Errata

Title & Document Type: 5328A Universal Counter Service Manual

Manual Part Number: 05328-90011

Revision Date: April 1976

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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Agilent Technologies

5328A

UNIVERSAL COUNTER

SERVICE MANUAL

SERIAL PREFIX: 1604A

This manual applies to Hewlett-Packard Model 5328A Universal Counters with serial prefix number 1604A.

SERIAL PREFIXES NOT LISTED

For serial prefixes above 1604A, a "Manual Change" sheet is included with this manual. For series prefixes below 1604A, refer to Section V of this manual.

5301 STEVENS CREEK BLVD., SANTA CLARA, CALIF. 95050

Printed: APR 1976

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MICROFICHE PART NUMBER 05328-90012

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HEWLETT hp PACKARD

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TABLES

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FIGURES (Cont'd)

SAFETY CONSIDERATIONS

GENERAL

This is a Safety Class I instrument. This instrument has been designed and tested according to IEC Publication 348, "Safety Requirements for Electronic Measuring Apparatus".

This manual contains information, cautions, and warnings which must be followed by the service person to ensure safe operation and to retain the instrument in safe condition.

WARNINGS

SAFETY

If this instrument is to be energized via an autotransformer for voltage reduction, make sure the common terminal is connected to the earthed pole of the power source.

BEFORE SWITCHING ON THIS INSTRUMENT, the protective earth terminals of this instrument must be connected to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding).

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided.

Whenever it is likely that the protection offered by fuses has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

GROUNDING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

HIGH VOLTAGE

Warning — These servicing instructions are for use by qualified personnel only. To avoid dangerous electric shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

CAUTIONS

LINE VOLTAGE SELECTION

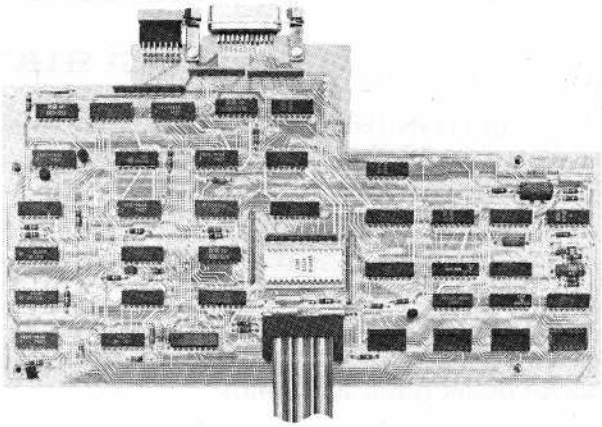
BEFORE SWITCHING ON THIS INSTRUMENT, make sure the instrument is set to the voltage of the power source. Verify that the power transformer primary is matched to the available line voltage. Verify that the correct fuse is installed.

GROUNDING

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

⚠ ATTENTION ⚠

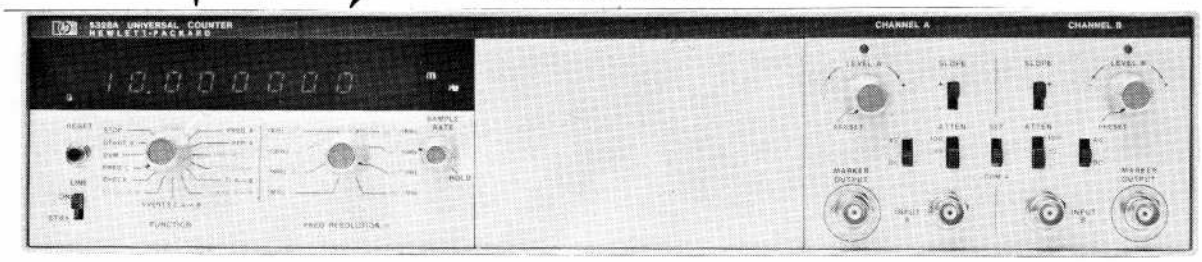
This symbol: ⚠ , which appears on the instrument means: Read the instruction manual before operating the instrument. If the instrument is operated without reading the instructions, it may not operate correctly.

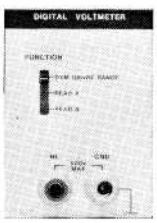


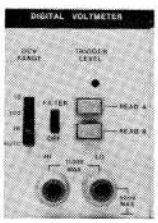
OPTION 010
OVEN
OSCILLATOR

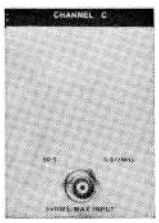
OPTION 011 *
HP-IB
INTERFACE

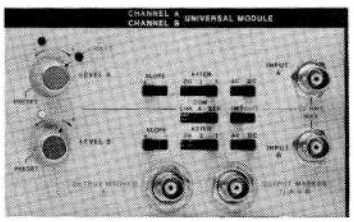
STANDARD 5328A











OPTION 020 *
DVM

OPTION 021 *
DVM

OPTION 030 *
CHANNEL C

OPTION 040 *
UNIVERSAL MODULE

*Service Information for these options is covered in separate service manuals.

Figure 1-1. Model 5328A Universal Counter with Options

SECTION I
GENERAL INFORMATION

1-1. SCOPE OF MANUAL

1-2. This manual provides service information for the Hewlett-Packard Model 5328A Universal Counter (including Option 010). A separate Installation and Service Manual is provided for each option supplied with the 5328A. Operating information for the 5328A (with options) is covered in the 5328A Users Manual.

1-3. This manual is divided into five sections containing the following information:

SECTION I GENERAL INFORMATION covers a description of the counter, options, equipment supplied, accessories available, and specifications.

SECTION II THEORY OF OPERATION covers a description of the general operating principles of the counter in reference to block and schematic diagrams of each assembly.

SECTION III MAINTENANCE contains maintenance and service information including a list of assemblies, recommended test equipment, performance checks and adjustments. Troubleshooting procedures and flowcharts are included in this section.

SECTION IV REPLACEABLE PARTS provides a complete list of replaceable parts and information for ordering parts.

SECTION V MANUAL CHANGES AND OPTIONS contains information on manual changes and available options. Field installation of Option 010 Oven Oscillator is contained in this section.

SECTION VI SCHEMATIC DIAGRAMS contains schematic diagrams and component locators. A description of reference designators, signal mnemonics and printed-circuit card identification is included.

1-4. DESCRIPTION

1-5. The standard 5328A mainframe measures frequency, period, period average, time interval, time interval average, and ratio. A totalize function is also provided. The capabilities of the instrument are expanded (as shown in Table 1-3) by installing the options described in paragraph 1-17. The 5328A provides an 8-digit (9 with Option 030) LED display, display storage, and leading zero blanking. Decimal point and unit readouts are displayed automatically. Two independent selectable input channels are provided for time interval measurements. Each input channel has an attenuator, trigger slope selector, level control, ac-dc coupling, and an oscilloscope marker output. Rear panel connectors provide a gate output, a time base output and an input for an external frequency standard. An ARM switch on the rear panel allows arming by the signal being measured (switch OFF) or by another input signal (switch ON).

1-6. INSTRUMENT IDENTIFICATION

1-7. Hewlett-Packard instruments have a 2-section, 10-character serial number (0000A00000), which is located on the rear panel. The 4-digit serial prefix identifies instrument changes. If the serial prefix of your instrument differs from that listed on the title page of this manual, there are differences between this manual and your instrument. Instruments having higher serial prefixes are covered with a "Manual Changes" sheet included with this manual. If the change sheet is missing, contact the nearest Hewlett-Packard Sales and Service Office listed at the back of this manual.

1-8. APPLICATIONS

1-9. Specific applications information is provided in Section IV of the 5328A Users Manual. The general application features of the 5328A are described in the following paragraphs.

1-10. The high sensitivity, frequency range, and signal conditioning controls (see Table 1-3) make the 5328A ideally suited for a wide range of applications. The direct count feature of the 5328A means that prescaling techniques are not used to achieve the 100 MHz frequency range (up to 512 MHz with Option 030). Direct count speed is required in high-speed totalizing or system applications. The dynamic range, input attenuators and trigger level range (see Table 1-3) permit measurements to be made on virtually any signal.

1-11. The controlled "arming" feature of the 5328A is useful in applications such as burst frequency measurements, and pulse amplitude measurements.

1-12. The optional integrating digital voltmeters measure trigger levels (critical in most time interval measurements) and external voltages. The hysteresis compensation feature of Option 040 means that the trigger level does not need resetting when the slope switch changes the polarity.

1-13. The standard 5328A single-shot resolution of 100 ns meets the requirements for applications such as mechanical and electromechanical device (relays) timing, time of flight measurements (ballistics), sonar ranging, radio ranging and navigation. The Option 040 provides increased resolution (to 10 ns) useful in applications such as computer/peripheral timing measurements, logic timing measurements, radar ranging and optical ranging. The delay feature of Option 040 allows unwanted signals to be ignored which would otherwise trigger the counter.

1-14. Using time interval averaging, time intervals as short as 100 ps, with resolution to 10 ps may be measured. Applications include cable length measurements, phase measurements, logic timing measurements, and integrated circuit propagation delay measurement.

1-15. Full bandwidth, sensitivity, and signal conditioning of the Channel A, B (and C for Option 030) input amplifiers is provided for ratio, totalizing, and scaling measurements.

1-16. The 5328A with Option 011 HP-IB Interface is able to output measurement data and be controlled (fully programmed) via the Hewlett-Packard Interface Bus (HP-IB). The 5328A is interfaced to HP-IB compatible instruments, calculators, or computers by simply interconnecting with an HP-IB cable.

1-17. OPTIONS

1-18. Several options are available with the 5328A, as listed below. If purchased as part of an initial order, options are installed at the factory and the instrument is ready for operation when received. Procedures for field installation of an option are described in the Installation and Service Manual supplied with each option (except for Option 010, Oscillator which is covered in this manual). Options 907, 908 and 909 are ordered by option number if part of an initial order, otherwise by part number listed in Table 1-2. The following options are available:

a. Option 010, High Stability Time Base. Oven oscillator with aging rate $<5 \times 10^{-10}$/day.

b. Option 011, HP-IB Interface. Allows 5328A to output data and be controlled via the HP Interface Bus.

c. Option 020, Digital Voltmeter (DVM). Single ended DVM for trigger level and external dc voltage measurements.

d. Option 021, High Performance DVM. Floating high accuracy DVM for trigger level and external dc voltage measurements.

e. Option 030, Channel C. Frequency measurements to 512 MHz; 15 mV rms sensitivity; direct count.

f. Option 040, High Performance Universal Module. Same as standard 5328A but with 10 ns single shot time interval; improved T.I. averaging; improved T.I. accuracy; measurements with delay; T.I. A—B marker; hysteresis compensation; switchable input impedance (1 MΩ/50Ω).

g. Option 907, Front Handle Kit.

h. Option 908, Rack Flange Kit (for instrument without handles).

i. Option 909, Rack and Handle Kit.

1-19. EQUIPMENT SUPPLIED AND ACCESSORIES AVAILABLE

1-20. Table 1-1 lists equipment supplied with the 5328A and Table 1-2 lists accessories available. The Service Kits listed in Table 1-2 are described in Section III.

Table 1-1. Equipment Supplied

DESCRIPTION	HP PART NO.
Detachable Power Cord 7½ ft (231 cm) long	8120-1348

Table 1-2. Accessories Available

DESCRIPTION	HP PART NO.
HP Interface Bus Interconnect Cable	10631A, 3 ft long (914 mm) 10631B, 6 ft long (1828 mm) 10631C, 12 ft long (3656 mm)
Front Handle Kit Rack Flange Kit (For instrument without handles) Rack and Handle Kit (Installation instructions included with above kits)	5061-0088 5061-0076 5061-0082
Service Kits: DVM Extender Board Kit Function Selector and ROM Kit Extender Board, 18 pin (2 required)	 05328-82020 05328-82004 05328-62016

1-21. SPECIFICATIONS

1-22. Table 1-3 lists detailed specifications for the 5328A including all options.

Table 1-3. Specifications

INPUT CHARACTERISTICS

Channel A and B (standard and option 040)

Sensitivity:
25 mV rms, 0—40 MHz (dc coupled)
20 Hz—40 MHz (ac coupled)
200 kHz—40 MHz (ac coupled and 50Ω with Opt. 040)
50 mV rms, 40 MHz—100 MHz
Min. pulse width: 5 ns, 140 mV p-p

Coupling: Ac or Dc, switch selectable

Impedance: 1 MΩ || <40 pF (switch selectable 1 MΩ or 50Ω nominal with Opt. **040**)

Trigger Level: Variable over ±2.5 volts times attenuator setting with 0 volt preset position.

Trigger Slope: independent selection of + or - slope

Attenuators: X1, X10, X100 (X1, X2, X20 with Opt. **040**)

Dynamic Range: 25 mV to 1 V rms x attenuator setting for 0—40 MHz; 50 mV to 500 mV rms x attenuator setting for 40—100 MHz

Maximum Input (dc coupled):

X1:	250 V rms, dc—50 kHz 1.25 x 10^7 V rms/freq., 50 kHz—2.5 MHz 5 V rms, 2.5—100 MHz
X10, X100:	250 V rms, dc—5 MHz 1.25 x 10^8 V rms/freq., 5—100 MHz
X2, X20 (Opt. **040**):	250 V rms, dc—500 kHz 1.25 x 10^8 V rms/freq., 0.5—25 MHz 5 V rms, 25—100 MHz
Ac coupled:	Vmax = 200 V (peak + dc) for dc—20 Hz; same as dc coupled for frequency greater than 20 Hz.
Opt. **040** 50Ω position:	5 V rms, dc—100 MHz

Channel Input: Common A or separate, switch selectable. In COM A position, sensitivity remains the same. Impedance becomes 1 MΩ || <65 pF for the standard and 500 kΩ || <65 pF for the Option 040 high impedance position. 50Ω position remains nominal 50Ω.

Channel C (option 030)

Sensitivity: 15 mV rms, 5 MHz—512 MHz
Coupling: dc
Trigger Level: 0 V, fixed
Impedance: 50Ω nominal
Maximum Input: 5 V rms
Input Protection: Fused

FREQUENCY MEASUREMENTS

Frequency A (standard and option 040)

Range: 0 — 100 MHz direct count
Resolution: 1 MHz to 0.1 Hz in decade steps
Accuracy: ±1 count ±timebase error
Display: kHz, MHz

Frequency C (option 030)

Range: 5 — 512 MHz direct count
Resolution: 1 MHz to 0.1 Hz in decade steps
Accuracy: ±1 count ±timebase error
Display: kHz, MHz

*Trigger error is <0.3% of one period for sinewaves of 40 dB S/N or better and amplitude equal to sensitivity of counter. For any waveshape, trigger error is less than

$$\frac{\pm 2 \times \text{peak noise voltage}}{\text{signal slope}}$$

$$\left(\text{or } \frac{\pm .0025\ \mu\text{sec}}{\text{signal slope in V/}\mu\text{sec}} \text{ for 40 dB S/N.}\right)$$

PERIOD MEASUREMENTS

Period A (standard and option 040)

Range: 0 — 10 MHz
Resolution: 100 ns to 1 s in decade steps (10 ns to 0.1 s with opt. **040**)
Accuracy: ±1 count ±timebase error ±trigger error*
Display: ns, μs, ms, s

Period Average A (standard and option 040) — the period of the signal at the A input is averaged over the number of periods, N, indicated by the resolution switch (N=1 to 10^7).

Range: 0 — 10 MHz
Resolution: 100 ns to .01 ps in decade steps (10 ns to .001 ps with opt. **040**)
Accuracy: ±1 count displayed ±timebase error

$$\pm \frac{\text{trigger error*}}{\text{no. periods averaged}}$$

TIME INTERVAL MEASUREMENTS

Time Interval A to B (standard and option 040)

Range: 100 ns — 10^8 s (10 ns — 10^7 s with opt. **040**)
Resolution: 100 ns to 1 s in decade steps (10 ns to 0.1 s with opt. **040**)
Accuracy: ±1 count ± timebase error ±trigger error*

Time Interval Average A to B (standard and option 040) — The time interval between a start signal at A and a stop signal at B is averaged over the number of time intervals, N, indicated by the resolution switch (N=1 to 10^7).

Range: 0.1 ns — 10 s (0.1 ns — 1 s with opt. **040**)

Resolution: $\frac{\pm 100\text{ ns}}{\sqrt{\text{no. intervals averaged}}}$ ± 10 ps

($\frac{\pm 10\text{ ns}}{\sqrt{\text{no. intervals averaged}}}$ ± 10 ps with opt. **040**)

Accuracy: $\frac{\pm 100\text{ ns} \pm \text{trigger error*}}{\sqrt{\text{no. intervals averaged}}}$ ± 4 ns ± timebase error

($\frac{\pm 10\text{ ns} \pm \text{trigger error*}}{\sqrt{\text{no. intervals averaged}}}$ ± 2 ns ± timebase error

with opt. **040**. The opt. **040** has a "jittered" clock in time interval averaging for those cases when the input is coherent with the 5328A's clock frequency.)

Minimum pulse width: 25 ns (10 ns with opt. **040**)

Minimum dead time: 150 ns (40 ns with opt. **040** and maximum repetition rate of 10 MHz) ("dead time" is the time between the preceding time interval's stop event and the current time interval's start event).

RATIO MEASUREMENTS

B/A and C/A (standard and option 040) — The ratio of the frequency at B (or C for C/A function when option 030 is installed) to the frequency at A is measured for N counts of A where N is selected by the resolution switch (N=1 to 10^7).

Range: A: 0 — 10 MHz
B: 0 — 100 MHz
C: 5 — 512 MHz

Resolution: 1 part in $\frac{B}{A} \times N$ (or $\frac{C}{A} \times N$)

Accuracy: ± 1 count of B (or C) ± trigger error* of A x freq. of B (or C) (N >1)
For N = 1, add ± 120 ns x freq. of B (or C)
(± 12 ns x freq. of B (or C) with **Opt. 040**)

Table 1-3. Specifications (Continued)

DIGITAL VOLTMETER MEASUREMENTS

DVM (option 020 and 021) — Trigger levels of input channels A and B and external voltages may be measured.

Maximum Sensitivity:	**OPT. 020**	**OPT. 021**
Meas. Time (N=):		
10 s ($N=10^7$)	1 mV	10 μV
1 s ($N=10^6$)	1 mV	100 μV
0.1 s ($N=10^5$)	2 mV	1 mV
10 ms ($N=10^4$)	20 mV	10 mV
1 ms ($N=10^3$)	200 mV	100 mV
Range:	0 to ±125 Vdc	±10, ±100, ±1000 Vdc, and AUTORANGE
Full range display resolution (1 sec measurement time):	±0.9999, ±9.999, ±99.99, ±125.0	±12.5000, ±125.000, ±1000.00
Accuracy: (20 min. warm-up)	±.5% reading ±4 mV	±.03% reading ±.004% range; for 1000 V range: ±.087% reading ±.004% range
Temp. Coefficient: (0 to 40°C)	±.05% reading/°C ±0.5 mV/°C	±.002% reading/°C ±.001% range/°C
Input Terminals:	Single ended	Floating pair
Input Impedance:	10 MΩ	10 MΩ
Normal Mode Rejection Ratio:	>60 dB at 60 Hz (50 Hz) ±0.1%	>80 dB at 50 Hz or greater with filter on
Effective Common Mode Rejection Ratio (1 kΩ unbalance):	—	DC: >120 dB AC: >120 dB for multiples of 60 Hz (50 Hz) with filter on
Response Time (step input):	70 ms	10 ms (filter off)
Maximum Input:	±500 V	HI to LO: ±1100 V all ranges; LO to chassis ground: ±500 V
Trigger Level Measurements:	2 mV display resolution	1 mV display resolution; trigger level reading automatically multiplied by setting of attenuator switch if using option **040** universal module

TOTALIZING AND SCALING MEASUREMENTS

Start A (standard and option 040) — The number of counts at the A input are totalized for N=1 on the resolution switch. For N >1, A/N is totalized and the scaled output (A/N) is available at the Timebase Out rear panel connector.

Range: 0 — 100 MHz for N=1
0 — 10 MHz for N >1

EVENTS C, A TO B (standard and option 040) — The number of events at the C input are totalized during the synchronized time interval (i.e., a multiple of 100 ns, or 10 ns for opt. 040) defined by inputs to channel A and B.

Accuracy: ±1 count of C ± trigger error* of A and B ± freq. of C x 120 ns
(±1 count of C ± trigger error* of A and B ± freq. of C x 12 ns with opt. **040**)

MEASUREMENTS WITH DELAY (Option 040)

Delay mode is activated by inner concentric knob on LEVEL A control of option 040 Universal Module (red LED indicates delay is activated). In delay mode, Channel A triggers and is then disabled from triggering again until the delay times out (disabled state occurs within 1 μs after triggering). Channel B is continuously disabled until the delay times out. After the delay, both A and B are enabled. The delay time may be measured by placing the counter in T.I. A→B and the Universal Module in check (CHK).

Delay range: 20 μs to 20 ms continuously adjustable

Minimum Dead Time: 1 μs between stop and next start (T.I. average measurements only)

Meaningful Functions: FREQ. A, PER A, PER AVG A, T.I. A→B, T.I. AVG A→B, RATIO C/A, START A, EVENTS C, A→B

HP-IB INTERFACE (Option 011)

Provides digital output of measurement data ("talker") as well as input for remote program control ("listener").

Programmable Functions: Function, Resolution, Sample rate (max, or manual control), Arming, Display modes, Measurement modes, Output modes, and Reset commands

HP-IB commands: responds to the following bus commands (see HP-IB Users Guides for definitions) — Unlisten, Untalk, Local Lockout, Device Clear, Serial Poll Enable, Serial Poll Disable, Go to Local, Selected Device Clear, and Group Execute Trigger.

Service Request (SRQ): if enabled, indicates end of measurement.

Maximum data output rate: 500 readings/sec

Table 1-3. Specifications (Continued)

GENERAL

Display: 8 digit (9 with Opt. 030) LED display

Blanking: Suppresses display of unwanted zeros to left of most significant digit

Storage: Holds reading between samples; can be overridden by rear panel switch.

Sample rate: Variable from less than 2 ms between measurements to HOLD which holds display indefinitely.

Gate output: Rear panel output; TTL levels; high when counter gate open

Timebase output: Rear panel output; TTL levels

Check signal: With function switch in CHECK, counter should display 10 MHz ±1 count. (With opt. **040**, place function switch in Freq A and universal module in CHECK (CHK) — counter should display 100 MHz ±1 count.)

Timebase:

standard crystal

Aging rate: $<3 \times 10^{-7}$/month
Temperature: $<2.5 \times 10^{-6}$ 0° to 50°C
Line voltage: $<1 \times 10^{-7}$ for 10% change

Opt. 010 oven oscillator

Aging rate: $<5 \times 10^{-10}$/day after 24-hour warm-up
Short term: $<1 \times 10^{-10}$ rms/sec
Temperature: $<7 \times 10^{-9}$ 0° to 50°C
Line voltage: $<\pm 5 \times 10^{-9}$ for 10% variation
Warm-up: $<\pm 5 \times 10^{-9}$ in 20 min.

Ext. Freq. Std. Input: 30 kHz to 10 MHz signal of amplitude >1.0 V rms into 1 kΩ. Maximum input: 5 V p-p. Correct reading obtained only with 10 MHz input. Other inputs give scaled readings. For opt. **040** only, the following constraints apply: ext. freq. std. must be 10 MHz for Period Avg., T.I. Avg., Period (N=1), and T.I. (N=1).

Trigger Lights: Light is ON when input is above trigger level; OFF when input is below trigger level; BLINKING when channel is triggering. Operative over frequency range 0—100 MHz.

Marker Outputs: Inverted channel A and channel B Schmitt trigger outputs available on front panel; 0 to -100 mV levels into 50Ω;<20 ns delay. (With Opt. **040**, inverted channel A Schmitt trigger and T.I. A→B marker outputs (0 to -50 mv) available on front panel—T.I. A→B is high during the time interval measured by the counter). Outputs protected from inadvertently applied voltage to ± 5 Vdc.

ARM: Rear panel switch turns arming ON or OFF. With arming ON, the measurement is armed by an input other than the input involved in the measurement. The following are armed by an event at B: FREQ A, PERIOD A, PERIOD AVG A, FREQ C, DVM, RATIO C/A; the following are armed by an event at C: T.I. A→B, T.I. AVG A→B, EVENTS C, A→B, RATIO B/A.

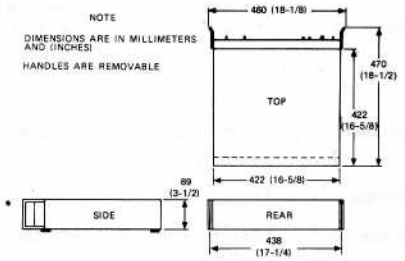
Operating Temperature: 0° to 50°C

Power Requirements: 100/120/220/240 V rms, +5%, -10% (switch selectable), 48—66 Hz; 150 VA max.

Accessories Furnished: Power cord, 229 cm (7½ ft.)

Weight: Net 8.5 kg (18 lb, 12 oz). Shipping 11.2 kg (24 lb. 12 oz)

Dimensions:



SECTION II

THEORY OF OPERATION

2-1. INTRODUCTION

2-2. This section contains a description of the operating principles of the counter in reference to an overall block diagram in this section and to individual block and schematic diagrams in Section VI. The standard mainframe assemblies are the A1 Motherboard, A2 Power Supply, A4 Function Selector, A10 Synchronizer, A19 Attenuator, and A16 Display. Detailed theory for Options 020 and 021 DVM's, Option 030 Channel C, Option 040 Universal Module, and Option 011 HP-IB Interface is covered in a separate manual for each option.

2-3. OVERALL DESCRIPTION

2-4. The 5328A is a basic universal counter mainframe that supports several options. In its standard configuration it offers the following universal counter functions:

- Frequency — 100 MHz direct count
- Period — 100 ns resolution or .1 μsec
- Period Average — 10 MHz clock
- Time Interval — 100 ns single-shot resolution of .1 μsec
- Time Interval Average
- Totalize — 100 MHz
- Ratio — 100 MHz/10 MHz
- Check

2-5. The inputs have matched (±4 ns) 100 MHz amplifiers with ac or dc coupling, ±2.5V trigger-level range, three-position attenuators (x1, x10, x100), 1 MΩ input impedance, slope controls, trigger lights that act like logic probes, and high speed output markers.

2-6. Capabilities can be greatly expanded by selecting options. Two DVM options provide dc voltage measurements. Option 020 is an economy version that offers millivolt sensitivity, 10 MΩ single ended inputs, 125V range, 0.5% accuracy, and the "read trigger level" function. Option 021 is a high performance unit that has 10 μV sensitivity, automatic or manual range control to 1000V, 10 MΩ floating inputs, switchable filter, 0.03% accuracy, read trigger level function, variable integration time, and high speed acquisition (up to 300 readings per second with two-dgit resolution). For applications requiring greater frequency range, a 5 to 512 MHz direct count Channel C Option 030 is available. This option offers 15 mV sensitivity across the band, 50Ω fuse-protected input, and a ninth digit added to the eight digit mainframe display. For applications requiring a precision time base, the high performance oven-stabilized time base Option 010 is available.

2-7. For greater precision in the basic counter functions, high performance universal module Option 040 is available. It has a 100 MHz clock for increased resolution in time interval and period measurements. Its functions are:

- Frequency — 100 MHz direct count
- Period — 10 ns resolution
- Period Average — 100 MHz clock
- Time Interval — 10 ns single-shot resolution
- Time Interval Average — 100 MHz phase jittered clock
- Totalize — 100 MHz
- Ratio — 100 MHz/10 MHz
- Check — 100 MHz

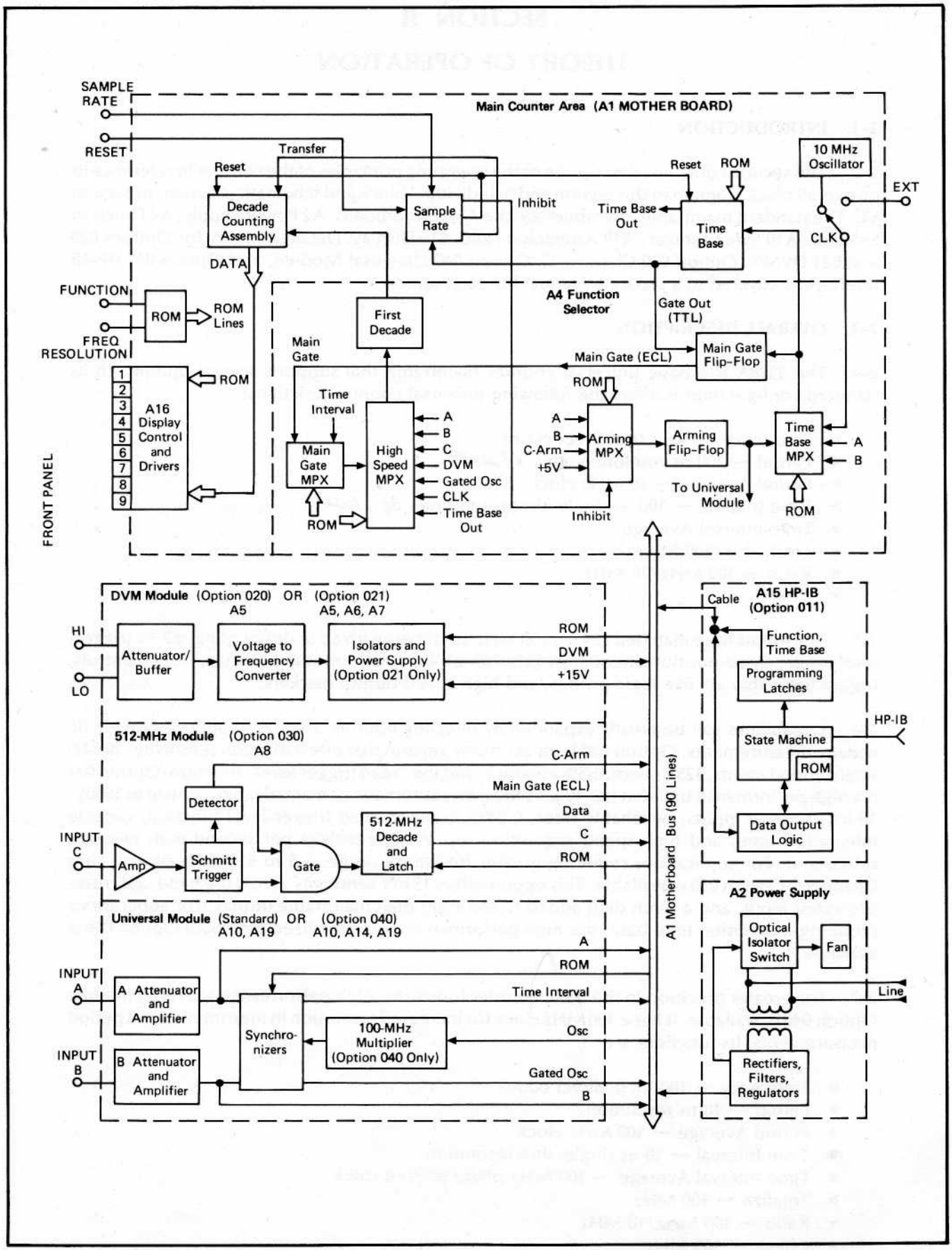


Figure 2-1. Block Diagram

2-8. The inputs have matched (±2 ns) amplifiers, ac/dc coupling, ±2.5V trigger level range, three-position attenuators (x1, x2, x20), 1 MΩ or 50Ω switchable input impedance, slope control, logic-probe trigger lights, channel A high speed marker, time interval A-to-B high speed marker, and a variable delay feature.

2-9. For systems applications Hewlett-Packard Interface Bus (HP-IB) Option 011 is available.

2-10. Configuration

2-11. The 5328A is organized into four main operating sections (refer to Figure 2-1):

- The main counter section
- The input options section
- The power supply section
- The Hewlett-Packard Interface Bus (HP-IB) option section

2-12. Each section operates relatively independently and communicates to the others through an internal bus system. The two-way bus consists of 90 lines.

2-13. The power supply provides regulated dc voltage for the other operating sections of the instrument. Its capacity is sufficient to accommodate any combination of options. The main on-off switch of the instrument operates only the central power supply regulator; the main ac power line is never broken. Unregulated dc is constantly fed to the oven oscillator (if installed), eliminating the need for time base warmup. The fan gets its power from the ac power line by way of a triac, which is switched off by an optical isolator when the instrument is turned off.

2-14. Main Counter Section

2-15. The main counter section on A1 Motherboard contains all of the functional subunits of a standard counter with the exception of input signal conditioning and special logic, which are contained in the input options section. The decade counting assembly contains eight decades of BCD counting logic, latches, and output multiplexing logic. The time base assembly contains eight counting decades, output multiplexing logic, and synchronizers to generate precise timing signals for the main gate. The oscillator section contains the standard room-temperature 10 MHz oscillator circuit and the input/output logic to accept an external signal via the rear panel or an internal signal from the optional crystal oven oscillator.

2-16. The sample rate circuit controls the instrument display cycle. Inhibit, reset, main gate, transfer, and sample rate signals are generated in this circuit, as is the BCD digit address code for the strobed display. Generation of decimal point and annunciators and decoding of BCD data are accomplished by the display control circuits. Data out of the decade counting assembly or the input option modules is decoded and displayed on the eight-digit LED display.

2-17. The A4 Function Selector serves as the main signal switch of the instrument. It routes input signals through multiplexers to the decade counting assembly and/or the time base. At the same time, it interacts with the display control circuits to determine the beginning and end of the display cycle. The precision ECL main gate signal is created on the function selector through interaction with the time base assembly. The function selector also has extensive interaction with the input option modules. It is the main receiver of the high speed data from the modules and the originator and receiver of module arming pulses.

2-18. The flexibility of the 5328A comes from the ability of all these operating subsections to accept diverse data from various combinations of input option modules. This is accomplished through the use of a 4K read-only memory (ROM) as the master control of the instrument. Located in the main counter section of the instrument, the ROM accepts the four-bit function code and the three-bit time base code from the front-panel switches or the HP-IB remote pro-

gramming board. The ROM generates 32 bits of output data which are transmitted throughout the instrument to set up each subsection for the particular measurement situation. Various combinations of input option modules are accommodated without circuit change as different ROMs are plugged into the instrument. This provides inherent obsolescence protection for the user. As each new input module is engineered, the mainframe needs only a new ROM (supplied in an update kit) to accept it.

2-19. Input Options Section

2-20. The input modules are the main interface between the instrument and the outside electronic environment. They accept input signals and convert them into the proper form to be handled by the main counter circuits.

2-21. The universal module contains the main input amplifiers, Schmitt triggers, and high-speed synchronizers for complex timing measurements. One of the key performance options of the 5328A is the selection of one of the two universal modules. The prime difference between the two is the basic clock rate. In the standard unit the basic 10 MHz clock provides 100 ns as the fundamental timing unit. In the high-performance unit (Option 040), a phase-lock multiplier extends this rate to 100 MHz and a basic timing unit of 10 ns. In the time interval averaging function, the multiplier unit, upon command from the ROM, phase modulates the 100 MHz clock with band-limited noise to prevent the synchronous lockup problems associated with this measurement.

2-22. The middle area of the option module section provides the instrument with extended frequency capability (Channel C Option 030). A 50Ω fuse-protected 512 MHz amplifier and Schmitt trigger feed the 512 MHz decade. Latches in this option strobe the ninth (least significant) digit from the module onto the data bus and into the display. In functions not requiring an input from this module, ROM lines deactivate the output strobing circuitry and the ninth digit on the display goes blank. The ninth LED digit is loaded into the mainframe display board only when the Channel C module is installed.

2-23. The third area of the option section contains the inputs for the optional digital voltmeters. Using a voltage-to-frequency conversion technique, these modules provide an output suited to the frequency measuring capabilities of the mainframe. The low-cost unit (Option 020) provides the 5328A with inexpensive access to the important capability of trigger level measurement as well as an excellent general-purpose single-ended voltmeter. In this unit and the high performance unit (Option 021), trigger level measurement is selected by means of switches located on the DVM front panel. When the user selects either READ LEVEL A or READ LEVEL B, the DVM module disconnects itself from the external banana input jacks, connects itself to the selected trigger level voltage, disengages the function and time base front-panel switches, places the code DVM on the function code bus and places 0.1s gate time (1 mV sensitivity) on the time base bus. Upon release of the READ LEVEL switch, the instrument returns to its previous state. Thus the user can check his trigger levels without having to change and reset his function and time base settings.

2-24. The high performance DVM option (021) provides the user with the measurement capability of a manual or autoranging floating DVM that has a range of 10 μV to 1000V and a basic accuracy of 0.03%. For particularly noisy environments, a switchable filter may be engaged to increase normal mode rejection to 50 dB at 50 or 60 Hz. Isolation for this option is accomplished through special high speed transformers, optical isolators, and an on-board switching dc-to-ac power supply. Although no remote programming of the front-panel controls is possible, remote controlled voltage measurement is quite easy. Through the use of special range controls in the V-to-F converter, a conversion factor of 10 kHz/volt is maintained regardless of the DVM's range. The voltmeter may be placed in autorange and the user simply programs the DVM function from the Hewlett-Packard Interface Bus (HP-IB) and any voltage from 10 μV to 1000V is measurable.

2-25. This technique results in a small problem. If, for example, the user puts 900 volts on the input terminals, the output frequency is 900 x 10 kHz = 9 MHz. In a measurement time of 1-

second, this would provide a resolution of 1 part in 9×10^6, far beyond the resolution limit of the V-to-F converter. To prevent the user from misinterpreting his results, the module blanks the meaningless data, thus providing the user with a display that contains only accurate data.

2-26. In the measurement of trigger levels, the high performance DVM performs much like the low-cost version, with an important exception. Measurement of trigger levels normally requires the user to compensate mentally for the attenuation factor used in the universal module input attenuator. For example, if one-volt is the trigger level voltage, x1 attenuation yields an effective trigger level of one-volt, x10 attenuation yields 10 volts, and x100 attenuation yields 100 volts. The high performance DVM, in combination with the high performance universal module, eliminates the need for mental multiplication, automatically reading out the effective trigger level in the three possible ranges of ±2.5 volts, ±5 volts, and ±50 volts.

2-27. Hewlett-Packard Interface Bus (HP-IB) Section

2-28. The fourth section of the instrument, the HP-IB assembly (Option 011), provides for control of the counter by the HP-IB. Plugging into the main instrument bus through a ribbon cable, the internally mounted HP-IB board controls function, time base, cycle rate, arming, and virtually all other controls in the instrument with the exception of the DVM and universal module front-panel controls. A special module programming system in the HP-IB board allows any future module to be programmed through the present HP-IB system. For a more detailed description of the capability of the HP-IB option, see the 5328A Users Manual.

2-29. A1 MOTHERBOARD

2-30. The A1 Motherboard (Figures 6-5 and 6-6) consists of five sections, as follows:

a. Display control.
b. State control.
c. Oscillator.
d. Decade Counting Assembly.
e. Time Base.

2-31. Display Control

2-32. The display control section on A1 Motherboard acts as an interface between the A16 Display Board and the other circuits of the counter.

2-33. The outputs of the A16 Display Board FUNCTION and RESOLUTION switches go to the ROM (A1U37). The outputs of the ROM position the decimal point and annunciators in the display and provide control functions for other circuits of the counter. Data from the data bus is translated from BCD to seven-segment form in decoder U41 and sent to the display which is strobed by U39. U39 decodes the digit address code from BCD to 1 of 10 form. Leading zero blanking is provided by the latch comprised of U32B and U40B. Latches U25, U26, U27, and U31 provide outputs related to function and time base codes for use in other sections of the instrument.

2-34. State Control

2-35. The state control section is comprised of circuits U1, U2, U3, U4, and U5. Decade Counter U1 generates the digit select strobe code for the display. Circuit U4 receives the Sample Rate signal and generates the main Reset, Transfer, and Inhibit signals.

2-36. Oscillator

2-37. The 5328A 10 MHz oscillator circuit consists of ECL crystal controlled oscillator Y1 and U15,

buffer amplifier, level shifting circuitry, internal/external mode control circuitry, and Option 010 oscillator control circuitry.

2-38. A ECL OR/NOR gate (U15A) as shown on the schematic diagram (Figure 6-6) functions as an amplifier with positive feedback. The positive feedback path is from the noninverting output, through a 10 MHz crystal and parallel configuration of fixed and trimmer capacitor (C17, C18), to one input of the gate. Negative feedback from the inverting output to the same input of the gate establishes the input bias for the gate amplifer. The noninverting output is buffered, translated to a TTL level and routed to a control gate (U17C). This gate is controlled by the rear panel DPDT EXT/INT switch and passes the internal oscillator signal when this switch is in the INT position. When installed, the Option 010 oscillator also appears at the input of this gate through J1. However, Option 010 disables the mainframe oscillator and its output is therefore passed through the control gate when in the internal oscillator operation. The output of the control gate goes to one input of gate U16B. The other input to this gate is the output of the external input signal Schmitt trigger gate U16A. When in internal mode, this signal is an enable signal to pass the internal oscillator signal. When in external, with a signal input at the rear panel OSC INT EXT connector, this signal is the external input. The output of this gate goes to the A4 Function Selector, Motherboard Bus, and EXT/INT switch S1. The EXT/INT switch and connector are connected such that the connector inputs an EXT signal in external operation and outputs the internal oscillator signal in internal operation. This oscillator circuit may be modified by installing Option 010 Oven Oscillator as described in Section V. The schematic diagram for Option 010 is shown in Figure 6-16.

2-39. Decade Counting Assembly (DCA)

2-40. The 5328A DCA is comprised of Decade Counter/Latches (U10 and U12) on the A1 Motherboard and U1A, U3, and U4B on A4 Function Selector Board. The Motherboard contains output enable circuitry (U6, U7, and U9) for controlling the counters output data, signal overflow indication, and circuitry for strobing data into the display (U41). The data output of each Decade Counter in the DCA corresponds to a digit on the display. The first Decade Counter in the sequence of operation corresponds to the least significant digit and the last to the most significant digit. Digits 0 through 5 are processed by U12, digit 6 by U10, and digit 7 by U11.

2-41. All measurements performed by the 5328A result in pulses being counted in the DCA. Pulses are admitted to the DCA by way of the Main Gate FF on A4 which is either controlled by a Gate Out signal from the Time Base (A1U19) or held open by the HOPN signal from A1U25.

2-42. Data strobe signals, transfer pulses, reset pulses, and an output disabling signal are routed to the DCA via the 5328A State Control Circuitry. These signals are processed in the DCA and are used to control transfer of the counter's output data to the latch outputs, strobe this data onto the Data Bus, disable the outputs that feed into the Data Bus, and reset the counters after a measurement cycle is over.

2-43. Time Base

2-44. The 5328A Time Base circuit is comprised of an 8 decade divider U21, shaping flip-flop U19A, and Synchronization flip-flop U19B. The Time Base input, depending on the particular measurement being made, is either the 10 MHz system clock or the channel A or B input signal. These signals are routed to the Time Base input via the ROM controlled Time Base Multiplexer U10 on the A4 Function Selector board.

2-45. The Time Base circuit has two modes of operation consistent with the two types of measurements performed by the 5328A. For frequency and time interval type measurements, the Time Base circuit generates a gate during which either oscillator or input pulses are counted. For totalize type measurements, the Time Base circuit divides its input by N as set on the RESOLUTION, N switch on the front panel and outputs the divided signal to be counted in the

DCA. The outputs of the Time Base circuit, corresponding to both operating modes, are generated simultaneously. Regardless of the type of measurement being performed, these outputs are made available to the A4 Function Selector which selects the proper signal to perform the function.

2-46. The length of the gate time generated by the Time Base circuit and the scale factor of the Time Base Input is determined by the Time Base code. The 5328A Mainframe ROM reads the codes of both the Time Base (RESOLUTION, N) and FUNCTION switches and outputs the proper code to the Time Base such that measurement resolution and scale factor agree with the information in the various (RESOLUTION, N) switch positions.

2-47. A2 POWER SUPPLY

2-48. The power supply shown in Figures 6-7 and 6-8 has five output voltages: +5, -5.2, +15, -15, and +3.5 volts, dc. The +5V and -5.2V circuits are essentially the same as are the +15V and -15V sections, so only the positive voltage sections will be described.

2-49. +5V Supply

2-50. The +5V supply is a switching regulator that has greater efficiency than a linear regulator of the same output. When the output voltage is below its nominal level, comparator U1 sees its + input being above its - input and hence its output goes positive turning on transistor Q5 which in turn turns on Q3 and Q1. The voltage at the collector of Q1 now goes high (greater than 17V) and current starts to build up through L1, charging the output capacitor and increasing the output voltage. At the same time positive feedback is provided via resistor R11 to maintain the situation until the output goes slightly above +5V. When the voltage reaches this point the comparator output voltage starts to fall turning off transistors Q5, Q3, and Q1 causing the voltage at the collector of Q1 to fall. This provides positive feedback via resistor R11 to reinforce the charge. As a result, transistors Q5, Q3, and Q1 are turned off hard, and the voltage at the collector of Q1 goes negative, except for diode CR3 which clamps the voltage to ground. During this part of the cycle, current flows through diode CR3 and coil L1 allowing the energy which has been stored in the field of L1 to go into the load. This goes on until the output voltage again goes low enough to overcome the offset at the input of comparator U1 and turn transistor Q1 on again.

2-51. The +15V supply is a simple linear regulator using transistor Q7 as the pass transistor. Transistor Q9 provides level shifting and current gain while U3 is used as comparator and gain block.

2-52. The +3.5V supply is also a simple linear regulator with the operational amplifier section of U5 being used as a comparator and gain block. Resistor R32 provides overcurrent limiting to protect against shorts.

2-53. A4 FUNCTION SELECTOR

2-54. The A4 Function Selector serves as the main high-speed switching module of the 5328A as shown in Figures 6-9 and 6-10. It receives high-speed differential ECL data from the Main Bus (from the modules that process the signal input) and routes that data to either the Time Base or the DCA. In addition, the Main Gate FF, the Arming Multiplexer and Arming FF, and the First Decade of the DCA are on the A4 Function Selector assembly.

NOTE

Refer to Table 6-1 for definitions of mnemonics.

2-55. High Speed Multiplexer, Main Gate, and 1st Decade

2-56. High speed multiplexer U6 serves as the main multiplexer and routes the following signals to the 1st decade of the DCA: A, B, GATED OSC (GOSC), C, DVM, TIME BASE OUT (TBO), and

OSCILLATOR (OSC). ROM lines IA, IB, and IC control the active address of the multiplexer. Pin 2 (enable) of the multiplexer serves as the Main Gate. The Low Time Interval (LTIF), Low Main Gate FF (LMGF), or (LTOT•LST), signal operating through U8 and enabled by ROM lines LMGF, LTIF, (LTOT•LST), respectively control the Main Gate. In addition, ROM line HOPN can override LTIF or LMGF and lock open Main Gate U6(2) through U8C. Main Gate status is detected and sent off the A4 Function Selector by ECL-to-TTL translator U2D. Capacitor C11 and resistor R35 serve to stretch any ECL gate signal present at U2(10) so that the slower TTL control chip A1U4 and gate light one-shot (Q6, U36B, E) can see the pulses and properly react. U8D differentially drives bus lines MG and $\overline{MG}$ to operate the remote Main Gate of channel C.

2-57. The output of the main multiplexer U6(15) feeds into first binary U1 of the main DCA. U1A is an ECL High-Speed binary the output of which couples to pins 14 and 15 of ECL-to-TTL translator U2. The TTL output of U2(13) clocks Schottky quinary U4 and U3. The outputs of the first decade U3(9), U4(9), U3(5), and U2(13) travel off the A4 Function Selector board to the DCA on the A1 Motherboard where they are latched and the carry feeds into the next decade of the DCA.

2-58. Arming Multiplexer and Arming FF

2-59. The Arming FF, the second half of U4, serves to inhibit various measurements by enabling or disabling Time Base Multiplexer U10 and the synchronizers in the Universal Module. This action occurs via the High Disables Synchronizers (HDS) signal from U4(6). The signal which sets or enables U4 comes from Arming Multiplexer U5(6). ROM lines control U5(10, 11) while the remaining address line (pin 9) is controlled by the Low Arm (L ARM) signal from the rear panel ARM switch. U5 thus selects either C-ARM, A, B, or free run (+5V) as the signal to send to U4 as the Arming signal. The A and B signals are derived from ECL-to-TTL translator U2A and U2B, respectively. Capacitors C4 and C5 and resistors R17 and R18 serve as pulse stretcher timing elements to enable the narrow ECL pulses on lines $\overline{A}$ and $\overline{B}$ to be seen by the TTL Arming FF U4.

2-60. Time Base Multiplexer and Main Gate FF

2-61. Time Base Multiplexer U10 selects either A, B, or OSC to send the Time Base Input (TBI) signal via pin 8 to the Time Base. This same signal is also sent to U1, the Main Gate FF, as a resynchronizing signal. ROM lines R(HTBA), R(HTBO), and R(HTBB) control the selection of the Time Base Input signal. The HDS signal to U10(13) or ROM line LTOT to U10(1) serve to enable or disable U10.

2-62. U1B is a high-speed ECL FF used to generate precise stable gate times for the Main Gate Multiplexer U8 and the remote gate in the Frequency C module. A TTL replica of the Main Gate signal (GATE OUT) is generated in the Time Base and sent to U1 via the line Main Gate Synchronizer on the Motherboard. Resistors R14 and R43B translate this TTL signal down to ECL levels at U1(10). The output of Time Base Multiplexer U10 via resistors R42 and R43D and capacitor C16 clocks U1(11) yielding a synchronized fast rise and fall time Main Gate signal on U1(14).

2-63. An Example of Operation

2-64. To show how the above mentioned function selector circuits operate together an example of the measurement of frequency A is given in the following paragraphs.

2-65. Assume the counter is in the middle of its display cycle. Low Inhibit (LINH) is TTL low, High Reset Time Base (HRTB) has momentarily gone high resetting U1 and U4 and High Reset Decade (HRD) has momentarily gone high resetting First Decade U1, U4, and U3. The control chip on the Motherboard releases LINH to go high. U9(13) goes low enabling Arming Multiplexer U5. Assuming that self arm has been selected, A will have been selected by the ROM on pins 9, 10, and 11 of U5. When the first A pulse occurs U4(4) goes low setting U4. U4(5) goes high turning on transistor Q1 which in turn pulls LINH low again and inhibits another measurement

from starting until Reset has occurred. In a frequency measurement, the ROM selects the Oscillator signal on pin 2 of U10 to be sent into the Time Base. Shortly after the Time Base returns, a high signal on Main Gate Synchronizer drives U1(10) high. On the next Oscillator signal (through U10) U10(11) gets clocked causing U1(14) to go low. This low signal propagates through U8(B and C) to U6(2) opening the Main Gate and initiating the count. Signal A has been selected on U6 by ROM lines R22, 23, and 24 thus each A event is counted into 1st decade U1A, U4A, and U3.

2-66. After the appropriate gate time has elapsed (N clock counts into the Time Base) the Main Gate Synchronizer signal goes low and the next Oscillator signal clocks Main Gate FF U1 closed. U2(10) detects the closing of the Main Gate and sends a TTL signal (LMGF) to U4 in the State Control section of the A1 Motherboard which initiates a new display cycle.

2-67. STANDARD TIME INTERVAL MODULE (A10 AND A19)

2-68. This module, shown in block form in Figure 6-11, is comprised of A19 Attenuator/Amplifier assembly and A10 Synchronizer assembly. These assemblies contain the 100 MHz A and B channels with signal conditioning (SLOPE, AC/DC, ATTEN, SEP/COM A) controls, amplifiers, Schmitt trigger, trigger lights and markers, and synchronizing circuitry for time interval and period type measurements. For most of the circuitry, channel A and B are identical. Therefore, only channel A will be discussed.

2-69. The A input signal enters the A19 board (Figure 6-12) through J2 and depending on the position of switch S3 is either ac coupled through capacitor C7 or dc coupled across the switch contacts. It then enters the 3 position attenuator (X1, X10, X100) and passes from the selected attenuation node through switch S4 to the FET impedance converter stage. This stage consists of Q1 A and B and resistors R3, R4, R6, and R7 connected in a zero offset totem-poll configuration. The signal at the node between resistors R6 and R7 follows closely the signal at the gate of Q1A. Resistor R3 is used to adjust any initial offset voltage. Diodes CR2 and CR3, resistors R8, R9, R10 and capacitors C4 and C5 form an overvoltage protection network to limit the signal to transistor Q1 and successive circuits to ±3.6 volts (max).

2-70. The SEP/COM A switch (S5) connects the input of the B channel impedance converter to either the B channel attenuator output or the A channel attenuator output.

2-71. The signal then passes through J5(6) to the A10 Synchronizer board (Figure 6-13), where it enters the dual Schmitt trigger U1. Trigger U1 compares the signal at pin 12 to a dc reference between ±2.5V generated by R1, R2, and R3 on its other input (pin 11) and changes state at its output whenever the input crosses this reference voltage. The output is ECL (≈ -.8V to -1.6V) and drives both the A trigger output and the exclusive OR gate U2B. U1 has approximately 15 mV peak-to-peak hysteresis at its input.

2-72. The exclusive OR gate U2B is used in conjunction with U3 to select the slope of the input waveform that is desired. When pin 5 on U2B is held to an ECL high level (SLOPE switch in + position), U2B acts as an inverter. When pin 5 goes low (SLOPE switch moved to - position), U2B does not invert the signal passing through it. Circuit U3 is a one-shot that only triggers on a negative edge, and therefore passes only trigger events that occur on the slope selected by U2B.

2-73. The output of U3D at pins 9 and 15 are differential ECL pulses of approximately 5—10 nanoseconds width. These pulses go to the A4 Function Selector to be counted as A events and to U4, an ECL-to-TTL converter and pulse stretcher. The feedback through capacitor C16 stretches the 5 nanosecond ECL pulse at pin 10 to an approximately 25 nanosecond TTL pulse at pin 12.

2-74. A similar pulse stretcher is used to convert the tigger output at Schmitt trigger U1(15) to a trigger light signal. A larger feedback capacitor (C20) is used to convert the output to a pulse of long enough duration to be seen when driving the trigger light LED. Because this pulse stretcher is dc coupled to the Schmitt trigger, it functions like a logic probe with adjustable threshold voltage.

When the channel A input is higher than the trigger level setting the trigger light LED is ON. When the input is lower, the LED is OFF, and whenever it passes through the trigger threshold, the LED blinks on or off depending on the polarity of the input signal.

2-75. The remaining circuitry consisting primarily of IC's U5, U6, U7, U9, and U10 is used to generate synchronized time interval and gated oscillator pulses for the mainframe to use in TI, TI AVE, PER and PER AVE functions. After a reset pulse enters on the High Disables Snychronizers (HDS) line, the RS FF's (U5) and D FF's (U7) are reset through U6B and $\overline{TI}$ is an ECL high, $\overline{GOSC}$ is an ECL high, and GOSC is at VBB ≈ -1.2V. When a start event enters U5(13), it sets the FF output at U5C low and pin 12 on U7 high. The next 10 MHz clock pulse synchronously sets U7(9) high, and $\overline{TI}$ goes low, telling the A4 Function Selector that the time interval has begun. $\overline{GOSC}$ also begins to output 10 MHz oscillator pulses. When a stop event occurs at U5(1), (U9 is a 2 input multiplexer and selects channel A as the stop event for PERIOD measurements and B as the stop event for TI measurements) the FF output at U5(3) goes high, and synchronous to the next oscillator pulse sets U7(6) low. This disables $\overline{TI}$ and $\overline{GOSC}$ sending them high again, then propogates through two U6 gates to reset all FF's and thus prepare them for the next measurement.

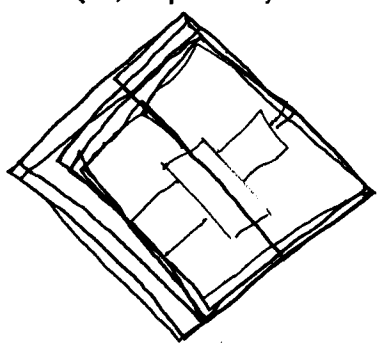
2-76. U7(8) is a control line which disables the stop channel in Period measurements until a start event has been detected.

2-77. A16 DISPLAY ASSEMBLY

2-78. The Display Assembly contains the display, as shown in the block diagram in Figure 6-14, in additon to switches S1 (POWER), S2 (RESET), S3 (FUNCTION), S4 (FREQ RESOLUTION, N) and SAMPLE RATE control R6 as shown in the schematic diagram in Figure 6-15.

2-79. The display consists of a 9-digit (9th digit used with Option 030, Frequency C only) seven-segment LED numeric display (DS1-DS9) and annunciators for indicating measurement units (DS10-DS16) in addition to overflow (DS17), remote (DS18), and gate (DS19). The display digits and annunciators are automatically displayed with the correct decimal point.

2-80. The digit address code from A1U39 on the Motherboard is applied to transistors Q1 through Q9 to strobe each digit which receives the seven-segment code from A1U41 through transistors Q13—Q20. The gate (DS19), remote (DS18), and overflow (DS17) LED's receive signals from the Motherboard through transistors Q10, Q11, and Q12, respectively.



SECTION III
MAINTENANCE

3-1. INTRODUCTION

3-2. This section gives maintenance and service information. Included is a table of assemblies, recommended test equipment, in-cabinet performance checks (which may be used to verify proper counter operations) and adjustments.

3-3. ASSEMBLY DESIGNATIONS

3-4. Table 3-1 lists the designations, name, and Hewlett-Packard part number of assemblies used in this instrument.

Table 3-1. Assembly Identification

Assembly	Description	HP Part No.
A1	Motherboard	05328-60001
A2	Power Supply	05328-60003
A3	Oven Oscillator Support Board (Option 010) Supports Plug-In Oscillator (10544A)	05328-60018
A4	Function Selector	05328-60005
A5	DVM (Option 020)	05328-60011
A5	PS Auto Range (Option 021)	05328-60012
A6	Buffer Amplifier (Option 021)	05328-60013
A7	VF Converter (Option 021)	05328-60014
A8	Frequency C (Option 030)	05328-60016
A9	Not Assigned	
A10	Synchronizer (Standard)	05328-60006
A10	Synchronizer (Option 040)	05328-60008
A11	Not Assigned	
A12	Not Assigned	
A13	Not Assigned	
A14	Multiplier (Option 040)	05328-60010
A15	HP-IB Board (Option 011)	05328-60019
A16	Display	05328-60004
A17	DVM Front Board (Option 021)	05328-60015
A18	Not Assigned	
A19	Attenuator (Standard)	05328-60007
A19	Attenuator/T.I. Amp (Option 040)	05328-60009

3-5. TEST EQUIPMENT

3-6. Test equipment recommended for maintaining and checking performance is listed in Table 3-2. Test equipment having equivalent characteristics may be substituted for the equipment listed.

Table 3-2. Recommended Test Equipment

Instrument Type	Required Characteristics	Recommended Type
Frequency Standard	1 MHz Output	HP 107AR
Oscilloscope Vertical Plug-In Time Base Plug-In	50 MHz Bandwidth 50 mV/cm Sensitivity 50 MHz Bandwidth	HP 180A HP 1801A HP 1820A
Test Oscillator	10 Hz to 10 MHz at 5V p-p	HP 651B
VHF Signal Generator	10 MHz to 480 MHz	HP 608E
Frequency Counter	10 to 80 MHz Frequency Measurements	HP 5381A
DC Voltmeter	0 to 200V dc, 1% accuracy	HP 970A
AC VTVM	0 to 250V ac	HP 400F
RF Voltmeter	1 mV to 3V	HP 3406A
Logic Probe	Logic State Test	HP 10525T
Logic Pulser	State Activator	HP 10526T
Logic Comparator	IC Test	HP 10529A
DVM Extender Board Kit		05328-82020
Function Selector and ROM Kit		05328-82004

3-7. ASSEMBLY CONNECTION IDENTIFICATION

3-8. Throughout the manual, connections to printed-circuit assemblies are referred to in abbreviated form. For example, connection to A4 pin 10 is A4(10).

3-9. PREVENTIVE MAINTENANCE

3-10. Preventive maintenance consists of periodic inspection, cleaning, performance checks, and oscillator calibration. Table 3-3 lists the recommended schedule of preventive maintenance routines.

Table 3-3. Preventive Maintenance

Routine	Schedule
Inspection	Weekly
Cleaning	Monthly
Performance Check	As required
Oscillator Calibration	Quarterly

3-11. Inspection

3-12. The 5328A should be inspected for indications of mechanical and electrical defects. Electronic components that shown signs of overheating, leakage, frayed insulation, and other signs of deterioration should be checked and a thorough investigation of the associated circuitry should be made to verify proper operation. Mechanical parts should be inspected for excessive wear, looseness, misalignment, corrosion, and other signs of deterioration.

3-13. Cleaning

3-14. The instrument should be kept free of dust, moisture, grease, and foreign matter to ensure trouble-free operation. A dry clean cloth, a soft bristled brush, or a cloth saturated with cleaning compound may be used.

WARNING

100/120/220/240 VAC SUPPLY WIRES ARE EXPOSED WHEN EITHER TOP OR BOTTOM COVER IS REMOVED. USE EXTREME CAUTION DURING TROUBLESHOOTING, ADJUSTMENT, OR REPAIR. AVOID DAMAGE TO INSTRUMENT BY REMOVING POWER BEFORE REMOVING OR REPLACING COVERS, ASSEMBLIES, OR COMPONENTS.

3-15. In-Cabinet Performance Check

3-16. GENERAL. The performance check (Table 3-4) and test card sheet that follows the check can be used to verify and record proper operation of all circuits of the counter and may also be used:

a. As part of an incoming inspection check of instrument specifications.

b. Periodically, for instruments used in systems where maximum reliability is important.

c. As part of a procedure to locate defective circuits.

d. After any repairs or adjustments and before returning instrument to regular service.

e. As a permanent record of instrument maintenance performed, because the test record pages are perforated and may be removed.

3-17. REPAIR

3-18. Printed Circuit Component Replacement

3-19. Component lead holes in the circuit boards have plated-through walls to ensure good electrical contact between conductors on opposite sides of the board. To prevent damage to the plating and the replacement component, apply heat sparingly, and work carefully.

3-20. Replacing Integrated Circuits

3-21. Following are two recommended methods of replacing integrated circuits:

a. SOLDER GOBBLER. This is the best method. Solder is removed from board by a soldering iron with a hollow tip connected to a vacuum source.

b. CLIP-OUT. This method should be used as a last resort only. Clip the leads as close to the base as possible. With a soldering iron and long nose pliers, carefully remove the wires from each hole. Then clean the holes.

Table 3-4. In-Cabinet Performance Check

1. TIME BASE STABILITY AND OUTPUT

a. Set counter front panel controls as follows:

SAMPLE RATE	Midrange
FUNCTION	FREQ A
FREQ RESOLUTION, N	.1 Hz
SLOPE (A)	+
AC/DC (A)	DC
ATTEN (A)	1
SEP-COM	SEP
LEVEL A	PRESET

b. Set counter rear panel controls as follows:

STORAGE	ON
OSC	INT
ARM	OFF

NOTE

Allow 30-minute warmup before proceeding to step c.

c. Connect 1 MHz frequency standard to INPUT A.

d. A counter display of OF 1000.0000 kHz indicates that counter time base frequency is exactly 10 MHz. The offset between counter time base and 1 MHz frequency standard can be determined by subtracting 10 MHz from the indicated oscillator frequency.

COUNTER DISPLAY	INTERNAL OSCILLATOR FREQUENCY
999.9950 kHz	10 000 050 Hz
999.9960 kHz	10 000 040 Hz
999.9970 kHz	10 000 030 Hz
999.9980 kHz	10 000 020 Hz
000.9990 kHz	10 000 010 Hz
1 000.0000 kHz	10 000 000 Hz
1 000.0010 kHz	9 999 990 Hz
1 000.0020 kHz	9 999 980 Hz
1 000.0030 kHz	9 999 970 Hz
1 000.0040 kHz	9 999 960 Hz
1 000.0050 kHz	9 999 950 Hz

e. Record frequency offset on test card that follows this table. For long term stability, operate the counter continuously for at least one month. Measure frequency offset at one month intervals.

f. To calibrate the counter time base to the frequency standard, perform time-base adjustment in paragraph 3-24.

NOTE

Temperature must be held constant or compensation for temperature difference must be made whenever a frequency difference is recorded. Unless a record of the temperature and date of last calibration is available, the frequency offset should not be considered drift or aging rate of the 10 MHz crystal.

Table 3-4. In-Cabinet Performance Check (Cont'd)

g. Connect oscilloscope vertical input to OSC jack on counter rear panel. Use 50-ohm termination.

h. Oscilloscope should display 10 MHz nominal at ≈1V. Record on test card.

i. Disconnect test equipment.

2. SELF CHECK

a. Set counter controls as follows:

FUNCTION	CHECK
SAMPLE RATE	CCW
OSC	INT
ARM ON/OFF (rear panel)	OFF
STORAGE ON/OFF (rear panel)	ON
RESOLUTION	DISPLAY
1 MHz (1)	10.
.1 MHz (10)	10.0
10 kHz (10^2)	10.00
1 kHz (10^3)	10.000
.1 kHz (10^4)	10.0000
10 Hz (10^5)	10.00000
1 Hz (10^6)	10.000000
.1 Hz (10^7)	OF 0.0000000

b. Push and hold RESET

(1) Display should read 88888888 with **all** annunciators and decimal points **ON**.

c. Sample Rate and Gate Light Check:

(1) Set RESOLUTION switch to 1 kHz (10^3).

(2) Adjust Sample Rate Control from full ccw to cw.

Gate light (G) should display a steady on to a flickering on-off condition.

d. Function Control:

(1) Set RESOLUTION to 1 Hz (10^6).

(2) Set FUNCTION

	DISPLAY	
CHECK	10.000000	MHz
*FREQ C	0.00	
*DVM	0.0000	
START A	0.	M
STOP	0.	M
FREQ A	0.000	kHz
PER A	0.0	S
PER AVG A	0.0000	NS
RATIO B/A	0.000000	
TI A→B	0.0	S
TI AVG A→B	0.0000	NS
*EVENTS C, A→B	0	
*RATIO C/A	0.00000	

*With no Options installed.

Table 3-4. In-Cabinet Performance Check (Cont'd)

3. FREQUENCY RESPONSE AND SENSITIVITY

a. Set counter controls as in 1a, except RESOLUTION to 1 Hz (10^6) and AC/DC switch to AC.

b. Connect a BNC T connector to INPUT A input jack. Connect HP 651B Test Oscillator output to T connector. Connector oscilloscope vertical input to T connector to monitor input signal amplitude; use a 50-ohm feedthrough at oscilloscope BNC.

c. Adjust HP 651B from 10 Hz to 10 MHz, maintaining 25 mV rms (70 mV p-p) input amplitude. Counter should properly display all frequencies in this range. Record on test card.

d. Repeat step 3c with an input from HP 608E VHF Signal Generator of 10 MHz to 100 MHz maintaining 50 mV rms (141 mV p-p).

e. Disconnect HP 608E and connect HP 651B through BNC T connector to INPUT A of 5328A and to Channel B of oscilloscope.

f. Adjust HP 651B output to 1000 Hz at 4 volts peak-to-peak.

g. Connect OUTPUT MARKER A of 5328A to Channel A of oscilloscope.

h. Set LEVEL A to PRESET and SEP-COM A to COM A.

i. Set DISPLAY control on oscilloscope to ALT.

j. Adjust oscilloscope for a symmetrical waveform on Channel B, centered at 0 volts. Adjust A POSITION so the top of the marker pulse is at 0 volts. (The top of the marker pulse should touch both the positive and the negative slope of the waveform. This indicates that the trigger level is at 0 volts in PRESET.)

k. Adjust A POSITION so the top of marker pulse is at least 1.8 volts above 0 volts. Rotate LEVEL A control until the top of the marker pulse touches both the positive and negative slope of the waveform. This indicates that the trigger level is at 1.8 volts.

l. Rotate LEVEL A control from full cw position to ccw. Top of marker pulse should be settable to at least 1.8 volts below 0 volts.

m. Disconnect cable from OUTPUT MARKER A and connect to OUTPUT MARKER B. Repeat steps j through l above.

4. PERIOD AND PERIOD AVERAGE

a. Set counter controls as in step 1a, with FUNCTION to PER A and RESOLUTION to 1 kHz (10^3) or as needed.

b. Connect HP 651B to INPUT A, using BNC T. Connect oscilloscope to T, using 50Ω feedthrough at oscilloscope BNC.

c. Vary the HP 651B output from 10 Hz to 10 MHz, maintaining 25 mV rms amplitude. Vary RESOLUTION switch as needed to maintain meaningful display with change of frequency. Counter should properly display the period of the frequencies in this range within accuracy specified in Table 1-3. Record on test card.

d. Set FUNCTION switch to PERIOD AVG A and repeat step c. Record on test card.

Table 3-4. In-Cabinet Performance Check (Cont'd)

5. TIME INTERVAL AND TIME INTERVAL AVERAGE

a. Set counter controls as follows:

SAMPLE RATE	Midrange
FUNCTION	T.I. A→B
RESOLUTION	1 MHz
SLOPE (A)	(+)
SLOPE (B)	(-)
AC/DC (A and B)	AC
ATTEN (A and B)	X1
LEVEL (A and B)	PRESET
SEP-COM A	COM A

b. Connect HP 651B to INPUT A. Set oscillator for 1 MHz output at 150 mV rms (425 mV p-p). Observe display for .5 μs ±1 count ± trigger error. Record on test card.

c. Set FUNCTION to T.I. AVG A→B, RESOLUTION to .1 kHz (10^4). Set signal source to <2 MHz (2 MHz must NOT be exact or display will be ambiguous). Counter should display one half the period of the input signal. For example, with a 1 MHz input signal the counter should display 500.00 ns.

$$\pm 2 \text{ ns} \pm \frac{\text{trigger error } \pm 100 \text{ ns } (\pm 1 \text{ count})}{\sqrt{\text{number of intervals averaged}}}$$

6. TOTALIZE

a. Connect HP 651B to INPUT A. Set oscillator for 1 MHz output at 150 mV rms (425 mV p-p). Set counter controls as follows:

FUNCTION	START A
RESOLUTION	1 Hz (10^6)
LEVEL (A and B)	PRESET

b. Check that display totalizes, Gate light (G) is on and LEVEL A and B lamps flash on and off. Record on test card.

c. Using 10:1 divider probe, connect oscilloscope vertical input to TB OUT jack on counter rear panel.

d. Check that oscilloscope indicates 1 Hz positive going pulses at least 3V p-p. Set RESOLUTION switch to .1 MHz (10) and observe 100 kHz output pulses (.1 μs).

e. Disconnect oscilloscope from TB OUT jack and connect TB OUT to 5381A 80 MHz Frequency Counter input.

f. Set HP 651B to 10 MHz at 150 mV rms (425 mV p-p).

Table 3-4. In-Cabinet Performance Check (Cont'd)

g. Set RESOLUTION as follows, and check for proper counter display (approximate). Record on test card.

RESOLUTION	5381A DISPLAY
1	No Output
10	1.0 MHz
10^2	100 kHz
10^3	10 kHz
10^4	1 kHz
10^5	100 Hz
10^6	10 Hz
10^7	1 Hz

7. RATIO B/A

a. Set counter controls as follows:

FUNCTION	RATIO B/A
RESOLUTION	.1 kHz (10^4)
SLOPE (A and B)	(+)
AC/DC (A and B)	AC
ATTEN 1-10-100	1
SEP-COM A	COM A
LEVEL A	+ Triggering
LEVEL B	+ Triggering

b. Set HP 651B to 10 MHz at 1V rms.

c. Connect BNC cable from OSC BNC on rear panel to INPUT A on front panel.

d. Display should read 1.0000, depending on accuracy of test oscillator setting.

8. GATE OUTPUT AND SAMPLE RATE

a. Connect equipment as in step 7c above except disconnect HP 651B.

b. Set counter controls as follows:

FUNCTION	FREQ A
RESOLUTION	.1 kHz (10^4)
SEP-COM A	SEP
SAMPLE RATE	MAX CCW

c. Using 10:1 divider probe, connect oscilloscope vertical input to GATE OUT and observe a positive pulse ≥2.4V with a pulse width of ≤10 ms. Record on test card.

d. Slowly rotate SAMPLE RATE clockwise and observe that the negative portion of the pulse width increases.

PERFORMANCE CHECK TEST CARD

HEWLETT-PACKARD MODEL 5328A
UNIVERSAL COUNTER

Test Performed by _____

Serial No. _____

Date _____

DESCRIPTION (Refer to Table 3-4)	CHECK
1. TIME BASE STABILITY AND OUTPUT	
Aging Rate: <3 parts in 10^7 per month	_____
Output: 10 MHz, ≈1V (square wave)	_____
2. DISPLAY, DECIMAL POINTS, AND DIVIDERS	
As per self-check procedures, Table 3-4	_____
3. FREQUENCY RESPONSE AND SENSITIVITY	
Frequency A Range: 0 to 40 MHz at 25 mV (70 mV p-p)	_____
40 MHz to 100 MHz at 50 mV (141 mV p-p)	_____
Channel A Preset: 0V	_____
Channel A Level: +1.8 to -1.8V	_____
Channel B Preset: 0V	_____
Channel B Level: +1.8 to -1.8V	_____
4. PERIOD AND PERIOD AVERAGE	
Frequency Range: 0 to 10 MHz at 25 mV (70 mV p-p)	_____
5. TIME INTERVAL AND TIME INTERVAL AVERAGE	
Time Interval: 0.5 μs at 150 mV	_____
Time Interval Average: $\frac{1}{2}$ period of input signal	_____
6. TOTALIZE	
Range: 0 to 10 MHz	_____
Output: Rear panel TB OUT BNC (for N>1)	_____
Factor: 1 to 10^7 in decade steps	_____
7. RATIO B/A	
Per Table 3-4, Step 7	_____
8. GATE OUTPUT AND SAMPLE RATE:	
Per Table 3-4, Step 8	_____

3-22. ADJUSTMENTS

3-23. Adjustment procedures are provided for the standard and Option 010 oscillator and for the standard time interval unit (sensitivity). The adjustments should not be done unless:

a. A trouble has been repaired which would affect these values.

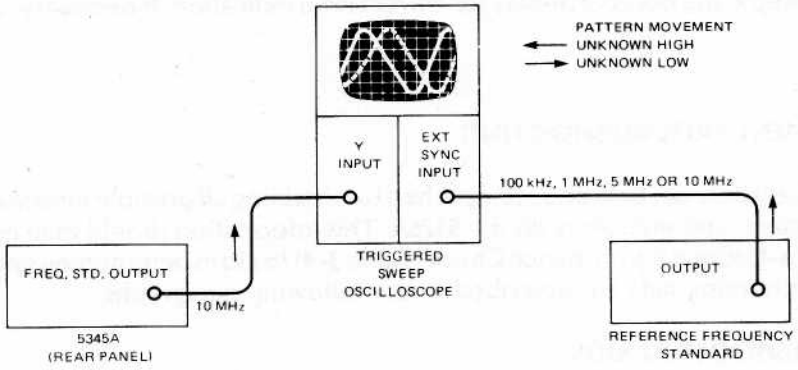
b. The instrument does not meet all specifications while performing the check in Table 3-4 (In-Cabinet Performance Check) or during periodic calibration.

3-24. Oscillator Adjustment (Standard or Option 010)

NOTE

When adjusting the standard 5328A oscillator, adjust capacitor C18 (see Figure 6-6). When adjusting the Option 010 oscillator, adjust FREQ ADJ on the 10544A crystal oscillator unit.

3-25. Periodically, the oscillator should be checked to a house standard. When adjustment is required, use the oscilloscope method shown below. Using the appropriate sweep speed, adjust the oscillator until the movement of the pattern is stopped or nearly stopped.



CALIBRATION

MOVEMENT	SWEEP SPEED			NOTES
	1μSEC/CM	0.1μSEC/CM	0.01μ SEC/CM	
1 CM/SEC	1×10^{-6}	1×10^{-7}	1×10^{-8}	TIME SCOPE TRACE MOVEMENT WITH SECOND HAND OF WATCH OR CLOCK
1 CM/10 SEC	1×10^{-7}	1×10^{-8}	1×10^{-9}	
1 CM/100 SEC	1×10^{-8}	1×10^{-9}	1×10^{-10}	

3-26. Sensitivity Adjustments

3-27. Adjust the sensitivity as follows:

a. Remove top cover of 5328A to gain access to variable resistors R3 and R18 on the A19 Attenuator Assembly (see Figure 6-12 component locator).

b. Set counter front panel controls as follows:

FUNCTION ..... FREQ A
RESOLUTION ..... 10^6 1 Hz
SLOPE (A) ..... +
AC/DC (A) ..... DC
ATTEN (A) 1
LEVEL A ..... PRESET
SEP-COM A ..... COM A
SAMPLE RATE ..... Midrange

c. Set counter rear panel controls as follows:

STORAGE	ON
OSC	INT
ARM	OFF

d. Connect HP 608 Signal Generator (or equivalent) to INPUT A. Set signal generator to 40 MHz at 50 mV rms.

e. Decrease signal generator output level slowly to 25 mV rms (70 mV p-p) and observe counter display for stable correct indication. If necessary, adjust resistor R3.

f. To check Channel B change settings of front panel controls as follows:

FUNCTION	RATIO B/A
RESOLUTION	1 kHz 10^3
SEP-COM A	SEP

g. With signal generator connected to INPUT A set to 10 MHz, connect a second signal generator to INPUT B set to 40 MHz at 50 mV rms.

h. Repeat step e and observe display for correct ratio indication. If necessary, adjust resistor R18.

3-28. INSTRUMENT TROUBLESHOOTING

3-29. Trouble isolation can best be accomplished by obtaining all possible information from the controls, connectors, and indicators on the 5328A. This information should then be analyzed by conducting the In-Cabinet Performance Check (Table 3-4) to aid in determining symptoms of the trouble. Troubleshooting aids are described in the following paragraphs.

3-30. TROUBLESHOOTING AIDS

3-31. Troubleshooting flowcharts for each assembly of the 5328A are provided at the back of this section. The use of extender boards and test cards, available as service kits, is described in the following paragraphs. This section also contains a table for analysis of functional signals and a table for IC troubleshooting.

3-32. DVM Extender Board Kit (05328-82020)

3-33. This kit consists of three extender boards that are used for servicing DVM Options 020 and 021. It allows circuit assemblies to be extended from their plug-in connectors for monitoring signals with the appropriate test equipment. The kit includes the following:

a. Extender board (05328-62020) with one 15-pin and one 18-pin connector. Extends A5 assembly for Option 020 or 021.

b. Extender board (05328-62021) with one 15-pin connector. Extends A6 or A7 assembly for Option 021. (Assembly A5 must be placed on its extender board before A6 can be extended due to space requirements.)

c. Extender board (05328-62022) for front of assemblies A5 and A6. Simulates front panel board of Option 021. Has cable attached to connect front connectors of A5 and A6 together.

3-34. Extender Board (05328-62016)

3-35. This type of extender board is available separately (not part of a service kit). Two of these extender boards are required to extend the A4 Function Selector Assembly or the Option 030 A8 Frequency C Assembly. One of these extender boards is required to extend the A10 assembly for the standard 5328A or the A10 or A14 assembly for Option 040.

3-36. Function Selector and ROM Kit (05328-82004)

3-37. This kit is used to replace the A4 Function Selector Assembly with a test card or to replace the ROM on the motherboard with a ROM simulator card. Use of this kit is required in the troubleshooting flowchart for A1 motherboard and is described in the following paragraphs.

3-38. The four test cards in the kit provide a total of 16 tests, one for each of the four-edge connectors on each card. The tests are described in paragraphs 3-45 through 3-115. The cards are inserted into A1 Motherboard connector XA4 to replace the A4 Function Selector assembly with test connections shown in the block diagram for each test. The test cards are numbered 1, 2, 3, and 4. The four-edge connectors on each card are numbered with tests 1, 2, 3, and 4 on Card 1, tests 5, 6, 7, and 8 on Card 2, tests 9, 10, 11, and 12 on Card 3 and tests 13, 14, 15, and 16 on Card 4. Part numbers of the cards are as follows:

a. Test Card 1, 05328-21004
b. Test Card 2, 05328-22004
c. Test Card 3, 05328-23004
d. Test Card 4, 05328-24004

3-39. The ROM Simulator card (05328-65005) is used in conjunction with Cable Assembly 8120-2176. The card and cable are supplied with this Service kit. The ROM simulator card contains three IC's, and a connector for each IC. The card replaces ROM A1U37 by connecting the cable from one of the card connectors to the connector for ROM A1U37 (after removing the ROM). Use of the ROM Simulator card is described in A1 Motherboard Troubleshooting Flowchart.

3-40. USING THE TEST CARDS

3-41. The test cards described in paragraphs 3-34 and 3-35 are used to test various functions of the 5328A as described in the following paragraphs.

3-42. Each of the following listed test card and test numbers are labeled on the card and card edge, respectively. The cards are keyed to prevent incorrect insertion into test connector XA4.

3-43. A description of the purpose of the test, a block diagram of test connections of circuits tested and procedures to perform are provided for each test.

CAUTION

TURN OFF POWER BEFORE REMOVING OR INSERTING CARDS.

3-44. To perform any of the following tests, insert the appropriate test card and observe the display.

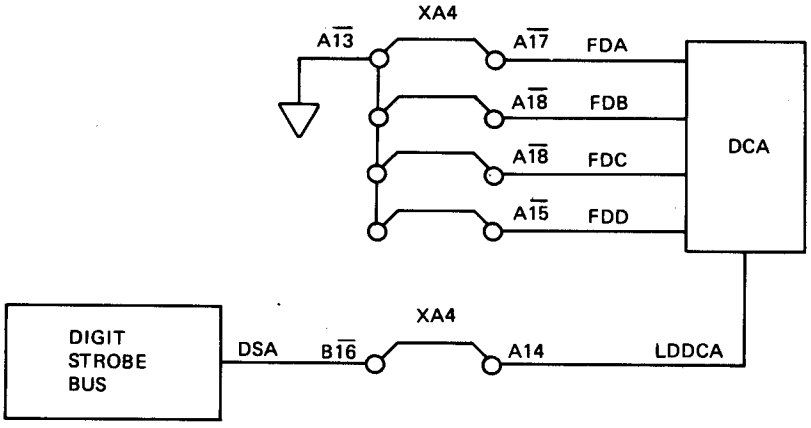
NOTE

To check the test connections shown in the block diagrams, refer to connector XA4(A and B) in Figure 6-17, A1 Motherboard Interconnection Diagram.

3-45. Test Card 1, Test 1, Low Disable Decade Counting Assembly (LDDCA)

3-46. Description. In this test the ability of the LDDCA line to disable the output of the DCA is checked. This line is used in most test card tests and during normal operation when any module wishes to strobe different data into the display or blank the display.

3-47. Block diagram of test connections:



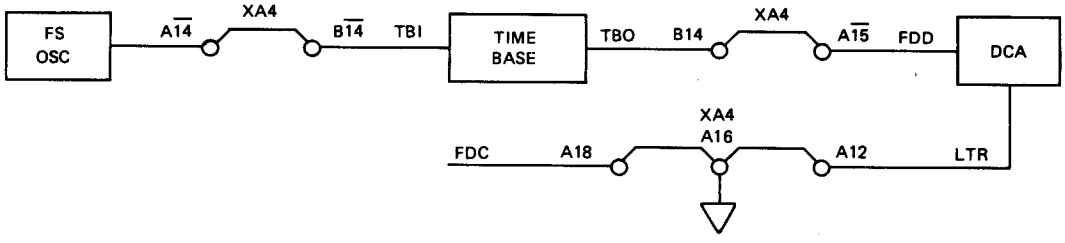
3-48. Procedure: Set FUNCTION switch to CHECK.

3-49. Display results: ▮▯▮▯▮▯▮

3-50. Test Card 1, Test 2, DCA and Time Base

3-51. Description. With this test, both the DCA and Time Base can be checked without the A4 Function Selector being used, enabling problem isolation to A1 Motherboard or A4 Function Selector.

3-52. Block diagram of test connections:



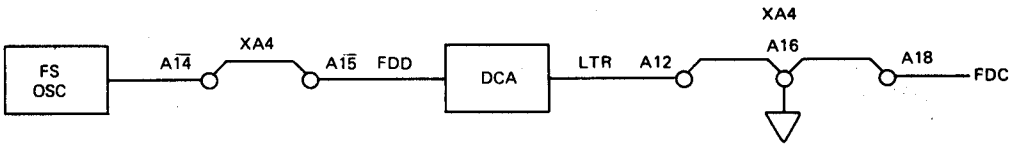
3-53. Procedure: Set FUNCTION switch to CHECK.

3-54. Display results: the MSD on the display should totalize at a rate of 10 MHz when N=1 and 1 MHz when N=10. As N is increased, the displayed digits will decrease in decade steps of 10. The MSD triggers OVFL indicator after the first cycle.

3-55. Test Card 1, Test 3, Decade Counting Assembly (DCA)

3-56. Description: If the DCA is suspected to be faulty this test will determine if it will count 10 MHz at the correct rate. The MSD should totalize and trigger the OVERFLOW indicator after its first cycle.

3-57. Block diagram of test connections:



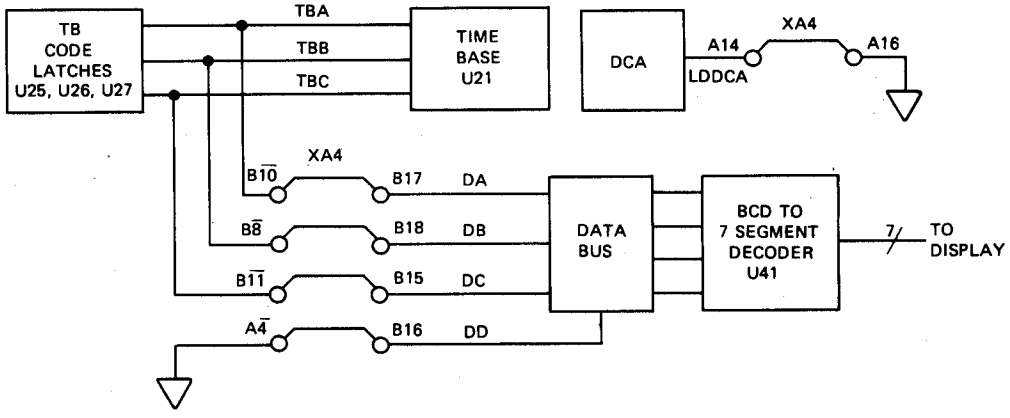
3-58. Procedure: Set FUNCTION switch to CHECK.

3-59. Display results: Display should totalize at 10 MHz.

3-60. Test Card 1, Test 4, Time Base Code

3-61. Description. This test will show whether the Time Base code going to the Time Base is correct.

3-62. Block diagram of test connections:



3-63. Procedure: Set FUNCTION switch to CHECK and RESOLUTION as shown in table below:

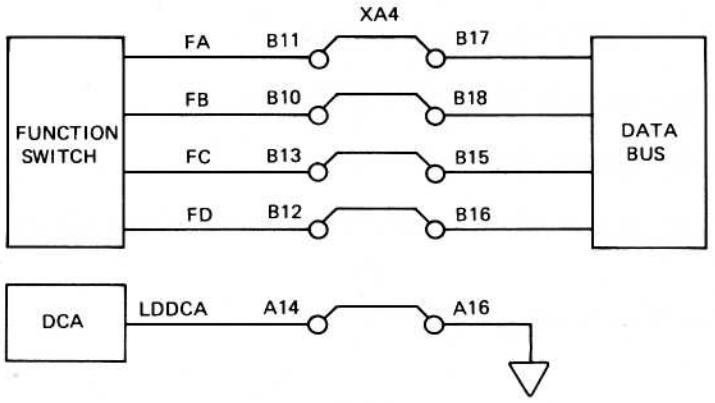
Table for Test Card 1, Test 4

RESOLUTION	DISPLAY	NOTE
1	0.	
10	1.1	
10^2	2.2	
10^3	3.3	
10^4	4.4	If Option 040 is installed the displayed digits will be 0 's.
10^5	5.5	
10^6	6.6	
10^7	7.7	

3-64. Test Card 2, Test 5, Function Code and Display

3-65. Description: This test can be used to verify the Function Code or as the rapid way to verify a faultless display.

3-66. Block diagram of test connections:



3-67. Procedure: Set RESOULTION switch to .1 kHz (10^4) and set FUNCTION switch to each position as listed in table below.

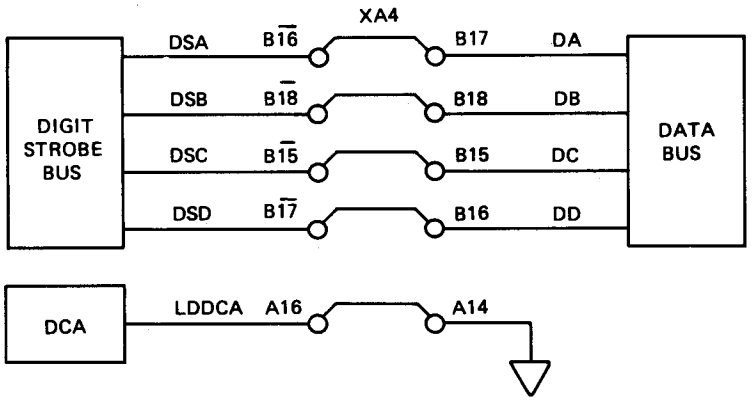
Table of Test Card 2, Test 5

FUNCTION	DISPLAY	NOTE
Check Freq C	44444444 ttttttttt	Ninth digit if Option 030 is installed.
DVM	▮▮▮▮▮▮▮▮	
START A	11111111	
STOP	▮▮▮▮0.00	
*START CLOCK	22222222	The "phantom" (unmarked) positions of the FUNCTION switch that follow (*) are located 1, 2, and 3 switch positions clockwise from STOP, respectively.
*DVM/A	33333333	
*DVM, A→B	55555555	
FREQ A	44444444	
PER A	66666666	
PER AVG A	77777777	
RATIO B/A	99999999	
TI A→B	88888888	
TI AVG A→B	cccccccc	
EVENTS C, A→B	333333333	
RATIO, C→A	555555555	Ninth digit if Option 030 is installed.

3-68. Test Card 2, Test 6, Strobe Code I Display

3-69. Description: This test displays the display strobe code (D bit grounded) showing the code on which each digit is strobed. This is useful in checking the display when the Function code is suspected to be faulty.

3-70. Block diagram of test connections:



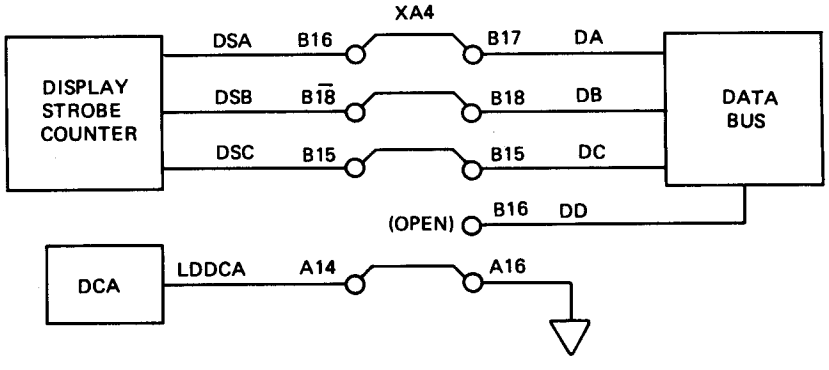
3-71. Procedure: Set FUNCTION switch to CHECK and RESOLUTION switch to 1 Hz (10^6).

3-72. Display results: Display should read ▮ 1.234567

3-73. Test Card 2, Test 7, Strobe Code II Display

3-74. Description. This test displays the strobe code except that the D bit is made high, allowing the higher order codes to be displayed.

3-75. Block diagram of test connections:



3-76. Procedure: Set FUNCTION switch to CHECK and RESOLUTION switch to 1 Hz (10^6).

3-77. Display results: 89.c=456▮8

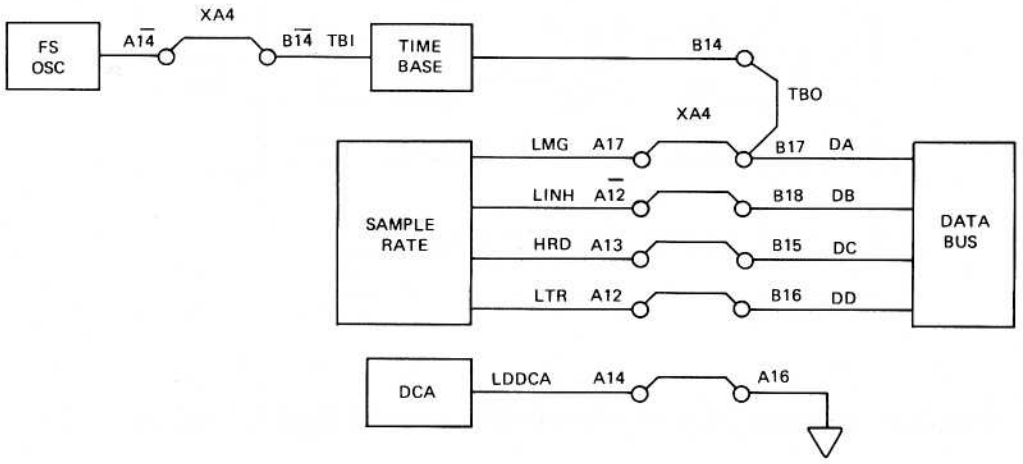
NOTE

Ninth digit if Option 030 installed.

3-78. Test Card 2, Test 8, Auto Sample Rate

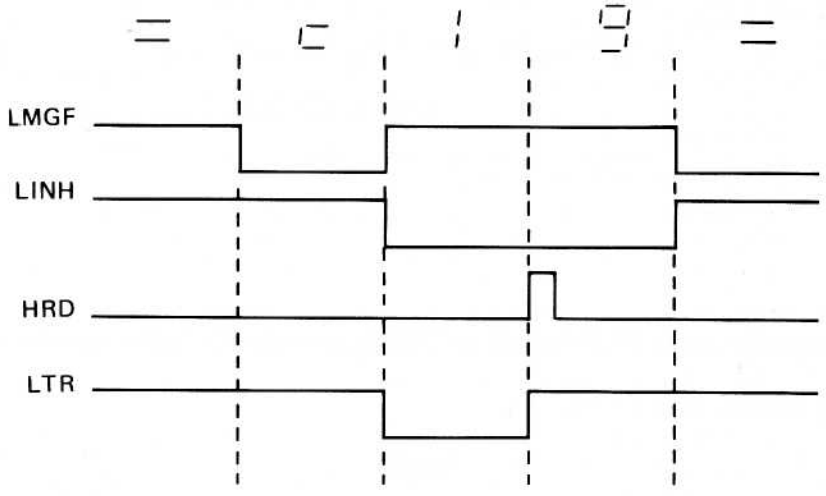
3-79. Description. This test allows the Sample Rate circuitry to be tested without an A4 Function Selector in the instrument, thus allowing for fault isolation between the A1 Motherboard and the A4 Function Selector. The Time Base output simulates the opening and closing of the main gate.

3-80. Block diagram of test connections:



3-81. Procedure: Set FUNCTION switch to CHECK and RESOLUTION switch to 1 Hz (10^6). Set SAMPLE RATE control approximately midpoint (1 O'Clock).

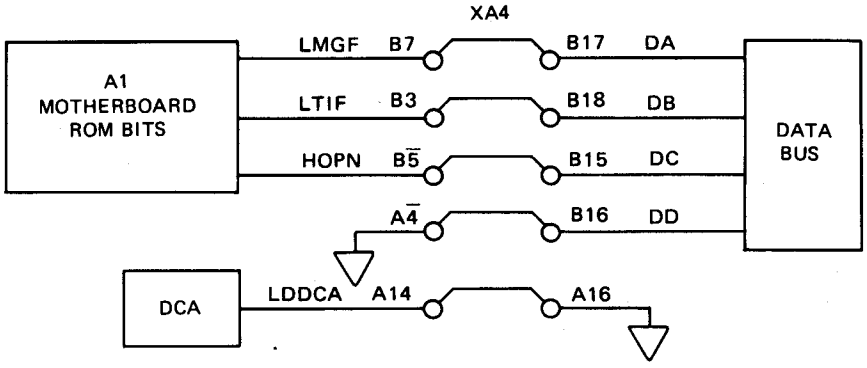
3-82. Display results: All digits will read the same. They will continuously cycle through the sequence of =C 19



3-83. Test Card 3, Test 9, Function Selector Main Gate ROM Bits (LMGF, LTIF, HOPN)

3-84. Description. This test tests the ROM bits that help determine which signal on the A4 Function Selector is used to establish the main gate signal.

3-85. Block Diagram of test connections:



3-86. Procedure: Set the FUNCTION and RESOLUTION switches to the positions shown in the table that follows.

Table for Test Card 3, Test 9

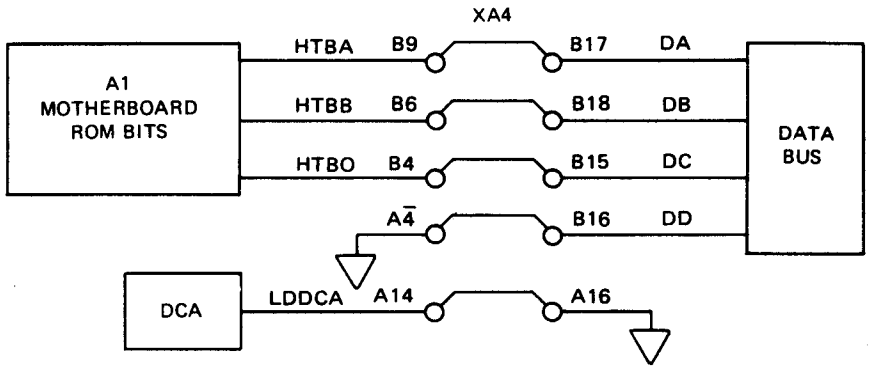
FUNCTION	RESOLUTION	
	10^0	10^1 –10^7
CHECK	9	9
FREQ C	7	7
DVM	3	3
START A	3	7
STOP	3	7
*START CLOCK	3	7
*DVM/A	–	3
FREQ A	3	3
*DVM A→B	–	–
PER A	5	–
PER AVG A	5	3
RATIO B/A	–	3
TI A→B	5	–
TI AVG A→B	5	3
EVENTS C, A→B	5	7
RATIO C/A	5	7

*Phantom Functions.

3-87. Test Card 3, Test 10, A4 Function Selector Time Base Input ROM Bits (HTBA, HTBB, HTBO)

3-88. Description. These ROM bits determine which signal goes to the input of the Time Base and Clock input of the Main Gate FF.

3-89. Block Diagram of test connections:



3-90. Procedure: Set the FUNCTION and RESOLUTION switches to the positions shown in the table that follows.

Table for Test Card 3, Test 10

FUNCTION	RESOLUTION							
	10^0	10^1	10^2—10^7	(10^3)	(10^4)	(10^5)	(10^6)	(10^7)
CHECK	4	4	4					
FREQ C	4	4	4					
DVM	4	4	4					
START A	0	1	1					
STOP	8	0.00	0.0 ††	0.	0.00	0.0	0.	0.00
*START CLOCK	0	4	4					
*DVM/A	0	1	1					
*DVM A→B	0	0	0					
FREQ A	4	4	4					
PER A	0	4/0†	4					
PER AVG A	0	1	1					
RATIO B/A	0	4	1					
TI A→B	0	4/0†	4					
TI AVG A→B	0	2	2					
EVENTS C, A→B	0	0	0					
RATIO C/A	0	1	1					

*Phantom Functions

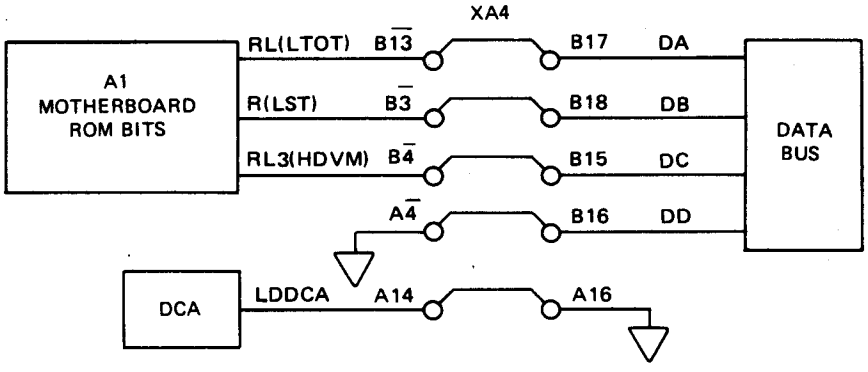
† Lower number for Option 040.

†† 10^2 only

3-91. Test Card 3, Test 11, A4 Function Selector Totalize ROM Bits and DVM Enable ROM Bit RL(LTOT), R(LST), RL4(HDVM)

3-92. Description. The ROM line LTOT turns storage off and disables the sample rate circuitry for the totalize mode functions. HDVM enables the DVM to strobe in a minus sign to the display and also blank portions of the display.

3-93. Block diagram of test connections:



3-94. Procedure: Set the FUNCTION and RESOLUTION switches to the position shown in the table that follows.

Table for Test Card 3, Test 11

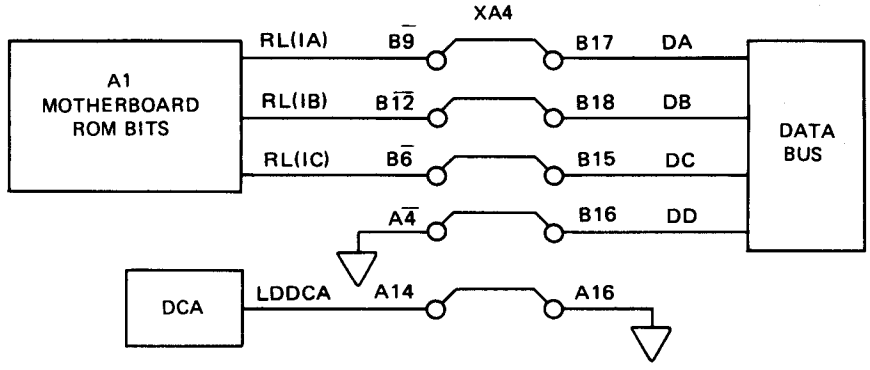
FUNCTION	RESOLUTION	
	10^0	10^1 — 10^7
CHECK		
FREQ C		
DVM		
START A		
STOP		
*START CLOCK		
*DVM/A		
*DVM A→B		
FREQ A		
PER A		
PER AVG A		
RATIO B/A		
TI A→B		
TI AVG A→B		
EVENTS C, TI A→B		
RATIO C/A		

*"Phantom" Functions

3-95. Test Card 3, Test 12, A4 Function Selector High Speed ROM Bits (IA, IB, IC)

3-96. Description. These ROM lines determine which input line is selected by U6 on the A4 Function Selector.

3-97. Block diagram of test connections:



3-98. Procedure: Set the FUNCTION and RESOLUTION switches to the position shown in the table that follows.

Table for Test Card 3, Test 12

FUNCTION	RESOLUTION		
	10^0	10^1	10^2 — 10^7
CHECK	6	6	6
FREQ C	0	0	0
DVM	3	3	3
START A	1	7	7
STOP	1	7	7
*START CLOCK	1	7	7
*DVM/A	3	3	3
*DVM A→B	3	3	3
FREQ A	1	1	1
PER A	5/5†	7/5†	7/6
PER AVG A	5	5	5
RATIO B/A	4	4	4
TI A→B	6/5†	7/6†	7
TI AVG A→B	5	5	5
EVENTS C, A→B	0	0	0
RATIO C/A	0	0	0

*"Phantom" Functions
†Second number for Option 040.

NOTE

In RATIO C/A, position 10^0 will display 0 as MSD only, position 10^1 will add a decimal to the right hand side, position 10^2 –10^7 will add a 0 and decimal to the left for each position until at 10^7 display will be 00000000

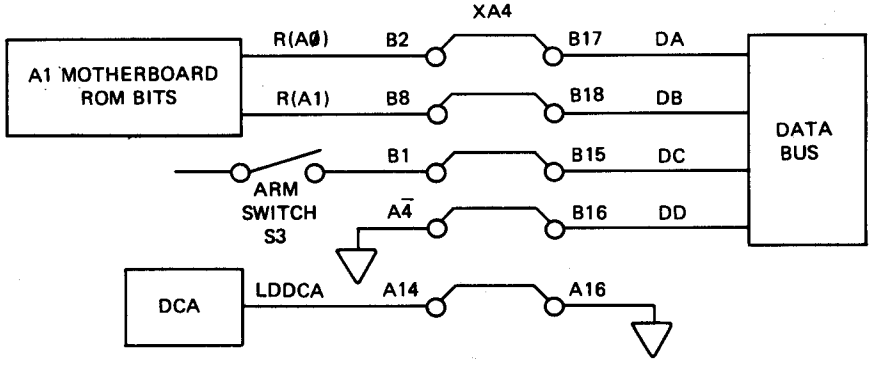
3-99. Test Card 4, Test 13, Arming ROM Bits (A0, A1) and ARM Switch

3-100. Description. These three bits determine which signal the counter should trigger on as defined by the following table:

Table for Arming ROM Bits

	ARM SWITCH (Rear Panel)	A1	A0	
ARMING ON	0	0	0	CH C
	0	0	1	CH B
	0	1	0	CH B
	0	1	1	CH B
ARMING OFF	1	0	0	FREE RUN
	1	0	1	FREE RUN
	1	1	0	C ARM
	1	1	1	CH A

3-101. Block diagram of test connections:



3-102. Procedure: Adjust the FUNCTION and ARM switches to the position shown in the table that follows.

Table for ARM Switch Test

FUNCTION	ARM SWITCH	
	OFF	ON
CHECK	5	-
FREQ C	9	2
DVM	5	-
START A	4	0
STOP	4	0
*START CLOCK	4	0
*DVM/A	5	-
*DVM A→B	4	0
FREQ A	7	3
PER A	5	-
PER AVG A	5	-
RATIO B/A	4	0
TI A→B	4	0
TI AVG A→B	4	0
EVENTS C, TI A→B	4	0
RATIO C/A	9	2

*"Phantom" positions.

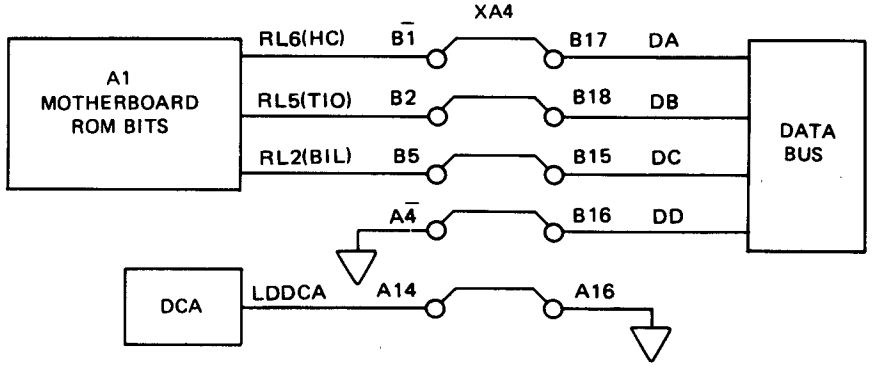
NOTE

When 0 's are displayed, all those to the left of the decimal, except the first, are blanked.

3-103. Test Card 4, Test 14, Auxiliary ROM Bits RL6(HC), RL5(TIO), RL2(BIL)

3-104. Description. The ROM bit RL6(HC) is used to program hysteresis compensation and have the syncronizers make a TI measurement when true. When false, there will be no hysteresis compensation and a period measurement will be made. The ROM line RL5(TIO) tells the synchronizer to send 100 MHz on the lines in the PER AVG A function (Option 040 only). The ROM line RL2(BIL) programs the A14 Multiplier Assembly (Option 040 only) to jitter its output in TI AVG A→B only.

3-105. Block diagram of test connections:



3-106. Procedure: Set FUNCTION and RESOLUTION switches as shown in table that follows:

Table for Test Card 4, Test 14

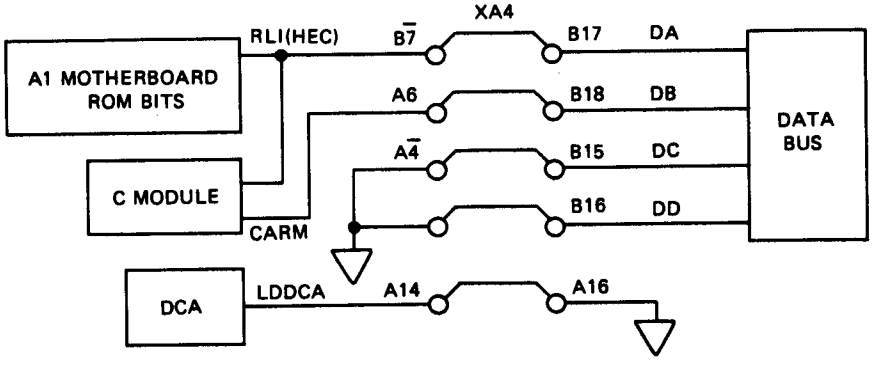
FUNCTION	RESOLUTION	
	10^0	$10^1 - 10^7$
CHECK	0	0
FREQ C	0	0
DVM	0	0
START A	0	0
STOP	0	0
*START CLOCK	0	0
*DVM/A	0	0
*DVM A→B	-	-
FREQ A	0	0
PER A	0	0
PER AVG A	0/2†	0
RATIO B/A	0	0
TI A→B	-	-
TI AVG A→B	5	5
EVENTS C, A→B	-	-
RATIO C/A	0	0

*"Phantom" positions.
†Lower number for Option 040.

3-107. Test Card 4, Test 15, C Module (ROM Bit HEC and CARM)

3-108. Description. ROM bit HEC enables the Channel C module to strobe its digit into the display. CARM tells the A4 Function Selector that the C Module is triggering (CARM high).

3-109. Block diagram of test connections:



3-110. Procedure: Set the FUNCTION switch and trigger Channel C as shown in the table that follows.

Table for Test Card 4, Test 15

FUNCTION	DISPLAY	
	C MODULE NOT TRIGGERING	C MODULE TRIGGERING
CHECK	0	2
FREQ C	1	3
DVM	0	0
START A	0	0
STOP	0	0
*START CLOCK	0	0
*DVM/A	0	0
*DVM A→B	0	0
FREQ A	0	0
PER A	0	0
PER AVG A	0	0
RATIO B/A	0	0
TI A→B	0	0
TI AVG A→B	0	0
EVENTS C, A→B	0	3
RATIO C/A	0	3

*"Phantom" Positions

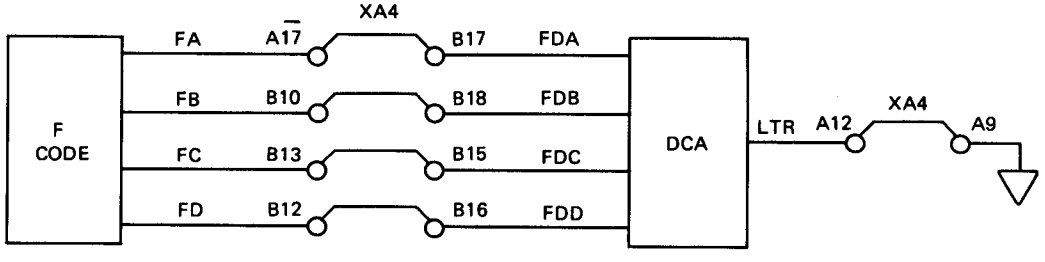
NOTE

The C module triggers if installed. If not installed, the same effect is obtained by grounding the CARM line of the bus.

3-111. Test Card 4, Test 16, Function Selector Digit (FDA, FDB, FDC, FDD)

3-112. Description. These lines are sent to the DCA where they are latched and strobed onto the Data Bus.

3-113. Block diagram of test connections:



3-114. Procedure: Set FUNCTION switch to each position listed in the table that follows.

3-115. Display Results: Observe only the Function Selector digit (2nd from right). It should be as shown below.

Table for Test Card 4, Test 16

FUNCTION	DISPLAY
CHECK	5
FREQ C	10
DVM	7
START A	1
STOP	0
*START CLOCK	0
*DVM/A	0
*DVM A→B	0
FREQ A	5
PER A	2
PER AVG A	7
RATIO B/A	6
TI A→B	0
TI AVG A→B	0
EVENTS C, TI A→B	1
RATIO C/A	5

*"Phantom" positions

3-116. IC Troubleshooting

3-117. To troubleshoot the IC's on the A1 Motherboard, proceed as follows:

a. Set the FUNCTION switch to CHECK.

b. Set the FREQ RESOLUTION, N switch to 1 MHz 1.

c. Remove top cover and remove A4 Function Selector Assembly.

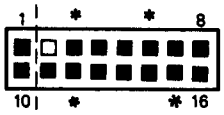
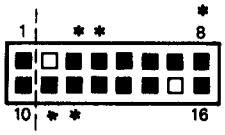
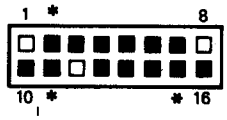
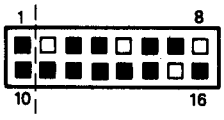
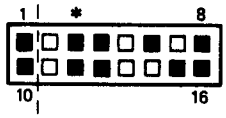
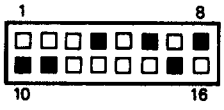
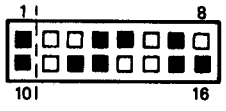
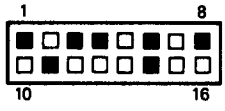
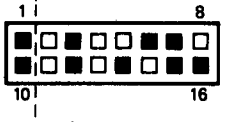
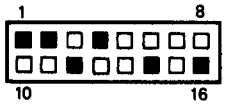
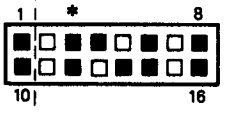
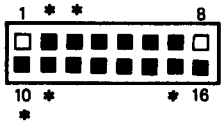
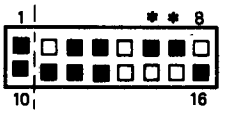
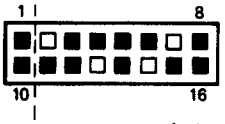
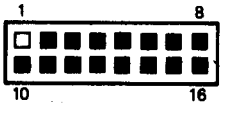
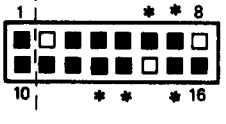
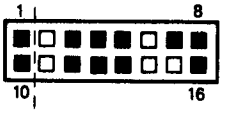
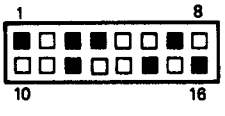
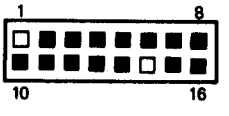
d. Apply power and check for the logic states as shown in Table 3-5, using an HP Model 10528A Logic Clip or a Model 10525T Logic Probe. A dark pattern indicates a logic high.

Table 3-5. IC Troubleshooting, A1 Motherboard

5328A Display: ■■■■ 0.00 7■
(See preceding initial conditions) ← 9th digit is for Option 030 Installed

NOTE

When checking a 14-pin IC with the 16-pin logic clip, ignore the patterns for pins 8 and 9 of the Logic Clip as shown by the dotted line on the pattern.

U22		14 PIN			
U23		14 PIN	U32		16 PIN
U24		14 PIN	U33		14 PIN
U25		16 PIN	U34		14 PIN
U26		16 PIN	U35		14 PIN
U27		16 PIN	U36		14 PIN
U28		16 PIN	U38		14 PIN
U29		14 PIN	U39		16 PIN
U30		14 PIN	U40		14 PIN
U31		16 PIN	U41		16 PIN

*Indicates dimly lit

Table 3-5. IC Troubleshooting, A1 Motherboard (Continued)

PINS U25		FUNCTION															
		CHECK	FREQ C	DVM	START A	STOP	*START CLOCK	*DVM/A	*DVM A→B	FREQ C	PER A	PER AVG A	RATIO B/A	TI A→B	TI AVG A→B	EVENTS C, TI A→B	RATIO C/A
INPUTS	2	L	L	H	H	H	H	H	H	L	H	H	H	H	H	H	H
	3	H	H	H	H	H	H	H	H	H	L	L	H	L	L	H	H
	6	H	L	H	H	H	H	H	H	H	H	H	H	H	H	L	L
	7	H	L	L	H	H	H	H	H	H	L	L	H	L	L	L	L
OUTPUTS	9	H	L	H	L	L	L	H	H	L	L	L	L	L	L	L	L
	10	H	H	H	L	L	L	H	H	H	H	H	H	H	H	H	H
	15	L	L	L	H	H	H	L	L	L	L	L	L	L	L	L	L
	16	L	H	L	L	L	L	L	L	L	H	H	L	H	H	H	H
U26																	
INPUTS	2	L	H	L	L	L	L	L	L	L	L	L	L	L	L	H	H
	3	H	L	H	H	H	H	L	L	H	H	H	H	H	H	L	L
	6	H	L	H	L	L	L	H	L	H	L	L	L	L	L	L	L
	7	L	H	L	L	L	L	L	L	H	H	H	L	L	L	L	H
OUTPUTS	9	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L
	10	H	L	L	L	L	L	L	L	L	H	H	H	H	H	L	L
	15	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	16	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
U27																	
INPUTS	2	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	3	L	L	L	H	H	H	H	H	L	H	H	H	H	H	H	H
	6	L	L	L	H	H	H	H	H	L	L	L	H	H	L	H	H
	7	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H
OUTPUTS	9	L	L	L	H	H	H	H	H	L	H	H	H	H	H	H	H
	10	L	L	H	H	H	H	H	H	H	H	H	L	H	H	L	L
	15	L	H	L	L	L	L	L	L	L	L	L	L	L	L	H	H
	16	L	L	L	H	H	H	L	L	L	L	L	L	L	L	L	L
U31																	
INPUTS	2	H	H	L	L	L	L	L	L	H	L	L	L	L	L	L	L
	3	L	L	L	L	H	H	L	L	L	L	L	L	L	L	L	L
	6	H	H	L	H		H	H	H	H	L	L	H	L	L	H	H
	7	L	L	H	H	H	H	H	H	L	L	L	H	L	L	H	H
OUTPUTS	9	L	L	L	L	L	L	L	H	L	L	L	L	H	H	H	L
	10	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	15	L	L	H	H	L	L	L	H	H	L	L	L	L	L	L	L
	16	H	H	H	H	H	H	L	L	H	L	L	L	L	L	L	L

Table 3-5. IC Troubleshooting, A1 Motherboard (Continued)

PINS U25		FREQ RESOLUTION							
		1 MHz 1	.1 MHz 10	10 kHz 10^2	1 kHz 10^3	.1 kHz 10^4	10 Hz 10^5	1 Hz 10^6	.1 Hz 10^7
INPUTS	2	L	L	L	L	L	L	L	L
	3	H	H	H	H	H	H	H	H
	6	H	H	L	L	H	H	L	L
	7	H	L	H	L	H	L	H	L
OUTPUTS	9	H	H	H	H	H	H	H	H
	10	H	H	H	H	H	H	H	H
	15	L	H	L	H	L	H	L	H
	16	L	L	L	L	L	L	L	L
U26									
INPUTS	2	L	L	L	L	L	L	L	L
	3	H	H	H	H	L	L	L	L
	6	H	H	H	H	H	H	H	H
	7	L	L	L	L	L	L	L	L
OUTPUTS	9	L	L	L	L	L	L	L	L
	10	H	H	H	H	H	H	H	H
	15	L	L	L	L	H	H	H	H
	16	L	L	L	L	H	H	H	H
U27									
INPUTS	2	L	L	L	L	L	L	L	L
	3	L	L	L	L	L	L	L	L
	6	L	L	L	L	L	L	L	L
	7	H	H	H	H	H	H	H	H
OUTPUTS	9	L	L	L	L	L	L	L	L
	10	L	L	L	L	L	L	L	L
	15	L	L	L	L	L	L	L	L
	16	L	L	H	H	L	L	H	H
U31									
INPUTS	2	H	H	H	H	H	H	H	H
	3	L	L	L	L	L	L	L	L
	6	H	H	H	H	H	H	H	H
	7	L	L	L	L	L	L	L	L
OUTPUTS	9	L	L	L	L	L	L	L	L
	10	L	L	L	L	L	L	L	L
	15	L	L	L	L	L	L	L	L
	16	H	H	H	H	H	H	H	H

Table 3-5. IC Troubleshooting, A1 Motherboard (Continued)

U37

(ROM STATES WITH A4 REMOVED)

1	-2V	15	L
2	+5V	16	GND
3	L	17	L
4	L	18	L
5	L	19	L
6	L	20	H
7	H	21	H
8	L	22	L
9	H	23	L
10	H	24	H
11	H	25	H
12	H	26	H
13	L	27	L
14	L	28	+12V

3-118. Functional Signals

3-119. Table 3-6 lists the functional signals at pertinent points for each position of the FUNCTION switch. This information can be used to isolate problems that may occur in any of the various modes of operation.

Table 3-6. 5328A Functional Signals

NOTE
N=0→7 (Exponent of 10 on FREQ RESOLUTION, N switch.
N=0 is position 1 on switch. All other positions N≠0).
CLK = 10 MHz
* = Don't care

Function Switch	Displayed Number FREQ • TIME (Hz) (Seconds)	Signal to TB (Output A4U10) IF N=0	IF N≠0	Signal to 1st Decade (Output A4U6) IF N=0	IF N≠0	Arming (Output A4U5) Norm	Armed	Main Gate (Input A4U6) IF N=0	IF N≠0	Gate (Opt. 030) (Input A8U4)
FREQ A	$A \bullet \frac{10^{(N+1)}}{CLK}$	CLK	CLK	A	A	A	B	MGFF	MGFF	*
PER A	$\frac{CLK}{10^N} \bullet$ PER A	*	CLK	GOSC	TBO	Free	B	Open	TI	*
PER A (Option 040)	$\frac{100\ MHz}{10^N} \bullet$ PER A	* (N=0 or 1)	CLK (N≠0 or 1)	GOSC (IF N=1, CLK)	TBO	Free	B	Open	RI	*
PER AVG A	CLK • 10^N PER A	*	A	GOSC	CLK	Free	B	Open	MGFF	*
PER AVG A (Option 040)	100 MHz • 10^N PER A	*	A	GOSC	100 MHz	Free	B	Open	MGFF	*
TI A→B	$\frac{CLK}{10^N} \bullet$ TI A→B	*	CLK	GOSC	TBO	Free	CA	Open	TI	*
TI A→B (Option 040)	$\frac{100\ MHz}{10^N} \bullet$ TI A→B	* (N=0 or 1)	CLK (N≠0 or 1)	GOSC (IF N=1, CLK)	TBO	Free	CA	Open	TI	*
TI AVG A→B	(CLK • 10^N) • TI A→B	*	B	GOSC	GOSC	Free	CA	Open	MGFF	*
TI AVG A→B (Option 040)	(100 MHz • 10^N) • TI A→B	*	B	GOSC	GOSC	Free	CA	Open	MGFF	*
FREQ C (Option 030)	$C \bullet \frac{10^{(N+1)}}{CLK}$	CLK	CLK	C	C	CA	B	Open	Open	MGFF
DVM (Option 020, 021)	$DVM \bullet \frac{10^{(N+1)}}{CLK}$	CLK	CLK	DVM	DVM	Free	B	MGFF	MGFF	*
†DVM, A→B	(In DVM, A→B TB Switch ignored)	*	*	DVM	DVM	Free	CA	TI	TI	*
EVENTS C, A→B	(EVENTS C A→B TB Switch ignored)	*	*	C	C	Free	CA	Open	Open	TI
START A, STOP	$\frac{A}{10^N} \bullet$ TI START TO STOP	*	A	A	TBO	Free	Free	LStart	Open	*
RATIO B/A	$B \bullet \frac{10^N}{A}$	††*	A	B	B	Free	CA	TI	MGFF	*
RATIO C/A (Option 030)	$C \bullet \frac{10^N}{A}$	*	A	C	C	Free	B	Open	Open	TI IF N=0 MGFF IF N≠0
†DVM/A	$DVM \bullet \frac{10^N}{A}$	*	A	DVM	DVM	Free	B	TI	MGFF	*
†START CLOCK	$\frac{CLK}{10^N} \bullet$ TI START TO STOP	*	CLK	*	TBO	Free	Free	Open	Open	*
CHECK	$CLK \bullet \frac{10^{(N+1)}}{CLK}$	CLK	CLK	CLK	CLK	Free	B	MGFF	MGFF	*

NOTES
† = Phantom Function (see 5328A Users Manual)
†† = ROM makes "A" into period = gate time
CA = CARM

3-120. REMOVAL AND REPLACEMENT INSTRUCTIONS

3-121. Removal and replacement instructions are provided for the instrument cover, the time interval module (assemblies A10 and A19) and A16 Display Assembly. Option 010 is covered in Section V and all other options are covered in the Installation and Service Manual for the option.

3-122. Instrument Cover Removal

3-123. To remove top or bottom cover, remove the screw at the rear edge that secures cover to instrument. Slide cover toward rear of instrument and lift off. To replace cover, reverse procedure.

WARNING

100/120/220/240 VAC SUPPLY WIRES ARE EXPOSED WHEN EITHER TOP OR BOTTOM COVER IS REMOVED. USE EXTREME CAUTION DURING TROUBLESHOOTING, ADJUSTMENT, OR REPAIR. AVOID DAMAGE TO INSTRUMENT BY REMOVING POWER BEFORE REMOVING OR REPLACING COVERS, ASSEMBLIES, OR COMPONENTS.

3-124. Time Interval Module (Assemblies A10 and A19) Removal and Replacement

3-125. To remove and replace the time interval module, proceed as follows:

a. Disconnect the power cable from the 5328A (Safety Precaution).

b. Remove the top cover from the 5328A.

c. Using a suitable flat-blade screwdriver as a prying tool, gently remove the plastic filler strip from the top of the cast front-panel frame.

d. Remove the two machine screws that secure the top of the module front panel to the top of the cast front-panel frame.

e. Turn the 5328A on its side and remove the two machine screws that secure the bottom of the module front panel to the bottom of the cast front-panel frame.

f. Slightly loosen all remaining machine screw along the top of the cast front-panel frame. This releases the compressive force on the module front panel.

g. Using a suitable allen wrench, remove the LEVEL A control knob from the module front panel.

h. Remove the A19 Attenuator Assembly, with front panel attached, by gently pushing the assembly from the rear. Note that the attenuator assembly is separated from the A10 Synchronizer Assembly during this operation.

i. Remove the front panel from the A19 Attenuator Assembly by removing the nut attached to each connector and removing the LEVEL B control knob.

j. Remove the A10 Synchronizer Assembly by pulling the assembly upward.

k. Replacement is essentially the reverse of removal.

3-126. A16 Display Assembly Removal and Replacement

3-127. To remove and replace the A16 Display Assembly, proceed as follows:

a. Disconnect the power cable from the 5328A (Safety Precaution).

b. Remove the top cover from the 5328A.

c. Using a suitable flat-blade screwdriver as a prying tool, gently remove the plastic filler strip from the top of the cast front-panel frame.

d. Remove the two machine screws that secure the top of the display front panel to the top of the cast front-panel frame.

e. Turn the 5328A on its side and remove the two machine screws that secure the bottom of the display front panel to the bottom of the cast front-panel frame.

f. Slightly loosen all remaining machine screws along the top of the cast front-panel frame. This release the compressive force on the module front panel.

g. Remove the A16 Display Assembly, with front panel attached, by gently pushing the assembly from the rear. Note that the display assembly is separated from the A1 Motherboard during this operation.

h. Using a suitable allen wrench, remove the SAMPLE RATE control knob from the module.

i. Remove the nuts that attach the SAMPLE RATE and RESET switches and separate the front panel from the display assembly.

NOTE

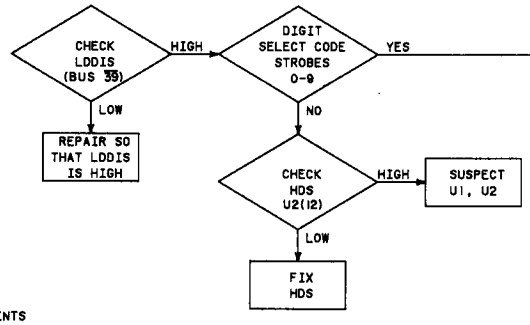
If the FUNCTION or FREQ RESOLUTION switch control knob is removed or if the associated printed-circuit board switch is disassembled, the knob and switch must be aligned during replacement as described in the following paragraph.

j. To realign the display switches with the proper knob positions, set the rear wafers with the slots directly towards each other. Set the knob of the FUNCTION switch to START A and set the knob of the FREQ RESOLUTION switch to 10^4 .1 kHz position and tighten the two set screws on each knob with a suitable allen wrench.

I SYMPTOM:

A. DISPLAY IS BLANK EVEN WHEN RESET IS PUSHED; POWER SUPPLY OK.

TEST:



NOTE:
FOR SYMPTOMS II THROUGH X, REFER TO USE OF SERVICE KITS, SECTION III

II SYMPTOM:

A. STRANGE DIGITS
B. NO DECIMAL POINTS/ALWAYS DECIMAL POINTS
C. DECIMAL POINT IN WRONG PLACE; 2 OR MORE DECIMAL POINTS

TEST:

1. INSERT TEST CARD 2, TEST 5 INTO XA4
2. CONNECT ROM BLOCK 1 INTO ROM SOCKET
3. SET FUNCTION SWITCH TO CHECK
4. ROTATE FUNCTION SWITCH CLOCKWISE ONE POSITION AT A TIME AND OBSERVE DISPLAY AS SHOWN BELOW:

```
4 4 4 4 4 4 4 4
E E E E E E E E OR b
   BLANK
1 1.1 1 1 1 1 1 1
0.0 0 0 0 0 0 0 0
2 2 2.2 2 2 2 2 2
3 3 3 3.3 3 3 3 3
5 5 5 5 5 5.5 5 5
4 4 4 4 4.4 4 4 4
6 6 6 6 6 6 6.6 6
7 7 7 7 7 7 7 7.7
9 9 9 9 9 9 9 9 9
8 8 8 8 8 8 8 8 8.
[ [ [ [ [ [ [ [ [
= = = = = = = = =
5 5 5 5 5 5 5 5 5
```

5. GO TO TEST WHERE BAD OUTPUT OCCURS (a OR b):
   a. STRANGE DIGIT PROBLEM
      TRACE BAD SEGMENT(S) THROUGH U41, SUSPECT U41
   b. BAD DECIMAL POINTS
      TRACE BAD OUTPUTS THROUGH U36,PIN 5,6; U22 PINS 8,9; U28 PIN 9; U29 AND U30.

III SYMPTOM:

A. NO ANNUNCIATORS
B. ANNUNCIATORS WRONG

TEST:

1. INSERT TEST CARD 2, TEST 5 INTO XA4
2. CONNECT ROM BLOCK 2.
3. SET FUNCTION SWITCH TO CHECK
4. ROTATE FUNCTION SWITCH CLOCKWISE ONE POSITION AT A TIME AND OBSERVE ANNUNCIATOR AS SHOWN BELOW:
5. REPEAT WITH ROM BLOCK 3.

ROM BLOCK 2		ROM BLOCK 3	
BLANK		BLANK	
BLANK		BLANK	
BLANK		BLANK	
V		V	
BLANK	← LEADING ZERO BECOMES ⊟	BLANK	
BLANK		BLANK	
K		V	ANNUNCIATORS (NOT DIGITS)
M		M	
S		S	
U		S	
n		M	
BLANK		BLANK	
HZ		HZ	
BLANK		HZ	
BLANK		BLANK	
BLANK		BLANK	

6. GO TO TEST WHERE BAD OUTPUT OCCURS. TRACE BAD OUTPUT THROUGH:

ROM BLOCK 2	ROM BLOCK 3
U33 PIN 5 & 6	U33 PIN 5 & 6
U22 PIN 11 & 13	U22 PIN 11 & 13
U23 PIN 1 & 2	U23 PIN 1 & 2
U23 PIN 9 & 10	U23 PIN 8 & 10
U28 PIN 7	U32 PIN 7
U29 PINS 1 - 6	U24 ALL PINS
U30 PINS 1 - 6	

IV SYMPTOM:

A. INSTRUMENT WILL NOT CYCLE (NO MEASUREMENT MADE, NO GATE LIGHT)
B. NO STORAGE-SHOWS DISPLAY COUNTING (REAR PANEL STORAGE SWITCH ON)
C. NO RESET

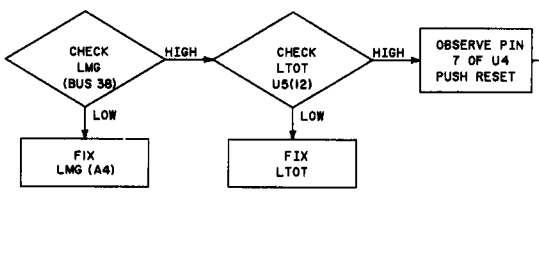
TEST:

1. SET RESOLUTION TO 1HZ
2. SET FUNCTION SELECTOR SWITCH TO CHECK
3. SET SAMPLE RATE TO MID RANGE
4. INSTALL TEST CARD 2 TEST 8 TO TEST SAMPLE RATE AUTOMATICALLY

OBSERVE:

```
= = = = = = = =
[ [ [ [ [ [ [ [
1 1 1 1 1 1 1 1
9 9 9 9 9 9 9 9
```

IF CORRECT DISPLAY IS NOT OBTAINED SEE TEST.



V SYMPTOM:

A. GATE TIMES SEEM WRONG

TEST:

1. SET FUNCTION SELECTOR SWITCH TO CHECK
2. INSERT TEST CARD 1, TEST 4 (DISPLAY TIME BAS
3. SET RESOLUTION SWITCH TO 1MHZ
4. ROTATE RESOLUTION SWITCH CLOCKWISE ONE POSIT TIME AND OBSERVE DISPLAY AS SHOWN BELOW:

```
0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3
4 4 4 4 4 4 4 4
5 5 5 5 5 5 5 5
6 6 6 6 6 6 6 6
7 7 7 7 7 7 7 7
```

5. TRACE INCORRECT TIME BASE THROUGH: U25 PIN 15, U26 PIN 15 AND U27 PIN 15 OF

VI SYMPTOM:

A. ANY OF THE FIRST 6 DIGITS WRONG; OTHERS OK
B. DIGIT 7 WRONG
C. DIGIT 8 WRONG

TEST:

1. SET FUNCTION SELECTOR SWITCH TO START CLOCK (ONE POSITION CLOCKWISE FROM STOP.)
2. SET RESOLUTION FOR .1HZ; OBSERVE 8TH DIGIT COUNT AT 1HZ RATE.
3. SET RESOLUTION FOR 1HZ RESOLUTION OBSERVE 7TH DIGIT COUNT AT 1HZ RATE.
4. CONTINUE INCREMENTING THE RESOLUTION SWITCH UNTIL THE FAULTY DECADE IS FOUND. DIGIT 8 COMES FROM THE FUNCTION SELECTOR DIGIT 7 COMES FROM U10 OF THE DCA ON THE DIGITS 1-6 COME FROM U12 OF THE DCA ON TH CHECK THE CARRY OUT OF EACH DECADE IF THE SUBSEQUENT DECADE WILL NOT COUNT.

VII SYMPTOM:

A. NO INTERNAL OSCILLATOR ON THE BUS

TEST:

VIII SYMPTOM:

A. OSCILLATOR AT WRONG FREQUENCY

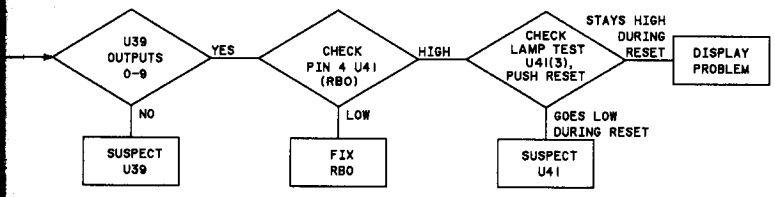
TEST:

1. ADJUST C18 FOR 10MHZ
2. CHANGE TEST SELECT CAPACITOR C17
3. SUSPECT Y1.

IX SYMPTOM:

A. NO OSCILLATOR ON BUS WHEN IN EXTERNAL.

TEST:



NOTE:

TO TRACE MOTHERBOARD BUS LINES, REFER TO INTERCONNECTION DIAGRAM, FIGURE 6-17.

V SYMPTOM:

A. GATE TIMES SEEM WRONG

TEST:

1. SET FUNCTION SELECTOR SWITCH TO CHECK
2. INSERT TEST CARD 1, TEST 4 (DISPLAY TIME BASE CODE)
3. SET RESOLUTION SWITCH TO 1MHZ
4. ROTATE RESOLUTION SWITCH CLOCKWISE ONE POSITION AT A TIME AND OBSERVE DISPLAY AS SHOWN BELOW:

```
0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3
4 4 4 4 4 4 4 4
5 5 5 5 5 5 5 5
6 6 6 6 6 6 6 6
7 7 7 7 7 7 7 7
```

5. TRACE INCORRECT TIME BASE THROUGH: U25 PIN 15, U26 PIN 16 AND U27 PIN 16 OF ROM LATCHES

VI SYMPTOM:

A. ANY OF THE FIRST 6 DIGITS WRONG; OTHERS OK
B. DIGIT 7 WRONG
C. DIGIT 8 WRONG

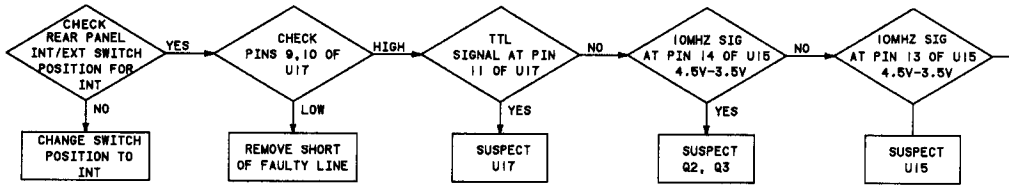
TEST:

1. SET FUNCTION SELECTOR SWITCH TO START CLOCK (ONE POSITION CLOCKWISE FROM STOP.)
2. SET RESOLUTION FOR .1HZ:
   OBSERVE 8TH DIGIT COUNT AT 1HZ RATE.
3. SET RESOLUTION FOR 1HZ RESOLUTION
   OBSERVE 7TH DIGIT COUNT AT 1HZ RATE.
4. CONTINUE INCREMENTING THE RESOLUTION SWITCH UNTIL THE FAULTY DECADE IS FOUND.
   DIGIT 8 COMES FROM THE FUNCTION SELECTOR BOARD
   DIGIT 7 COMES FROM U10 OF THE DCA ON THE MOTHER BOARD.
   DIGITS 1-6 COME FROM U12 OF THE DCA ON THE MOTHER BOARD.
   CHECK THE CARRY OUT OF EACH DECADE IF THE SUBSEQUENT DECADE WILL NOT COUNT.

VII SYMPTOM:

A. NO INTERNAL OSCILLATOR ON THE BUS

TEST:



VIII SYMPTOM:

A. OSCILLATOR AT WRONG FREQUENCY

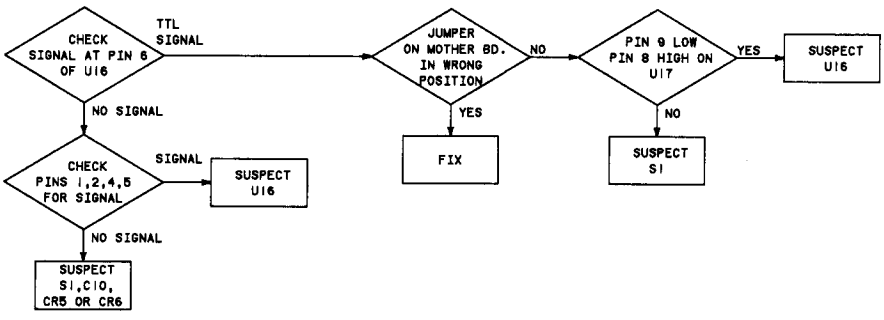
TEST:

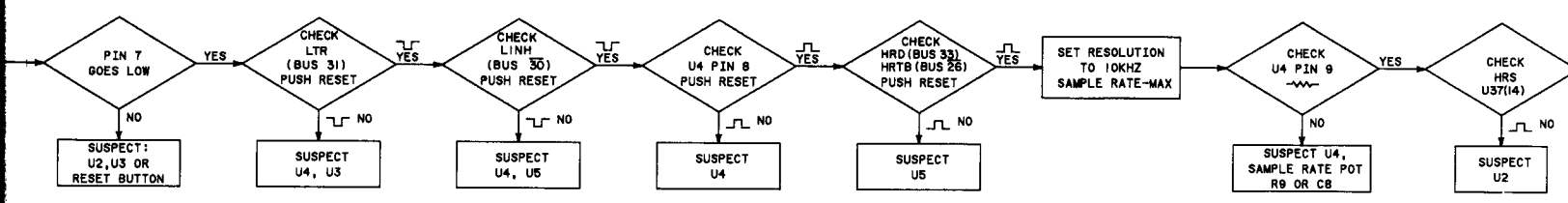
1. ADJUST C18 FOR 10MHZ
2. CHANGE TEST SELECT CAPACITOR C17
3. SUSPECT Y1.

IX SYMPTOM:

A. NO OSCILLATOR ON BUS WHEN IN EXTERNAL.

TEST:





Figure

NOTE:
TO TRACE MOTHERBOARD BUS LINES, REFER TO INTERCONNECTION DIAGRAM, FIGURE 6-17.

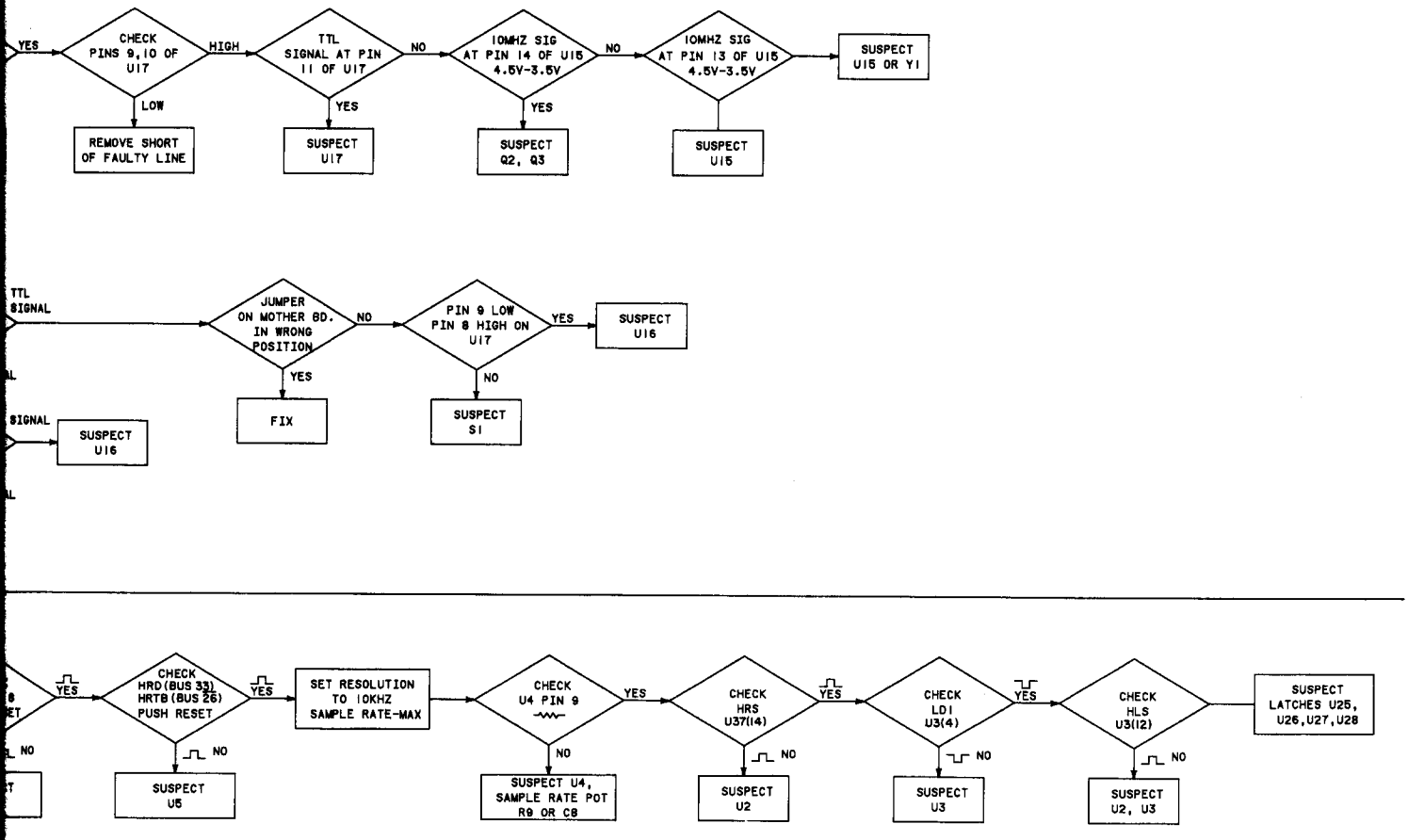
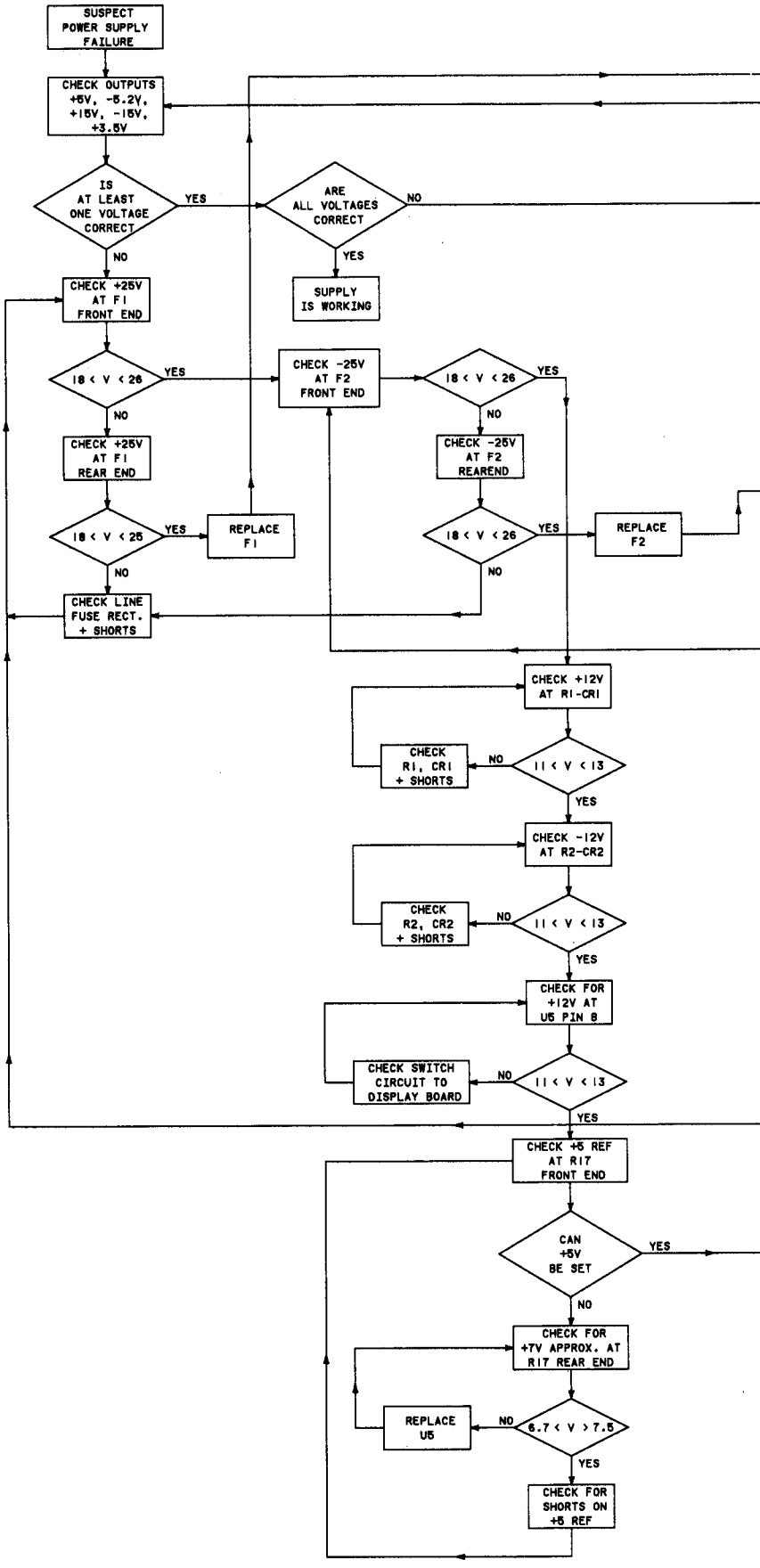


Figure 3-1. A1 Motherboard Troubleshooting Flowchart

A2 POWER SUPPLY TROUBLESHOOTING FLOWCHART



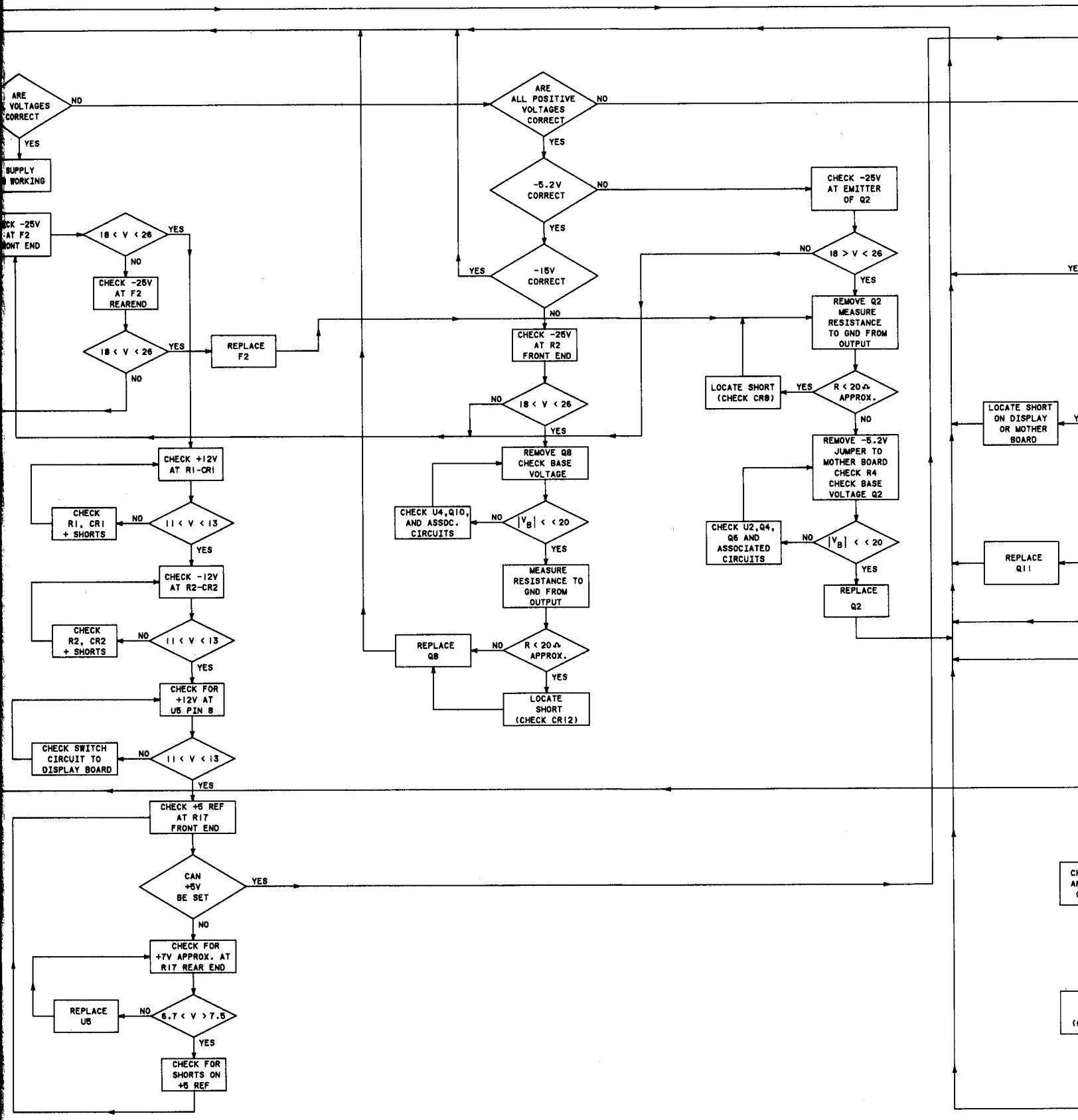

ARE VOLTAGES CORRECT
NO
YES
SUPPLY WORKING
CK -25V AT F2 ONT END
18 < V < 26
YES
NO
CHECK -25V AT F2 REAREND
18 < V < 26
YES
NO
REPLACE F2
ARE ALL POSITIVE VOLTAGES CORRECT
NO
YES
-5.2V CORRECT
NO
YES
-15V CORRECT
YES
NO
CHECK -25V AT R2 FRONT END
18 < V < 26
NO
YES
CHECK -25V AT EMITTER OF Q2
18 > V < 26
NO
YES
REMOVE Q2 MEASURE RESISTANCE TO GND FROM OUTPUT
LOCATE SHORT (CHECK CR8)
YES
R < 20Ω APPROX.
NO
REMOVE -5.2V JUMPER TO MOTHER BOARD CHECK R4 CHECK BASE VOLTAGE Q2
CHECK U2,Q4, Q6 AND ASSOCIATED CIRCUITS
NO
|VB| < < 20
YES
REPLACE Q2
LOCATE SHORT ON DISPLAY OR MOTHER BOARD
REPLACE Q11
REMOVE Q8 CHECK BASE VOLTAGE
CHECK U4,Q10, AND ASSOC. CIRCUITS
NO
|VB| < < 20
YES
MEASURE RESISTANCE TO GND FROM OUTPUT
REPLACE Q8
NO
R < 20Ω APPROX.
YES
LOCATE SHORT (CHECK CR12)
CHECK +12V AT R1-CR1
CHECK R1, CR1 + SHORTS
NO
11 < V < 13
YES
CHECK -12V AT R2-CR2
CHECK R2, CR2 + SHORTS
NO
11 < V < 13
YES
CHECK FOR +12V AT U5 PIN 8
CHECK SWITCH CIRCUIT TO DISPLAY BOARD
NO
11 < V < 13
YES
CHECK +5 REF AT R17 FRONT END
CAN +5V BE SET
YES
NO
CHECK FOR +7V APPROX. AT R17 REAR END
REPLACE U5
NO
6.7 < V > 7.5
YES
CHECK FOR SHORTS ON +5 REF

Figure 3

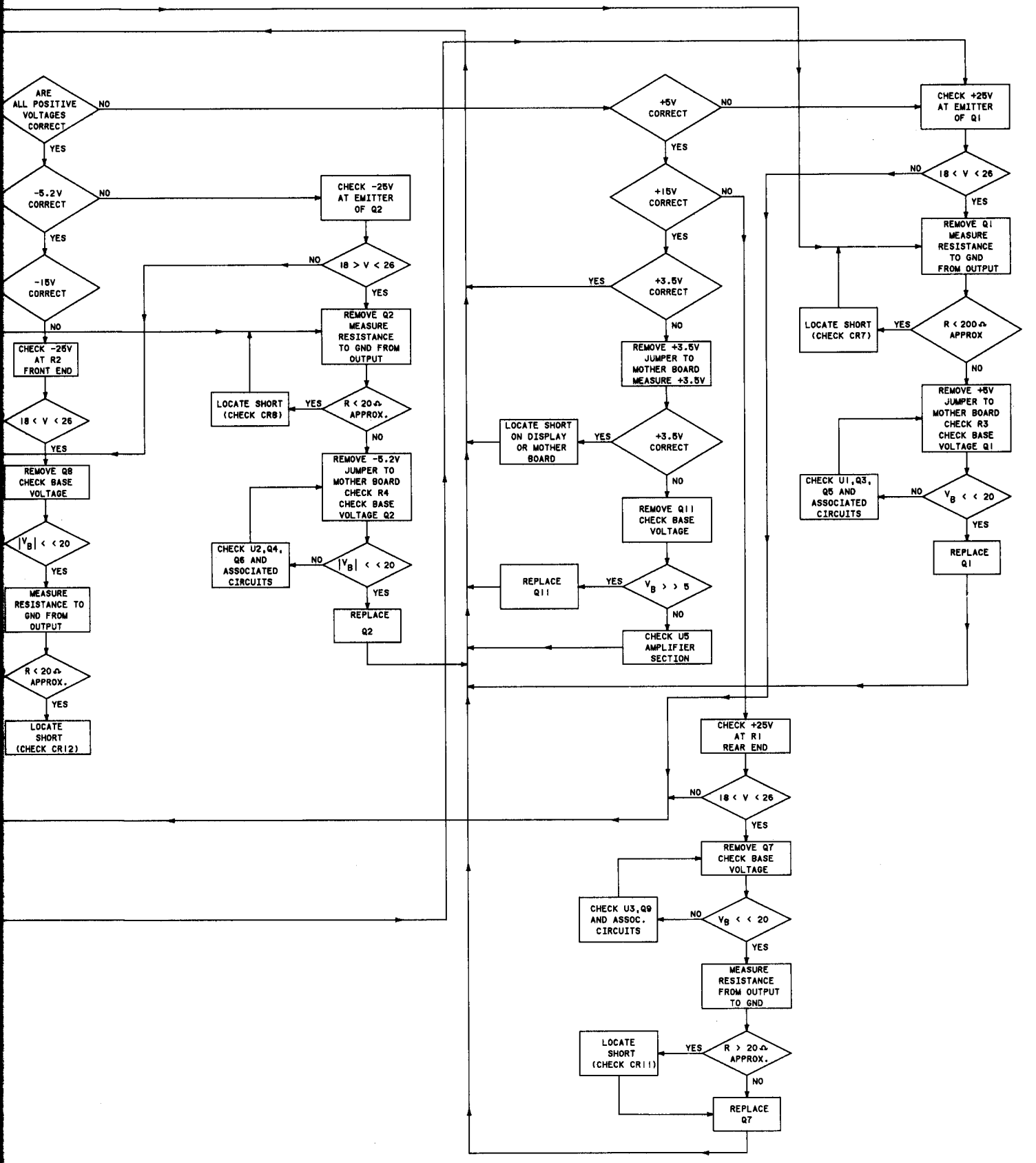
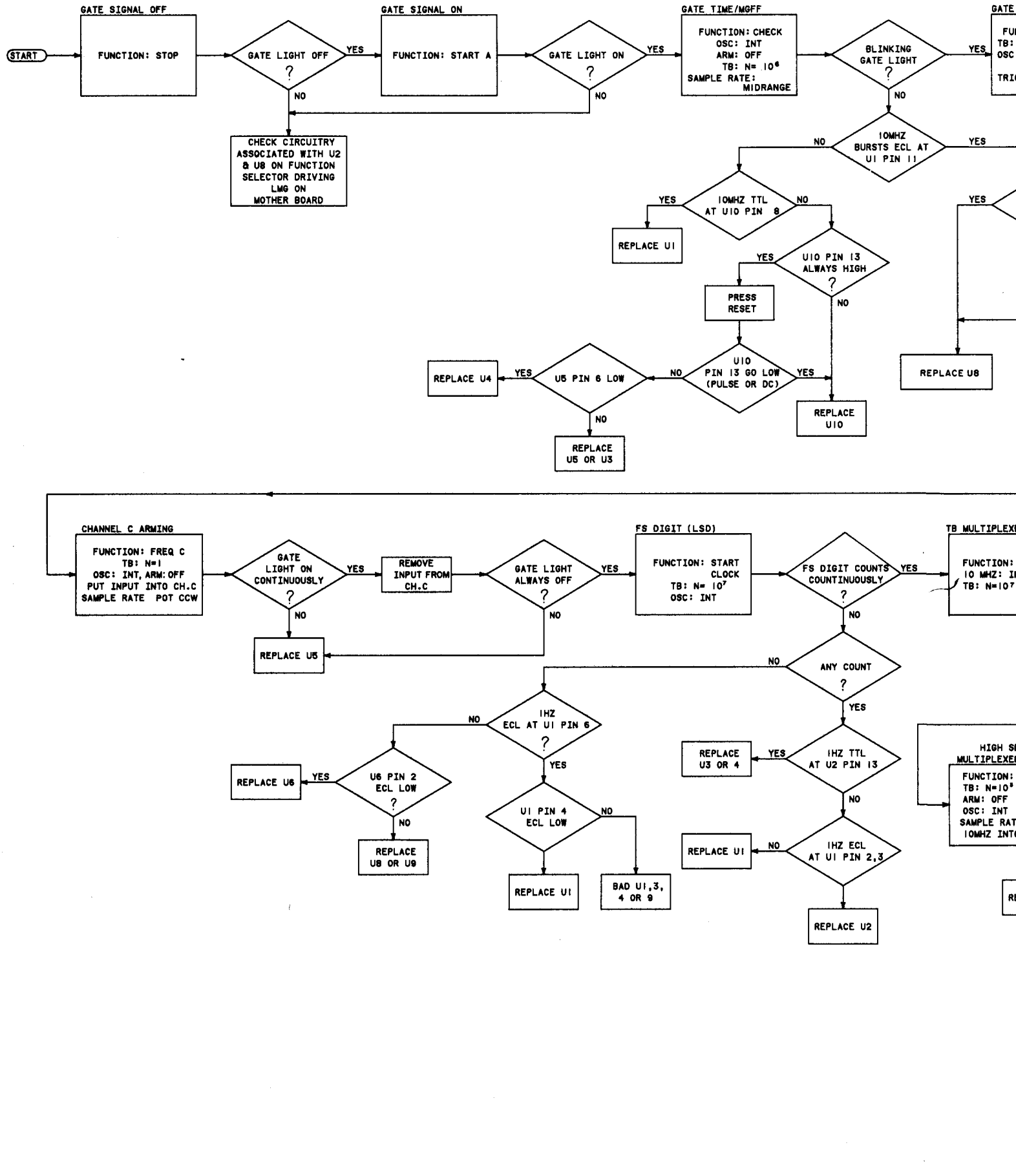
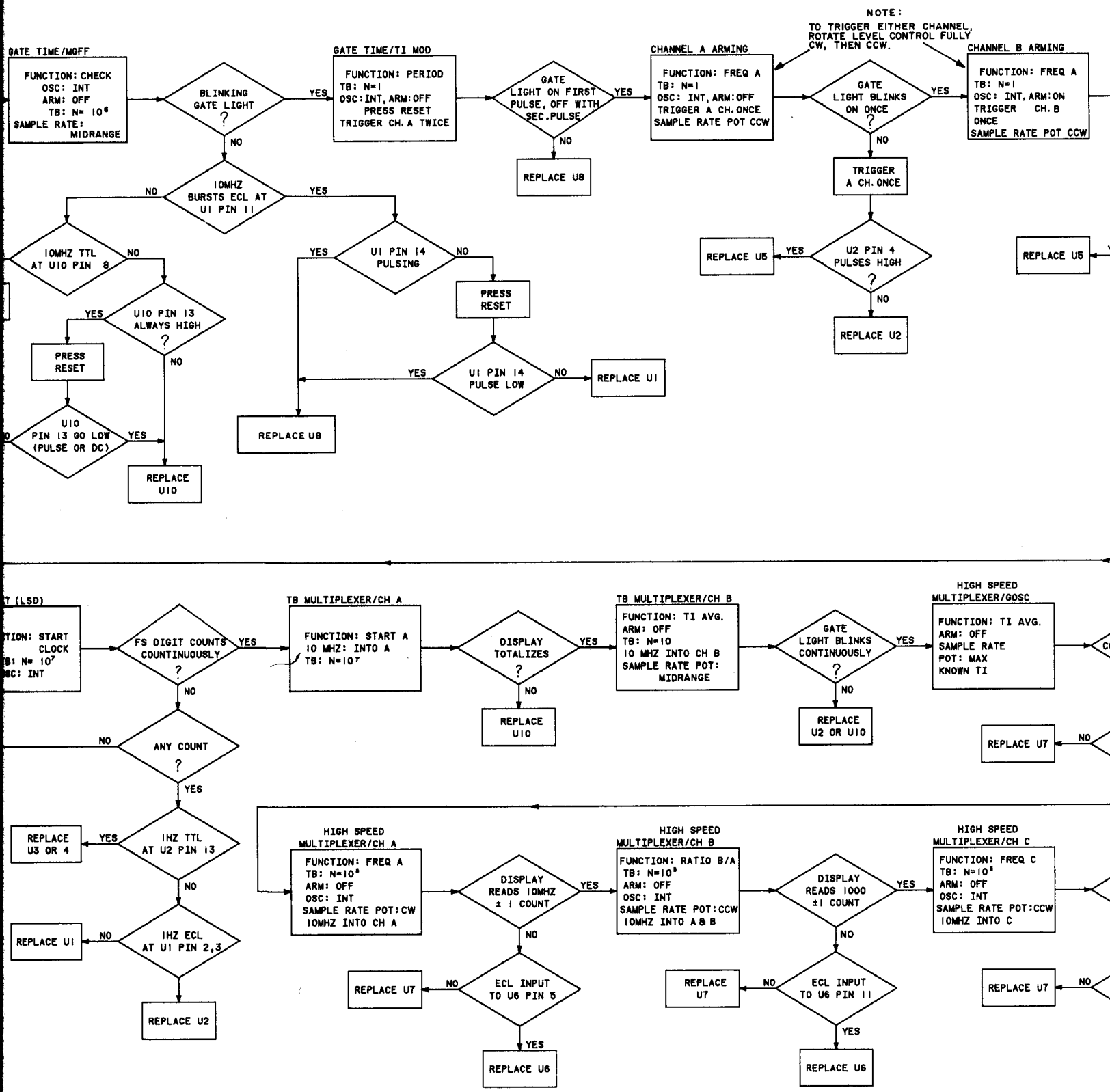


Figure 3-2. A2 Power Supply Troubleshooting Flowchart

A4 FUNCTION SELECTOR TROUBLE SHOOTING FLOWCHART




GATE TIME/MGFF
FUNCTION: CHECK OSC: INT ARM: OFF TB: N= 10⁶ SAMPLE RATE: MIDRANGE
BLINKING GATE LIGHT ?
YES
NO
GATE TIME/TI MOD
FUNCTION: PERIOD TB: N=1 OSC: INT, ARM: OFF PRESS RESET TRIGGER CH. A TWICE
GATE LIGHT ON FIRST PULSE, OFF WITH SEC. PULSE
REPLACE U8
CHANNEL A ARMING
FUNCTION: FREQ A TB: N=1 OSC: INT, ARM: OFF TRIGGER A CH. ONCE SAMPLE RATE POT CCW
NOTE: TO TRIGGER EITHER CHANNEL, ROTATE LEVEL CONTROL FULLY CW, THEN CCW.
GATE LIGHT BLINKS ON ONCE ?
CHANNEL B ARMING
FUNCTION: FREQ A TB: N=1 OSC: INT, ARM: ON TRIGGER CH. B ONCE SAMPLE RATE POT CCW
TRIGGER A CH. ONCE
U2 PIN 4 PULSES HIGH ?
REPLACE U5
REPLACE U2
10MHZ BURSTS ECL AT U1 PIN 11
10MHZ TTL AT U10 PIN 8
U10 PIN 13 ALWAYS HIGH ?
PRESS RESET
U10 PIN 13 GO LOW (PULSE OR DC)
REPLACE U10
U1 PIN 14 PULSING
PRESS RESET
U1 PIN 14 PULSE LOW
REPLACE U1
REPLACE U8
T (LSD)
TION: START CLOCK
B: N= 10⁷
C: INT
FS DIGIT COUNTS COUNTINUOUSLY ?
ANY COUNT ?
TB MULTIPLEXER/CH A
FUNCTION: START A 10 MHZ: INTO A TB: N=10⁷
DISPLAY TOTALIZES ?
REPLACE U10
TB MULTIPLEXER/CH B
FUNCTION: TI AVG. ARM: OFF TB: N=10 10 MHZ INTO CH B SAMPLE RATE POT: MIDRANGE
GATE LIGHT BLINKS CONTINUOUSLY ?
REPLACE U2 OR U10
HIGH SPEED MULTIPLEXER/GOSC
FUNCTION: TI AVG. ARM: OFF SAMPLE RATE POT: MAX KNOWN TI
REPLACE U7
1HZ TTL AT U2 PIN 13
REPLACE U3 OR 4
1HZ ECL AT U1 PIN 2,3
REPLACE U1
REPLACE U2
HIGH SPEED MULTIPLEXER/CH A
FUNCTION: FREQ A TB: N=10⁸ ARM: OFF OSC: INT SAMPLE RATE POT: CW 10MHZ INTO CH A
DISPLAY READS 10MHZ ± 1 COUNT
ECL INPUT TO U6 PIN 5
REPLACE U7
REPLACE U6
HIGH SPEED MULTIPLEXER/CH B
FUNCTION: RATIO B/A TB: N=10⁸ ARM: OFF OSC: INT SAMPLE RATE POT: CCW 10MHZ INTO A & B
DISPLAY READS 1000 ±1 COUNT
ECL INPUT TO U6 PIN 11
REPLACE U7
REPLACE U6
HIGH SPEED MULTIPLEXER/CH C
FUNCTION: FREQ C TB: N=10⁸ ARM: OFF OSC: INT SAMPLE RATE POT: CCW 10MHZ INTO C
REPLACE U7

Figu

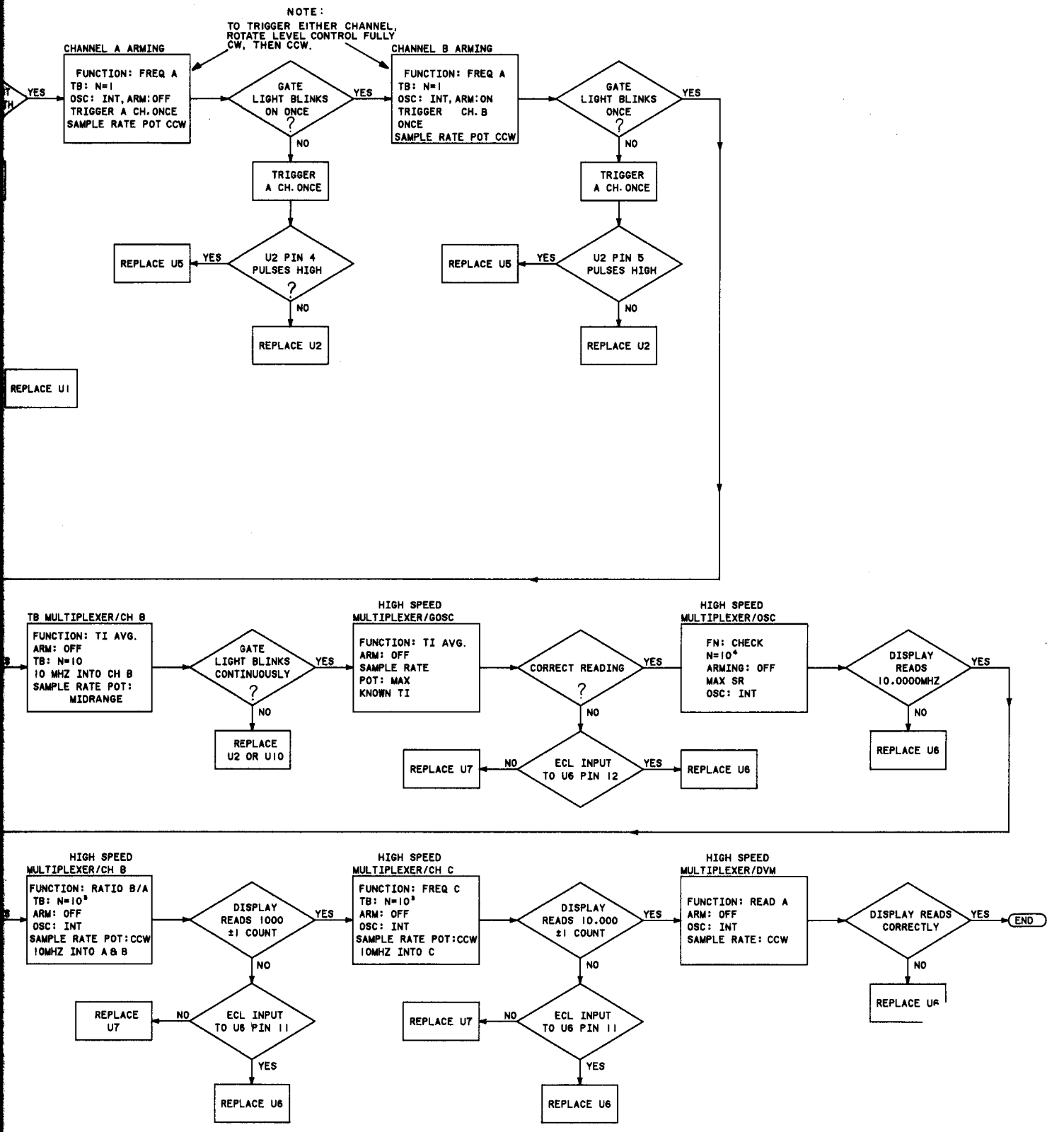
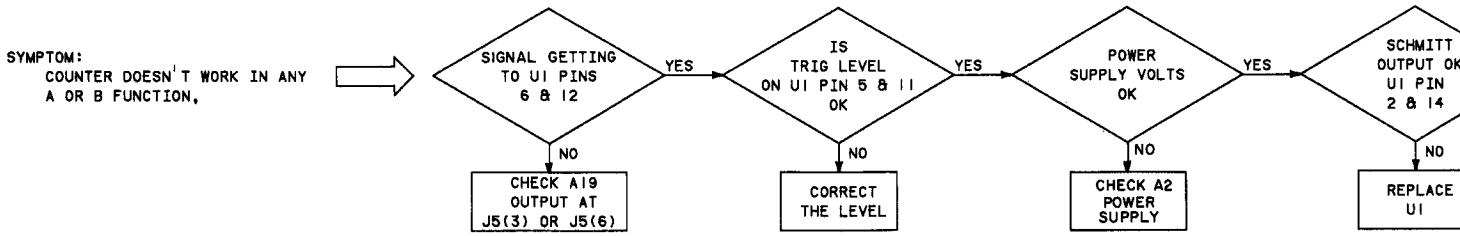
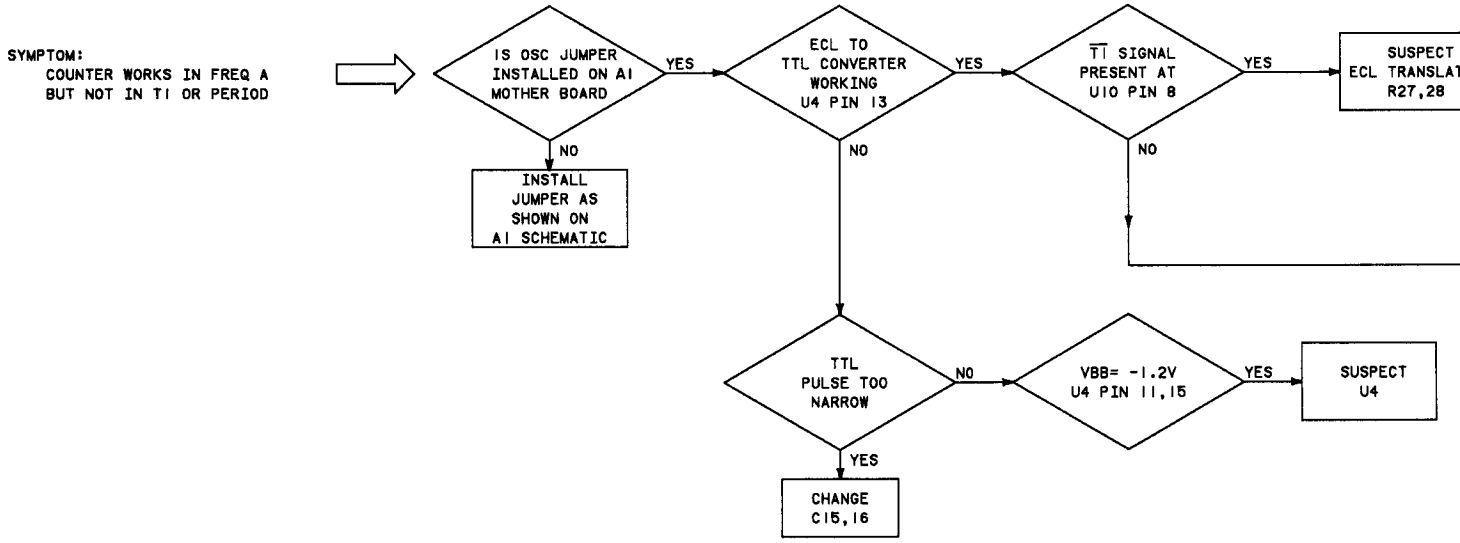
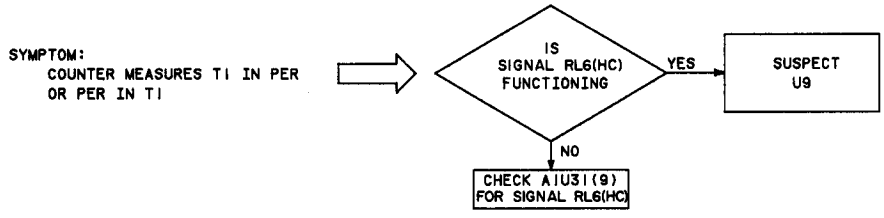


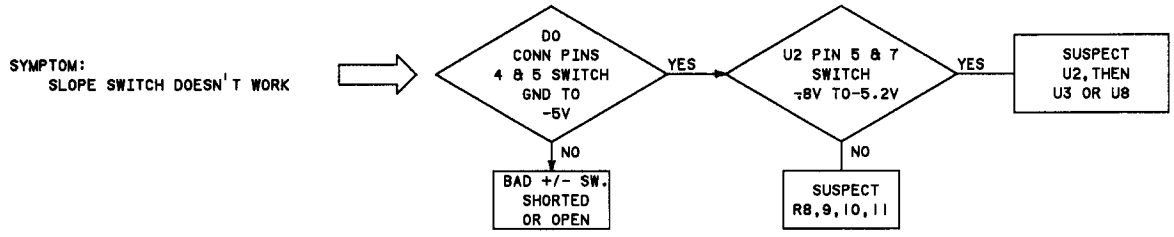
Figure 3-3. A4 Function Selector Troubleshooting Flowchart

A10 STANDARD SYNCHRONIZER TROUBLESHOOTING FLOWCHART









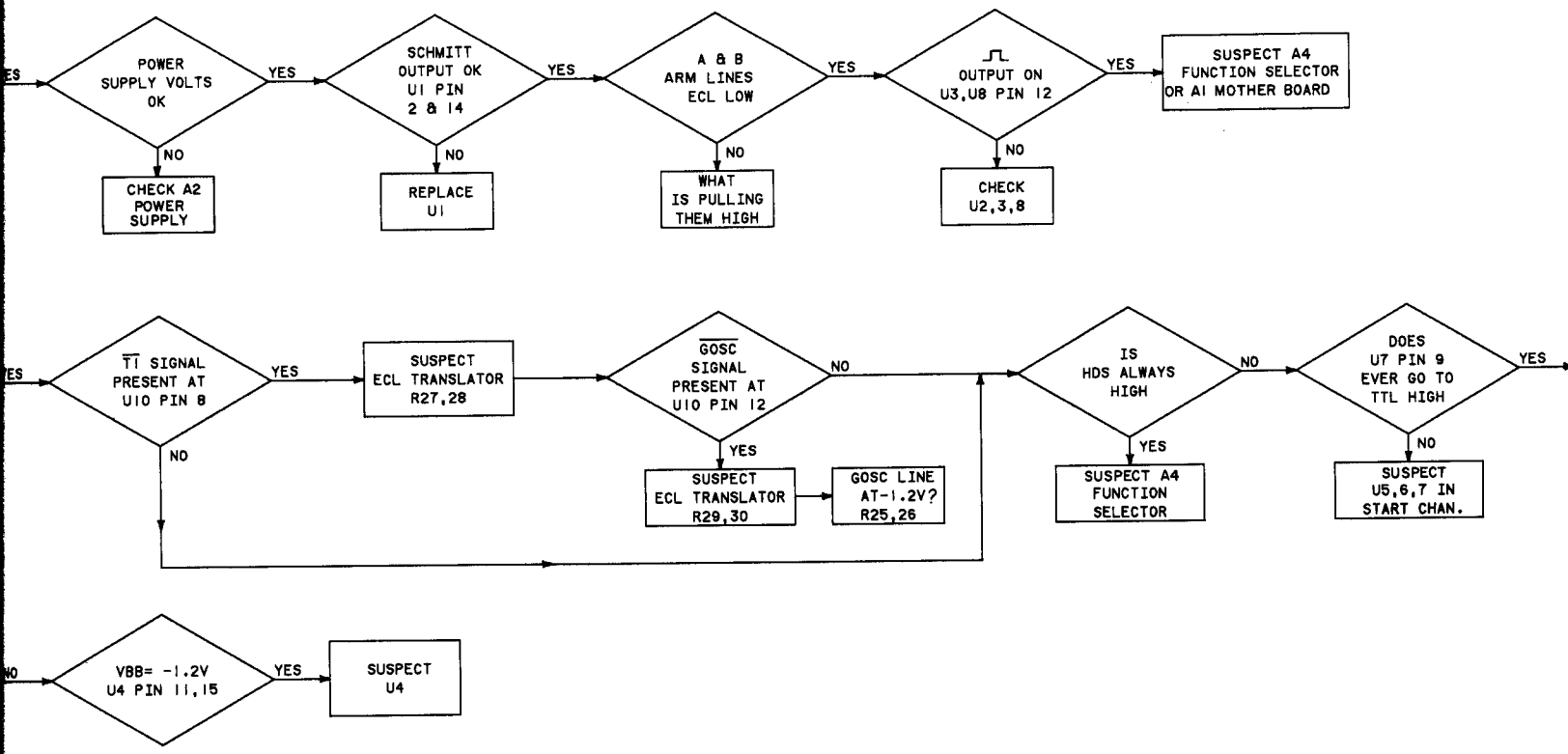


Figure 3–4. Standard A10

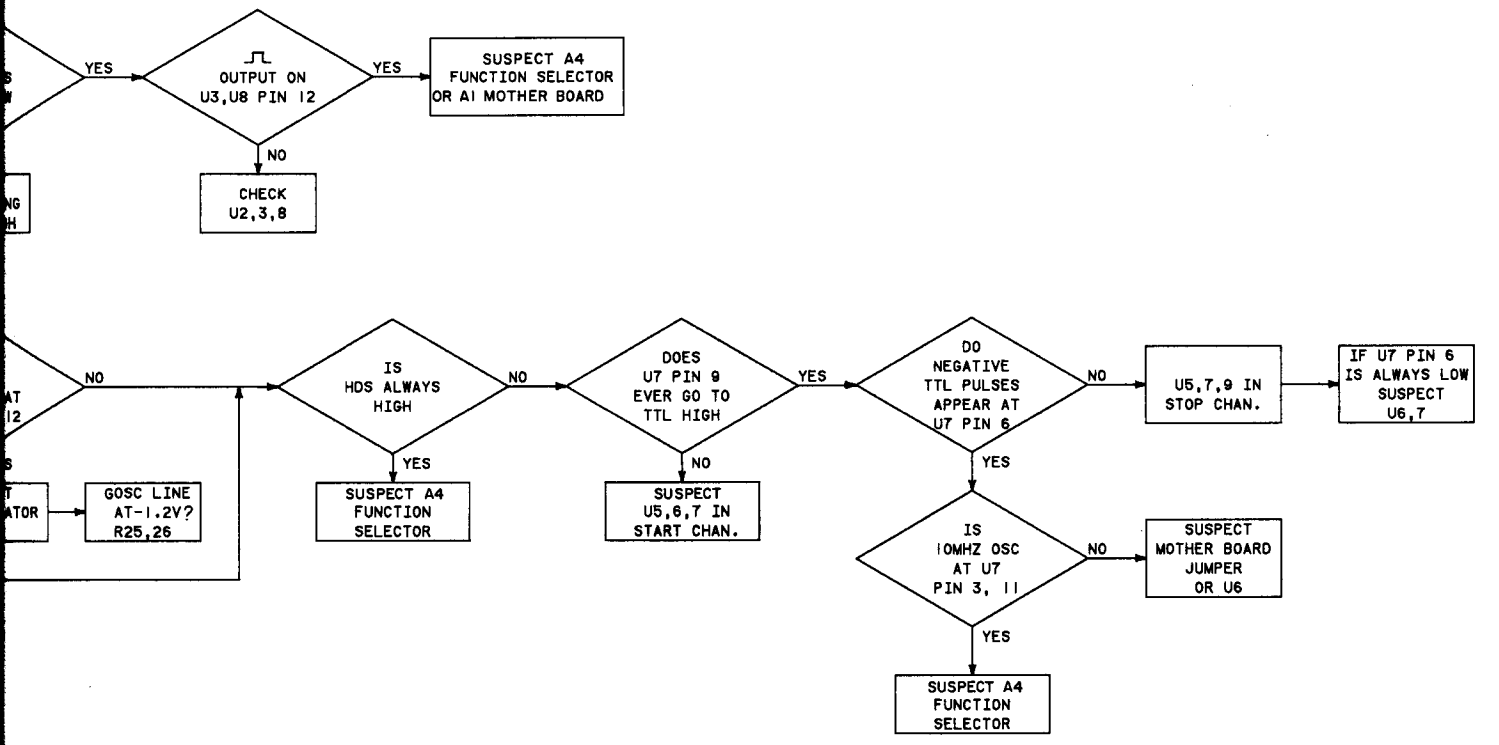


Figure 3-4. Standard A10 Synchronizer Assembly Troubleshooting Flowchart

A19 STANDARD ATTENUATOR ASSEMBLY TROUBLESHOOTING FLOWCHART

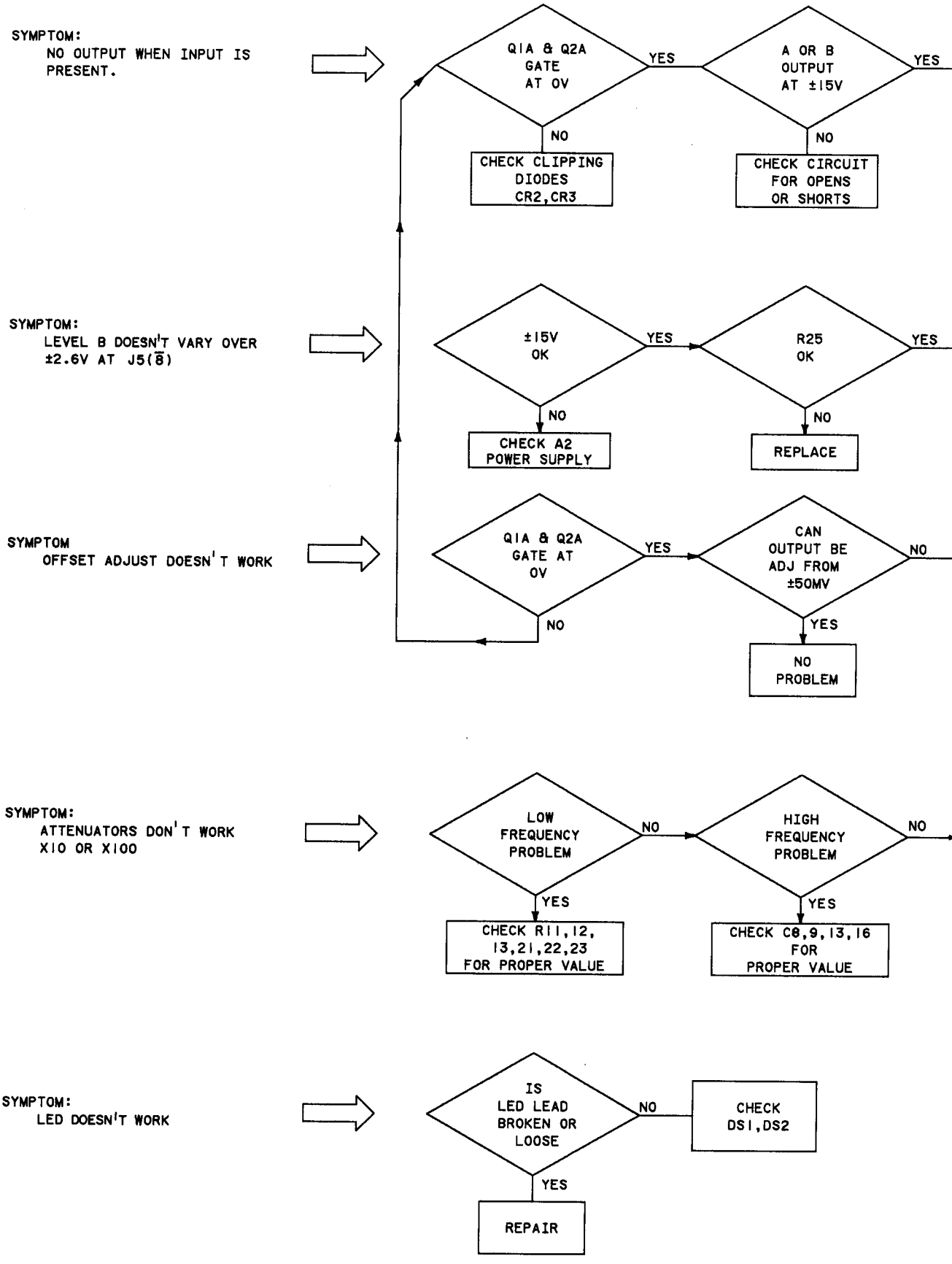


Figure 3-5. Standard A19 A

R ASSEMBLY TROUBLESHOOTING FLOWCHART

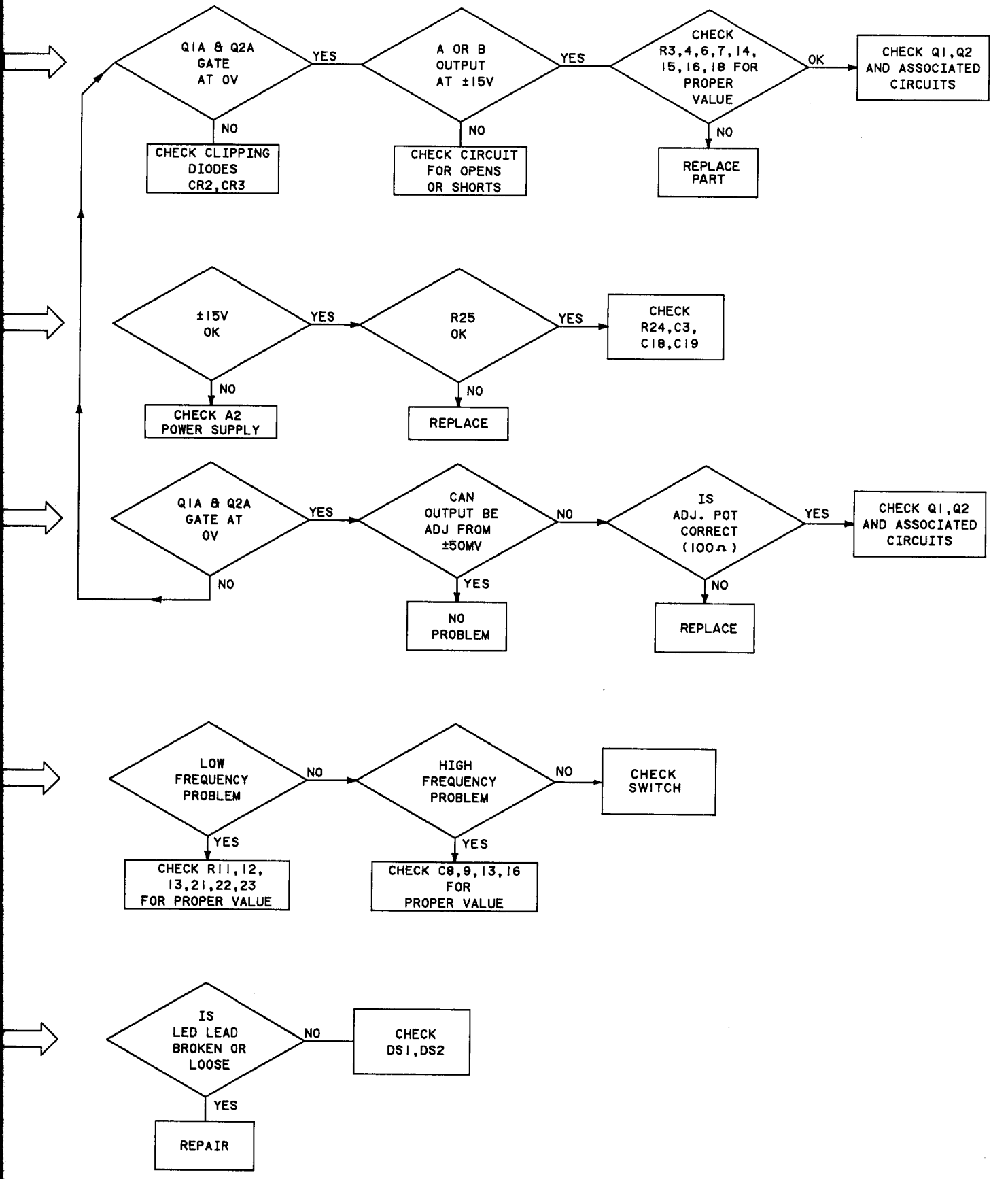


Figure 3–5. Standard A19 Attenuator Assembly Troubleshooting Flowchart

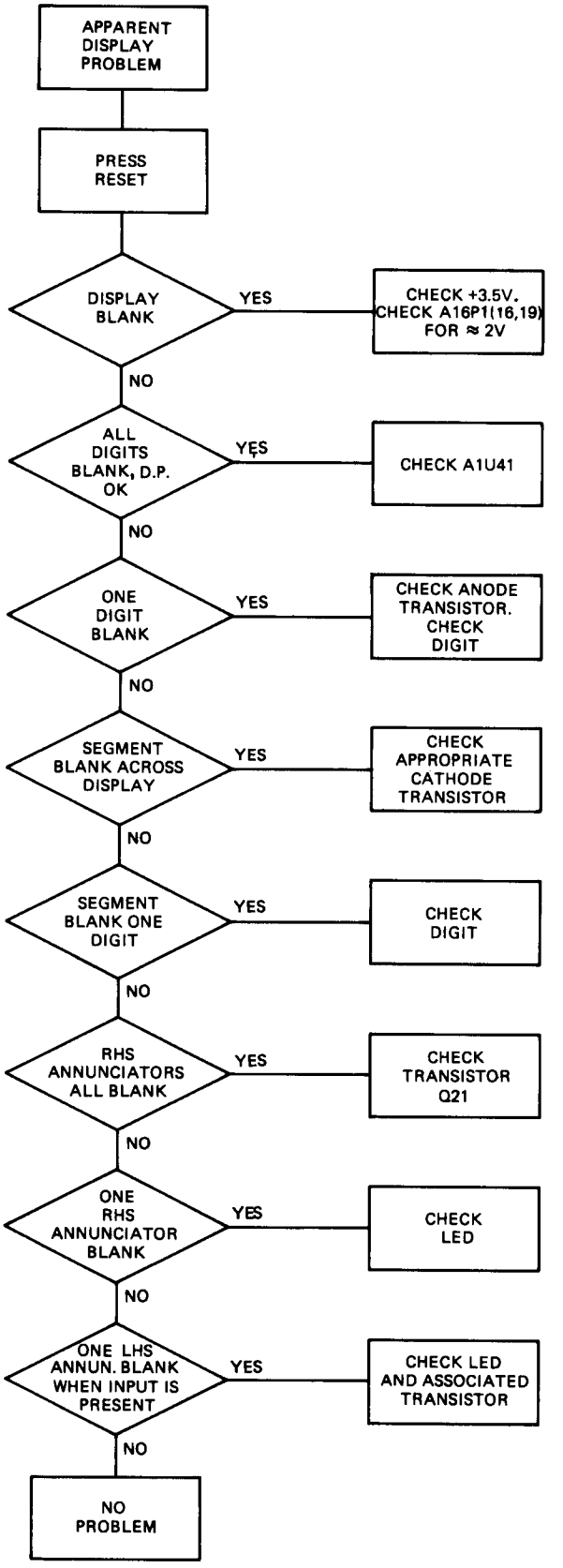


Figure 3-6. A16 Display Assembly Troubleshooting

SECTION IV
REPLACEABLE PARTS

4-1. INTRODUCTION

4-2. This section contains information for ordering replacement parts. Table 4-1 lists parts in alphanumerical order of their reference designators and indicates the description and HP Part Number of each part, together with any applicable notes. The table includes the following information.

a. Description of part (see abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in Table 4-2.

c. Manufacturer's part number.

d. Total quantity used in the instrument (Qty column).

4-3. HP 5328A options parts are listed in the Installation and Service Manual for each option.

REFERENCE DESIGNATIONS

A	= assembly	E	= micellaneous electrical part	MP	= miscellaneous mechanical part	TP	= test point
AT	= attenuator; isolator; termination	F	= fuse	P	= electrical connector (movable portion); plug	U	= integrated circuit; microcircuit
B	= fan; motor	FL	= filter			V	= electron tube
BT	= battery	H	= hardware	Q	= transistor; SCR; triode thyristor	VR	= voltage regulator; breakdown diode
C	= capacitor	HY	= circulator	R	= resistor	W	= cable; transmission path; wire
CP	= coupler	J	= electrical connector (stationary portion); jack	RT	= thermistor	X	= socket
CR	= diode; diode thyristor; varactor	K	= relay	S	= switch	Y	= crystal unit-piezo-electric
DC	= directional coupler	L	= coil; inductor	T	= transformer	Z	= tuned cavity; tuned circuit
DL	= delay line	M	= meter	TB	= terminal board		
DS	= annunciator; signaling device (audible or visual); lamp; LED			TC	= thermocouple		

ABBREVIATIONS

A	= ampere	BCD	= binary coded decimal	COMP	= composition	°K	= degree Kelvin
ac	= alternating current	BD	= board	COMPL	= complete	DEPC	= deposited carbon
ACCESS	= accessory	BE CU	= beryllium copper	CONN	= connector	DET	= detector
ADJ	= adjustment	BFO	= beat frequency oscillator	CP	= cadmium plate	diam	= diameter
A/D	= analog-to-digital	BH	= binder head	CRT	= cathode-ray tube	DIA	= diameter (used in parts list)
AF	= audio frequency	BKDN	= breakdown	CTL	= complementary transistor logic	DIFF AMPL	= differential amplifier
AFC	= automatic frequency control	BP	= bandpass	CW	= continuous wave	div	= division
AGC	= automatic gain control	BPF	= bandpass filter	cw	= clockwise	DPDT	= double-pole, double-throw
AL	= aluminum	BRS	= brass	D/A	= digital-to-analog	DR	= drive
ALC	= automatic level control	BWO	= backward-wave oscillator	dB	= decibel	DSB	= double sideband
AM	= amplitude modulation	CAL	= calibrate	dBm	= decibel referred to 1 mW	DTL	= diode transistor logic
AMPL	= amplifier	ccw	= counterclockwise	dc	= direct current	DVM	= digital voltmeter
APC	= automatic phase control	CER	= ceramic	deg	= degree (temperature interval or difference)	ECL	= emitter coupled logic
ASSY	= assembly	CHAN	= channel	...°	= degree (plane angle)	EMF	= electromotive force
AUX	= auxiliary	cm	= centimeter	°C	= degree Celsius (centrigrade)	EDP	= electronic data processing
avg	= average	CMO	= coaxial	°F	= degree Fahrenheit	ELECT	= electrolytic
AWG	= american wire gauge	COEF	= coefficient				
BAL	= balance	COM	= common				

ABBREVIATIONS (CONTINUED)

ENCAP = encapsulated
EXT = external
F = farad
FET = field-effect transistor
F/F = flip-flop
FH = flat head
FOL H = fillister head
FM = frequency modulation
FP = front panel
FREQ = frequency
FXD = fixed
g = gram
GE = germanium
GHz = gigahertz
GL = glass
GND = ground(ed)
H = henry
h = hour
HET = heterodyne
HEX = hexagonal
HD = head
HDW = hardware
HF = high frequency
HG = mercury
HI = high
HP = Hewlett-Packard
HPF = high pass filter
HR = hour (used in parts list)
HV = high voltage
Hz = Hertz
IC = integrated circuit
ID = inside diameter
IF = intermediate frequency
IMPG = impregnated
in = inch
INCD = incandescent
INCL = include(s)
INP = input
INS = insulation
INT = internal
kg = kilogram
kHz = kilohertz
kΩ = kilohm
kV = kilovolt
lb = pound
LC = inductance-capacitance
LED = light-emitting diode
LF = low frequency
LG = long
LH = left hand
LIM = limit
LIN = linear taper (used in parts list)
lin = linear
LK WASH = lockwasher
LO = low; local oscillator
LOG = logarithmic taper (used in parts list)
log = logarithm(ic)
LPF = low pass filter
LV = low voltage
m = meter (distance)
mA = milliampere
MAX = maximum
MΩ = megohm
MEG = meg (10^6) (used in parts list)
MET FLM = metal film
MET OX = metal oxide
MF = medium frequency; microfared (used in parts list)
MFR = manufacturer
mg = milligram
MHz = megahertz
mH = millihenry
mho = mho
MIN = minimum
min = minute (time)
... = minute (plane angle)
MINAT = miniature
mm = millimeter
MOD = modulator
MOM = momentary
MOS = metal-oxide semi-conductor
ms = millisecond
MTG = mounting
MTR = meter (indicating device)
mV = millivolt
mVac = millivolt, ac
mVdc = millivolt, dc
mVpk = millivolt, peak
mVp-p = millivolt, peak-to-peak
mVrms = millivolt, rms
mW = milliwatt
MUX = multiplex
MY = mylar
μA = microampere
μF = microfarad
μH = microhenry
μmho = micromho
μs = microsecond
μV = microvolt
μVac = microvolt, ac
μVdc = microvolt, dc
μVpk = microvolt, peak
μVp-p = microvolt, peak-to-peak
μVrms = microvolt, rms
μW = microwatt
nA = nanoampere
NC = no connection
N/C = normally closed
NE = neon
NEG = negative
nF = nanofarad
NI PL = nickel plate
N/O = normally open
NOM = nominal
NORM = normal
NPN = negative-positive-negative
NPO = negative-positive zero (zero temperature coefficient)
NRFR = not recommended for field replacement
NSR = not separately replaceable
ns = nanosecond
nW = nanowatt
OBD = order by description
OD = outside diameter
OH = oval head
OP AMPL = operational amplifier
OPT = option
OSC = oscillator
OX = oxide
oz = ounce
Ω = ohm
P = peak (used in parts list)
PAM = pulse-amplitude modulation
PC = printed circuit
PCM = pulse-code moudulation; pulse-count modulation
PDM = pulse-duration modulation
pF = picofarad
PH BRZ = phosphor bronze
PHL = Phillips
PIN = positive-instrinsic-negative
PIV = peak inverse voltage
pk = peak
PL = phase lock
PLO = phase lock oscillator
PM = phase modulation
PNP = positive-negative-positive
P/O = part of
POLY = polystyrene
PORC = porcelain
POS = positive; position(s) (used in parts list)
POSN = position
POT = potentiometer
p-p = peak-to-peak
PP = peak-to-peak (used in parts list)
PPM = pulse-position modulation
PREAMPL = preamplifier
PRF = pulse-repetition frequency
PRR = pulse repetition rate
ps = picosecond
PT = point
PTM = pulse-time modulation
PWM = pulse-width modulation
PWV = peak working voltage
RC = resistance capacitance
RECT = rectifier
REF = reference
REG = regulated
REPL = replaceable
RF = radio frequency
RFI = radio frequency interference
RH = round head; right hand
RLC = resistance-inductance-capacitance
RMO = rack mount only
rms = root-mean-square
RND = round
ROM = read-only memory
R&P = rack and panel
RWV = reverse working voltage
S = scattering parameter
s = second (time)
... = second (plane angle)
S-B = slow-blow (fuse (used in parts list)
SCR = silicon controlled rectifier; screw
SE = selenium
SECT = sections
SEMICON = semiconductor
SHF = superhigh frequency
SI = silicon
SIL = silver
SL = slide
SNR = signal-to-noise ratio
SPDT = single-pole, double-throw
SPG = spring
SR = split ring
SPST = single-pole, single-throw
SSB = single sideband
SST = stainless steel
STL = steel
SQ = square
SWR = standing-wave ratio
SYNC = synchronize
T = timed (slow-blow fuse)
TA = tantalum
TC = temperature compensating
TD = time delay
TERM = terminal
TFT = thin-film transistor
TGL = toggle
THD = thread
THRU = through
TI = titanium
TOL = tolerance
TRIM = trimmer
TSTR = transistor
TTL = transistor-transistor logic
TV = television
TVI = television interference
TWT = traveling wave tube
U = micro (10^{-6}) (used in parts list)
UF = microfarad (used in parts list)
UHF = ultrahigh frequency
UNREG = unregulated
V = volt
VA = voltampere
Vac = volts ac
VAR = variable
VCO = voltage-controlled oscillator
Vdc = volts dc
VDCW = volts dc, working (used in parts list)
V(F) = volts, filtered
VFO = variable-frequency oscillator
VHF = very-high frequency
Vpk = volts peak
Vp-p = Volts peak-to-peak
Vrms = volts rms
VSWR = voltage standing wave ratio
VTO = voltage-tuned oscillator
VTVM = vacuum-tube voltmeter
V(X) = volts, switched
W = watt
W/ = with
WIV = working inverse voltage
WW = wirewound
W/O = without
YIG = yttrium-iron-garnet
Zo = characteristic impedance

NOTE

All abbreviations in the parts list will be in upper case.

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10^{12}
G	giga	10^9
M	mega	10^6
k	kilo	10^3
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	atto	10^{-18}

4-4. ORDERING INFORMATION

4-5. To obtain replacement parts, address order of inquiry to your local Hewlett-Packard Sales and Service Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard part numbers.

a. Instrument model number.
b. Instrument serial number.
c. Description of the part.
d. Function and location of the part.

4-6. HP PART NUMBER ORGANIZATION

4-7. Following is a general description of the HP part number system.

4-8. Component Parts and Materials

4-9. Generally, the prefix of HP part numbers identifies the type of device. Eight digit part numbers are used, where the four digit prefix identifies the type of component, part, or material and the four digit suffix indicates the specific type. Following is a list of some of the more commonly used prefixes for component parts. The list includes HP manufactured parts and purchased parts.

Prefix	Component/Part/Material
0121--	Capacitors, Variable (mechanical)
0122-	Capacitors, Voltage Variable (semiconductor)
0140-	Capacitors, Fixed
0150-	Capacitors, Fixed Non-Electrolytic
0160-	Capacitors, Fixed
0180-	Capacitors, Fixed Electrolytic
0330-	Insulating Materials
0340-	Insulators, Formed
0370-	Knobs, Control
0380-	Spacers and Standoffs
0410-	Crystals
0470-	Adhesives
0490-	Relays
0510-	Fasteners
0674- thru 0778-	Resistors, Fixed (non wire wound)
0811- thru 0831-	Resistors (wire wound)
1200-	Sockets for components
1205-	Heat Sinks
1250-	Connectors (RF and related parts)
1251-	Connectors (non RF and related parts)
1410-	Bearings and Bushings
1420-	Batteries
1820-	Monolithic Digital Integrated Circuits
1826-	Monolithic Linear Integrated Circuits
1850-	Transistors, Germanium PNP
1851-	Transistors, Germanium NPN
1853-	Transistors, Silicon PNP
1854-	Transistors, Silicon NPN
1855-	Field-Effect-Transistors
1900- thru 1912-	Diodes
1920- thru 1952-	Vacuum Tubes
1990-	Semiconductor Photosensitive and Light-Emitting Diodes
3100- thru 3106-	Switches
8120-	Cables
9100-	Transformers, Coils, Chokes, Inductors, and Filters

4-10. For example, 1854-0037, 1854-0221, and 1851-0192 are all NPN transistors. The first two are silicon and the last is germanium.

4-11. General Usage Parts

4-12. The following list gives the prefixes for HP manufactured parts used in serveral instruments, e.g., side frames, feet, top and bottom covers, etc. These are eight-digit part numbers with the four-digit prefix identifying the type of parts as shown below:

Type of Part	Prefix
Sheet Metal	5000- to 5019-
Machined	5020- to 5039-
Molded	5040- to 5059-
Assemblies	5060- to 5079-
Components	5080- to 5099-

4-13. Specific Instrument Parts

4-14. These are HP manufactured parts for use in individual instruments or series of instruments. For these parts, the prefix indicates the instrument and the suffix indicates the type of part. For example, 05328-60001 is an assembly used in the 5328A. Following is a list of suffixes commonly used.

Type of Part	P/N Suffix
Sheet Metal	-00000 to -00499
Machined	-20000 to -20499
Molded	-40000 to -40499
Assembly	-60000 to -60499
Component	-80000 to -80299
Documentation	-90000 to -90249

4-15. FACTORY SELECTED PARTS

4-16. Some of the values in the parts lists are selected during manufacture to meet circuit requirements. These parts are marked with an asterisk (*) in the parts list and schematic diagrams, with average values shown.

Table 4-1. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1	05328-60001	1	MOTHER BOARD ASSEMBLY SERIES 1604	28480	05328-60001
A1C1			NOT ASSIGNED		
A1C2			NOT ASSIGNED		
A1C3	0180-1735	1	CAPACITOR-FXD .22UF+-10% 35VDC TA	56289	150D224X9035A2
A1C4	0160-0161	2	CAPACITOR-FXD .01UF +-10% 200WVDC POLYE	56289	292P10392
A1C5	0180-0106	2	CAPACITOR-FXD 60UF +-20% 6VDC TA	56289	150D606X0006B2
A1C6	0140-0177	1	CAPACITOR-FXD 400PF +-1% 300WVDC MICA	72136	DM15F401F0300WV1CR
A1C7	0160-0155	1	CAPACITOR-FXD 3300PF +-10% 200WVDC POLYE	56289	292P33292
A1C8	0180-0230	3	CAPACITOR-FXD 1UF+-20% 50VDC TA	56289	150D105X0050A2
A1C9			NOT ASSIGNED		
A1C10	0160-0314	1	CAPACITOR-FXD .01UF +-5% 100WVDC POLYE	84411	663UW10354M2
A1C11 THRU A1C16			NOT ASSIGNED		
A1C17*	0160-2264	1	CAPACITOR-FXD 20PF +-5% 500 WVDC CER *FACTORY SELECTED PART	28480	0160-2264
A1C18	0121-0060	1	CAPACITOR-V TRMR-CER 2/8PF 350V PC-MTG	0086S	304322 2/8PF NPO
A1C19			NOT ASSIGNED		
A1C20	0160-0161		CAPACITOR-FXD .01UF +-10% 200WVDC POLYE	56289	292P10392
A1C21	0180-0210	9	CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A1C22	0160-2055	26	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C23 THRU A1C28			NOT ASSIGNED		
A1C29	0180-0230		CAPACITOR-FXD 1UF+-20% 50VDC TA	56289	150D105X0050A2
A1C30	0160-0153	1	CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
A1C31	0180-0230		CAPACITOR-FXD 1UF+-20% 50VDC TA	56289	150D105X0050A2
A1C32	0180-0106		CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
A1C33	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C34	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A1C35	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C36	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A1C37	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C38	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C39	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C40	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A1C41	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C42	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A1C43	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C44	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1C45	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A1C46	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A1C47	0160-4084	6	CAPACITOR-FXD .1UF +-20% 50WVDC CER	28480	0160-4084
A1CR1	1901-0040	17	DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1CR2	1910-0016	4	DIODE-GE 60V 60NA 1US DO-7	28480	1910-0016
A1CR3	1910-0016		DIODE-GE 60V 60NA 1US DO-7	28480	1910-0016
A1CR4	1902-0031	1	DIODE-ZNR 12.7V 5% DO-7 PD=.4W TC=+.061%	04713	SZ10939-212
A1CR5	1901-0050	2	DIODE-SWITCHING 80V 200NA 2NS DO-7	28480	1901-0050
A1CR6	1901-0050		DIODE-SWITCHING 80V 200NA 2NS DO-7	28480	1901-0050
A1CR7	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1CR8	1902-3082	1	DIODE-ZNR 4.64V 5% DO-7 PD=.4W TC=-.023%	04713	SZ 10939-86
A1CR9	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1CR10	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1CR11	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1CR12	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1CR13	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1CR14	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1CR15	1910-0016		DIODE-GE 60V 60NA 1US DO-7	28480	1910-0016
A1CR16	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A1L1	9100-2276	1	COIL-FXD MOLDED RF CHOKE 100UH 10%	24226	10/103
A1Q1	1854-0071	5	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q2	1853-0015	2	TRANSISTOR PNP SI PD=200MW FT=500MHZ	28480	1853-0015
A1Q3	1853-0015		TRANSISTOR PNP SI PD=200MW FT=500MHZ	28480	1853-0015
A1Q4	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q5	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q6	1854-0092	3	TRANSISTOR NPN SI PD=200MW FT=600MHZ	28480	1854-0092
A1Q7	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q8	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1R1	0683-2715	9	RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A1R2	1810-0055	5	NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0055
A1R3	0683-2725	5	RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A1R4	0683-3355	1	RESISTOR 3.3M 5% .25W FC TC=-900/+1100	01121	CB3355
A1R5	1810-0055		NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0055
A1R6	0683-2725		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A1R7	0683-1035	21	RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R8	0683-4725	5	RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A1R9	0683-1525	9	RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A1R10	0683-1025	18	RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R11	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R12	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R13	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R14	0683-4725		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A1R15	1810-0041	2	NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0041
A1R16	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R17	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R18	0683-1525		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A1R19	1810-0055		NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0055
A1R20	0683-1525		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A1R21	0698-4037	1	RESISTOR 46.4 1% .125W F TC=0+-100	16299	C4-1/8-T0-46R4-F
A1R22	0683-2715		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A1R23	0683-2015	1	RESISTOR 200 5% .25W FC TC=-400/+600	01121	CB2015
A1R24	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R25	0683-1525		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A1R26	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R27	0683-1525		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A1R28	1810-0055		NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0055
A1R29	0683-4725		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A1R30	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R31	0683-5105	3	RESISTOR 51 5% .25W FC TC=-400/+500	01121	CB5105
A1R32	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R33	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R34	0683-2715		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A1R35	0683-5115	13	RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A1R36	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R37	0683-2715		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A1R38	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R39	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R40	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R41	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R42	1810-0055		NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0055
A1R43	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R44	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R45	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R46	0683-1545	1	RESISTOR 150K 5% .25W FC TC=-800/+900	01121	CB1545
A1R48	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R52	0683-5635	1	RESISTOR 56K 5% .25W FC TC=-400/+800	01121	CB5635
A1R55	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R56	0683-4725		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A1R47, R49-R51, R53, R54	----------		NOT ASSIGNED		
A1R57	0683-6815	4	RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A1R58	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R59	0683-5605	10	RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R60	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R61	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R62	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R63	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R64	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R65	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R66	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R67	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R68	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R69	0757-0935	1	RESISTOR 3K 2% .125W F TC=0+-100	24546	C4-1/8-T0-3001-G
A1R70	0757-0950	1	RESISTOR 12K 2% .125W F TC=0+-100	24546	C4-1/8-T0-1202-G
A1R71	0757-0279	1	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A1R72	0757-0931	1	RESISTOR 2K 2% .125W F TC=0+-100	24546	C4-1/8-T0-2001-G
A1R73	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R74	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R75	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R76	0683-1015	4	RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A1R77	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1S1	3101-1977	3	SWITCH-SL DPDT-NS SUBMIN .5A 125VAC PC	28480	3101-1977
A1S2	3101-1977		SWITCH-SL DPDT-NS SUBMIN .5A 125VAC PC	28480	3101-1977
A1S3	3101-1977		SWITCH-SL DPDT-NS SUBMIN .5A 125VAC PC	28480	3101-1977

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1U1	1820-0055	2	IC SN74 90 N COUNTER	01295	SN7490N
A1U2	1820-1056	1	IC SN74 132 N COUNTER	01295	SN74132N
A1U3	1820-0175	1	IC SN74 05 N INV	01295	SN7405N
A1U4	1820-1401	1	IC DIGITAL	28480	1820-1401
A1U5	1820-0513	2	IC SN74 09 N GATE	01295	SN7409N
A1U6	1820-0282	4	IC SN74 86 N GATE	01295	SN7486N
A1U7	1820-0511	1	IC SN74 08 N GATE	01295	SN7408N
A1U8	1820-0174	6	IC SN74 04 N INV	01295	SN7404N
A1U9	1820-0661	2	IC SN74 32 N GATE	01295	SN7432N
A1U10	1820-1143	1	IC DM85 52N COUNTER	27014	DM8552N
A1U11	1820-0301	5	IC SN74 75 N LATCH	01295	SN7475N
A1U12	1820-0634	1	IC COUNTER	28480	1820-0634
A1U13	1820-0269	2	IC SN74 03 N GATE	01295	SN7403N
A1U14	1820-0513		IC SN74 09 N GATE	01295	SN7409N
A1U15	1820-0803	1	IC MC10105L GATE	04713	MC10105P
A1U16	1820-0537	1	IC SN74 13 N SCHMITT	01295	SN7413N
A1U17	1820-0068	1	IC SN74 10 N GATE	01295	SN7410N
A1U18	1820-0174		IC SN74 04 N INV	01295	SN7404N
A1U19	1820-0077	1	IC SN74 74 N FLIP-FLOP	01295	SN7474N
A1U20	1820-0055		IC SN74 90 N COUNTER	01295	SN7490N
A1U21	1820-0633	1	IC DIGITAL	28480	1820-0633
A1U22	1820-0269		IC SN74 03 N GATE	01295	SN7403N
A1U23	1820-0328	2	IC:TTL QUAD 2-INPT NOR GATE	01295	SN7402N
A1U24	1820-0282		IC SN74 86 N GATE	01295	SN7486N
A1U25	1820-0301		IC SN74 75 N LATCH	01295	SN7475N
A1U26	1820-0301		IC SN74 75 N LATCH	01295	SN7475N
A1U27	1820-0301		IC SN74 75 N LATCH	01295	SN7475N
A1U28	1820-0538	2	IC SN74 23 N GATE	01295	SN7423N
A1U29	1820-0282		IC SN74 86 N GATE	01295	SN7486N
A1U30	1820-0282		IC SN74 86 N GATE	01295	SN7486N
A1U31	1820-0301		IC SN74 75 N LATCH	01295	SN7475N
A1U32	1820-0538		IC SN74 23 N GATE	01295	SN7423N
A1U33	1820-0174		IC SN74 04 N INV	01295	SN7404N
A1U34	1820-0174		IC SN74 04 N INV	01295	SN7404N
A1U35	1820-0174		IC SN74 04 N INV	01295	SN7404N
A1U36	1820-0174		IC SN74 04 N INV	01295	SN7404N
A1U38	1820-0661		IC SN74 32 N GATE	01295	SN7432N
A1U39	1820-0214	1	IC:TTL BCD-TO-DECIMAL DECODER	01295	SN7442N
A1U40	1820-0054	1	IC SN74 00 N GATE	01295	SN7400N
A1U41	1820-0914	1	IC DECODER	07263	9307DC
A1XA-Y1	1200-0153	1	SOCKET-XSTR 3-CONT TO-5-PKG	91459	1211-CL-I
A1Y1	0410-0405	1	CRYSTAL:QUARTZ 10 MHZ	28480	0410-0405
			A1 MISCELLANEOUS		
	0360-0124	7	TERMINAL-STUD SPCL-PRESS MTG	28480	0360-0124
	1200-0473	2	SOCKET IC 16-PIN DUAL IN-LINE	28480	1200-0473
	1200-0549	4	SOCKET-IC 14-CONT STRIP-PKG	00779	583773-6
	1251-2026	7	CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS	71785	252-18-30-300
	1251-2035	5	CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-300
	8159-0005	6	WIRE 22AWG W PVC 1X22 80C	00736	L-2007-1
A2	05328-60003	1	POWER SUPPLY ASSEMBLY SERIES 1548	28480	05328-60003
A2C1	0180-0480	2	CAPACITOR, FXD 4500UF +75 -10% 25VDC AL	56289	36DX452G025AA2A
A2C2	0180-0480		CAPACITOR, FXD 4500UF +75 -10% 25VDC AL	56289	36DX452G025AA2A
A2C3	--------		NOT ASSIGNED		
A2C4	0170-0055	2	CAPACITOR-FXD .1UF +-20% 200WVDC POLYE	56289	292P10402
A2C5	0140-0202	3	CAPACITOR-FXD 15PF +-5V 500VDCW MICA	72186	DM15C150J0500WV1CR
A2C6	0140-0202		CAPACITOR-FXD 15PF +-5V 500VDCW MICA	72186	DM15C150J0500WV1CR
A2C7	0170-0055		CAPACITOR-FXD .1UF +-20% 200WVDC POLYE	56289	292P10402
A2C8	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A2C9	0160-0174	2	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A2C10	0160-0174		CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A2C11	0180-1867	2	CAPACITOR-FXD 1600UF+75-10% 10VDC AL	56289	39D168G010FL4
A2C12	0180-1867		CAPACITOR-FXD 1600UF+75-10% 10VDC AL	56289	39D168G010FL4
A2C13	0180-0119	2	CAPACITOR-FXD 1UF+75-10% 25VDC AL	56289	30D105G0258A2
A2C14	0180-0119		CAPACITOR-FXD 1UF+75-10% 25VDC AL	56289	30D105G0258A2
A2C15	0140-0209	2	CAPACITOR-FXD 5PF +-10% 500WVDC MICA	72136	DM15C050K0500WV1CR
A2C16	0140-0209		CAPACITOR-FXD 5PF +-10% 500WVDC MICA	72136	DM15C050K0500WV1CR
A2C17	0180-1746	4	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A2C18	0180-1746		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A2C19	0150-0096	1	CAPACITOR-FXD .05UF +80-20% 100WVDC CER	28480	0150-0096
A2CR1	1902-0774	2	DIODE-ZNR 12.1V 10% DO-15 PD=1W	28480	1902-0774
A2CR2	1902-0774		DIODE-ZNR 12.1V 10% DO-15 PD=1W	28480	1902-0774
A2CR3	1901-1086	2	DIODE-PWR RECT 50V 5A	04713	MR820
A2CR4	1901-1086		DIODE-PWR RECT 50V 5A	04713	MR820
A2CR5	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2CR6	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A2CR7	1902-0074	2	DIODE-ZNR 7.15V 5% DO-7 PD=.4W TC=+.047%	04713	SZ 10939-140
A2CR8	1902-0074		DIODE-ZNR 7.15V 5% DO-7 PD=.4W TC=+.047%	04713	SZ 10939-140
A2CR9	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A2CR10	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A2CR11	1902-3224	2	DIODE-ZNR 17.8V 5% DO-7 PD=.4W TC=+.067%	04713	SZ 10939-254
A2CR12	1902-3224		DIODE-ZNR 17.8V 5% DO-7 PD=.4W TC=+.067%	04713	SZ 10939-254
A2CR13	1901-0638	1	DIODE-MULT FULL WAVE BRIDGE RECTIFIER	28480	1901-0638
A2F1	2110-0003	2	FUSE 3A 250V 1.25X.25 UL IEC	71400	AGC-3
A2F2	2110-0003		FUSE 3A 250V 1.25X.25 UL IEC	71400	AGC-3
A2L1	9100-3017	2	INDUCTOR	28480	9100-3017
A2L2	9100-3017		INDUCTOR	28480	9100-3017
A2Q1	1853-0363	2	TRANSISTOR PNP SI PD=50W	03508	D45H5
A2Q2	1854-0635	3	TRANSISTOR NPN SI PD=50W	03508	D44H5
A2Q3	1853-0326	10	TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A2Q4	1854-0634	1	TRANSISTOR NPN SI PD=1W FT=50MHZ	04713	MPS-U01
A2Q5	1854-0246	14	TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A2Q6	1853-0016	2	TRANSISTOR PNP SI TO-92 PD=300MW	28480	1853-0016
A2Q7	1853-0363		TRANSISTOR PNP SI PD=50W	03508	D45H5
A2Q8	1854-0635		TRANSISTOR NPN SI PD=50W	03508	D44H5
A2Q9	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A2Q10	1853-0016		TRANSISTOR PNP SI TO-92 PD=300MW	28480	1853-0016
A2Q11	1854-0635		TRANSISTOR NPN SI PD=50W	03508	D44H5
A2Q12	1884-0055	1	THYRISTOR-TRIAC	28480	1884-0055
A2R1	0761-0026	2	RESISTOR 220 5% 1W MO TC=0+-200	24546	FP32-1-T00-221-J
A2R2	0761-0026		RESISTOR 220 5% 1W MO TC=0+-200	24546	FP32-1-T00-221-J
A2R3	0683-1015		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A2R4	0683-1015		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A2R5	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A2R6	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A2R7	0683-6815		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A2R8	0683-6815		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A2R9	0698-3620	2	RESISTOR 100 5% 2W MO TC=0+-200	24546	FP42-2-T00-100R-J
A2R10	0698-3620		RESISTOR 100 5% 2W MO TC=0+-200	24546	FP42-2-T00-100R-J
A2R11	0683-2055	2	RESISTOR 2M 5% .25W FC TC=-900/+1100	01121	CB2055
A2R12	0683-2055		RESISTOR 2M 5% .25W FC TC=-900/+1100	01121	CB2055
A2R13	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A2R14	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A2R15	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A2R16	0698-3160	1	RESISTOR 31.6K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3162-F
A2R17	0757-0428	1	RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F
A2R18	0757-0454	1	RESISTOR 33.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3322-F
A2R19	0683-6825	1	RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A2R20	0683-7525	1	RESISTOR 7.5K 5% .25W FC TC=-400/+700	01121	CB7525
A2R21	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A2R22	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A2R23	0757-0449	2	RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
A2R24	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
A2R25	0757-0442	5	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R26	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R27	2100-1738	1	RESISTOR-TRMR 10K 10% C TOP-ADJ 1-TURN	30983	ET50W103
A2R28	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R29	0683-4725		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A2R30	0683-1135	1	RESISTOR 11K 5% .25W FC TC=-400/+800	01121	CB1135
A2R31	0683-2715		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A2R32	0811-3050	1	RESISTOR .75 5% .5W PW TC=0+-150	75042	BW20-1-3/4-J
A2R33	0683-2715		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A2U1	1820-0223	4	IC LM 301A OP AMP	27014	LM301AH
A2U2	1820-0223		IC LM 301A OP AMP	27014	LM301AH
A2U3	1820-0223		IC LM 301A OP AMP	27014	LM301AH
A2U4	1820-0223		IC LM 301A OP AMP	27014	LM301AH
A2U5	1820-0196	1	IC UA 723C V RGLTR	07263	723HC
A2U6	1990-0449	1	OPTO-ISOLATOR LAMP-PCNDCT IF = 50MA-MAX	03911	1990-0449
			A2 MISCELLANEOUS		
	1200-0544	3	SOCKET-STRP 3-CONT DIP-SLDR-TERMS	00779	1-583773-1
	1251-3246	5	CONNECTOR 3-PIN F	27264	09-52-3030
	2110-0269	4	FUSEHOLDER, CLIP TYPE .25 FUSE	91506	6008-32CN
	05328-00010	1	BRACKET, REAR	28480	05328-00010
			OPTION 010, OSCILLATOR ASSEMBLY SERIES 1516		
A3	05328-60018	1	SUPPORT BOARD ASSEMBLY	28480	05328-60018

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A3A1	10544A	1	CRYSTAL OSCILLATOR ASSEMBLY (PLUGS ONTO A3 BOARD)	28480	10544A
A3C1	0180-2125	2	CAPACITOR-FXD 15UF+-5% 20VDC TA	56289	150D156X502082
A3C2	0160-3466	1	CAPACITOR-FXD 100PF +-10% 1000WVDC CER	28480	0160-3466
A3C3	0160-4084		CAPACITOR-FXD .1UF +-20% 50WVDC CER	28480	0160-4084
A3C4	0160-4084		CAPACITOR-FXD .1UF +-20% 50WVDC CER	28480	0160-4084
A3C5	0180-2125		CAPACITOR-FXD 15UF+-5% 20VDC TA	56289	150D156X502082
A3J1	1251-2035		CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-300
A3L1	9140-0131	1	COIL-FXD MOLDED RF CHOKE 10MH 5%	24226	24/105
A3L2	9100-1788	2	COIL; FXD; NON-MOLDED RF CHOKE; .75UH	02114	VK200-20/4B
A3MP1	0380-0310	1	STANDOFF-RVT-ON .75LG 6-32THD .250D BRS	00866	19218
A3R1	0683-0825	1	RESISTOR 8.2 5% .25W FC TC=-400/+500	01121	CB8265
A3R2	0757-0200	1	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5621-F
A3R3	0757-0439	1	RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-TO-6811-F
A3R4	0683-1225	4	RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A3R5	0683-1015		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A3U1	1820-0439	1	IC UA 723C V RGLTR	07263	723PC
A4	05328-60005	1	FUNCTION SELECTOR ASSEMBLY SERIES 1548	28480	05328-60005
A4C1			NOT ASSIGNED		
A4C2	0160-3879	12	CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A4C3	0160-4084		CAPACITOR-FXD .1UF +-20% 50WVDC CER	28480	0160-4084
A4C4	0140-0215	2	CAPACITOR-FXD 80PF +-2% 300WVDC MICA	72136	DM15E800G0300WV1CR
A4C5	0140-0215		CAPACITOR-FXD 80PF +-2% 300WVDC MICA	72136	DM15E800G0300WV1CR
A4C6	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C7	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A4C8	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C9	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A4C10	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C11	0160-0342	1	CAPACITOR-FXD 800PF +-1% 300WVDC MICA	28480	0160-0342
A4C12*	0140-0214	1	CAPACITOR-FXD 60PF +-1% 300 WVDC MICA	28480	0140-0214
A4C13	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C14	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C15	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER *FACTORY SELECTED PART	28480	0160-2055
A4C16	0140-0202		CAPACITOR-FXD 15PF +-5% 300WVDC MICA	28480	0140-0202
A4Q1	1854-0215	3	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A4Q2	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A4Q3	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A4R1	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A4R2	0683-1315	3	RESISTOR 130 5% .25W FC TC=-400/+600	01121	CB1315
A4R3	0683-8205	3	RESISTOR 82 5% .25W FC TC=-400/+500	01121	CB8205
A4R4	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A4R5	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A4R6	0683-2025	6	RESISTOR 2K 5% .25W FC TC=-400/+700	01121	CB2025
A4R7	0683-1815	7	RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A4R8	0683-2025		RESISTOR 2K 5% .25W FC TC=-400/+700	01121	CB2025
A4R9	0683-1815		RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A4R10	0683-2025		RESISTOR 2K 5% .25W FC TC=-400/+700	01121	CB2025
A4R11	0683-1815		RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A4R12	0683-2025		RESISTOR 2K 5% .25W FC TC=-400/+700	01121	CB2025
A4R13	0683-1815		RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A4R14	0683-1825	11	RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R15	0683-4315	4	RESISTOR 430 5% .25W FC TC=-400/+600	01121	CB4315
A4R16	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R17	0683-1815		RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A4R18	0683-1815		RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A4R19	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R20	0683-8205		RESISTOR 82 5% .25W FC TC=-400/+500	01121	CB8205

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4R21	0683-1315		RESISTOR 130 5% .25W FC TC=-400/+600	01121	CB1315
A4R22	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R23	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R24	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R25	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R26	0683-4315		RESISTOR 430 5% .25W FC TC=-400/+600	01121	CB4315
A4R27	0683-2715		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A4R28	0683-3315	3	RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A4R29	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R30	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R31	0683-2725		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A4R32	0683-2725		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A4R33	0683-2725		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A4R34	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R35	0683-1815		RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A4R36	0683-8205		RESISTOR 82 5% .25W FC TC=-400/+500	01121	CB8205
A4R37	0683-1315		RESISTOR 130 5% .25W FC TC=-400/+600	01121	CB1315
A4R38	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A4R39	0683-2715		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A4R40	0683-2715		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A4R41	0683-6815		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A4R42	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4R43	1810-0041		NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0041
A4R44	1810-0080	3	NETWORK-RES 8-PIN-SIP .125-PIN-SPCG	28480	1810-0080
A4R45	0698-5103	1	RESISTOR 430 5% .125W CC TC=0+882	01121	BB4315
A4R46	0683-1825		RESISTOR 1.8K 5% .25W FC TC=-400/+700	01121	CB1825
A4U1	1820-1225	1	IC MC10231P FLIP-FLOP	04713	MC10231P
A4U2	1820-1052	2	IC MC10125L XLTR-LGC	04713	MC10125L
A4U3	1820-0629	2	IC SN74S 112 N FLIP-FLOP	01295	SN74S112N
A4U4	1820-0629		IC SN74S 112 N FLIP-FLOP	01295	SN74S112N
A4U5	1820-0622	1	IC SN74 151 N MUXR	01295	SN74151N
A4U6	1820-0829	1	IC MC10164L MUXR	04713	MC10164L
A4U7	1820-0809	1	IC MC10115 RCVR	04713	MC10115P
A4U8	1820-0802	3	IC MC10102P GATE	04713	MC10102P
A4U9	1820-0328		IC:TTL QUAD 2-INPT NOR GATE	01295	SN7402N
A4U10	1820-0074	1	IC SN74 54 N GATE	01295	SN7454N
			A4 MISCELLANEOUS		
	1480-0116	2	EXTRACTOR PIN:1/16" DIA	73957	GP24-063X250-12
	4040-0752	1	EXTRACTOR-PC BD YEL POLYC .062-BD-THKNS	28480	4040-0752
			REFER TO OPTION MANUAL FOR OPTIONS BELOW		
A5			SEE OPT. 020 AND 021 MAN. LISTING FOR A5		
A6			SEE OPT. 021 MAN. LISTING FOR A6		
A7			SEE OPT. 021 MAN. LISTING FOR A7		
A8			SEE OPT. 030 MAN. LISTING FOR A8		
A9			NOT ASSIGNED		
A10			SEE OPTION 040 MANUAL LISTING FOR OPTION 040 ASSEMBLY A10. SEE BELOW FOR STANDARD A10.		
A10	05328-60006	1	SYNCHRONIZER ASSEMBLY (SERIES 1516)	28480	05328-60006
A10C1	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C2	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C3	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C4	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C5	0160-0128	2	CAPACITOR-FXD 2.2UF +-20% 50WVDC CER	28480	0160-0128
A10C6	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C7	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C8	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C9	0160-0128		CAPACITOR-FXD 2.2UF +-20% 50WVDC CER	28480	0160-0128
A10C10	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C11	0180-0428	3	CAPACITOR-FXD 68UF+-20% 6VDC TA	28480	0180-0428
A10C12	0180-0428		CAPACITOR-FXD 68UF+-20% 6VDC TA	28480	0180-0428
A10C13	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C14	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C15	0160-3874	2	CAPACITOR-FXD 10PF +-.5PF 200WVDC CER	28480	0160-3874

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A10C16	0160-3874		CAPACITOR-FXD 10 PF +-.5PF 200WVDC CER	28480	0160-3874
A10C17	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C18	0180-0428		CAPACITOR-FXD 68UF+-20% 6VDC TA	28480	0180-0428
A10C19	0180-1746		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X902082
A10C20	0180-1746		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X902082
A10C21	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A10C22	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C23	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C24	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C25	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C26	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10L1	9140-0137	2	COIL-FXD MOLDED RF CHOKE 1MH 5%	24226	19/104
A10L2	9140-0137		COIL-FXD MOLDED RF CHOKE 1MH 5%	24226	19/104
A10L3	9100-1788		COIL: FXD: NON-MOLDED RF CHOKE: .75UH	02114	VK200-20/4B
A10Q1	1853-0020	2	TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A10Q2	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A10Q3	1854-0092		TRANSISTOR NPN SI PD=200MW FT=600MHZ	28480	1854-0092
A10Q4	1854-0092		TRANSISTOR NPN SI PD=200MW FT=600MHZ	28480	1854-0092
A10R1	2100-3439	1	RESISTOR-VAR W/SW 10K 20% LIN DPST-NO-NC P/O A10S1	01121	70K1G132L103M
A10R2	0683-1525		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A10R3	0683-4315		RESISTOR 430 5% .25W FC TC=-400/+600	01121	CB4315
A10R4	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A10R5	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A10R6	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A10R7	0683-4315		RESISTOR 430 5% .25W FC TC=-400/+600	01121	CB4315
A10R8	0683-3615	3	RESISTOR 360 5% .25W FC TC=-400/+600	01121	CB3615
A10R9	0683-3615		RESISTOR 360 5% .25W FC TC=-400/+600	01121	CB3615
A10R10	0683-2025		RESISTOR 2K 5% .25W FC TC=-400/+700	01121	CB2025
A10R11	0683-2025		RESISTOR 2K 5% .25W FC TC=-400/+700	01121	CB2025
A10R12	1810-0080		NETWORK-RES 8-PIN-SIP .125-PIN-SPCG	28480	1810-0080
A10R13	1810-0080		NETWORK-RES 8-PIN-SIP .125-PIN-SPCG	28480	1810-0080
A10R14	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A10R15	0683-2415	4	RESISTOR 240 5% .25W FC TC=-400/+600	01121	CB2415
A10R16	0683-2415		RESISTOR 240 5% .25W FC TC=-400/+600	01121	CB2415
A10R17	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A10R18	0683-3315		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A10R19	0683-5105		RESISTOR 51 5% .25W FC TC=-400/+500	01121	CB5105
A10R20	0683-5105		RESISTOR 51 5% .25W FC TC=-400/+500	01121	CB5105
A10R21	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A10R22	0683-3315		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A10R23	0683-1525		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A10R24	0683-1525		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A10R25	0683-1225		RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A10R26	0683-3615		RESISTOR 360 5% .25W FC TC=-400/+600	01121	CB3615
A10R27	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A10R28	0683-1225		RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A10R29	0683-1225		RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A10R30	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A10S1			P/O A10R1		
A10U1*	1820-0624	1	IC, ECL *FACTORY SELECTED PART (1820-0624 OR 1820-1566)	01295	MC1651
		1			
A10U2	1820-0805	1	IC MC10107 GATE	04713	MC10107P
A10U3	1820-0802		IC MC10102P GATE	04713	MC10102P
A10U4	1820-1052		IC MC10125L XLTR-LGC	04713	MC10125L
A10U5	1820-0681	2	IC SN74S 00 N GATE	01295	SN74S00N
A10U6	1820-1322	1	IC SN74S 02 N GATE	01295	SN74S02N
A10U7	1820-0693	1	IC SN74S 74 N FLIP-FLOP	01295	SN74S74N
A10U8	1820-0802		IC MC10102P GATE	04713	MC10102P
A10U9	1820-0681		IC SN74S 00 N GATE	01295	SN74S00N
A10U10	1820-0685	1	IC SN74S 10 N GATE	01295	SN74S10N
			A10 MISCELLANEOUS		
	1480-0116		EXTRACTOR PIN:1/16" DIA	73957	GP24-063X250-12
	4040-0748	1	EXTRACTOR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748
A11			NOT ASSIGNED		
A12			NOT ASSIGNED		

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A13			NOT ASSIGNED		
A14			SEE OPTION 040 MAN. LISTING FOR A14		
A15			SEE OPTION 011 MAN. LISTING FOR A15		
A16	05328-60004	1	DISPLAY ASSEMBLY (SERIES 1544)	28480	05328-60004
A16C1	0180-0124		CAPACITOR-FXD 200UF+75-10% 6VDC AL	56289	30D207G006DC2
A16CR1	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A16CR2	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A16CR3	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A16CR4	1910-0016		DIODE-GE 60V 60NA 1US DO-7	28480	1910-0016
A16CR5	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A16DS1	1990-0452	8	DISPLAY NUM SEG 1 CHAR .3 IN HIGH	28480	1990-0452
A16DS2	1990-0452		DISPLAY NUM SEG 1 CHAR .3 IN HIGH	28480	1990-0452
A16DS3	1990-0452		DISPLAY NUM SEG 1 CHAR .3 IN HIGH	28480	1990-0452
A16DS4	1990-0452		DISPLAY NUM SEG 1 CHAR .3 IN HIGH	28480	1990-0452
A16DS5	1990-0452		DISPLAY NUM SEG 1 CHAR .3 IN HIGH	28480	1990-0452
A16DS6	1990-0452		DISPLAY NUM SEG 1 CHAR .3 IN HIGH	28480	1990-0452
A16DS7	1990-0452		DISPLAY NUM SEG 1 CHAR .3 IN HIGH	28480	1990-0452
A16DS8	1990-0452		DISPLAY NUM SEG 1 CHAR .3 IN HIGH	28480	1990-0452
A16DS9			NOT ASSIGNED (SEE OPTION 030 MAN. LISTING)		
A16DS10	1990-0406	10	LED-VISIBLE	28480	1990-0406
A16DS11	1990-0406		LED-VISIBLE	28480	1990-0406
A16DS12	1990-0406		LED-VISIBLE	28480	1990-0406
A16DS13	1990-0406		LED-VISIBLE	28480	1990-0406
A16DS14	1990-0406		LED-VISIBLE	28480	1990-0406
A16DS15	1990-0406		LED-VISIBLE	28480	1990-0406
A16DS16	1990-0406		LED-VISIBLE	28480	1990-0406
A16DS17	1990-0406		LED-VISIBLE	28480	1990-0406
A16DS18	1990-0406		LED-VISIBLE	28480	1990-0406
A16DS19	1990-0406		LED-VISIBLE	28480	1990-0406
A16P1	1251-2582	1	CONNECTOR-PC EDGE 24-CONT/ROW 2-ROWS	71785	252-24-30-300
A16Q1	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q2	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q3	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q4	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q5	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q6	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q7	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q8	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q9	1853-0326		TRANSISTOR PNP SI PD=1W FT=50MHZ	28480	1853-0326
A16Q10	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q11	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q12	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q13	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q14	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q15	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q16	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q17	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q18	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q19	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q20	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16Q21	1854-0246		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	SPS 233
A16R1	0683-3905	3	RESISTOR 39 5% .25W FC TC=-400/+500	01121	CB3905
A16R2	0683-3905		RESISTOR 39 5% .25W FC TC=-400/+500	01121	CB3905
A16R3	0683-3905		RESISTOR 39 5% .25W FC TC=-400/+500	01121	CB3905
A16R4	1810-0213	1	NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0213
A16R5	0683-3995	1	RESISTOR 3.9 5% .25W FC TC=-400/+500	01121	CB39G5
A16R6	2100-3455	1	RESISTOR-VAR CONTROL CC 2.5M 20% 10CW	01121	WP4G048P255RZ
A16R7	0683-2005	1	RESISTOR 20 5% .25W FC TC=-400/+500	01121	CB2005
A16S1	3101-0574	1	SWITCH-SL DPDT-NS MINTR 1A 120VAC PC	28480	3101-0574
A16S2	3101-1940	1	SWITCH-PB DPDT MOM .02A 20VAC PC	28480	3101-1940
A16S3	05328-60101	2	SWITCH ASSEMBLY, DISPLAY	28480	05328-60101
	3130-0384	2	CONTACT, PC, ROTARY SWITCH	28480	3130-0384
	3130-0385	2	SPRING:PC ROTARY SWITCH	28480	3130-0385
	3130-0386	2	INSULATOR, PC,ROTARY SWITCH, MALE	28480	3130-0386
	3130-0387	2	INSULATOR, PC,ROTARY SWITCH, FEMALE	28480	3130-0387
	3130-0498	2	SHAFT AND INDEX, 8-POSITION	28480	3130-0498
	3130-0499	2	SHAFT AND INDEX, 16-POSITION	28480	3130-0499
A16S4	05328-60101		SWITCH ASSEMBLY, DISPLAY	28480	05328-60101
	3130-0384		CONTACT, PC, ROTARY SWITCH	28480	3130-0384
	3130-0385		SPRING:PC ROTARY SWITCH	28480	3130-0385
	3130-0386		INSULATOR, PC,ROTARY SWITCH, MALE	28480	3130-0386
	3130-0387		INSULATOR, PC,ROTARY SWITCH, FEMALE	28480	3130-0387
	3130-0498		SHAFT AND INDEX, 8-POSITION	28480	3130-0498

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	3130-0499		SHAFT AND INDEX, 16-POSITION	28480	3130-0499
			A16 MISCELLANEOUS		
	1200-0474	9	SOCKET; ELEC; IC 14-CONT DIP SLDR TERM	28480	1200-0474
	05328-20252	4	SPACER, STANDOFF	28480	05328-20252
	05328-20253	10	ANNUNCIATOR	28480	05328-20253
A17			SEE OPTION 021 MANUAL LISTING FOR A17		
A18			NOT ASSIGNED		
A19			SEE OPTION 040 MANUAL LISTING FOR OPTION 040 ASSEMBLY A19. SEE BELOW FOR STANDARD A19.		
A19	05328-60007	1	ATTENUATOR ASSEMBLY (SERIES 1516)	28480	05328-60007
A19C1	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A19C2	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A19C3	0160-4084		CAPACITOR-FXD .1UF +-20% 50WVDC CER	28480	0160-4084
A19C4*	0160-0571	2	CAPACITOR-FXD 470PF +-20% 100WVDC CER *FACTORY SELECTED PART	28480	0160-0571
A19C5*	0160-3876	2	CAPACITOR-FXD 47PF +-20% 200WVDC CER *FACTORY SELECTED PART	28480	0160-3876
A19C6	0180-1701	2	CAPACITOR-FXD 6.8UF+-20% 6VDC TA	56289	150D685X0006A2
A19C7	0160-4256	2	CAPACITOR-FXD .047UF +-20% 200WVDC CER	6F364	300-200-W5R-473M
A19C8*	0160-2244	2	CAPACITOR-FXD 3PF +-.25PF 500WVDC CER *FACTORY SELECTED PART	28480	0160-2244
A19C9*	0140-0190	2	CAPACITOR-FXD 39PF +-5% 300WVDC MICA *FACTORY SELECTED PART	72136	DM15E390J0300WV1CR
A19C10	0160-4084		CAPACITOR-FXD .1UF +-20% 50WVDC CER	28480	0160-4084
A19C11*	0160-3876		CAPACITOR-FXD 47PF +-20% 200WVDC CER *FACTORY SELECTED PART	28480	0160-3876
A19C12*	0160-0571		CAPACITOR-FXD 470PF +-20% 100WVDC CER *FACTORY SELECTED PART	28480	0160-0571
A19C13*	0140-0190		CAPACITOR-FXD 39PF +-5% 300WVDC MICA *FACTORY SELECTED PART	72136	DM15E390J0300WV1CR
A19C14			NOT ASSIGNED		
A19C15			NOT ASSIGNED		
A19C16*	0160-2244		CAPACITOR-FXD 3PF +-.25PF 500WVDC CER *FACTORY SELECTED PART	28480	0160-2244
A19C17	0160-4256		CAPACITOR-FXD .047UF +-20% 200WVDC CER	6F364	300-200-W5R-473M
A19C18	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A19C19	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A19C20	0180-1701		CAPACITOR-FXD 6.8UF+-20% 6VDC TA	56289	150D685X0006A2
A19CR1	1902-0126	2	DIODE-ZNR 2.61V 5% DO-7 PD=.4W TC=-.073%	04713	SZ 10939-14
A19CR2	1901-0376	4	DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A19CR3	1901-0376		DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A19CR4	1901-0376		DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A19CR5	1901-0376		DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A19CR6	1902-0126		DIODE-ZNR 2.61V 5% DO-7 PD=.4W TC=-.073%	04713	SZ 10939-14
A19DS1	1990-0485	2	LED-VISIBLE	28480	1990-0485
A19DS2	1990-0485		LED-VISIBLE	28480	1990-0485
A19Q1	1855-0213	2	TRANSISTOR-JFET DUAL 2N5912 N-CHAN	28480	1855-0213
A19Q2	1855-0213		TRANSISTOR-JFET DUAL 2N5912 N-CHAN	28480	1855-0213
A19R1	0683-2415		RESISTOR 240 5% .25W FC TC=-400/+600	01121	CB2415
A19R2	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A19R3	2100-1984	2	RESISTOR-TRMR 100 10% C TOP-ADJ 1-TURN	30983	ET50W101
A19R4	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A19R5	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A19R6	0698-5996	4	RESISTOR 560 5% .125W CC TC=0+882	01121	BB5615
A19R7	0698-5996		RESISTOR 560 5% .125W CC TC=0+882	01121	BB5615
A19R8	0698-6283	2	RESISTOR 10 5% .125W CC TC=0+588	01121	BB1005
A19R9	0683-1055	2	RESISTOR 1M 5% .25W FC TC=-800/+900	01121	CB1055
A19R10*	0683-2005	2	RESISTOR 20 5% .25W FC TC=-400/+500 *FACTORY SELECTED PART	01121	CB2005
A19R11	0698-6974		RESISTOR 90K .25% .125W F TC=0+-25	24546	NE55
A19R12	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19R13	0698-6431	2	RESISTOR 900K .5% .125W F TC=0+-100	24546	NA4
A19R14	0698-5996		RESISTOR 560 5% .125W CC TC=0+882	01121	BB5615
A19R15	0698-5996		RESISTOR 560 5% .125W CC TC=0+882	01121	BB5615
A19R16	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01121	CB5115
A19R17	0698-6283		RESISTOR 10 5% .125W CC TC=0+588	01121	BB1005
A19R18	2100-1984		RESISTOR-TRMR 100 10% C TOP-ADJ 1-TURN	30983	ET50W101

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A19R19	0683-1055		RESISTOR 1M 5% .25W FC TC=-800/+900	01121	CB1055
A19R20*	0683-2005		RESISTOR 20 5% .25W FC TC=-400/+500 *FACTORY SELECTED PART	01121	CB2005
A19R21	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19R22	0698-6974	2	RESISTOR 90K .25% .125W F TC=0+-25	24546	NE55
A19R23	0698-6431		RESISTOR 900K .5% .125W F TC=0+-100	24546	NA4
A19R24	2100-3438	1	RESISTOR-VAR W/SW 10K 20% LIN DPST-NO-NC P/O A19S8	01121	70K1G100L103M
A19R25	0683-1525		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A19R26	0683-2415		RESISTOR 240 5% .25W FC TC=-400/+600	01121	CB2415
A19S1	3101-1933	5	SWITCH-SL SPDT-NS SUBMIN .5A 125V	28480	3101-1933
A19S2	3101-1933		SWITCH-SL SPDT-NS SUBMIN .5A 125V	28480	3101-1933
A19S3	3101-1933		SWITCH-SL SPDT-NS SUBMIN .5A 125V	28480	3101-1933
A19S4	3101-0551	2	SWITCH-SL 4P3T-NS MINTR .3A 125VAC PC	28480	3101-0551
A19S5	3101-1933		SWITCH-SL SPDT-NS SUBMIN .5A 125V	28480	3101-1933
A19S6	3101-0551		SWITCH-SL 4P3T-NS MINTR .3A 125VAC PC	28480	3101-0551
A19S7	3101-1933		SWITCH-SL SPDT-NS SUBMIN .5A 125V	28480	3101-1933
A19S8			P/O A19R24		
			A19 MISCELLANEOUS		
	1250-1453	4	CONNECTOR-RF BNC CKT BD MTG	28480	1250-1453
	1251-1626	1	CONNECTOR-PC EDGE 12-CONT/ROW 2-ROWS	71785	252-12-30-300
	05328-20254	2	SPACER, LED	28480	05328-20254
			CHASSIS PARTS		
B1	3160-0209	1	FAN-TBAX 45-CFM 115V 50/60-HZ 1.5-THK	28480	3160-0209
S1	3101-1609	1	SWITCH-SL 2-DPDT-NS STD 1.5A 250VAC SLDR	82389	11E-1036
T1	9100-3046	1	TRANSFORMER	28480	9100-3046
U37	1818-2251	1	IC-ROM-NMOS 4K	28480	1818-2251
			MISCELLANEOUS PARTS (5328A)		
	0370-1005	1	KNOB-BASE-PTR .375 IN JGK SGI-DECAL	28480	0370-1005
	0370-1097	2	KNOB-BASE-PTR .5 IN JGK SGI-DECAL	28480	0370-1097
	0370-1107	2	KNOB-BASE-PTR AND BAR .5 IN JGK	28480	0370-1107
	0510-0043	2	RETAINER-RING .141-DIA CD PL STL	0018A	1500-14-CD
	0570-1171	2	SCREW	00000	OBD
	1250-0083	4	CONNECTOR-RF BNC FEM SGL HOLE FR	24931	28JR-130-1
	1251-2357	1	CONNECTOR-AC PWR HP-9 MALE FLG MTG	28480	1251-2357
	1460-1345	2	WIREFORM 1.34-W 3-LG SST	28480	1460-1345
	2110-0001	1	FUSE 1A 250V NORM-BLO 1.25X.25 UL IEC	71400	AGC-1
	2110-0002	1	FUSE 2A 250V 1.25X.25 UL IEC	71400	AGC-2
	2110-0464	1	FUSEHOLDER-EXTR POST 20A 300V UL/IEC	75915	345002-010
	2110-0465	1	FUSEHOLDER-EXTR POST UL/IEC .25X1.25FUSE	28480	2110-0465
	2950-0001	2	NUT-HEX-DBL-CHAM 3/8-32-THD .094-THK	12697	20/4-13
	2950-0035	2	NUT-HEX-DBL-CHAM 15/32-32-THD .078-THK	28480	2950-0035
	2950-0038	2	NUT-SPCLY 1/2-24-THD .125-THK .688-A/F	75915	903-12
	3101-0851	1	CAP-PB BLACK; .2-IN DIA; .155-IN L; FOR	28480	3101-0851
	7120-0644	1	WRN LBL "WARNING HIGH VOLTAGE"	28480	7120-0644
	8120-1378	1	CABLE ASSY 3-COND 18-AWG	28480	8120-1378

See introduction to this section for ordering information

Table 4-1. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			CABINET PARTS FOR SERIAL PREFIXES 1504A, 1516A, 1544A AND 1548A (SEE FIGURE 4-1)		
MP1	5020-8801	1	FRONT FRAME	28480	5020-8801
MP2	5020-8802	1	REAR FRAME	28480	5020-8802
MP3	5020-8831	2	SIDE STRUT	28480	5020-8831
MP4†	5020-8895	2	FRONT HANDLE TRIM	28480	5020-8895
MP5	5040-7201	4	FOOT	28480	5040-7201
MP6	5040-7202	1	TOP TRIM	28480	5040-7202
MP7†	5060-9898	2	FRONT HANDLE ASSEMBLY	28480	5060-9898
MP8†	5061-1910	1	COVER, TOP	28480	5061-1910
MP9†	5061-1911	1	COVER, BOTTOM	28480	5061-1911
MP10	05328-00001	1	BRACKET, MAIN	28480	05328-00001
MP11	05328-00002	3	BRACKET, CORNER	28480	05328-00002
MP12	05328-00003	3	BRACKET, FRONT	28480	05328-00003
MP13	05328-00006	1	BRACKET, POWER SUPPLY	28480	05328-00006
MP14	05328-00012	1	PANEL, REAR	28480	05328-00012
MP15	05328-00013	1	PLATE, COVER	28480	05328-00013
MP16	05328-20201	1	PANEL, DISPLAY	28480	05328-20201
MP17	05328-20202	1	PANEL, DOUBLE, BLANK	28480	05328-20202
MP18	05328-20203	1	PANEL, TI	28480	05328-20203
MP19	05328-20251	1	WINDOW	28480	05328-20251
			CABINET PARTS FOR SERIAL PREFIX 1604A AND HIGHER		
			DELETE ABOVE PARTS MARKED WITH DAGGER (†) AND ADD THE FOLLOWING:		
	5001-0438	2	SIDE TRIM	28480	5001-0438
	5040-7219	1	FRONT CAP	28480	5040-7219
	5040-7220	1	REAR CAP	28480	5040-7220
	5060-9803	1	STAP HANDLE	28480	5060-9803
	5060-9851	1	COVER, SIDE (W/O HANDLE RECESS)	28480	5060-9851
	5060-9846	1	COVER, BOTTOM	28480	5060-9846
	5060-9875	1	COVER, SIDE (W/HANDLE RECESS)	28480	5060-9875
	05328-00015	1	INSULATOR	28480	05328-00015
	05328-00016	1	COVER, TOP	28480	05328-00016

See introduction to this section for ordering information

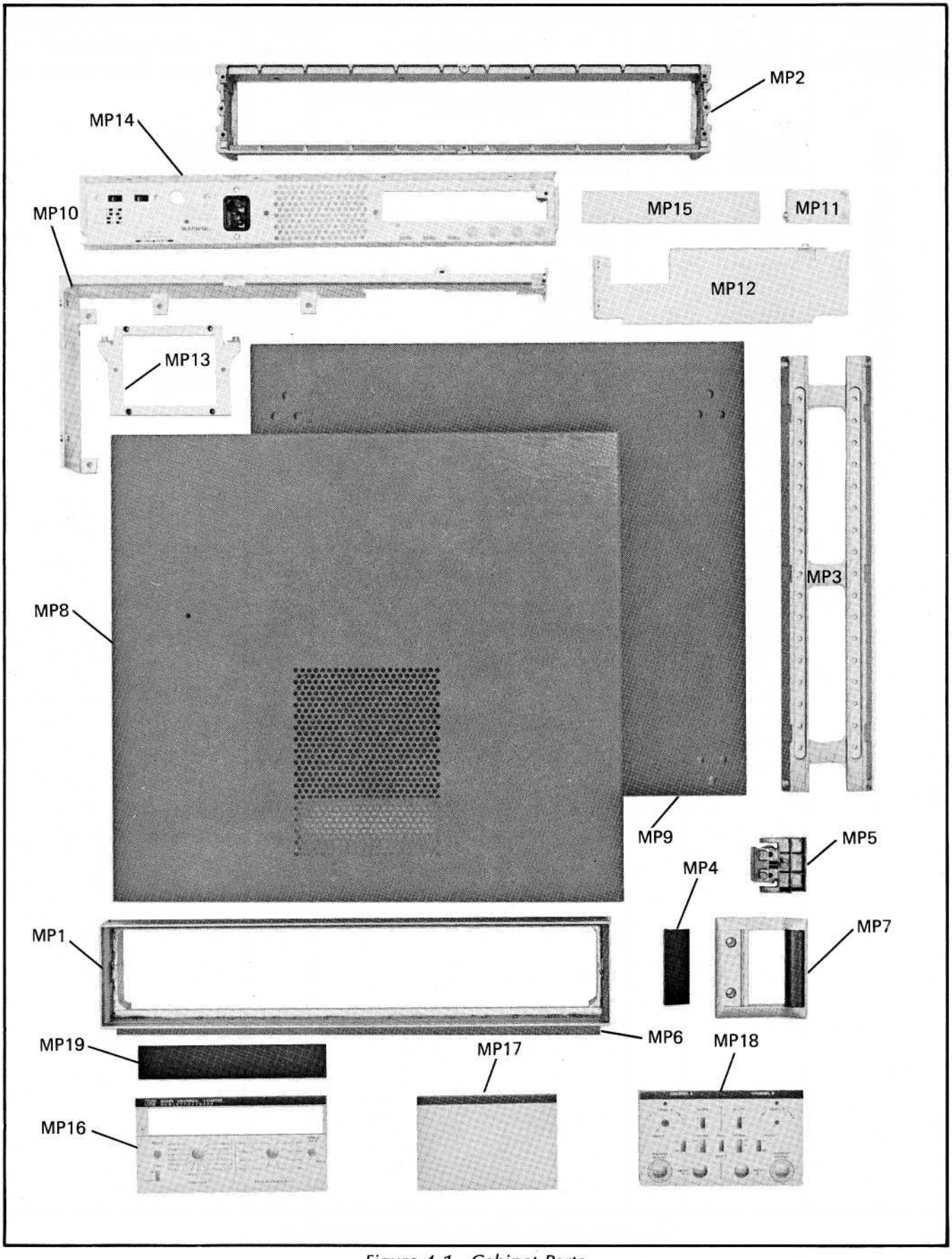


Figure 4–1. Cabinet Parts

Table 4–2. Manufacturers Code List

Mfr No.	Manufacturer Name	Address	Zip Code
00000	U.S.A. Common	Any Supplier of the U.S.A.	
0018A	Ar Tech Packaging Corp	Lowell, MA	01854
0073G	Gettig Engrg & Mfg Co Inc	Spring Mills, PA	16875
00779	Amp Inc	Harrisburg, PA	17105
0086S	Stettner-Trush Inc	Cazenovia, NY	13035
00866	Goe Engineering Co Inc	City of Industry, CA	91746
01121	Allen-Bradley Co	Milwaukee, WI	53212
01295	Texas Instr Inc Semicond Cmpnt Div	Dallas, TX	75231
02114	Ferroxcube Corp	Saugerties, NY	12477
03508	GE Co Semiconductor Prod Dept	Syracuse, NY	13201
03911	Clairex Corp	Mt. Vernon, NY	10550
04713	Motorola Semiconductor Products	Phoenix, AZ	85008
05123	Gulton Ind Inc Matl & Ceramics Div	Metuchen, NJ	08840
07263	Fairchild Semiconductor Div	Mountain View, CA	94040
12697	Clarostat Mfg Co Inc	Dover, NH	03820
16299	Corning Gl Wk Elec Cmpnt Div	Raleigh, NC	27604
24226	Gowanda Electronics Corp	Gowanda, NY	14070
24546	Corning Glass Works (Bradford)	Bradford, PA	16701
24931	Specialty Connector Co Inc	Indianapolis, IN	46227
27014	National Semiconductor Corp	Santa Clara, CA	95051
27264	Molex Products Co	Downers Grove, IL	60515
28480	Hewlett-Packard Co Corporate HQ	Palo Alto, CA	94304
30983	Mepco/Electra Corp	San Diego, CA	92121
56289	Sprague Electric Co	North Adams, MA	01247
6F364	Centre Engineering Inc	State College, PA	16801
71279	Cambridge Thermionic Corp	Cambridge, MA	02138
71400	Bussman Mfg Div of McGraw-Edison Co	St. Louis, MO	63017
71785	TRW Elek Components Cinch Div	Elk Grove Village, IL	60007
72136	Electro Motive Mfg Co Inc	Willimantic, CT	06226
73957	Groov-Pin Corp	Ridgefield, NJ	07657
75042	TRW Inc Philadelphia Div	Philadelphia, PA	19108
75915	Littlefuse Inc	Des Plaines, IL	60016
82389	Switchcraft Inc	Chicago, IL	60630
84411	TRW Capacitor Div	Ogallala, NE	69153
91459	Alcon Metal Products Inc	Chicago, IL	60647
91506	Augat Inc	Attleboro, MA	02703

SECTION V
MANUAL CHANGES AND OPTIONS

5-1. INTRODUCTION

5-2. This section contains information necessary to adapt this manual to apply to older instruments. Also included is information regarding available options.

5-3. MANUAL CHANGES

5-4. This manual applies directly to Model 5328A Universal Counters with serial number prefix 1604A.

5-5. Newer Instruments

5-6. As engineering changes are made, newer instruments may have serial prefix numbers higher than those listed on the title page of this manual. The manuals for these instruments will be supplied with "manual changes" sheets containing the required information. Replace affected pages or modify existing manual information as directed in the "manual changes" pages. Contact the nearest Hewlett-Packard Sales and Service Office if the change information is missing.

5-7. Older Instruments

5-8. To adapt this manual to instruments having serial prefixes below 1604A, refer to Table 5-1 for backdating that applies to your instrument serial prefix.

Table 5-1. Manual Backdating

If Your Instrument Has Serial Prefix	Make the Following Changes to Your Manual
1548	1
1544	1, 2
1516	1, 2, 3
1504	1, 2, 3, 4

NOTE

Refer to the four-digit series number stamped on the printed-circuit board in your instrument before making manual changes to ensure the changes are applicable.

CHANGE 1

Table 4-1, A1 MISCELLANEOUS:

Change "SERIES 1604" in "Description" column to "SERIES 1544."

Change "0360-0124; 7; TERMINAL STUD SPCL-PRESS MTG; 28480; 0360-0124" to "0360-0451; 4; TERMINAL-STUD SGL-PIN SWGFRM-MTG; 71279; 2970-3".

Figure 6-6, A1 Schematic:

Change "SERIES 1604" at top of schematic to "SERIES 1544."

CHANGE 2

Table 4–1, A2 Replaceable Parts:

Change "SERIES 1548" in A2 "Description" to "SERIES 1544."

Delete the entries for A2C5 and A2C6.

Change "SERIES 1548" in A4 "Description" to "SERIES 1544."

Change A4C12 from 0140–0214 to 0160–2201; CAPACITOR-FXD 51 PF + –5% 300 WVDC MICA; 28480; 0160–2201.

Change A4C16 from 0140-0202 to 0160-2202; 1; CAPACITOR-FXD 75 PF + –5% 300 WVDC MICA; 28480; 0160-2202.

Change A4R42 from 0683-1825 to 0683-2225; 1; RESISTOR 2.2K 5% .25W FC TC = –400/ +700; 01121; CB2225.

Figure 6–8, A2 Schematic:

Change "SERIES 1548" at top of schematic to "SERIES 1544."

Change A2C5 and A2C6 from 15 pF to 5 pF. Change NOTE 3 on schematic to read "Capacitors C3, C5 and C6 are normally not installed."

Figure 6–10, A4 Schematic:

Change "SERIES 1548" at top of schematic to "SERIES 1504."

Change A4C12 from 60 pF to 51 pF.

Change A4C16 from 15 pF to 75 pF.

Change A4R42 from 1800 to 2200 ohms.

CHANGE 3

Table 4–1, A1 Replaceable Parts:

Change "SERIES 1604" in A1 "Description" to "SERIES 1516."

Change A1C5 from 0180-0106 to 0180-0124; 2; CAPACITOR-FXD 200 UF +75 –10% 6 VDC AL; 56289; 30D207G006DC2.

Under "A1 MISCELLANEOUS" delete 1200-0473; 2; SOCKET IC 16-PIN DUAL IN-LINE; 28480; 1200-0473.

Table 4–1, A2 Replaceable Parts:

Change "SERIES 1548" to "SERIES 1516."

Under A2 MISCELLANEOUS change "Qty" for 1251-3246 from "5" to "2".

Figure 6-8, A2 Schematic Diagram:

Change "SERIES 1548" at top of schematic to "SERIES 1516."

Table 4–1, A3 Replaceable Parts:

Change "SERIES 1516" in A1 "Description" column to "SERIES 1504."

Change A3C1 from 0180-2125 to 0180-0374; 1; CAPACITOR-FXD 10 UF + –10% 20 VDC TA; 56289; 150D106X9020B2.

Change A3R2 from 0757-0200 to 0698-3155; 1; RESISTOR 4.64K 1% .125W F TC = 0 +–100; 16299; C4-1/8-TO–4641–F.

Change A3R4 from 0683-1225 to 0683-2025; RESISTOR 2K 5% .25W FC TC = –400/+700; 01121; CB2025.

Delete A3C3, A3C4, A3C5, A3L2, A3R5 and descriptions.

Figure 6-13, A3 Schematic:
Change A3C1 to 10 UF.

Change A3R2 to 3830 ohms.

Change A3R4 to 2000 ohms.

Delete A3C3, A3C4, A3C5, A3L2 and A3R5.

Change "SERIES 1516" at top of schematic to "SERIES 1504."

Table 4-1, A16 Replaceable Parts:
Change "SERIES 1544" in A16 "Description" to "SERIES 1504."

Delete entry for A16R7.

Figure 6-15, A16 Schematic Diagram:
Change "SERIES 1544" at top of schematic to "SERIES 1516."

Delete resistor R7 from schematic.

CHANGE 4
Table 4-1, A1 Replaceable Parts:
Change "SERIES 1604" in A1 "Description" to "SERIES 1504."

Change A1C17 from 0160-2264 to 0160-2266; 1; CAPACITOR-FXD 24 PF + -5% 500 WVDC CER; 28480; 0160-2266.

Table 4-1, A2 Replaceable Parts:
Change "SERIES 1548" in A2 "Description" to "SERIES 1504."

Table 4-1, A19 Replaceable Parts:
Change "SERIES 1516" in A19 "Description" to "SERIES 1504."

Under "A19 MISCELLANEOUS" change 1250-1453 to 1250-1163.
Figure 6-12, A19 Schematic Diagram:
Change "SERIES 1516 " at top of schematic to "SERIES 1504."

Figure 6-6, A1 Schematic Diagram:
Change "SERIES 1604" at top of schematic to "SERIES 1504."

Change A1C17 (in Y1 oscillator circuit) from *20P to 24P.

Figure 6-8, A2 Schematic Diagram and Figure 6-13, A10 Schematic Diagram:
Change "SERIES 1516" at top of schematic to "SERIES 1504."

5-9. OPTIONS

5-10. Options are described in Section I of this manual. Operating instructions for all options are provided in the 5328A Users Manual. Field installation and service instructions for each option are provided in a separate manual for each option with the exception of Option 010, Oven Oscillator and Support Board. Installation instructions for Option 010 are given in the following paragraphs.

5-11. FIELD INSTALLATION OF OPTION 010

5-12. To install Option 010, use field installation kit HP Part No. 05328-80010, consisting of the following parts:

ITEM	PART NUMBER	QUANTITY
Screw, 6-32 x $^5/_{16}$	2360-0115	1
Support Board	05328-60018	1
Oven Oscillator Assembly	10544-60011	1

5–13. To install the parts, proceed as follows:

a. Disconnect the power cable from the 5328A (Safety Precaution).

WARNING

THE AC POWER CIRCUITS TO TRANSFORMER T1 AND THE UNREGULATED DC VOLTAGE ARE STILL ON EVEN WHEN THE POWER SWITCH IS OFF. CONTACT WITH THESE CIRCUITS CAN RESULT IN INJURY TO PERSONNEL OR DAMAGE TO EQUIPMENT.

b. Remove the top and bottom covers of the 5328A.

CAUTION

REFER TO THE REPAIR PARAGRAPH IN SECTION III FOR INSTRUCTIONS ABOUT COMPONENT REMOVAL AND REPLACEMENT.

c. Remove the 10 MHz crystal (Y1) HP Part No. 0410–0405 from its socket on the motherboard.

d. Apply power to the 5328A and check pin 2 of connector XA3 for 25 volts, dc. Check all other voltages at connector XA3 for the values shown on the schematic diagram of the Motherboard (Figure 6–6).

e. Disconnect the power cable from the 5328A.

f. Ensure that the oven oscillator is secured to the connector on the Support Board. Plug the Support Board into XA3 on the Motherboard with the stud mount facing the rear panel.

g. Install a 6-32 x $\frac{5}{16}$-inch screw through 5328A main bracket into support Board stud mount and secure.

h. Apply power to the 5328A and verify counter operation by performing the In-Cabinet Performance Check in Section III.

SECTION VI
SCHEMATIC DIAGRAMS

6-1. INTRODUCTION

6-2. This section contains schematic diagrams and part locators. The part locators show the location by reference designator.

6-3. SCHEMATIC DIAGRAM SYMBOLS AND REFERENCE DESIGNATORS

6-4. Figure 6-1 shows the symbols used on the schematic diagrams. At the bottom of Figure 6-1, the system for reference designators, assemblies, and subassemblies are shown.

6-5. Reference Designations

6-6. Assemblies such as printed-circuit boards are assigned numbers in sequence, A1, A2, etc. As shown in Figure 6-1, subassemblies within an assembly are given a subordinate A number. For example, rectifier subassembly A1 has the complete designator of A25A1. For individual components, the complete designator is determined by adding the assembly number and subassembly number if any. For example, CR1 on the rectifier assembly is designated A25A1CR1.

6-7. SIGNAL MNEMONICS

6-8. Table 6-1 contains a list of the mnemonics used to identify signals on the schematic diagrams.

6-9. IDENTIFICATION MARKINGS ON PRINTED-CIRCUIT BOARDS

6-10. HP printed-circuit boards (see Figure 6-1) have four identification numbers: an assembly part number, a series number, a revision letter, and a production code.

6-11. The assembly part number has 10 digits (such as 05328-60018) and is the primary identification. All assemblies with the same part number are interchangeable. When a production change is made on an assembly that makes it incompatible with previous assemblies, a change in part number is required. The series number (such as 1504A) is used to document minor electrical changes. As changes are made, the series number is incremented. When replacement boards are ordered, you may receive a replacement with a different series number. If there is a difference between the series number marked on the board and the schematic in this manual, a minor electrical difference exists. If the number on the printed-circuit board is lower than that on the schematic, refer to Section V for backdating information. If it is higher, refer to the loose leaf manual change sheets for this manual. If the manual change sheets are missing, contact your local Hewlett-Packard Sales and Service Office. See the listing on the back cover of this manual.

6-12. Revision letters (A, B, etc.) denote changes in printed-circuit layout. For example, if a capacitor type is changed (electrical value may remain the same) and requires different spacing for its leads, the printed-circuit board layout is changed and the revision letter is incremented to the next letter. When a revision letter changes, the series number is also usually changed. The production code is the four-digit seven-segment number used for production purposes.

6-13. Symbols are used on PC boards to aid in identifying pin number, diode elements, etc., as follows:

Δ OR □

IDENTIFIES:

Pin 1 of dip and flat-pack IC's.
Tab of TO cases.
+ side of electrolytic capacitors.
Pin 1 of resistor packs.
Cathode of diodes.
Section 1 of dip switches.

6-14. ASSEMBLY LOCATIONS AND COMPONENT LOCATORS

6-15. Figures 6-2, 6-3, and 6-4 show the front, rear, and top views of the 5328A, respectively. The front and rear views shows reference designators of the front and rear panel controls, connectors, and indicators. The top view shows assembly locations. Component locators for each printed circuit assembly are located next to the schematics.

6-16. FACTORY SELECTED COMPONENTS

6-17. Factory selected parts are identified by an asterisk on the schematic and in the parts list. The nominal value is shown on the schematics and is listed in the table of replaceable parts. A table-format summary on the schematic indexes factory selected parts by reference designator, describes what they are selected for and the range of normal values.

6-18. SCHEMATIC DIAGRAMS

6-19. Each schematic diagram contains a table that shows all reference designations used for the assembly and a table of active elements (diodes, transistors and IC's) including part numbers. The schematics contain to/from information for inputs and outputs. This information is supplemented by an overall interconnection diagram of the motherboard and block diagrams of each assembly. Diagrams are as follows:

Figure 6-5. A1 Motherboard Block Diagram
Figure 6-6. A1 Motherboard
Figure 6-7. A2 Power Supply Block Diagram
Figure 6-8. A2 Power Supply Assembly
Figure 6-9. A4 Function Selector Assembly Block Diagram
Figure 6-10. A4 Function Selector Assembly
Figure 6-11. Standard Time Interval Module (A10 and A19) Block Diagram
Figure 6-12. Standard A19 Attenuator/Amplifier Assembly
Figure 6-13. Standard A10 Synchronizer Assembly
Figure 6-14. A16 Display Assembly Block Diagram
Figure 6-15. A16 Display Assembly
Figure 6-16. Option 010 A3 Oscillator Support Board and 10 MHz Oscillator Assembly
Figure 6-17. A1 Motherboard Interconnection Diagram

SYMBOLS

FRONT PANEL

REAR PANEL

INTERIOR AND PC BOARDS

WIPER MOVES TOWARD "CW" WHEN CONTROL IS ROTATED CLOCKWISE

POWER LINE GROUND

CIRCUIT COMMON GROUND

FLOATING GROUND

CHASSIS GROUND

KNOB CONTROL

SCREWDRIVER ADJUST

MAIN SIGNAL PATH

FEEDBACK PATH

TEST POINT

"AND" GATE

"OR" GATE

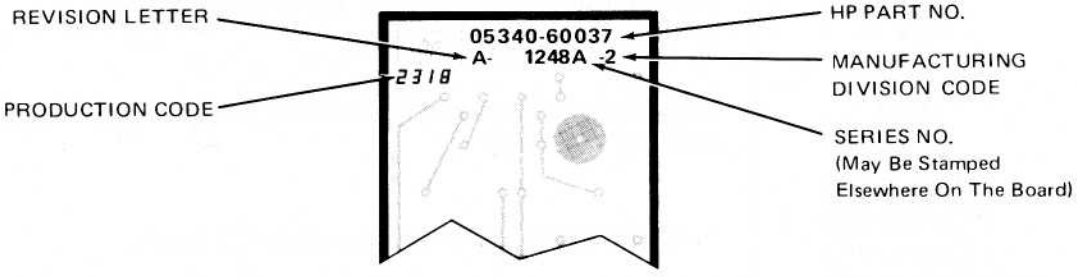
INVERTER

NAND GATE

NOR GATE

EXCLUSIVE NOR

PRINTED CIRCUIT BOARD IDENTIFICATION



REFERENCE DESIGNATIONS

REFERENCE DESIGNATIONS WITHIN ASSEMBLIES ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION. JACKS ARE THE STATIONARY CONNECTORS AND PLUGS ARE THE MORE MOVEABLE OF TWO CONNECTORS.

ASSEMBLY	ABBREVIATION	COMPLETE DESCRIPTION
A25	C1	A25C1
A25A1	CR1	A25A1CR1
NO PREFIX	J3	J3

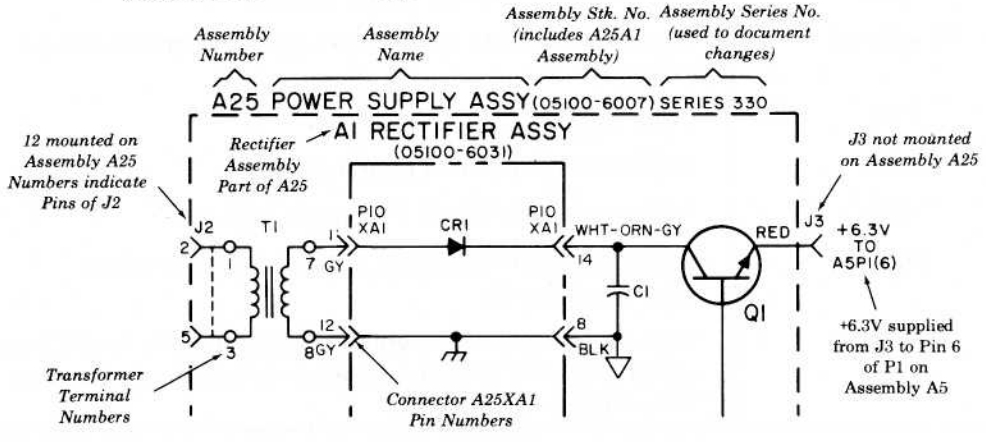


Figure 6-1. Schematic Diagram Notes

Table 6-1. Signal Mnemonics

MNEMONIC	DESCRIPTION
A $\overline{A}$	Output of Time Interval Unit, A channel. ECL levels.
R (AØ) R (A1)	Non-latched ROM bits that drive Arming Multiplexer select lines on Function Selector. TTL levels.
B $\overline{B}$	Output of Time Interval Unit, B channel. ECL levels.
C $\overline{C}$	Output of C module, the carry input for the FS decade. ECL levels.
C ARM	Active high TTL line used for module C arming measurement.
CLK	Clock. Digit address clock to display. TTL levels.
Data A Data B Data C Data D	TTL 4-bit BCD code. Data going to display and HP-IB.
Digit A Digit B Digit C Digit D	TTL 4-bit digit address code. Controls interchange of data.
DVM	Frequency line counted by Function Selector to give display reading. ECL level.
F Code A (FA) F Code B (FB) F Code C (FC) F Code D (FD)	Function code from function switch. TTL levels.
FS	Function Selector.
$\overline{GOSC}$ GOSC	Gated oscillator. ECL levels.
HDS	TTL level high disables synchronizers.
HDSA	Used by Option 011 HP-IB Interface to strobe bus data in remote listener.
HLS	TTL level line used to strobe latches.
RL (HOPN)	Latched ROM line which locks open Function Selector main gate.
HPL	Same as LDP.
HRD	High resets decades. TTL active high.
HRS	High strobes 4K ROM. TTL active high.
HRTB	High resets time base. TTL active high. Also resets Function Selector.
R (HTBA)	Non-latched ROM bit which enables the TTL level Channel A signal from the Function Selector to be counted by the Time Base.

Table 6-1. Signal Mnemonics (Continued)

MNEMONIC	DESCRIPTION
RL (HTBB)	Latched ROM bit which enables the TTL level Channel B signal from the Function Selector to be counted by the Time Base.
R (HTBO)	Non-latched ROM bit which enables the time base to count the oscillator output.
RL (IA) RL (IB) RL (IC)	TTL level latched ROM bits that drive High Speed Multiplexer select lines on Function Selector.
L ANN	Low annunciators. TTL active low turns RHS annunciators on. Must be timed with digit address code to display selected annunciators.
LDDCA	Low disable Decade Counting Assembly (DCA). TTL active low disables DCA so that all DCA outputs are high.
LDI	Low disable indicators. TTL active low blanks RHS annunciators and all decimal points.
LDDIS	Low disable display. TTL active low blanks display except LHS annunciators.
LDP	Low decimal point. TTL active low turns decimal points on. Must be timed with digit address code to display selected decimal points.
LDSW	Low disable switches. The active low disables the FUNCTION RESOLUTION and RESET switches. Allows module control.
LEXT	Low external. TTL active low disables function and resolution switches for external control and lights RM annunciator.
LINH	Low inhibit. TTL active low inhibits starting new measurement.
LMG	Low main gate. TTL active low indicates main gate open.
RL (LMGF)	Latched ROM bit to Function Selector which selects the main gate F/F on the Function Selector to establish the gate time.
LMRES	Low when reset signal comes from display. Provides power-up type reset.
LRES	Low reset. TTL active low resets when FUNCTION, RESOLUTION, or RESET switch settings are changed. Also resets when DVM switches are changed. Provides power-up type of reset.
R (LST)	Non-latched ROM line which is high in stop totalize and low in start.
RL (LTOT)	Low totalize. Latched ROM bit low in totalize mode. TTL level.
LTR	Low transfer. TTL active low used in DCA.
$\frac{MG}{\overline{MG}}$	Main gate. Accurate signal to drive remote gate such as channel C. ECL levels.
OSC	10 MHz oscillator. TTL level.

Table 6-1. Signal Mnemonics (Continued)

MNEMONIC	DESCRIPTION
$\frac{\text{OSC}}{\overline{\text{OSC}}}$	100 MHz oscillator. ECL levels.
OVFL	Overflow. TTL active low indicates display overflow.
RG	ROM bit. Used to recognize period and institute hysteresis compensation. TTL level.
RL1 (HEC)	Latched ROM bit. TTL level enables channel C to strobe its digit onto the bus.
RL2 (BIL)	Latched ROM bit. High for time interval average. TTL level.
RL3 (HDVM)	Latched ROM bit. Enables DVM to strobe a minus sign on the display or blank characters. TTL level.
RL4 (LTIF)	Latched ROM bit. TTL level low in time interval or period measurement.
RL5 (TIO)	Latched ROM bit. TTL level used to recognize period average.
RL6 (HC)	Latched ROM bit which turns hysteresis compensation on and has a time interval as opposed to a period measurement made by the Time Interval unit. TTL level.
SRT	The charge node line that controls the sample rate speed.
RL (TBA) RL (TBB) RL (TBC)	Latched ROM bits that drive Time Base select code inputs.
TBI	TTL signal that drives Time Base.
TBO	Time Base scaled output. TTL levels.
TBS Code A (TBSA) TBS Code B (TBSB) TBS Code C (TBSC)	Time Base code input to ROM controlled by the Time Base switch. TTL levels.
$\frac{\text{TI}}{\overline{\text{TI}}}$	Time interval. Output of Time Interval module used in time interval measurements. ECL levels.

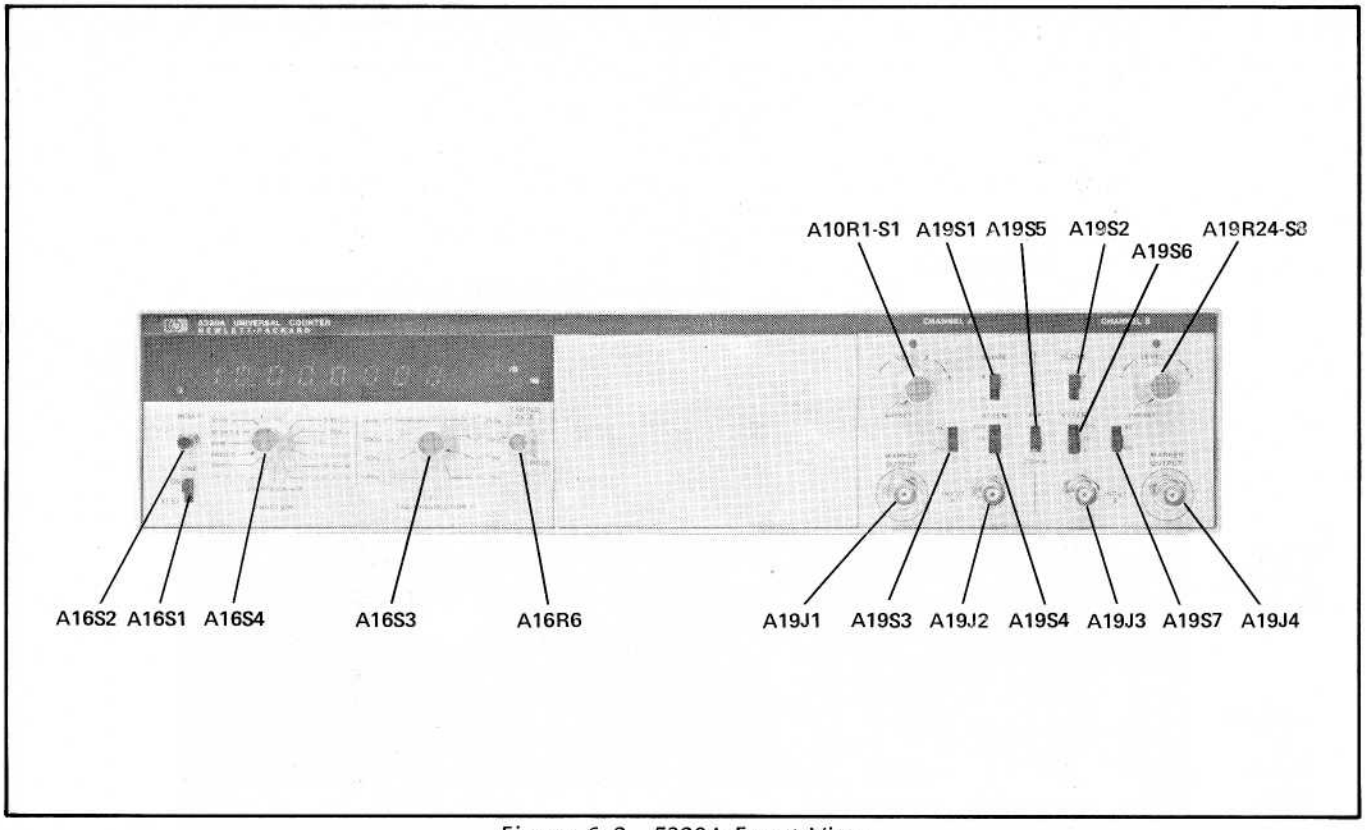


Figure 6-2. 5328A Front View

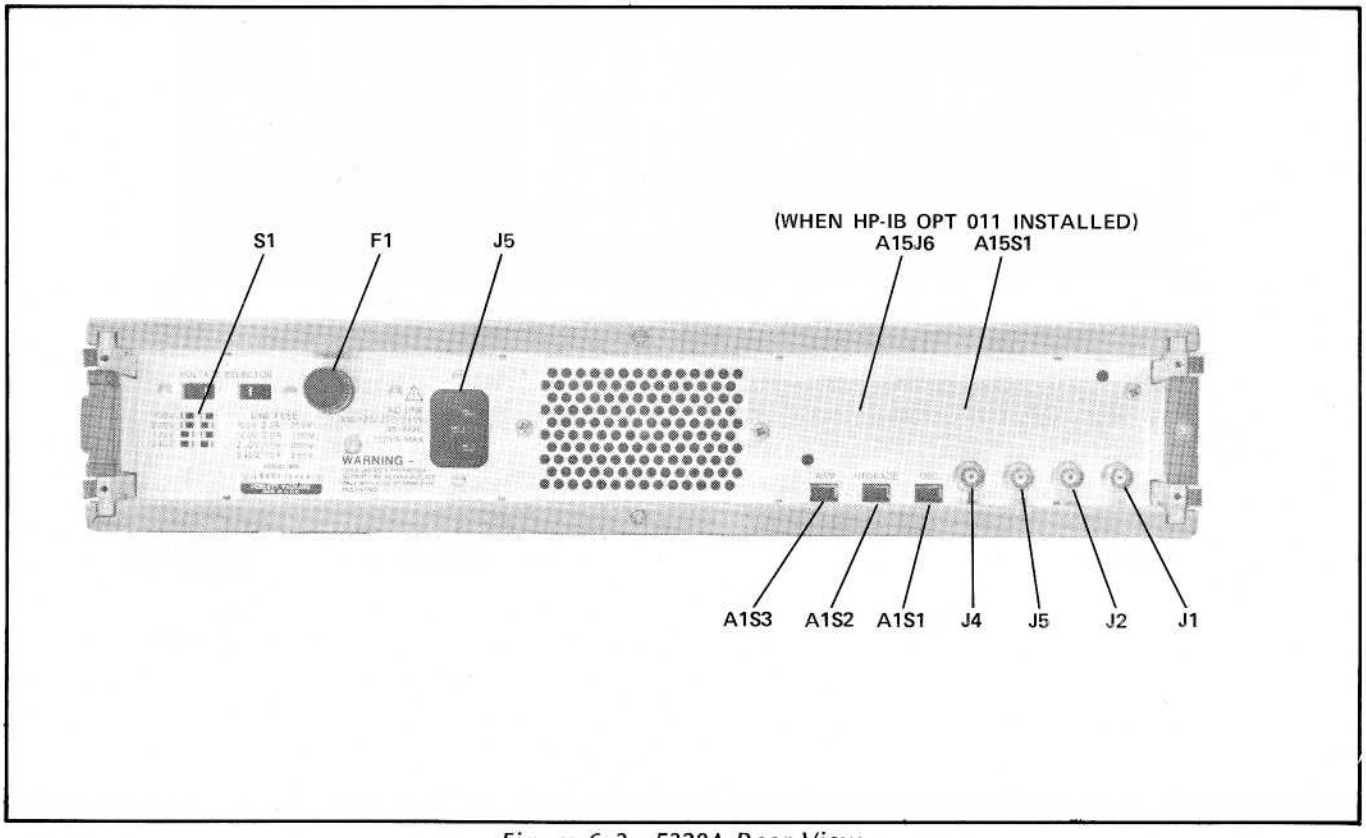


Figure 6-3. 5328A Rear View

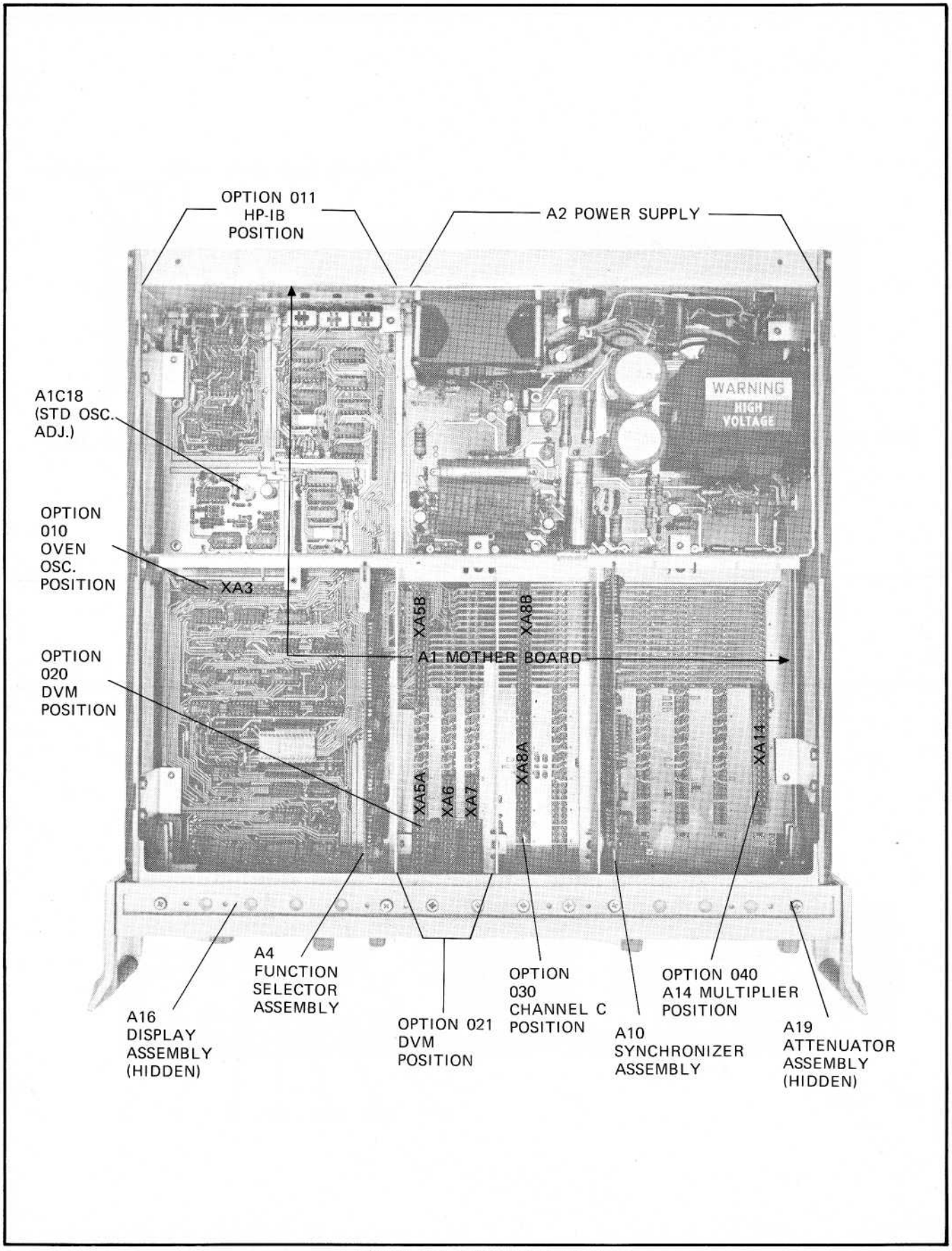
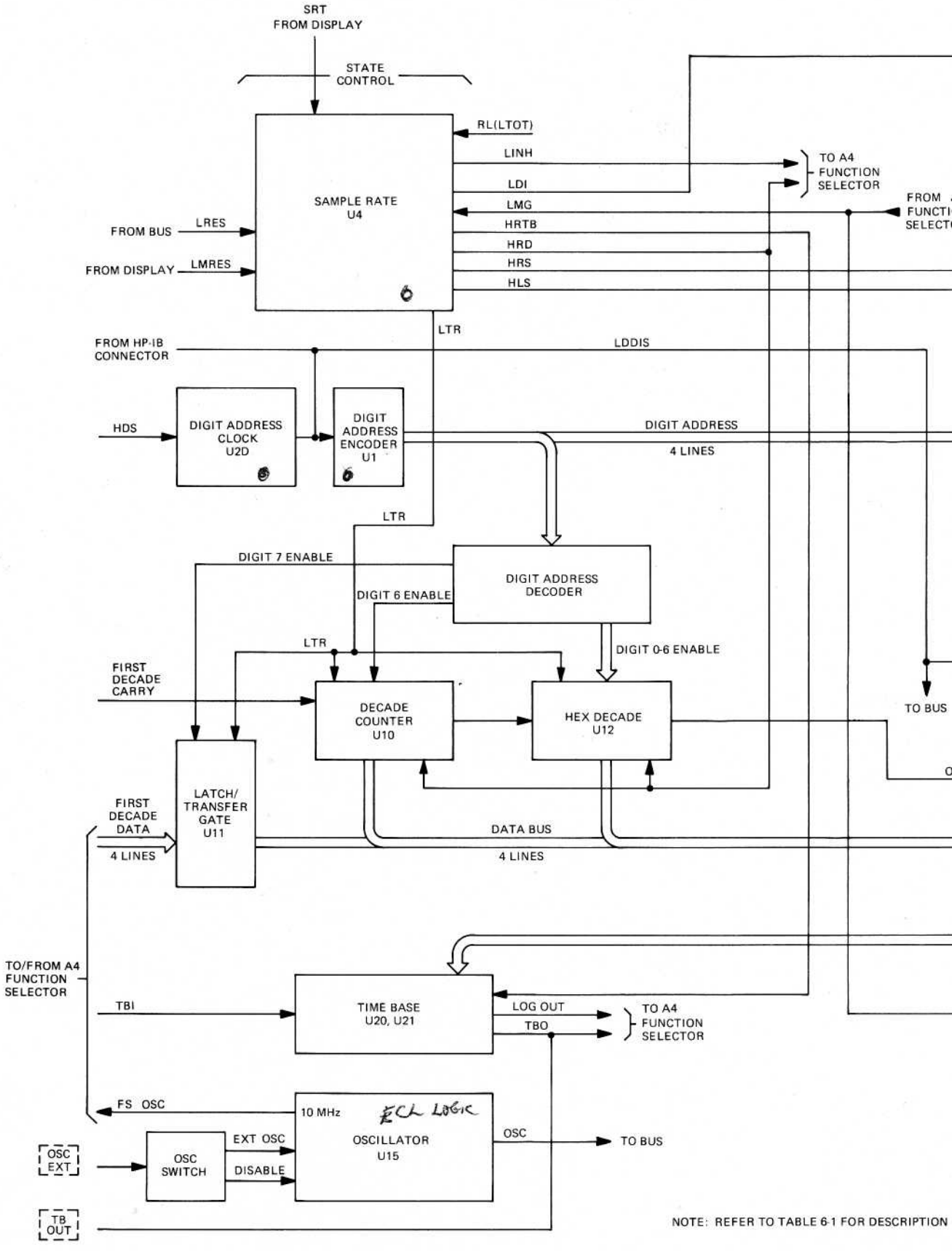
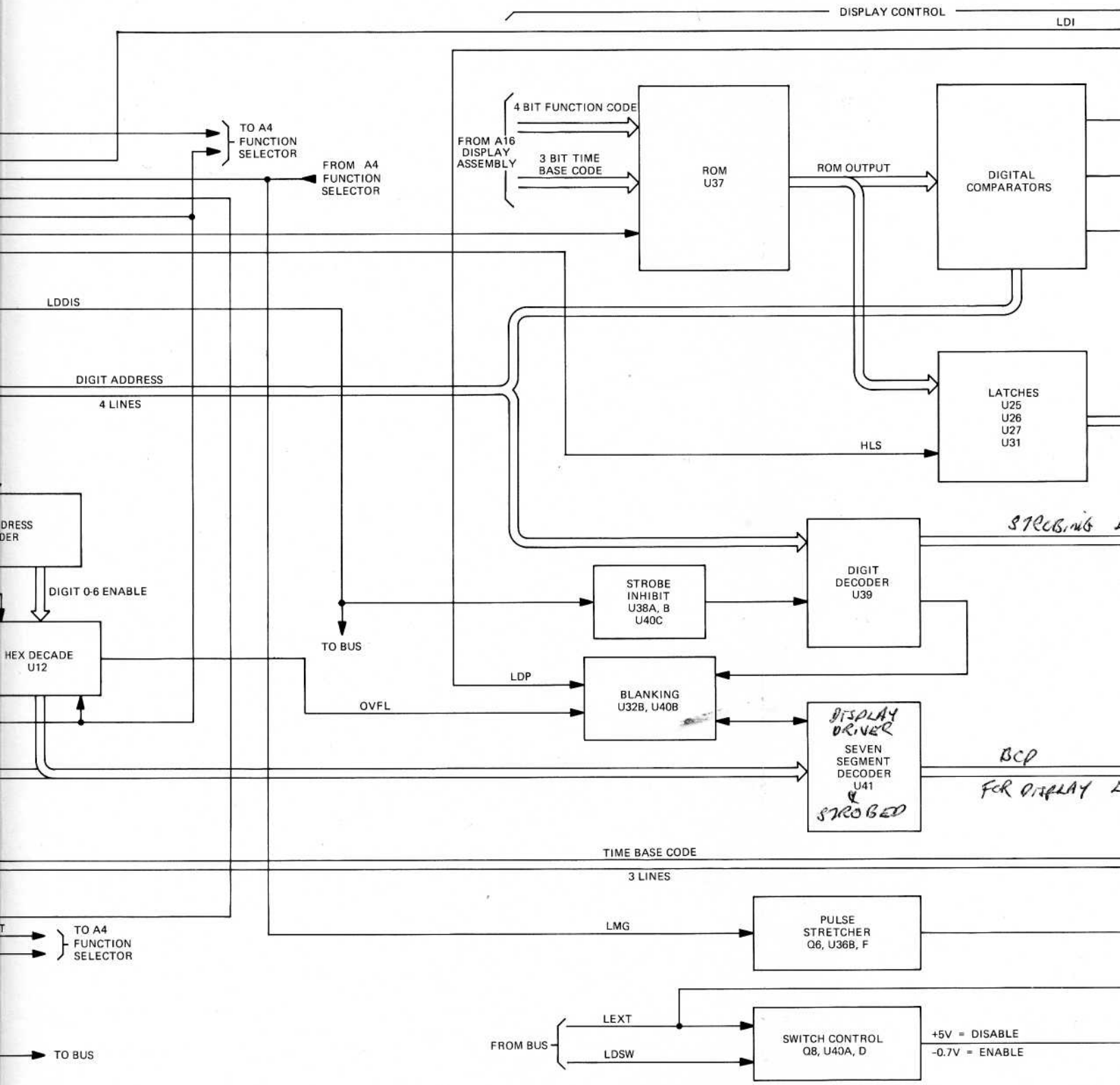


Figure 6-4. 5328A Top View



NOTE: REFER TO TABLE 6-1 FOR DESCRIPTION



NOTE: REFER TO TABLE 6-1 FOR DESCRIPTION OF SIGNAL MNEMONICS.

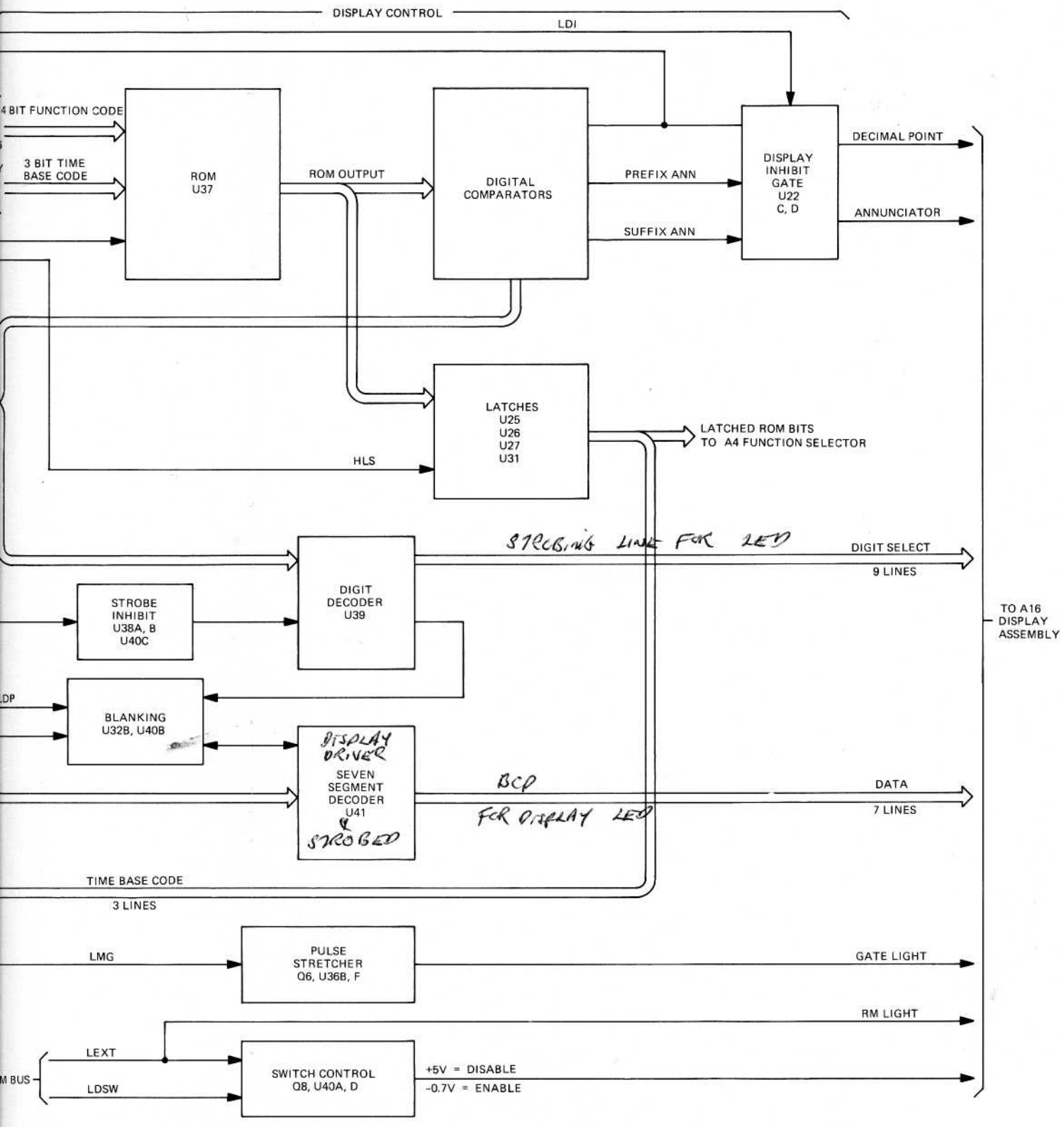


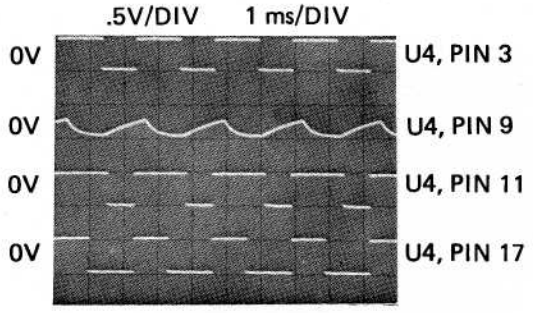
Figure 6–5. A1 Motherboard Block Diagram

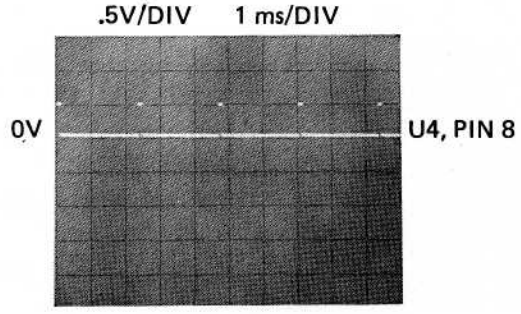
5328A

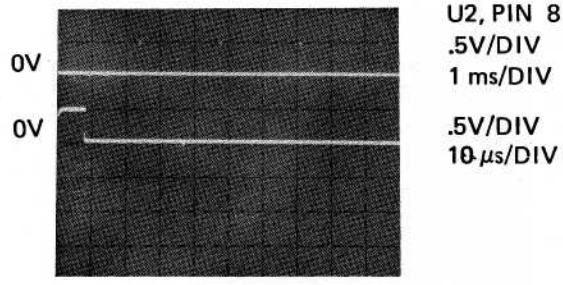
FUNCTION: CHECK
FREQ RESOLUTION: 1 kHz 10^3

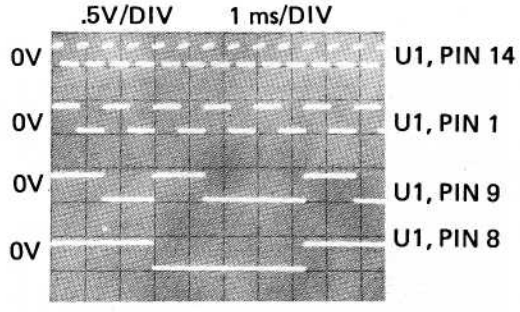
OSCILLOSCOPE

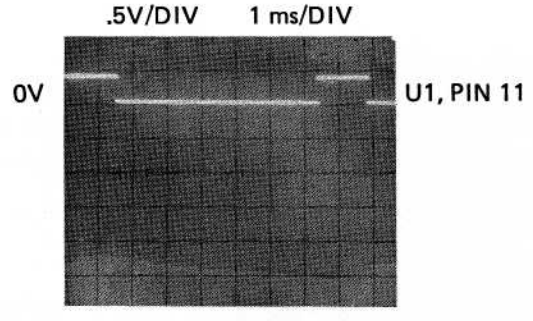
HP 180A/1801A/1821A WITH 10:1 PROBE
COUPLING: DC
SLOPE: +
SYNCH: INT, ACF

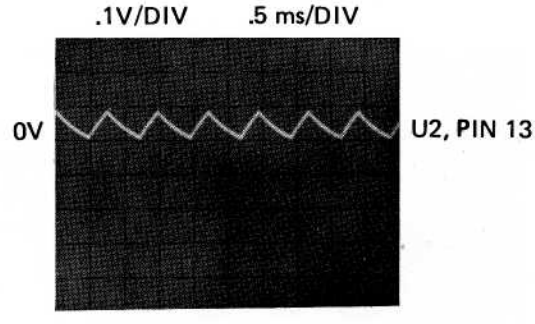












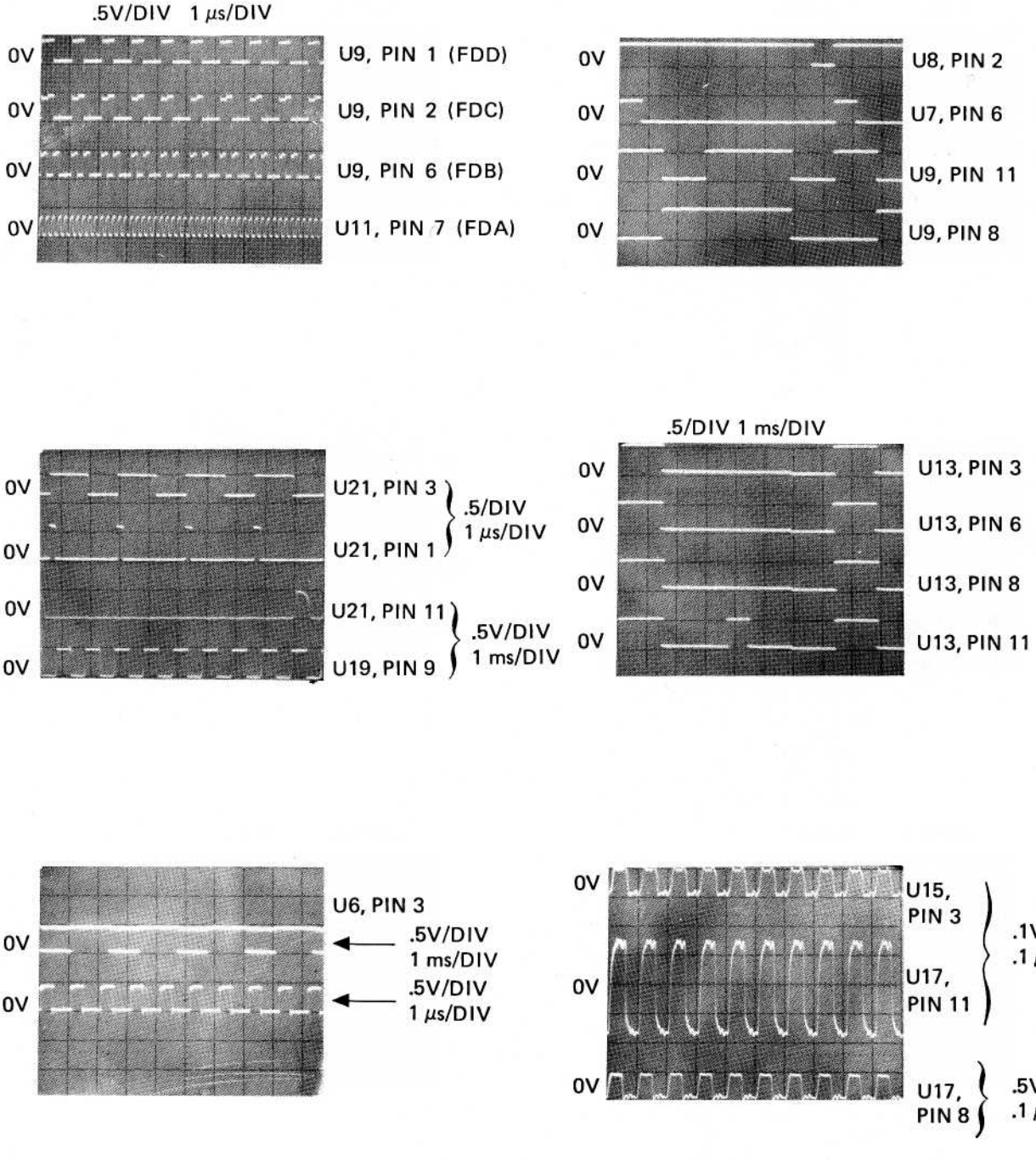
P/O Figure 6-6. A1 Motherboard Assembly

5328A

FUNCTION: CHECK
FREQ RESOLUTION: 1 kHz 10^3

OSCILLOSCOPE

HP 180A/1801A/1821A WITH 10:1 PROBE
COUPLING: DC
SLOPE: +
SYNCH: INT, ACF



P/O Figure 6-6. A1 Motherboard Assembly

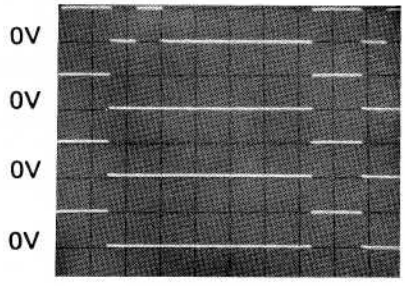
5328A

FUNCTION: CHECK
FREQ RESOLUTION: 1 kHz 10^3

OSCILLOSCOPE

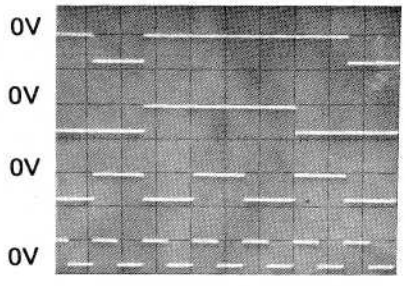
HP 180A/1801A/1802A WITH 10:1 PROBE
COUPLING: DC
SLOPE: +
SYNCH: INT, ACF

.5V/DIV 1 ms/DIV



DIGIT ADDRESS	BUS LINE NO.
A	$\overline{45}$
B	45
C	$\overline{44}$
D	44

.5V/DIV 1 ms/DIV



DATA	BUS LINE NO.
A	$\overline{43}$
B	43
C	$\overline{42}$
D	42

P/O Figure 6-6. A1 Motherboard Assembly

A1 ACTIVE ELEMENTS

REFERENCE DESIGNATIONS	PART NUMBERS
CR1, CR7, CR9-CR14, CR16	1901-0040
CR2, CR3, CR15	1901-0016
CR4	1902-0031
CR5, CR6	1901-0050
CR8	1902-3082
Q1, Q4, Q5, Q7, Q8	1854-0071
Q2, Q3	1853-0015 2N3640
Q6	1854-0092 2N3563
U1, U20	1820-0055 SN7490N
U2	1820-1056 SN74132N
U3	1820-0175 SN7405N
U4	1820-1401
U5, U14	1820-0513 SN7409N
U6, U24, U29, U30	1820-0282 SN7486N
U7	1820-0511 SN7408N
U8, U18, U33, U34, U35, U36	1820-0174 SN7404N
U9, U38	1820-0661 SN7432N
U10	1820-1143 DM8552N
U11, U25, U26, U27, U31	1820-0301 SN7475N
U12	1820-0634
U13	1820-0269 SN7403N
U15	1820-0803 MC10105P
U16	1820-0537 SN7413N
U17	1820-0068 SN7410N
U19	1820-0077 SN7474N
U21	1820-0633
U23	1820-0328 SN7402N
U28, U32	1820-0538 SN7423N
U39	1820-0214 SN7442N
U40	1820-0054 SN7400N
U41	1820-0914 9307DC

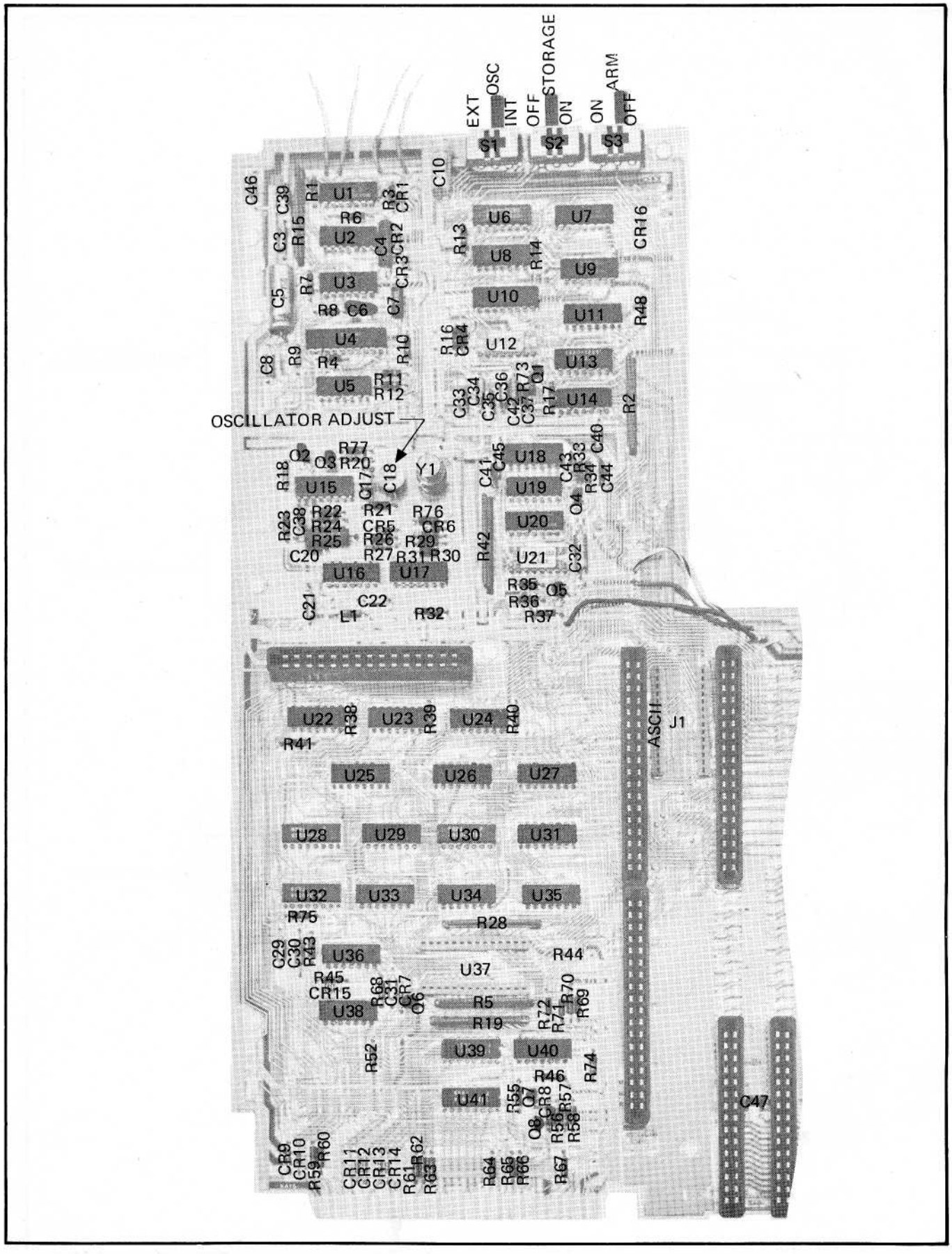
REFERENCE DESIGNATIONS

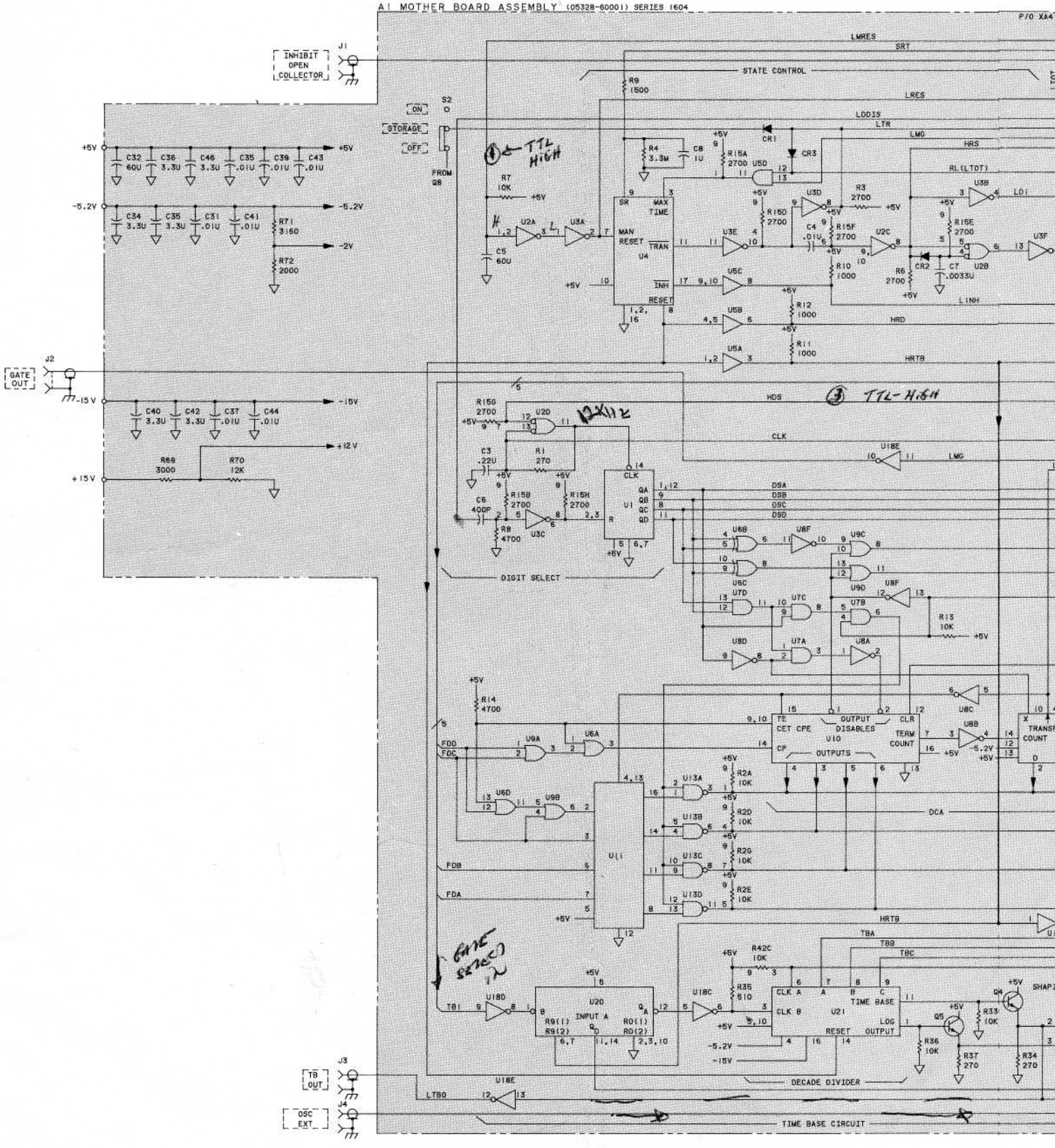
A1
C1, C2 NOT ASSIGNED
C3-C8
C9
C10
C11-C16 NOT ASSIGNED
C17-C18
C19 NOT ASSIGNED
C20-C22
C23-C28 NOT ASSIGNED
C29-C47
CR1-CR16
L1
Q1-Q8
R1-R46
R47 NOT ASSIGNED
R48
R49-R51 NOT ASSIGNED
R52
R53, R54 NOT ASSIGNED
R55-R77

FACTORY SELECTED PART

REFERENCE DESIGNATOR	SELECTED FOR	NORMAL VALUE RANGE
C-17	10 MHz oscillation adjusted by C-18	24 pf ±5 pf

P/O Figure 6-6. A1 Motherboard Assembly


EXT
OSC
INT
OFF
STORAGE
ON
ON
ARM
OFF
S1
S2
S3
OSCILLATOR ADJUST
ASCII
J1
C47



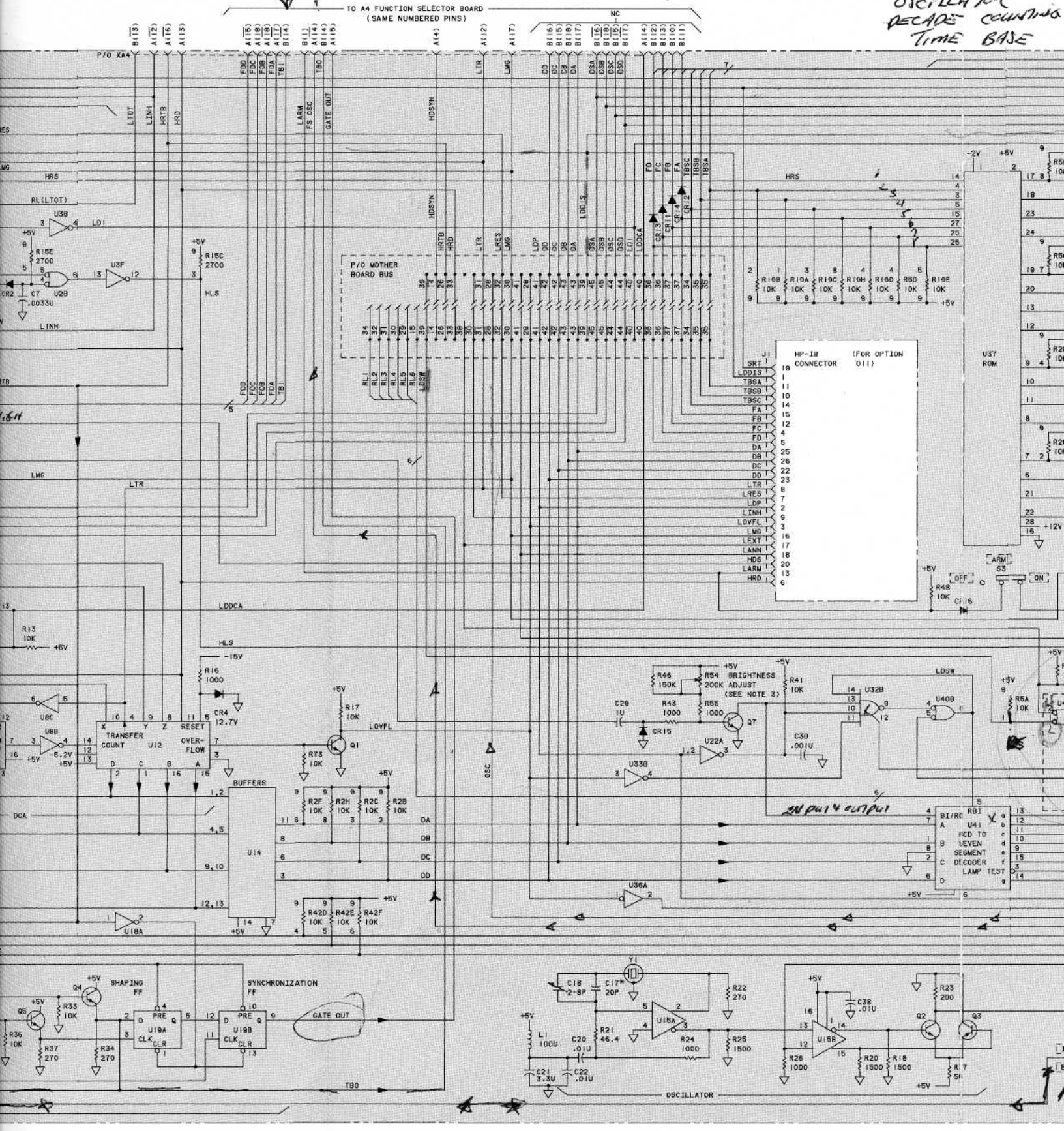
U21- pin 7, 8, 9-
pin 6- 10 MHz
" 14- Reset
" 11- Time Ba
" 3- 1 MHz

GATE IN

16MHz TO OSC. A4

P.P. 3-33

FIVE SECTION
DISPLAY CONTROL
STATE CONTROL
OSCILLATOR
DECADE COUNTING
TIME BASE



1, 8, 9 – TIME BASE SELECT CODE

16 – 16 MHz INPUT

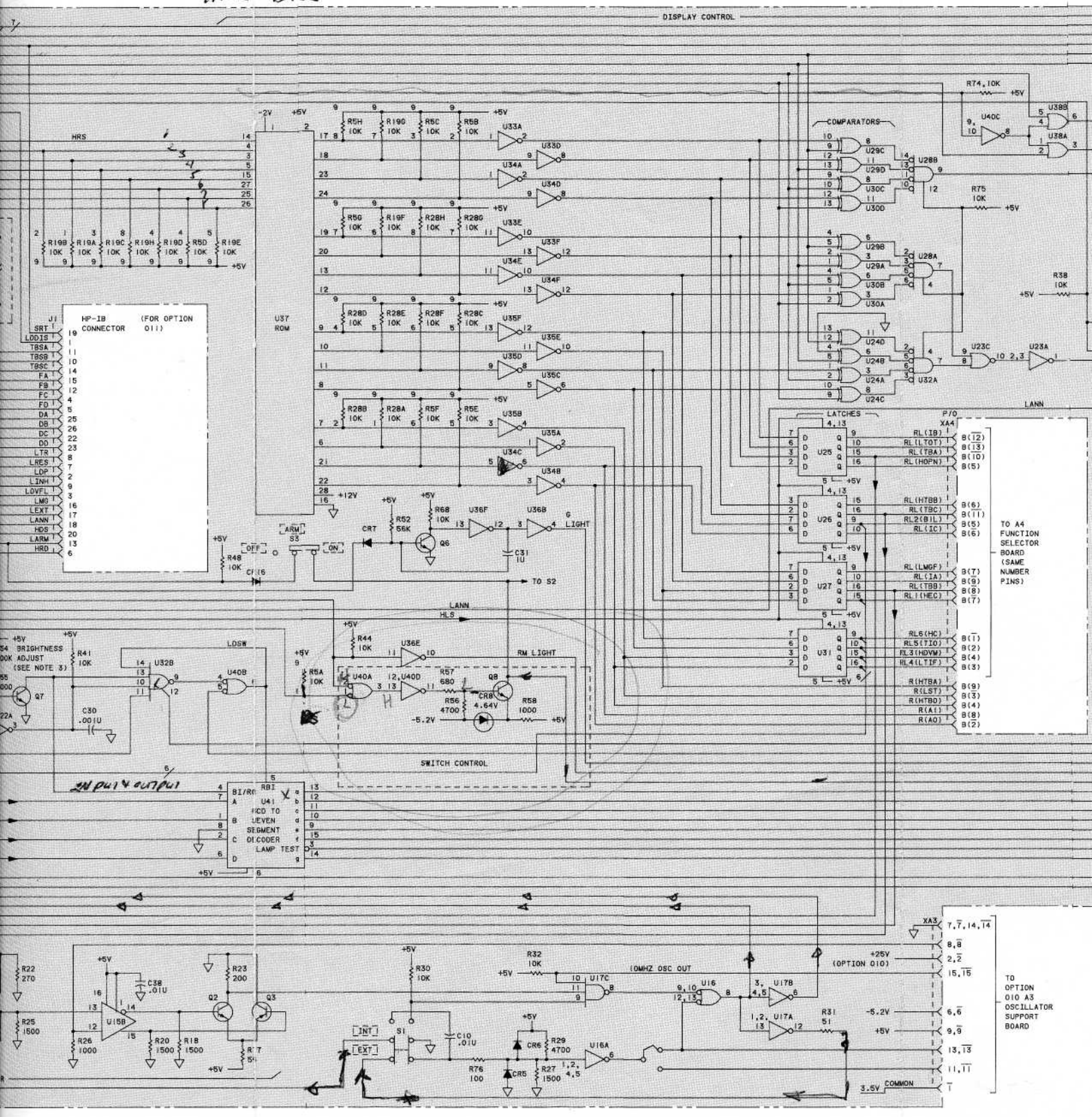
14 – RESET LINE

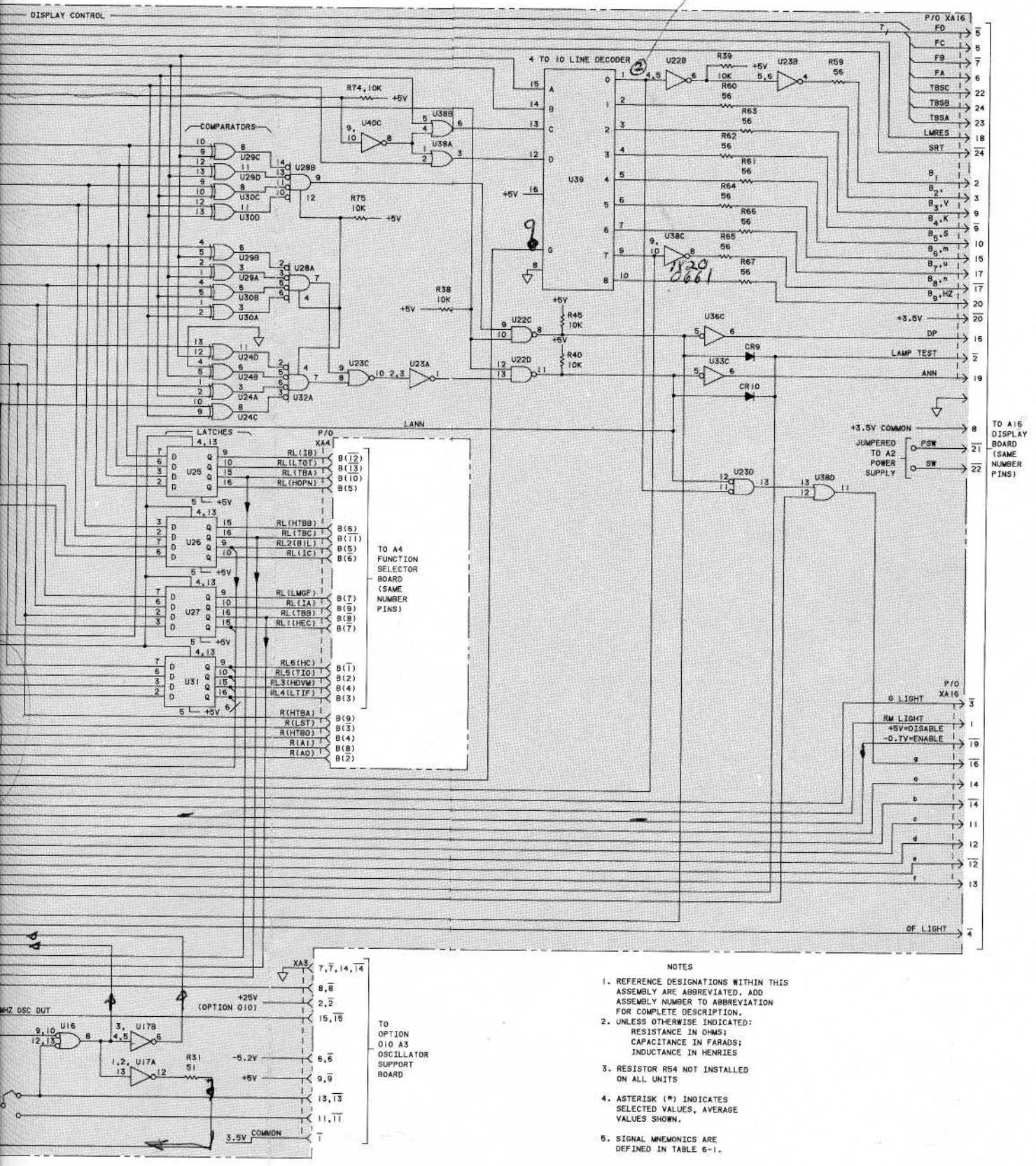
11 – TIME BASE OUTPUT SELECT

3 – 1 MHz INPUT.

FIVE SECTION

DISPLAY CONTROL
STATE CONTROL
OSCILLATOR
DECADE COUNTING ASSEMBLY
TIME BASE





NOTES

1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN FARADS;
   INDUCTANCE IN HENRIES
3. RESISTOR R54 NOT INSTALLED ON ALL UNITS
4. ASTERISK (*) INDICATES SELECTED VALUES, AVERAGE VALUES SHOWN.
5. SIGNAL MNEMONICS ARE DEFINED IN TABLE 6-1.

Figure 6-6. A1 Motherboard Assembly

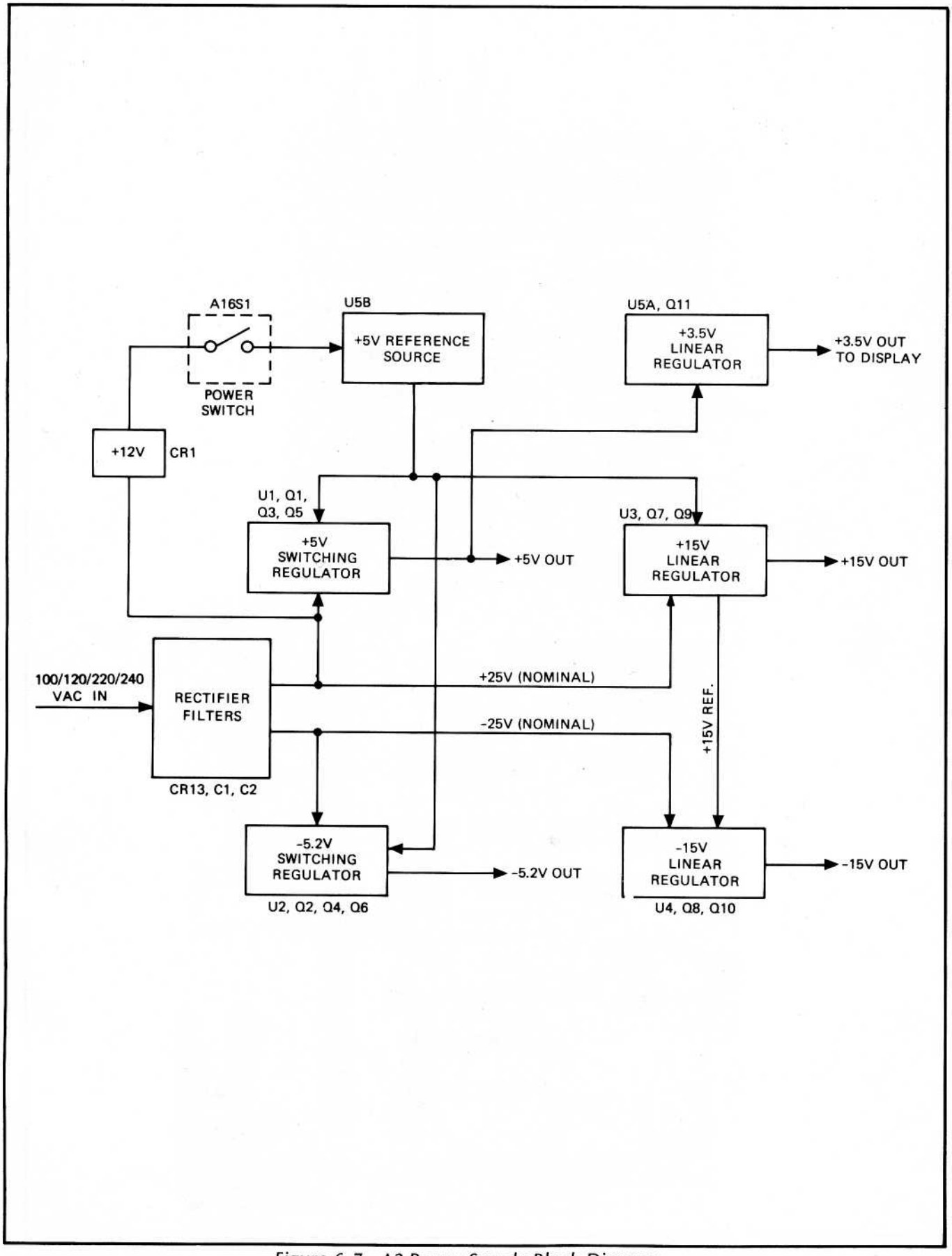
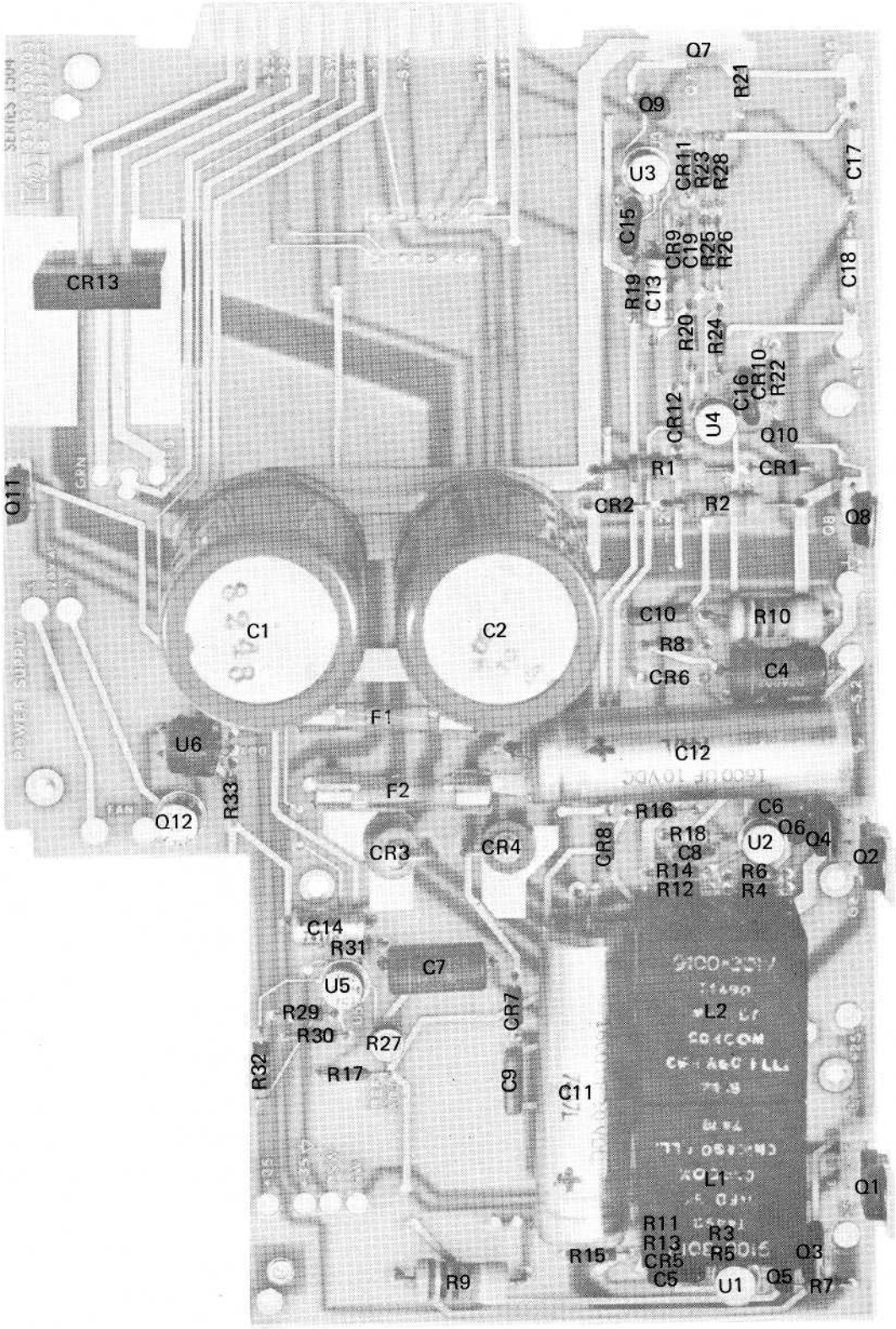
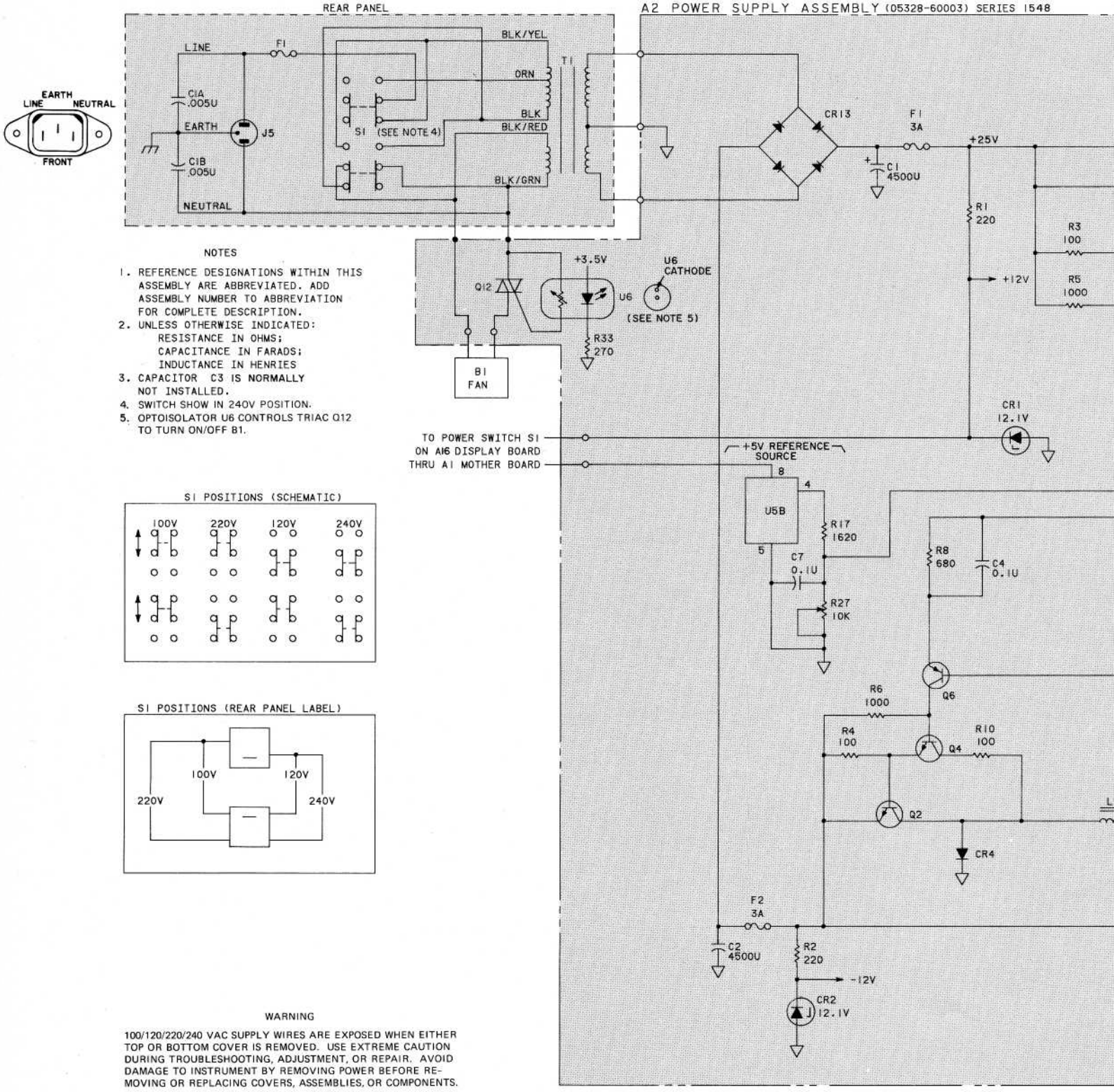


Figure 6-7. A2 Power Supply Block Diagram

FEEDBACK CONNECTOR





NOTES

1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN FARADS;
   INDUCTANCE IN HENRIES
3. CAPACITOR C3 IS NORMALLY NOT INSTALLED.
4. SWITCH SHOW IN 240V POSITION.
5. OPTOISOLATOR U6 CONTROLS TRIAC Q12 TO TURN ON/OFF B1.

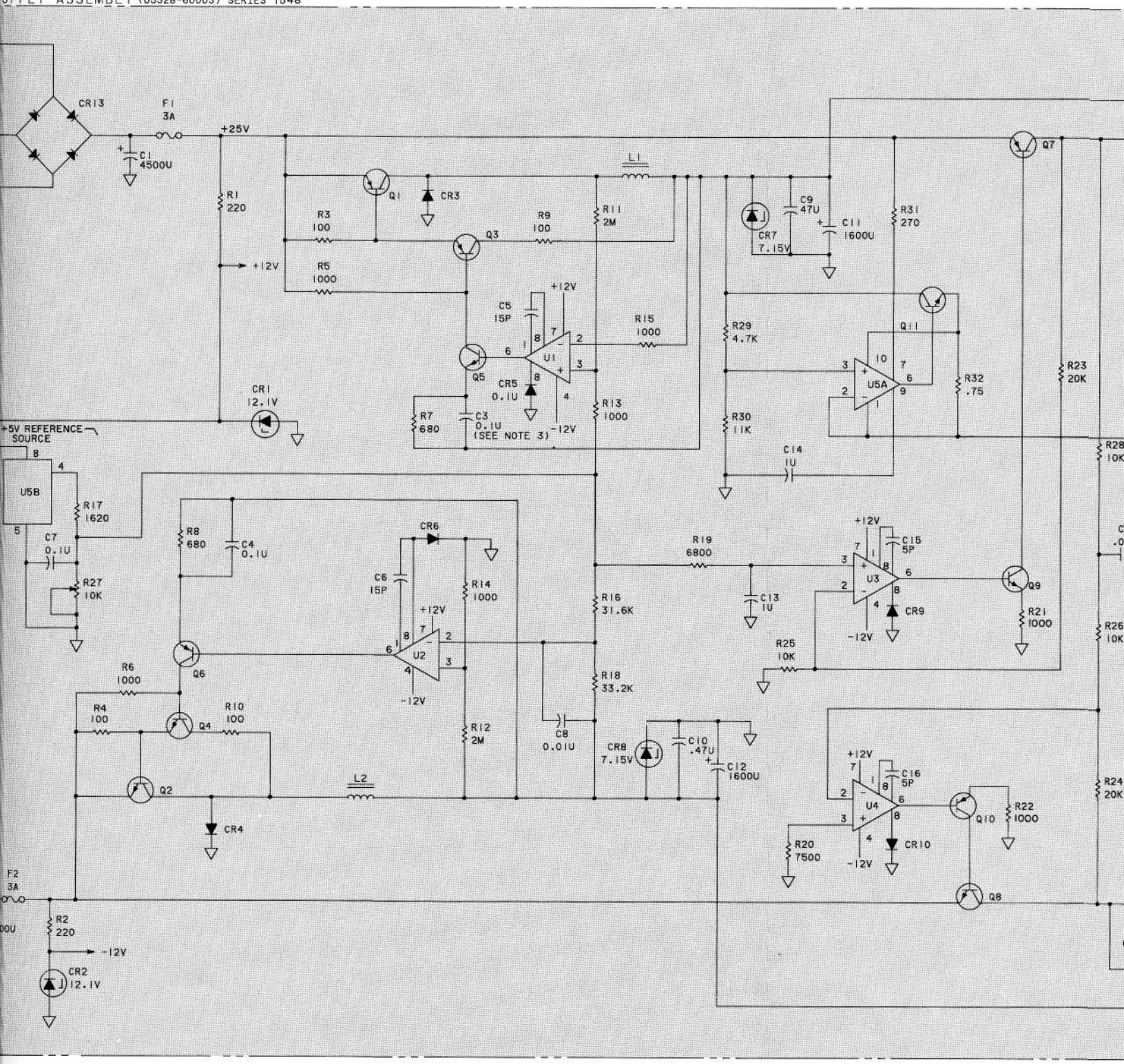
S1 POSITIONS (SCHEMATIC)

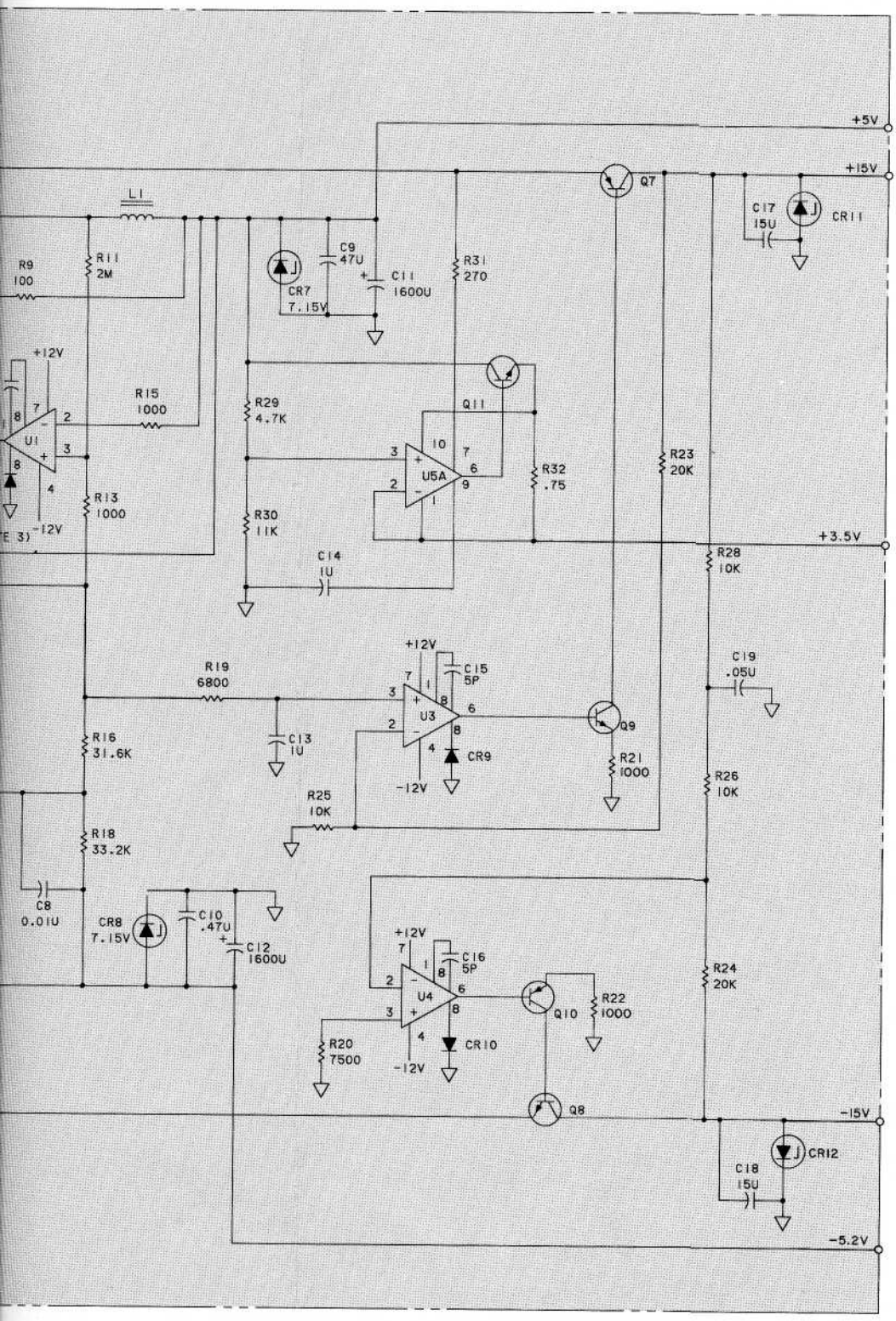
S1 POSITIONS (REAR PANEL LABEL)

WARNING

100/120/220/240 VAC SUPPLY WIRES ARE EXPOSED WHEN EITHER TOP OR BOTTOM COVER IS REMOVED. USE EXTREME CAUTION DURING TROUBLESHOOTING, ADJUSTMENT, OR REPAIR. AVOID DAMAGE TO INSTRUMENT BY REMOVING POWER BEFORE REMOVING OR REPLACING COVERS, ASSEMBLIES, OR COMPONENTS.

UPPLY ASSEMBLY (05328-60003) SERIES 1548





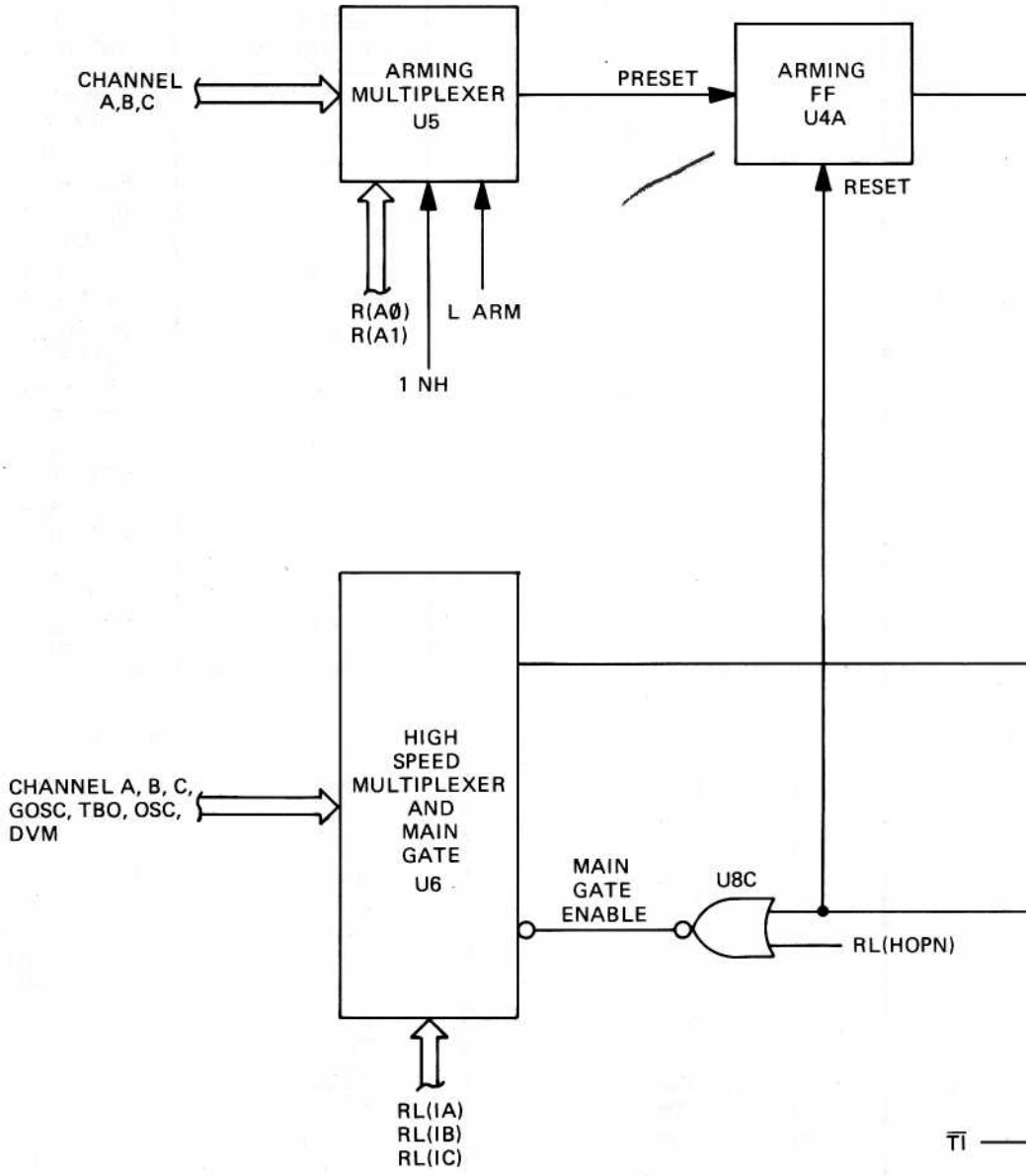
REFERENCE DESIGNATIONS

A2
C1, C2 C3 NOT ASSIGNED C4 C7-C19 CR1-CR13 F1, F2 L1, L2 Q1-Q12 R1-R33

A2 ACTIVE ELEMENTS

REFERENCE DESIGNATIONS	PART NUMBERS
CR1, CR2 CR3, CR4 CR5, CR6, CR9, CR10	1902-0774 1901-1086 1901-0040
CR7, CR8 CR11, CR12 CR13 Q1, Q7	1902-0074 1902-3224 1901-0638 1853-0363 D45H5
Q2, Q8, Q11	1854-0635 D44H5
Q3	1853-0326
Q4	1854-0634 MPS-U01
Q5, Q9	1854-0246 2N3643
Q6, Q10	1853-0016 2N3638
Q12	1884-0055 R40529
U1, U2, U3, U4	1820-0223 LM301AH
U5	1820-0196 723HC

Figure 6–8. A2 Power Supply Assembly



NOTE: REFER TO TABLE 6-1
FOR DESCRIPTION
OF SIGNAL MNEMONICS.

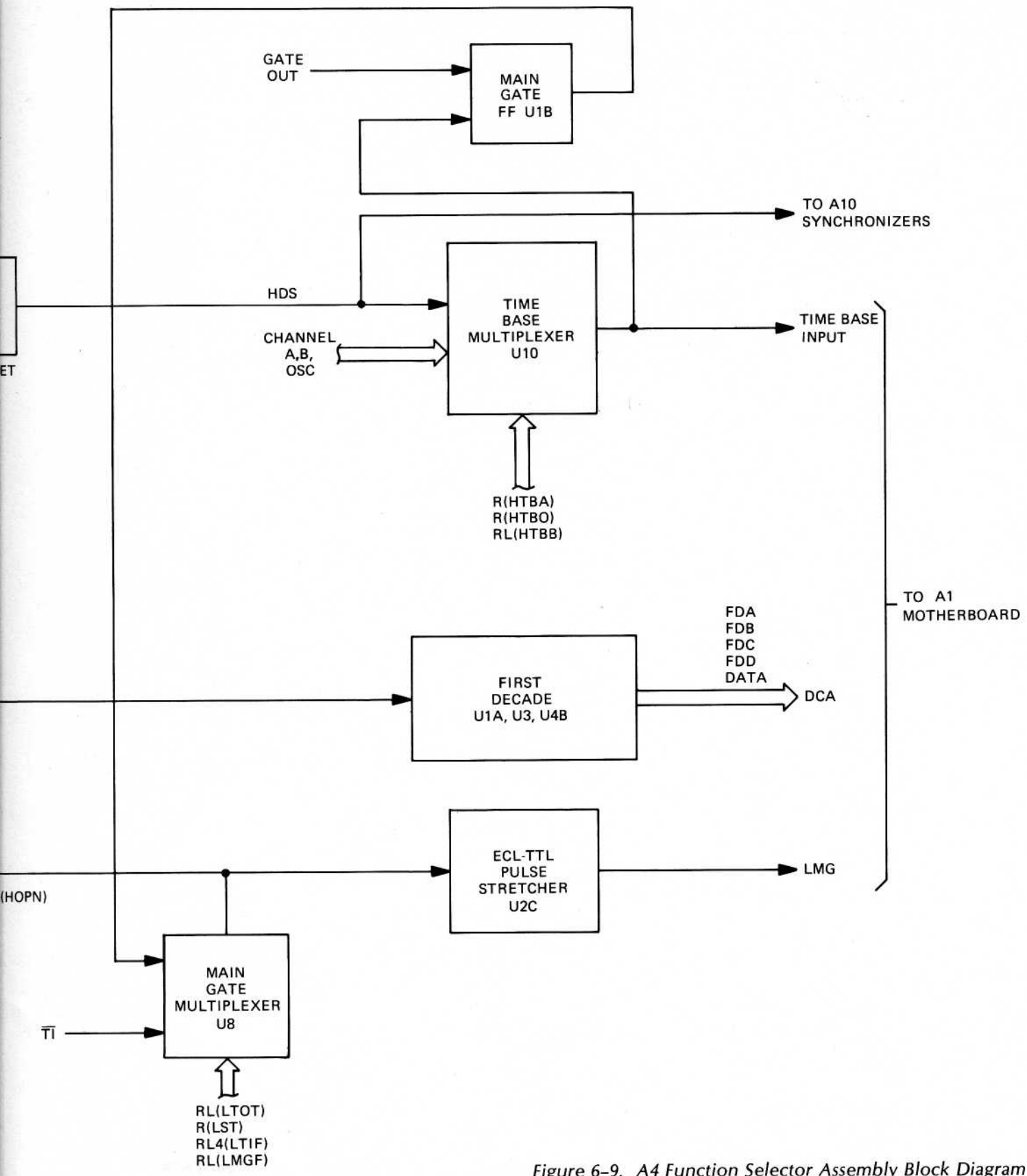


Figure 6-9. A4 Function Selector Assembly Block Diagram

REFERENCE DESIGNATIONS

A4
C1 NOT ASSIGNED C2-C16 Q1-Q3 R1-R46 U1-U10

A4 ACTIVE ELEMENTS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1-Q3	1854-0215 2N3904
U1	1820-1225 MC10231P
U2	1820-1052 MC10125L
U3, U4	1820-0629 SN74S112N
U5	1820-0622 SN74151N
U6	1820-0829 MC10164L
U7	1820-0809 MC10115P
U8	1820-0802 MC10102P
U9	1820-0328 SN7402N
U10	1820-0074 SN7454N

P1A PINS

1	–	$\overline{\text{DVM}}$	$\overline{1}$	–	DVM
2	–	-15V	$\overline{2}$	–	-5.2V
3	–	+5V	$\overline{3}$	–	+15V
4	–	HDS*	$\overline{4}$	–	GND
5	–	$\overline{\text{C}}$	$\overline{5}$	–	C
6	–	C ARM	$\overline{6}$	–	$\overline{\text{MG}}$*
7	–	MG*	$\overline{7}$	–	A
8	–	$\overline{\text{A}}$	$\overline{8}$	–	B
9	–	GND	$\overline{9}$	–	B
10	–	TI	$\overline{10}$	–	$\overline{\text{TI}}$
11	–	GOSC	$\overline{11}$	–	$\overline{\text{GOSC}}$
12	–	LTR	$\overline{12}$	–	GND
13	–	HRD	$\overline{13}$	–	FS OSC
14	–	LDDCA	$\overline{14}$	–	FS OSC
15	–	GATE OUT	$\overline{15}$	–	FDD*
16	–	GND	$\overline{16}$	–	HRTB
17	–	LMG*	$\overline{17}$	–	FDA*
18	–	FDC*	$\overline{18}$	–	FDB*

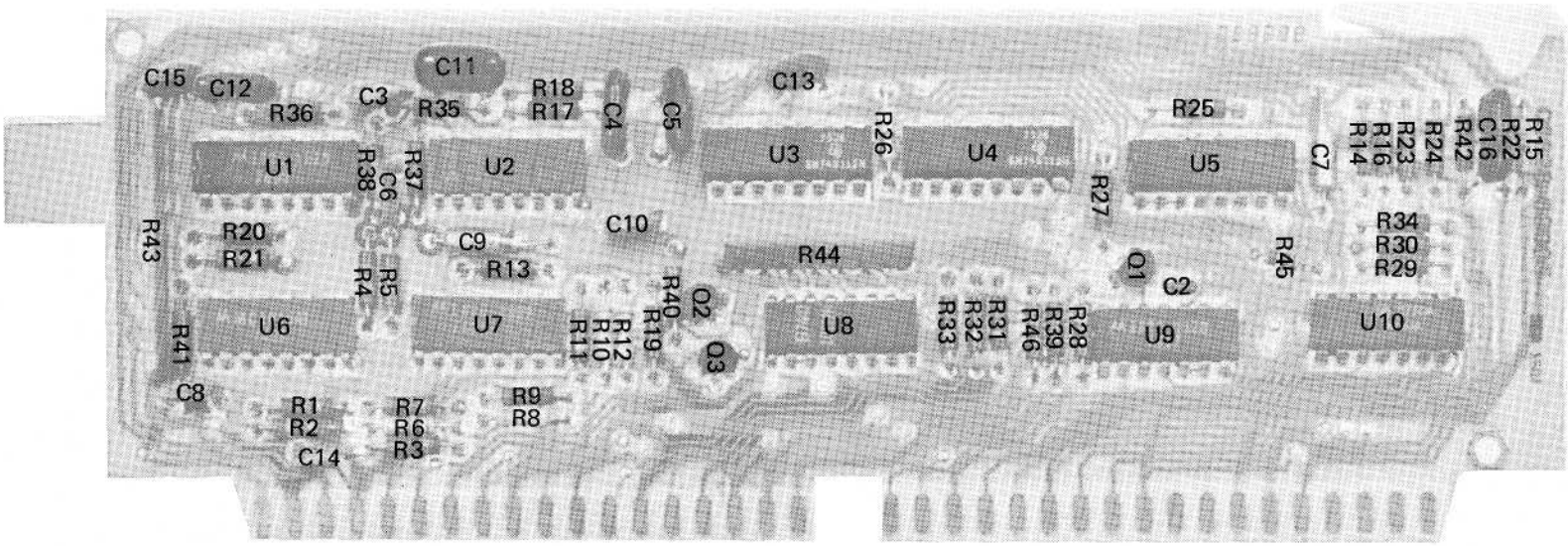
*SIGNAL SOURCE

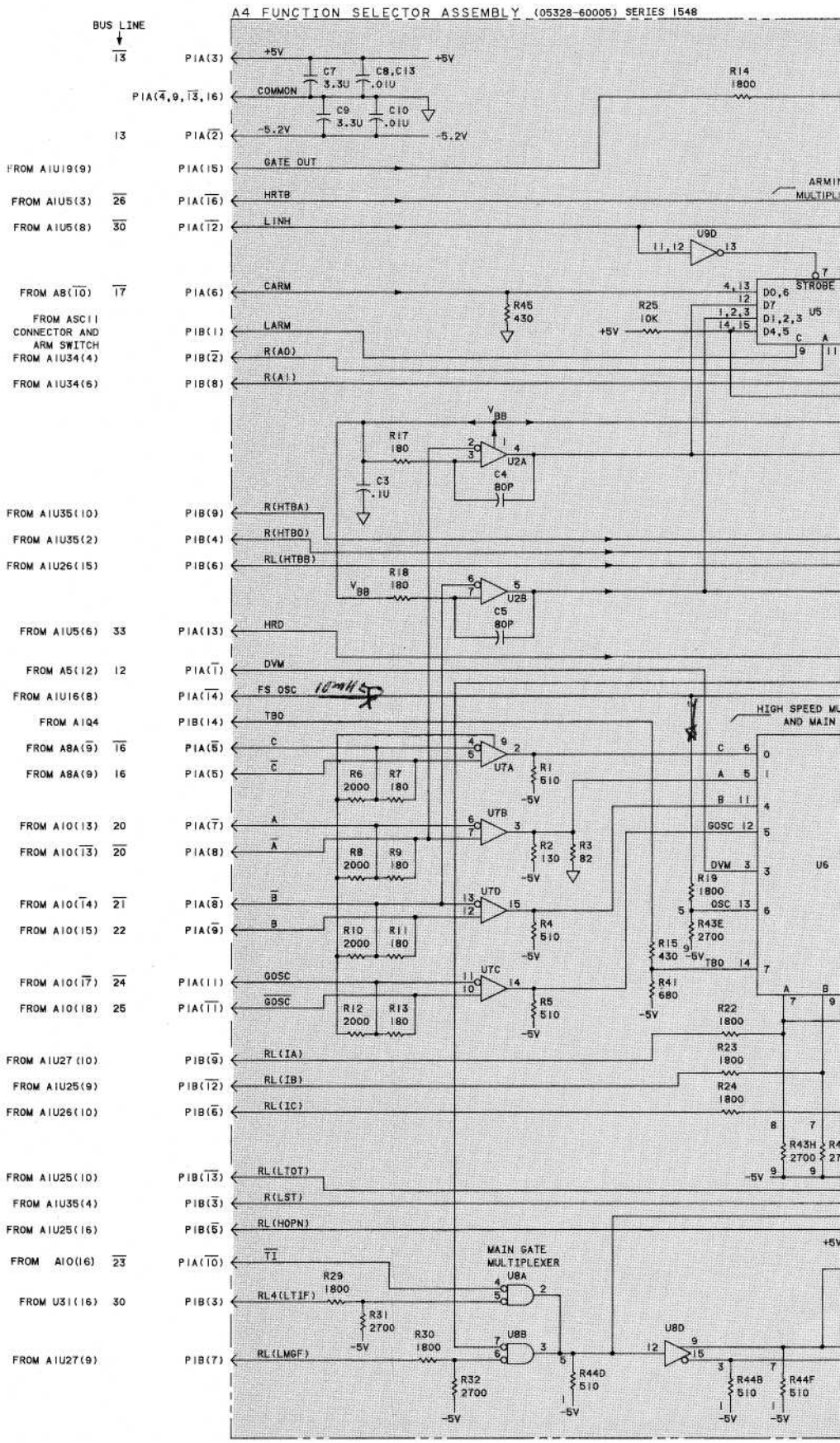
P1B PINS

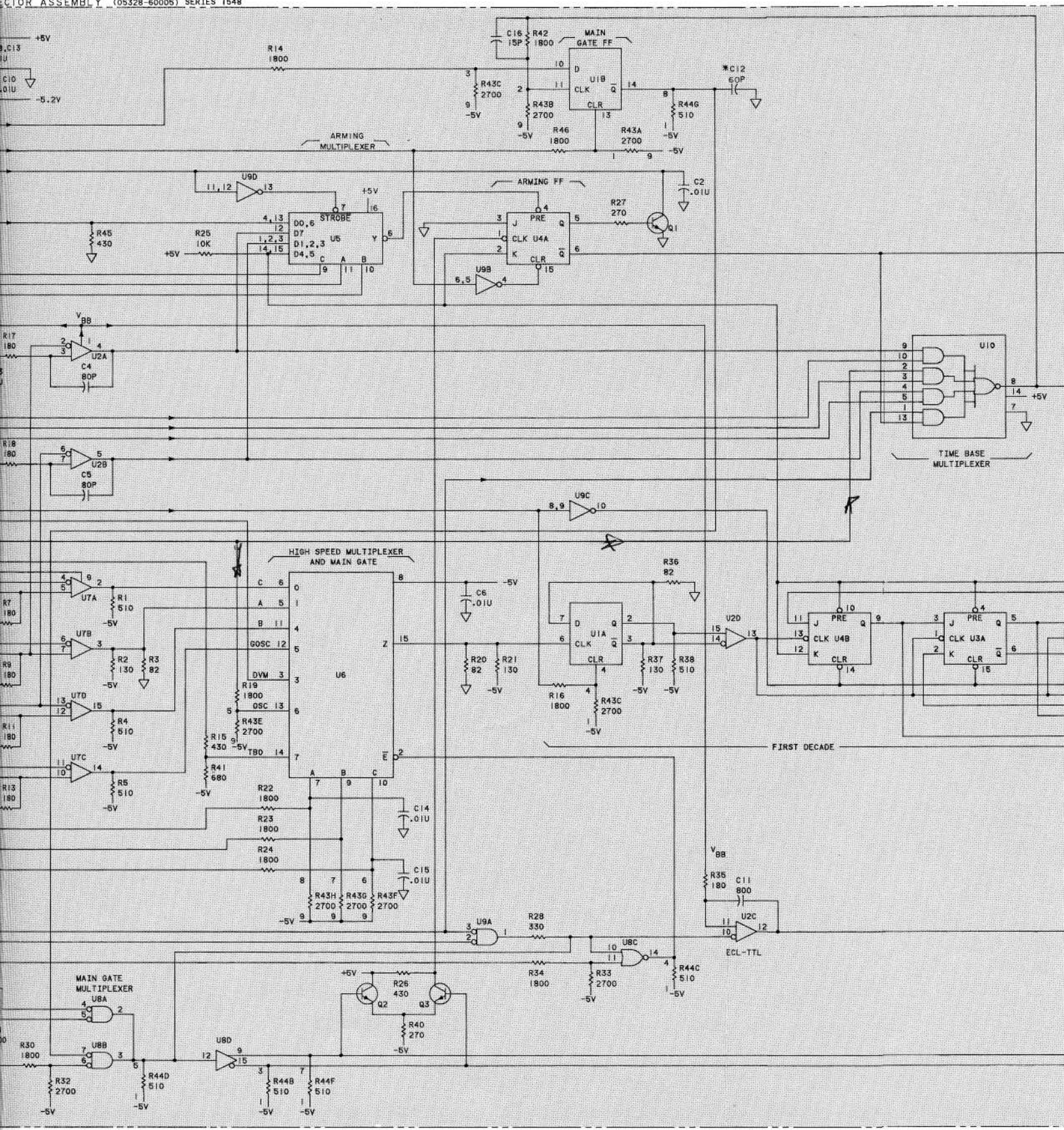
1	–	L ARM	$\overline{1}$	–	RL6(HC)	
2	–	RL5(TIO)	$\overline{2}$	–	R(À0)	
3	–	RL4(LTIF)	$\overline{3}$	–	R(LST)	
4	–	R(HTBO)	$\overline{4}$	–	RL3(HDVM)	
5	–	RL2(BIL)	$\overline{5}$	–	RL(HOPN)	
6	–	RL(HTBB)	$\overline{6}$	–	RL(IC)	
7	–	RL(LMGF)	$\overline{7}$	–	RL1(HEC)	
8	–	R(A1)	$\overline{8}$	–	RL(TBB)	
9	–	R(HTBA)	$\overline{9}$	–	RL(IA)	
10	–	FB	$\overline{10}$	–	RL(TBA)	
11	–	FA	$\overline{11}$	–	RL(TBC)	
12	–	FD	$\overline{12}$	–	RL(IB)	
13	–	FC	$\overline{13}$	–	RL(LTOT)	
14	–	TBO	$\overline{14}$	–	TBI*	NC
15	–	DATA C	$\overline{15}$	–	DS C	
16	–	DATA D	$\overline{16}$	–	DS A	NC
17	–	DATA A	$\overline{17}$	–	DS D	
18	–	DATA B	$\overline{18}$	–	DS B	

*SIGNAL SOURCE

P/O Figure 6-10. A4 Function Selector Assembly


C15
C12
C11
C3
R36
R35
R18
R17
C4
C5
C13
R26
R25
U1
R38
C6
R37
U2
U3
U4
U5
C7
R27
R15
R22
C16
R42
R24
R23
R16
R14
R43
R20
R21
C9
C10
R44
R45
R34
R30
R29
Q1
C2
R4
R5
R13
R40
Q2
R31
R32
R33
R28
R39
R46
U6
U7
U8
U9
U10
R41
R12
R10
R11
R19
Q3
C8
R1
R2
C14
R7
R6
R3
R9
R8
COMPONENT SIDE 1
SOLDER SIDE 1
18
18
1
1
18
18
P1A
P1B


A4 FUNCTION SELECTOR ASSEMBLY (05328-60005) SERIES 1548
BUS LINE
PIA(3)
+5V
C7 3.3U
C8,C13 .01U
PIA(4,9,13,16)
COMMON
C9 3.3U
C10 .01U
PIA(2)
-5.2V
FROM A1U19(9)
PIA(15)
GATE OUT
FROM A1U5(3) 26
PIA(16)
HRTB
FROM A1U5(8) 30
PIA(12)
LINH
U9D
FROM A8(10) 17
PIA(6)
CARM
R45 430
R25 10K
STROBE
FROM ASCII CONNECTOR AND ARM SWITCH
PIB(1)
LARM
FROM A1U34(4)
PIB(2)
R(A0)
FROM A1U34(6)
PIB(8)
R(A1)
R17 180
U2A
C3 .1U
C4 80P
FROM A1U35(10)
PIB(9)
R(HTBA)
FROM A1U35(2)
PIB(4)
R(HTBO)
FROM A1U26(15)
PIB(6)
RL(HTBB)
R18 180
U2B
C5 80P
FROM A1U5(6) 33
PIA(13)
HRO
FROM A5(12) 12
PIA(1)
DVM
FROM A1U16(8)
PIA(14)
FS OSC
FROM A1Q4
PIB(14)
TBO
FROM A8A(9) 16
PIA(5)
C
FROM A8A(9) 16
PIA(5)
C
R6 2000
R7 180
U7A
R1 510
FROM A1O(13) 20
PIA(7)
A
FROM A1O(13) 20
PIA(8)
A
R8 2000
R9 180
U7B
R2 130
R3 82
FROM A1O(14) 21
PIA(8)
B
FROM A1O(15) 22
PIA(9)
B
R10 2000
R11 180
U7D
R4 510
FROM A1O(17) 24
PIA(11)
GOSC
FROM A1O(18) 25
PIA(11)
GOSC
R12 2000
R13 180
U7C
R5 510
FROM A1U27(10)
PIB(9)
RL(IA)
FROM A1U25(9)
PIB(12)
RL(IB)
FROM A1U26(10)
PIB(6)
RL(IC)
FROM A1U25(10)
PIB(13)
RL(LTOT)
FROM A1U35(4)
PIB(3)
R(LST)
FROM A1U25(16)
PIB(5)
RL(HOPN)
FROM A1O(16) 23
PIA(10)
TI
MAIN GATE MULTIPLEXER
U8A
R29 1800
FROM U31(16) 30
PIB(3)
RL4(LTIF)
R31 2700
R30 1800
U8B
FROM A1U27(9)
PIB(7)
RL(LMGF)
R32 2700
R44D 510
U8D
R44B 510
R44F 510
R14 1800
R19 1800
R43E 2700
R15 430
R41 680
R22 1800
R23 1800
R24 1800
R43H 2700
HIGH SPEED MU
AND MAIN
U6
GOSC
DVM
OSC
TBO
-5V
+5V


MAIN GATE FF
ARMING MULTIPLEXER
ARMING FF
TIME BASE MULTIPLEXER
HIGH SPEED MULTIPLEXER AND MAIN GATE
FIRST DECADE
MAIN GATE MULTIPLEXER
ECL-TTL
STROBE
PRE
CLR
CLK
+5V
-5V
-5.2V

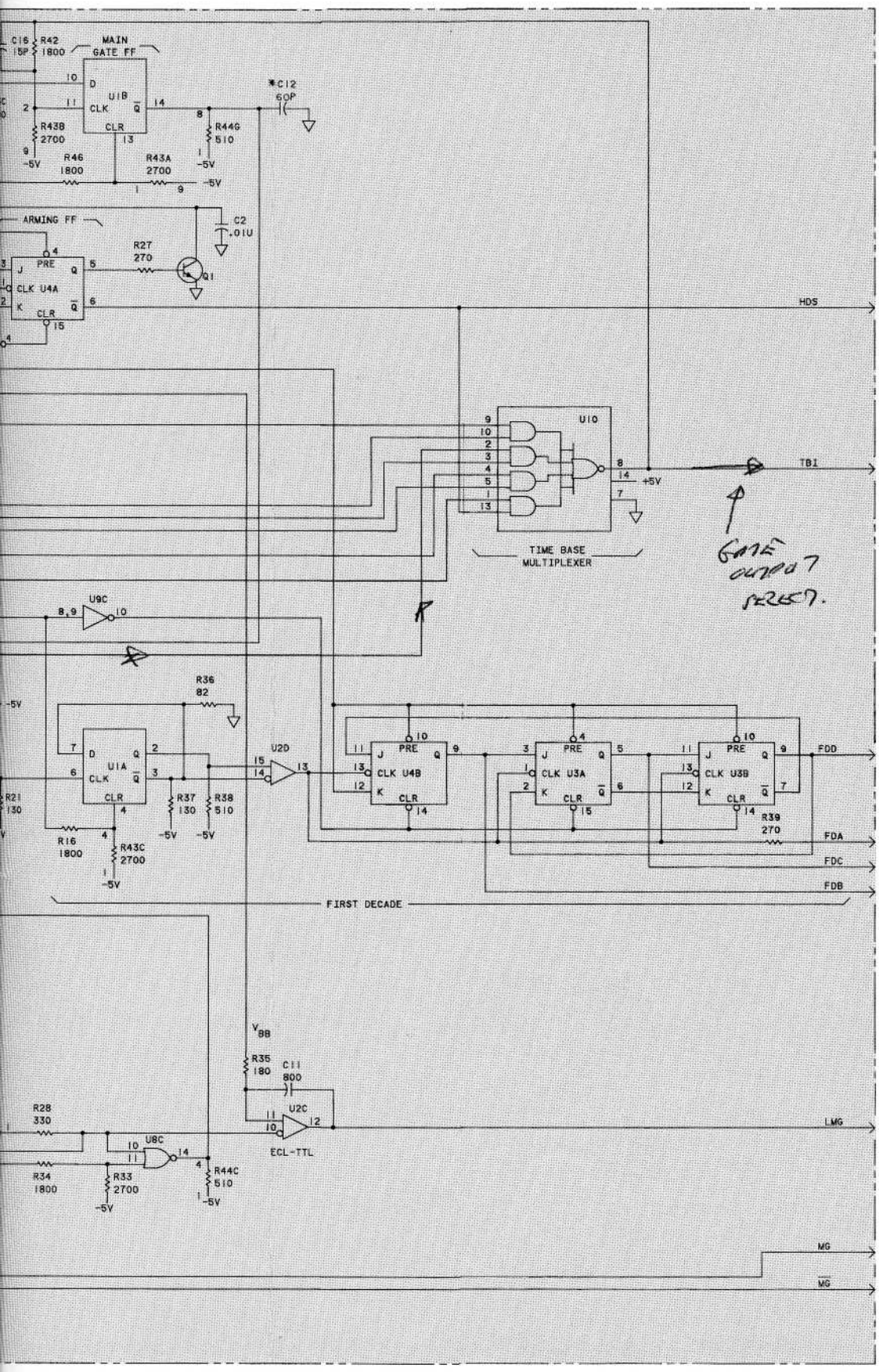
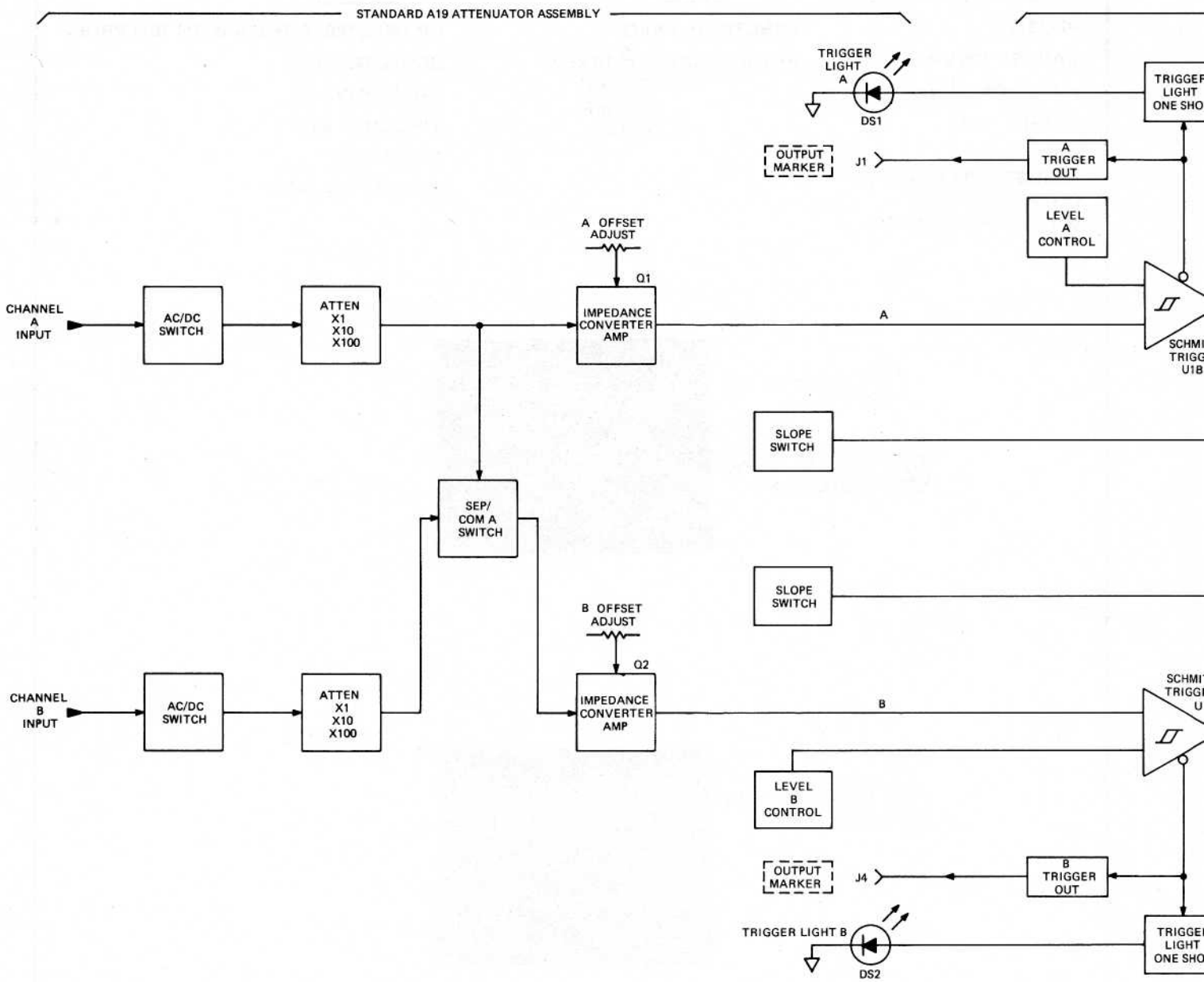


Figure 6–10. A4 Function Selector Assembly


STANDARD A19 ATTENUATOR ASSEMBLY
TRIGGER LIGHT A
DS1
TRIGGER LIGHT ONE SHO
OUTPUT MARKER
J1
A TRIGGER OUT
LEVEL A CONTROL
A OFFSET ADJUST
Q1
CHANNEL A INPUT
AC/DC SWITCH
ATTEN X1 X10 X100
IMPEDANCE CONVERTER AMP
A
SCHMI TRIGG U18
SLOPE SWITCH
SEP/ COM A SWITCH
SLOPE SWITCH
B OFFSET ADJUST
Q2
CHANNEL B INPUT
AC/DC SWITCH
ATTEN X1 X10 X100
IMPEDANCE CONVERTER AMP
B
SCHMI TRIGG U
LEVEL B CONTROL
OUTPUT MARKER
J4
B TRIGGER OUT
TRIGGER LIGHT B
DS2
TRIGGE LIGHT ONE SHO

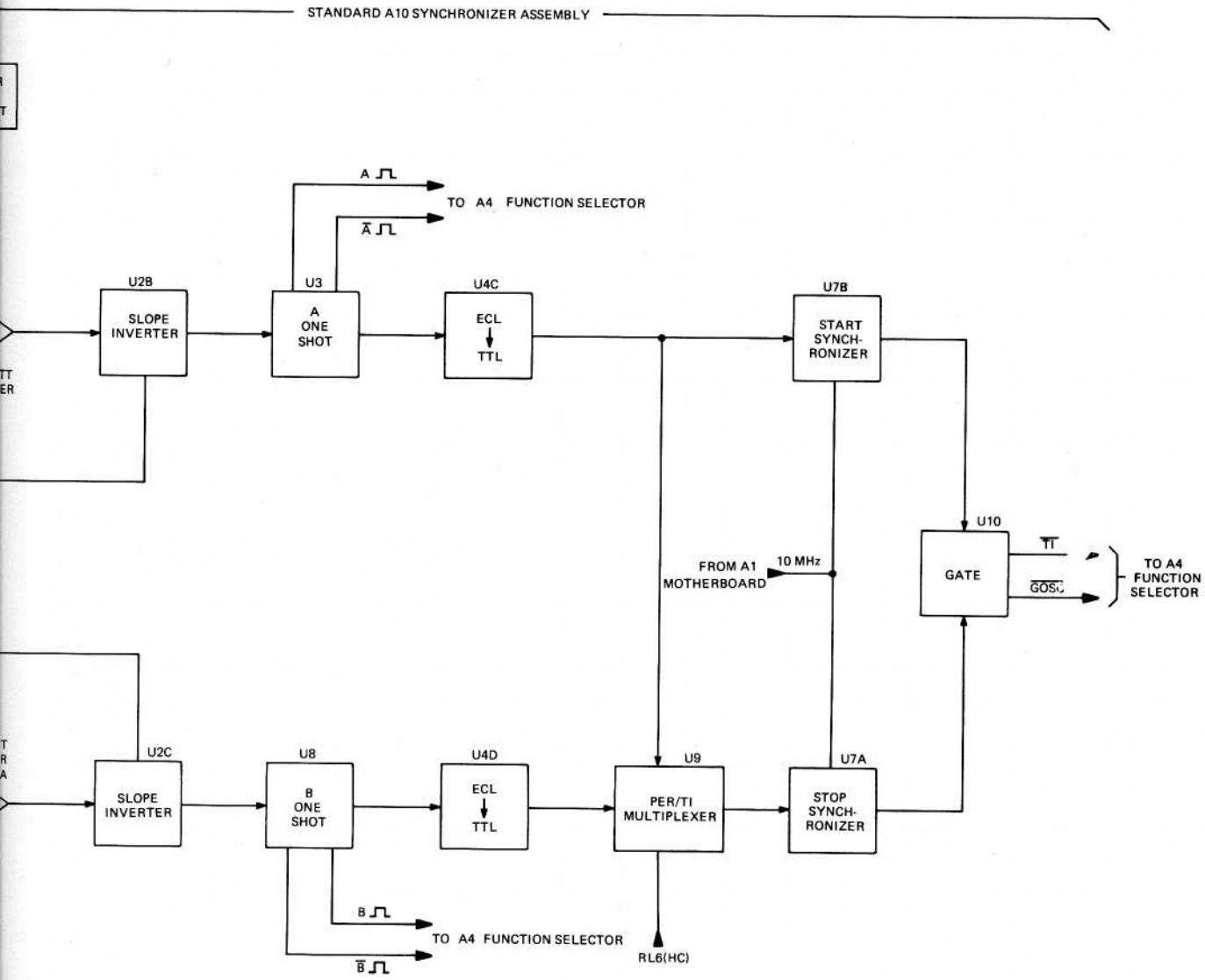


Figure 6–11. Standard Time Interval Module (A10 and A19) Block Diagram

FUNCTION GENERATOR

HP 3312A
RANGE: 100 kHz
FUNCTION: ⊓⊔
OFFSET: CAL
SYM: CAL
ADJUST AMPLITUDE TO OUTPUT MARKER
WAVEFORM ≈ 0.8V PP

5328A

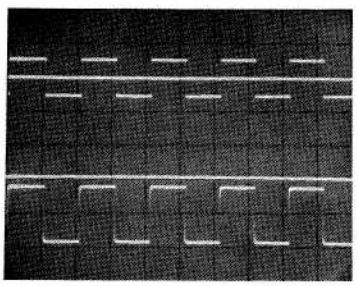
FUNCTION: FREQ A
RESOLUTION: 10^5 10 kHz (DC, X1, + SLOPE, COMA.)

OSCILLOSCOPE

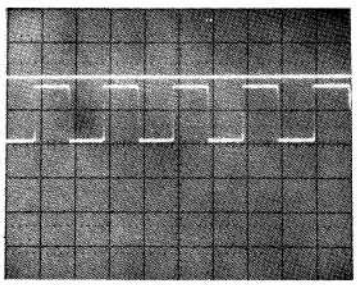
HP 180A/1801A/1821A WITH 10:1 PROBE
COUPLING: DC
VOLTS/DIV: .5
TIME/DIV: 5 μs
SLOPE: +
SYNCH: INT, ACF

(1) INPUT A 0V

(2) OUTPUT MARKER A 0V

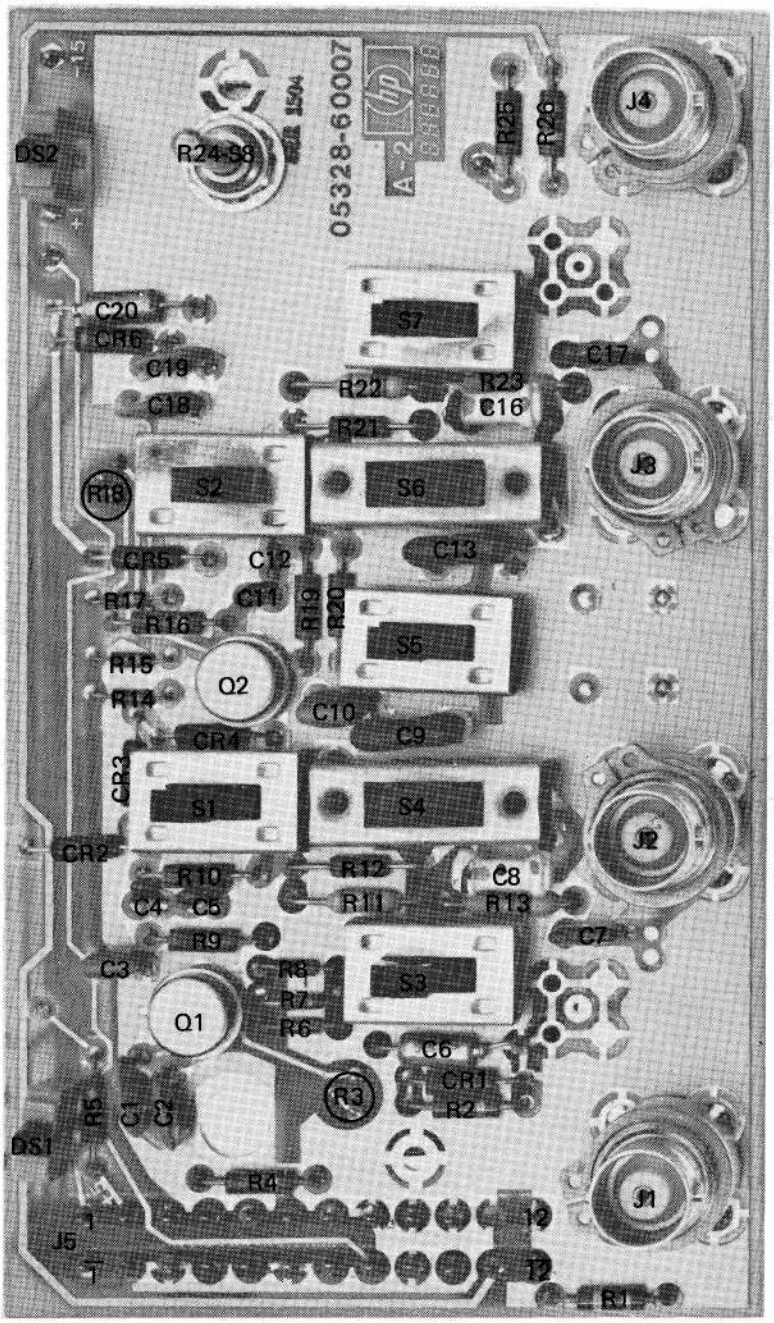


(3) OUTPUT MARKER B 0V

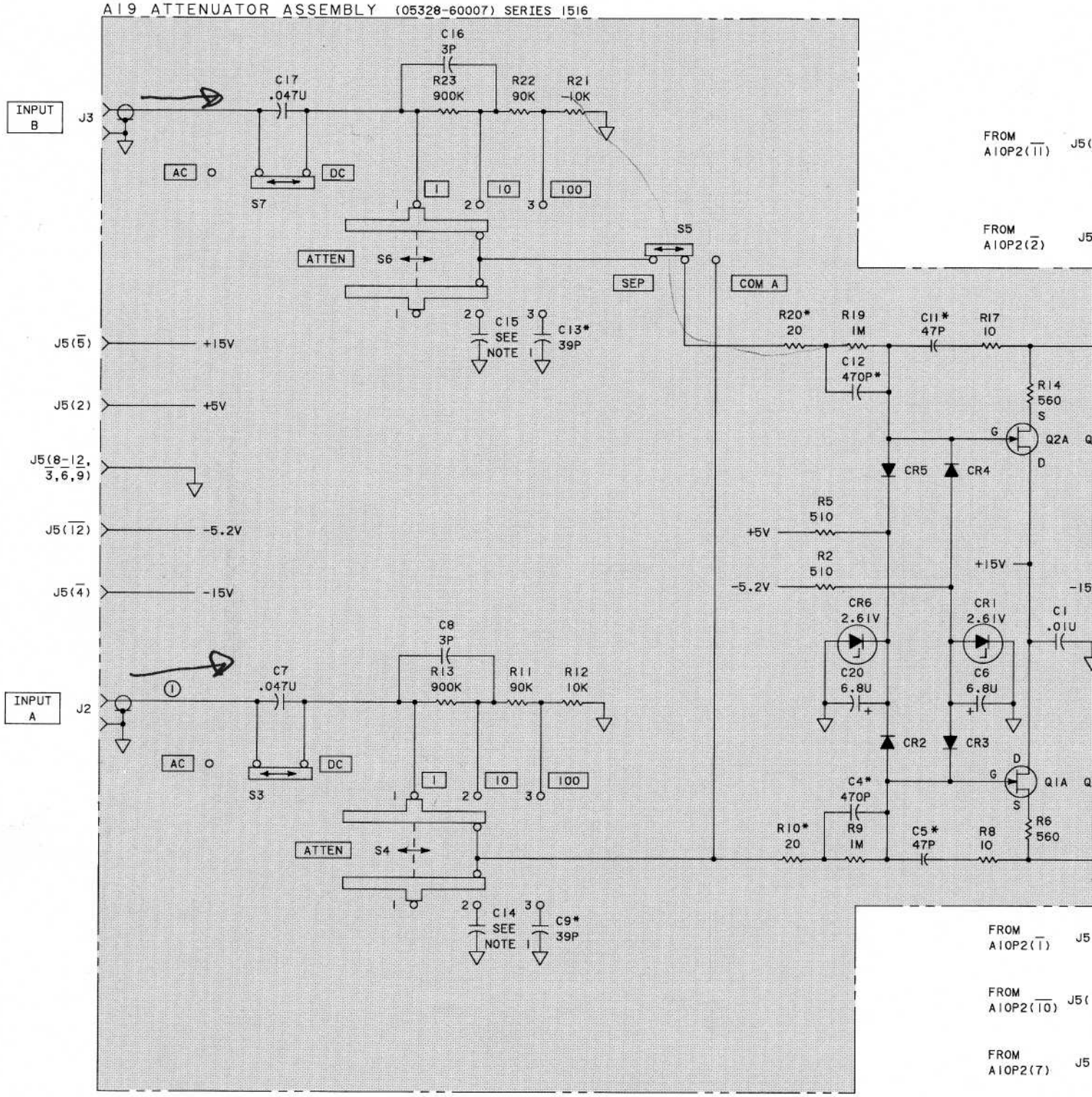


P/O Figure 6-12. Standard A19 Attenuator Assembly

R3 = A OFF. ADJ. (ON BACK)
R18 = B OFF. ADJ.

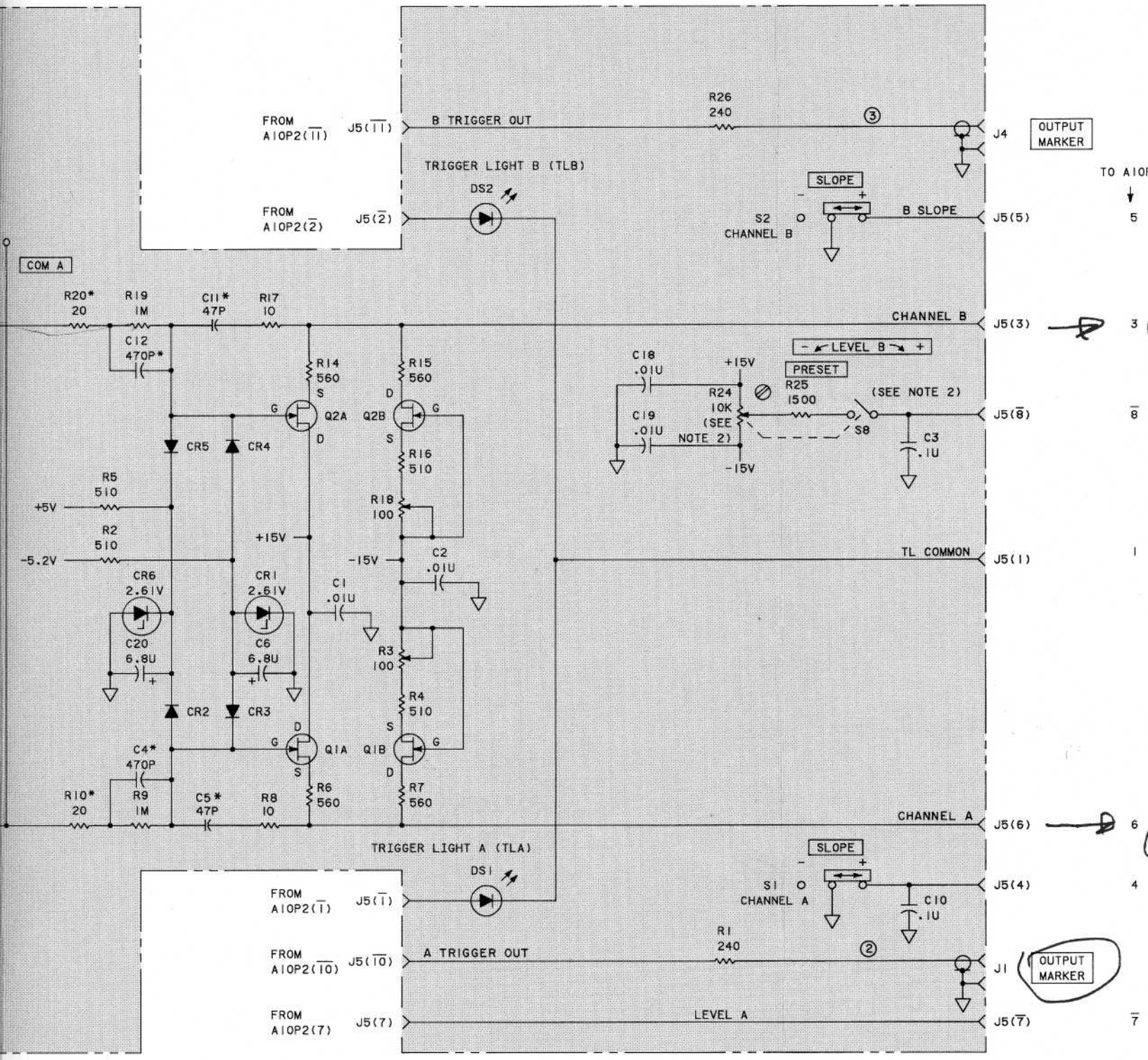


A19 ATTENUATOR ASSEMBLY (05328-60007) SERIES 1516



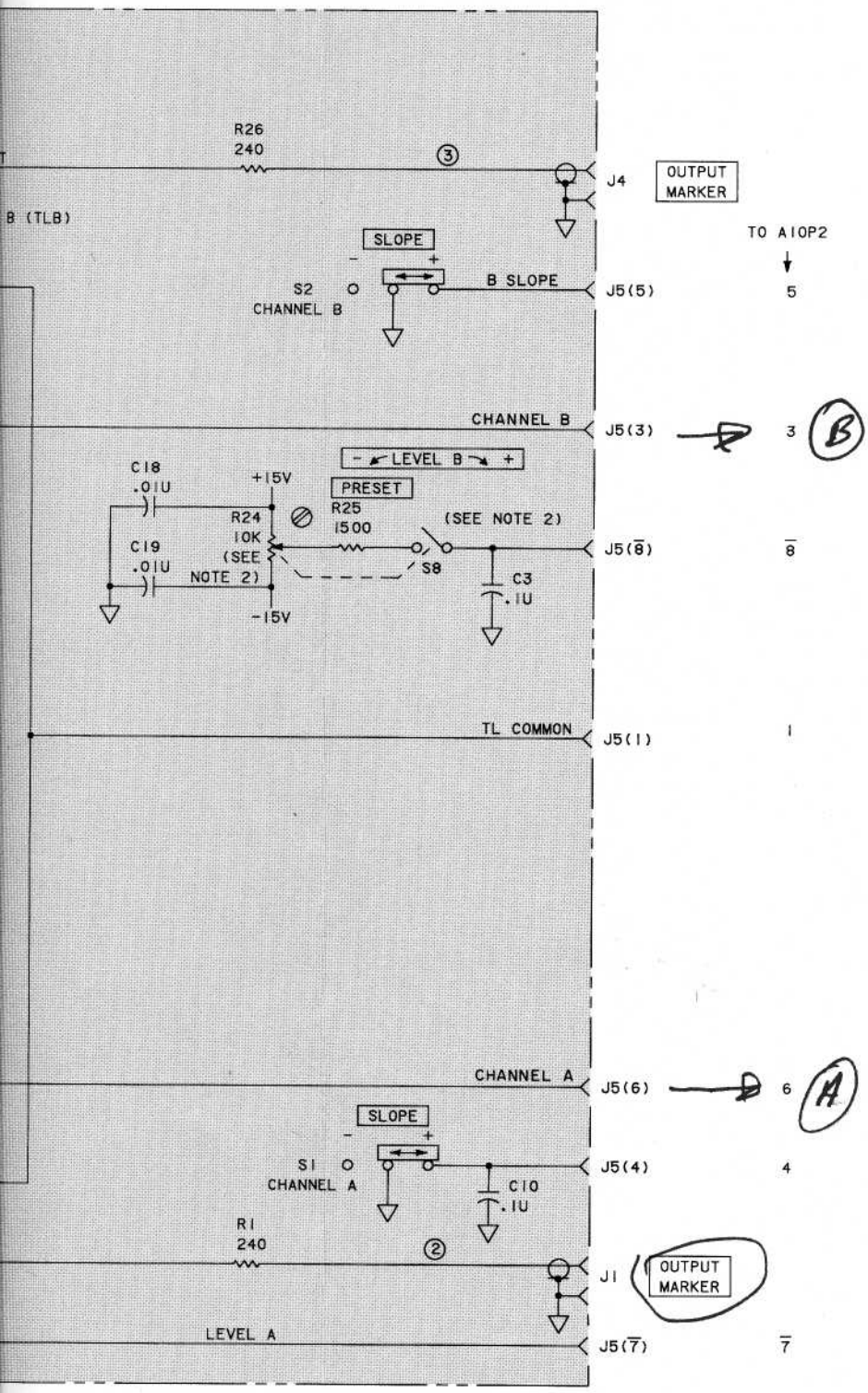
NOTES:

1. CAPACITORS C14 AND C15 ARE NORM REPRESENTED BY PARASITIC CAPAC OF THE BOARD.
2. S8 AND R24 ARE PART OF THE SA
3. ASTERISK (*) INDICATES SELECTE AVERAGE VALUE SHOWN.
4. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS; CAPACITANCE IN FARADS.



NOTES:

1. CAPACITORS C14 AND C15 ARE NORMALLY REPRESENTED BY PARASITIC CAPACITANCE OF THE BOARD.
2. S8 AND R24 ARE PART OF THE SAME COMPONENT.
3. ASTERISK (*) INDICATES SELECTED VALUE, AVERAGE VALUE SHOWN.
4. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN FARADS.



REFERENCE DESIGNATIONS

A19
C1-C13
C14, C15 NOT ASSIGNED
C16-C20
CR1-CR6
DS1, DS2
Q1, Q2
R1-R26
S1-S8

A19 ACTIVE ELEMENTS

REFERENCE DESIGNATIONS	PART NUMBERS
CR1, CR6	1902-0126
CR2-CR5	1901-0376
Q1, Q2	1855-0213 2N5912

FACTORY SELECTED PART

REFERENCE DESIGNATOR	SELECTED FOR	NORMAL VALUE RANGE
C9 C8 C14	Flat frequency response in all attenuator positions	39 pf ±10 3 pf ±2 0 ±5
C13 C16 C15	Flat frequency response in all attenuator positions	39 pf ±10 3 pf ±2 0 ±5 pf
R-10 C-4 C-5	Flat frequency response in A channel	20 ±5 470 pf ±40 47 pf ±5
R-70 C-12 C-11	Flat frequency response in A channel	20 ±5Ω 470 pf ±40 47 pf ±5

J5 PINS

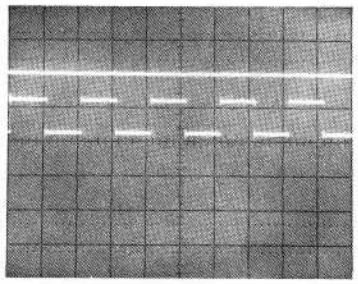
1	–	TL COMMON
2	–	+5V
3	–	CHANNEL B }
4	–	A SLOPE } *TO A10
5	–	B SLOPE }
6	–	CHANNEL A
7	–	LEVEL A (IN)
8	–	GND
9	–	GND
10	–	GND
11	–	GND
12	–	GND
$\overline{1}$	–	TLA (TRIGGER LIGHT A)
$\overline{2}$	–	TLB (TRIGGER LIGHT B)
$\overline{3}$	–	GND
$\overline{4}$	–	-15V
$\overline{5}$	–	+15V
$\overline{6}$	–	GND
$\overline{7}$	–	LEVEL A } TO A10
$\overline{8}$	–	LEVEL B }
$\overline{9}$	–	GND
$\overline{10}$	–	"A" TRIGGER OUT } FROM A10
$\overline{11}$	–	"B" TRIGGER OUT }
$\overline{12}$	–	-5.2V

*SIGNAL SOURCE

Figure 6–12. Standard A19 Attenuator Assembly

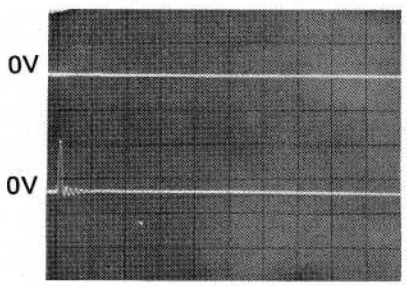
FUNCTION GENERATOR	5328A	OSCILLOSCOPE
HP 3312A	FUNCTION: FREQ A	HP 180A/1801A/1821A WITH 10:1 PROBE
RANGE: 100 kHz	RESOLUTION: 10^5, 10 kHz (DC, X1, + SLOPE, COMA.)	COUPLING: DC
FUNCTION: ⊓⊔		SYNCH: INT, ACF
OFFSET: CAL		SLOPE: +
SYM: CAL		

.1V/DIV 5 μs/DIV



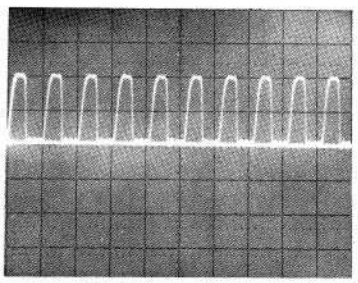
④

.05/DIV .1 μs/DIV



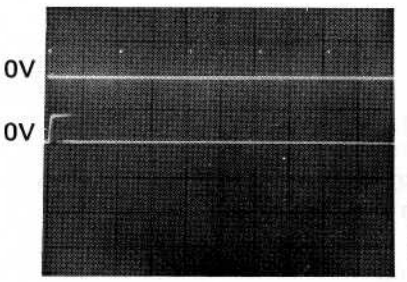
⑤

FOR AND SET 5328A FUNCTION SWITCH TO TI A⟶B



.2V/DIV
.1 μs/DIV

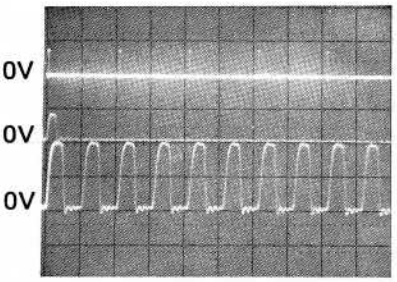
⑥



.5V/DIV
5 μs/DIV

.5V/DIV
.2 μs/DIV
(EXPANDED)

⑦



.5V/DIV
5 μs/DIV

.5V/DIV
.1 μs/DIV

(EXPANDED)

⑧

.2V/DIV
.1 μs/DIV

⑨

P/O Figure 6-13. A10 Synchronizer Assembly

P1 PINS

1	–	NC
2	–	NC
3	–	LBDVM*
4	–	LADVM*
5	–	NC
6	–	-5.2V
7	–	+15V
8	–	RL6(HC)
9	–	A ARM
10	–	GND
11	–	GND
12	–	NC
13	–	A*
14	–	GND
15	–	B
16	–	TI(NC)
17	–	GND
18	–	$\overline{\text{GOSC}}$* (TO A4 FUNCTION SELECTOR)
$\overline{1}$	–	NC
$\overline{2}$	–	NC
$\overline{3}$	–	NC
$\overline{4}$	–	NC
$\overline{5}$	–	-15V
$\overline{6}$	–	+5V
$\overline{7}$	–	HDS
$\overline{8}$	–	GND
$\overline{9}$	–	B ARM
$\overline{10}$	–	NC
$\overline{11}$	–	OSC (10 MHz)
$\overline{12}$	–	GND
$\overline{13}$	–	$\overline{\text{A}}$*
$\overline{14}$	–	$\overline{\text{B}}$*
$\overline{15}$	–	GND
$\overline{16}$	–	$\overline{\text{TI}}$* (TO A4 FUNCTION SELECTOR)
$\overline{17}$	–	GOSC* (TO A4 FUNCTION SELECTOR)
$\overline{18}$	–	GND

*SIGNAL SOURCE

P2 PINS

1	–	TL GND	$\overline{1}$	–	TLA*
2	–	+5V	$\overline{2}$	–	TLB*
3	–	CHANNEL B	$\overline{3}$	–	B GND
4	–	A SLOPE	$\overline{4}$	–	-15V
5	–	B SLOPE	$\overline{5}$	–	+15V
6	–	CHANNEL A	$\overline{6}$	–	"A" GND
7	–	LEVEL A	$\overline{7}$	–	LEVEL A*
8	–	GND	$\overline{8}$	–	LEVEL B
9	–	GND	$\overline{9}$	–	GND
10	–	GND	$\overline{10}$	–	A TRIGGER OUT*
11	–	GND	$\overline{11}$	–	B TRIGGER OUT*
12	–	GND	$\overline{12}$	–	-5.2V

*SIGNAL SOURCE

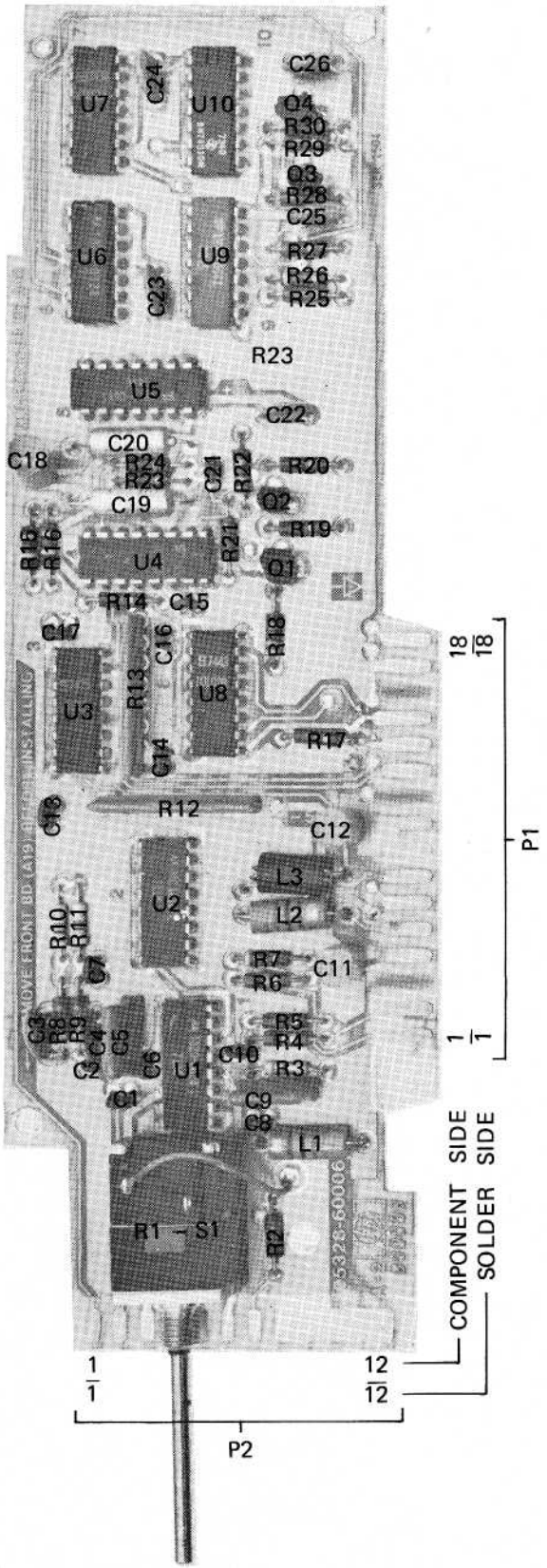
REFERENCE DESIGNATIONS

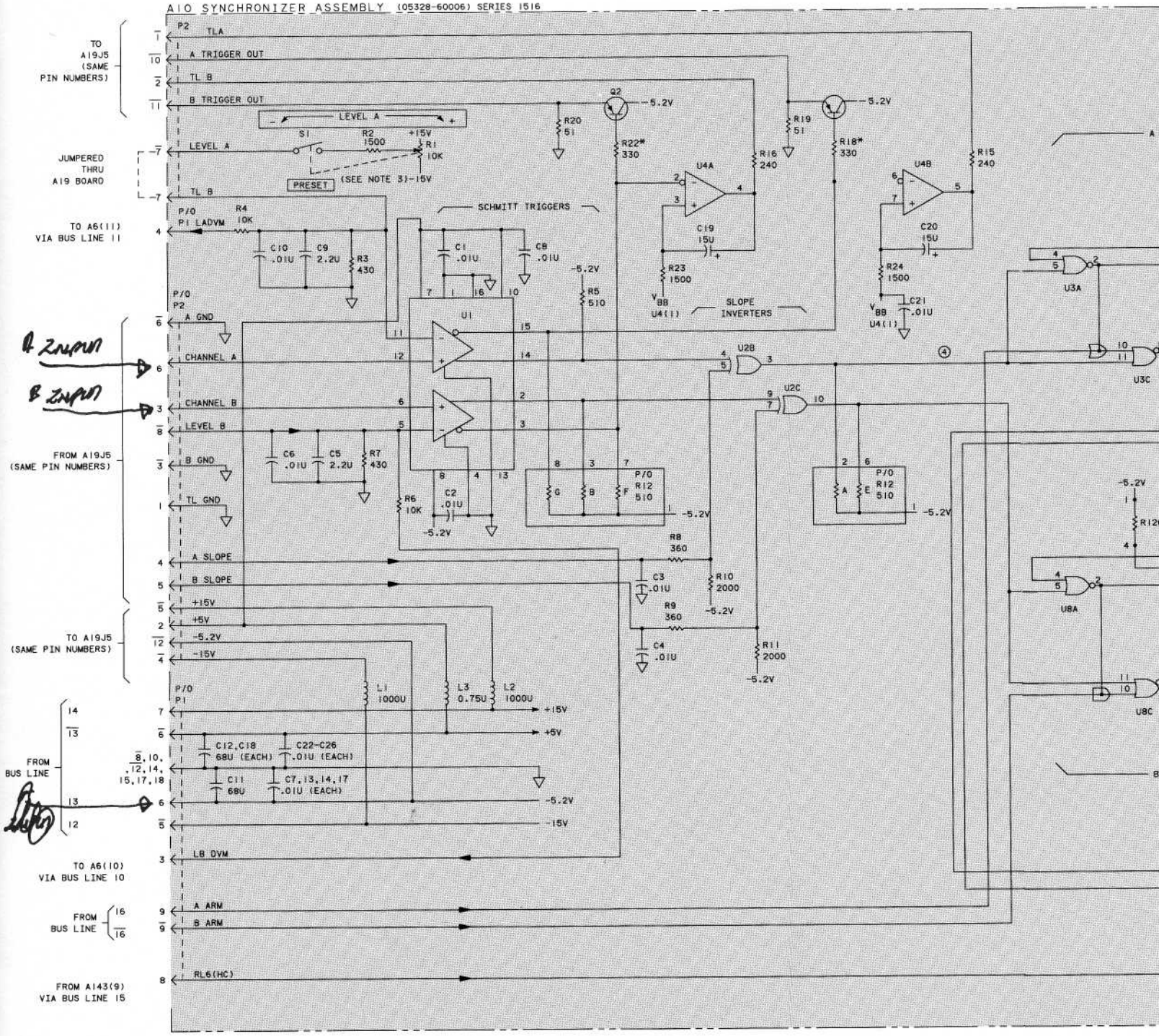
A10
C1-C26 L1-L3 Q1-Q4 R1-R30 S1 U1-U10

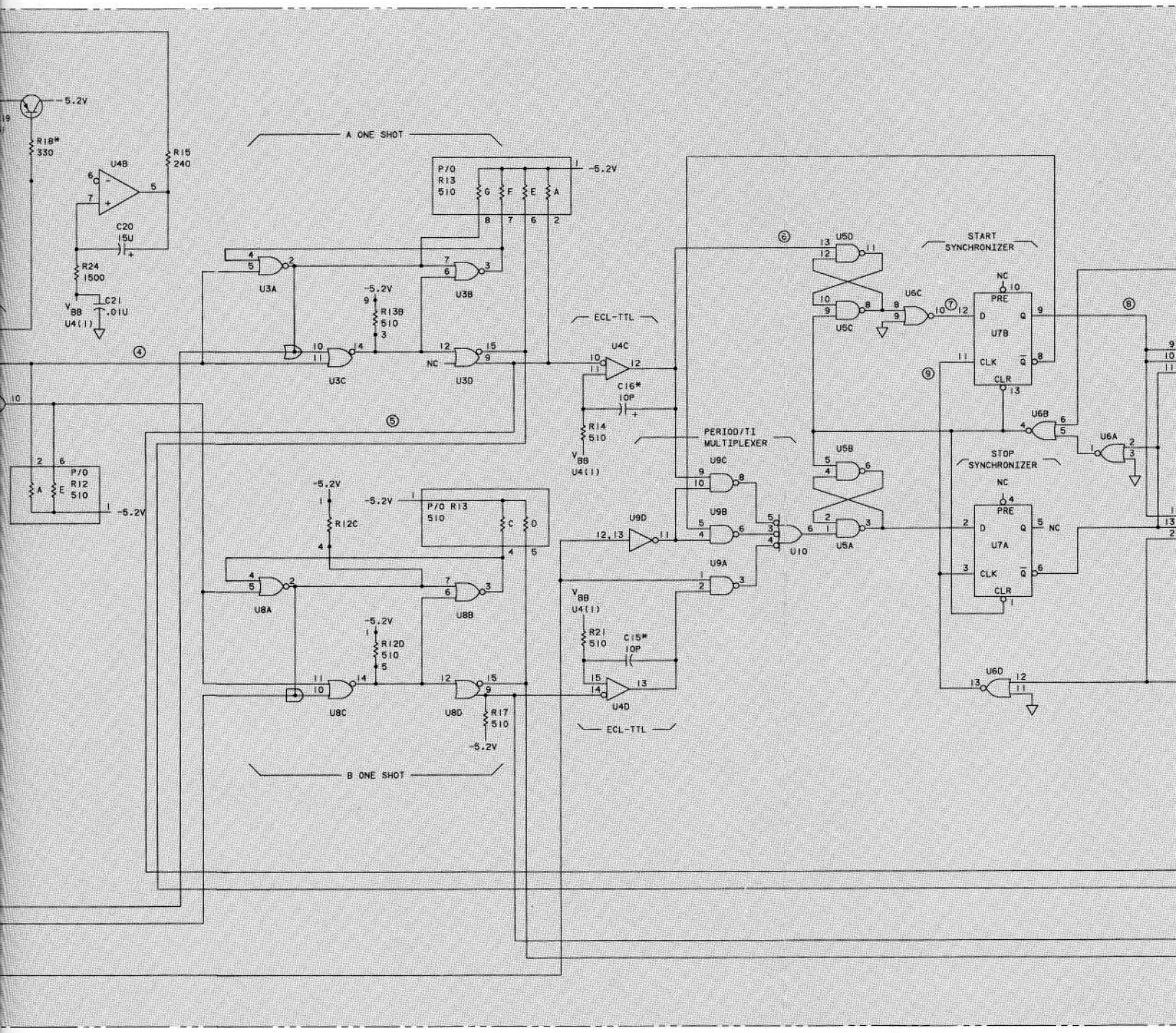
A10 ACTIVE ELEMENTS

REFERENCE DESIGNATIONS	PART NUMBERS
Q1, Q2	1853-0020
Q3, Q4	1854-0092 2N3563
U1	1820-0624 (FOR SERIES 1504) 1820-1566 (FOR SERIES 1516)
U2	1820-0805 MC10107P
U3, U8	1820-0802 MC10102P
U4	1820-1052 MC10125L
U5, U9	1820-0681 SN74500N
U6	1820-1322 SN74S02N
U7	1820-0693 SN74S74N
U10	1820-0685 SN74S10N

P/O Figure 6-13. Standard A10 Synchronizer Assembly


U7
C24
U10
C26
Q4
R30
R29
Q3
R28
C25
R27
R26
R25
U6
C23
U9
R23
U5
C22
C20
C18
R24
R23
C21
R22
R20
C19
Q2
R19
R15
R16
U4
R21
Q1
R14
C15
C17
C16
R18
U3
R13
U8
R17
C14
C13
R12
C12
L3
U2
L2
R10
R11
C7
R7
R6
C11
C3
R8
R9
C4
C5
R5
R4
C2
C6
U1
C10
R3
C1
C9
C8
L1
R1 - S1
R2
P1
P2
18
18
1
1
1
1
12
12
COMPONENT SIDE
SOLDER SIDE


A10 SYNCHRONIZER ASSEMBLY (05328-60006) SERIES 1516
TO A19J5 (SAME PIN NUMBERS)
JUMPERED THRU A19 BOARD
TO A6(11) VIA BUS LINE 11
FROM A19J5 (SAME PIN NUMBERS)
TO A19J5 (SAME PIN NUMBERS)
FROM BUS LINE
TO A6(10) VIA BUS LINE 10
FROM BUS LINE
FROM A143(9) VIA BUS LINE 15
P2
TLA
A TRIGGER OUT
TL B
B TRIGGER OUT
LEVEL A
S1
R2 1500
+15V
R1 10K
PRESET
(SEE NOTE 3)-15V
TL B
P/O P1 LADVM
R4 10K
C10 .01U
C9 2.2U
R3 430
SCHMITT TRIGGERS
C1 .01U
C8 .01U
-5.2V
R5 510
P/O P2
A GND
CHANNEL A
CHANNEL B
LEVEL B
B GND
TL GND
C6 .01U
C5 2.2U
R7 430
R6 10K
C2 .01U
U1
P/O R12 510
A SLOPE
B SLOPE
+15V
+5V
-5.2V
-15V
P/O P1
L1 1000U
L3 0.75U
L2 1000U
C12,C18 68U (EACH)
C22-C26 .01U (EACH)
C11 68U
C7,13,14,17 .01U (EACH)
LB DVM
A ARM
B ARM
RL6(HC)
Q2
R20 51
R22* 330
R19 51
R18* 330
R15 240
R16 240
U4A
U4B
C19 15U
C20 15U
R23 1500
R24 1500
C21 .01U
U4(1)
SLOPE INVERTERS
R8 360
R9 360
R10 2000
R11 2000
C3 .01U
C4 .01U
U2B
U2C
U3A
U3C
U8A
U8C
R12
A ZWISCHEN
B ZWISCHEN


A ONE SHOT
B ONE SHOT
ECL-TTL
ECL-TTL
PERIOD/TI MULTIPLEXER
START SYNCHRONIZER
STOP SYNCHRONIZER
-5.2V
R18* 330
R15 240
U4B
C20 15U
R24 1500
C21 .01U
P/O R13 510
U3A
U3B
U3C
U3D
R13B 510
U4C
C16* 10P
R14 510
P/O R12 510
P/O R13 510
R12C
U8A
U8B
U8C
U8D
R12D 510
R17 510
U4D
C15* 10P
R21 510
U9D
U9C
U9B
U9A
U10
U5B
U5A
U5D
U5C
U6C
U7B
U6B
U6A
U7A
U6D
PRE
CLR
CLK
NC

Fig

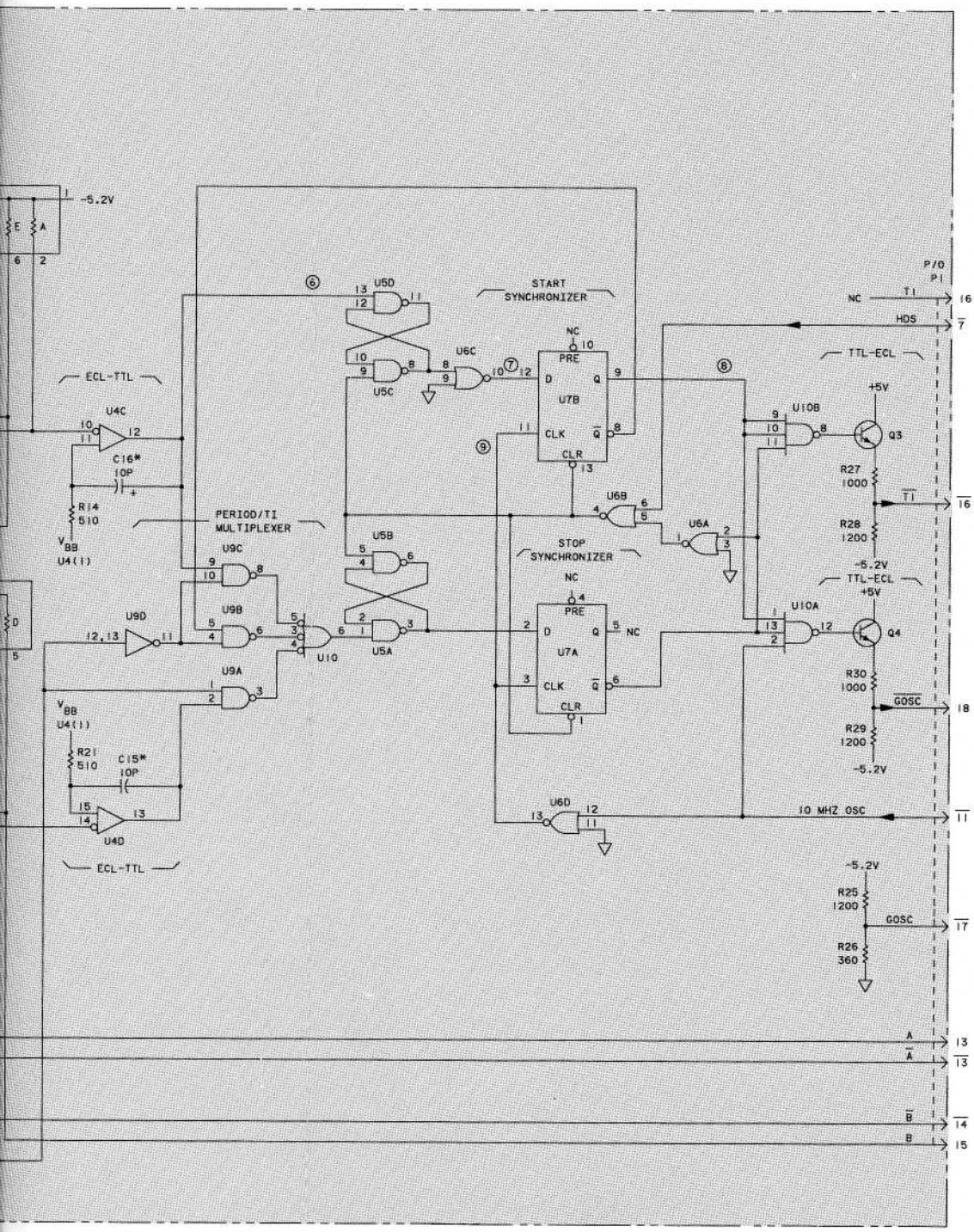


Figure 6–13. Standard A10 Synchronizer Assembly

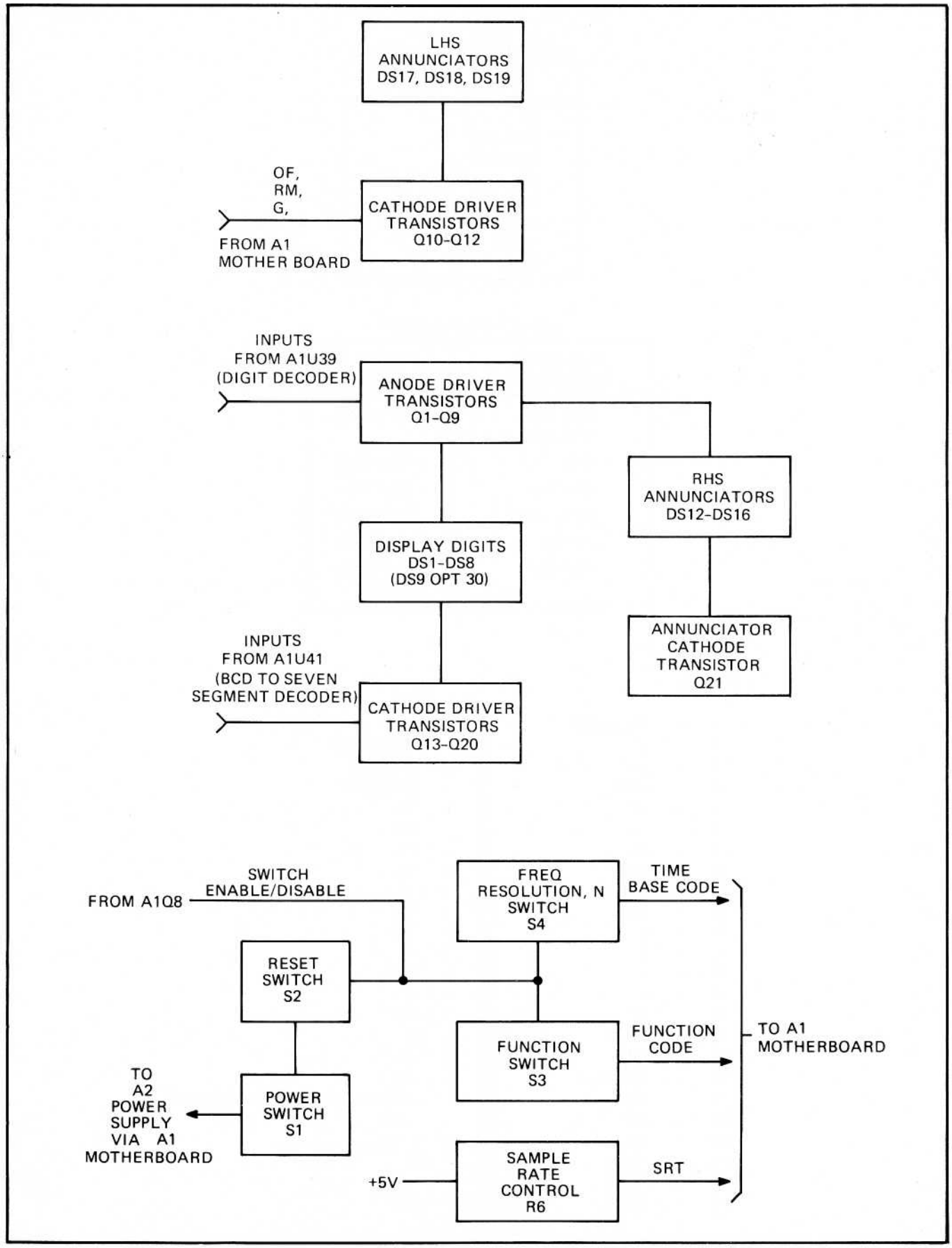


Figure 6-14. A16 Display Assembly Block Diagram

REFERENCE DESIGNATIONS

A16
C1 CR1-CR5 DS1-DS8 DS9 (Option 30 only) DS10-DS19 Q1-Q21 R1-R7 S1-S4

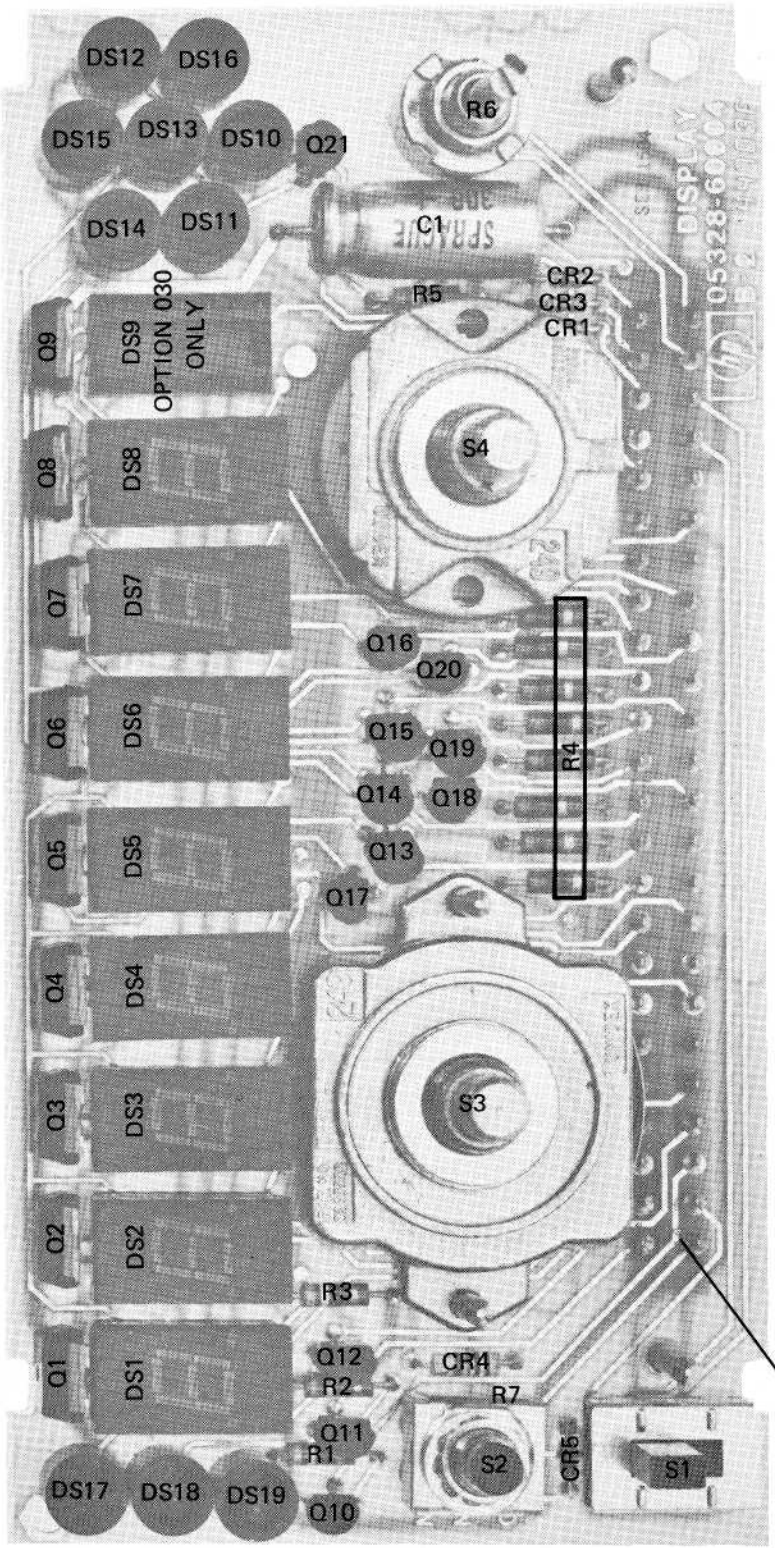
A16 ACTIVE ELEMENTS

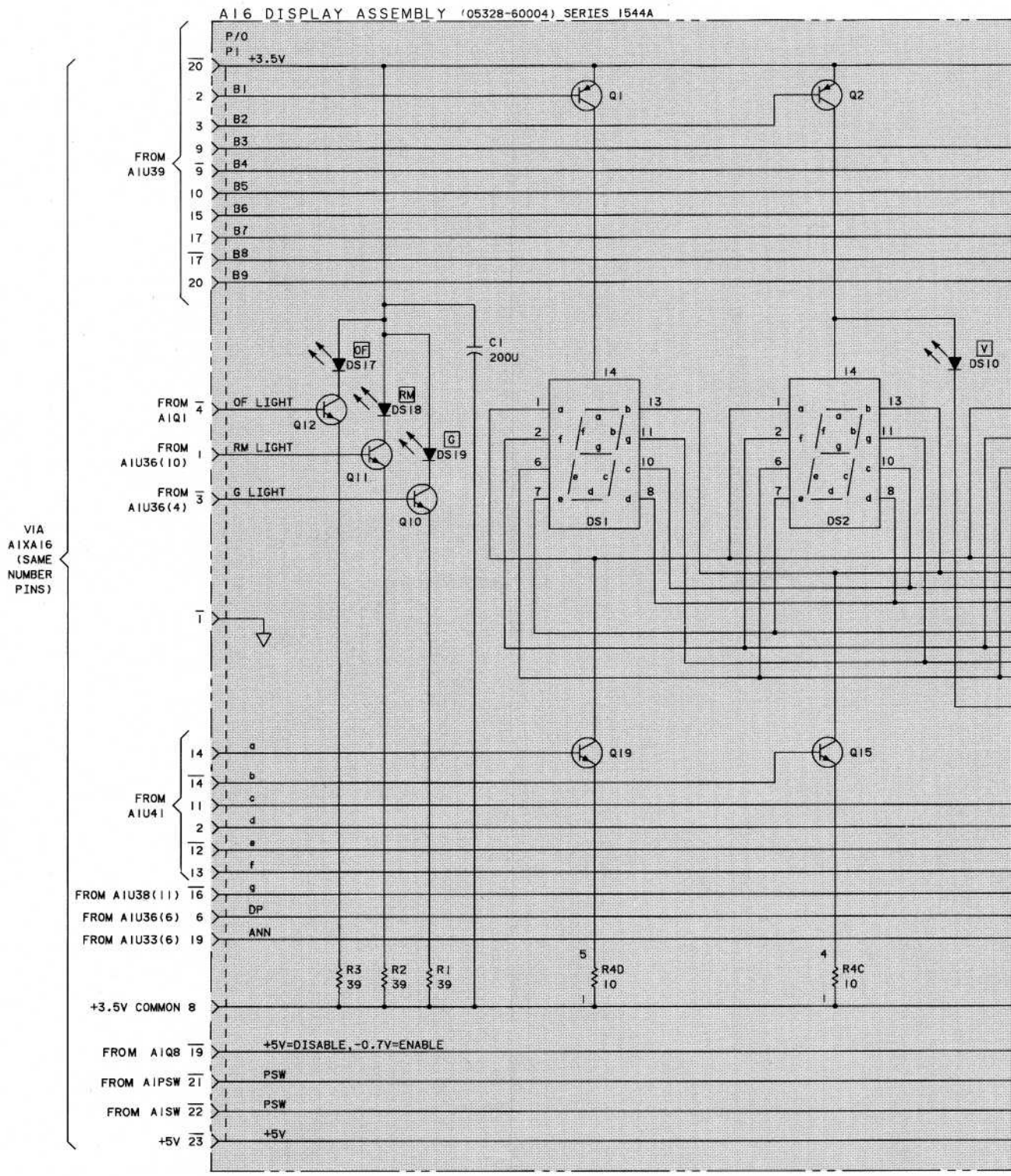
REFERENCE DESIGNATIONS	PART NUMBERS
CR1, CR2, CR3, CR5	1901-0040
CR4	1910-0016
DS1-DS8	1990-0452
DS10-DS19	1990-0406
Q1-Q9	1853-0326
Q10-Q21	1854-0246 2N3643

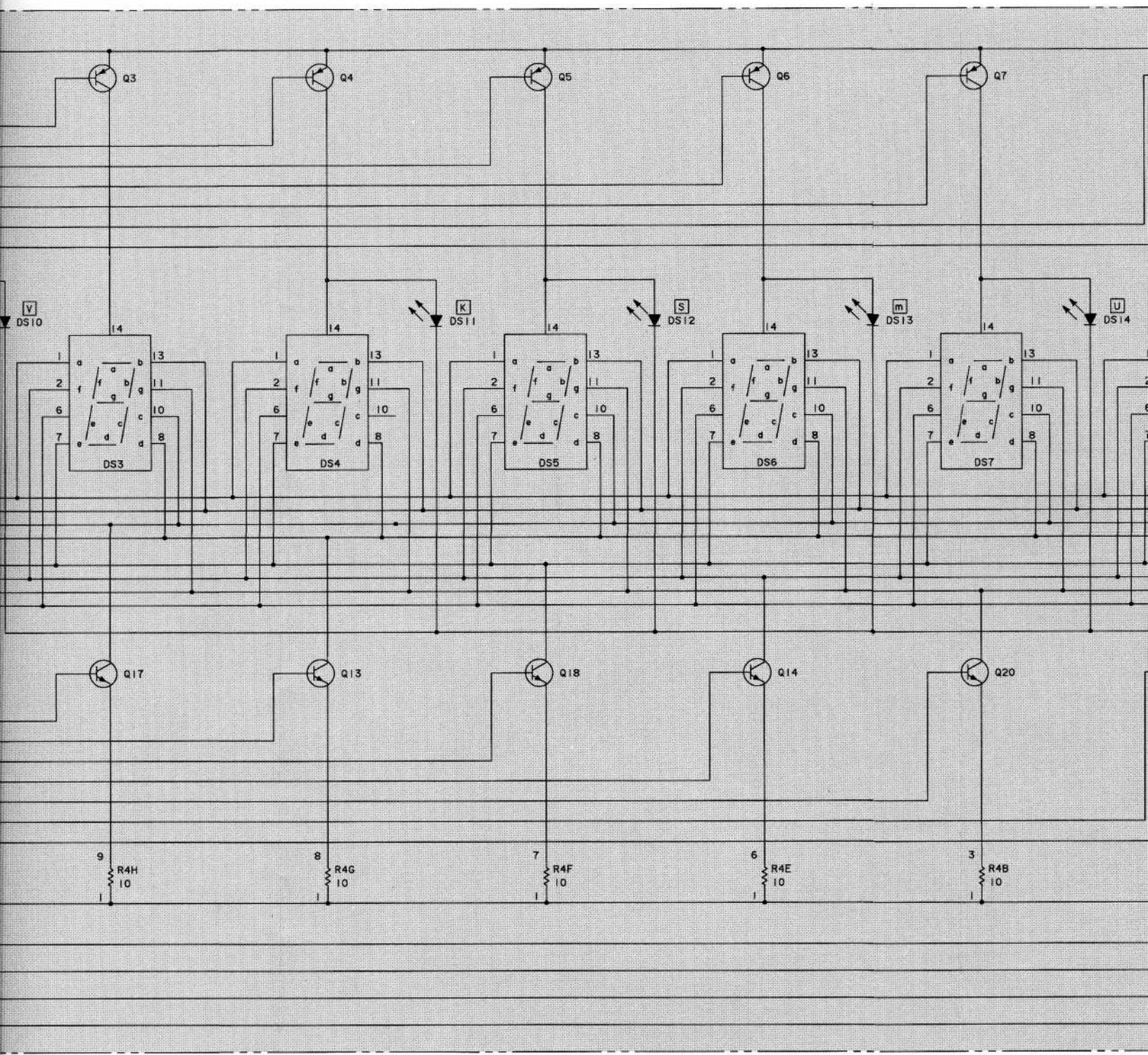
P1 PINS

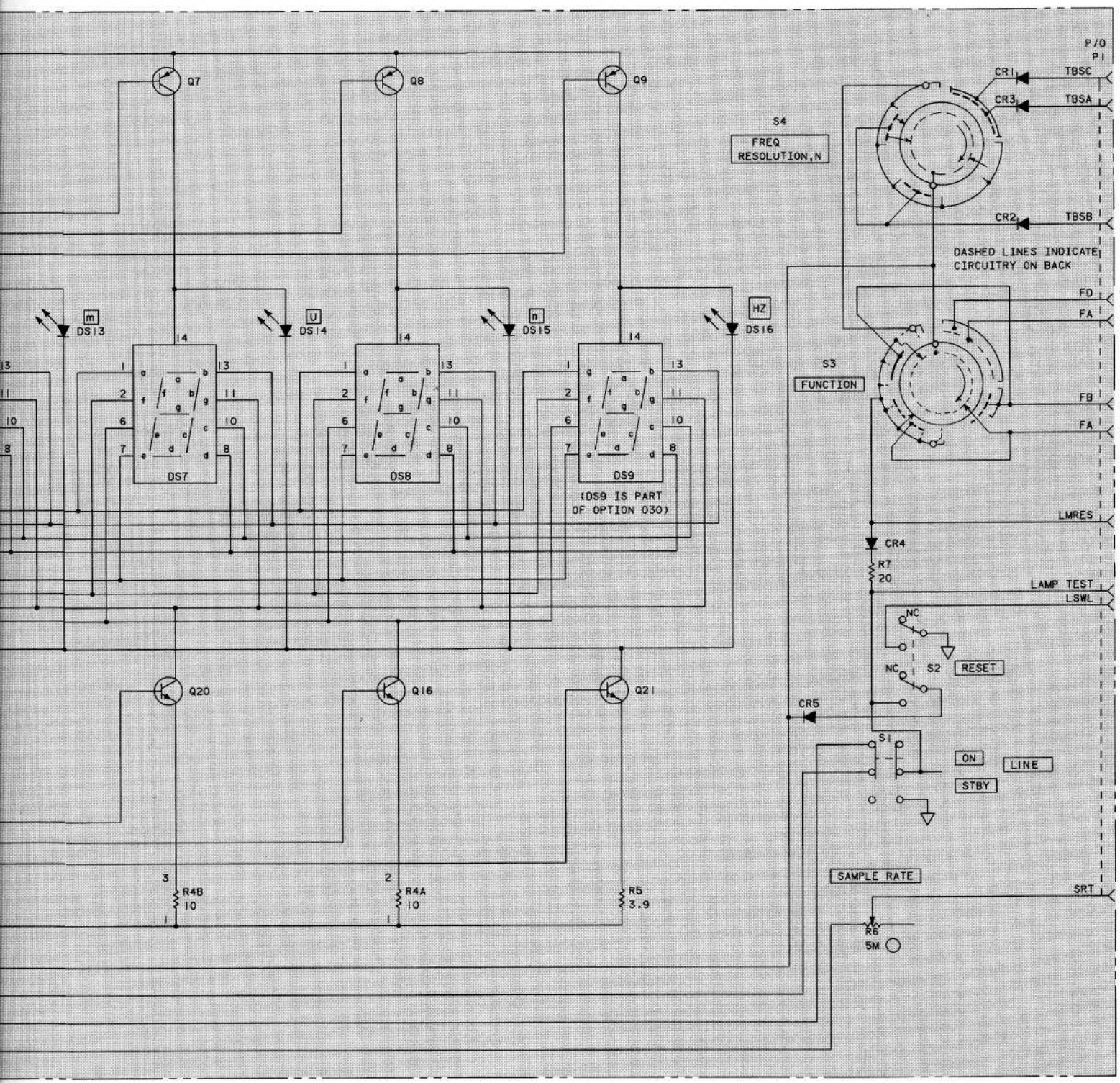
1	–	RM LIGHT	$\overline{1}$	–	GND
2	–	B1	$\overline{2}$	–	LAMP TEST
3	–	B2	$\overline{3}$	–	G LIGHT
4	–	LSWL	$\overline{4}$	–	OF LIGHT
5	–	FC	$\overline{5}$	–	FD
6	–	FA	$\overline{6}$	–	NC
7	–	NC	$\overline{7}$	–	FB
8	–	GND	$\overline{8}$	–	NC
9	–	B3	$\overline{9}$	–	B4
10	–	B5	$\overline{10}$	–	NC
11	–	c	$\overline{11}$	–	NC
12	–	d	$\overline{12}$	–	e
13	–	f	$\overline{13}$	–	NC
14	–	a	$\overline{14}$	–	b
15	–	B6	$\overline{15}$	–	NC
16	–	DP	$\overline{16}$	–	g
17	–	B7	$\overline{17}$	–	B8
18	–	LMRES	$\overline{18}$	–	NC
19	–	ANN	$\overline{19}$	–	+5V = DISABLE, -0.7V = ENABLE
20	–	B9	$\overline{20}$	–	+3.5V
21	–	LSLO NC	$\overline{21}$	–	} POWER SWITCH
22	–	TBS C	$\overline{22}$	–	
23	–	TBS A	$\overline{23}$	–	+5V
24	–	TBS C	$\overline{24}$	–	SRT

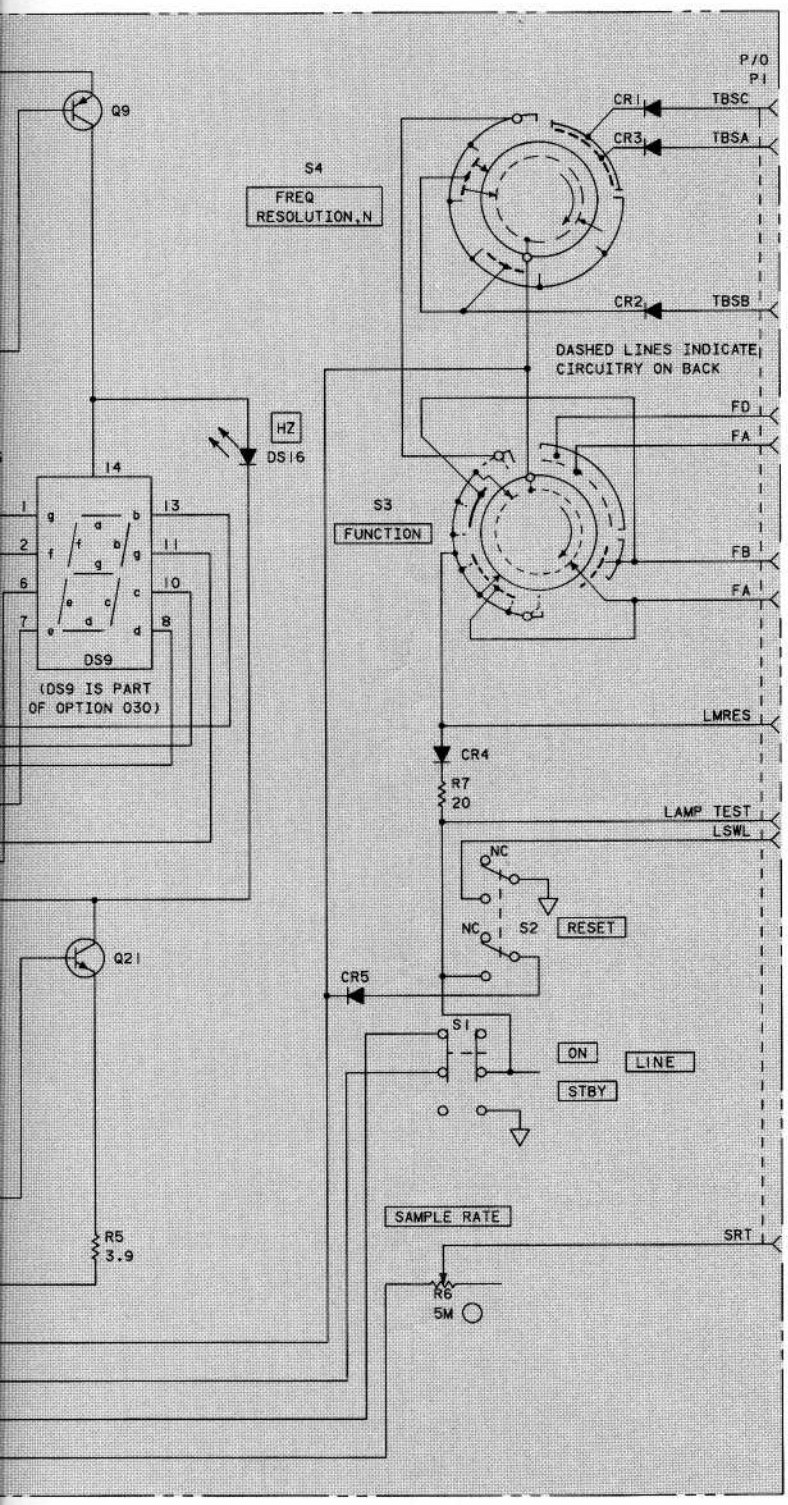
P/O Figure 6-15. A16 Display Assembly


DS12
DS16
DS15
DS13
DS10
Q21
DS14
DS11
R6
C1
R5
CR2
CR3
CR1
DS9
OPTION 030
ONLY
Q9
DS8
Q8
S4
DS7
Q7
Q16
Q20
DS6
Q6
Q15
Q19
R4
Q14
Q18
DS5
Q5
Q13
Q17
DS4
Q4
DS3
Q3
S3
DS2
Q2
R3
DS1
Q1
Q12
CR4
R2
R7
Q11
R1
S2
CR5
S1
DS17
DS18
DS19
Q10
P1
24
24


A16 DISPLAY ASSEMBLY (05328-60004) SERIES 1544A
P/O P1
+3.5V
B1
B2
B3
B4
B5
B6
B7
B8
B9
FROM A1U39
VIA A1XA16 (SAME NUMBER PINS)
Q1
Q2
C1 200U
OF DS17
RM DS18
G DS19
V DS10
FROM A1Q1 OF LIGHT
Q12
FROM A1U36(10) RM LIGHT
Q11
FROM A1U36(4) G LIGHT
Q10
DS1
DS2
a
b
c
d
e
f
g
DP
ANN
FROM A1U41
FROM A1U38(11)
FROM A1U36(6)
FROM A1U33(6)
Q19
Q15
R3 39
R2 39
R1 39
R4D 10
R4C 10
+3.5V COMMON
FROM A1Q8 +5V=DISABLE, -0.7V=ENABLE
FROM A1PSW PSW
FROM A1SW PSW
+5V


Q3
Q4
Q5
Q6
Q7
V
DS10
K
DS11
S
DS12
m
DS13
U
DS14
DS3
DS4
DS5
DS6
DS7
Q17
Q13
Q18
Q14
Q20
R4H
10
R4G
10
R4F
10
R4E
10
R4B
10


Q7
Q8
Q9
m
DS13
U
DS14
n
DS15
HZ
DS16
DS7
DS8
DS9
(DS9 IS PART OF OPTION 030)
Q20
Q16
Q21
R4B 10
R4A 10
R5 3.9
S4
FREQ RESOLUTION, N
S3
FUNCTION
P/O P1
BUS LINE
CR1
CR3
CR2
TBSC
TBSA
TBSB
22 34
23 35
24 35
DASHED LINES INDICATE CIRCUITRY ON BACK
FD
FA
FB
FA
5 36
5 36
7 37
6 37
LMRES
18 TO A
CR4
R7 20
LAMP TEST
LSWL
2 TO A
4
NC
NC
S2
RESET
CR5
S1
ON
STBY
LINE
SAMPLE RATE
SRT
24 A1U4 A1U3
R6 5M



S4 TABLE

	TBS C	TBS B	TBS A	RESOLUTION	
	0	0	0	1MHZ(1)	1US
	0	0	1	1MHZ(10)	10US
	0	1	0	10KHZ(10^2)	100US
	0	1	1	1KHZ(10^3)	1MS
	1	0	0	1KHZ(10^4)	(.015), 10MS
	1	0	1	10HZ(10^5)	(.15) 100MS
	1	1	0	1HZ(10^6)	1S
*	1	1	1	.1HZ(10^7)	10S

* SWITCH S4 SHOWN IN THIS POSITION

S3 TABLE

	FD	FC	FB	FA	FUNCTION
*	1	1	0	0	CHECK
	1	1	1	0	FREQ 'C'
	1	1	1	1	DVM
	0	0	0	1	START A
	0	0	0	0	STOP
	0	1	0	0	FREQ A
	0	1	1	0	PER A
	0	1	1	1	PER AVG A
	1	0	0	1	RATIO B/A
	1	0	0	0	TI A → B
	1	0	1	0	TI AVG A → B
	1	0	1	1	EVENTS C,A → B
	1	1	0	1	RATIO C/A

* SWITCH S3 SHOWN IN THIS POSITION

NOTES

1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN FARADS;
   INDUCTANCE IN HENRIES
3. ASTERISK(*) INDICATES SELECTED COMPONENT, AVERAGE VALUES SHOWN

Figure 6-15. A16 Display Assembly

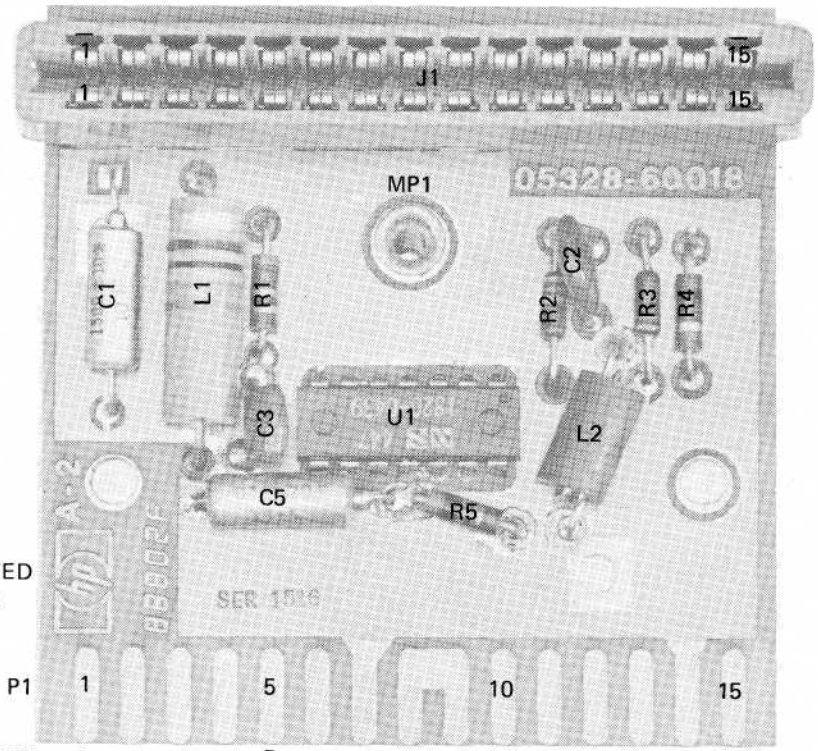
REFERENCE DESIGNATIONS

A3
A1 C1-C5 J1 L1, L2 R1-R5 U1

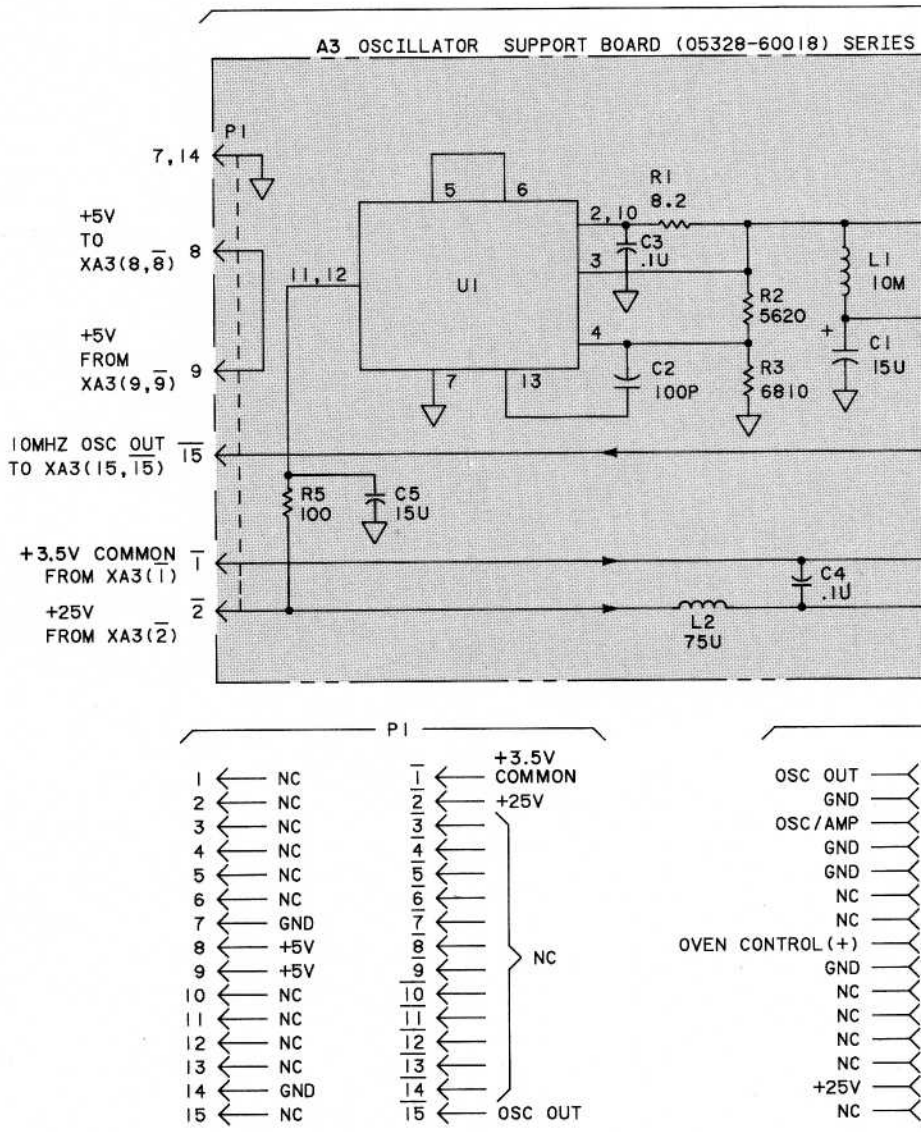
A3 ACTIVE ELEMENTS

REFERENCE DESIGNATIONS	PART NUMBERS
A1	10544A
U1	1820-0439 723PC

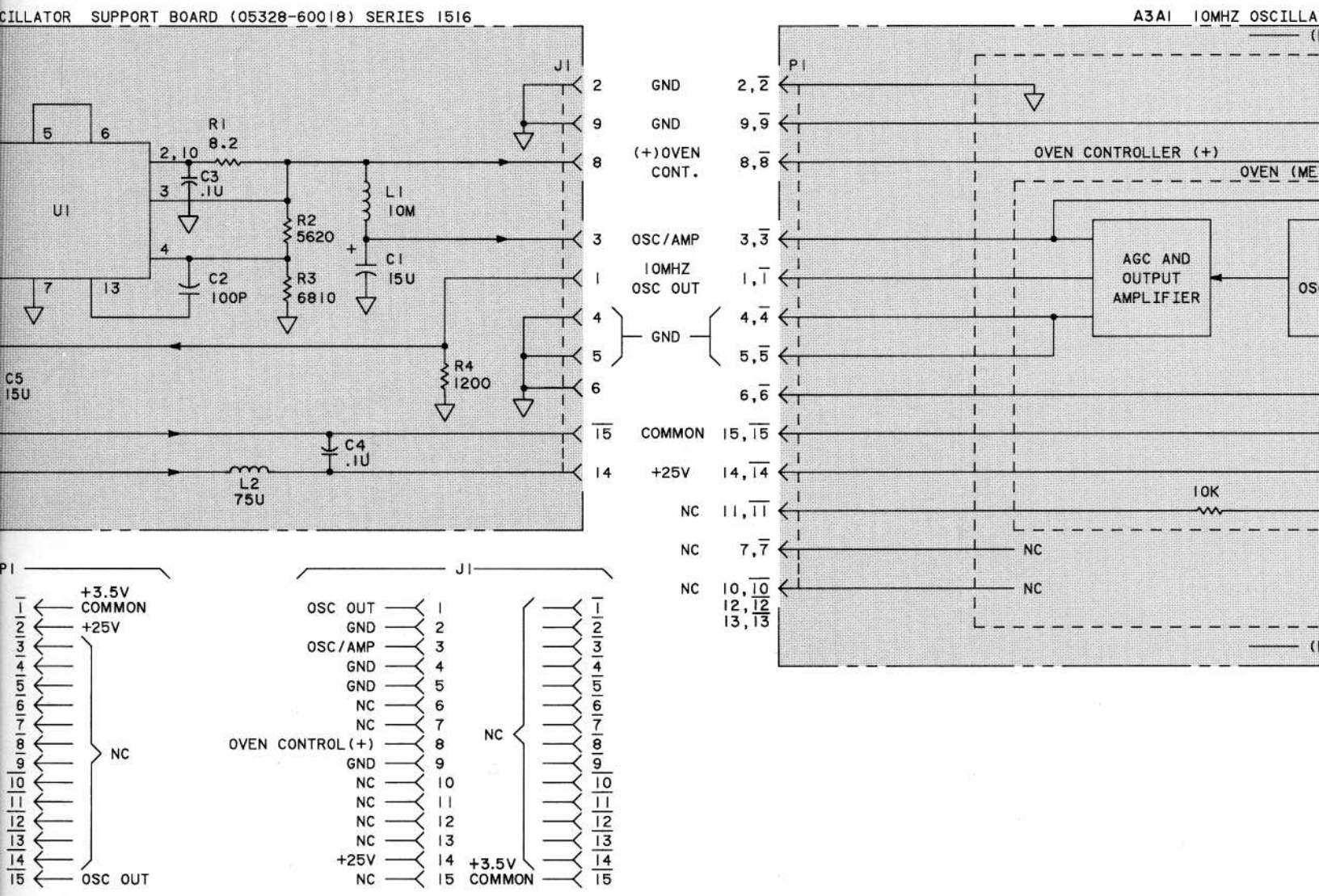
P/O Figure 6-16. Option 010 A3 Oscillator Support Board and 10 MHz Oscillator Assembly

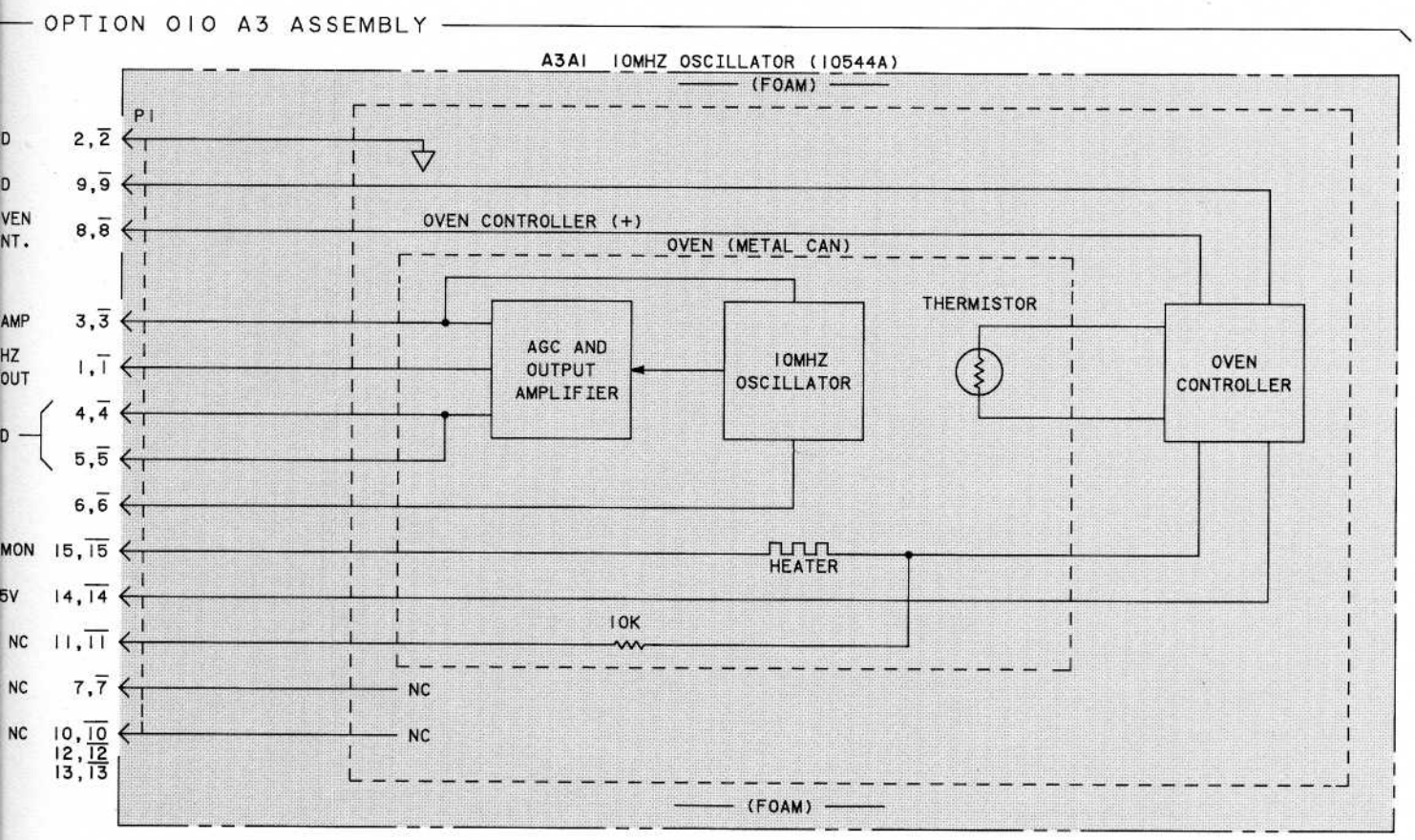

J1
MP1
05328-60018
C1
L1
R1
C2
R2
R3
R4
C3
U1
L2
C5
R5
A3C4 MOUNTED ON REVERSE SIDE
P1
1
5
10
15
COMPONENT SIDE
SOLDER SIDE


10544A
HEWLETT • PACKARD
CRYSTAL OSCILLATOR
HEWLETT PACKARD
+
FREQ. ADJ


A3 OSCILLATOR SUPPORT BOARD (05328-60018) SERIES
P1
7, 14
+5V TO XA3(8, 8) 8
+5V FROM XA3(9, 9) 9
10MHZ OSC OUT TO XA3(15, 15) 15
+3.5V COMMON FROM XA3(1) 1
+25V FROM XA3(2) 2
U1
5
6
11, 12
2, 10
3
4
7
13
R1 8.2
C3 .1U
R2 5620
R3 6810
C2 100P
L1 10M
C1 15U
R5 100
C5 15U
C4 .1U
L2 75U
P1
1 NC
2 NC
3 NC
4 NC
5 NC
6 NC
7 GND
8 +5V
9 +5V
10 NC
11 NC
12 NC
13 NC
14 GND
15 NC
1 +3.5V COMMON
2 +25V
3
4
5
6
7
8
9
10
11
12
13
14
15 OSC OUT
NC
OSC OUT
GND
OSC/AMP
GND
GND
NC
NC
OVEN CONTROL (+)
GND
NC
NC
NC
NC
+25V
NC

OPTION 010 A3 ASSEMBLY

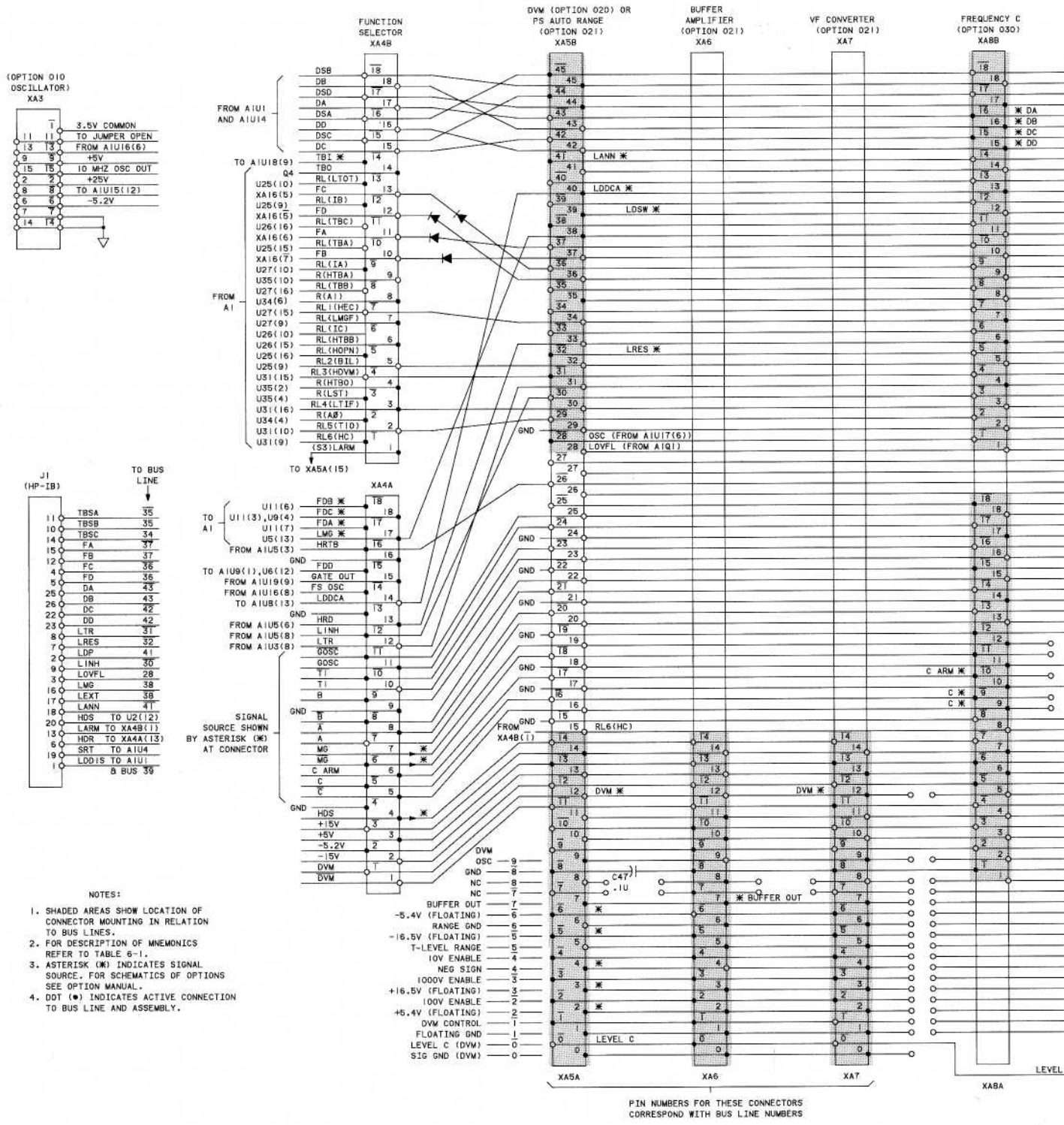




NOTES

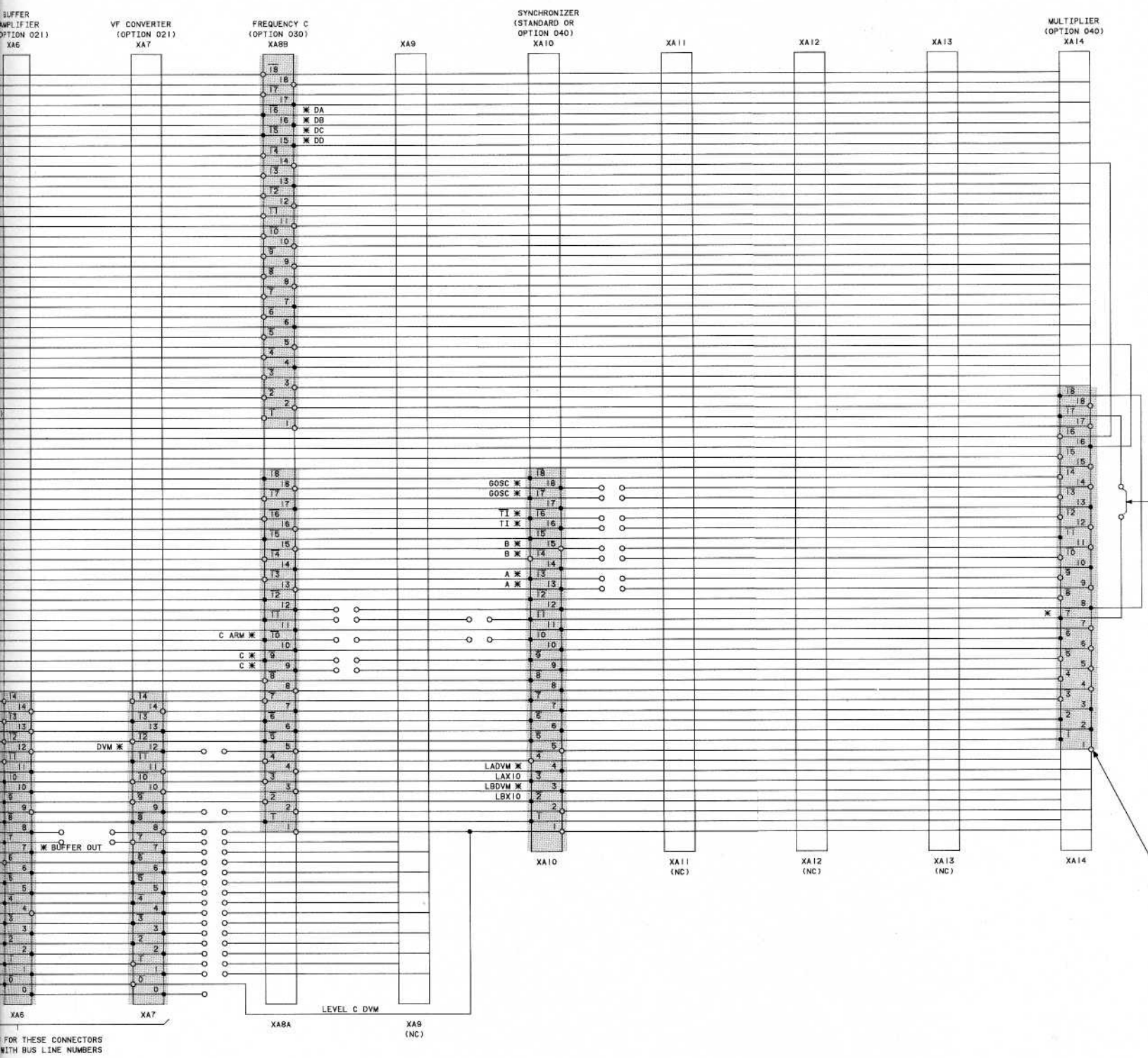
1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN FARADS;
   INDUCTANCE IN HENRIES
3. CAPACITORS C3, C4, C5, RESISTOR R5 AND COIL L2 ARE NOT INSTALLED ON SERIES 1504 BOARDS AND THE FOLLOWING PART VALUES ARE CHANGED: C1 = 100, R2 = 4640, R4 = 2000.

Figure 6-16. Option 010 A3 Oscillator Support Board and 10 MHz Oscillator Assembly



NOTES:

1. SHADED AREAS SHOW LOCATION OF CONNECTOR MOUNTING IN RELATION TO BUS LINES.
2. FOR DESCRIPTION OF MNEMONICS REFER TO TABLE 6-1.
3. ASTERISK (*) INDICATES SIGNAL SOURCE. FOR SCHEMATICS OF OPTIONS SEE OPTION MANUAL.
4. DOT (•) INDICATES ACTIVE CONNECTION TO BUS LINE AND ASSEMBLY.


BUFFER AMPLIFIER (OPTION 021) XA6
VF CONVERTER (OPTION 021) XA7
FREQUENCY C (OPTION 030) XA8B
XA9
SYNCHRONIZER (STANDARD OR OPTION 040) XA10
XA11
XA12
XA13
MULTIPLIER (OPTION 040) XA14
✱ DA
✱ DB
✱ DC
✱ DD
GOSC ✱
GOSC ✱
TI ✱
TI ✱
B ✱
B ✱
A ✱
A ✱
C ARM ✱
C ✱
C ✱
DVM ✱
✱ BUFFER OUT
LADVM ✱
LAX10
LBDVM ✱
LBX10
LEVEL C DVM
XA10
XA11 (NC)
XA12 (NC)
XA13 (NC)
XA14
XA6
XA7
XA8A
XA9 (NC)
FOR THESE CONNECTORS WITH BUS LINE NUMBERS

Figure

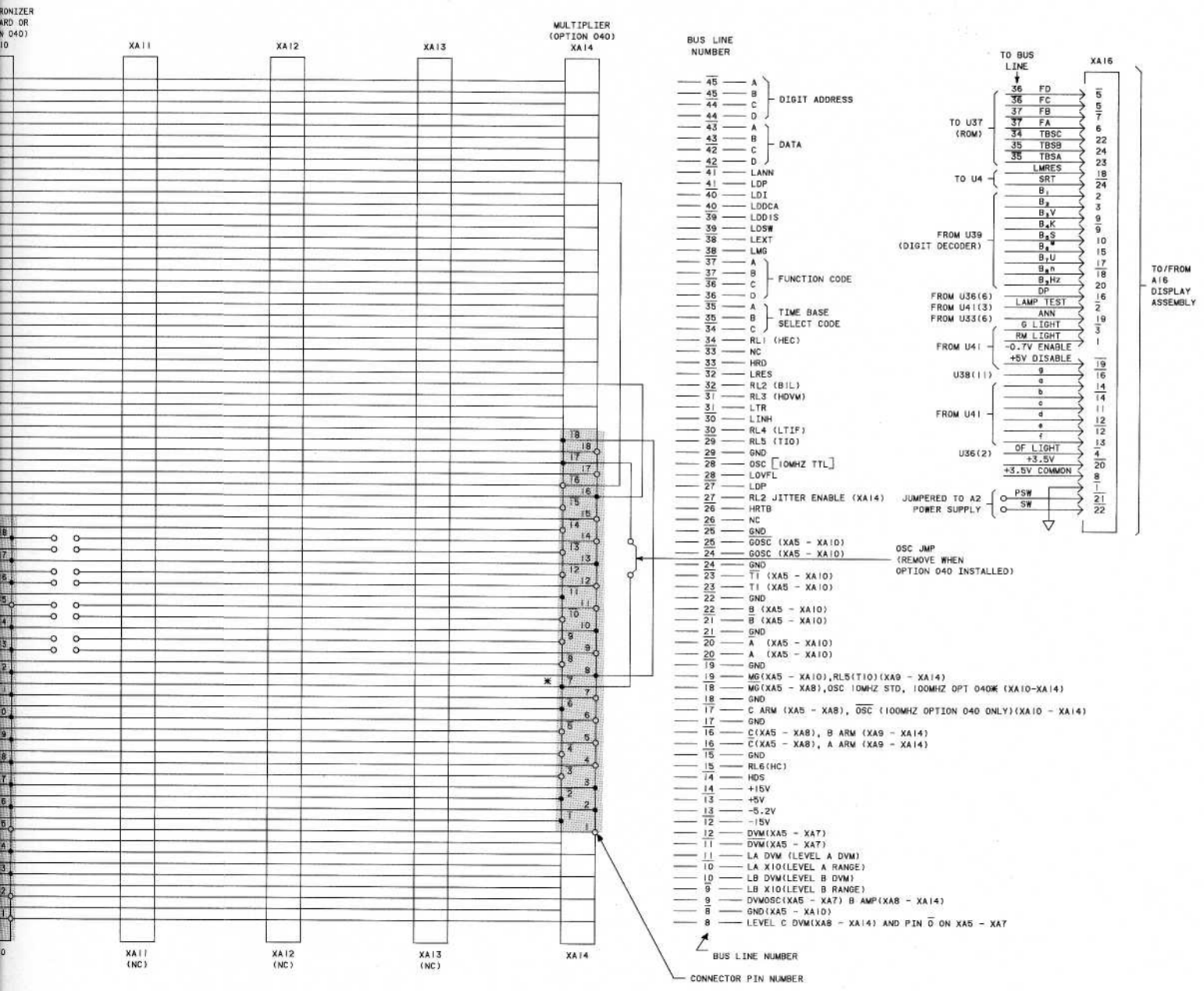


Figure 6–17. A1 Motherboard Interconnection Diagram