depress the LCL/INIT key on the Model 1110 to initialize the instrument. Connect the HI and LOW outputs using the balanced cable and adapters to the Analyzer HI and LOW inputs. Perform the following procedure.

a. On the Model 1110 enter a level of 3.000 Volts and depress the AF ON key.

b. Enable the Analyzer ratio mode.

c. Connect the 600 ohm load across the binding post adapters at the input of the Analyzer.

d. Note the display and calculate the output impedance using the following formula and record Z_{OUT} in Table 5-3.

$$Z_{OUT} = \left(\frac{100.6\ \%}{\text{DISP}\ \%} - 1 \right) 596.4$$

e. Disable the ratio mode and remove the 600 ohm load.

f. Depress the 150 OHMS key on the Model 1110 .

g. Enable the Analyzer ratio mode.

h. Connect the 150 ohm load across the binding post adapters at the input of the Analyzer.

i. Note the display and calculate the output impedance using the following formula and record Z_{OUT} in Table 5-3.

$$Z_{OUT} = \left(\frac{100.15\ \%}{\text{DISP}\ \%} - 1\right) 149.8$$

j. Disable the ratio mode and remove the 150 ohm load.

k. Depress the 50 OHMS key on the Model 1110.

l. Enable the Analyzer ratio mode.

m. Connect the 50 ohm load across the binding post adapters at the input of the Analyzer.

n. Note the display and calculate the output impedance using the following formula and record Z_{OUT} in Table 5-3.

$$Z_{OUT} = \left(\frac{100.05\ \%}{\text{DISP}\ \%} - 1\right) 49.98$$

o. Disable the ratio mode and remove the 50 ohm load.

5-22. Level Accuracy. In this test the Analyzer level reference is set using the precision calibrator. The accuracy of the Model 1110 is then measured at the same test levels and compared to the measurements using the calibrator thereby eliminating the Analyzer measurement errors.

5-23. Depress the LCL/INIT keys on the Audio Analyzer and the Model 1110 to initialize the instruments. Depress the AF ON and 50 OHMS keys and enable the Analyzer floating mode. Perform the following procedure for each test level listed in Table 5-4.

a. Connect the AC Calibrator to the Analyzer HI and LOW inputs using the balanced cable and adapters.

b. On the Audio Analyzer enter the Model 5100B level in the ANALYZER display window to set and hold the input level range.

c. On the AC Calibrator enter the Model 5100B level at a frequency of 1 kHz.

d. After the Analyzer display settles enable the ratio mode to set the calibrator level reference.

e. Connect the Model 1110 HI and LOW outputs to the Analyzer HI and LOW inputs using the balanced cable and adapters.

f. Enter the Model 1110 test level at a frequency of 1 kHz and record the measurment in the ACTUAL column in Table 5-4.

5-24. AC Level Flatness. The level flatness test is made using the Analyzer ratio mode where a level reference is set at a frequency of 1 kHz and at a specific test level. The frequency is then varied and the resultant relative amplitude errors are measured. In this test the Analyzer flatness is first verified using the precision AC calibrator and recorded. The Model 1110 flatness is then measured at the same test levels and compared to the measurements using the calibrator thereby eliminating the Analyzer measurement errors.

5-25. Depress the LCL/INIT key on the Audio Analyzer to initialize the instrument and enter special function 17 to enable the slow detector mode. Connect the Wideband Calibrator output using the balanced cable and adapters to the Analyzer HI and LOW inputs and connect the 50 ohm load accross the binding post adapters at the Analyzer input. Perform the following procedure for each test level listed in Table 5-5.

a. On the Calibrator enable the wideband source output and enter the Model 5100B test level at a frequency of 1 kHz.

b. On the Audio Analyzer enter the calibrator level in the ANALYZER display window to set and hold the input level range.

c. Enable the Analyzer level ratio mode to set the flatness reference.

d. On the Calibrator enter the test frequencies between 10 Hz and 100 kHz indicated in Table 5-5 and record the Analyzer ratio measurements in the REFERENCE column.

5-26. Depress the LCL/INIT keys on the Audio Analyzer and the Model 1110 to initialize the instruments. Connect the HI and LOW outputs using the balanced cable and adapters to the Analyzer HI and LOW inputs. Depress the AF ON and 50 OHMS keys. Enable the Analyzer floating mode and connect the 50 ohm load across the binding post adapters at the Analyzer input. Perform the following procedure for each test level listed in Table 5-5.

a. On the Model 1110 enter the test level at a frequency of 1 kHz. Before entering the 6.0 mV down-scale test level,

the 300 mV range must be held by entering special function 18 while the 300 mV level is set.

b. On the Audio Analyzer enter the Model 5100B test level in the ANALYZER display window to set and hold the input level range.

c. Enable the Analyzer level ratio mode to set the flatness reference.

d. On the Model 1110 enter the test frequencies indicated in Table 5-5.

e. Note the display and calculate the actual flatness by subtracting the value in the REFERENCE column in Table 5-5 from the displayed measurment and record the result in the ACTUAL column. At the 150 kHz test frequency subtract the 100 kHz value in the REFERENCE column from the displayed measuremnt and record the result.

5-27. Residual Distortion and Noise. Depress the LCL/INIT keys on the Audio Analyzer and the Model 1110 to initialize the instruments. Connect the HI and LOW outputs using the balanced cable and adapters to the Analyzer HI and LOW inputs. Depress the AF ON and 50 OHMS keys. Enable the Analyzer floating mode and connect the 50 ohm load across the binding post adapters at the Analyzer input. Perform the following procedure for each test level listed in Table 5-6.

a. Enter the Model 1110 test level and frequency listed in Table 5-6.

b. Enable the low-pass filter on the Audio Analyzer specified in the BW column.

c. Record the results, pass or fail, in Table 5-6.

TABLE 5-2. FREQUENCY ACCURACY TEST RECORD.

AUDIO OSCILLATOR	FREQUENCY ACCURACY		
FREQUENCY	MINIMUM	PASS/FAIL	MAXIMUM
190.000 Hz	189.997 Hz	PASS FAIL	190.003 Hz
1900.00 Hz	1899.97 Hz	PASS FAIL	1900.03 Hz
19000.0 Hz	18999.7 Hz	PASS FAIL	19000.3 Hz
150000 Hz	149997 Hz	PASS FAIL	150003 Hz

TABLE 5-3. SOURCE IMPEDNCE ACCURACY TEST RECORD.

IMPEDANCE	TOLERANCE	ZOUT
50 ohms	+- 1.0 ohm	_____
150 ohms	+- 1.5 ohms	_____
600 ohms	+- 6.0 ohms	_____

TABLE 5-4. AC LEVEL ACCURACY TEST RECORD.

TEST LEVEL		ANALYZER AC LEVEL MEASUREMENT		
Model 5100B	Model 1110	MINIMUM	ACTUAL	MAXIMUM
1.200 mV	0.600 mV	46.95	_____	52.95
3.000 mV	3.000 mV	98.95	_____	100.95
30.00 mV	30.00 mV	99.45	_____	100.45
300.0 mV	300.0 mV	99.45	_____	100.45
3.000 V	3.000 V	99.45	_____	100.45
16.000 V	16.000 V	99.45	_____	100.45

TABLE 5-5. AC LEVEL FLATNESS TEST RECORD.

TEST SETTINGS			ANALYZER AC RATIO MEASUREMENT			
Model 5100B	Model 1110	FREQUENCY	REFERENCE	MINIMUM	ACTUAL	MAXIMUM
1.5 V	3.0 V	10 Hz	_____	-0.50	_____	+0.50
1.5 V	3.0 V	50 kHz	_____	-0.50	_____	+0.50
1.5 V	3.0 V	100 kHz	_____	-1.00	_____	+1.00
	3.0 V	150 kHz		-1.50	_____	+1.50
15 mV	30 mV	50 kHz	_____	-0.50	_____	+0.50
15 mV	30 mV	100 kHz	_____	-1.00	_____	+1.00
	30 mV	150 kHz		-1.50	_____	+1.50
150 mV	300 mV	50 kHz	_____	-0.50	_____	+0.50
150 mV	300 mV	100 kHz	_____	-1.00	_____	+1.00
	300 mV	150 kHz		-1.50	_____	+1.50
3.0 mV	6.0 mV	50 kHz	_____	-0.50	_____	+0.50
3.0 mV	6.0 mV	100 kHz	_____	-1.00	_____	+1.00
	6.0 mV	150 kHz		-1.50	_____	+1.50

TABLE 5-6. RESIDUAL DISTORTION AND NOISE TEST RECORD.

AUDIO OSCILLATOR		DISTORTION MEASUREMENT		
LEVEL	FREQUENCY	BW	PASS/FAIL	MAXIMUM
16.000 V	10 Hz	80 kHz	PASS FAIL	-80.00 dB
16.000 V	20 Hz	80 kHz	PASS FAIL	-80.00 dB
16.000 V	100 Hz	80 kHz	PASS FAIL	-80.00 dB
16.000 V	1000 Hz	80 kHz	PASS FAIL	-80.00 dB
16.000 V	10000 Hz	80 kHz	PASS FAIL	-80.00 dB
16.000 V	20000 Hz	80 kHz	PASS FAIL	-80.00 dB
16.000 V	50000 Hz	220 kHz	PASS FAIL	-74.00 dB
16.000 V	100000 Hz	500 kHz	PASS FAIL	-65.00 dB
16.000 V	140000 Hz	500 kHz	PASS FAIL	-60.00 dB
200.0 mV	10 Hz	80 kHz	PASS FAIL	-80.00 dB
200.0 mV	20 Hz	80 kHz	PASS FAIL	-80.00 dB
200.0 mV	100 Hz	80 kHz	PASS FAIL	-80.00 dB
200.0 mV	1000 Hz	80 kHz	PASS FAIL	-80.00 dB
200.0 mV	10000 Hz	80 kHz	PASS FAIL	-80.00 dB
200.0 mV	20000 Hz	80 kHz	PASS FAIL	-80.00 dB
200.0 mV	50000 Hz	220 kHz	PASS FAIL	-74.00 dB
178.6 mV	100000 Hz	500 kHz	PASS FAIL	-65.00 dB
100.0 mV	140000 Hz	500 kHz	PASS FAIL	-60.00 dB

5-28. ADJUSTMENTS.

5-29. The Model 1110 adjustments are listed in Table 5-7. Test equipment required for the adjustments is listed in Table 5-1.

5-30. A11 Power Supply Adjustment.

5-31. The power supply has only one adjustment which is the power supply Power Fail adjustment. The Power Fail adjustment sets the low line trip level that interrupts the processor operation until the proper AC voltage is applied.

5-32. A11R4 Power Fail Adjustment. Perform the adjustment as follows:

a. Disconnect all power to the Model 1110 and remove the top cover.

b. Set the rear panel line voltage switch to the appropriate voltage.

c. Verify that the line fuse is the proper value as listed on the LINE VOLTAGE SELECT chart located on the rear panel.

d. Connect the variac to an appropriate power source and adjust for a line indication of nominal - 10 % (90, 108, 200 or 216 volts).

WARNING

There are voltages at various points in the instrument which can, if contacted, cause personal injury. Observe all safety precautions.

e. Connect the Model 1110 power cord to the variac and set the LINE ON/OFF switch to ON.

f. Observe the display and adjust A11R4 clockwise until the display just blanks, then slowly counterclockwise until the display returns.

5-33. A5 C.P.U. Adjustment.

5-34. The only adjustment on the C.P.U. Board is the Timebase Frequency adjustment which is adjusted to provide the specific frequency accuracy for the system time standard.

5-35. A5Y1 Timebase Frequency Adjustment. Perform the procedure as follows:

a. Remove the IEEE-488 interface cable on the C.P.U. Board.

b. Remove the cover screw in the top of A5Y1 to expose the trimmer adjustment.

c. Connect the House Standard frequency reference to the rear panel X CLK input.

d. Set the Option switches A4S1-7 and A4S1-8 to the open position and depress the LCL/INIT key.

e. Observe the Audio Oscillator display and adjust A5Y1 until the display indicates 10000.00 kHz +- 1 count.

f. Set the Option switches A4S1-7 and A4S1-8 to the closed position, replace the cover screw and cable.

TABLE 5-7. LIST OF ADJUSTMENTS.

ADJUSTMENT		LOCATION
A11R6	Power Fail	Power Supply Board
A5Y1	Timebase Frequency	C. P. U. Board
A6R23	Oscillator Level	Source Board
A7R21	Attenuator Bit 2	Output Board
A7R17	Attenuator Bit 1	Output Board
A7R15	Attenuator Bit 0	Output Board

5-36. A7 Output Board Adjustments.

The Output Board adjustments consist of three attenuator adjustments which trim the most significant bits of the programmable attenuator for optimum level accuracy.

5-37. A7R21, A7R17, and A7R15 Adjustments.

Perform the adjustments as follows:

a. Depress the LCL/INIT key on the MOdel 1110 to initialize the instrument. Connect the Model 1110 output HI and LOW to the Multimeter input HI and LOW using the balanced cable and adapters and depress the AF ON and 50 OHMS keys.

b. Set the Multimeter to measure AC level.

c. Set the level (open circuit) to 511 mV.

d. Observe the Multimeter display.

e. Set the level to 512 mV and adjust A7R21 for an increase of 1 mV +- 0.3 mV above the measurement in step d above.

f. Set the level to 1023 mV.

g. Observe the Multimeter display.

h. Set the level to 1024 mV and adjust A7R17 for an increase of 1 mV +- 0.5 mV above the measurement in step g above.

i. Set the level to 2047 mV.

j. Observe the Multimeter display.

k. Set the level to 2048 mV and adjust A7R15 for an increase of 1 mV +- 0.5 mV above the measurement in step j above.

5-38. A6 Source Board Adjustments.

The only adjustment on the Source Board is the Output Level adjustment which sets the full scale output level of the Model 1110.

5-39. A6R2 Output Level Adjustment.

Perform the adjustments as follows:

a. Connect the Calibrator output to the Multimeter input using the balanced cable and adapters and set the Multimeter to measure AC level.

b. Set the Calibrator to 1.000 kHz and 3.000 volts and enable the Calibrator output.

c. After the Multimeter measurement settles, depress the OFFSET key to enable the level ratio mode.

d. Disconnect the Calibrator and connect the Model 1110 output HI and LOW to the Multimeter input using the balanced cable and adapters.

e. Set the Model 1110 level to 3.000 volts at a frequency of 1 kHz and depress the AF ON and 50 OHMS keys.

f. Note the Multimenter display and adjust A6R23 for a Multimeter level ratio display of 0.00 +- 1.0 mV.

5-40. TROUBLESHOOTING. Instrument malfunction will generally be evident from front panel indications, or IEEE-488 bus responses. The problems will fall into two general categories: catastrophic failures or selective failure of one subsystem.

5-41. Catastrophic failures would generally cause the Model 1110 to be completely inoperative. For instance, if the microprocessor was not operating properly, the display would contain meaningless symbols and the keyboard would not be responsive. Such failures are usually located in the power supply circuits, interconnecting cables, and the CPU plug-in board.

5-42. Selective failures and performance out of specification are usually limited to one section of the instrument and will be evident from manipulation of the front panel controls. For example, incorrect or erratic amplitude over the entire level range of the Model 1110 will indicate a fault in the ALC circuits on the Source plug-in board. However, if the error is limited to one specific amplitude range, the fault may be found in the level ranging circuits on the Output plug-in board. Further isolation of the problem requires an understanding of the simplified block diagrams detailed in the theory of operation section of this manual and experience in troubleshooting analog and digital circuits.

5-43. TROUBLE LOCALIZATION.

5-44. Special Diagnostic Function Codes. Special function codes 30 and 31 are provided to localize selective failures in the analog and frequency counter circuits. When entered, these codes continuously execute the designated test sequence until the LCL/INIT key is depressed.

5-45. During the initialization sequence and execution of the counter test, error codes are reported if a fault is encountered. Table 5-7 lists the ranges, error codes and probable causes to aid in localizing a fault.

5-46. DAC Test Code. Contained in the Model 1110 are two digital-to-analog converters (DAC) which can be configured to generate a low frequency ramp waveform using special function 30. A coarse stepped ramp waveform is usually an indication of missing data bits in the DAC circuits. The display will indicate the "dac tst" message when the test is active.

5-47. The first 12 bit DAC, A7U1, is used to fine tune the oscillator frequency and is located on the Output plug-in board. The ramp can be found at A7U2 pin 7 (TP3) and will have a peak to peak amplitude of 20 volts from -6 to +14 volts.

5-48. The remaining 12 bit DAC is used to generate the rear panel X AXIS output. The ramp from this DAC can be found at the rear panel recorder output connector and will have a peak amplitude extending form 0 to +5 volts. The PEN output is toggled between 0 an +5 volts at the ramp frequency to provide an external sync signal.

5-49. Counter Plug-In Board Test Code. The period counter can be tested using special function 31. In this test sequence the counter is configured to measure the timebase reference. The reference is divided in decade increments from 1 to 10,000 by the period ranging circuits. Each of the five frequency ranges is sequentially checked for accuracy while the LEVEL display indicates the range being tested. The FREQUENCY display will indicate an error code if a fault is evident on the tested range.

TABLE 5-8. DIAGNOSTIC ERROR CODE DESCRIPTIONS.

FAULT	DESCRIPTION	PROBABLE CAUSE
Error 30	10 - 125 Hz freq. lock	A6Q5, A6Q17, A6U13
Error 31	125 - 1250 Hz freq. lock	A6Q4, A6Q16, A6U13
Error 32	1.25 - 7.5 kHz freq. lock	A6Q3, A6Q15, A6U13
Error 33	7.5 - 55 kHz freq. lock	A6Q2, A6Q14, A6U13
Error 34	55 - 150 kHz freq. lock	A6Q2-Q5, A6Q14-Q17, A6U13
All 30-34	10 Hz - 140 kHz freq. lock	A6Q18-25, A6Q6-13, A6U1, A6U7, A6U8, A6U13-17, A7U1-U3
Error 50	199.999 Hz range	A4U5, A4U9, A4U13
Error 51	1.99999 kHz range	A4U6, A4U9, A4U13
Error 52	19.9999 kHz range	A4U6, A4U9, A4U13
Error 53	199.999 kHz range	A4U7, A4U9, A4U13
Error 54	1999.99 kHz range	A4U7, A4U9, A4U13
All 50-54	Counter accumulator	A4U5, A4U9, A4U10, A4U3, A4U12-16, A5Y1

SECTION VI
PARTS LIST

6-1. INTRODUCTION.

6-2. The replaceable parts for the Model 1110 are listed in Table 6-2. The replaceable parts list contains the reference symbol, description, manufacturer, and both the BEC and manufacturer part numbers. Table 6-1 lists the manufacturer's federal supply code numbers.

TABLE 6-1. MANUFACTURER'S FEDERAL SUPPLY CODE NUMBERS.

01121	Allen Bradley
01295	Texas Instruments
02114	Ferroxcube Corp.
02735	RCA Solid State Division
03888	Pyrofilm (KDI)
04222	AVX Ceramics Company
04713	Motorola Semiconductor
04901	Boonton Electronics Corporation
06383	Panduit Corporation
06665	Precision Monolithics
06776	Robinson Nugent, Inc.
07263	Fairchild Semiconductor
11961	Semicon
13812	Dialco Division of Amperex
14655	Cornell-Dubilier
14752	Electro Cube, Inc.
17856	Siliconix, Inc.
18324	Signetics Corporation
19505	Applied Eng'r. Products
19701	Mepco Electra
20307	Arco - Micronics
24226	Gowanda Electronics
27014	National Semiconductor
27264	Molex, Inc.
27735	F-Dyne Electronics
27802	Vectron Labs
28480	Hewlett-Packard Corporation
31313	Components Corporation
31781	EDAC
31918	ITT Schadow, Inc.
32293	Intersil, Inc.
32575	AMP
33297	NEC
33883	RMC
34335	Advanced Micro Devices
34371	Harris Semiconductor
49956	Raytheon Corporation
51406	Murata Corporation of America
51640	Analog Devices, Inc.
54420	Dage - MTI
54426	Buss Fuses
54473	Panasonic
56289	Sprague Electric Company
56708	Zilog, Inc.
57582	Kahgan Electronics Corporation
61637	Kemet - Union Carbide
64537	Pyrofilm (KDI)
71450	CTS Corporation
73138	Beckman Instruments, Helipot Division
74970	E. F. Johnson
75915	Littlefuse
81073	Grayhill
82389	Switchcraft
91637	Dale Electronics
S4217	United Chemicon, Inc.

TABLE 6-2. REPLACEABLE PARTS LIST.

11100201A `1110' FRAME ASSEMBLY
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A4	PWA `1120' FREQUENCY COUNTER	04901	11201900A	1	11201900A
A5	PWA `1120' CPU	04901	11202000A	1	11202000A
A6	PWA `1120' SOURCE	04901	11202100A	1	11202100A
A7	PWA `1120' OUTPUT	04901	11202200B	1	11202200B
A8	PWA `8200' EXTENDER	04901	08252300A	1	08252300A
A11	PWA `1110' POWER SUPPLY	04901	11102800A	1	11102800A
A17	`1110' FRONT PANEL ASSY	04901	11200402A	1	11200402A
A18	`1110' CARD CAGE ASSEMBLY	04901	11201201A	1	11201201A
A21	`1110' REAR PANEL ASSY			1	11104100A
W14	CABLE ASSY WIRE 22GA 3C 7.00L	04901	57124200A	1	57124200A
W16	CABLE ASSY WIRE 22GA 5C 6.50L	04901	57121901A	1	57121901A
W21	CABLE ASSY FLAT 26CKT 14.75L	04901	92016100A	1	92016100A
W46	CABLE ASSY COAX RG316/U 9.875L	04901	57224800A	1	57224800A
W47	CABLE ASSY WIRE 22GA 5C 9.00L	04901	57124000A	1	57124000A
W48	CABLE ASSY WIRE 22GA 5C 8.00L	04901	57124100A	1	57124100A

11200402A `1110' FRONT PANEL ASSY
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A13	PWA `1110' KEYBOARD	04901	11201001A	1	11201001A
A23	`1110' SUB PANEL ASSY	04901	11200502A	1	11200502A

11200502A `1110' SUB PANEL ASSY
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A12	PWA `1120' DISPLAY	04901	11200900A	1	11200900A
A14	POWER SWITCH ASSEMBLY	04901	1120601A	1	11200601A
A16	BRACKET CONN ASSY (OUTPUT)	04901	11104600A	1	11104600A

11200601A POWER SWITCH ASSEMBLY
MODEL: 1120-S/I

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
S1	SWITCH ROCKER DPDT	13812	572-2121-0103-010	1	465286000
W17/W22	CABLE ASSY WIRE 22/24GA 2/4C L	04901	57124600A	1	57124600A

11104600A BRACKET CONN ASSY (OUTPUT)
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
J4	CONNECTOR BINDING POST GROUND	74970	111-2223-001	1	47945400A
J5-6	CONN COAX BNC	54420	UG-625B/U	2	479123000
L1	INDUCTOR 5.6uH 10%	24226	15/561	1	400308000
W30	CABLE ASSY COAX RG316/U 8.00L	04901	57224701A	1	57224701A

11201201A `1110' CARD CAGE ASSEMBLY
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A10	PWA `1110' MOTHER	04901	11102600A	1	11102600A

11104100A `1110' REAR PANEL ASSY
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A19	REAR PANEL UNIT	04901	60339900A	1	60339900A
A20	`1110' HEAT SINK ASSY	04901	11100400A	1	11100400A
A24	PWA `1110' POWER AMPLIFIER	04901	11103400A	1	11103400A
F1	FUSE 0.75 AMP 250V MDL SLO BLO	54426	MDL-3/4	1	545533000
FL1	FILTER LINE	56289	3JX5421A	1	439004000
J8-10	CONN COAX BNC	54420	UG-625B/U	3	479123000
J12	CONN COAX BNC	54420	UG-625B/U	1	479123000
T1	TRANSFORMER POWER	04901	44609600A	1	44609600A
T2	TRANSFORMER ASSY	04901	11104500A	1	11104500A
W8	CABLE ASSY COAX RG316/U 22.00L	04901	57223613A	1	57223613A
W9	CABLE ASSY COAX RG316/U 23.00L	04901	57223614A	1	57223614A
W15	CABLE ASSY WIRE 22GA 3C 10.50L	04901	57121705A	1	57121705A
W20	CABLE ASSY, FLAT (GPIB)	04901	57223002A	1	57223002A
W25	CABLE ASSY WIRE 22GA 2C 26.50L	04901	57124301A	1	57124301A
W38-39	CABLE ASSY WIRE 20GA 1C 10.50L	04901	57121801A	2	57121801A
W43	CABLE ASSY WIRE 24GA 4C 24/27L	04901	57123900A	1	57123900A

11104500A TRANSFORMER ASSY
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
P20	CONNECTOR 3 CIRCUIT	06383	CE156-22-3-C	1	479406000
P21	CONNECTOR 2 PIN	06383	CE156F22-2-C or D	1	479405000
T2	TRANSFORMER POWER	04901	44609100A	1	44609100A

11100400A `1110' HEAT SINK ASSY
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1	CAP TANT 1.0uF 10% 35V ONLY	56289	196D105X9035HA1	1	283216000
C20	CAP CER 0.01uF 20% 500V	33883	BGP 25U W/FDCL	1	224271000
C33	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
CR1	DIODE BRIDGE SDA-980-1	11961	SDA-980-1	1	532030000
U4	IC 323K REGULATOR	27014	LM323K	1	535024000
U5	IC UA7805UC VOLT REG	07263	uA7805UC	1	53511700A
U6	IC UA79M05AUC VOLT REG	07263	uA79M05AUC	1	535093000
U7-8	IC UA7805UC VOLT REG	07263	uA7805UC	2	53511700A
U10	IC UA79M05AUC VOLT REG	07263	uA79M05AUC	1	535093000
W18	CABLE ASSY WIRE 22GA 3C 8.00L	04901	57121704A	1	57121704A
XU4	SOCKET TRANSISTOR PWR TO-3	06776	MP-3452G	1	47308000A

11201901A PWA '1110' FREQUENCY COUNTER
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C2	CAP EL 100uF 20% 25V	54217	SM-25-VB-100-M	1	283334000
C3-9	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	7	224268000
C10-12	CAP EL 100uF 20% 25V	54217	SM-25-VB-100-M	3	283334000
C13	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C14	CAP MPC 0.0022uF 2% 50V	14752	653A-1-A222G	1	234165000
C15	CAP CER 3900pF 10% 100V	61637	C052K392K1X5CA	1	224319000
C16	CAP CER 560pF 10% 200V	61637	C052K561K2X5CA	1	224290000
C17	CAP TANT 4.7uF 10% 10V	56289	196D475X9010HA1	1	283226000
C18-22	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	5	224268000
C23	CAP EL 100uF 20% 25V	54217	SM-25-VB-100-M	1	283334000
C24	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C25	CAP MICA 250pF 5% 50V	57582	KD251J101	1	205037000
C26-27	CAP TANT 2.2uF 20% 35V	61637	T368B225M035ASC2513	2	283317000
CR1-9	DIODE SIG 1N914	01295	1N914	9	530058000
CR10-11	DIODE SIG FDH-300	07263	FDH300	2	530052000
CR12-13	DIODE SIG 1N914	01295	1N914	2	530058000
CR14	DIODE ZENER 1N5231B 5.1V 5%	04713	1N5231BSZ	1	530169000
DS1	LED RED DIFF 5082-4684	28480	HLMP-1301	1	536024000
DS2-5	LED RED DIFF HLMP-6620	28480	HLMP-6620	4	536026000
L1	INDUCTOR VK200/19-4B	02114	VK200/19-4B	1	400410000
L2-3	INDUCTOR 5.6uH 10%	24226	15/561	2	400308000
Q1	TRANS PNP 2N3906	04713	2N3906	1	528076000
R1	RES MF 215 OHM 1% 1/4W	19701	5043ED215R0F	1	341232000
R2	RES MF 332 OHM 1% 1/4W	19701	5043ED332R0F	1	341250000
R3	RES MF 499 OHM 1% 1/4W	19701	5043ED499R0F	1	341267000
R4	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R5	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R6-7	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	2	341400000
R8-10	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	3	341300000
R11-12	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	2	341400000
R13	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R14	RES NETWORK 3K/6.2K 2% 2.7W	73138	785-5-R3K/6.2K	1	345031000
R15-19	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	5	341367000
R20-21	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	2	341346000
R22-23	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	2	341300000
R24	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R25-26	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	2	341300000
R27	RES MF 56.2K 1% 1/4W	19701	5043ED56K20F	1	341472000
R28	RES MF 5.000K 0.1% 1/8W	64537	PME55-T2	1	324326000
R30	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R31	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R32	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
S1	SWITCH ROCKER (8 SW)	81073	76SB08S	1	465283000
TP1-12	TERMINAL WIRE LOOP TEST POINT	31313	TP-103-02	12	48330600A
U1	IC 393 OP AMP	27014	LM393N	1	535107000
U2	IC 74LS04 HEX INVERTER	01295	SN74LS04N	1	534155000
U3-4	IC 74LS00 2 INP POS NAND	01295	SN74LS00N	2	534167000
U5	IC 74F151PC	07263	74F151PC	1	534374000
U6-8	IC 74LS490 DUAL DEC COUNTER	18324	N74LS490N	3	534238000
U9	IC 74F151PC	07263	74F151PC	1	534374000
U10	IC 74F74PC DUAL D FLIP FLOP	07263	74F74PC	1	534367000
U11	IC 74LS138 DECDR/MPX	01295	SN74LS138N	1	534246000
U12	IC 74F74PC DUAL D FLIP FLOP	07263	74F74PC	1	534367000
U13-14	IC 8255APC PERIPH INTERFACE	34335	AM8255APC	2	534171000
U15-16	IC 4040B COUNTER/DIVIDER	02735	CD4040BE	2	534275000
U18	IC 5532A DUAL OP AMP 8 DIP	01295	NE5532AP	1	53512100A
U19	IC AD7549JN DUAL 12 BIT DAC	24355	AD7549JN	1	53512700A

1120190/A PWA `1110/20/30'FRQ CTR
MODEL: 1110,20,30

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
XS1	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU1	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU2-4	SOCKET IC 14 PIN	06776	ICN-143-S3-G	3	473019000
XU5-9	SOCKET IC 16 PIN	06776	ICN-163-S3-G	5	473042000
XU10	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU11	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU12	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU13-14	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	2	473052000
XU15-16	SOCKET IC 16 PIN	06776	ICN-163-S3-G	2	473042000
XU17-18	SOCKET IC 8 PIN	06776	ICN-083-S3-G	2	473041000
XU19	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000
XU20	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU21	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000

11202001A PWA `1110' CPU
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
B1	CELL LITHIUM 3V	54473	BR2325-1HB	1	556007000
C1-6	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	6	224268000
C7	CAP TANT 15uF 10% 20V	56289	199D156X9020DA1	1	283227000
C8-9	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	2	224268000
C10	CAP TANT 15uF 10% 20V	56289	199D156X9020DA1	1	283227000
C11-15	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	5	224268000
C16	CAP EL 100uF 20% 25V	84217	SM-25-VB-100-M	1	283334000
CR1-3	DIODE SIG 1N914	01295	1N914	3	530058000
J20-21	SOCKET IC 24 PIN	06776	ICN-246-S4-G	2	473043000
L1	INDUCTOR VK200/19-4B	02114	VK200/19-4B	1	400410000
Q1	TRANS NPN 2N3904	04713	2N3904	1	528071000
R1	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R2	RES MF 332 OHM 1% 1/4W	19701	5043ED332R0F	1	341250000
R3	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R4	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R5	RES MF 22.1K 1% 1/4W	19701	RN55D-2212-F	1	341433000
R6	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R7	RES NETWORK 3K/6.2K 2% 1.5W	73138	783-5-R3K/6.2K	1	345033000
R8-9	RES NETWORK 3K/6.2K 2% 2.7W	73138	785-5-R3K/6.2K	2	345031000
U1	IC 74LS04 HEX INVERTER	01295	SN74LS04N	1	534155000
U2	IC 74LS32 QUAD 2 INPUT OR	01295	SN74LS32N	1	534168000
U3-4	IC 8304BN 8 BIT TRI ST TRANS	27014	DP8304BN	2	534251000
U5	IC 4066A CMOS BILAT SW	02735	CD4066AE	1	534078000
U6	IC 4023B COS/MOS NAND	02735	CD4023AE	1	534143000
U7	IC Z80 MICROPRCS 6 MHz CMOS	56708	Z84C00-06PE	1	53440906A
U8-10	IC 74LS541 OCTAL BUFFER	01295	SN74LS541N	3	534381000
U11	IC 5564 8Kx8 RAM CMOS 28 DIP	TOSHIB	TC5564PL-15	1	534403000
U12	IC 74LS32 QUAD 2 INPUT OR	01295	SN74LS32N	1	534168000
U13	IC 74F74PC DUAL D FLIP FLOP	07263	74F74PC	1	534367000
U14	PROM 1110 A5 U14 CPU PWA	04901	53447100A	1	53447100A
U15	IC 74LS138 DECDR/MPX	01295	SN74LS138N	1	534246000
U16	IC 9914ANL IEEE BUS PROCESSOR	01295	TMS9914ANL	1	534288000
U17	IC 75160 IEEE BUS TRANSCEIVER	01295	SN75160BN	1	534286000
U18	IC 75161 IEEE BUS TRANSCEIVER	01295	SN75161BN	1	534287000
XU1-2	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU3-4	SOCKET IC 20 PIN	06776	ICN-203-S3-G	2	473065000
XU5-6	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU7	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU8-10	SOCKET IC 20 PIN	06776	ICN-203-S3-G	3	473065000
XU11	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU12-13	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU14	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU15	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU16	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU17-18	SOCKET IC 20 PIN	06776	ICN-203-S3-G	2	473065000
Y1	OSC CRYSTAL 10 MHz	27802	CO-251-B16	1	547904000

11103000A PWA '1110' SOURCE
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1	CAP CER 1.0uF 20% 50V	04222	SR305E105MAA	1	224264000
C2	CAP MPC 0.22uF 2% 50V	14752	652A-1-A224G	1	234167000
C3-4	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	2	283334000
C5	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C6	CAP CER 0.022uF 10% 50V	61637	C052K223K5X5CA	1	224302000
C7	CAP TANT 4.7uF 10% 10V	56289	196D475X9010HA1	1	283226000
C8	CAP MPC 0.15uF 2% 50V	14752	652A-1-A-154G	1	234145000
C9	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	1	283334000
C10	CAP CER 0.001uF 10% 100V	04222	SR151C102KAA	1	224270000
C11-12	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	2	283334000
C13	CAP MICA 390pF 5% 500V	57582	KD15391J501	1	200108000
C14	CAP MICA 680pF 1% 300V	14655	CD15FC681F03	1	200015000
C15	CAP MICA 8200pF 1% 100V	14655	CD19FA822F	1	200532000
C16	CAP MPC 0.047uF 2% 50V	14752	652A-1-A473G	1	234144000
C17	CAP MPC 0.47uF 1% 50V	27735	MPC-53-0.47-50-1	1	23417500A
C18	CAP MICA 390pF 5% 500V	57582	KD15391J501	1	200108000
C19	CAP MICA 680pF 1% 300V	14655	CD15FC681F03	1	200015000
C20	CAP MICA 8200pF 1% 100V	14655	CD19FA822F	1	200532000
C21	CAP MPC 0.047uF 2% 50V	14752	652A-1-A473G	1	234144000
C22	CAP MPC 0.47uF 1% 50V	27735	MPC-53-0.47-50-1	1	23417500A
C23-25	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	3	224268000
C26	CAP TANT 4.7uF 10% 10V	56289	196D475X9010HA1	1	283226000
C27	CAP CER 0.001uF 10% 100V	04222	SR151C102KAA	1	224270000
C28-29	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	2	224268000
C30	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	1	283334000
C31	CAP MICA 100pF 5% 300V	20307	DM5-FC101J	1	205006000
CR1	DIODE SIG 1N914	01295	1N914	1	530058000
CR2	DIODE ZENER 1N5230B 4.7V 5%	04713	1N5230B	1	530103000
CR3-4	DIODE SIG 1N914	01295	1N914	2	530058000
CR5	DIODE ZENER 1N5242B 12V 5%	04713	1N5242B	1	530146000
CR6-10	DIODE SIG 1N914	01295	1N914	5	530058000
CR11-12	DIODE ZENER 1N5231B 5.1V 5%	04713	1N5231BSZ	2	530169000
CR13-14	DIODE SIG 1N914	01295	1N914	2	530058000
L1-2	INDUCTOR 5.6uH 10%	24226	10/561	2	400408000
L3	INDUCTOR VK200/20-4B	02114	VK-200-20/4B	1	400409000
Q1	TRANS FET PN4391	27014	PN4391	1	52815900A
Q2-25	TRANS FET J108	17856	J-108	24	52815600A
R1	RES MF 1.00M 1% 1/4W	14674	5043ED1M000F	1	341600000
R2	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	1	341367000
R3	RES MF 20.0K 1% 1/4W	19701	5043ED20K00F	1	341429000
R4	RES MF 2.21K 1% 1/4W	19701	5043ED2K210F	1	341333000
R5	RES MF 20.0K 1% 1/4W	19701	5043ED20K00F	1	341429000
R6	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	1	341367000
R7	RES MF 1.82K 1% 1/4W	19701	5043ED1K820F	1	341325000
R8	RES MF 3.32K 1% 1/4W	19701	5043ED3K320F	1	341350000
R9-11	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	3	341367000
R12	RES MF 7.50K 1% 1/4W	19701	5043ED7K500F	1	341384000
R13	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R14	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	1	341367000
R15	RES MF 6.19K 1% 1/4W	19701	5043ED6K190F	1	341376000
R16	RES MF 3.92K 1% 1/4W	19701	5043ED3K920F	1	341357000
R17	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R18	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R19	RES MF 39.2K 1% 1/4W	19701	5043ED39K20F	1	341457000
R20	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R21	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	1	341367000
R22	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R23	RES VAR 1K 10% 0.5W	73138	82PAR1K	1	311370000
R24	RES NETWORK 100K 2% 1.5W	71450	750-61-R100K	1	345032000
R25-26	RES MF 49.9K 1% 1/4W	19701	5043ED49K90F	2	341467000
R27-28	RES MF 80.6K 1% 1/4W	19701	5043ED80K60F	2	341487000
R29	RES NETWORK 100K 2% 1.5W	71450	750-61-R100K	1	345032000

11103000A PWA '1110' SOURCE
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
R30-31	RES MF 49.9K 1% 1/4W	19701	5043ED49K90F	2	341467000
R32-33	RES MF 68.1K 1% 1/4W	19701	5043ED68K10F	2	341480000
R34	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R35	RES MF 49.9K 1% 1/4W	19701	5043ED49K90F	1	341467000
R36	RES MF 4.02K 1% 1/4W	19701	5043ED4K020F	1	341358000
R37-39	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	3	341400000
R40	RES MF 6.19K 1% 1/4W	19701	5043ED6K190F	1	341376000
R41	RES MF 5.000K 0.1% 1/8W	64537	PME55-T2	1	324326000
R42	RES MF 10.00K 0.1% 1/8W	91637	CMF55-1002-B-T2	1	32593100A
R43	RES MF 20.00K 0.1% 1/8W	03888	PME55 TO	1	32591800A
R44	RES MF 40.00K 0.1% 1/8W	03888	PME55 TO	1	32591900A
R45	RES MF 5.000K 0.1% 1/8W	64537	PME55-T2	1	324326000
R46	RES MF 10.00K 0.1% 1/8W	91637	CMF55-1002-B-T2	1	32593100A
R47	RES MF 20.00K 0.1% 1/8W	03888	PME55 TO	1	32591800A
R48	RES MF 40.00K 0.1% 1/8W	03888	PME55 TO	1	32591900A
R49	RES MF 5.000K 0.1% 1/8W	64537	PME55-T2	1	324326000
R50	RES MF 10.00K 0.1% 1/8W	91637	CMF55-1002-B-T2	1	32593100A
R51	RES MF 20.00K 0.1% 1/8W	03888	PME55 TO	1	32591800A
R52	RES MF 40.00K 0.1% 1/8W	03888	PME55 TO	1	32591900A
R53	RES MF 5.000K 0.1% 1/8W	64537	PME55-T2	1	324326000
R54	RES MF 10.00K 0.1% 1/8W	91637	CMF55-1002-B-T2	1	32593100A
R55	RES MF 20.00K 0.1% 1/8W	03888	PME55 TO	1	32591800A
R56	RES MF 40.00K 0.1% 1/8W	03888	PME55 TO	1	32591900A
R57	RES MF 1.82K 1% 1/4W	19701	5043ED1K820F	1	341325000
R58	RES MF 3.32K 1% 1/4W	19701	5043ED3K320F	1	341350000
R59	RES MF 619K 1% 1/4W	19701	RN55D-6193-F	1	341576000
R60	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R61	RES MF 1.50K 1% 1/4W	19701	5043ED1K500F	1	341317000
R62	RES MF 102 OHM 1% 1/4W	19701	5043ED102R0F	1	341201000
R63	RES MF 1.50K 1% 1/4W	19701	5043ED1K500F	1	341317000
R64	RES MF 102 OHM 1% 1/4W	19701	5043ED102R0F	1	341201000
R65	RES NETWORK 3.3K 2% 0.9W 6pin	71450	750-61-R3.3K	1	34504500A
R66	RES NETWORK 3.3K 2% 1.5W 10pin	71450	750-101-R3.3K	1	345030000
R67-68	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	2	341200000
R69	RES MF 10.0 OHM 1% 1/4W	19701	5043ED10R00F	1	341100000
U1	IC HA3-2625-5-M OP AMP	34371	HA3-2625-5	1	53511900A
U2	IC TL072CP DUAL OP AMP	01295	TL072CP	1	535092000
U3	IC OP-07EP OP AMP	06665	OP-07EP	1	535110000
U4	IC HA3-2625-5-M OP AMP	34371	HA3-2625-5	1	53511900A
U5	IC 74123 MONO MULTI	01295	SN74123N	1	534071000
U6	IC 74LS02 2 INPT POS NOR	01295	SN74LS02N	1	534154000
U7	IC REF-02-CZ 5 VOLT REFERENCE	06665	PMI REF-12CZ	1	53512900A
U8	IC SMP-11GY SAMPLE & HOLD AMPL	06665	SMP11GY	1	53444601A
U9	IC HA1-5320-5 SAMPLE AND HOLD	34371	HA1-5320-5	1	53513000A
U10	IC 4200ADE ANALOG MULTIPLIER	49956	RC4200ADE	1	53508301A
U11-12	IC 5532A DUAL OP AMP 8 DIP	01295	NE5532AP	2	53512100A
U13-14	IC 339 QUAD COMPARATOR	27014	LM339N	2	535018000
U15-16	IC 74LS273 OCTAL D FLIPFLOP	01295	SN74LS273N	2	534263000
U17	IC 339 QUAD COMPARATOR	27014	LM339N	1	535018000
U18	IC 4200ADE ANALOG MULTIPLIER	49956	RC4200ADE	1	53508301A
XU1-4	SOCKET IC 8 PIN	06776	ICN-083-S3-G	4	473041000
XU5	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU6	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU7	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU8-9	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU10-12	SOCKET IC 8 PIN	06776	ICN-083-S3-G	3	473041000
XU13-14	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU15-16	SOCKET IC 20 PIN	06776	ICN-203-S3-G	2	473065000
XU17	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU18	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000

11103200A PWA '1110' OUTPUT
MODEL: 1110/20

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1	CAP MICA 5.0pF 10% 300V	14655	CD5CC050D	1	205000000
C3	CAP MICA 18pF 5% 300V	14655	CD5CC180J	1	205046000
C7	CAP MICA 22pF 5% 300V	14655	CD5CC220J	1	205036000
C10-12	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	3	224268000
C18-21	CAP EL 100uF 20% 25V	54217	SM-25-VB-100-M	4	283334000
C22-23	CAP EL 10uF 20% 25V	54217	SM-25-VB-10-M	2	283336000
C24	CAP TANT 10uF 20% 25V	56289	196D106X0025KA1	1	283293000
C25-27	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	3	224268000
C28	CAP MICA 300pF 5% 50V	14655	CD5FY301J	1	205026000
C29-30	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	2	224268000
CR1-2	DIODE SIG 1N914	01295	1N914	2	530058000
J1	HEADER 5 PIN STRAIGHT	06383	MPSS156-5-D	1	477345000
J2	CONNECTOR "SMB"	19505	209	1	477317000
L1-3	INDUCTOR 5.6uH 10%	24226	15/561	3	400308000
Q1	TRANS NPN 2N3904	04713	2N3904	1	528071000
Q2-14	TRANS FET PN4391	27014	PN4391	13	52815900A
R1	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R2	RES MF 15.0K 1% 1/4W	19701	5043ED15K00F	1	341417000
R3	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	1	341367000
R4-6	RES NETWORK 100K 2% 1.5W	71450	750-61-R100K	3	345032000
R7	RES MF 1.82K 1% 1/4W	19701	5043ED1K820F	1	341325000
R8	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R9	RES MF 900 OHM 0.1% 1/8W	64537	PME55-T2	1	324235000
R10	RES MF 9.000K 0.1% 1/4W	64537	PME55-T2	1	324354000
R11	RES MF 10.0 OHM 1% 1/4W	19701	5043ED10R00F	1	341100000
R13	RES MF 5.49K 1% 1/4W	19701	5043ED5K490F	1	341371000
R14	RES MF 33.2K 1% 1/4W	19701	5043ED33K20F	1	341450000
R15	RES VAR 50K 10% 0.5W	73138	82PAR50K	1	311375000
R16	RES MF 11.0K 1% 1/4W	19701	5043ED11K00F	1	341404000
R17	RES VAR 50K 10% 0.5W	73138	82PAR50K	1	311375000
R18	RES MF 95.3K 1% 1/4W	19701	5043ED95K30F	1	341494000
R19	RES MF 24.3K 1% 1/4W	19701	5043ED24K30F	1	341437000
R20	RES MF 90.9K 1% 1/4W	19701	5043ED90K90F	1	341492000
R21	RES VAR 50K 10% 0.5W	73138	82PAR50K	1	311375000
R22	RES MF 40.00K 0.1% 1/8W	03888	PME55 TO	1	32591900A
R23	RES MF 80.00K 0.1% 1/8W	03888	PME55 TO	1	32592000A
R24	RES MF 160.0K 0.1% 1/8W	03888	PME55 TO	1	32592100A
R25	RES MF 320.0K 0.1% 1/8W	03888	PME55 TO	1	32592200A
R26	RES MF 1.50K 1% 1/4W	19701	5043ED1K500F	1	341317000
R27	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R28	RES MF 40.00K 0.1% 1/8W	03888	PME55 TO	1	32591900A
R29	RES MF 80.00K 0.1% 1/8W	03888	PME55 TO	1	32592000A
R30	RES MF 160.0K 0.1% 1/8W	03888	PME55 TO	1	32592100A
R31	RES MF 320.0K 0.1% 1/8W	03888	PME55 TO	1	32592200A
R32	RES MF 649K 1% 1/4W	19701	5043ED649K0F	1	34157800A
R33-34	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	2	341367000
R36	RES MF 100 OHM 0.1% 1/8W	64537	PME55-T2	1	324118000
R37	RES MF 499K 1% 1/4W	19701	5043ED499K0F	1	341567000
R38-44	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	7	341400000
U1	IC AD7548 12 BIT DAC CMOS	51640	AD7548	1	53512000A
U2	IC TL072ACP OPER AMPLIFIER	01295	TL072ACP	1	53507400A
U3	IC REF-01CP VOLTAGE REFERENCE	06665	REF-01CP	1	535116000
U4-5	IC 74LS273 OCTAL D FLIPFLOP	01295	SN74LS273N	2	534263000
U6-9	IC 339 QUAD COMPARATOR	27014	LM339N	4	535010000
U10	IC 5534AN OP AMP	18324	NE553AN	1	535061000
U11	IC 13201N ANALOG SWITCH	27014	LF13201N	1	535106000
U12	IC 74LS139 DECODE/MULTPXR	01295	SN74LS139N	1	534188000
U13	IC 5534AN OP AMP	18324	NE553AN	1	535061000
XU1	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000
XU2-3	SOCKET IC 8 PIN	06776	ICN-083-S3-G	2	473041000
XU4-5	SOCKET IC 20 PIN	06776	ICN-203-S3-G	2	473065000
XU6-9	SOCKET IC 14 PIN	06776	ICN-143-S3-G	4	473019000
XU10	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU11-12	SOCKET IC 16 PIN	06776	ICN-163-S3-G	2	473042000
XU13	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000

11201001A PWA '1110' KEYBOARD
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1-2	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	2	224268000
C3-4	CAP TANT 15uF 10% 20V	56289	199D156X9020DA1	2	283227000
C5	CAP TANT 4.7uF 10% 10V	56289	196D475X9010HA1	1	283226000
C6	CAP CER 0.01uF 10% 100V	04222	SR201C103KAA	1	224269000
J1-2	WIRE,BARE,SOLID 24 AWG	04901	920148240	2	920148240
J33A-33B	CONNECTOR 17 PIN (F)	27264	22-02-2175	1	47945617A
J34	CONNECTOR 20 PIN	27264	22-02-2205	1	479399000
R1-2	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	2	341329000
R3-4	RES MF 100K 1% 1/4W	19701	5043ED100K0F	2	341500000
R5	RES MF 49.9K 1% 1/4W	19701	5043ED49K90F	1	341467000
R6	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	1	341367000
S1	SWITCH PUSH BUTTON W/O LED	31918	200330	1	465294000
S2-3	SWITCH PUSH BUTTON W/LED	31918	200480	2	465293000
S5-9	SWITCH PUSH BUTTON W/O LED	31918	200330	5	465294000
S10-11	SWITCH PUSH BUTTON W/LED	31918	200480	2	465293000
S13-17	SWITCH PUSH BUTTON W/O LED	31918	200330	5	465294000
S18	SWITCH PUSH BUTTON W/LED	31918	200480	1	465293000
S20-24	SWITCH PUSH BUTTON W/O LED	31918	200330	5	465294000
S25	SWITCH PUSH BUTTON W/LED	31918	200480	1	465293000
S27-31	SWITCH PUSH BUTTON W/O LED	31918	200330	5	465294000
S32	SWITCH PUSH BUTTON W/LED	31918	200480	1	465293000
S34-38	SWITCH PUSH BUTTON W/O LED	31918	200330	5	465294000
S40-41	SWITCH PUSH BUTTON W/LED	31918	200480	2	465293000
S43-44	SWITCH PUSH BUTTON W/LED	31918	200480	2	465293000
S46-52	SWITCH PUSH BUTTON W/LED	31918	200480	7	465293000
U1	IC 74123 MONO MULTI	01295	SN74123N	1	534071000
U2	IC 7555 TIMER CMOS 8 DIP	32293	ICM7555IPA	1	53512600A
U3	IC 74LS02 2 INPT POS NOR	01295	SN74LS02N	1	534154000
U4	IC 4066A CMOS BILAT SW	02735	CD4066AE	1	534078000

11200900A PWA `1120' DISPLAY
MODEL: 1120

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1-11	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	11	224260000
C12	CAP EL 100uF 20% 25V	54217	SM-25-VB-100-M	1	283334000
C13-16	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	4	224260000
C17	CAP EL 100uF 20% 25V	54217	SM-25-VB-100-M	1	283334000
DS1-6	DISPLAY NUMERIC 5082-7651	28480	5082-7651	6	536811000
DS7-8	LED LIGHT BAR MOD HLMP-2620	28480	HLMP-2620	2	536027000
DS9-16	DISPLAY NUMERIC 5082-7651	28480	5082-7651	8	536811000
DS17-19	LED LIGHT BAR MOD HLMP-2620	28480	HLMP-2620	3	536027000
DS20-21	DISPLAY NUMERIC 5082-7651	28480	5082-7651	2	536811000
DS22	LED LIGHT BAR MOD HLMP-2620	28480	HLMP-2620	1	536027000
J31	CONNECTOR HEADER 2 PIN RT ANLE	06383	HPAS156-2-C	1	477385000
J32	CONN M 26 CKT RT ANGLE 3 WALL	06776	IDH-26K-SR3-TG30	1	47741326A
P33A-33B	CONNECTOR HEADER 17 PIN	27264	22-03-2171	1	47741117A
P34	CONNECTOR 20 PIN STRAIGHT	27264	22-03-2201	1	477397000
R1	RES NETWORK 22 OHM +-2 OHM 2W	01121	316B-220	1	345034000
R2-3	RES NETWORK 3K/6.2K 2% 2.7W	73138	785-5-R3K/6.2K	2	345031000
R4-6	RES NETWORK 150 OHM 2% 1.5W	73138	898-3-R150	3	345026000
R7-10	RES NETWORK 330 OHM 2% 1.5W	73138	898-3-R330	4	345027000
U1	IC ULN2803A TRANSISTOR ARRAY	56289	ULN2803A	1	534274000
U2-3	IC UDN2585A	56289	UDN2585A	2	534392000
U4	IC 8279-2 KEYBD/DISP INTERFACE	33297	uPD8279C-2	1	534211000
U5-7	IC 74LS138 DECDR/MPX	01295	SN74LS138N	3	534246000
U8-10	IC 74LS273 OCTAL D FLIPFLOP	01295	SN74LS273N	3	534263000
U12	IC 74LS273 OCTAL D FLIPFLOP	01295	SN74LS273N	1	534263000
U14	IC 74LS273 OCTAL D FLIPFLOP	01295	SN74LS273N	1	534263000
U16	IC 74LS273 OCTAL D FLIPFLOP	01295	SN74LS273N	1	534263000
U17-19	IC 74LS138 DECDR/MPX	01295	SN74LS138N	3	534246000
U20	IC 74LS00 2 INP POS NAND	01295	SN74LS00N	1	534167000
XDS1-6	SOCKET IC 14 PIN	06776	ICN-143-WB-G	6	473066000
XDS7-8	SOCKET IC 16 PIN	06776	ICN-163-WB-TG	2	473047000
XDS9-16	SOCKET IC 14 PIN	06776	ICN-143-WB-G	8	473066000
XDS17-19	SOCKET IC 16 PIN	06776	ICN-163-WB-TG	3	473047000
XDS20-21	SOCKET IC 14 PIN	06776	ICN-143-WB-G	2	473066000
XDS22	SOCKET IC 16 PIN	06776	ICN-163-WB-TG	1	473047000
XR1	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XR4-10	SOCKET IC 16 PIN	06776	ICN-163-S3-G	7	473042000
XU1-3	SOCKET IC 18 PIN	06776	ICN-183-S3-TG	3	473045000
XU4	SOCKET IC 40 PIN LOW PROFILE	06776	ICT-406-S-TG	1	473068000
XU5-7	SOCKET IC 16 PIN	06776	ICN-163-S3-G	3	473042000
XU8-10	SOCKET IC 20 PIN	06776	ICN-203-S3-G	3	473065000
XU12	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000
XU14	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000
XU16	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000
XU17-19	SOCKET IC 16 PIN	06776	ICN-163-S3-G	3	473042000
XU20	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000

11102800A PWA '1110' POWER SUPPLY
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C2-4	CAP CER 0.01uF 100V	33883	BT Z5U	3	224119000
C5	CAP EL 26000uF 20% 16V	56289	622D263M016AC2A	1	283340000
C6	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C7	CAP EL 4500uF 20% 35V	56289	622D452M035AA2A	1	283339000
C8	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C9	CAP EL 4500uF 20% 35V	56289	622D452M035AA2A	1	283339000
C10	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C11	CAP EL 4700uF -10%+50% 16V	S4217	SM-25-VB-100-M	1	283352000
C12	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C13	CAP EL 4500uF 20% 35V	56289	622D452M035AA2A	1	283339000
C14	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C15	CAP EL 4500uF 20% 35V	56289	622D452M035AA2A	1	283339000
C17	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	1	283334000
C18	CAP CER 0.001uF 10% 100V	04222	SR151C102KAA	1	224270000
C19	CAP TANT 10uF 20% 25V	56289	196D106X0025KA1	1	283293000
C21	CAP CER 0.001uF 10% 100V	04222	SR151C102KAA	1	224270000
C22	CAP MICA 270pF 5% 50V	57582	KD5271J101	1	205045000
C23	CAP EL 2200uF -10%+50% 35V	57582	KSMM-2200-35	1	283351000
C24-25	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	2	224268000
C26-28	CAP TANT 10uF 20% 25V	56289	196D106X0025KA1	3	283293000
C29	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	1	283334000
C30-32	CAP TANT 10uF 20% 25V	56289	196D106X0025KA1	3	283293000
C35-37	CAP MICA 270pF 5% 50V	57582	KD5271J101	3	205045000
CR2-4	DIODE BRIDGE FWLD-50	11961	FWLA-50	3	532028000
CR5-8	DIODE SIG 1N4001	04713	1N4001	4	530151000
CR9	DIODE ZENER 1N5242B 12V 5%	04713	1N5242B	1	530146000
CR10	DIODE SIG 1N4001	04713	1N4001	1	530151000
CR11	DIODE ZENER 1N5242B 12V 5%	04713	1N5242B	1	530146000
CR12	DIODE SIG 1N4001	04713	1N4001	1	530151000
CR14	DIODE SIG 1N4001	04713	1N4001	1	530151000
CR15	DIODE ZENER 1N5242B 12V 5%	04713	1N5242B	1	530146000
CR16	DIODE SIG 1N4001	04713	1N4001	1	530151000
CR17	DIODE ZENER 1N5242B 12V 5%	04713	1N5242B	1	530146000
CR19-20	DIODE SIG 1N4001	04713	1N4001	2	530151000
CR22-24	DIODE SIG 1N4001	04713	1N4001	3	530151000
J14-15	HEADER 3 PIN STRAIGHT .156 SPA	06383	HPSS156-3-C	2	477343000
J16	HEADER 5 PIN STRAIGHT	06383	HPSS156-5-D	1	477345000
J17	HEADER 2 PIN STRAIGHT	06383	HPSS156-2-C	1	477342000
J18	HEADER 3 PIN STRAIGHT .156 SPA	06383	HPSS156-3-C	1	477343000
J19	HEADER 5 PIN STRAIGHT	06383	HPSS156-5-D	1	477345000
J20	HEADER 3 PIN STRAIGHT .156 SPA	06383	HPSS156-3-C	1	477343000
J21	HEADER 2 PIN STRAIGHT	06383	HPSS156-2-C	1	477342000
R1-2	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	2	341300000
R3	RES MF 200K 1% 1/4W	19701	5043ED200K0F	1	341529000
R4	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R5	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R6	RES VAR 1K 10% 0.5W	73138	72PR1K	1	311316000
R7	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R8	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R9	RES NETWORK 10K .1% 1.5W 16pin	73138	698-3R10KD	1	345010000
R10	RES MF 301 OHM 1% 1/4W	19701	5043ED301R0F	1	341246000
R11	RES NETWORK 10K .1% 1.5W 16pin	73138	698-3R10KD	1	345010000
R12	RES MF 301 OHM 1% 1/4W	19701	5043ED301R0F	1	341246000
U1	IC 78L05 VOLT REG	07263	uA78L05AWC	1	535044000
U2	IC 339 QUAD COMPARATOR	27014	LM339N	1	535018000
U3	IC TL072CP DUAL OP AMP	01295	TL072CP	1	535092000
U9	IC TL072CP DUAL OP AMP	01295	TL072CP	1	535092000
U11-12	IC REF-01CP VOLTAGE REFERENCE	06665	REF-01CP	2	535116000
W36	CABLE ASSY WIRE 22GA 2C 6.50L	04901	571206000	1	571206000
W40	CABLE ASSY WIRE 24GA 3C 3.25L	04901	57120303A	1	57120303A
W41	CABLE ASSY WIRE 24GA 3C 4.50L	04901	571204000	1	571204000
W42	CABLE ASSY WIRE 24GA 3C 5.25L	04901	57120304A	1	57120304A
W44	CABLE ASSY WIRE 24GA 3C 3.50L	04901	57120305A	1	57120305A
W45	CABLE ASSY WIRE 24GA 3C 3.50L	04901	57120306A	1	57120306A
XR9	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XR11	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU2	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU3	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU9	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU11-12	SOCKET IC 8 PIN	06776	ICN-083-S3-G	2	473041000

11102600A PWA '1110' MOTHER
MODEL: 1110

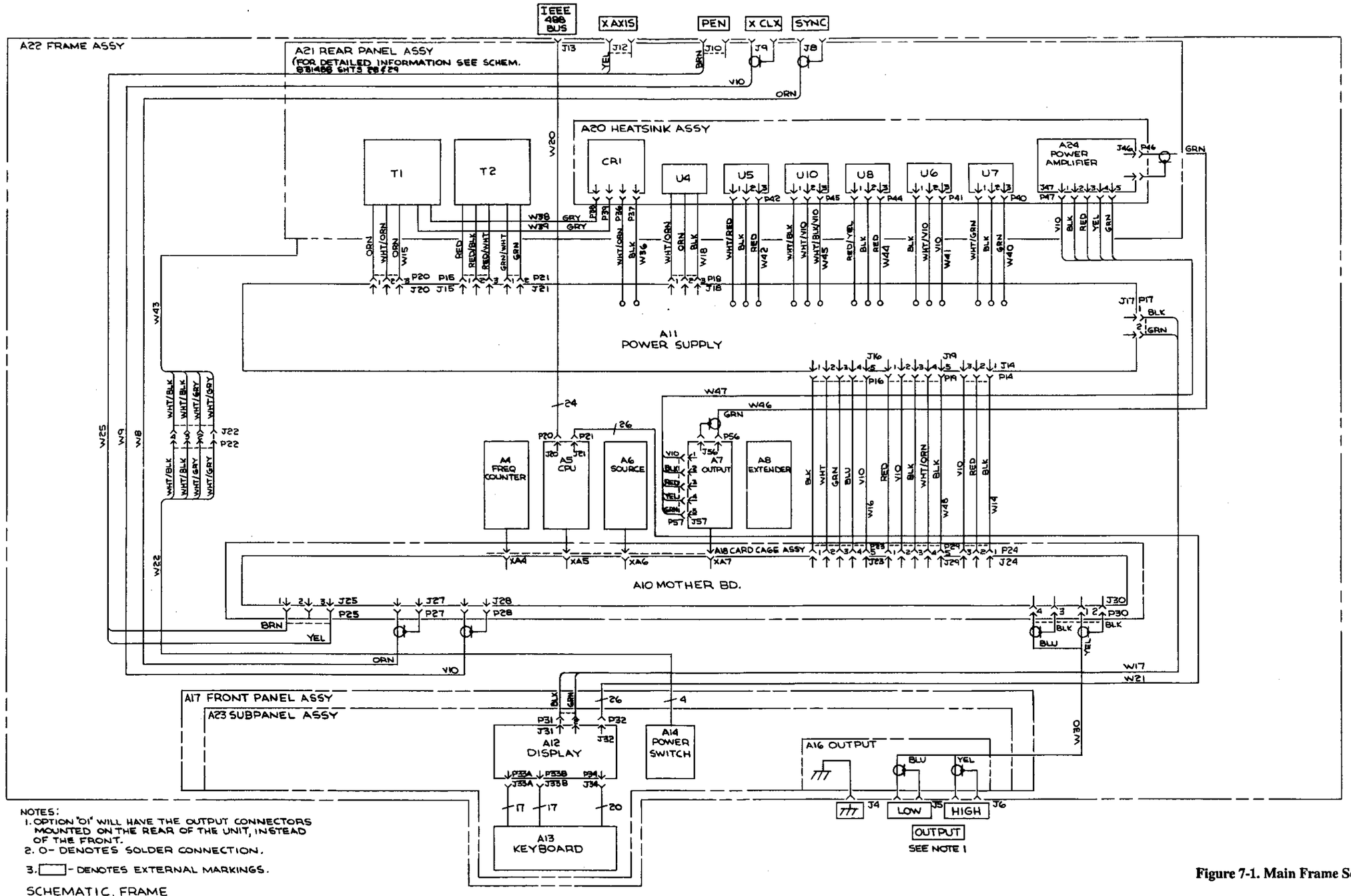
REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C2	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C3	CAP CER 0.01uF 10% 100V	04222	SR201C103KAA	1	224269000
C4	CAP CER 0.01uF 100V	33883	BT Z5U	1	224119000
C5	CAP TANT 100uF 20% 20V	56289	196D107X0020TE4	1	283313000
C6	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C7-16	CAP CER 0.01uF 100V	33883	BT Z5U	10	224119000
C17	CAP TANT 100uF 20% 20V	56289	196D107X0020TE4	1	283313000
C18-21	CAP CER 0.01uF 100V	33883	BT Z5U	4	224119000
C22	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C23	CAP CER-0.22uF 10% 200V	61637	C340C224M2R5CA	1	22439200A
C24	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
CR1	DIODE HSCH1001 (1N6263)	28480	HSCH-1001	1	530174000
CR2-3	DIODE SIG 1N914	01295	1N914	2	530058000
CR4	DIODE HSCH1001 (1N6263)	28480	HSCH-1001	1	530174000
CR5-9	DIODE SIG 1N914	01295	1N914	5	530058000
F1	FUSE 0.3 AMP 125V MICRO	75915	273.300	1	54554212A
F2	FUSE 1-1/2 AMP 125V MICRO	75915	27301.5	1	54554220A
FH1-2	FUSEHOLDER PWB VERT MOUNT	75915	281.005	2	48211801A
J23	HEADER 5 PIN STRAIGHT	06383	MPSS156-5-D	1	477345000
J24-25	HEADER 3 PIN STRAIGHT .156 SPA	06383	MPSS156-3-C	2	477343000
J27-28	CONNECTOR "SMB"	19505	209	2	477317000
J29	HEADER 5 PIN STRAIGHT	06383	MPSS156-5-D	1	477345000
J30	HEADER 4 PIN STRAIGHT	06383	MPSS156-4-C	1	477344000
K1-2	RELAY DPDT	TAKAMI	RZ-12W-C	2	47105700A
K3-5	RELAY FORM A 12V HEAVY DUTY	TAKAMI	JY-12H-K	3	47105800A
Q1-7	TRANS NPN 2N3904	04713	2N3904	7	528071000
Q8	TRANS NPN D44H11	04713	D44H11	1	52816100A
R1	RES MF 511 OHM 1% 1/4W	19701	5043ED511R0F	1	341268000
R2	RES MF 2.21K 1% 1/4W	19701	5043ED2K210F	1	341333000
R3-4	RES NETWORK 330 OHM 2% 1.5W	73138	898-3-R330	2	345027000
R5	RES MF 475 OHM 1% 1/4W	19701	5043ED475R0F	1	341265000
R6	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R7	RES NETWORK 470 OHM 2% 1.5W	71450	750-61-R470	1	345029000
R8	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R9	RES MF 332 OHM 1% 1/4W	19701	5043ED332R0F	1	341250000
R10	RES MF 511 OHM 1% 1/4W	19701	5043ED511R0F	1	341268000
R11	RES NETWORK 470 OHM 2% 2.3W	71450	750-101-R470	1	34504414A
R12	RES MF 200 OHM 0.1% 1/2W	91637	CMF652000BT2	1	32677600A
R13	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R14	RES MF 62.5 OHM 0.1% 1W	03888	PME70 T9 62R5 .1%	1	32677500A
R15	RES MF 450.0 OHM 0.1% 1/2W	91637	CMF65450R0BT9	1	32677300A
R16	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R17	RES MF 55.5 OHM 0.1% 1W	91637	CMF7055R5BT9	1	32677100A
R18	RES MF 100.0 OHM 0.1% 1W	91637	CMF65100R0BT2	1	32677200A
R19-20	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	2	341329000
R21	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R22	RES MF 450.0 OHM 0.1% 1/2W	91637	CMF65450R0BT9	1	32677300A
R23	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R24-25	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	2	341200000
R26	RES MF 100.0 OHM 0.1% 1W	91637	CMF65100R0BT2	1	32677200A
R27	RES MF 2.74K 1% 1/4W	19701	5043ED2K740F	1	341342000
R28	RES MF 3.09K 1% 1/4W	19701	5043ED3K090F	1	341347000
R29	RES MF 100.0 OHM 0.1% 1W	91637	CMF65100R0BT2	1	32677200A
TP1-5	TERMINAL WIRE LOOP TEST POINT	31313	TP-103-02	5	48330600A
U3	IC 74LS138 DECDR/MPX	01295	SN74LS138N	1	534246000
U4-17	OPTO-COUPLER HCPL-2601	28480	HCLP-2601	14	536037000
U18	IC 74LS541 OCTAL BUFFER	01295	SN74LS541N	1	534381000
XR3-4	SOCKET IC 16 PIN	06776	ICN-163-S3-G	2	473042000
XU3	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU4-17	SOCKET IC 8 PIN	06776	ICN-083-S3-G	14	473041000
XU18	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000

11103400A PWA '1110' POWER AMPLIFIER
MODEL: 1110

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1	CAP MICA 10pF 5% 300V	14655	CD5WCC100J	1	205002000
C2-5	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	4	224268000
C6-9	CAP CER 2200pF 10% 250V	16546	CF-222	4	224309000
C11	CAP MICA 10pF 5% 300V	14655	CD5WCC100J	1	205002000
C12-13	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	2	224268000
C14-15	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	2	283334000
CR1-12	DIODE SIG 1N914	01295	1N914	12	530058000
J46	CONNECTOR "SMB"	19505	209	1	477317000
J47	HEADER 5 PIN STRAIGHT	06383	MPS8156-5-D	1	477345000
Q1	TRANS NPN 2N3904	04713	2N3904	1	528071000
Q2-3	TRANS PNP 2N3906	04713	2N3906	2	528076000
Q4	TRANS PNP D45H11	04713	D45H11	1	52816200A
Q5	TRANS NPN 2N3904	04713	2N3904	1	528071000
Q6	TRANS NPN D44H11	04713	D44H11	1	52816100A
Q7	TRANS PNP D45H11	04713	D45H11	1	52816200A
Q8	TRANS PNP 2N3906	04713	2N3906	1	528076000
Q9	TRANS NPN 2N3904	04713	2N3904	1	528071000
Q10	TRANS NPN D44H11	04713	D44H11	1	52816100A
Q11	TRANS PNP 2N3906	04713	2N3906	1	528076000
Q12	TRANS NPN 2N3904	04713	2N3904	1	528071000
R1	RES MF 5.000K 0.1% 1/8W	64537	PME55-T2	1	324326000
R2	RES MF 7.500K 0.1% 1/4W	91637	CMF557501BT9	1	32593200A
R3-4	RES MF 2.49K 1% 1/4W	19701	5043ED2K490F	2	341338000
R5	RES MF 200 OHM 1% 1/4W	19701	5043ED200R0F	1	341229000
R6	RES MF 301 OHM 1% 1/4W	19701	5043ED301R0F	1	341246000
R7	RES MF 39.2 OHM 1% 1/4W	19701	5043ED39R20F	1	341157000
R8-9	RES MF 150 OHM 1% 1/4W	19701	5043ED150R0F	2	341217000
R10	RES MF 39.2 OHM 1% 1/4W	19701	5043ED39R20F	1	341157000
R11	RES MF 301 OHM 1% 1/4W	19701	5043ED301R0F	1	341246000
R12	RES MF 200 OHM 1% 1/4W	19701	5043ED200R0F	1	341229000
R13-15	RES MF 3.92 OHM 1% 1/2W	91637	CMF603R92 T2	3	34205700A
R16	RES MF 301 OHM 1% 1/4W	19701	5043ED301R0F	1	341246000
R17	RES MF 39.2 OHM 1% 1/4W	19701	5043ED39R20F	1	341157000
R18-19	RES MF 150 OHM 1% 1/4W	19701	5043ED150R0F	2	341217000
R20	RES MF 39.2 OHM 1% 1/4W	19701	5043ED39R20F	1	341157000
R21	RES MF 301 OHM 1% 1/4W	19701	5043ED301R0F	1	341246000
R22	RES MF 3.92 OHM 1% 1/2W	91637	CMF603R92 T2	1	34205700A
R23-24	RES MF 200 OHM 1% 1/4W	19701	5043ED200R0F	2	341229000
R25-26	RES MF 2.49K 1% 1/4W	19701	5043ED2K490F	2	341338000
R27	RES MF 7.500K 0.1% 1/4W	91637	CMF557501BT9	1	32593200A
R28	RES MF 5.000K 0.1% 1/8W	64537	PME55-T2	1	324326000
R29	RES MF 7.500K 0.1% 1/4W	91637	CMF557501BT9	1	32593200A
R30	RES MF 5.000K 0.1% 1/8W	64537	PME55-T2	1	324326000
R31	RES MF 3.92 OHM 1% 1/2W	91637	CMF603R92 T2	1	34205700A
U1-2	IC 5534AN OP AMP	18324	NE553AN	2	535061000
XU1-2	SOCKET IC 8 PIN	06776	ICN-083-S3-G	2	473041000

SECTION VII
SCHEMATIC DIAGRAMS

TABLE 7-1. LIST OF SCHEMATICS.



NOTES:
1. OPTION "01" WILL HAVE THE OUTPUT CONNECTORS MOUNTED ON THE REAR OF THE UNIT, INSTEAD OF THE FRONT.
2. O- DENOTES SOLDER CONNECTION.
3. ☐ - DENOTES EXTERNAL MARKINGS.

SCHEMATIC, FRAME
83148B20A, SHT. 20

Figure 7-1. Main Frame Schematic.

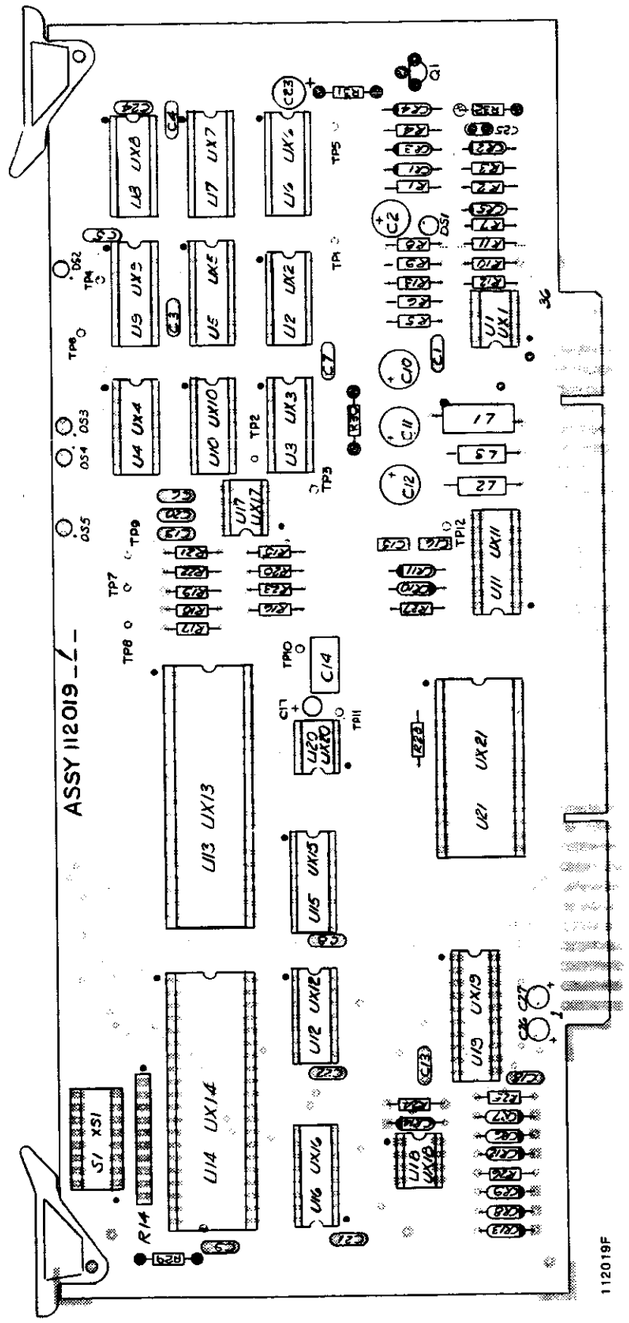


Figure 7-2. Counter Board A4 Parts Location Diagram.

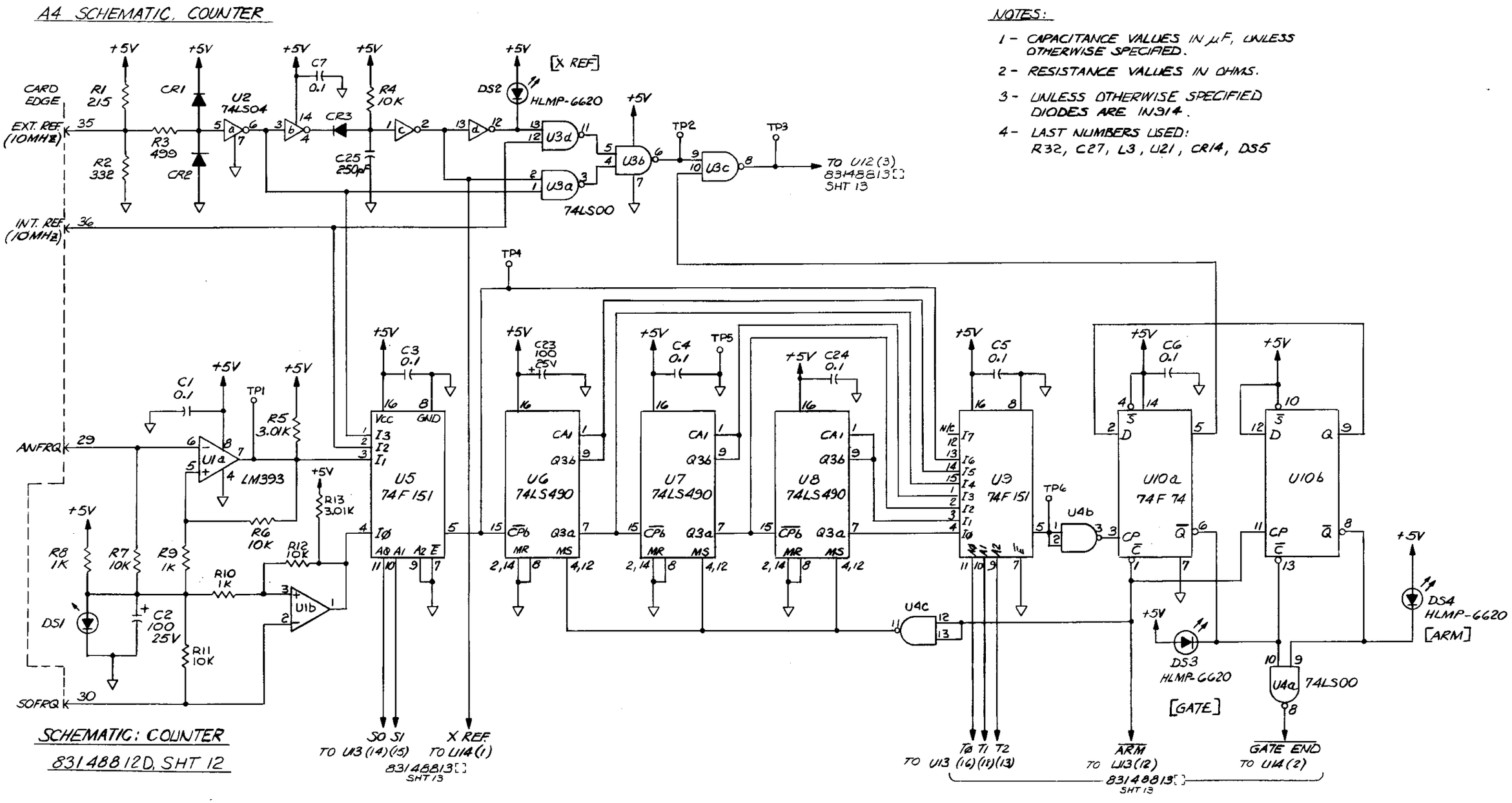


Figure 7-3. Counter Board A4 Schematic Sheet 1.

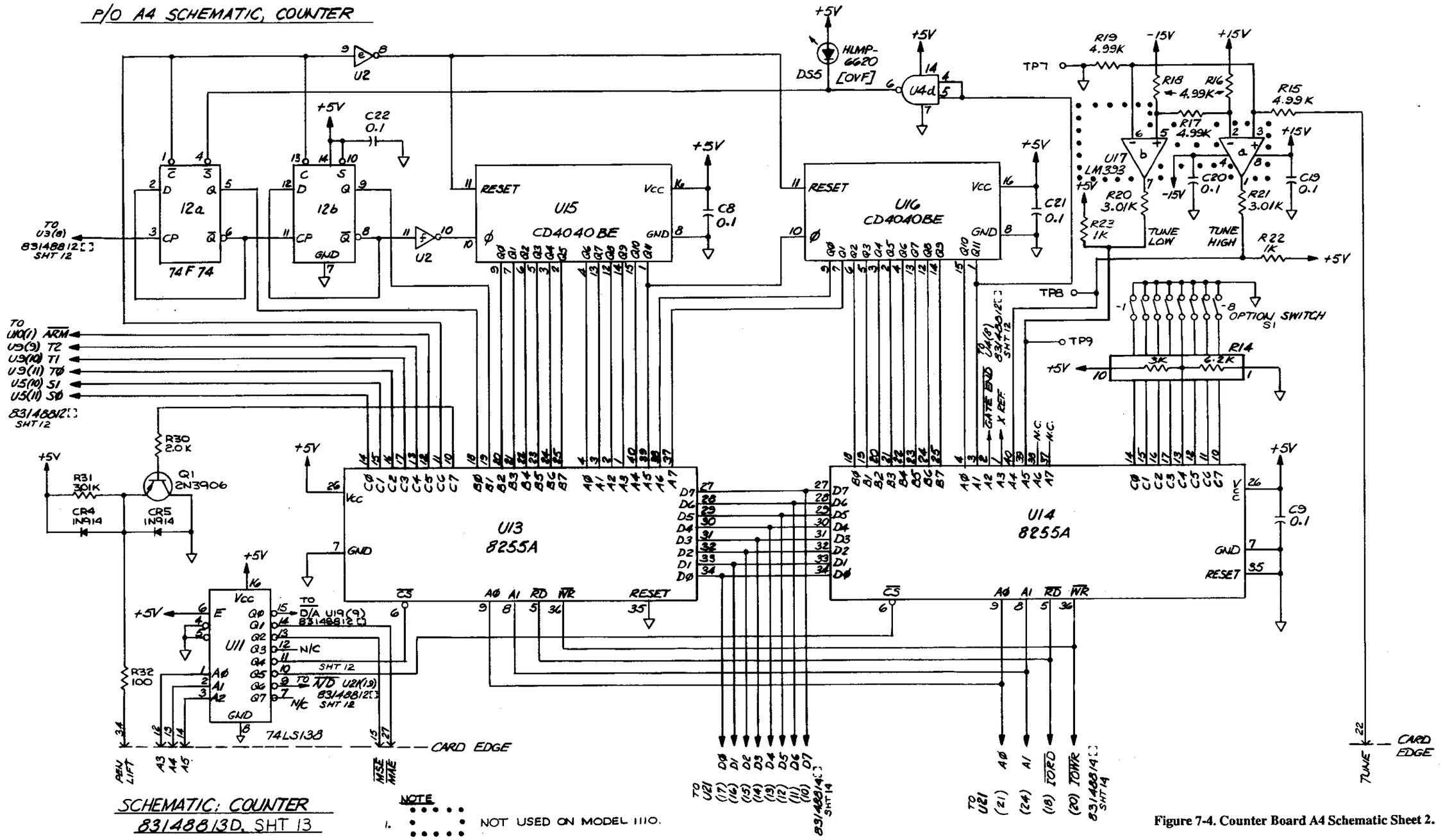


Figure 7-4. Counter Board A4 Schematic Sheet 2.

P/O A4 SCHEMATIC, COUNTER

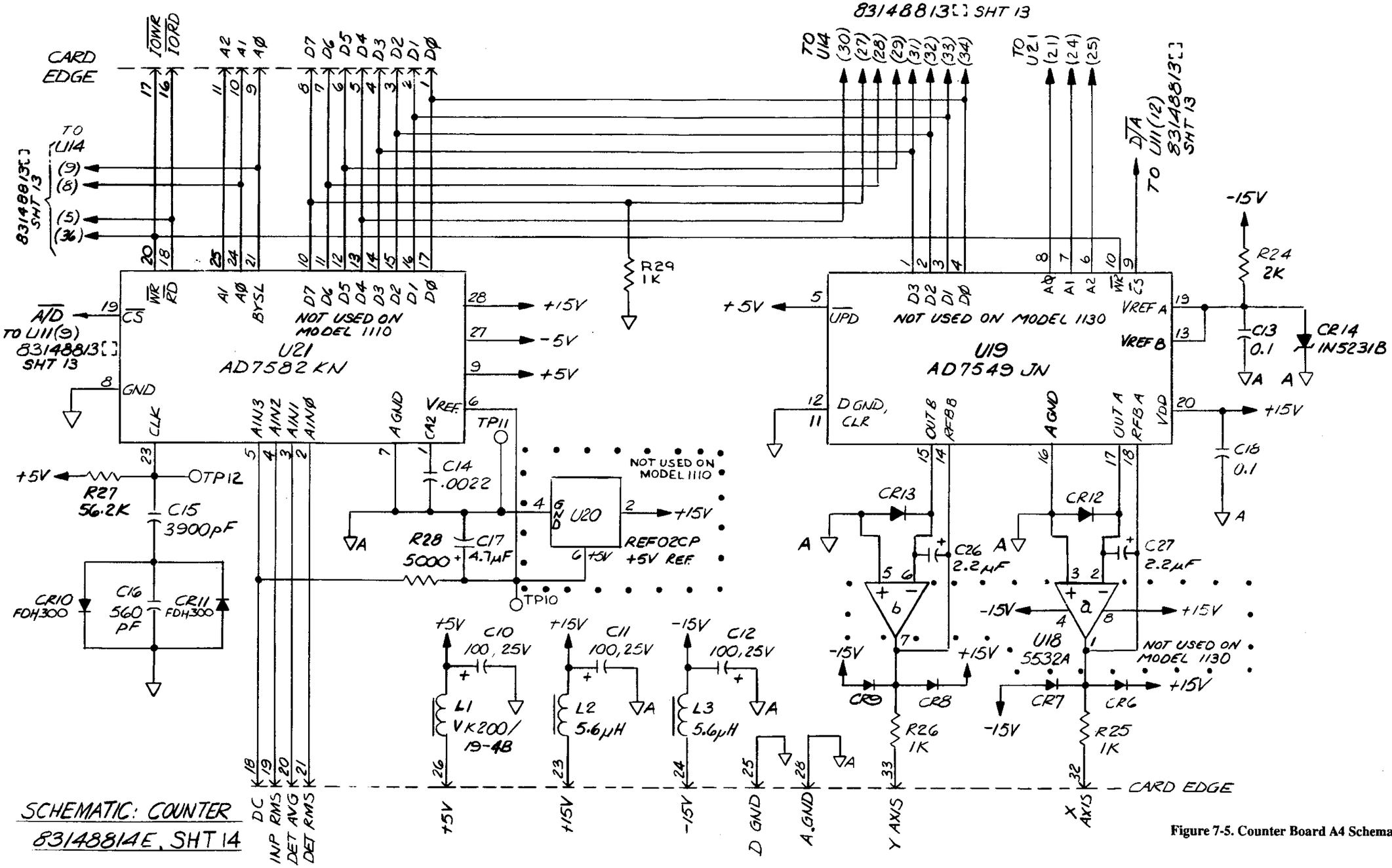


Figure 7-5. Counter Board A4 Schematic Sheet 3.

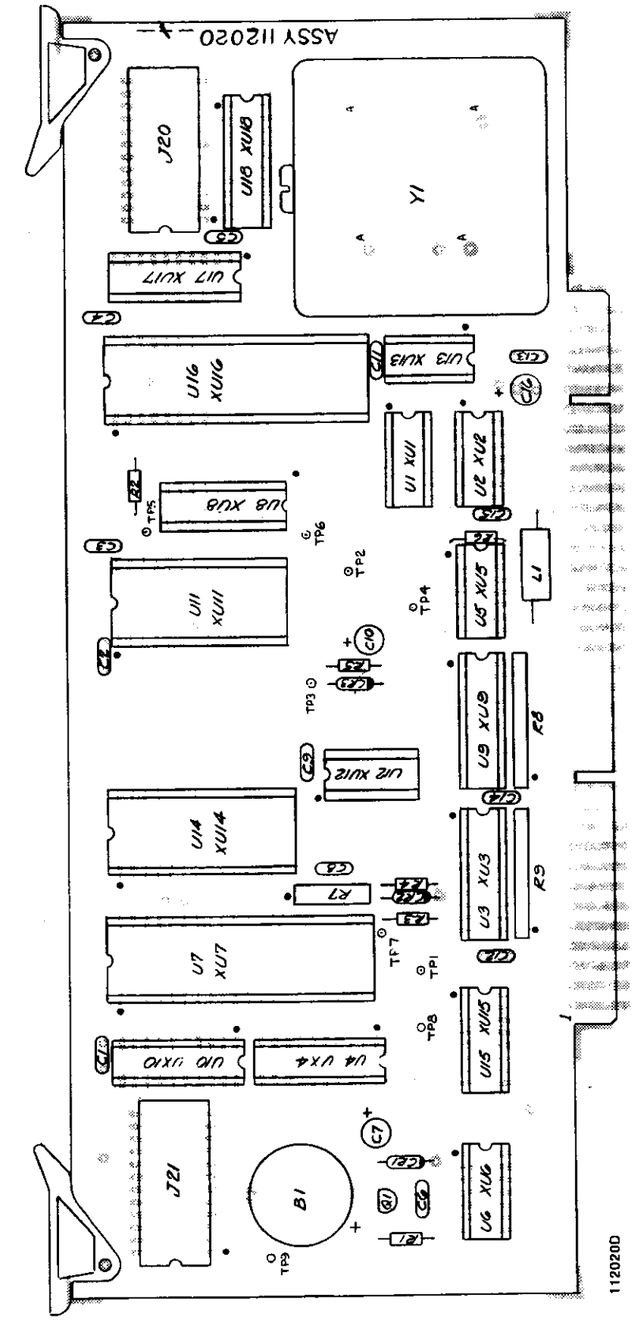


Figure 7-6. C.P.U. Board A5 Parts Location Diagram.

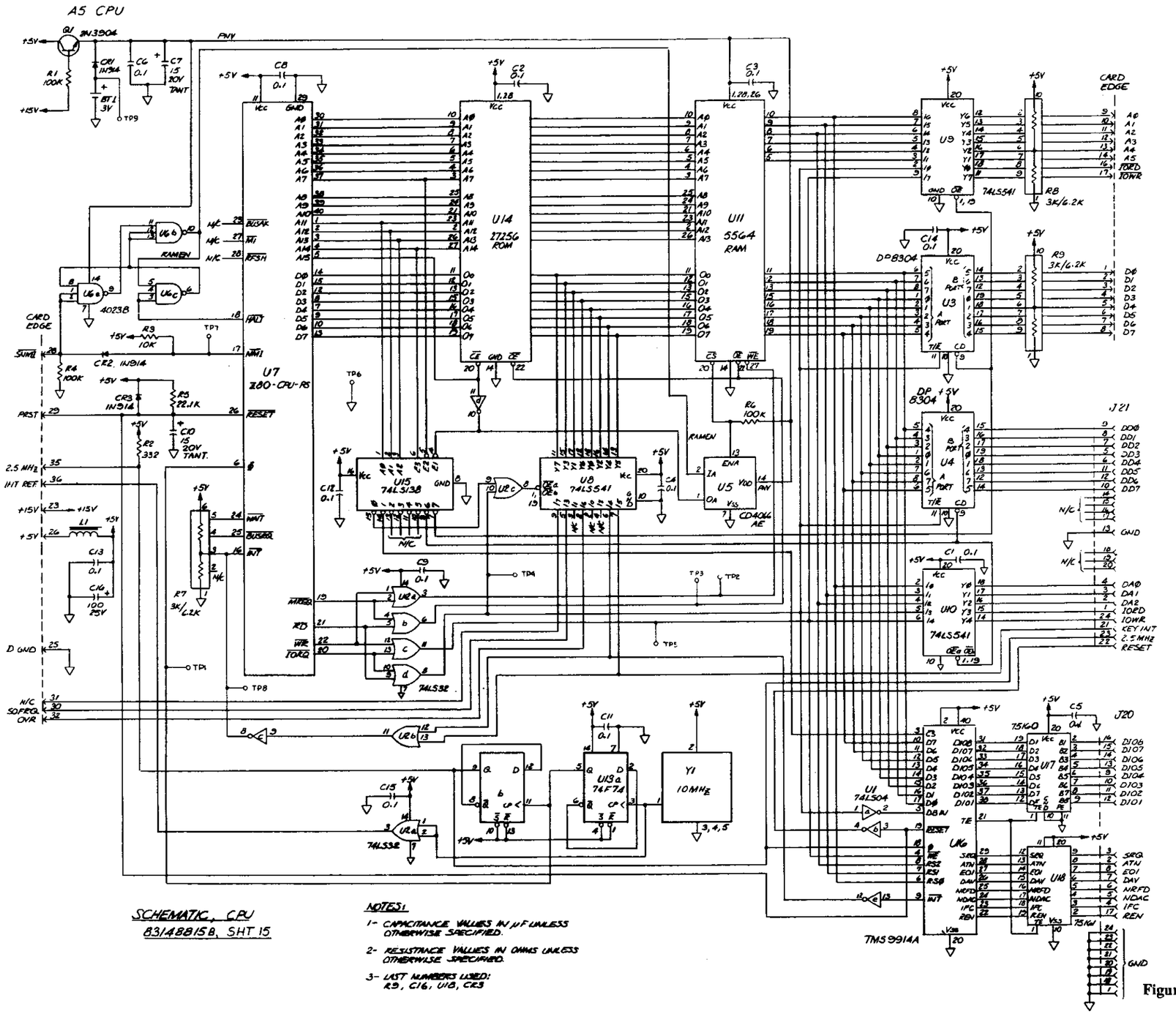


Figure 7-7. C.P.U. Board A5 Schematic.

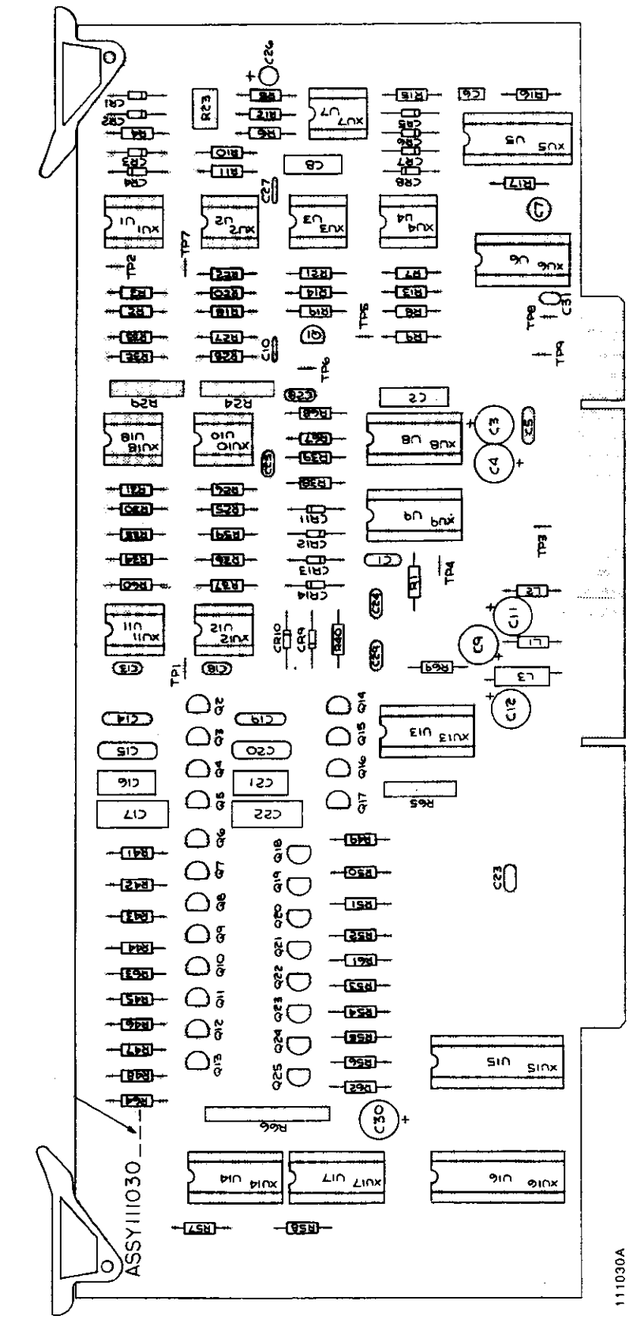


Figure 7-8. Source Board A6 Parts Location Diagram.

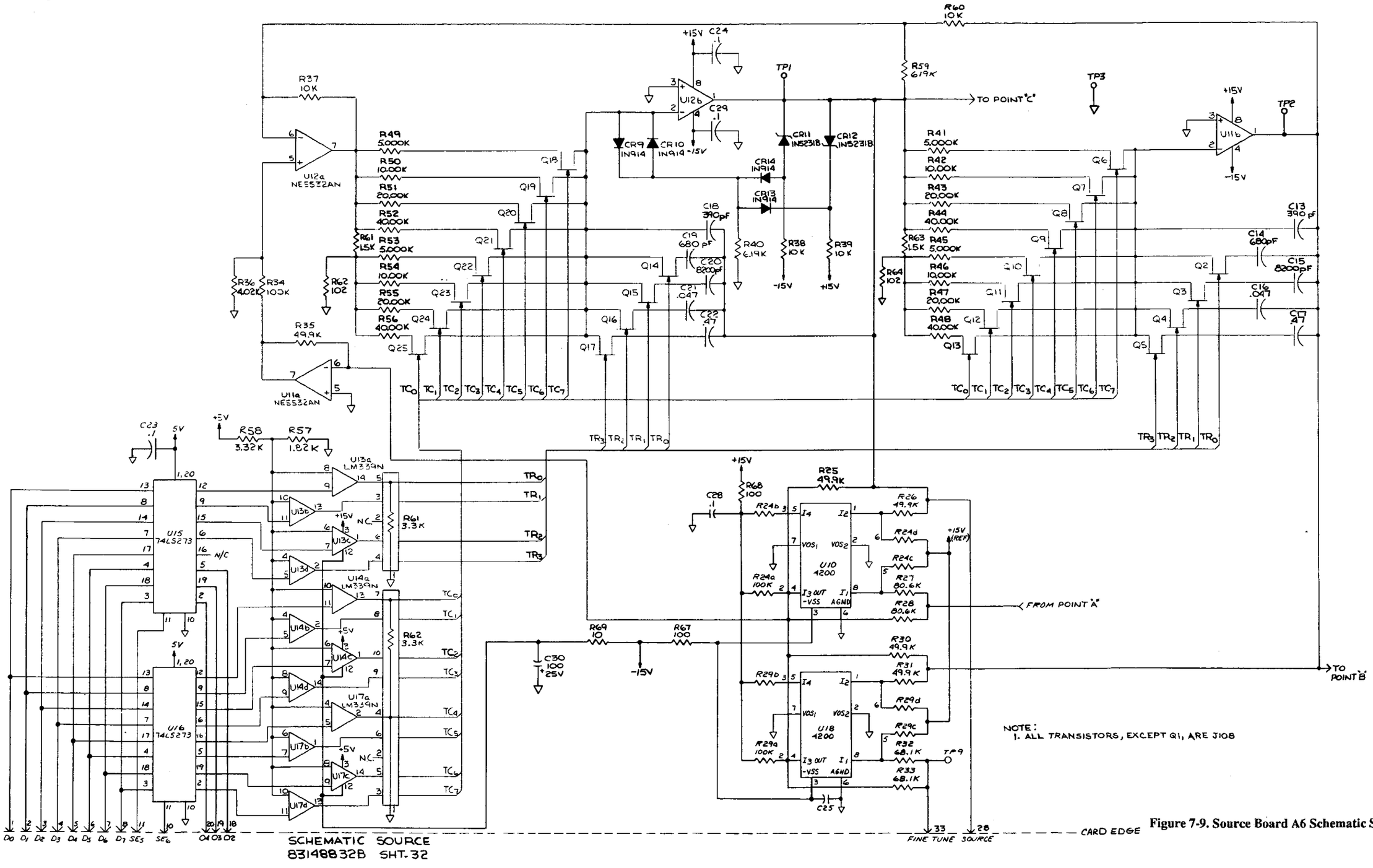


Figure 7-9. Source Board A6 Schematic Sheet 1.

P/O A6

NOTES:
1. CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. LAST NUMBERS USED:
C25, R62, U18, Q25

SCHEMATIC, SOURCE
83148831B SHT. 31

Figure 7-10. Source Board A6 Schematic Sheet 2.

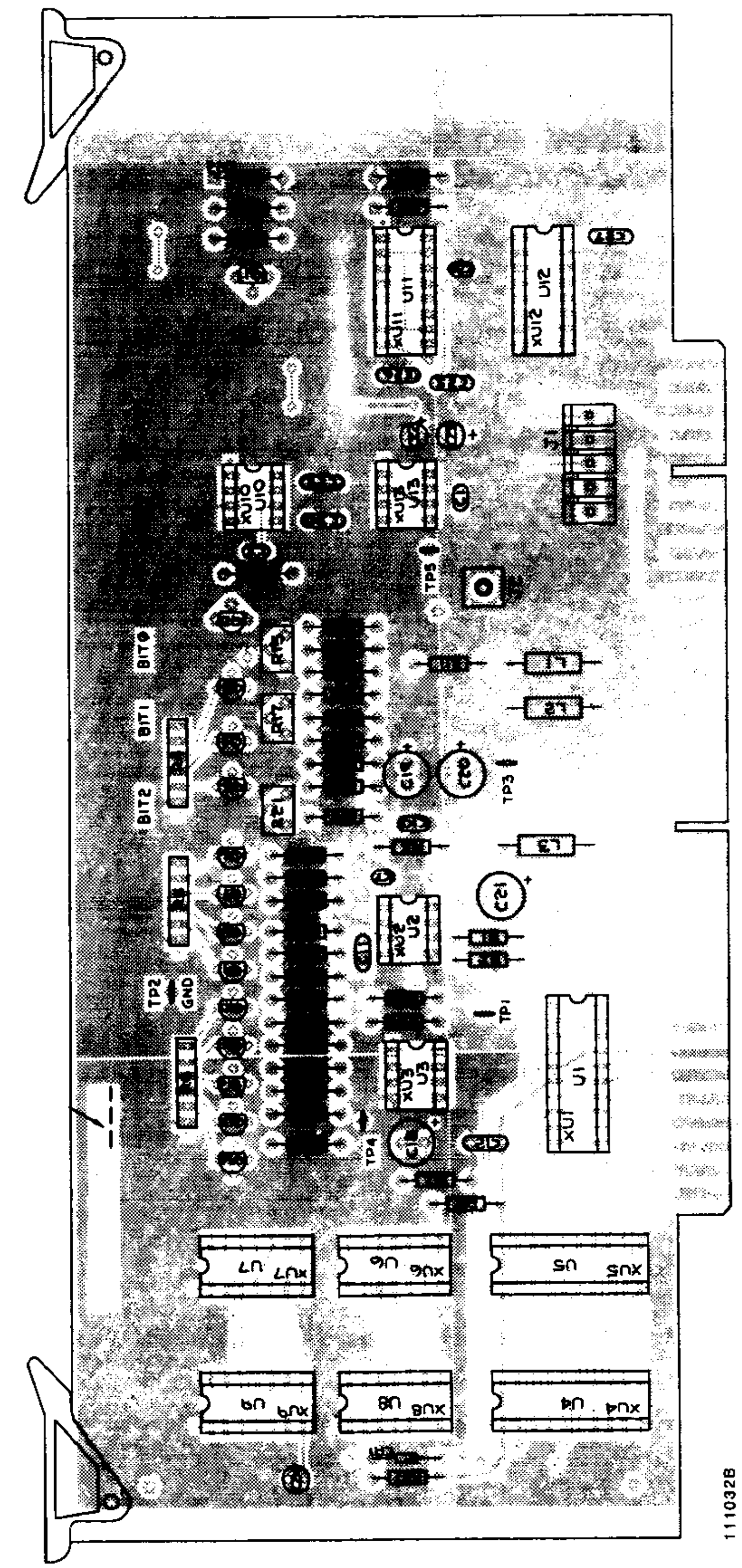
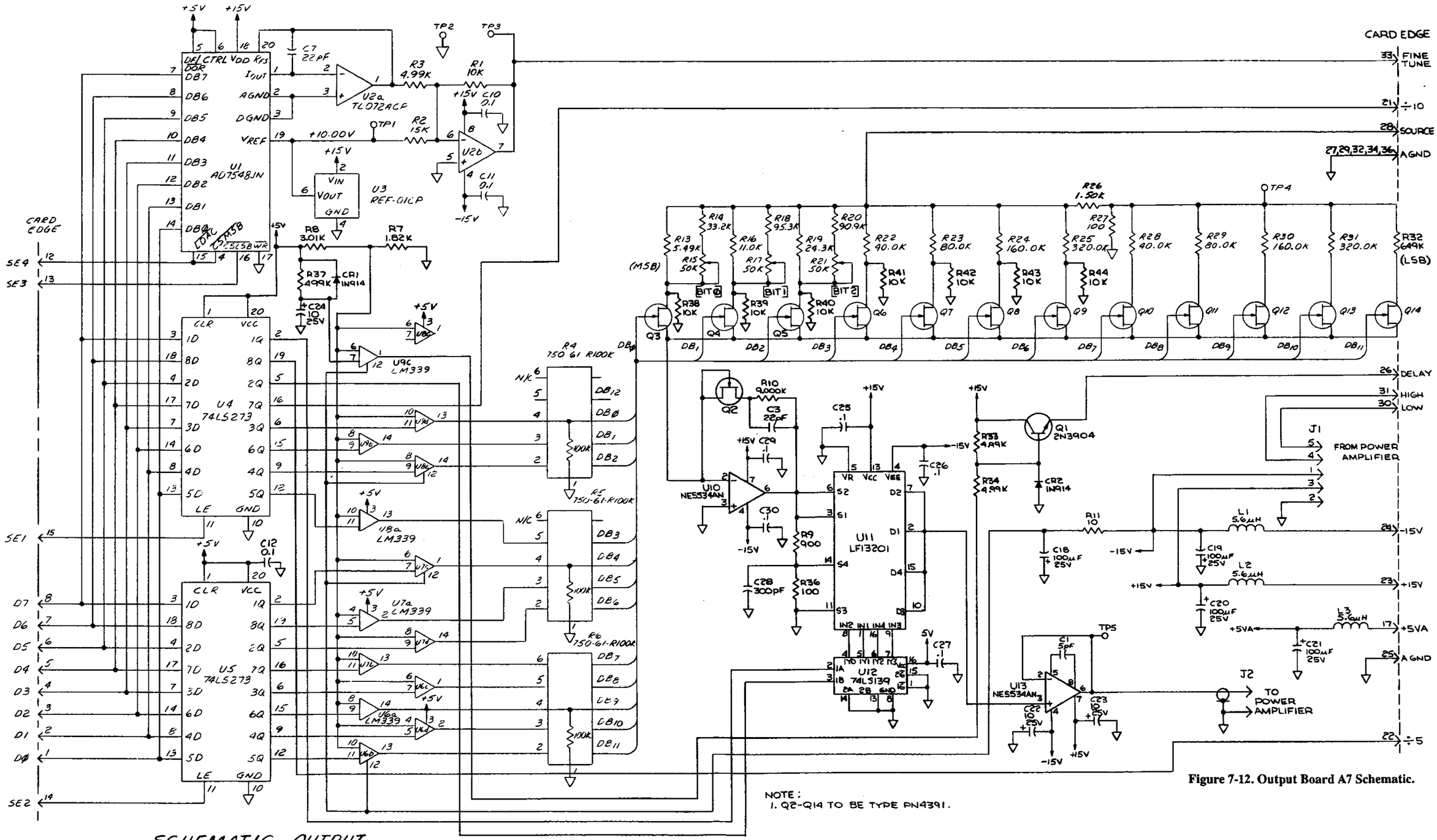


Figure 7-11. Output Board A7 Parts Location Diagram.

A7 OUTPUT



NOTE:
1. Q2-Q14 TO BE TYPE PN4391.

SCHEMATIC, OUTPUT
83148833B SHT. 33

Figure 7-12. Output Board A7 Schematic.

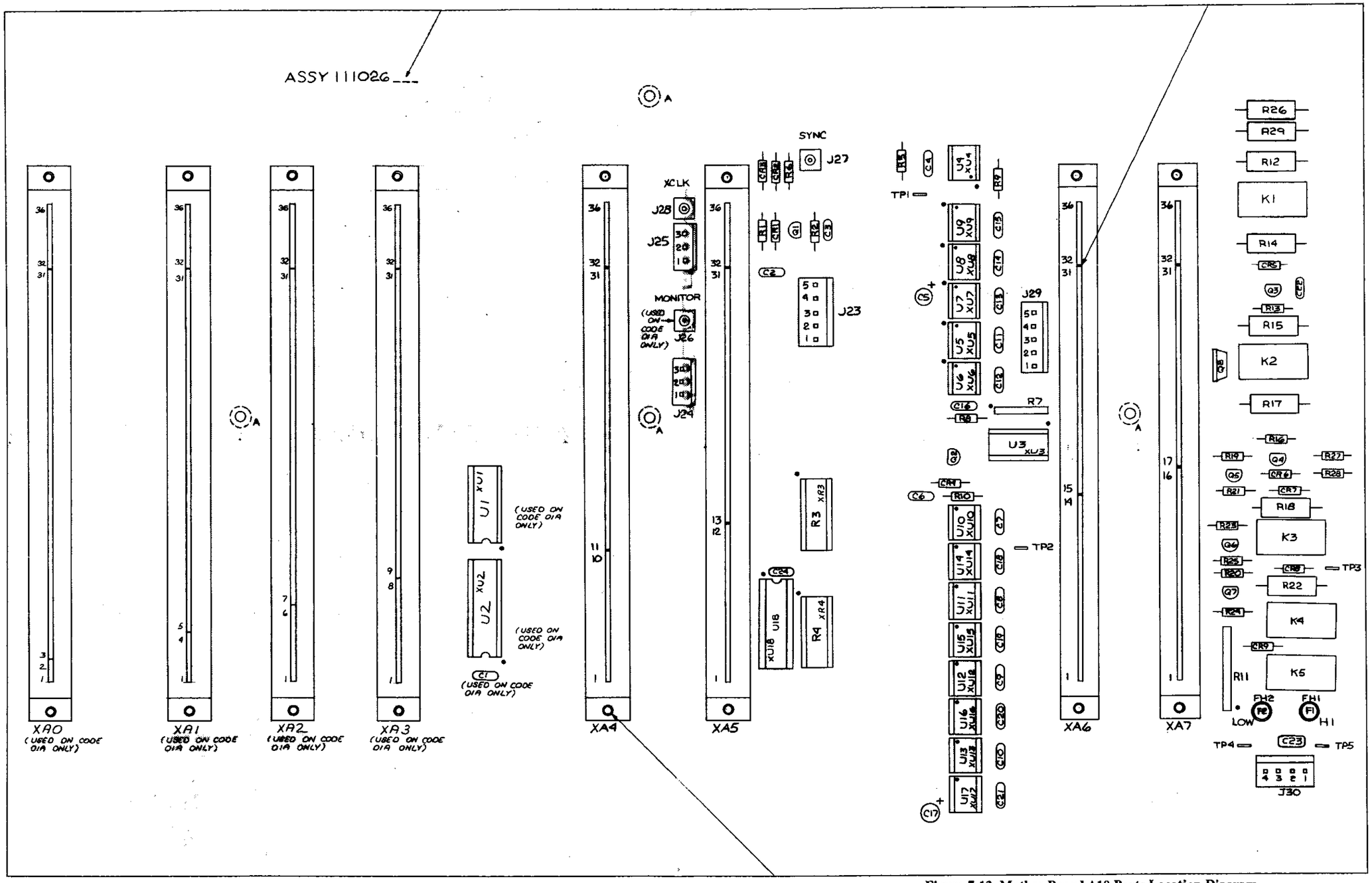


Figure 7-13. Mother Board A10 Parts Location Diagram.

111026B

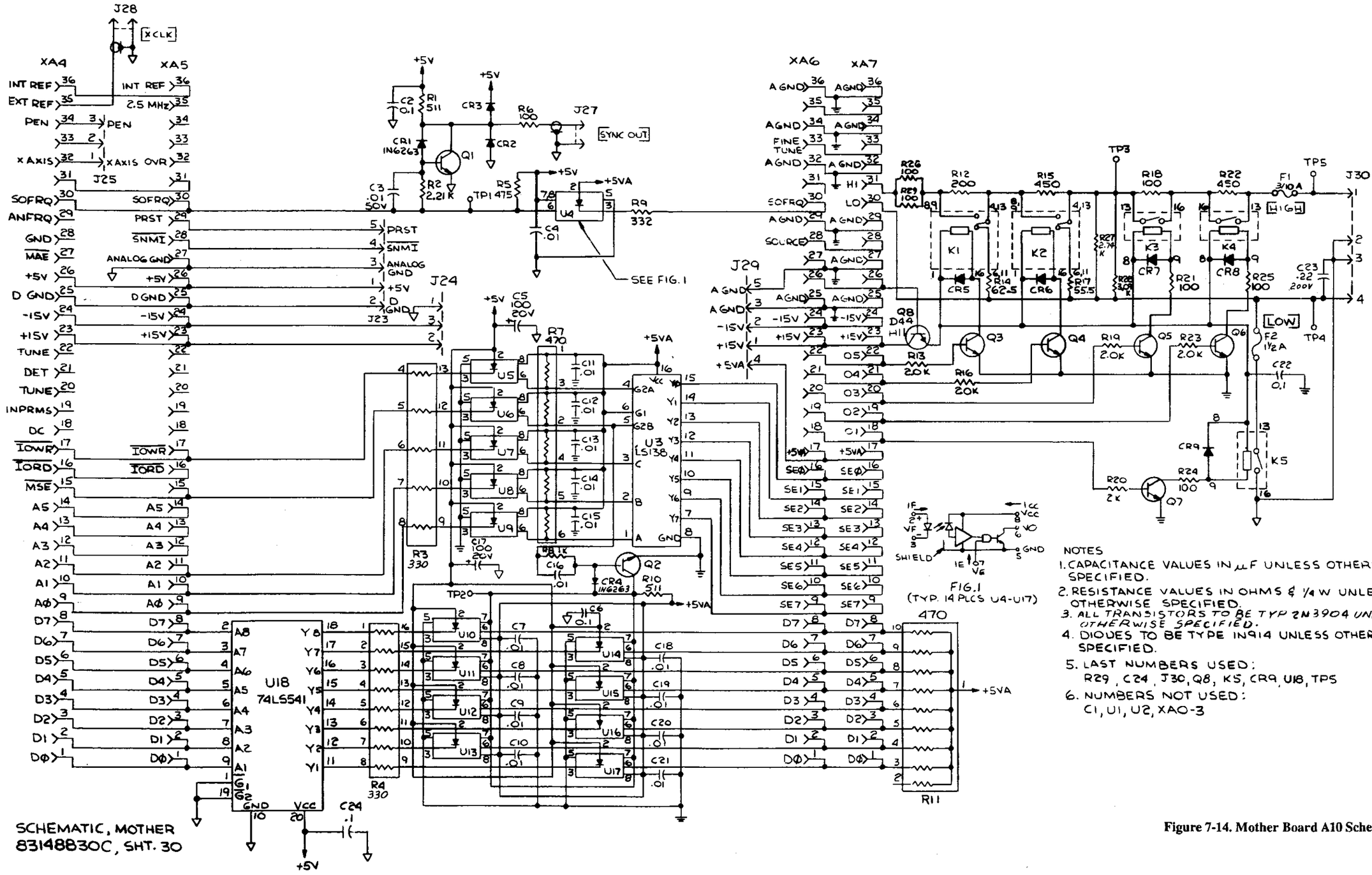
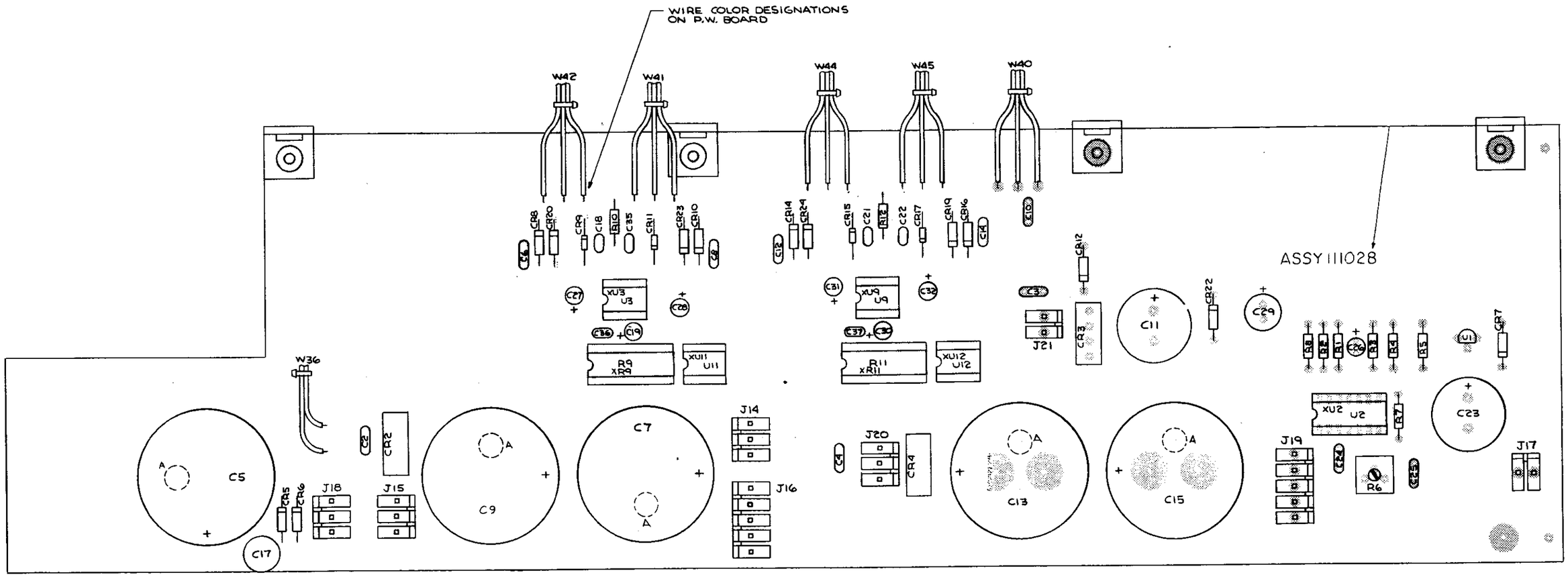


Figure 7-14. Mother Board A10 Schematic.



111028A

Figure 7-15. Power Supply A11 Parts Location Diagram.

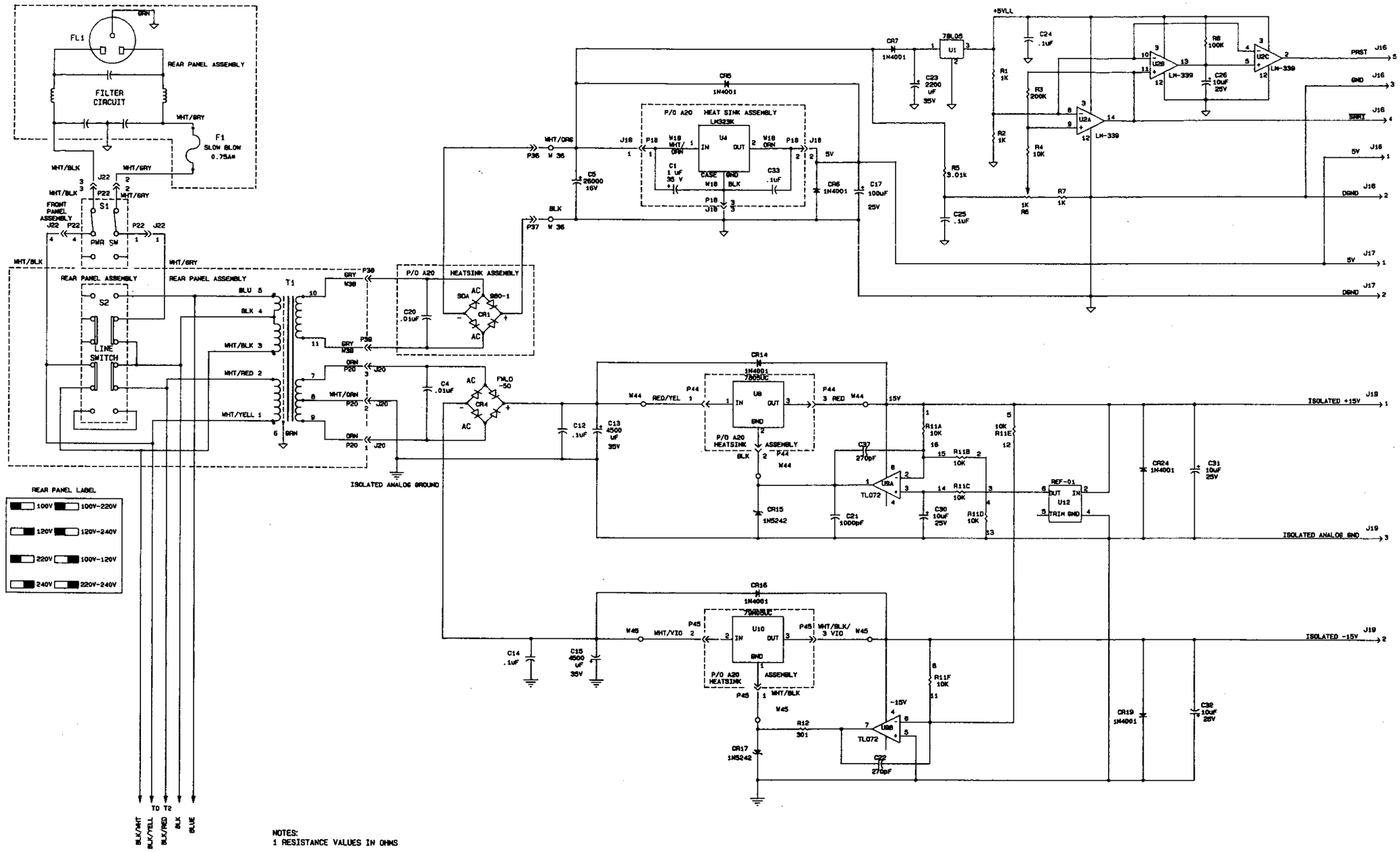
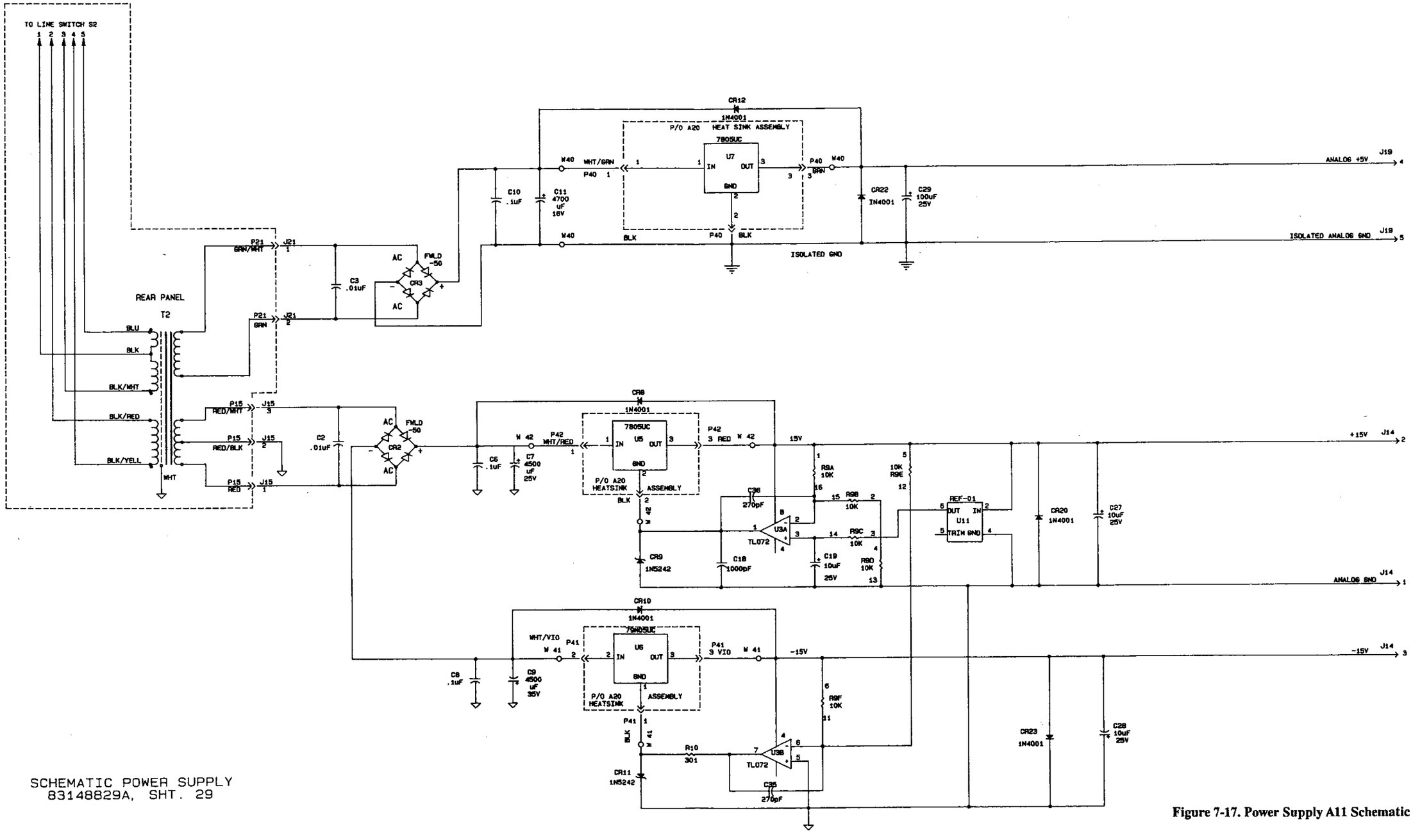


Figure 7-16. Power Supply A11 Schematic Sheet 1.

SCHEMATIC POWER SUPPLY
83148828A, SHT. 28



SCHEMATIC POWER SUPPLY
83148829A, SHT. 29

Figure 7-17. Power Supply A11 Schematic Sheet 2.

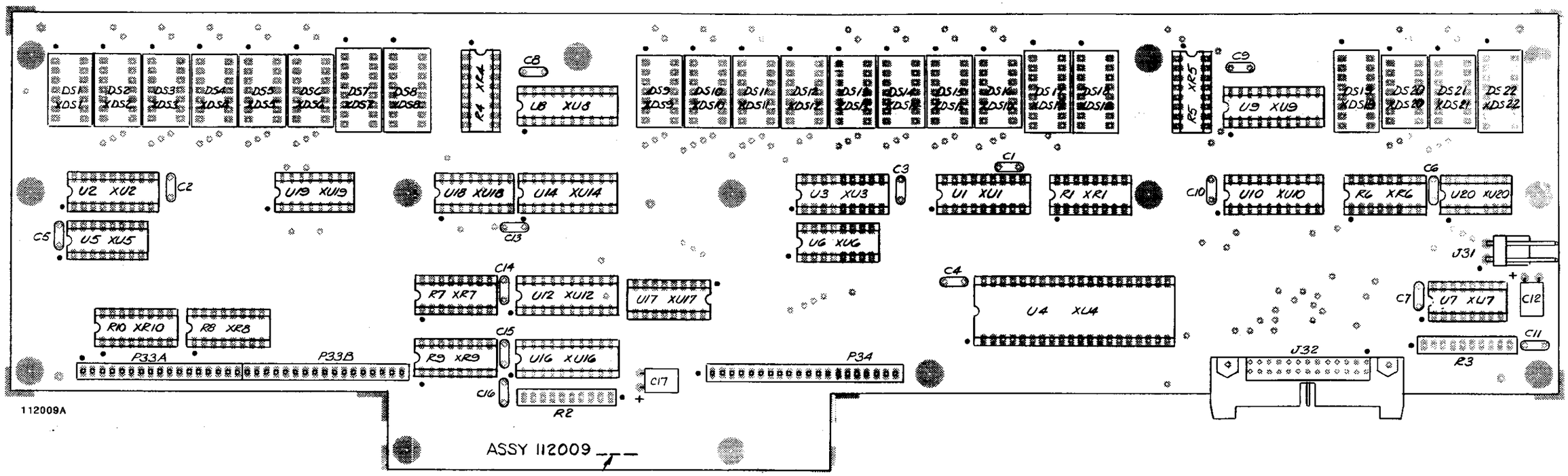
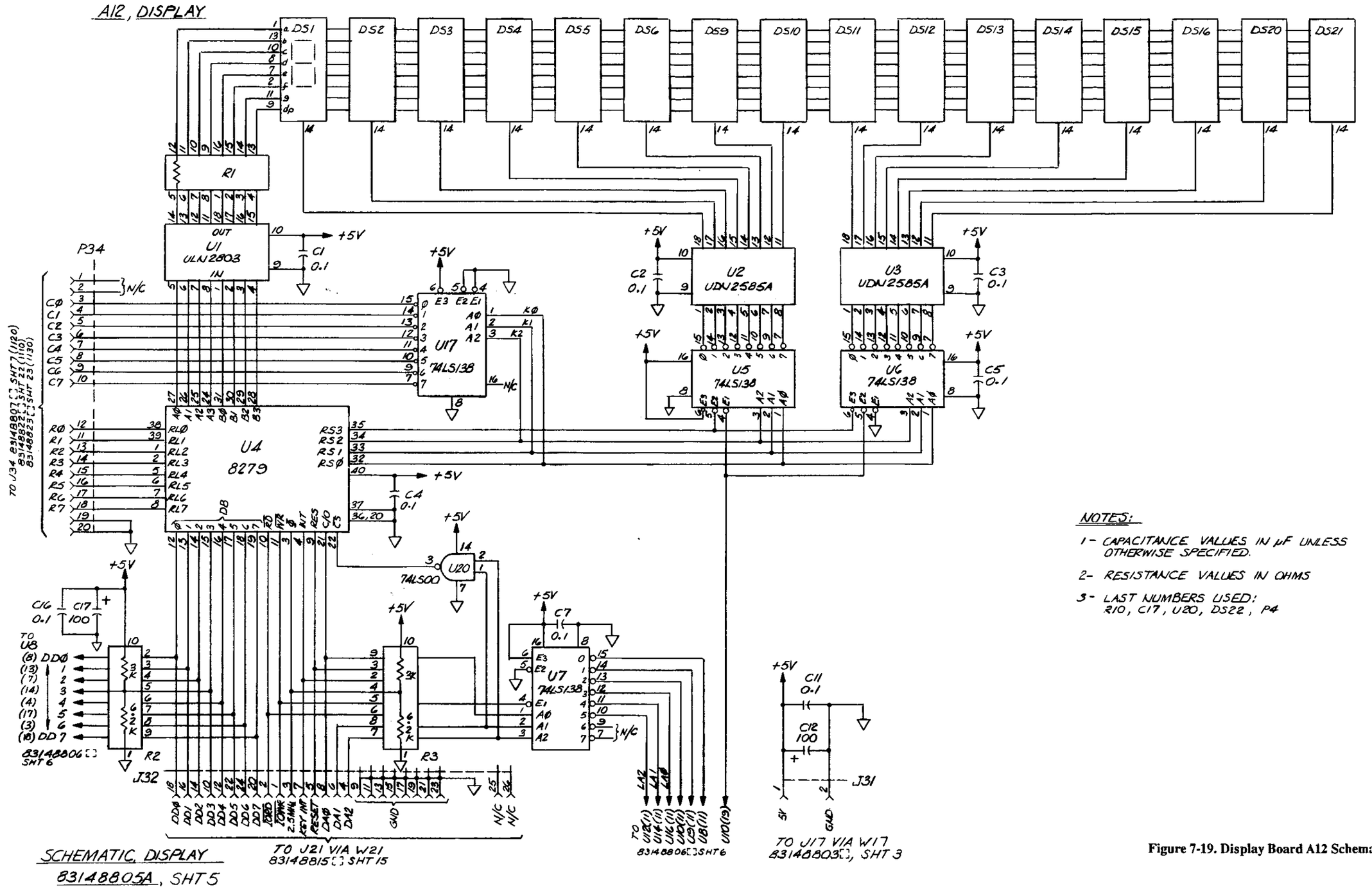


Figure 7-18. Display Board A12 Parts Location Diagram.



NOTES:

1- CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED.

2- RESISTANCE VALUES IN OHMS

3- LAST NUMBERS USED:
R10, C17, U20, DS22, P4

Figure 7-19. Display Board A12 Schematic Sheet 1.

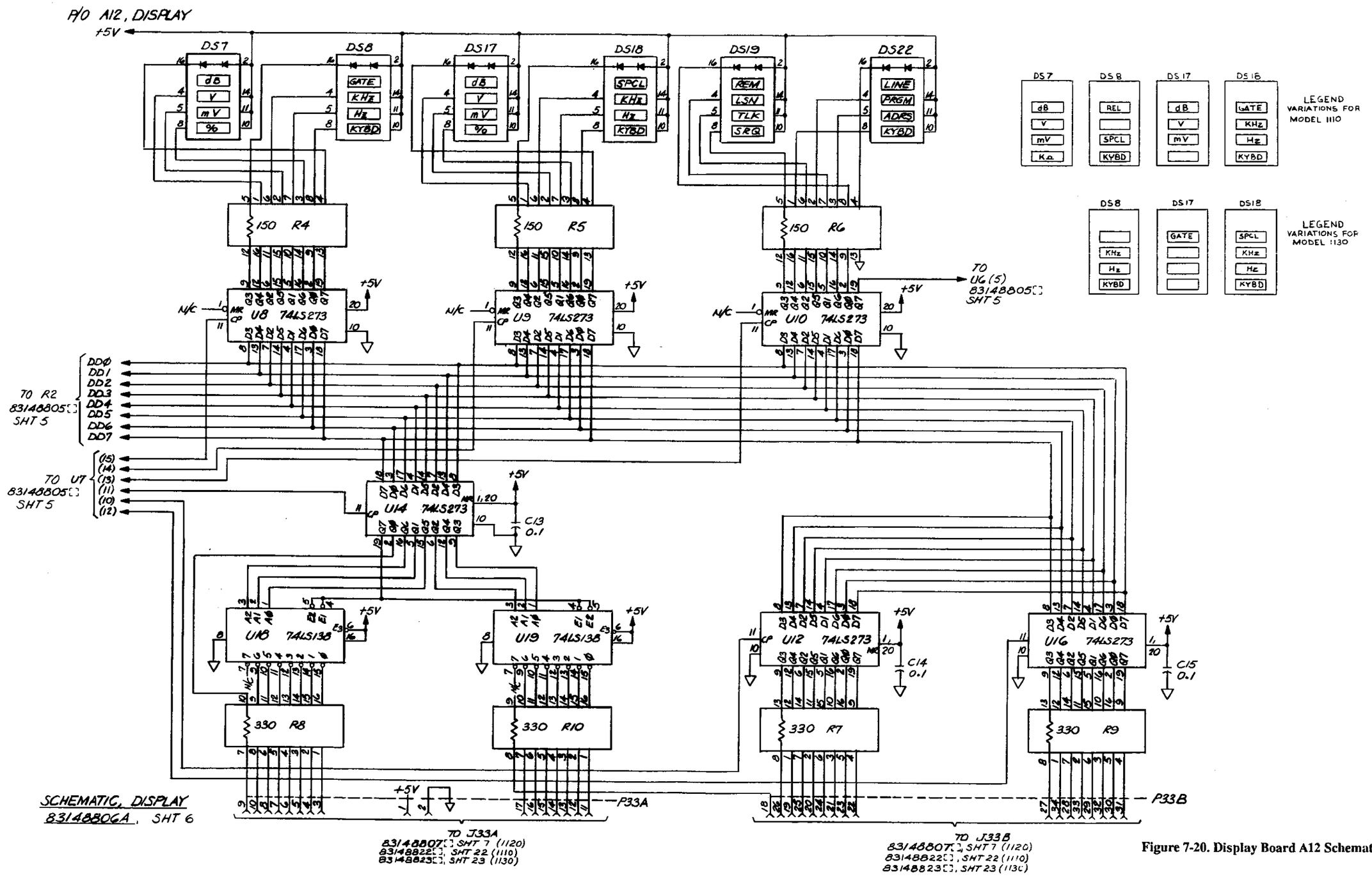


Figure 7-20. Display Board A12 Schematic Sheet 2.

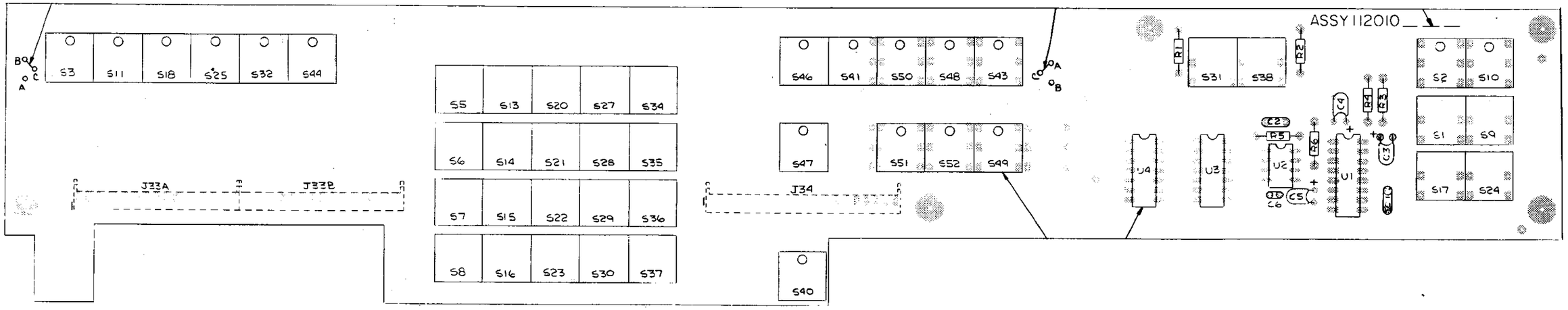
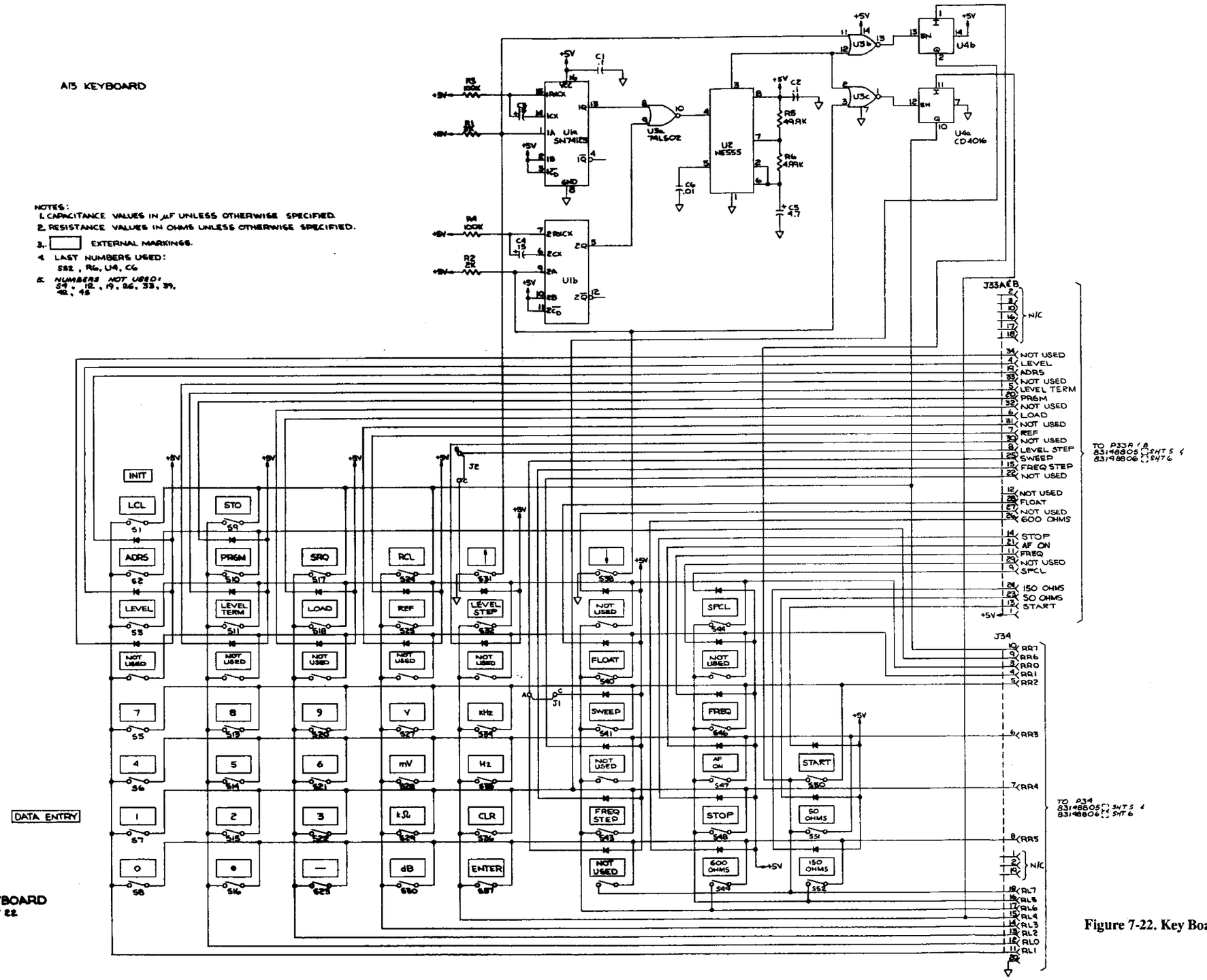


Figure 7-21. Key Board A13 Parts Location Diagram.



SCHEMATIC, KEYBOARD
83148B 22.B, SHT 22

Figure 7-22. Key Board A13 Schematic.

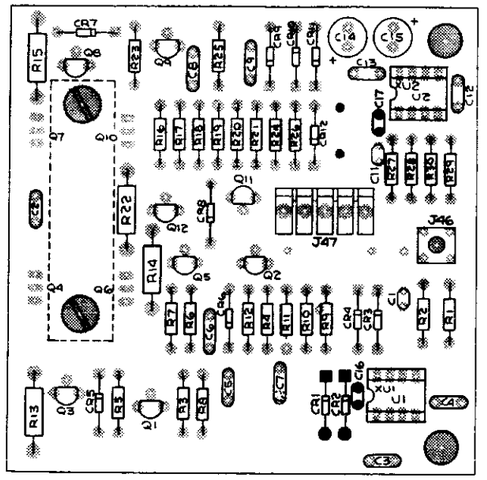


Figure 7-23. Amplifier Board A24 Parts Location Diagram.

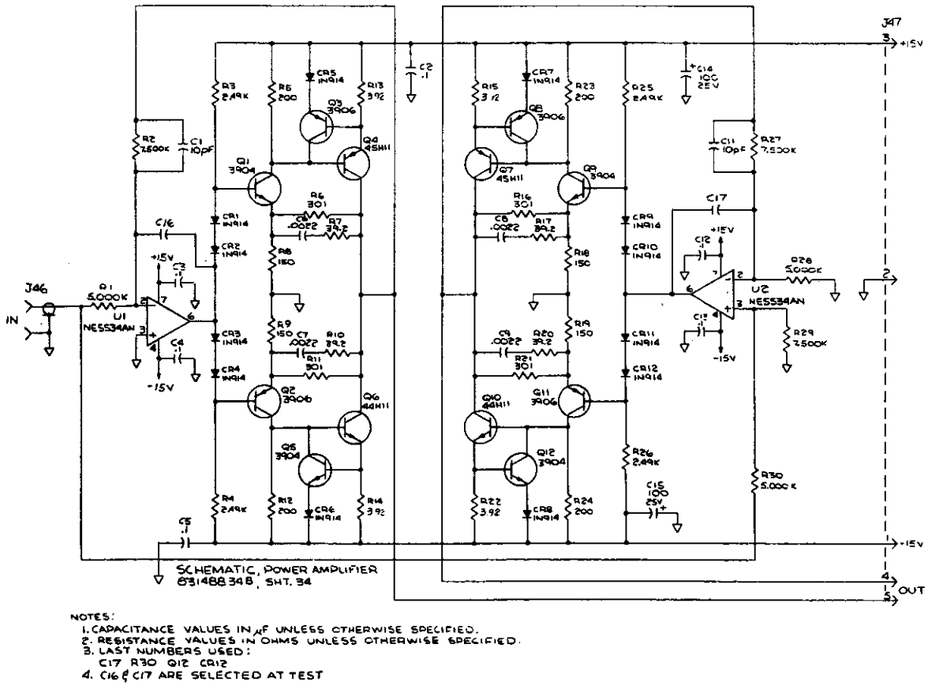


Figure 7-24. Amplifier Board A24 Schematic.