



**Operating and  
Programming Manual**

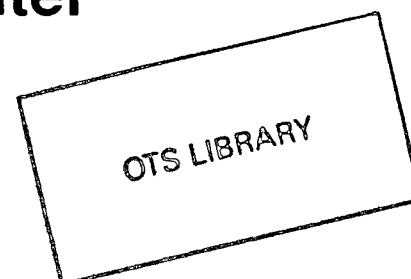
**HP 5386A  
Frequency Counter**

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2093

# OPERATING AND SERVICE MANUAL

## HP 5386A Frequency Counter



**Serial Prefix: 3206A**

This manual applies to Serial Prefix 3206A, unless accompanied by a Manual Change Sheet indicating otherwise.

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5301 STEVENS CREEK BOULEVARD, SANTA CLARA, CALIFORNIA 95052-8059

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## CERTIFICATION

*Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (formerly National Bureau of Standards), to the extent allowed by that organization's calibration facility, and to the calibration facilities of other International Standards Organization members.*

## WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

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## ASSISTANCE

*Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.*

*For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.*

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## SAFETY CONSIDERATIONS

### GENERAL

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

This product is a Safety Class I instrument (provided with a protective earth terminal).

### BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed. Refer to Section II, Installation.

### SAFETY EARTH GROUND

An uninterruptible safety earth ground must be provided from the mains power source to the product input wiring terminals or supplied power cable.

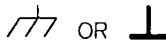
### SAFETY SYMBOLS



Instruction manual symbol; the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual.



Indicates hazardous voltages.



Indicates terminal is connected to chassis when such connection is not apparent.



Alternating current.



Direct current.

#### WARNING

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

#### CAUTION

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

## SAFETY INFORMATION

#### WARNING

Any interruption of the protective grounding conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection.)

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

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

Instructions for adjustments while covers are removed and for servicing are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform such adjustments or servicing unless qualified to do so.

For continued protection against fire, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay). Do not use repaired fuses or short circuited fuseholders.

When measuring power line signals, be extremely careful and always use a step-down isolation transformer whose output voltage is compatible with the input measurement capabilities of this product. This product's front and rear panels are typically at earth ground, so **NEVER TRY TO MEASURE AC POWER LINE SIGNALS WITHOUT AN ISOLATION TRANSFORMER.**

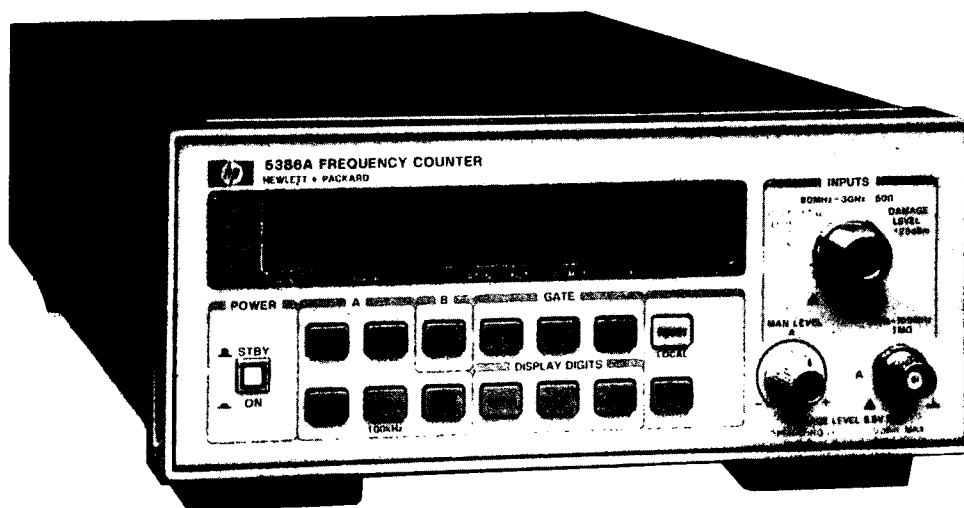
#### ACOUSTIC NOISE EMISSION:

LpA <40 dB; no fans installed.

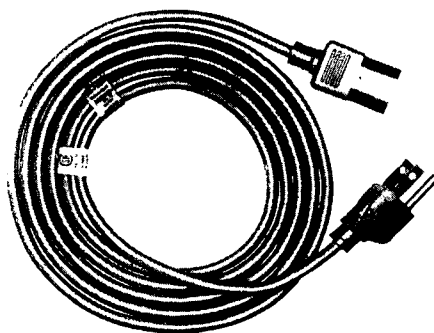
#### GERAeUSCHEMISSION:

LpA <40 dB: Kein Ventilator eingebaut.





Model HP 5386A



POWER CORD  
PART NO. 8120-1378

Figure 1-1. Model HP 5386A Frequency Counter and Accessories

## SECTION I GENERAL INFORMATION

### 1-1. INTRODUCTION

1-2. This manual provides you with information pertaining to the installation, operating, programming, performance tests, adjustments, and maintenance of the Hewlett-Packard Model 5386A Frequency Counter, shown in *Figure 1-1*.

### 1-3. MANUAL SUMMARY

1-4. The manual is divided into eight sections, each covering a particular topic for the operation of the HP 5386A Frequency Counter. The topics by section number are:

Section	Topic
I	General Information
II	Installation
III	Operation and Programming
IV	Performance Tests
V	Adjustments
VI	Replaceable Parts
VII	Manual Changes
VIII	Service

### 1-5. SPECIFICATIONS

1-6. The instrument specifications and option specifications are listed in *Table 1-1*. These specifications are performance standards or limits against which the instrument may be tested.

### 1-7. SAFETY CONSIDERATIONS

1-8. This is a Safety Class I instrument. This instrument has been designed and tested according to international safety requirements.

1-9. This manual contains information, cautions, and warnings which must be followed by operating and service personnel to ensure safe operation and to retain the instrument in safe condition.

### 1-10. DESCRIPTION

1-11. The Hewlett-Packard Model 5386A is a frequency counter that makes frequency and period measurements. The HP 5386A has a frequency range of 10 Hz to 3 GHz. The counter is a microcomputer based instrument with a data bus port for remote operation through HP-IB.

1-12. Channel "A" has a female BNC type connector. Channel "B" has a female N type connector.

1-13. To the left of the "A" channel input connector is a control that allows you to set the trigger level of Channel A.

1-14. A 100 kHz low pass filter can be toggled in or out of the Channel A signal path.

1-15. Measurement display and mode annunciators are shown on a 12-character alphanumeric liquid crystal display (LCD). Frequency and period measurements are displayed in engineering format, with three alpha characters used to designate units, e.g., MHz. The display will also give you brief messages and diagnostic prompts.

1-16. The HP 5386A is designed so it may either be rack mounted or stacked.

1-17. A 10 MHz reference oscillator output is included. The connector for the 10 MHz output may also be used as an external 10 MHz reference oscillator input connection.

1-18. Option 004 is an ovenized oscillator that provides a high stability time base giving substantially higher accuracy over variations in time and temperature.

1-19. HP-IB is the Hewlett-Packard Interface Bus for remote control of the counters by computers and controllers. It is a standard feature in the instrument.

1-20. The HP-IB, (Hewlett-Packard Interface Bus) is Hewlett-Packard's implementation of IEEE Standard 488-1978 and ANSI Standard MC 1.1. HP-IB is a high-speed parallel interface bus. All devices on the bus are capable of being addressed at one time. However, only one device may respond at a time. A controller is used to command which device responds. (The HP 5386A would make measurements and return data upon commands from a controller.)

1-21. HP-IB allows the HP 5386A to output data to other devices or, on a more complex level, respond to remote programming instructions to make a specific type of measurement, trigger that measurement, then read the result and send the reading back to the controller, or to another device on the interface.

## 1-22. OPTION 004

1-23. Option 004 is an ovenized oscillator that gives the HP 5386A increased accuracy by providing a more stable time base reference signal. The oven maintains the crystal at a constant elevated temperature for increased stability over the ambient temperature range.

## 1-24. INSTRUMENT IDENTIFICATION

1-25. Hewlett-Packard instruments have a 2-section, 10-character serial number (0000A00000), which is located on the rear panel. The four-digit serial prefix identifies the 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 Support Office listed at the back of this manual. Instruments having a lower serial prefix than that listed on the title page are covered in Section VII.

## 1-25. ACCESSORIES

1-26. The accessory supplied is a detachable power cord 229 cm long (7½ feet), part number 8120-1378.

1-27. Side Handle Kit: 5061-0088

1-28. Rack Mount Kits:

Single: HP Part Number 5061-0072

Dual: HP Part Number 5061-0074

and HP Part Number 5061-0094

## 1-29. RECOMMENDED TEST EQUIPMENT

1-30. The test equipment listed in *Table 1-2* is recommended for use during performance tests, adjustments, and troubleshooting. Substitute test equipment may be used if it meets the required characteristics listed in the table.

Table 1-1. Model HP 5386A Specifications

## HP 5386A INPUT CHARACTERISTICS

### CHANNEL A

**Range:** 10 Hz to 100 MHz

**Sensitivity:** [MAN LEVEL] off

15 mVrms sine wave 10 Hz to 100 MHz  
45 mV pk-pk 5 ns minimum pulse width

**Dynamic Range:** 45 mV to 4 V pk-pk × attenuator setting.

**Coupling:** AC

**Impedance:**

X1: 1 MΩ NOMINAL || <25 pF

X20: 500 kΩ NOMINAL || <25 pF

**Attenuator:** X1 or X20 NOMINAL, X20 increases to X40 below 50 Hz.

**Low Pass Filter:** 100 kHz NOMINAL 3 dB point

**Trigger Level:**

[MAN LEVEL] ON: variable from -0.1 V to +0.1 V × attenuator setting about average signal value.

[MAN LEVEL] OFF: automatically set to average value of signal.

**Damage Level:**

X1:

10 - 200 Hz 350 V (DC + AC peak)  
0.2 - 420 kHz 170 V (DC + AC peak)  
0.42 - 10 MHz (5 × 10<sup>7</sup> Vrms Hz)/FREQ  
>10 MHz 5 Vrms

X20:

<1 MHz, same as X1  
>1 MHz, 50 Vrms

### CHANNEL B

**Range:** 90 MHz to 3 GHz, prescaled.

**Sensitivity:** 15 mVrms (-23.5 dBm)

**Dynamic Range:** 10 mV to .5 Vrms (-27 dBm to +7 dBm)

**Coupling:** AC

**Impedance:** 50 Ω NOMINAL

VSWR <2.5:1 TYPICAL

Note: Manual level not active for Channel B.

**Damage Level:**

AC > 4V (+25 dBm)  
DC ± 5V

### FREQUENCY A and B

**Range Channel A:** 10 Hz - 100 MHz

**Range Channel B:** 90 MHz - 3 GHz, prescaled.

**LSD Displayed:** 10 Hz to 1 nHz

**LSD:**  $\frac{4 \text{ nsec}}{\text{Gate Time}} \times \text{FREQ}$ , rounded to nearest decade

**Resolution:** ± 1 LSD

$\pm \frac{(1.4 \times \text{Trigger Error} + 1 \text{ nsec rms})}{\text{Gate Time}} \times \text{FREQ}$

**Accuracy:** ± Resolution ± Time Base  
Error × Frequency

### PERIOD A

**Range:** 10 ns to .1 sec

**LSD Displayed:** .001 fs to 10 ns

**LSD:**  $\frac{4 \text{ nsec}}{\text{Gate Time}} \times \text{period}$ , rounded to nearest decade

**Resolution:** ± 1 LSD

$\pm \frac{(1.4 \times \text{Trigger Error} + 1 \text{ nsec rms})}{\text{Gate Time}} \times \text{period}$

**Accuracy:** ± Resolution ± Time Base  
Error × Period

### TIMEBASE (TCXO)

**Frequency:** 10 MHz

**Aging Rate:** <1 × 10<sup>-7</sup>/month

**Temperature:** <2 × 10<sup>-6</sup>, 0-40°C  
(±1 × 10<sup>-6</sup>, 0-40°C if referenced to 25°C, and set to the offset frequency.) (See AN 200-2).

**Line Voltage:** <5 × 10<sup>-8</sup> for ±10% variation.

### OPTION 004, OVEN TIMEBASE

**Frequency:** 10 MHz

**Aging Rate:** <3 × 10<sup>-8</sup>/month, after 30 days of continuous operation.

**Temperature:** ±1 × 10<sup>-7</sup>, 0-50°C  
referenced to 25°C.

**Line Voltage:** <2 × 10<sup>-9</sup> for ±10% variation

### HEWLETT-PACKARD INTERFACE BUS

**Programmable Functions:** Frequency A, Frequency B, Period A.

**Programmable Controls:** X20 Attn A, FILTER A, MAN LEVEL A, Gate Time.

**Display:** Normal, Increment, Decrement, (number of digits displayed); any 12 character message can be displayed on the LCD via a system controller.

**Misc. Functions & Operating Commands:** Diagnostics, 10 MHz Check, reset, initialize, Wait to send ON/OFF, Device ID.

**Interface Functions:** Device Clear, Group Execute Trigger, Interface Clear, Local, Local Lockout, Send Status, Remote, Service Request, SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PPO, DC1, DT1, C0, E1.

**Data Output:**

Output will be maximum resolution for the gate time selected and is not affected by the front panel Display Digits keys.

**Format:** 17 characters plus CR and LF (blanks may be inserted).

**Rate:** 4 readings/sec maximum at .1 sec gate

**Talk only:** Set with address switch=31

### GENERAL

**Check:** 10 MHz Self-test

**Gate Times:** 0.1, 1, or 10 seconds NOMINAL  
Accuracy: ± 15% + up to 1 period of input signal

**Display:** 12-digit alphanumeric liquid crystal

**Display Digits (variable):** Frequency, 3 to 11;  
Period, 3 to 8

**Timebase Output:** 10 MHz 25 mV pk-pk  
NOMINAL into 50 Ω load.

**External Timebase Input:** 10 MHz, .5 Vrms  
into 500 Ω; 15 V (DC+AC pk) maximum.

**Operating Temperature:** 0°C to 50°C

**Power Requirements:**

**AC Operation:** Selectable, 30 VA maximum  
115V + 10%, -25%: 48-66 Hz  
230V + 10%, -15%: 48-66 Hz  
115V + 10%, -10%: 380-420 Hz

**Weight:** Net, 3.4 kg (7 lbs. 8 oz.) Shipping 5.3 kg  
(11 lbs. 9 oz.)

**Dimensions:** 212.3 mmW × 88.1 mmH × 421.6 mmD  
(8 1/3 × 3 1/2 × 16 1/2 in.)

Table 1-1. Model HP 5386A Specifications (Continued)

### Definitions

**Measurement Gate Time:** selected value  $\pm 15\%$  + up to 1 period of input.

**Dynamic Range:** Minimum to maximum input voltage swing allowed for correct frequency counting.

**LSD Displayed:** dependent on gate time, input signal, and DISPLAY DIGITS control. In NORM mode, 8 digit are displayed. Using the display control, up to 11 digits may be present for frequency measurements, 8 digits maximum for period.

**LSD:** unit value of least significant digit rounded to the nearest decade, i.e. 4 Hz becomes 1 Hz, 6 Hz becomes 10 Hz.

**Trigger Error:**

**Channel A:**

$$\frac{\sqrt{(e_i)^2 + (e_n)^2}}{\text{Input slew rate at trigger point}} \quad \text{sec rms,}$$

where  $e_i$  and  $e_n$  are input noise voltages (rms) for the counter and signal, respectively, for a 100 MHz bandwidth.

$$e_i \leq 100 \mu\text{Vrms}$$

**Channel B:** negligible due to high signal slew rate at the trigger point.

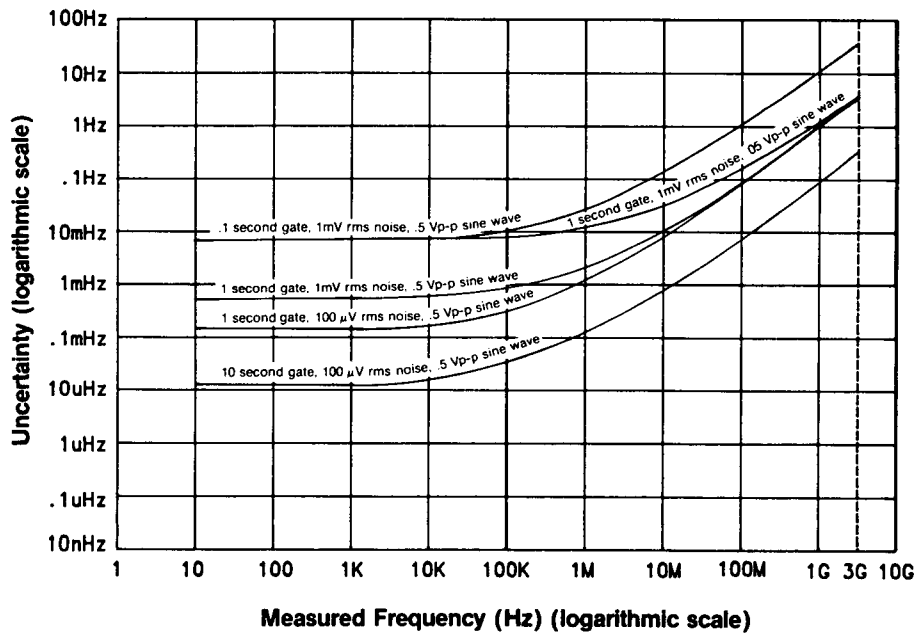


Figure 1. Uncertainties in frequency measurements result from noise on the input signal (trigger error). These uncertainties can be reduced by increasing the gate time, reducing the noise on the input signal, and increasing the input signal amplitude (increasing the slew rate).

Table 1-1. Model HP 5386A Specifications (Continued)

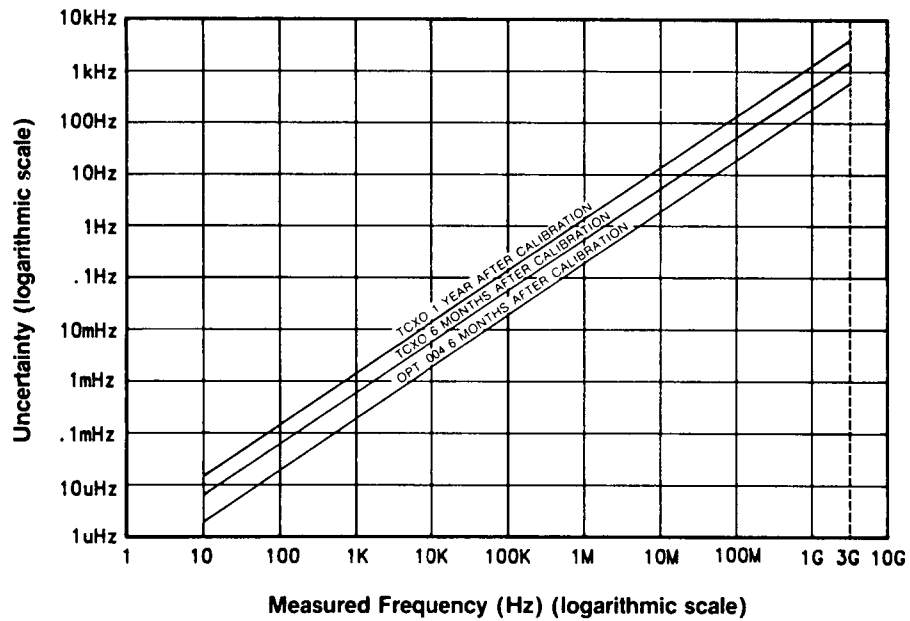


Figure 2. Aging of the counter timebase will contribute to the uncertainty of a frequency measurement. This uncertainty can be reduced by calibrating the timebase more frequently, or using a timebase with a better aging rate.

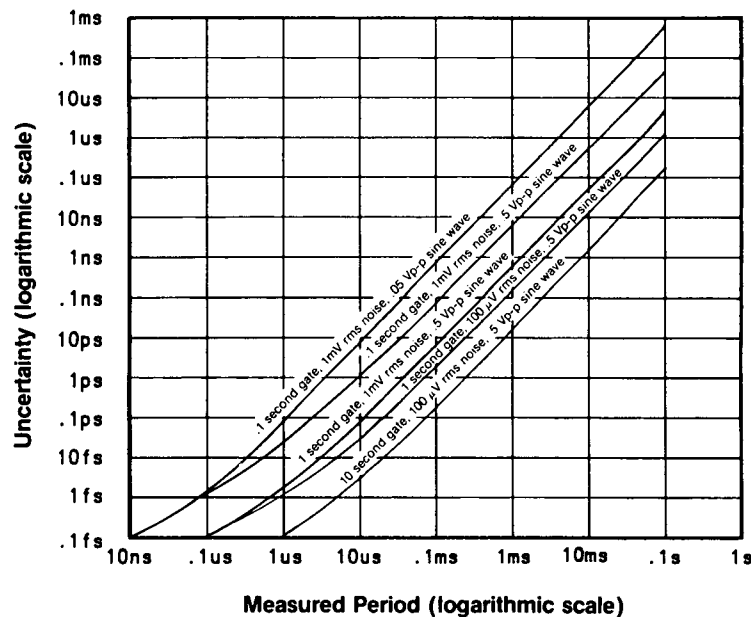


Figure 3. Uncertainties in period measurements result from noise on the input signal (trigger error). These uncertainties can be reduced by increasing the gate time, reducing the noise on the input signal, and increasing the input signal amplitude (increasing the slew rate).

Table 1-1. Model HP 5386A Specifications (Continued)

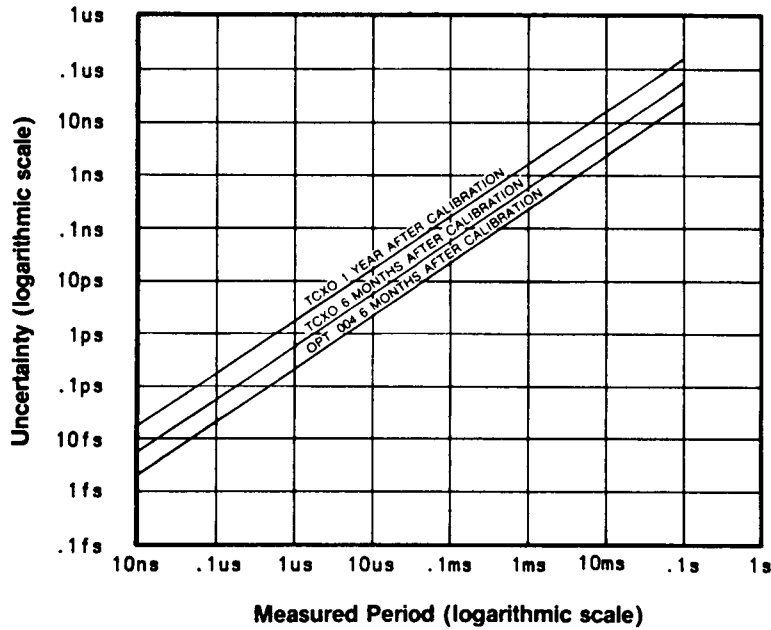


Figure 4. Aging of the counter timebase will contribute to the uncertainty of a period measurement. This uncertainty can be reduced by calibrating more frequently, or using a timebase with a better aging rate.

Table 1-2. Recommended Test Equipment

Instrument	Critical specifications	Recommended Model	Use
50 Ohm Feedthrough	BNC Type	HP 10100C	P,A,T
Tee Connector	BNC Type	HP 1250-0781	P,A,T
Cables	BNC 50 ohm	HP 11170C	P,A,T
Oscilloscope	100 MHz Bandwidth	HP 1740A	A,T
Synthesized Sweeper	10 MHz-26.5 GHz	HP 8340A/41A	P
Signal Generator	50-225 MHz	HP 8656A	P,A,T,
Signal Generator	90-1000 MHz	HP 804A	P,T
Synthesized Function Generator	10 Hz to 20 MHz	HP 3325A	P,A,T
DC Voltmeter	20V Range, 0.05V resolution	HP 3465	A,T
Power Splitter	90 MHz-1 GHz Cal. output	HP 11667A	A,T
Power Meter/Sensor	90 MHz-1 GHz, -9 to -24 dBm	HP 436A/8481A	P
10 dB Attenuator		HP 8491A	P
Adapter, Coaxial (2 required)	Type N(male)-to-BNC(female)	1250-07680	P
Adapter, Coaxial	Type N(male)-to-BNC(male)	1250-0082	P
Controller	HP-IB Compatible	HP-85F*	
Resistor	10Ω 20W	0811-1655	A

\*HP-85F consists of the following:

- Controller ..... HP-85A
- I/O ROM ..... 00085-15003
- ROM Drawer ..... HP 82936A
- HP-IB Interface Card/Cable ..... HP 82937A

## SECTION II INSTALLATION

### 2-1. INTRODUCTION

2-2. This section contains information for unpacking, inspection, storage, and installation.

### 2-3. UNPACKING AND INSPECTION

2-4. If the shipping carton is damaged, inspect the instrument for visible damage (scratches, dents, etc.). If the instrument is damaged, notify the carrier and the nearest Hewlett-Packard Sales and Service Office immediately (offices are listed at the back of this manual). Keep the shipping and packing material for the carrier's inspection. The Hewlett-Packard Sales and Service Office will arrange for repair or replacement of your instrument without waiting for the claim against the carrier to be settled.

### 2-5. PREPARATION FOR USE

#### CAUTION

Before connecting the instrument to ac power lines, be sure that the voltage selector is properly positioned as described below.

### 2-6. POWER REQUIREMENTS

2-7. The counter has the following ac power requirements:

- 115V, +10%, -25%, 48-66 Hz single phase
- 230V, +10%, -15%, 48-66 Hz single phase
- 115V, +10%, -10%, 380-420 Hz single phase

### 2-8. LINE VOLTAGE SELECTION

2-9. The power line voltage is selected by the position of the LINE SELECT switch on the rear panel. Sliding the switch to the left selects 115V operation, sliding the switch to the right selects 230V operation. The voltages available are printed on the switch. The specific voltage selected will be visible on the LINE SELECT switch, as shown in *Figure 2-1*. Before applying power, verify that the LINE SELECT switch is properly set for the desired ac supply voltage and that the correct fuse is installed.

### 2-10. AC Line Fuse Selection

2-11. The ac line fuse is accessible from the outside of the cabinet. To replace the ac fuse use a small, flat-

blade screwdriver to remove the fuse from the fuseholder. The correct fuse value is 250 mA/250V Slow Blow for 115V operation. For 230V operation, use 125 mA/250V Slow Blow.

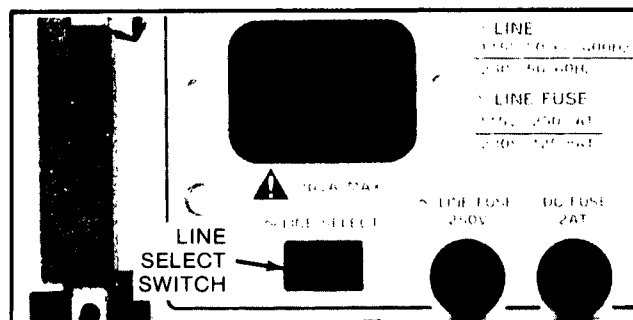


Figure 2-1. Line Voltage Selection

### 2-12. DC Fuse Selection

2-13. To replace the dc fuse use a small flat-bladed screwdriver to remove the fuse from the fuseholder. Press in slightly and turn counterclockwise, until the fuse carrier springs free. Replace the fuse in the fuse carrier and reinstall by inserting and turning clockwise. Be sure to install the correct fuse value; 2 AT Slow Blow.

2-14. The dc fuse is the main protective device for the instrument.

### 2-15. Power Cable

2-16. The counter is shipped with a three-wire power cable. When the cable is connected to an appropriate ac power source, this cable connects the instrument chassis to earth ground. The type of power cable plug shipped with each instrument depends on the country of destination. Refer to *Figure 2-2* for the part numbers of the power cable and plug configurations available.

#### WARNING

**BEFORE ENERGIZING THIS INSTRUMENT, THE PROTECTIVE EARTH TERMINAL 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 EARTH (GROUNDING) CONDUCTOR.**



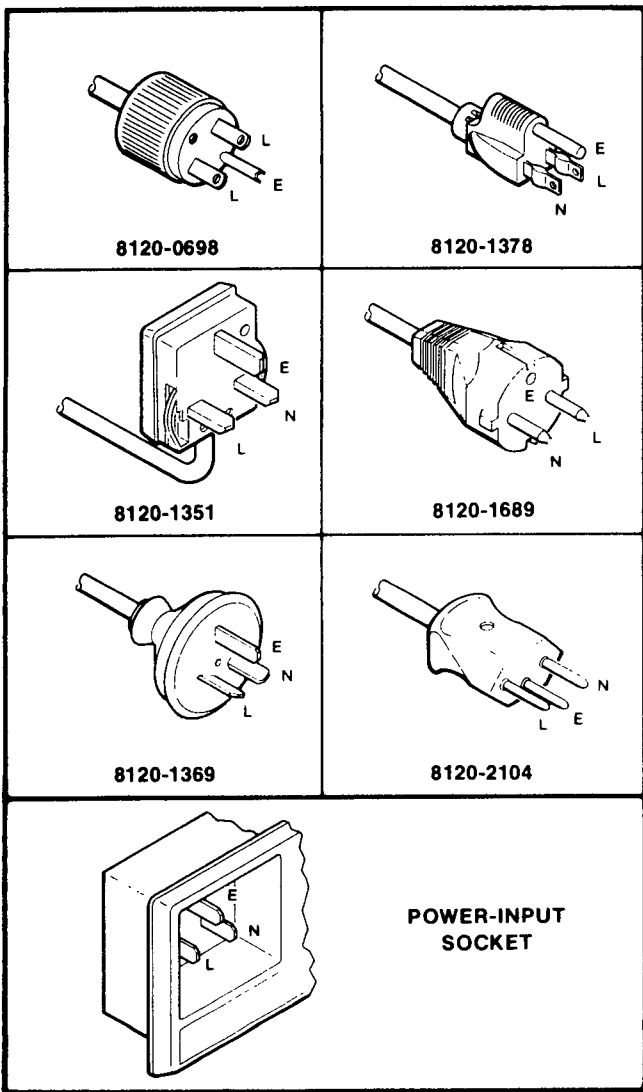


Figure 2-2. Power Cable HP Part Number versus Mains Plugs Available

## 2-17. HP-IB Interconnections

2-18. HEWLETT-PACKARD INTERFACE BUS. The counter with HP-IB is compatible with the Hewlett-Packard Interface Bus. Interconnection data concerning the rear panel HP-IB connector is provided in Figure 2-3. This connector is compatible with the HP 10833A/B/C/D cables. (See Table 2-1 for cable descriptions). The HP-IB system allows interconnection of up to 15 (including the controller) HP-IB compatible instruments.

Table 2-1. HP-IB Cable Descriptions

HP Model	Cable Length
10833A	1 metre (3.3 feet)
10833B	2 metres (6.6 feet)
10833C	4 metres (13.2 feet)
10833D	0.5 metres (1.6 feet)

2-19. The HP-IB cables have identical "piggy-back" connectors on both ends so that several cables can be connected to a single source without special adapters or switch boxes. System components and devices may be connected in virtually any configuration desired. There must, of course, be a path from the calculator (or other controller) to every device operating on the bus. As a practical matter, avoid stacking more than three or four cables on any one connector. If the stack gets too large, the force on the stack produces great leverage which can damage the connector mounting. Be sure each connector is firmly (finger tight) screwed in place to keep it from working loose during use.

2-20. CABLE LENGTH RESTRICTIONS. To achieve design performance with the HP-IB, the proper voltage levels and timing relationships must be maintained. If the system cable is too long, the lines cannot be driven properly, and the system will fail to perform properly. Therefore, when interconnecting an HP-IB system, it is important to observe the following rules.

- a. The total cable length for the system must be less than or equal to 20 metres (65.6 feet).
- b. The total cable length for the system must be less than or equal to 2 metres (6.6 feet) times the total number of devices connected to the bus.
- c. The total number of instruments connected to the bus must not exceed 15.

## 2-21. HP-IB Talk/Listen Address Switch

2-22. The HP 5386A provides a rear panel HP-IB instrument address selection switch. This switch determines the mode of remote operation as "Talk Only" or "addressable", and selects the HP-IB address. Instructions for changing the address are provided in Section III of this manual.

## 2-23. HP-IB Description

2-24. A description of the HP-IB is provided in Section III of this manual. A study of this information is necessary if the user is not familiar with the HP-IB concept. Additional information concerning the design criteria and operation of the bus is available in IEEE Standard 488-1978, titled "IEEE Standard Digital Interface for Programmable Instrumentation".

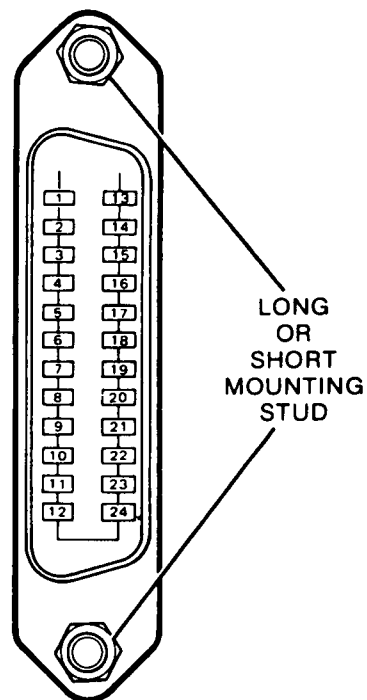


The above symbol when located in the upper corner of a page indicates HP-IB information is contained on that page. This information may be operation, performance, adjustments, or service related.



PIN	LINE
1	DIO1
2	DIO2
3	DIO3
4	DIO4
13	DIO5
14	DIO6
15	DIO7
16	DIO8
5	EOI
17	REN
6	DAV
7	NRFD
8	NDAC
9	IFC
10	SRQ
11	ATN
12	SHIELD-CHASSIS GROUND
18	P/O TWISTED PAIR WITH PIN 6
19	P/O TWISTED PAIR WITH PIN 7
20	P/O TWISTED PAIR WITH PIN 8
21	P/O TWISTED PAIR WITH PIN 9
22	P/O TWISTED PAIR WITH PIN 10
23	P/O TWISTED PAIR WITH PIN 11
24	ISOLATED DIGITAL GROUND

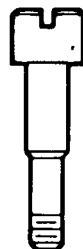
THESE PINS  
ARE  
INTERNALLY  
GROUNDED



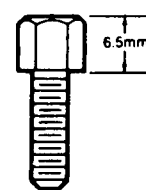
**CAUTION**

The HP 5386A contains metric threaded HP-IB cable mounting studs as opposed to English threads. Metric threaded HP 10833A, B, C, or D HP-IB cable lockscrews must be used to secure the cable to the instrument. Identification of the two types of mounting studs and lockscrews is made by their color. English threaded fasteners are colored silver and metric threaded fasteners are colored black. DO NOT mate silver and black fasteners to each other or the threads of either or both will be destroyed. Metric threaded HP-IB cable lockscrew illustration and part number follows.

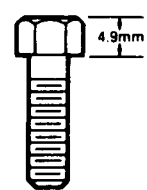
LOCKSCREW  
1390-0360



LONG MOUNTING  
STUD  
0380-0643



SHORT MOUNTING  
STUD  
0380-0644



**Logic Levels**

The Hewlett-Packard Interface Bus logic levels are TTL compatible, i.e., the true (1) state is 0.0V dc to 0.4V dc and the false (0) state is +2.5V dc to +5.0V dc.

**Programming and Output Data Format**

Refer to Section III, Operation

**Mating Connector**

HP 1251-0293; Amphenol 57-30240.

**Mating Cables Available**

HP 10833A, 1 metre (3.3 ft.), HP 10833B, 2 metres (6.6 ft.),  
HP 10833C, 4 metres (13.2 ft.), HP 10833D, 1/2 metre (1.6 ft.).

**Cabling Restrictions**

1. A Hewlett-Packard Interface Bus System may contain no more than 2 metres (6.6 ft.) of connecting cable per instrument.
2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus System is 20.0 metres (65.6 ft.).
3. The maximum number of instruments in one system is fifteen.

Figure 2-3. Hewlett-Packard Interface Bus Connections

## 2-25. Operating Environment

2-26. TEMPERATURE. The counter may be operated in temperatures from 0°C to +50°C.

2-27. HUMIDITY. The counter may typically be operated in environments with humidity up to 95% at 40°C. However, it should be protected from extreme temperatures which may cause condensation in the instrument.

2-28. ALTITUDE. The counter may be typically operated at altitudes up to 4,600 metres (15,000 feet).

## 2-29. STORAGE AND SHIPMENT

### 2-30. Environment

2-31. The instrument may be stored or shipped in environments within the following limits:

TEMPERATURE ..... -40°C to +75°C  
HUMIDITY .... Up to 95% noncondensing  
ALTITUDE ..... 15,240 Metres (50,000 feet)

2-32. The instrument should also be protected from temperature and humidity extremes which cause condensation within the instrument.

### 2-33. Packaging

2-34. ORIGINAL PACKAGING. Containers and materials identical to those used in the factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number, and full serial number. Also, mark the container FRAGILE to ensure careful handling. In any correspondence, refer to the instrument by model number and full serial number.

2-35. OTHER PACKAGING. The following general instructions should be used for repacking with commercially available materials.

a. Wrap the instrument in heavy paper or plastic. If you are shipping to a Hewlett-Packard office or service center, attach a tag indicating the type of service required, return address, model number, and full serial number.

b. Use a strong shipping container. A double-wall carton made of 350-pound test material is adequate.

c. Use a layer of shock-absorbing material 70 to 100 mm (3- to 4-inch) thick around all sides of the instrument to provide firm cushioning and prevent

movement inside the container. Protect the control panel with cardboard.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to ensure careful handling.

f. In any correspondence, refer to the instrument by model number and full serial number.

## 2-36. WHERE TO SHIP YOUR UNIT FOR REPAIR

2-37. Return your unit to the nearest designated Hewlett-Packard Sales and Support Office. Check the back of this manual for the address.

## 2-38. FIELD INSTALLATION OF OPTION 004

2-39. The following information provides instructions for installation of option 004 for the HP 5386A.

2-40. Refer to *Table 2-2* for a list of the parts required for installation of option 004.

*Table 2-2. Required Parts for Field Installation of Option 004*

Opt.	Ref. Des.	Description	Pt. No.
004	Y1B	10 MHz Oven Oscillator Module	0960-0636
	R96	121 ohm	0757-0403

### 2-41. Option 004 Oven Oscillator Installation

2-42. The Option 004 Oven Oscillator replaces the TCXO in the 5386A. To install the Option 004 proceed as follows:

a. Remove ac power cord.

b. Loosen screw on top cover at rear of instrument.

c. Slide cover toward rear of counter, lift off.

d. Loosen screw on bottom cover at rear of instrument.

e. Lift instrument from bottom cover.

f. Remove HP-IB board for access to TCXO.

g. Unsolder and remove TCXO.

h. Install oven oscillator Y1B and 121 ohm resistor in R96 position.

i. Refer to Section V for the oscillator adjustment procedure.

j. Reassemble the counter by following steps "a" through "f" in reverse order.

## SECTION III OPERATION AND PROGRAMMING

### 3-1. INTRODUCTION

3-2. This section gives complete operating and programming information for the HP 5386A Frequency Counter. Descriptions of all front panel controls, connectors, and indicators, as well as an operator's check, operating instructions, programming instructions and codes, and operator's maintenance, are provided.

### 3-3. OPERATING CHARACTERISTICS

3-4. The HP 5386A can be configured for system or benchtop use. The counter makes frequency and period measurements. Inputs enter through two channels. Raw data from the input measurements are used by the counter's microcomputer to compute and format the result either for display or transmission over the HP-IB. The operating range, resolution and accuracy for each functional mode is given in the Specifications, *Table 1-1*.

3-5. Descriptions of and operating instructions for Option 004 is provided in this section.

### 3-6. OPERATING INSTRUCTIONS

3-7. Information and instructions for operating the HP 5386A in both local and remote modes are provided in this section. The following paragraphs summarize the organization and content of the operating information.

3-8. LOCAL OPERATION. The operating information for local (or manual) operation of the counter consists of the following topics:

General Operation Information. The General Operation Information describes the basic operation of the instrument display, the inputs, and the front panel keyboard.

Front and Rear Panel Features. The front and rear panel features consists of *Figures 3-7* through *3-9* which locate and describe all the operator controls and indicators.

Making Frequency and Period Measurements. Making Frequency and Period Measurements describes the recommended procedure for making a measurement.

3-9. REMOTE OPERATION. A good working knowledge of the local operation of the counter is essential

for remote programming, as most of the data messages perform the same key-stroke-like sequences. The Remote Operation/Programming instructions describe the following:

- Interface Description
- Interface Functional Overview
- Interface System Overview
- Address Selection
- Interface Function
- Interface Commands
- Input Format
- Output Format
- Measurement Triggering in Remote SRQ, SRQ Mask, and Status Byte
- Device Dependent Commands
- Device Command Definitions
- Power-up and Default States
- Programming Examples

### 3-10. OPERATOR'S MAINTENANCE

3-11. The only maintenance the operator should normally perform is the replacement of either fuse. Refer to Section II, Line Voltage Selection, for instructions on changing the fuses.

3-12. TCXO adjustment is also accessible from the rear panel. The oscillator is factory set at 10 MHz. Once adjusted, the oscillator should need little future attention except for periodic calibration using a precision frequency source. To adjust the oscillator, refer to Section V.

### 3-13. GENERAL OPERATION INFORMATION

#### 3-14. Introduction

3-15. The following paragraphs describe the general operating features of the HP 5386A Frequency Counter.

#### 3-16. Display

3-17. All display functions are performed by a Liquid Crystal Display assembly. The assembly contains 12 alphanumeric characters; the display format for all measurements is in engineering notation. The leftmost character is CHARACTER 1 and the rightmost is CHARACTER 12. The scale or units designation will normally be shown in character positions 10, 11, and 12. If positions 10 and 11 are required to display a high resolution measurement, only character position 12 will be used to designate the scale or units.

3-18. Annunciation for all operating modes is also indicated by the display. When a mode is selected, an arrow appears at the bottom of the display just above the name of the mode label on the front panel.

### 3-19. Keyboard

3-20. The keyboard, located on the front panel, is a 14-position pushbutton assembly which is connected to a port on the microcomputer. The keyboard is divided into several groups, according to the purpose of the keys. From the left after the power switch, is the A, B, GATE, and DISPLAY DIGITS keys.

3-21. A blue RESET/LOCAL key and the CHECK key complete the keyboard assembly of the counter.

### 3-22. INPUTS

3-23. Immediately to the right of the keyboard is the INPUTS section. There are two inputs (Channels A and B) and a control for adjusting the trigger level of Channel A. Channel A has a female BNC connector and Channel B has a female type N connector.

### 3-24. Power-Up/Self-Check

#### WARNING

**BEFORE USING THE INSTRUMENT, ALL PROTECTIVE EARTH TERMINALS, EXTENSION CORDS, AUTOTRANSFORMERS AND DEVICES CONNECTED TO IT SHOULD BE CONNECTED TO A PROTECTIVE EARTH GROUNDED SOCKET. ANY INTERRUPTION OF THE PROTECTIVE EARTH GROUND WILL CAUSE A POTENTIAL SHOCK HAZARD THAT COULD RESULT IN PERSONAL INJURY.**

#### CAUTION

**Before energizing the counter, the instrument must be set to the voltage of the power source or damage to the instrument may result. See Section II.**

3-25. When you power-up the counter, an internal check is automatically made of several major components in its circuitry. During this cycle, all 12 Liquid Crystal Display (LCD) digits will be momentarily activated in a starburst pattern. Also activated are the colons and annunciators. The address of the interface will briefly be displayed.

3-26. After the power-up sequence, the counter initializes itself. That is, Frequency A mode is selected for

display and the preset trigger level mode is selected. The ATTN and LPF modes are disabled, and the gate time is set to 0.1 s. If no input signal is present after the Power-Up cycle, 00000000 will appear on the display. The power-up initialize state is listed in *Table 3-1*.

Table 3-1. Power-Up Initialize States

FUNCTION	STATE
REMOTE/LOCAL	LOCAL
GATE TIME	0.1 s
MANUAL LEVEL	OFF
WAIT-TO-SEND	OFF
DISPLAY DIGITS	NORMAL
FUNCTION	FREQ A
X20 ATTN	X1
FILTER	OFF
REMOTE DISPLAY	OFF

3-27. Any failure during the power-up cycle will cause an error message to be displayed momentarily. After the error is displayed, the counter will attempt to operate normally.

### 3-28. Error Messages

3-29. The counter will display error messages whenever the instrument enters an error state. Errors can occur either during self-test or after an improper operation has been attempted through the interface.

3-30. If an error occurs during power-up self-test, error messages will appear on the display. The message will be displayed for approximately one second to give the operator sufficient time to read the message. One second after the error is displayed, the counter will attempt to operate normally.

3-31. If an error occurs during the power-up self-test, the ERROR annunciator will be turned on. This annunciator will stay on as long as the instrument does not enter the diagnostic mode to warn the operator of potentially inaccurate results.

3-32. Several types of errors can occur when an improper operation is attempted through the interface. Whenever an error message is generated because of an illegal operation, the error message will be displayed until the RESET/LOCAL key is pressed or a DCL (device clear) command is sent to the counter by the controller.

3-33. Illegal commands can either be commands not recognizable to the counter or commands which are recognizable, but are invalid if the counter is in the diagnostic or talk only modes.

3-34. Instrument error messages are listed in Table 3-2.

Table 3-2. Error Messages

Error	Messages
10	Self-test error
50	Unrecognizable mnemonic in command
51	Illegal numeric in command
52	First character of command is illegal
53	Illegal character in the "DR" (remote display) command
55	Invalid HP 5386A command protocol or frame error
56	Invalid diagnostic command
60	ROM failure in I/O processor
61	RAM failure in I/O processor
70	Controller connected to talk-only instrument

### 3-35. FRONT PANEL FEATURES

3-36. The front panel controls, indicators, and connectors are shown in Figures 3-7 through 3-9.

3-37. The following paragraphs describe the general purpose and use of the operator keys and controls. They are discussed by functional grouping, as follows:

- a. ON/STBY
- b. A CHANNEL
- c. B CHANNEL
- d. GATE and DISPLAY DIGITS
- e. RESET/LOCAL and CHECK
- f. INPUTS

### 3-38. POWER ON/STBY

3-39. The ON/STBY switch connects or disconnects the output from the +5-volt supply to the rest of the instrument. It does not control the ac power line at the primary of the power transformer. If Option 004, the ovenized oscillator is installed, +5 volts is supplied to the oscillator whether the power switch is in the STBY (standby) mode or in the ON mode (with the ac power cord connected). Figure 3-1 shows the ON/STBY switch.

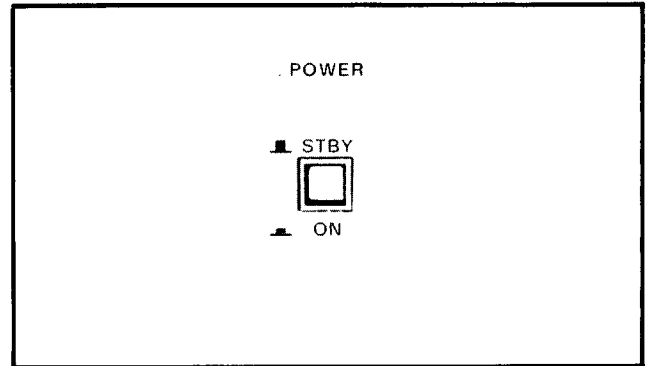


Figure 3-1. Front Panel ON/STBY Switch

### 3-40. A CHANNEL

3-41. Function selection for the HP 5386A is accomplished through a simple one key per function keyboard. You may select from five function modes (labeled in black) accessible from the five keys grouped under A. The arrows appearing in the bottom of the display identifies which functions are active. The five functions in the A channel group are: FREQ, X20 ATTN, PER, FILTER, MAN LEVEL. Refer to Figure 3-2, Front Panel A Channel Function Keys.

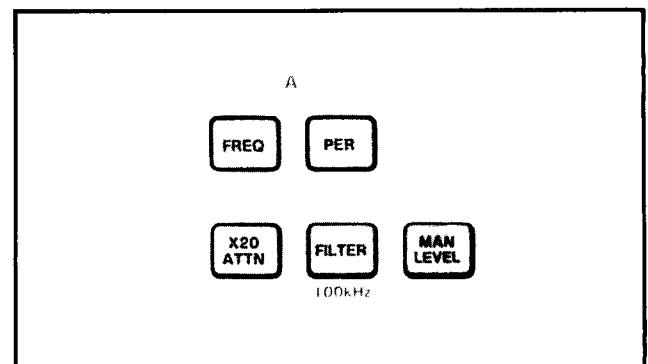


Figure 3-2. Front Panel A Channel Function Keys

3-42. FREQ key selects the frequency mode of operation for the A channel input. The frequency range of Channel A is 10 Hz to 100 MHz. When Channel A is selected, a black arrow appears in the bottom of the LCD over the "A" label located directly below the display window. The frequency at input A is measured and displayed.

3-43. If the counter has just been powered-up, Channel A is automatically selected (initialize mode) with a gate time of 0.1 s. If the counter has been operated since being powered-up, the frequency measurement is made using the last gate time selected.

3-44. PER key selects the period mode of operation for the Channel A input. When the PER key is pressed, the period of the signal at input A is measured. The measurement is automatically made using the last gate time selected. The gate time is displayed in the right side of the LCD. As in frequency measurements, the resolution of the measurement is affected by the gate time, since the HP 5386A is a reciprocal counter.

3-45. Reciprocal counters use the gate time to accumulate events (cycles of input signal) during the length of the gate time. The gate time is divided by the number of events (by the microcomputer) to determine the average period of the signal. The longer the gate time, the larger the number of events are accumulated. An increased number of accumulated events will increase the resolution of the measurement.

3-46. X20 ATTN key provides attenuation of the input signal on Channel A by a factor of approximately 20. Each press of the X20 ATTN key toggles between enabling and disabling an attenuation circuit. When a black arrow appears in the LCD above the "ATTN" label, the signal is attenuated. When no arrow appears, the signal is not attenuated.

3-47. The X20 ATTN sets the sensitivity of the Channel A input to either 15 mV rms or 300 mV rms range if the MANUAL LEVEL A control (discussed later) is in midrange position or disabled. The X20 ATTN operates independently of the front panel key MAN LEVEL. When the MAN LEVEL key is enabled, the X20 ATTN function will cause the range of the MANUAL LEVEL A control to increase approximately 20 times.

3-48. The FILTER key provides a 100 kHz Low Pass Filter that can be toggled into or out of the Channel A signal path. The Low Pass Filter will attenuate frequencies above 100 kHz. When the FILTER is in the signal path, a black arrow will appear in the LCD above the label "FILT".

3-49. The FILTER will improve the accuracy and resolution of frequency measurements below 100 kHz by blocking high frequency signals and noise that may be riding on the low frequency being measured.

3-50. MAN LEVEL key enables or disables the front panel MAN LEVEL A control in the INPUTS section.

3-51. When the MAN LEVEL A control is enabled (on), an arrow will appear in the LCD above the (MAN LVL A) label. The trigger level of channel A becomes manually variable. Channel B is not affected by the MAN LEVEL A control.

3-52. When the MAN LEVEL A control is disabled (off), the MANUAL LEVEL A control has no effect on input sensitivity of either channel.

### 3-53. B CHANNEL

3-54. Figure 3-3 shows the front panel B channel function key. The FREQ key selects the frequency mode of operation for the B Channel input for display on the LCD. Channel B frequency range for the HP 5386A is 90 MHz to 3 GHz.

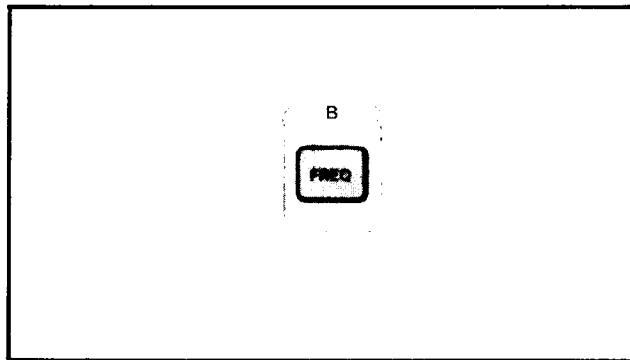


Figure 3-3. Front Panel B Channel Function Key

3-55. When channel B is selected, a black arrow appears in the bottom of the LCD over the "B" label located directly below the display window.

### 3-56. GATE and DISPLAY DIGITS

3-57. The GATE keys are shown in Figure 3-4. The GATE keys select the approximate gate time in decade ranges. The actual gate time is determined by the microcomputer.

3-58. The 0.1 s, 1.0 s, and 10 s keys select gate times from 0.1 second to 10 seconds for frequency, period and check measurements.

3-59. The greater the gate time the greater the accuracy and the number of digits of resolution you may obtain.

- 0.1 s 3 to 8 digits
- 1.0 s 3 to 9 digits
- 10 s 3 to 10 digits

If the most significant digits of a measurement are between 1.0 and 1.299... one extra digit is displayed, giving a maximum of 11 digits.

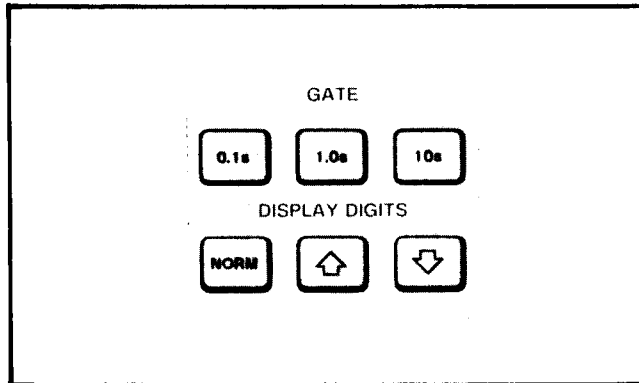
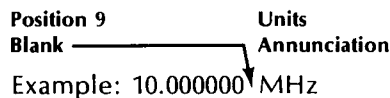


Figure 3-4. Front Panel GATE Select DISPLAY DIGITS Keys

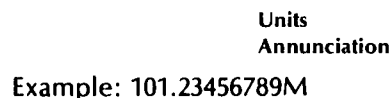
3-60. The DISPLAY DIGITS keys are shown in Figure 3-4. They select the number of digits displayed on the LCD. However, these keys do not affect the resolution of the measurement sent over the interface bus. Measurements are always sent with maximum resolution over the interface.

3-61. NORM key selects the normal display resolution of eight digits and a three letter units annunciation.

3-62. The measurement display will begin on the left of the LCD (character position 1) and occupy the eight leftmost character positions. The three rightmost digits (character positions 10, 11, and 12) are used for units annunciation. Character position nine is left blank.



3-63. ↑ key will cause the number of digits displayed to increase to eight maximum for period measurements and 11 for frequency measurements. One press of the key causes one increment increase in the digits displayed. When more than eight digits are displayed, the scale annunciation is reduced to only one character.



3-64. This key will not affect the data sent over the interface. The counter will not display digits beyond the calculated LSD. That is, if you ask for 11 digit resolution, you may get 7, 8, 9, 10, or 11 digits.

3-65. ↓ key will cause the number of digits displayed to decrease to a minimum of three digits. One press of

the key decreases the number of digits displayed by one digit.

6-66. Changes do not show on the display until completion of the next gate cycle, which could be up to 10 seconds. A new gate cycle is initiated when any key on the front panel is pressed. So, pressing any key on the front panel may cause a delay of up to 10 seconds before you will see the expected change in the display.

### 3-67. RESET/LOCAL and CHECK

3-68. The RESET/LOCAL and CHECK keys are shown in Figure 3-5.

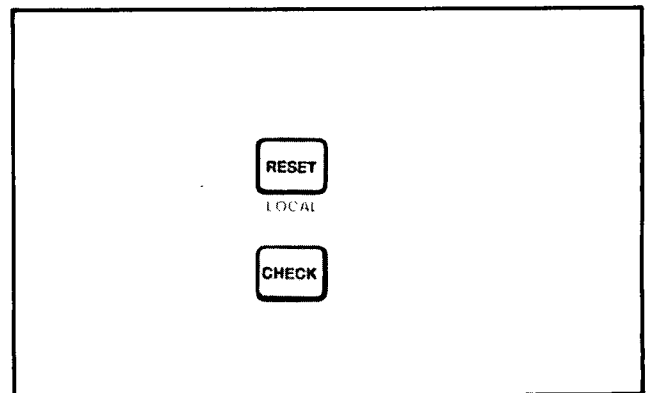


Figure 3-5. Front Panel RESET/LOCAL and CHECK Keys

3-69. When the counter is in the remote state and the local lockout (LLO) is not enabled, pressing the blue RESET/LOCAL key will return the counter to local keyboard control. The REM (remote) indicator arrow at the bottom left of the display will disappear. All functions and controls previously selected remain and a new measurement is initiated with the display reset to "00000000". If LLO is active, the RESET/LOCAL key as well as all other front panel keys are disabled.

3-70. If diagnostics are being executed while the counter is in either the local or remote state and the RESET/LOCAL key is pressed, the counter exits the diagnostic mode and defaults to the initialize mode of local operation.

3-71. If the counter is in local and not executing diagnostics, pressing the RESET/LOCAL key resets the display and initiates a new measurement.

3-72. The CHECK key is used to initiate tests that verify proper operation of the oscillator, shift register, microcomputer, display operation, and other hardware.



### 3-73. INPUTS

3-74. The INPUTS section consists of two input connectors and a MANUAL TRIG LEVEL single-turn potentiometer that controls the trigger level for channel A. Figure 3-6 shows the INPUTS section.

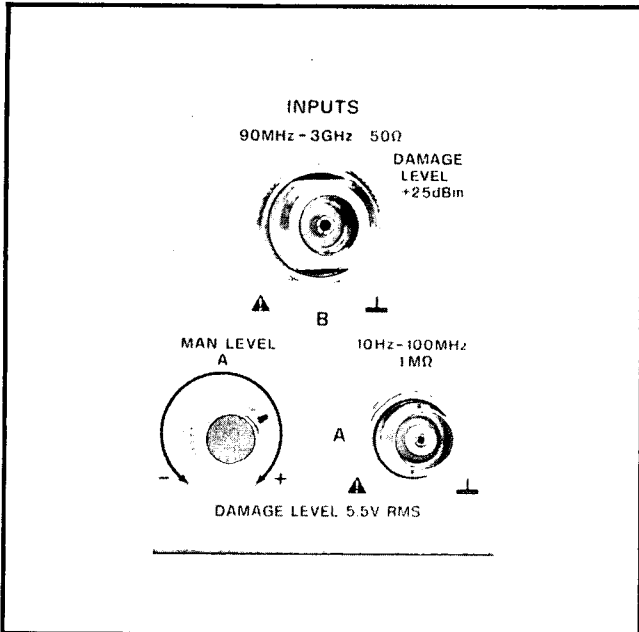


Figure 3-6. Front Panel INPUTS Section

3-75. Signals to be measured are connected to either channel A or channel B input connectors.

3-76. When the MANUAL LEVEL A control is enabled, Channel A trigger level is manually variable. Channel B is not affected. See the specifications in Section I.

3-77. MANUAL LEVEL A is enabled or disabled by the MAN LEVEL key. When disabled, the MANUAL LEVEL A control has no effect on input sensitivity of Channel A or B. Channel A sensitivity is maximum and Channel B sensitivity is controlled by an automatic gain control circuit. After power-up, the control is automatically disabled (initialize mode).

3-78. When the MANUAL LEVEL A control is enabled, an arrow will appear on the LCD above the label MAN LVL. The DC offset level of Channel A input is manually variable. A variable DC offset has the effect of being a polarity and trigger level control. When the X20 ATTN is disabled, the trigger level of input A may be set from -0.1 volts to +0.1 volts peak. At midrange, 0.0 volt level, Channel A input sensitivity will be approximately 15 mV rms or  $\pm 21$  mV peak. If the X20 ATTN is enabled, these values increase by a nominal factor of 20.

3-79. There are two input connectors; Channel A and Channel B. Channel A input frequency range is from 10 Hz to 100 MHz. Channel B input frequency range is 90 MHz to 3 GHz.

3-80. Both inputs are ac coupled with dc blocking up to 350 Vdc for Channel A and 5Vdc for Channel B.

### 3-81. REAR PANEL FEATURES

3-82. A number of signal inputs, outputs, connectors and controls are provided on the rear panel. Figure 3-9 shows the rear panel.

3-83. The Input/Output interface connector provides remote control capabilities with the Hewlett-Packard Interface Bus (HP-IB).

3-84. The interface address switch (ADDR) is a seven-position switch that is used to manually set the remote control address of the counter. The five rightmost switch positions are externally accessible and can be used by the operator for setting the address. The two leftmost switch positions are not used for normal operation. For a complete description of address selection, refer to Table 3-4, Address Selection, in the Remote Programming Instructions in this section.

3-85. The HP-IB capabilities of the counter is listed above the interface port. For a complete description of the listed capabilities, refer to paragraph 3-112, Interface Commands.

3-86. The AC LINE INPUT connector accepts the ac input power cord. The protective grounding conductor also connects to the instrument through the ac power connector.

3-87. The LINE SELECT switch selects the instrument line voltage. The switch selects either 115 or 230 volts. The number visible on the switch indicates the nominal line voltage to which the instrument must be connected for proper operation.

3-88. The DC FUSE is a two-ampere slow-blow fuse for the protection of the dc power supply to the instrument. The dc fuse is the main protection for the counter. The ac fuse is a .25 ampere slow blow type that protects the transformer against overvoltage.

3-89. The 10 MHz IN/OUT BNC connector provides a 10 MHz signal that may be used for calibration when the INT EXT switch is in the INT position. When the INT EXT switch is in the EXT position, the IN/OUT BNC



connector becomes the external reference input for the counter.

### 3-90. MAKING FREQUENCY AND PERIOD MEASUREMENTS

3-91. The recommended sequence for setting-up and making a measurement with the HP 5386A Frequency counter is given below.

- a. Set the power switch to ON. The counter should perform a power-up self-check, then preset to the power-up initialize settings shown in *Table 3-1*.
- b. Press the key for the desired operating mode (frequency, period etc.).
- c. Connect a signal into the channel selected.
- d. If the display is unstable, use the attenuator, filter, or manual trigger level control and adjust for a stable reading. The above mentioned controls have limitations. They cannot compensate for excessively noisy or unstable signal sources.
- e. If desired, select a gate time and the number of display digits desired.

#### NOTE

The display for frequency measurements of less than 1 Hertz will have a "less than" symbol (<) on the left of the Hertz symbol (Hz). Refer to *Table 3-3*.

*Table 3-3. Units Display Format*

FUNCTION	UNITS	
	<=8 DIGITS	>8 DIGITS
FREQUENCY A/ FREQUENCY B	< HZ HZ KHZ MHZ GHZ	< H K M G
PERIOD A	KSC SEC MS US NS	
CHECK	MHZ	M

### 3-92. REMOTE PROGRAMMING

#### 3-93. Introduction

3-94. The HP 5386A frequency counter is compatible with the Hewlett-Packard Interface Bus. Remote programming allows the instrument to respond to

remote control instructions and output measurement data via the interface. At the simplest level, the counter can output data in the talk only mode to other devices such as a printer. In more sophisticated systems, a controller can remotely program the counter to perform a specific type of measurement, trigger the measurement, and output the results.

#### NOTE

HP-IB is Hewlett-Packard's implementation of IEEE Std. 488-1978, "Standard Digital Interface for Programmable Instrumentation".

3-95. To remotely program the counter efficiently, the operator must be familiar with the selected controller and the local (manual) operation of the counter. Typical controllers for the HP-IB are the HP 9825A/B, HP 9826A, HP 9830A, HP 9835/45A, or HP 85A. Users of the HP-IB interface should find the following manuals useful background information:

Condensed Description of the Hewlett-Packard Interface Bus (P/N 59401-90030)

HP-IB programming Hints for Selected Instruments (P/N 59300-90005)

Tutorial Description of the Hewlett-Packard Interface Bus (P/N 5952-0156)

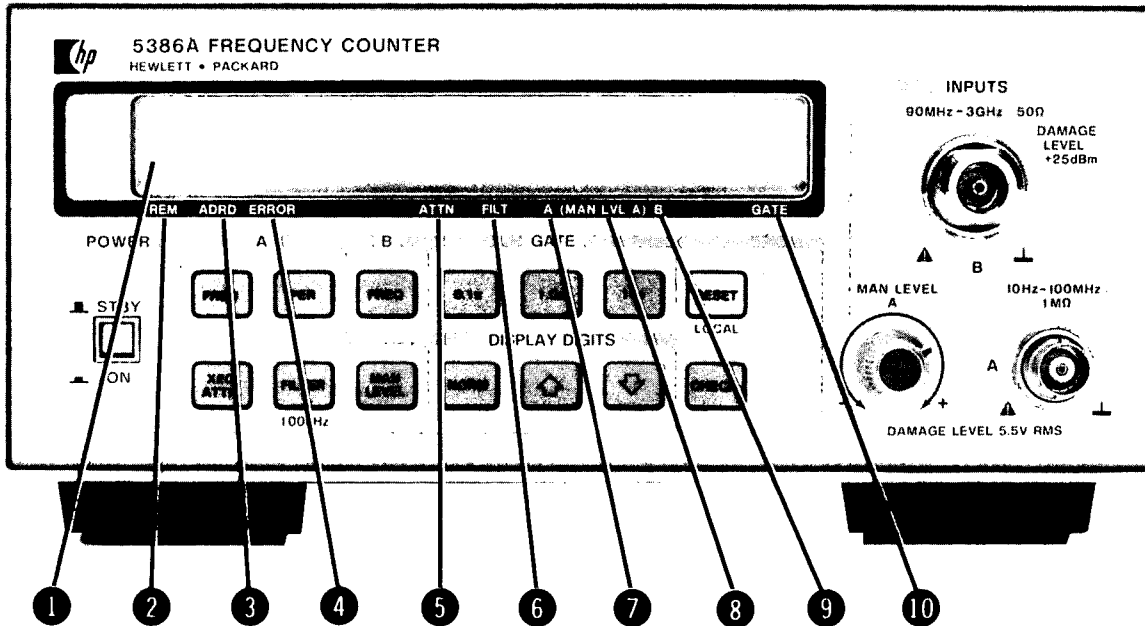
### 3-96. INTERFACE DESCRIPTION

#### 3-97. Hewlett-Packard Interface Bus (HP-IB)

3-98. The Hewlett-Packard Interface Bus (HP-IB) system utilizes a party-line bus structure (devices share signal lines) to which a maximum of 15 devices may be connected in one continuous bus. Sixteen signal lines and 8 ground lines are used to interconnect devices in parallel arrangement and maintain an orderly flow of device and interface related information.

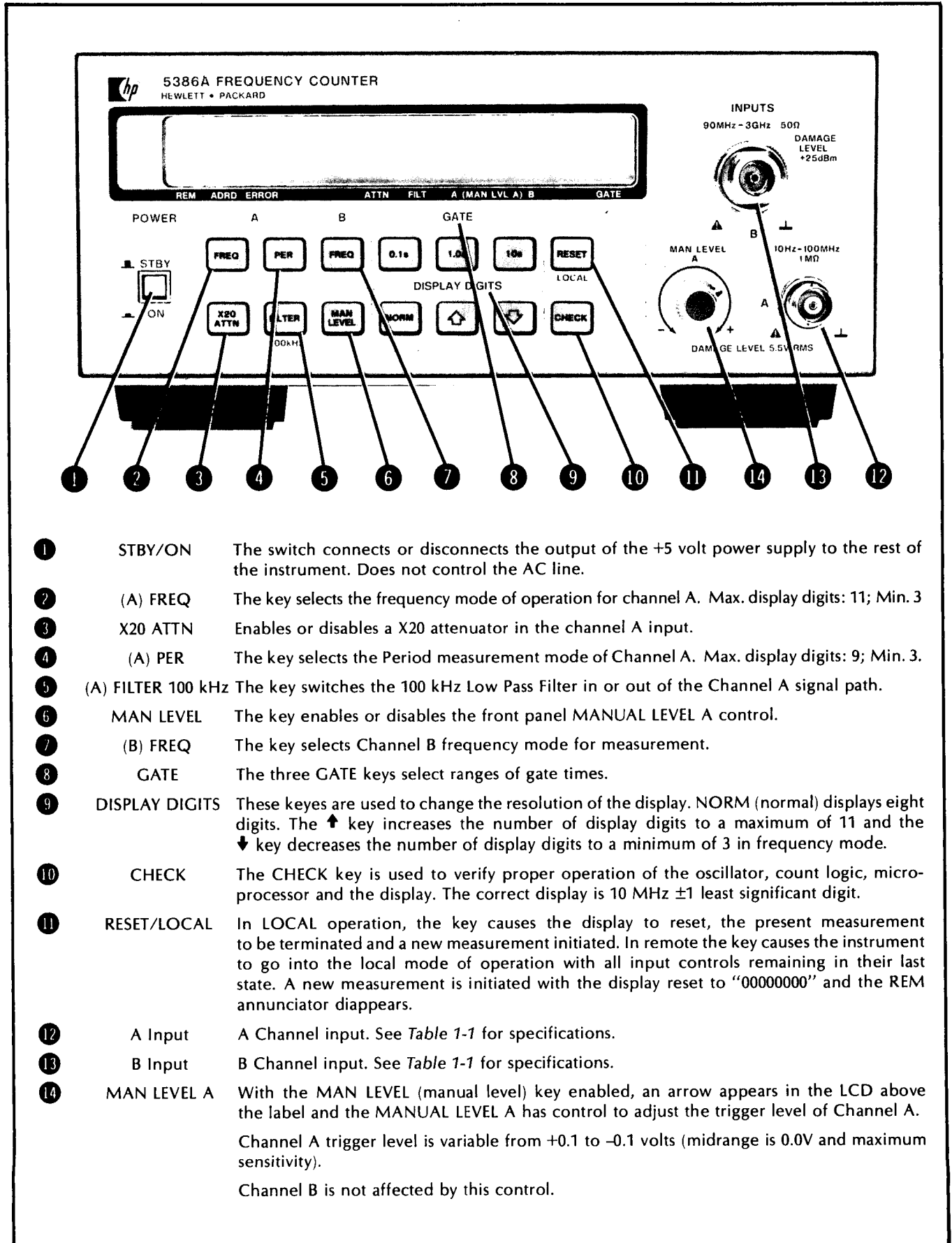
### 3-99. INTERFACE FUNCTIONAL OVERVIEW

3-100. Each device on the interface may possess one or more of the following major device capabilities: Controller, Talker, or Listener. The controller, as the name implies, has the responsibility to control interface activity. The controller, of course, must be equipped with the proper interface module. Controllers transmit all device independent commands to other devices in the interface and usually have Talker and Listener capabilities. The counter cannot serve as a controller.



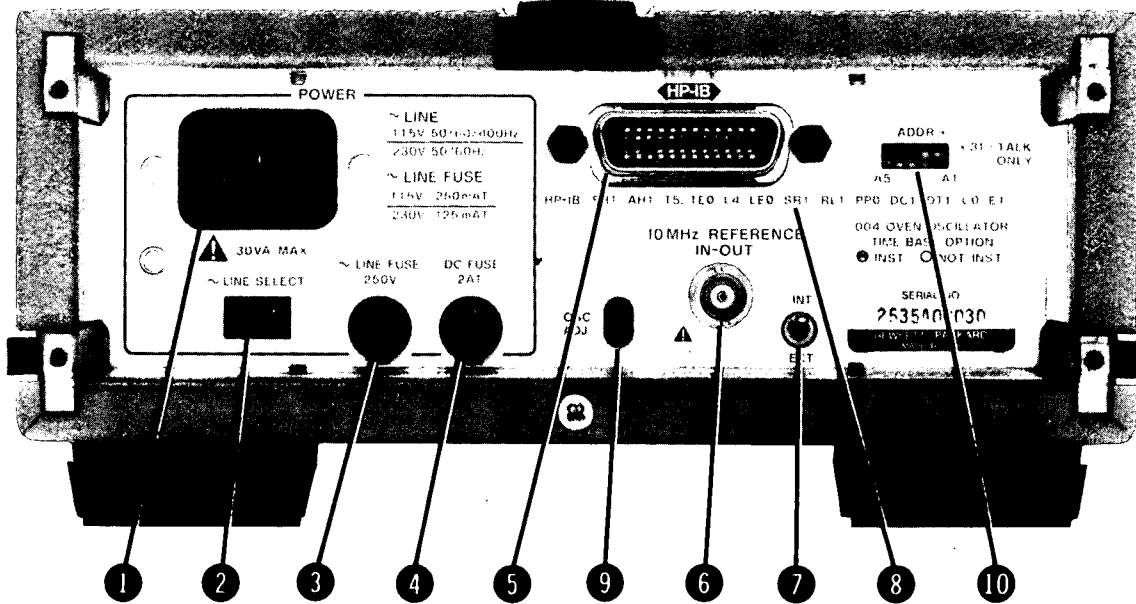
- |   |           |  |
|---|-----------|--|
| ① | DISPLAY   | The liquid Crystal Display contains the 12-digit, 14-segment display.  |
| ② | REM       | An arrow appears above the REM (remote) label indicating the counter is in remote operation. The arrow does not appear in local operation.                                       |
| ③ | ADDR      | An arrow appears above the ADDR (addressed) label indicating the counter is addressed by the controller. When the counter is addressed it may or may not be in remote operation. |
| ④ | ERROR     | An arrow appears above the ERROR (error) label when a failure occurs in the micro-processor. All other failures will cause an error number ("Ernn") to appear in the display.    |
| ⑤ | ATTN      | An arrow appears above the ATTN (attenuator) label when the X20 attenuator is in the Channel A signal path.  |
| ⑥ | FILT      | An arrow appears above the FILT (filter) label when the 100 kHz low pass filter is in the A Channel signal path.   |
| ⑦ | A         | An arrow appears above the "A" label when the counter is set-up to make a frequency measurement or period measurement on Channel A.  |
| ⑧ | MAN LVL A | An arrow appears above the (MAN LVL A) label when the MANUAL LEVEL control is enabled.   |
| ⑨ | B         | An arrow appears above the "B" label when the counter is set up to make a frequency measurement on Channel B.  |
| ⑩ | GATE      | An arrow appears above the GATE label to indicate that a measurement is in progress.   |

Figure 3-7. Front Panel Indicators



- ① STBY/ON The switch connects or disconnects the output of the +5 volt power supply to the rest of the instrument. Does not control the AC line.
- ② (A) FREQ The key selects the frequency mode of operation for channel A. Max. display digits: 11; Min. 3
- ③ X20 ATTN Enables or disables a X20 attenuator in the channel A input.
- ④ (A) PER The key selects the Period measurement mode of Channel A. Max. display digits: 9; Min. 3.
- ⑤ (A) FILTER 100 kHz The key switches the 100 kHz Low Pass Filter in or out of the Channel A signal path.
- ⑥ MAN LEVEL The key enables or disables the front panel MANUAL LEVEL A control.
- ⑦ (B) FREQ The key selects Channel B frequency mode for measurement.
- ⑧ GATE The three GATE keys select ranges of gate times.
- ⑨ DISPLAY DIGITS These keys are used to change the resolution of the display. NORM (normal) displays eight digits. The ↑ key increases the number of display digits to a maximum of 11 and the ↓ key decreases the number of display digits to a minimum of 3 in frequency mode.
- ⑩ CHECK The CHECK key is used to verify proper operation of the oscillator, count logic, micro-processor and the display. The correct display is 10 MHz ±1 least significant digit.
- ⑪ RESET/LOCAL In LOCAL operation, the key causes the display to reset, the present measurement to be terminated and a new measurement initiated. In remote the key causes the instrument to go into the local mode of operation with all input controls remaining in their last state. A new measurement is initiated with the display reset to "00000000" and the REM annunciator disappears.
- ⑫ A Input A Channel input. See Table 1-1 for specifications.
- ⑬ B Input B Channel input. See Table 1-1 for specifications.
- ⑭ MAN LEVEL A With the MAN LEVEL (manual level) key enabled, an arrow appears in the LCD above the label and the MANUAL LEVEL A has control to adjust the trigger level of Channel A. Channel A trigger level is variable from +0.1 to -0.1 volts (midrange is 0.0V and maximum sensitivity). Channel B is not affected by this control.

Figure 3-8. Front Panel Controls



- ① AC LINE INPUT The connector accepts the ac input power cord.
- ② LINE SELECT The LINE SELECT switch selects line voltage of 115 or 230 volts. The selected voltage range is visible on the switch.
- ③ AC FUSE The AC FUSE is a .25 ampere slow blow fuse. Provides transformer overvoltage protection.
- ④ DC FUSE The DC FUSE is a 2 ampere slow blow fuse. Provides main instrument protection.
- ⑤ Interface The input/output interface connector provides remote control capabilities with HP-IB.
- ⑥ 10 MHz IN/OUT BNC Connector The 10 MHz IN/OUT BNC connector provides a 10 MHz calibration signal when the INT EXT switch is in the INT position. With the switch in the EXT position, the IN/OUT BNC connector becomes the external reference input for the counter.
- ⑦ INT EXT The switch selects the internal 10 MHz oscillator or an external reference oscillator.
- ⑧ Interface Capabilities The interface capability label lists the standard interface functions of the counter for HP-IB.
- ⑨ TCXO ADJ ONLY The internal time base oscillator is adjusted through this opening.
- ⑩ ADDR (address) The address switch is used to manually set the remote control address of the counter. The five rightmost switch positions determine the address.

Figure 3-9. Rear Panel Features



3-101. Talkers are devices that have the ability to send data or device dependent commands through the interface. Note that a talker will not actually send its data or information until told to do so by the controller. The counter has Talker capabilities. In special situations, one device may be classified as a Talk-only device and sends information to Listen-only devices. Such a system would not have a controller. For example, the counter can be configured to the Talk-only mode and send measurement results to a printer. (TALK ONLY Address = 31).

3-102. Listeners are devices with the capability to receive information over the interface. Listeners must also be enabled by the controller to receive the information.

### 3-103. INTERFACE SYSTEM TERMS

3-104. The following paragraphs define the terms and concepts used to describe HP-IB system operations.

a. ADDRESS: Each device in the interface is assigned an address. The address is used to specify which device on the interface will receive information or send information.

b. BYTE: A byte is a unit of information consisting of eight binary digits called bits.

c. DEVICE: Any instrument or unit that is HP-IB compatible is called a device.

d. DEVICE DEPENDENT: An action a device performs in response to information sent through the interface. The action is characteristic of a particular instrument and will probably vary from device to device.

e. DEVICE INDEPENDENT COMMAND: A command predefined by the interface standard to have a specified bit pattern and resulting action.

f. DEVICE DEPENDENT COMMAND: A command not predefined by the interface standard, which is specific to a particular instrument or family of instruments.

g. POLLING: Polling is a process typically used by a controller to locate a device that has requested service from the controller. There are two types of polling; Serial Poll and Parallel Poll:

1. Serial Poll. When the controller executes a serial poll, the addressed device sends one byte of operational information called a status byte. If more than one device in the interface is capable of requesting service, each device on

the interface must be serial polled until the device that requested service is located.

2. Parallel Poll. When the controller executes a parallel poll, all devices on the interface respond, each one setting or clearing a particular data bit to indicate whether or not it requested service.

### 3-105. ADDRESS SELECTION

3-106. MANUAL ADDRESSING. To use the counter in a system, set the rear panel address switches to the desired address. Addresses 0 through 30 represent the addressable mode range. Address 31 selects the Talk-only mode. The addressable mode is used when the counter functions as a talker and a listener. The TALK ONLY mode (*Figure 3-10*) is employed when the counter is operating in an output-only condition (no controller on the bus) and sends its data to another device on the bus, such as a printer, set to LISTEN ONLY.

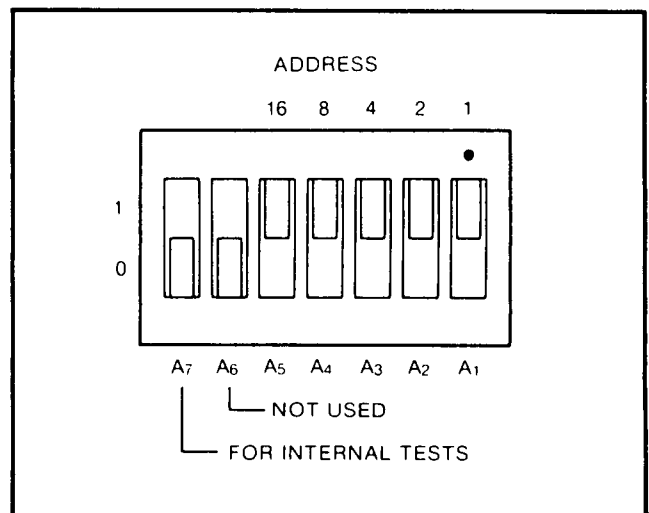


Figure 3-10. 5386A Address Switch  
Shown in Address 31

3-107. The five rightmost switches, A<sub>5</sub> through A<sub>1</sub>, set the address of the counter. *Table 3-4* shows all possible address settings and the corresponding ASCII codes used by some controllers for talk and listen. The counter is factory set to address 03 as shown in *Table 3-4*. Address 21 is not allowed because that address is assigned to the controller device.

3-108. The interface status of the counter is indicated on the front panel by an arrow appearing above the REM and/or ADRD labels on the front panel.



Table 3-4. Address Selection

Rear panel address switch:

ADDRESS  
16 8 4 2 1

(Shown in addressable mode, and address 03)

**NOTE**  
Select the decimal address from the table below and set the address switches to the corresponding positions.

ASCII CODE CHARACTER		ADDRESS SWITCHES					5-BIT DECIMAL CODE
LISTEN	TALK	A5	A4	A3	A2	A1	
SP	@	0	0	0	0	0	00
!	A	0	0	0	0	1	01
"	B	0	0	0	1	0	02
#	C	0	0	0	1	1	03
\$	D	0	0	1	0	0	04
%	E	0	0	1	0	1	05
&	F	0	0	1	1	0	06
'	G	0	0	1	1	1	07
(	H	0	1	0	0	0	08
)	I	0	1	0	0	1	09
*	J	0	1	0	1	0	10
+	K	0	1	0	1	1	11
,	L	0	1	1	0	0	12
-	M	0	1	1	0	1	13
.	N	0	1	1	1	0	14
/	O	0	1	1	1	1	15
0	P	1	0	0	0	0	16
1	Q	1	0	0	0	1	17
2	R	1	0	0	1	0	18
3	S	1	0	0	1	1	19
4	T	1	0	1	0	0	20
5	U	1	0	1	0	1	21
6	V	1	0	1	1	0	22
7	W	1	0	1	1	1	23
8	X	1	1	0	0	0	24
9	Y	1	1	0	0	1	25
:	Z	1	1	0	1	0	26
;		1	1	0	1	1	27
<	\	1	1	1	0	0	28
=	]	1	1	1	0	1	29
>	~	1	1	1	1	0	30

### 3-109. INTERFACE COMMANDS

3-110. The commands that the counter recognizes can be separated into two classes: device dependent commands and device independent commands. Device dependent commands are those that are unique to the instrument and are defined by the instrument designer. They are normally sent to an instrument as ASCII strings. A detailed description of device dependent commands begins in paragraph 3-129, Device Dependent Commands.

3-111. Device independent commands, on the other hand, are defined by the interface standard document and are the same in all instruments. These commands are identified by a three letter mnemonic such as GTL, which represents Go to Local. Device independent commands are sent as specially encoded bytes on the interface and not as ASCII strings. Thus these commands cannot be sent using the OUTPUT statement on the HP-85A. However, many controllers do incorporate a command of the form SEND7;CMDnnn, where nnn is the decimal equivalent to the bit pattern corresponding to a particular device independent command.

### 3-112. INTERFACE CAPABILITIES

3-113. Since the device independent commands are standardized and are the same in all instruments, the functions these commands perform can be listed on the instrument in a standardized manner. This is known as the interface capability label.

HP-IB SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1

3-114. The number following the interface function code indicates the particular capability of that function.

3-115. Table 3-5 provides a list of the interface capabilities of the instrument.



Table 3-5. Interface Capabilities

HP-IB	DESCRIPTION
SH1	The instrument can generate messages.
AH1	The instrument can interpret received messages.
T5	The instrument can function as a talker. In addition, it can operate as a Talker Only instrument and can respond to serial poll, send device ID, and send accessory ID.
TE0	The instrument cannot function as an extended talker.
L4	The instrument can function as a listener. It will accept commands via the interface. In addition, it will untalk itself if addressed as a listener.
LE0	The instrument cannot function as an extended listener.
SR1	The instrument can generate a service request.
RL1	The instrument can operate in both remote and local modes. In addition, it can respond to local lockout.
PP0	The instrument does not support parallel poll.
DC1	The instrument supports both the device clear (DCL) and selected device clear (SDC) commands.
DT1	The instrument can be remotely triggered.
C0	The instrument cannot function as a controller.
E1	The instrument places one load on the HP-IB system.

### 3-116. META MESSAGES

3-117. In order to simplify the use of the HP-IB interface, HP has developed what is called the Meta Message concept. Rather than requiring the user to remember all the device independent messages and their interactions, useful sequences of these commands have been integrated into a single command on many of HP's controllers. For example, to clear the instrument at address 03 using the device independent commands, it is necessary to send the sequence ATN, UNL, MTA, LAD 03, SDC. In the HP-85, the command CLEAR 703 causes this sequence to be sent with no further user interaction. This greatly simplifies the use of the interface.

3-118. Many of the meta messages as implemented on the HP-85A may be sent in either of two forms, either with or without addressing. The form with addressing will normally listen address the instrument. For example, the command REMOTE 703 will

send REN and then make the instrument a listener. In the following tables, the form with addressing is shown.

3-119. Table 3-6 lists the meta messages, their results in the counter, and typical interface message sequences corresponding to them. The sequences are typical in that different controllers may send different sequences, while still obtaining the same results.

Table 3-6. Meta Messages

MESSAGE	DESCRIPTION/RESPONSE
DATA	A means to send device dependent command and receive measurement data. HP-IB:  UNL, MTA, LADn, data
TRIGGER	Starts a new measurement.
CLEAR	Will clear the display. If in error state, clears error only.  UNL, MTA, LADn, SDC
REMOTE	Disables front panel keys (except for Reset/Local).  REN, UNL, MTA, LADn
LOCAL	Enables the front panel keys.  UNL, MTA, LADn, GTL
LOCAL and CLEAR LOCKOUT	Enables the front panel keys and clears Local Lockout. HP-IB:  REN
LOCAL LOCKOUT	Disables the Reset/Local key when in remote.  LLO
SERVICE REQUEST	This command is ignored when received by the instrument. It will be sent by the instrument when an enabled service condition is present.
STATUS BYTE	Presents status information.  UNL, MLA, TADn, SPE, data, SPD, UNT
STATUS BIT	Single bit parallel poll response indicates whether this instrument is requesting service.  IDY
PASS CONTROL	Not supported.
ABORT	Terminates bus communications by unlistening and untalking all instruments.  IFC
DEVICE ID	Causes the instrument to send the string "HP 5386A"  UNL, MLA, TADn, SDI, data
ACCESSORY ID	Causes the instrument to send the number 81 in binary. This identifies the instrument as a measuring instrument.  UNL, MLA, TADn, SAI, data





3-120. Table 3-7 lists the meta messages and the HP 9825 and HP-85 commands that correspond to them. (Only the addressed form is shown for the commands that support both the unaddressed and addressed forms.) The table assumes the instrument is set to address 03 and the interface to select code 7.

Table 3-7. Meta Messages and Controller Commands

MESSAGE	HP 9825	HP-85
DATA	wrt 703, A\$ red 703, A\$	OUTPUT 703; A\$ ENTER 703; A\$
TRIGGER	trg 703	TRIGGER 703
CLEAR	clr 703	CLEAR 703
REMOTE	rem 703	REMOTE 703
LOCAL	lcl 703	LOCAL 703
LOCAL/ CLEAR LOCKOUT	lcl 7	LOCAL 7
LOCKOUT	llo 7	LOCAL LOCKOUT 7
SERVICE REQUEST		STATUS 7,1; A
STATUS BYTE	rds (703)	S POLL (703)
STATUS BIT		P POLL (7)
PASS CONTROL		
ABORT	cli 7	ABORTIO 7
DEVICE ID		SEND 7; CMD 255
ACCESSORY ID		SEND 7; CMD 254

### 3-121. SRQ, SRQ MASK, AND STATUS BYTE

#### 3-122. SRQ and Status Byte

3-123. When in remote operation, the counter can send a service request (SRQ) to the controller to indicate the need for attention and can act as an interrupt to the current sequence of events. Typically, SRQ indicates data is ready to transmit and/or an error condition exists. The counter can send an SRQ to the controller under any, all, or none of the following conditions, as defined by the Service Request Mask.

The Service Request Mask (SM command) must be set prior to the condition. Refer to paragraph 3-127.

- a. DATA READY. A measurement has been completed and is available for collection.
- b. ERROR. An Error or Failure condition exists, and is displayed.
- c. LOCAL. The instrument is in local.

3-124. In general, the controller can read the counter Status Byte at any time to check selected operating conditions. During remote operation, you may selectively program the counter Service Request Mask (SMnnn) to identify the conditions which you feel may require service or data collection.

3-125. Once SRQ has been sent, the controller can identify which condition or conditions caused the Service Request by reading the Status Byte. When the Status Byte is read, conditions that exist will be set to 1 whether or not enabled as a condition to generate SRQ. Sending a "rds (703)" with the HP 9825A, or "A=SPOLL (703)" with the HP-85A requests the eight-bit binary status byte. The number returned will be a decimal equivalent to the sum of the different status bits set, as shown in Table 3-8.

Table 3-8. HP 5386A Status Byte

D7	D6	D5	D4	D3	D2	D1	D0
0	SRQ FLAG	POWER ON	LOCAL	0	ERROR or FAIL	0	DATA READY
128	64	32	16	8	4	2	1

3-126. For example; the instrument requested service (SRQ) and reading the Status Byte returned a value of "97". This can be interpreted as  $64 + 32 + 1 = 97$ , meaning the SRQ FLAG is set, power is on, and data is ready. The bits of the Status Byte are set regardless of the Service Request Mask. However, if that bit is masked out, it will not generate an SRQ.

#### 3-127. Service Request Mask

3-128. Upon receipt of the Service Request Mask Command (SM Command), the instrument will load the binary value of "nnn" into the service request mask register. The SRQ line bit will be "set" if a bit in the status byte becomes set and the corresponding bit in the service request mask is set. To specify the service request mask, send the SM command, followed by the decimal number that represents the sum of the bits that you want enabled. You may send any number



between "0" and "255", although only the five least significant bits are used. The binary value of "nnn" is interpreted as follows:

BIT	MEANING	(DECIMAL) WEIGHT
<b>NOT MASKABLE</b>		
Bit 7	Always 0 .....	128
Bit 6	SRQ .....	64
Bit 5	Power On .....	32
<b>MASKABLE BITS</b>		
Bit 4	Instrument in Local .....	16
Bit 3	Always 0 .....	8
Bit 2	Error or Fail Condition ...	4
Bit 1	Always 0 .....	2
Bit 0	Data Ready .....	1

For example, sending the command "SM5" will generate a service request (SRQ) after an error or fail condition or data is ready (4 + 1). Sending the command "SM0" masks off (or disables) all SRQ conditions. The condition or conditions which caused the service request may be determined by reading the Status Byte.

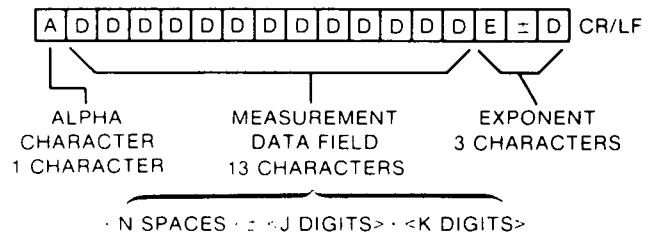
### 3-129. DEVICE DEPENDENT COMMANDS

3-130. The counter will accept command strings in either upper or lower case. Spaces, commas, and semicolons between commands are interpreted as command terminators. In addition, parity bits will be ignored. Depending upon the controller, this can help to speed-up programming. The following free format command statements will produce identical results:

OUTPUT 703; "FU1,AT1,FI1,ML1,GA2,DN"  
OUTPUT 703; "fu1,at1,fi1,ml1,ga2,dn"

### 3-131. Output Formats

3-132. Data is output to the HP-IB in the following format:



- Alpha character
- Variable number of blanks
- + or - sign
- Digit
- Decimal Point
- Variable number of digits
- E
- + or - sign
- One exponent digit
- Carriage Return
- Line Feed

3-133. Blanks are inserted to make the message 17 bytes long.

For example:

F +4.5834126E+5<CR/LF>  
| |  
17 characters

#### NOTE

There will be no decimal point in the string if it occurs just before the E (this will occur only for measurements with only one significant digit).

### 3-134. Numeric Entry

3-135. Numeric entry follows the code and format guidelines of the IEEE 728 standard for NR3 numbers. This is a "free format" type of input, with spaces allowed before a numeric entry begins, but not afterwards. A decimal point is allowed anywhere in the mantissa, but not required.

3-136. All local functions are programmable with individual command codes via the interface. In general, all functions operate the same in remote as in local. The counter commands are listed in Table 3-9, Instrument Programming Command Set.



Table 3-9. Instrument Command Set

CODE	FUNCTION	DESCRIPTION
FU1	Freq. A	Measure frequency of A-Input
FU2	Per A	Measure period of A-Input
FU3	Freq. B	Measure frequency of B-Input
CK	CHECK 10MHz	Check mode (10 MHz)
AT0	Attn A (X1)	Select X1 A-Input
AT1	Attn A (X20)	Select X20 A-Input
FI0	FILTER A (off)	Disable A-Input 100 kHz LPF
FI1	FILTER A (on)	Enable A-Input 100 kHz LPF
ML0	MAN LVL (off)	Disable Manual level control
ML1	MAN LVL (on)	Enable Manual level control
GA1	0.1s	Select 0.1 sec gate time
GA2	1.0s	Select 1.0 sec gate time
GA3	10s	Select 10 sec gate time
RE	Reset Gate	Reset Display & restart measurement
DI	Digit Inc	Increment display digits
DD	Digit Dec	Decrement display digits
DN	Digit Norm	Display digits normal
FN11	Diag. 1	CPU self-test
FN12	Diag. 2	I/O Address
FN13	Diag. 3	Interpolator short-cal
FN14	Diag. 4	Interpolator long-cal
IN	Initialize	Reset & go to Default state
WA0	Wait (off)	Wait-to-send data mode off
WA1	Wait (on)	Wait-to-send data mode on
DR<string>	Rmte Dspy	Write to LCD "string"
DL	Lcl Dspy	Return LCD to local
ID or SI	Send ID	Send Device ID
SM<num>	SRQ mask	Set service request mask = <num>
LE	Load Error	Loads data into Error Code Register
SE	Send Error	Send error code

3-137. The examples at the end of this section demonstrate programming capabilities of the counter. The examples are written for the HP-85A controller. A summary of the program operation and a line-by-line description are provided for each example.

### 3-138. IN Initialize

3-139. This command causes the instrument to exit its current state and go to the power on initialize state unless the instrument is in an error state. If the instrument is in an error state, the error condition must be cleared before the "IN" command is accepted. The error may be cleared by pressing the blue reset key on the front panel or by sending a DCL or SDC command to the instrument.

### 3-140. WA0 and WA1 Wait to Send Mode Off/On

3-141. The wait to send mode forces the instrument to wait for a measurement to be read by the controller before it can start a new measurement. This mode is especially useful when used with service request. The instrument will make a measurement and when the measurement is complete, it will assert SRQ alerting the controller to the fact that the measurement is complete. This process ensures that the controller knows when the measurement was made and that it does not have to wait for the full duration of the measurement to receive data.

3-142. WA1 places the instrument in the wait to send mode. WA0 takes the instrument out of the wait to send mode and allows it to function in its normal state. In the normal state, measurements are made continuously regardless of whether or not those measurements were read by the controller.

### 3-143. DR (string) Remote Display

3-144. The remote display command is legal only when the counter is in the measurement mode. If the command is received while the counter is in the diagnostic mode, an error will be flagged.

3-145. The remote display command allows the user to send any message, 12 characters in length excluding punctuation, to the LCD. A punctuation mark (comma, colon, or decimal point) can be sent between each of the characters.

3-146. Although the counter will continue making measurements, the LCD will contain the message sent with the "DR" command rather than the measurement data.

3-147. Whenever a new message is to be displayed, the remote display command must be sent. Thus each new message must be sent in the form "DRXXXXXXXX", where the X's represent the message to be displayed. Carriage return, line feed, form feed, horizontal tab, and vertical tab can be used as terminators for a



remote display message. A message sent to the display will remain there until a command which causes a change in the display is sent to the counter.

3-148. The remote display mode can be terminated in several ways. Sending a "DL" (display local) command will terminate the remote display mode without changing the state of the counter in any other way. When the counter receives this command, it will clear the display and resume displaying measurement data. Sending a diagnostic command also terminates the remote display mode, but it causes the counter to exit the measurement mode as well. Pressing the RESET/LOCAL key is another way of terminating the remote display mode, however, the key will cause the counter to exit the remote state and enter the local state. Any transition from the remote state to the local state, caused by the controller, will terminate the remote display mode as well.

3-149. If an error condition is generated while the instrument is in the remote display mode, the error message will be displayed just as in any other case. However, when the error is cleared, the counter will no longer be in the remote display mode; it will begin displaying the measurement data rather than the message contained in the LCD prior to the error condition.

### 3-150. DL Display Local

3-151. The display local command allows the user to terminate the remote display mode without changing the state of the counter in any other way. When the counter receives this command, it will clear the remote display message and begin displaying measurement data.

### 3-152. ID and SI Send Device ID

3-153. These two commands perform the same function. Whenever the counter receives either of

these two commands, it will send its ID to the controller. "HP 5386A" will be sent to the controller. The counter will wait until the device ID is read by the controller before it will resume taking measurements again.

### NOTE

The counter will not return a device ID when set to Channel B and no signal is applied to Channel B.

### 3-154. SE Send Error

3-155. When the send error command is received, the instrument will send the number of the detected error (there may be more than one) to the interface bus. We recommend the "SE" command be used in a string by itself.

### 3-156. LCD Character Set

3-157. *Table 3-10* shows the characters the instrument can produce. Included in the table is the code needed to produce the character and how the displayed character will look.

### 3-158. PROGRAM EXAMPLES

3-159. The following examples demonstrate programming capabilities of the HP 5386A. The four examples are written for the HP-85A controller. A summary of the program operation and a line-by-line description are provided for each example.

- Example 1 Instrument Identification
- Example 2 Reading Status Byte
- Example 3 Frequency A
- Example 4 Remote Display



### EXAMPLE 1. INSTRUMENT IDENTIFICATION

The following example demonstrates how to display the identification address of the counter on the display screen of the controller. The program clears the HP 5386A then requests the instrument identification. The response is read into "N\$", which is then displayed.

#### PROGRAM

```
10 REM Example #1: INSTRUMENT IDENTIFICATION
20 CLEAR @ DISP USING "5/"
30 DISP "Searching for 5386A address . . ." @ DISP
40 N$="NOT 5386A"
50 FOR S=700 TO 730
60 IF S=721 THEN 140
70 DISP S @ BEEP 250,75
80 SET TIMEOUT 7;100
90 OUTPUT S ; "ID"
100 ENTER S ; N$
110 IF N$="HP5386A" THEN 230
120 CLEAR S
130 ABORTIO 7
140 NEXT S
150 BEEP 200,200
160 CLEAR @ DISP USING "5/"
170 DISP "Address not found." @ DISP
180 DISP "Verify HP-IB connection and that the 5386A is not in the TALK"
190 DISP "ONLY mode."
200 DISP @ DISP "Press 'CONT' when ready."
210 PAUSE
220 GOTO 20
230 DISP @ BEEP @ DISP "HP 5386A FOUND AT ADDRESS";S;"!"
240 END
```

#### PROGRAM DESCRIPTION

- Line 10 Remarks; comments only, does not affect the program.
- Line 20 Clears the controller display only and places the cursor near the middle of the controller display screen.
- Line 30 Message inside quotes is displayed on controller display screen and the cursor skips one line.
- Line 40 Set "N\$" equal to "not 5386A".
- Line 50 Loop "S" from address 700 to 730
- Line 60 If instrument value = 721 (calculator address) then go to line 140.
- Line 70 Display instrument address and beep. The number "75" determines the length of time of the beep and "250" determines the pitch.
- Line 80 Set time out on address 7 to 100 ms.
- Line 90 Send "ID" command to instrument with address = to "S".
- Line 100 Read instrument "ID" response into "N\$".
- Line 110 If contents of "N\$" equals "5386A", then jump to line 230.
- Line 120 Clear instrument at address "S".
- Line 130 Terminates any data transfer on address 7.
- Line 140 Increment to next address.
- Line 150 Beep.
- Line 160 Clears controller display only and places the cursor near the middle of the controller display.
- Line 170 Display string within quotes on the controller display and skip on line.
- Line 180 Display string within quotes on controller screen.
- Line 190 Display string within quotes on controller screen.
- Line 200 Skip one line and display string within quotes on controller display.
- Line 210 Halt program until user presses "CONT".
- Line 220 Go to line 20.
- Line 230 Skip a line, beep and display string within quotes and the address of HP 5386A.
- Line 240 End program execution.



## EXAMPLE 2. READING STATUS BYTE

The following example reads the status byte of the HP 5386A by a serial poll at address 03. The value returned is input into "A". The program first displays the status byte prior to the error condition. After the error condition is generated by sending an illegal command "FU5", the program again displays the status byte of a different value.

### PROGRAM

```

10 REM Example #2: READING STATUS BYTE
20 S=703
30 CLEAR @ DISP USING "3/"
40 OUTPUT S ; "SM5"
50 A=SPOLL(S)
60 DISP "The value of the status byte prior to the error condition is"
70 DISP "equal to";A;","
80 DISP
90 DISP "press 'CONT' to generate an SRQ and alter the status byte value."
100 DISP @ PAUSE
110 BEEP
120 OUTPUT S ; "FU5"
130 A=SPOLL(S)
140 DISP "The value of the status byte after the error condition is"
150 DISP "equal to";A;","
160 END

```

### PROGRAM DESCRIPTION

Line 10 Remarks; comments only, does not affect the program.

Line 20 Set "S" = to 703.

Line 30 Clears the controller display only and the cursor skips three lines. The reason for skipping 3 lines is simply to bring the cursor near the middle of the display screen.

Line 40 Send service request mask to HP 5386A at address equal to "S" for error or failure condition or data ready condition.

Line 50 Read status of HP 5386A (into A) by a serial poll at address equal to "S".

Line 60 Display message within quotes.

Line 70 Display message within quotes and the status byte.

Line 80 Skip one line on controller screen.

Line 90 Display message within quotes.

Line 100 Skip one line on controller screen and halt program execution until user presses "CONT".

Line 110 Beep.

Line 120 Output "FU5" command to HP 5386A at address "S" ("FU5" will generate an error condition).

Line 130 Read the status of HP 5386A (into A) by a serial poll at address "S".

Line 140 Display message within quotes.

Line 150 Display message within quotes and status byte.

Line 160 End program execution.



### EXAMPLE 3. FREQUENCY A

The following example demonstrates how to display a Frequency A measurement on the controller display screen. The address is set to 03 and the "IN" command is sent to the HP 5386A. The response is read into "A\$", which is then displayed.

#### PROGRAM

```
10 REM Example #3: FREQUENCY A
20 S=703
30 OUTPUT S ;"IN"
40 ENTER S ; A$
50 DISP "FREQUENCY A ="; A$|2|
60 GOTO 30
70 END
```

#### PROGRAM DESCRIPTION

Line 10 Remarks; comments only, does not affect the program.  
Line 20 Set "S" equal to 703.  
Line 30 Output "IN" command to HP 5386A at address "S".  
Line 40 Read HP 5386A response into "A\$".  
Line 50 Display "Frequency A="; followed by the contents of the second character onward of "A\$".  
Line 60 Go to line 30.  
Line 70 End program execution.

### EXAMPLE 4. REMOTE DISPLAY

The following example demonstrates how to send messages to the display of the counter. The program sets the address to 03 then sends a message to the display of the counter.

#### PROGRAM

```
10 REM Example #4: REMOTE DISPLAY
20 S=703
30 OUTPUT S ;"DR HP 5386A"
40 END
```

#### PROGRAM DESCRIPTION

Line 10 Remarks; comments only, does not affect the program.  
Line 20 Set "S" equal to 703.  
Line 30 Send remote display message (HP 5386A) to instrument at address "S".  
Line 40 End program execution.



Table 3-10. LCD Character Set

LCD CHAR.	ASCII CHAR.	DECIMAL	LCD CHAR.	ASCII CHAR.	DECIMAL	LCD CHAR.	ASCII CHAR.	DECIMAL
	NULL, @	0, 64		SYNC, V	22, 86		,	44
	SOH, A	1, 65		ETB, W	23, 87		—, m	45, 109
	STX, B	2, 66		CAN, X	24, 88		.	46,
	EXT, C	3, 67		EM, Y	25, 89		/, o	47, 111
	EOT, D	4, 68		SUB, Z	26, 90		0, p	48, 112
	ENQ, E	5, 69		ESC,	27, 91		1, q	49, 113
	ACK, F	6, 70		FS, \	28, 92		2, r	50, 114
	BELL, G	7, 71		GS,	29, 93		3, s	51, 115
	BS, H	8, 72		RS, ^	30, 94		4, t	52, 116
	HT, I	9, 73		US, _	31, 95		5, u	53, 117
	LF, J	10, 74	space	space, `	32, 96		6, v	54, 118
	VT, K	11, 75		!, a	33, 97		7, w	55, 119
	FF, L	12, 76		", b	34, 98		8, x	56, 120
	CR, M	13, 77		#, c	35, 99		9, y	57, 121
	SO, N	14, 78		\$, d	36, 100		z	122
	SI, O	15, 79		%, e	37, 101		:	58, 122
	DLE, P	16, 80		&, f	38, 102		;	59, 123
	DC1, Q	17, 81		', g	39, 103		<,	60, 124
	DC2, R	18, 82		(, h	40, 104		=, }	61, 125
	DC3, S	19, 83		), i	41, 105		>, ~	62, 126
	DC4, T	20, 84		*, j	42, 106		?, DEL	63, 127
	NAK, U	21, 85		+, k	43, 107		l	108
							n	110





## SECTION IV PERFORMANCE TESTING

### 4-1. INTRODUCTION

4-2. The procedures in this section provide two types of tests. First, a complete performance test for the HP 5386A Frequency Counter. They can be performed without access to the interior of the instrument. The second test is an HP-IB verification test using the HP85A controller and a test tape.

### 4-3. EQUIPMENT REQUIRED

4-4. Equipment required for complete test and operation verification is listed in *Table 1-2*. Any equipment which satisfies the critical specifications given in the table may be substituted for the recommended model numbers.

### 4-5. TEST RECORD

4-6. Results of the complete performance test should be recorded on a copy of the Performance Test Card at the end of this section.

### 4-7. ERROR MESSAGES

4-8. Under certain conditions the counter will display Error messages. Error messages typically occur during the power-up, initialize cycle. These messages indicate a hardware failure or the user has attempted an improper operation, either through the keyboard or the interface.

### 4-9. PERFORMANCE TEST

4-10. The performance test is given in *Table 4-1*. The performance test verifies all specifications listed in *Table 1-1*. All tests can be performed without access to the interior of the instrument.

### 4-11. HP-IB VERIFICATION TEST TAPE

4-12. A verification test program using an HP-85A controller is available for the functional verification of the HP 5386A. The program primarily tests the HP-IB commands and the interface bus. The part number for ordering the test tape is 59300-10002.

Table 4-1. Performance Test

#### I. POWER-UP CHECK

##### Description:

The HP 5386A Frequency Counter power is set to STBY, then on. The counter will be cycled through its power-up, initialize subroutine. This test is performed with no external time base signal applied to the counter. A test is made of all the major function blocks, then goes to its initialize state.

##### a. Set-up:

Insure that no cables are connected to input A or to the interface connector. Cycle the POWER switch from STBY to ON.

##### b. Verify the following:

1. A display "starburst" is shown in all 12-character positions for about one second.
2. The selected address of the instrument interface is displayed for about one second.
3. The display shows "00000000" and an arrow appears over the "A" for "A" channel.

##### c. Record the result on the test card (Pass/Fail).

#### II. CHANNEL A FREQUENCY RESPONSE AND SENSITIVITY TEST

##### Description:

A signal generator with a calibrated output is set to the specified HP 5386A channel A minimum signal sensitivity level. The frequency is 10 Hz, 50 Hz and 100 MHz. The HP 5386A reading is checked for the proper count. For the range of 20 MHz to 100 MHz, a different generator is used.

Specifications: 10 Hz to 100 MHz:

15 mV rms, sinewave, 10 Hz to 100 MHz

a. 10 Hz

1. Connect the HP 3325A synthesizer/function generator to the HP 5386A channel A input as shown in *Figure 4-1*.
2. Select a 1 second gate time on the HP 5386A.
3. Turn the 100 kHz filter on by pressing the FILTER key.
4. Increase the resolution of the HP 5386A until there are 7 digits of resolution beyond the decimal point.
5. Set the HP 3325A to output a 10 Hz sinewave at 15 mV rms. Verify the HP 5386A displays 10.0000000 Hz  $\pm$ 5 milliHertz. Record the results on the test card (Pass/Fail).

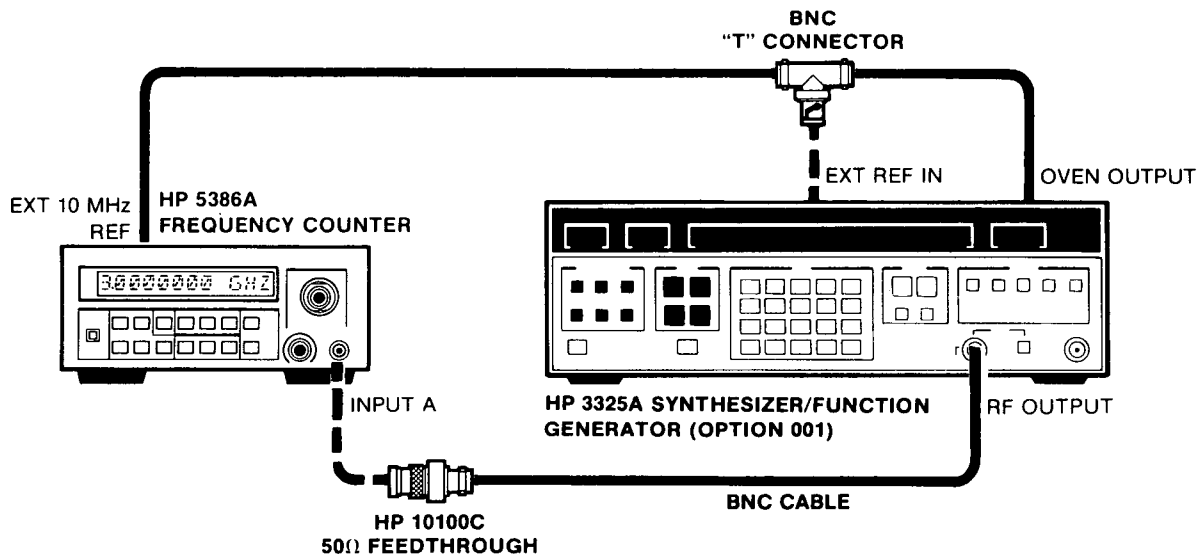


Figure 4-1. Channel A Frequency Response and Sensitivity Test Setup (HP 5386A)

**NOTE:** Dashed lines in figure define a direct connection without cabling.

b. 50 Hz

1. Use the same set-up shown in *Figure 4-1*.
2. Set the HP 3325A to output a 50 Hz sinewave at 15 mV rms. Verify the HP 5386A displays 50.0000000 Hz  $\pm$  5 milliHertz. Record the results on the test card (Pass/Fail).

c. 100 MHz

1. Connect the HP 8656A Signal Generator to the HP 5386A channel A input as shown in Figure 4-2.
2. Set the HP 8656A to output a 100 MHz sinewave at 15 mVrms.
3. Turn off the 100 kHz filter by pressing the FILTER Key.
4. Verify the counter displays 100.0000000 MHz  $\pm$  0.4 Hz.
5. Record the results on the test card.

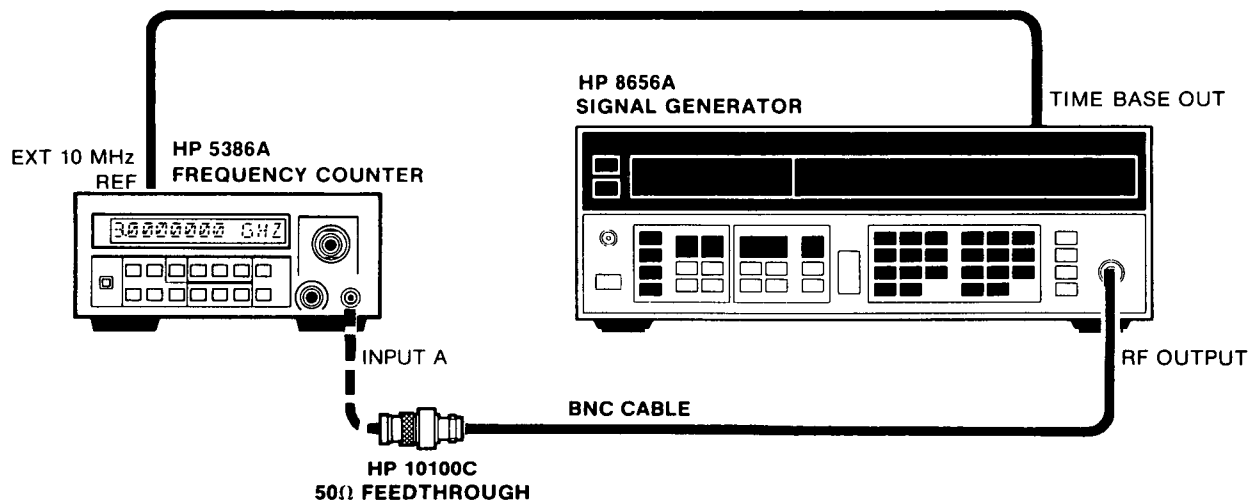


Figure 4-2. Channel A Frequency Response and Sensitivity Test Setup for HP 5386A

**NOTE:** Dashed lines in figure define a direct connection without cabling.

### III. CHANNEL B FREQUENCY RESPONSE AND SENSITIVITY TEST FOR HP 5386A

**Description:**

A signal generator is connected through a power splitter to the HP 5386A channel B input and to a power meter. The signal generator is set to 90 MHz, 1 GHz, and 3 GHz while maintaining the specified signal level. The counter should display the correct frequencies.

**Specifications:**

15 mV rms (−23.5 dBm) sine wave, 90 MHz to 3000 Mhz

a. 90 MHz

1. Connect the HP 8340 Synthesized Sweeper and the power meter to the HP 5386A channel B input as shown in Figure 4-3.

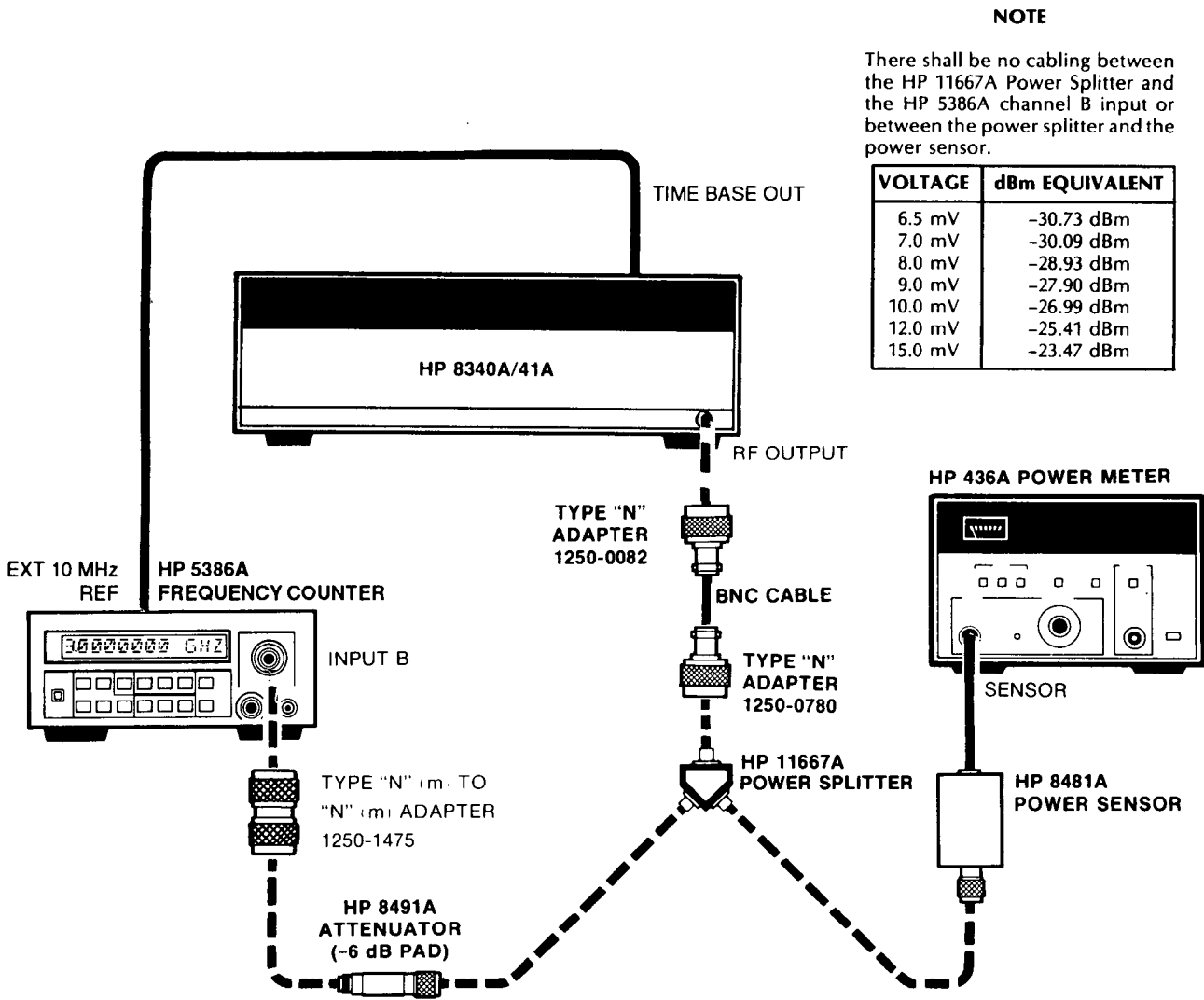


Figure 4-3. Channel B Frequency Response and Sensitivity Test Setup for HP 5386A

**NOTE:** Dashed lines in figure define a direct connection without cabling.

2. Set the HP 8340A Synthesized Sweeper so that the HP 436A Power Meter reads  $-17.5$  dBm at 90 MHz. Increase the frequency of the signal generator while maintaining a  $-17.5$  dBm reading on the power meter. Verify the HP 5386A displays  $90.0000000$  GHz  $\pm 0.4$  Hz. Record the results on the test card (Pass/Fail).
- b. 1 GHz
  1. Set the HP 8340A Synthesized Sweeper so the power meter reads  $-17.5$  dBm at 1 GHz. Verify the HP 5386A displays  $1.0000000$  GHz  $\pm 4$  Hz. Record the results on the test card (Pass/Fail).
- c. 3 GHz
  1. Connect the HP 8340A Synthesized Sweeper and power meter as shown in Figure 4-3.
  2. Set the HP 8340A Synthesized Sweeper so the power meter reads  $-17.5$  dBm at 3 GHz. Verify the HP 5386A displays  $3.0000000$  GHz  $\pm 20$  Hz.
  3. Record the results on the test card (Pass/Fail).

#### IV. PERIOD A TEST

**Description:**

A signal generator with a calibrated output drives channel A of the HP 5386A under test. The counter is set to measure the period of the signal. The HP 5386A should display the proper count.

Specifications: 10 nanoseconds to 0.1 seconds (100 MHz to 10 Hz)

- a. Connect the HP 3325A synthesizer/function generator to the HP 5386A Channel A input as shown in Figure 4-4.

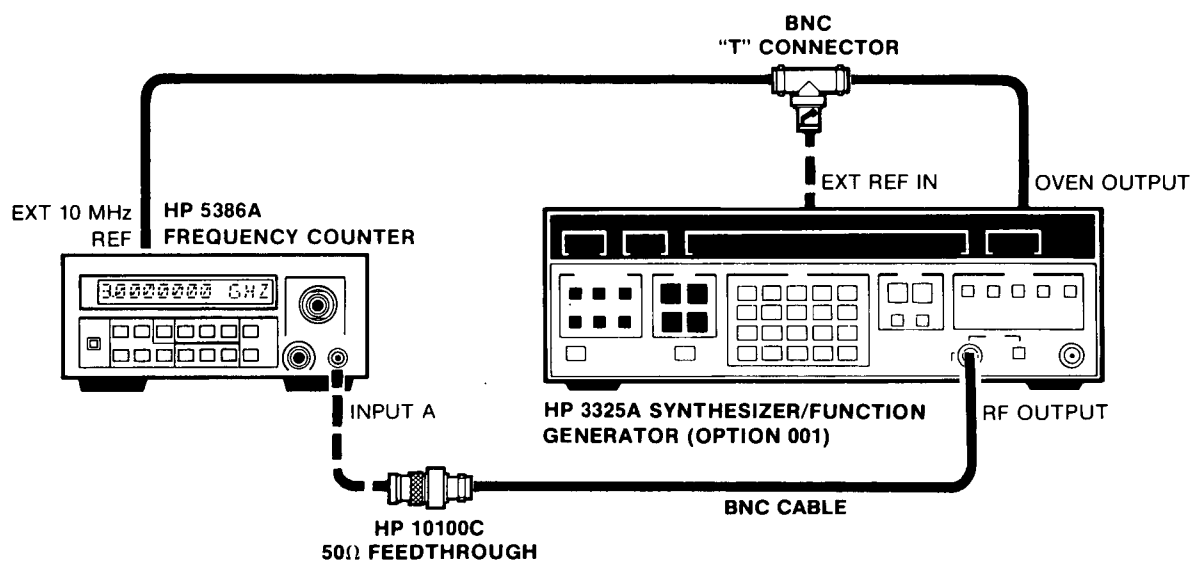


Figure 4-4. Period A Test Setup

**NOTE:** Dashed lines in figure define a direct connection without cabling.

- b. Set the counter power switch from STBY to ON and select PERIOD A. Set the GATE time to 1.0 seconds.
- c. Set the HP 3325A synthesizer to 10 Hz at 100 mV rms output.
- d. Verify the counter displays 100.00000 milliseconds  $\pm 70$  microseconds. Record the results on the test card (pass/fail).

#### V. CHANNEL A FILTER AND ATTENUATOR TEST

**Description:**

A signal generator with a calibrated output drives the channel A of the HP 5386A under test. The counter is set up for its Frequency A function, and the channel A filter is exercised at frequencies below and above its normal 3 dB point. The channel A attenuator is also exercised. The counter should display the proper frequencies.

Specifications:

Low Pass Filter, 100 kHz, nominal at 3 dB point.  
X1 or X20, nominal, selectable.

Perform the following steps to use the Channel A Filter and Attenuator tests.

- a. Set the counter POWER switch from STBY to ON; set the gate time to 1.0 seconds.
- b. Connect the HP 3325A Synthesizer/Function Generator to the HP 5386A Channel A input as shown in Figure 4-5.

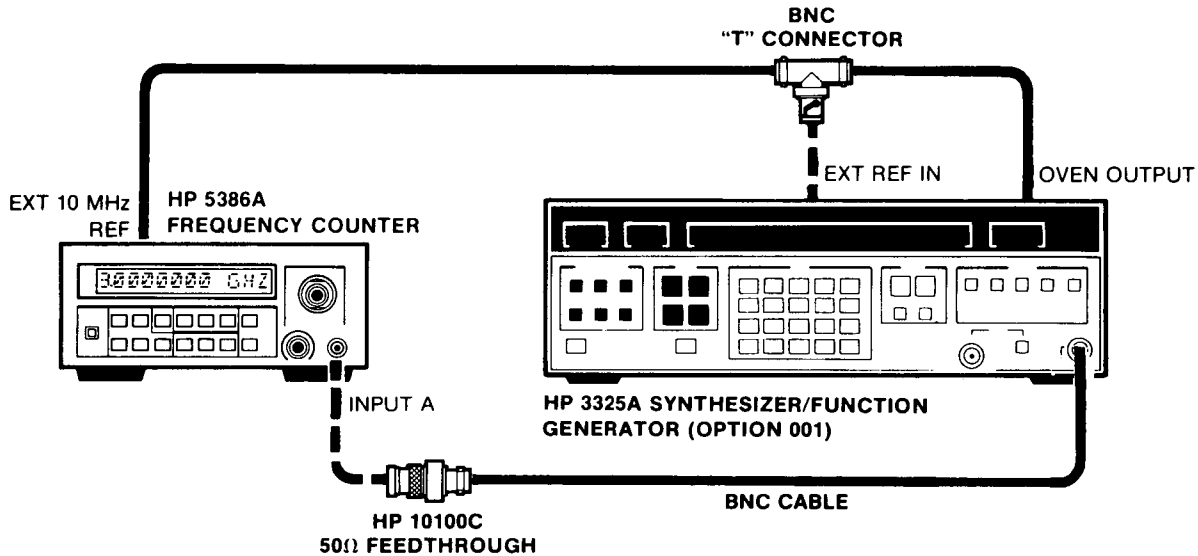


Figure 4-5. Channel A Filter and Attenuator Test Setup

- c. Press the 1 second gate time Key.
- d.
  1. Set the HP 3325A to output a 50 kHz sinewave at 15 mV rms.
  2. Verify that the counter displays  $50.000000K \pm 3$  milliHertz, with a continuous indication above "A" and a flashing indicator above "GATE" on the front panel.
  3. Enable the channel A FILTER function; observe that the HP 5386A display has not changed and an indicator arrow appears in the display above the "FILT" label on the front panel.
  4. Disable the FILTER function.
- e.
  1. Set the HP 3325A to output a 10 MHz sinewave at 100 mV rms.
  2. Verify counter displays  $10.0000000 \pm 10$  milliHertz.
  3. Enable the channel A FILTER function; observe that the counter displays all zeros.
  4. Disable the FILTER function and observe that the counter displays  $1.00000000 \text{ MHz} \pm 10$  milliHertz.
  5. Record the results on the test card (Pass/Fail).
- f.
  1. Enable the channel A X20 ATTENUATOR; observe the HP 5386A display showing eight zeros with indicators above "ATTN" and "A" only. Disable the X20 ATTN function, and observe the counter displaying the same value as in step e. Record the results on the test card (Pass/Fail).

**PERFORMANCE TEST RECORD**

<b>HEWLETT-PACKARD MODEL 5386A FREQUENCY COUNTER</b>		Repair/Work Order No. _____
Serial Number: _____	Temperature: _____	
Test Performed By: _____	Relative Humidity: _____	
Date: _____	Post Calibration Test: <input type="checkbox"/>	
Notes: _____	Pre Calibration Test: <input type="checkbox"/>	

PARAGRAPH NUMBER	TEST	RESULTS	
		YES	NO
I.	<b>POWER-UP CHECK</b> "Starburst" Displayed All Positions Selected Address Displayed 8 Zeroes and Arrow Over "A" Channel Displayed	_____ _____ _____	_____ _____ _____
		<b>MINIMUM</b>	<b>ACTUAL</b>
II.	<b>CHANNEL A FREQUENCY RESPONSE AND SENSITIVITY TEST</b>  10 Hz @ 15 mV rms 50 Hz @ 15 mV rms 90 MHz @ 15 mV rms	9.9950000 49.9950000 89.9999996	_____ _____ _____ 10.0050000 50.0050000 90.0000004
III.	<b>CHANNEL B FREQUENCY RESPONSE AND SENSITIVITY TEST</b>  90 MHz @ -17.5 dBm* 1 GHz @ -17.5 dBm* 3 GHz @ -17.5 dBm*  * Power Meter Display	89.9999996 .99999996 2.99999998	_____ _____ _____ 90.0000004 1.00000004 3.00000002
IV.	<b>PERIOD A TEST</b>  100.00000 milliseconds	99.93000	_____ 100.07000
			<b>YES</b>
V.	<b>CHANNEL A FILTER AND ATTENUATOR TEST</b>  50 kHz @ 15 mVrms Filter Enabled, 50 kHz and "FILT" Arrow Displayed Counter Displays 10 MHz @ 100 mV rms Display all zeroes, Filter Enabled Counter Displays 10 MHz @ 100 mVrms X20 ATTENUATOR Enabled — Display 8 Zeroes X20 ATTENUATOR Disabled — Display 10 MHz		<b>NO</b> _____ _____ _____ _____ _____ _____ _____



## SECTION V ADJUSTMENTS

### 5-1. INTRODUCTION

5-2. This section describes the adjustments required to maintain the HP 5386A operating characteristics within specifications. Adjustments should be made when required, such as after a performance test failure or when components are replaced that may affect an adjustment.

5-3. *Table 5-1* lists the adjustment procedures, in the recommended order of performance, and indicates the adjustable components involved.

### 5-4. EQUIPMENT REQUIRED

5-5. The test equipment required for the adjustment procedures is listed in *Table 1-4*, Recommended Test Equipment. Substitute instruments may be used if they meet the critical specifications.

### 5-6. ADJUSTMENT LOCATIONS

5-7. Adjustment locations are identified in the procedure for each adjustment.

### 5-8. SAFETY CONSIDERATIONS

5-9. This section contains warnings that must be followed for your protection and to avoid damage to the instrument.

**WARNING**

**MAINTENANCE DESCRIBED HEREIN IS PERFORMED WITH POWER SUPPLIED TO THE INSTRUMENT AND PROTECTIVE COVERS REMOVED. SUCH MAINTENANCE SHOULD BE PERFORMED ONLY BY SERVICE-TRAINED PERSONNEL WHO ARE AWARE OF THE HAZARDS INVOLVED (FOR EXAMPLE, FIRE AND ELECTRICAL SHOCK), WHERE MAINTENANCE CAN BE PERFORMED WITHOUT POWER APPLIED, SHOULD BE REMOVED.**

**BEFORE ANY REPAIR IS COMPLETED, ENSURE THAT ALL SAFETY FEATURES ARE INTACT AND FUNCTIONING, AND THAT ALL NECESSARY PARTS ARE CONNECTED TO THEIR PROTECTIVE GROUNDING MEANS.**

*Table 5-1. Adjustments*

ASSEMBLY	ADJUSTMENT	COMMENTS
A1 Motherboard	A1R1	HP 5386A +3 Vdc Adjustment
A1 Motherboard	A1R38	HP 5386A Channel A Input Amplifier Adjustment
A1 Motherboard	Y1A	TCXO Oscillator Adjustment
A1 Motherboard	Y1B	Oven Oscillator Adjustment

### 5-10. HP 5386A ADJUSTMENT PROCEDURES

#### 5-11. HP 5386A +3 Volt dc Adjustment Procedure

5-12. The only voltage supply in the HP 5386A that requires adjustment is the +3 Volts. To perform this adjustment, proceed as follows:

- a. Switch the counter from STBY to ON.
- b. Connect the positive terminal of the DVM to TP3 and the negative terminal to chassis ground at the ground test pin.
- c. Adjust A1R1 for a DVM reading of 3.00 Volts,  $\pm 30$  mV.
- d. Switch the counter from ON to STBY. Disconnect the test equipment.

#### 5-13. HP 5386A Channel A Input Amplifier Adjustment Procedure

5-14. To perform the sensitivity adjustment, proceed as follows:

- a. Remove the HP 5386A top and bottom covers; locate variable resistor A1R38 as shown in *Figure 5-1*, Assembly Adjustment Locator.
- b. Cycle the power switch from STBY to ON. Allow 30 minutes warm-up time.
- c. Connect the HP 8656A Signal Generator as shown in *Figure 5-2*.
- d. Set the HP 8656A to output a 10 MHz sinewave at 10 mV rms.

e. Connect the HP 1740A oscilloscope probe at U10 Pin 14. See *Figure 5-1* for probe connection point.

f. Adjust A1R38 for a 50/50 duty cycle. Refer to the waveform in *Figure 5-3*.

g. Vary the frequency of the signal generator from 10 MHz to 100 MHz, and verify that the counter shows a stable display throughout.

h. Connect a suitable generator (such as the HP 3325A) to input A that can provide a 15 mV rms sine wave between 10 Hz and 50 Hz. Vary the generator frequency between 10 Hz and 50 Hz and verify that the displayed counts are stable.

i. Adjustments are complete. Disconnect equipment.

## 5-15. Oscillator Adjustment Procedures

### 5-16. TCXO Adjustment Procedure

5-17. Two procedures are given for the adjustment of the TCXO (Temperature compensated Crystal Oscillator). If the operation of the counter will be solely at 25°C (77°F), then adjust the oscillator frequency as close as possible to 10 MHz using the procedure in paragraph 5-18. If the operation of the counter will be over the full temperature range (0°C to 40°C) then the TCXO must be offset by the amount labeled on its cover to keep the TCXO frequency within the manufacturers frequency specifications over the temperature range of 0°C to 40°C. In this case use the procedure in paragraph 5-19. The TCXO is factory set for use near 25°C.

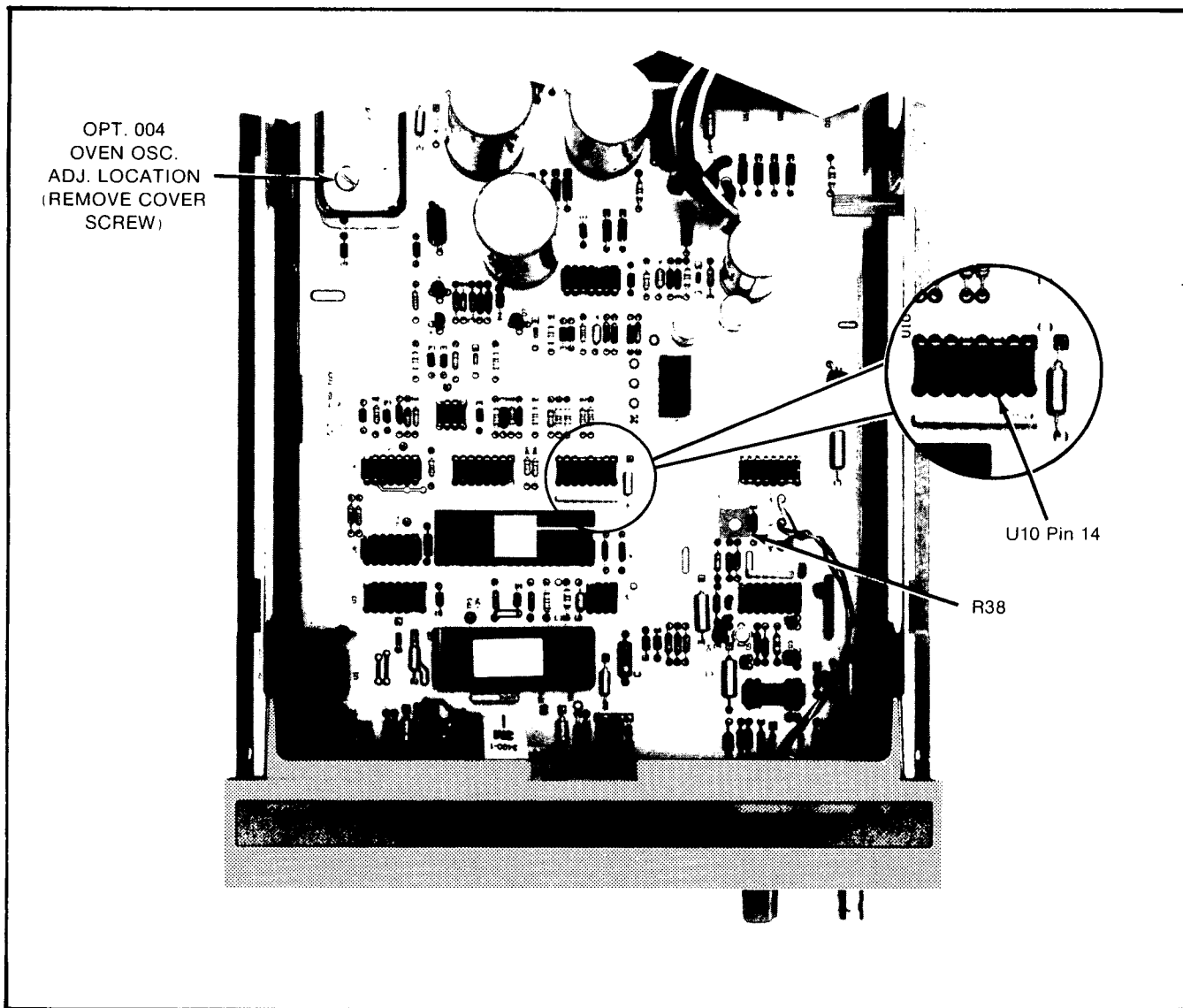


Figure 5-1. Assembly Adjustment Locator

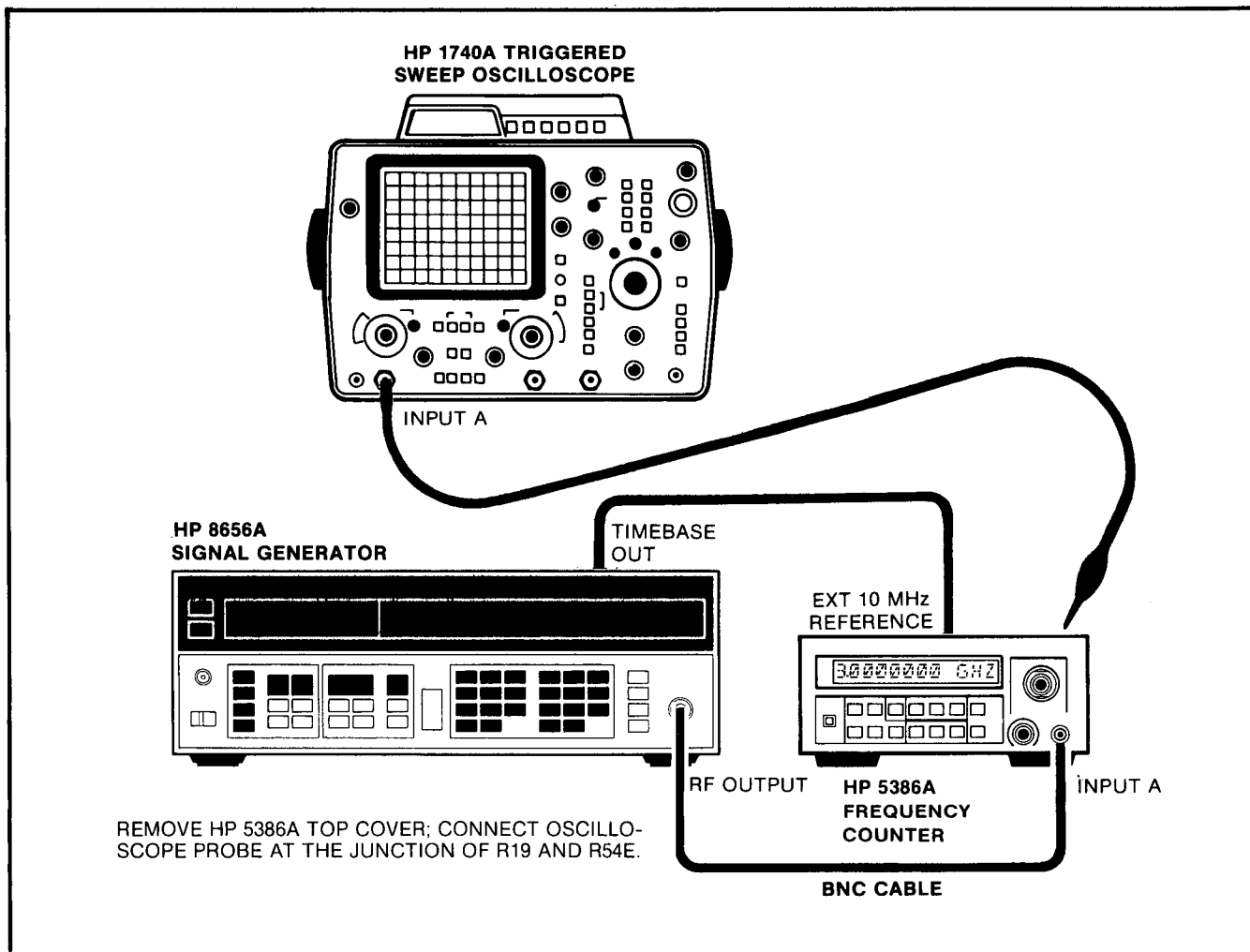


Figure 5-2. Channel A Input Amplifier Adjustment Setup

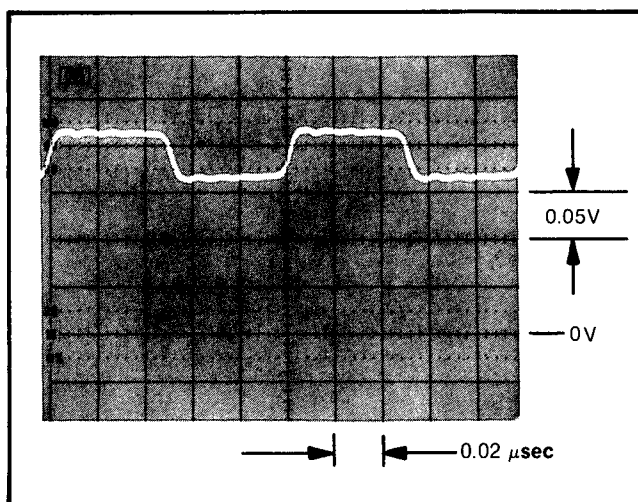


Figure 5-3. Input Amplifier Adjustment Waveform

5-18. Adjustment of the TCXO at 25°C

**NOTE**

Allow 30 minutes warm-up time for the counter.

- a. Connect a house standard (reference frequency) to the EXT TRIGGER input of an HP 1740A oscilloscope as shown in Figure 5-4. Set the HP 1740A oscilloscope to EXT (trigger).
- b. Connect the HP 5386A rear panel 10 MHz REFERENCE IN OUT to the channel A input of the HP 1740A oscilloscope as shown in Figure 5-5.
- c. Select INT with the 10 MHz REFERENCE INT EXT select switch on the rear of the instrument (see Figure 5-5).

d. Adjust the frequency for minimum sideways movement of the 10 MHz signal with the OSC ADJ located on the rear of the instrument (see Figure 5-5).

e. By timing the sideways movement (in cm/second), the approximate offset can be determined based on the HP 1740A oscilloscope sweep speed as shown in Table 5-2.

f. This completes the adjustment of the standard oscillator or the TCXO for use near 25°C.

Table 5-2. Approximate Offset Determination Table

MOVEMENT	SWEEP SPEED			NOTES
	1 $\mu$ s/cm	0.1 $\mu$ s/cm	0.01 $\mu$ s/cm	
1cm/s	1 $\times$ 10 <sup>-6</sup>	1 $\times$ 10 <sup>-7</sup>	1 $\times$ 10 <sup>-8</sup>	Time scope trace movement with seconds indicator of watch or clock
1cm/10s	1 $\times$ 10 <sup>-7</sup>	1 $\times$ 10 <sup>-8</sup>	1 $\times$ 10 <sup>-9</sup>	
1cm/1000s	1 $\times$ 10 <sup>-8</sup>	1 $\times$ 10 <sup>-9</sup>	1 $\times$ 10 <sup>-10</sup>	

5-19. Adjustment Of The TCXO With Offset (0° to 40°C).

a. To observe the offset stamped on the label of the TCXO, remove the top cover by removing the screw located at the rear of the top cover. Lift off the top.

b. Connect a house standard (reference frequency) to Channel A of the HP 5386A as shown in Figure 5-4.

c. Cycle the HP 5386A from STBY to ON. Press the DISPLAY DIGITS "up" ( ) key once.

**NOTE**

Allow 30 minutes warm-up time for the counter.

d. Adjust the TCXO frequency to 10 MHz  $\pm$  the offset labeled on the TCXO. For example, if the offset is +3.5 Hz (3.5 Hz above 10 MHz), then the TCXO should be adjusted so the 10 MHz input frequency appears to be 9.999965 MHz (which is 3.5 Hz below the TCXO frequency) on the counter display at a room temperature of 25°C.

e. Reinstall the covers; the TCXO offset adjustment is completed.

**5-20. Oven Oscillator Adjustment Procedure**

a. Remove the top cover by removing the screw located at the rear of the cover. Lift off the top.

b. The HP 5386A should now be allowed to operate for at least 30 minutes before proceeding with the oscillator adjustment.

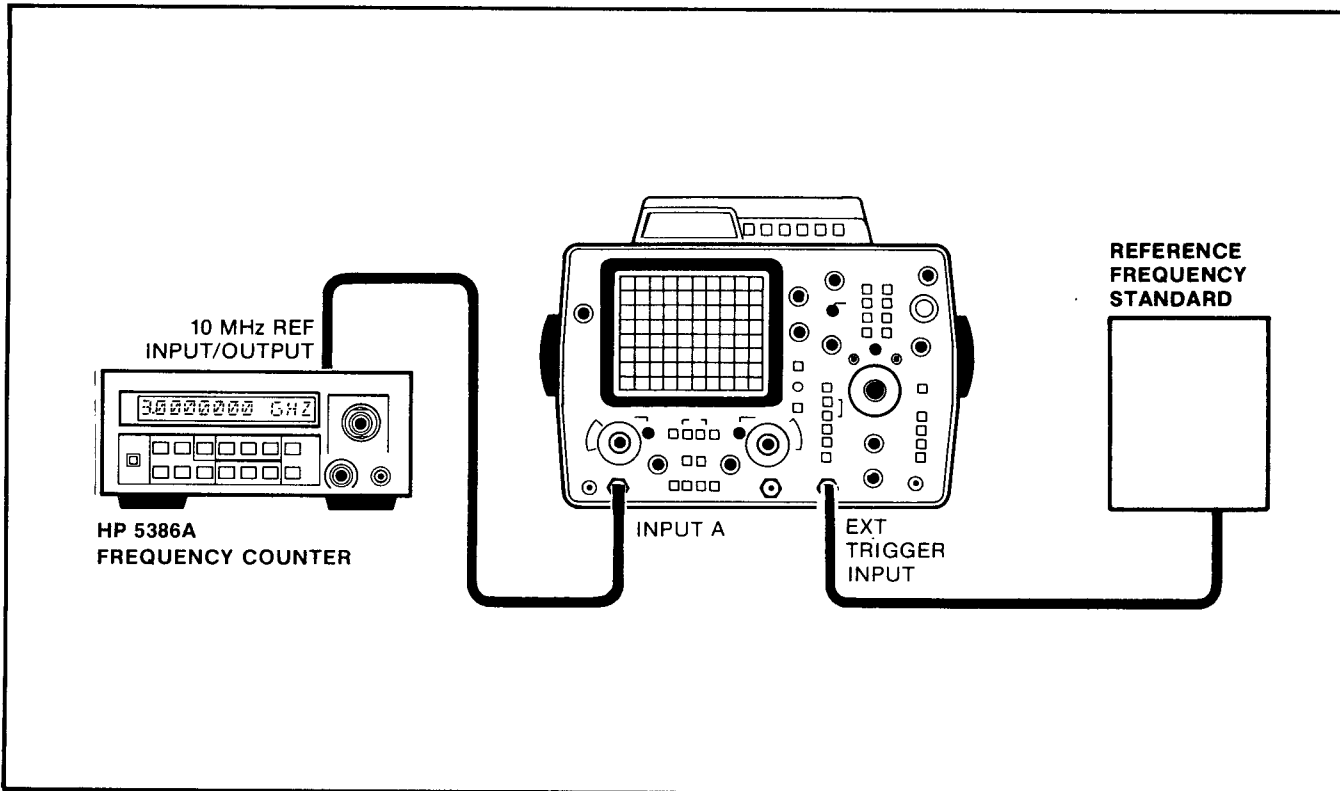


Figure 5-4. TCXO and Oven Oscillator Test Setup

c. Connect a house standard (reference frequency) to the EXT TRIGGER input of an HP 1740A oscilloscope as shown in *Figure 5-4*. Set the 1740A Oscilloscope to External Trigger.

d. Connect the HP 5386A rear panel 10 MHz REFERENCE IN OUT to the Channel A input of the HP 1740A oscilloscope as shown in *Figure 5-4*.

e. Access the oscillator adjustment screw by removing the screw on top of the oven oscillator. See *Figure 5-1* for adjustment location.

f. Turn the adjustment screw on the oven oscillator for minimum sideways movement of the signal on the oscilloscope.

g. By timing the sideways movement (in cm/second), the approximate offset can be determined based on the HP 1740A oscilloscope sweep speed as shown in *Table 5-2*.

h. Reinstall the screw on the oscillator. Install covers. Oven oscillator adjustment is complete.

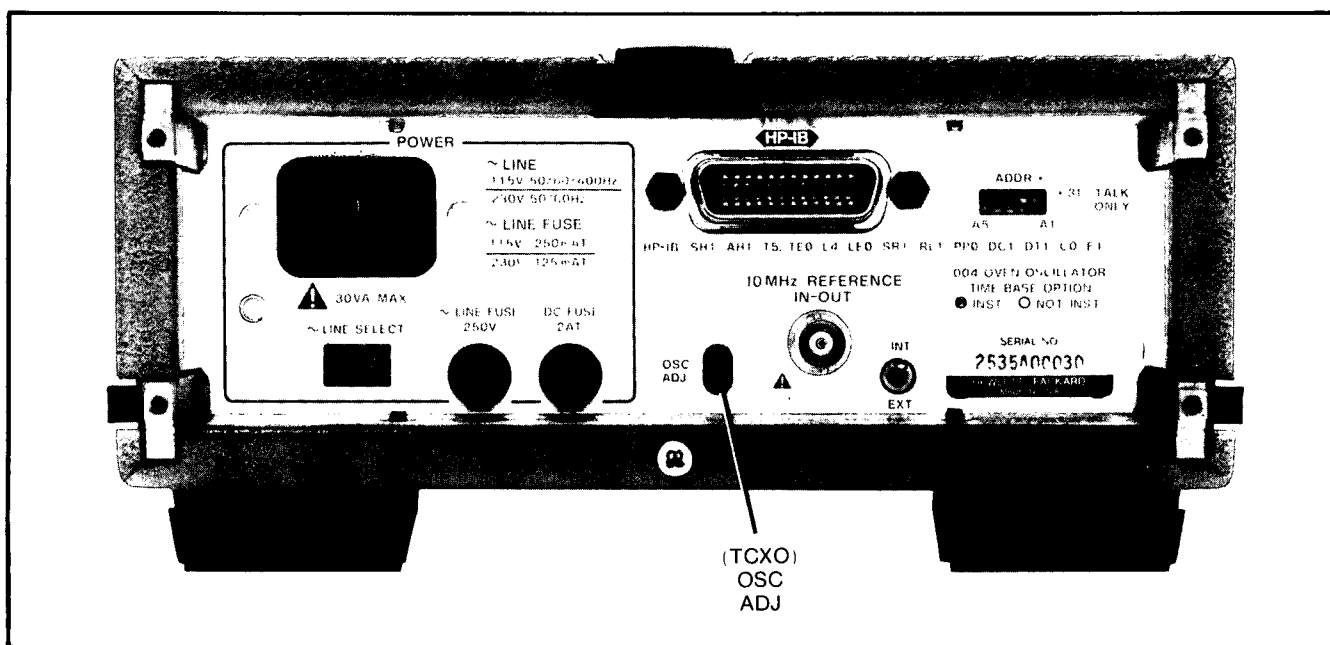


Figure 5-5. TCXO Oscillator Adjustment

## SECTION VI REPLACEABLE PARTS

### 6-1. INTRODUCTION

6-2. This chapter contains information for ordering parts. The following replaceable parts lists are included.

Table 6-1	Abbreviations and Reference Designations
Table 6-2	A1 Motherboard Assembly Replaceable Parts
Table 6-3	A2 Front Panel Display Assembly Replaceable Parts
Table 6-4	A3 Hybrid Assembly Replaceable Parts
Table 6-5	A5 HP-IB Assembly Replaceable Parts
Table 6-6	Replaceable Mechanical Parts
Table 6-7	Code List of Manufacturers

### 6-3. REFERENCE DESIGNATIONS

6-4. *Table 6-1* lists the abbreviations and reference designations used in the parts lists, block diagrams, and throughout the manual.

### 6-5. REPLACEABLE PARTS

6-6. *Tables 6-2 through 6-6* are lists of replaceable parts and are organized as follows:

1. Electrical assemblies in alphanumeric order by reference designation.
2. Chassis-mounted electrical parts in alphanumeric order by reference designation.
3. Chassis-mounted mechanical parts in alphanumeric order by reference designation.

6-7. The information given for each part consists of the following:

1. Reference Designation
2. Hewlett-Packard part number
3. Part number check digit (CD)
4. Total quantity (QTY) in instrument. The total quantity is given once and at the first appearance of the part number in the list.

5. Description of the part.

6. Typical manufacturer's part number for the part.

### 6-8. EXCHANGE ASSEMBLIES

6-9. The Channel B Pre-Scaler Assembly may be replaced on an exchange basis. Factory repaired and tested exchange assemblies are available only on a trade-in basis; therefore, the defective assemblies must be returned for credit. For this reason, assemblies required for spare parts stock must be ordered by the "new assembly" part number. The part numbers for the Pre-Scaler Assembly are listed below:

ASSEMBLY	NEW ASSEMBLY HP PART NO.	EXCHANGE ASSEMBLY HP PART NO.
A3 Channel B Pre-Scaler Assembly	05386-60102	05386-69102

### 6-10. HOW TO ORDER A PART

6-11. Hewlett-Packard wants to keep your parts ordering process as simple and efficient as possible. Think of the process as having the following steps:

- Identifying the part and the quantity that you want.
- Determining the ordering method to be used and contacting Hewlett-Packard.

### 6-12. Parts Identification

6-13. When ordering from Hewlett-Packard, the important numbers to note from the Parts List are the HP Part Number and part-number check digit (in the "CD" column), and the quantity of the part you want.

6-14. If the part you want is NOT identified in the manual, you can call on Hewlett-Packard for help (see the following section "Contacting Hewlett-Packard"). Please have the following information at hand when you contact HP for help:

- Instrument Model Number (example "HP 5386A").
- Complete instrument Serial Number (example "1234A56789"). Information about where to find the serial number is given in paragraph 1-24.

- Description of the part and its use.
- Quantity of the part required.

### 6-15. Contacting Hewlett-Packard

6-16. Depending on where you are in the world, there are one or more ways in which you can get parts or parts information from Hewlett-Packard.

- Outside the United States, contact your local HP sales office. HP sales offices are listed at the back of this manual.
- Within the United States, we encourage you to order replacement parts or request parts information directly by telephone or mail from the HP Support Materials Organization, using the telephone numbers or address listed below. (You can also contact your local HP sales office. HP sales offices are listed at the back of this manual.)

6-17. By telephone:

- For Parts Ordering, use our toll-free number (800) 227-8164, Monday through Friday (except Holidays), 6 am to 5 pm (Pacific Time).

- If you need a part in a hurry, an extra-cost Hotline phone ordering service is available, 24 hours a day. Use the toll free number above at the times indicated; at other times, use (415) 968-2347.

- For Parts Identification Assistance, call us at (916) 783-0804. Our Parts Identification hours are from Monday through Friday, 6 am to 5 pm (Pacific Time).

- For mail correspondence, use the address below:

Hewlett-Packard  
Support Materials Roseville  
P.O. Box 1145  
Roseville, CA 95661-1145

### 6-18. CABINET PARTS AND HARDWARE

6-19. To locate and identify miscellaneous cabinet parts, refer to *Figure 6-1*. This figure provides an exploded view of the cabinet parts identified by reference designations; the reference designations correspond with the ones in *Table 6-6*.

Table 6-1. Reference Designations and Abbreviations

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

ABBREVIATIONS			
A	= ampere	HDW	= hardware
ac	= alternating current	HF	= high frequency
ACCESS	= accessory	HG	= mercury
ADJ	= adjustment	HI	= high
A/D	= analog-to-digital	HP	= Hewlett-Packard
AF	= audio frequency	HPF	= high pass filter
AFC	= automatic frequency control	HR	= hour (used in parts list)
AGC	= automatic gain control	HV	= high voltage
AL	= aluminum	Hz	= hertz
ALC	= automatic level control	IC	= integrated circuit
AM	= amplitude modulation	ID	= inside diameter
AMPL	= amplifier	IF	= intermediate frequency
APC	= automatic phase control	IMPG	= impregnated
ASSY	= assembly	IN	= inch
AUX	= auxiliary	INCD	= incandescent
AVG	= average	INCL	= include(s)
AWG	= american wire gauge	INP	= input
BAL	= balance	INS	= insulation
BCD	= binary-coded decimal	INT	= internal
BD	= board	kg	= kilogram
BE CU	= beryllium copper	kHz	= kilohertz
BFO	= beat frequency oscillator	kV	= kilovolt
BH	= binder head	lb	= pound
BKDN	= breakdown	LC	= inductance-capacitance
BP	= bandpass	LED	= light-emitting diode
BPF	= bandpass filter	LF	= low frequency
BRS	= brass	LG	= long
BWO	= backward wave oscillator	LH	= left hand
CAL	= calibrate	LIM	= limit
ccw	= counterclockwise	LIN	= linear taper (used in parts list)
CER	= ceramic	lin	= linear
CHAN	= channel	LK WASH	= lock washer
cm	= centimeter	LO	= low; local oscillator
CMO	= cabinet mount only	LOG	= logarithmic taper (used in parts list)
COEF	= coefficient	log	= logarithmic
COM	= common	LPF	= low pass filter
COMP	= composition	LV	= low voltage
COMPL	= complete	m	= metre (distance)
CONN	= connector	mA	= milliampere
CP	= cadmium plate	MAX	= maximum
CRT	= cathode ray tube	MΩ	= megohm
CTL	= complementary transistor logic	MEG	= meg (10 <sup>6</sup> ) (used in parts list)
CW	= continuous wave	MET FILM	= metal film
cw	= clockwise	MET OX	= metal oxide
dBA	= digital-to-analog	MF	= medium frequency;
dB	= decibel	MFR	= manufacturer
dBm	= decibel referred to 1mW	mg	= milligram
dc	= direct current	MHz	= megahertz
deg	= degree (temperature interval or difference)	mH	= millihenry
...°	= degree (plane angle)	mho	= conductance
°C	= degree Celsius (centigrade)	MIN	= minimum
°F	= degree Fahrenheit	min	= minute (time)
°K	= degree Kelvin	...	= minute (plane angle)
DEPC	= deposited carbon	MINAT	= miniature
DET	= detector	mm	= millimeter
diam	= diameter	MOD	= modulator
DIA	= diameter (used in parts list)	MOM	= momentary
DIFF AMPL	= differential amplifier	MOS	= metal-oxide semiconductor
div	= division	ms	= millisecond
DPDT	= double-pole, double-throw	MTG	= mounting
DR	= drive	MTR	= meter (indicating device)
DSB	= double sideband	MUX	= multiplexer
DTL	= diode-transistor logic	mV	= millivolt
DVM	= digital voltmeter	mVac	= millivolt, ac
ECL	= emitter-coupled logic	mVdc	= millivolt, dc
EMF	= electromotive force	mVpk	= millivolt, peak
EDP	= electronic data processing	mVp-p	= millivolt, peak-to-peak
ELECT	= electrolytic	mVrms	= millivolt, rms
ENCAP	= encapsulated	farad	= farad
EXT	= external	mW	= milliwatt
F	= field-effect transistor	MY	= mylar
FET	= field-effect transistor	μA	= microampere
F/F	= flip-flop	μF	= microfarad
FIL H	= flat head	μH	= microhenry
FIL H	= filister head	μmho	= micromho
FM	= frequency modulation	μs	= microsecond
FP	= front panel	μV	= microvolt
FREQ	= frequency	μVac	= microvolt, ac
FXD	= fixed	μVdc	= microvolt, dc
g	= gram	μVpk	= microvolt, peak
Ge	= germanium	μVp-p	= microvolt, peak-to-peak
GHz	= gigahertz	μVrms	= microvolt, rms
GL	= glass	μW	= microwatt
GND	= ground(ed)	nA	= nanoampere
H	= henry	NC	= no connection
h	= hour	N/C	= normally closed
HET	= heterodyne	NE	= neon
HEX	= hexagonal	NEG	= negative
HD	= head		
		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
		ns	= nanosecond
		NSR	= not separately replaceable
		nW	= nanowatt
		OB	= 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 modulation; pulse-count modulation
		PDM	= pulse-duration modulation
		pF	= picofarad
		PH BRZ	= phosphor bronze
		PHL	= philips
		PIN	= positive-intrinsic-negative
		PIV	= peak inverse voltage
		pk	= peak
		PL	= phase lock
		PLL	= phase-lock loop
		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	= potentiometer
		POT	= peak-to-peak
		p-p	= peak-to-peak (used in parts list)
		PP	= pulse-position modulation
		PPM	= preamplifier
		PREAMPL	= pulse-repetition frequency
		PRF	= pulse-repetition rate
		REG	= picosecond
		REPL	= point
		RF	= pulse-time modulation
		RFI	= pulse-width modulation
		RH	= peak working voltage
		RLC	= resistance capacitance
		RMS	= rectifier
		RND	= reference
		R&P	= regulated
		RWW	= replaceable
		S	= radio frequency
		S	= radio frequency interference
		S-B	= round head; right hand
		SCR	= resistance-inductance-capacitance
		SE	= rack mount only
		SECT	= root-mean-square
		SEMICON	= round
		SHF	= read-only memory
		SIL	= rack and panel
		SL	= reverse working voltage
		SNR	= scattering parameter
			= second (time)
			= second (plane angle)
			= slow-blow fuse (used in parts list)
			= silicon controlled rectifier; screw
			= selenium
			= sections
			= semiconductor
			= super-high frequency
			= silicon
			= silver
			= slide
			= signal-to-noise ratio
		SPDT	= single-pole, double-throw
		SPL	= spring
		SPST	= special
		SR	= single-pole, single-throw
		SSB	= split ring
		SST	= single sideband
		STL	= stainless steel
		SQ	= steel
		SWR	= square
		SYNC	= standing-wave ratio
		T	= synchronize
		TA	= timed (slow-blow fuse)
		TC	= tantalum
		TD	= temperature compensating
		TERM	= time delay
		TFT	= terminal
		TGL	= thin-film transistor
		THD	= toggle
		THRU	= thread
		TOL	= through
		TRIM	= titanium
		TRM	= tolerance
		TSR	= trimmer
		TV	= transistor
		TVI	= transistor-transistor logic
		TWT	= television
		U	= television interference
		UF	= traveling wave tube
		UH	= micro (10 <sup>-6</sup> ) (used in parts list)
		UNREG	= microfarad (used in parts list)
		V	= ultra-high frequency
		V(F)	= unregulated
		VHF	= volt
		Vpk	= voltampere
		Vrms	= volts ac
		VSWR	= volts dc
		VTO	= voltage-controlled oscillator
		VTVM	= volts dc
		V(X)	= volts, dc, working (used in parts list)
		W	= volts, filtered
		W/	= variable-frequency oscillator
		W/V	= very-high frequency
		W/W	= volts peak
		W/O	= volts peak-to-peak
		YIG	= volts rms
		Zo	= voltage standing wave ratio
			= voltage-tuned oscillator
			= vacuum-tube voltmeter
			= volts, switched
			= watt
			= with
			= working inverse voltage
			= wirewound
			= without
			= yttrium-iron-garnet
			= characteristic impedance

NOTE

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

MULTIPLIERS

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



Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	05386-60001	8	1	BOARD ASSEMBLY, MOTHER	28480	05386-60001
A1C1	0160-4204	4	1	CAPACITOR-FXD .033UF +-10% 500VDC CER	51642	300-500-X74-333K
A1C2	0180-4129	3	8	CAPACITOR-FXD 1UF +-10% 35VDC TA	56289	T322B105R03A5AS
A1C3	0160-4554	7	14	CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C4	0160-4808	4	3	CAPACITOR-FXD 470PF +-5% 100VDC CER	28480	0160-4808
A1C5	0180-4129	3		CAPACITOR-FXD 1UF +-10% 35VDC TA	56289	T322B105R03A5AS
A1C6	0160-4557	0	5	CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A1C7	0160-5649	3	1	CAPACITOR-FXD 100PF +-5% 500VDC CER	28480	0160-5649
A1C8	0180-4129	3		CAPACITOR-FXD 1UF +-10% 35VDC TA	56289	T322B105R03A5AS
A1C9	0180-4135	7	4	CAPACITOR-FXD 33UF +-10% 10VDC TA	04200	T322D336K010AS
A1C10	0160-3874	2	3	CAPACITOR-FXD 10PF +-.5PF 200VDC CER	28480	0160-3874
A1C11	0180-4135	7		CAPACITOR-FXD 33UF +-10% 10VDC TA	04200	T322D336K010AS
A1C12	0180-4129	3		CAPACITOR-FXD 1UF +-10% 35VDC TA	56289	T322B105R03A5AS
A1C13	0160-0573	2	1	CAPACITOR-FXD 4700PF 20% 100V CER X74	28480	0160-0573
A1C14	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C15	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C16	0160-0572	1	1	CAPACITOR-FXD 2200PF +-20% 100VDC CER	28480	0160-0572
A1C17	0160-3874	2		CAPACITOR-FXD 10PF +-.5PF 200VDC CER	28480	0160-3874
A1C18	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C19	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C20	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A1C21	0180-4135	7		CAPACITOR-FXD 33UF +-10% 10VDC TA	04200	T322D336K010AS
A1C22	0160-3879	7	2	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A1C23	0160-3874	2		CAPACITOR-FXD 10PF +-.5PF 200VDC CER	28480	0160-3874
A1C24	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
A1C25	0160-4822	2	4	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A1C26	0180-4129	3		CAPACITOR-FXD 1UF +-10% 35VDC TA	56289	T322B105R03A5AS
A1C27	0180-4135	7		CAPACITOR-FXD 33UF +-10% 10VDC TA	04200	T322D336K010AS
A1C28	0160-4808	4		CAPACITOR-FXD 470PF +-5% 100VDC CER	28480	0160-4808
A1C29	0160-4808	4		CAPACITOR-FXD 470PF +-5% 100VDC CER	28480	0160-4808
A1C30	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C31	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A1C32	0160-4810	8	1	CAPACITOR-FXD 330PF +-5% 100VDC CERR	28480	0160-4810
A1C33	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C34	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C35	0160-4801	7	2	CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A1C36	0180-4129	4	1	CAPACITOR-FXD 1UF 10% 35V TA	28480	0180-4129
A1C37	0180-2865	1	1	CAPACITOR-FXD 100UF +100 -10% 15VDC AL	28480	0180-2865
A1C38	0180-2827	5	1	CAPACITOR-FXD 47UF +100-10% 40VDC AL	28480	0180-2827
A1C39	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C40	0160-4801	7		CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A1C41	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A1C42	0180-2724	1	1	CAPACITOR-FXD 550UF +75-10% 40VDC AL	00853	300GJ551U040B
A1C43	0180-2991	4	2	CAPACITOR-FXD 3900UF +100-10% 20VDC AL	56289	674D398H020JL5A
A1C44	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C45	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C46	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C47	0160-5755	2	1	CAPACITOR-FXD .1UF +-10% 100VDC CER	28480	0160-5755
A1C48	0180-4129	3		CAPACITOR-FXD 1UF +-10% 35VDC TA	56289	T322B105R03A5AS
A1C49	0180-2991	4		CAPACITOR-FXD 3900UF +100-10% 20VDC AL	56289	674D398H020JL5A
A1C50	0180-3280	1		CAPACITOR-FXD 1800UF +100-10% 40VDC AL	04200	674D17862U040B
A1C51	0180-2991	4		CAPACITOR-FXD 3900UF +100-10% 20VDC AL	56289	674D398H020JL5A
A1C52	0180-3279	3	1	CAPACITOR-FXD 390UF +100-10% 12VDC AL	28480	0180-3279
A1C53	0180-4134	1		CAPACITOR-FXD 22UF 15V TA	12340	T322D226K015AS
A1C54	0160-4819	7	2	CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4819
A1C55	0160-4805	1	1	CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30	28480	0160-4805
A1C56	0160-4819	7		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4819
A1C57	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A1C58	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A1C59	0180-4129	3		CAPACITOR-FXD 1UF +-10% 35VDC TA	56289	T322B105R03A5AS
A1C60	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1C61	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A1C62	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A1CR1	1901-0050	3	13	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A1CR2	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A1CR3	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A1CR4	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A1CR5	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050

See introduction to this section for ordering information  
\*Indicates factory selected value

Table 6-2. A1 Motherboard Assembly Replaceable Parts (Continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1CR6	1901-0376	6	2	DIODE-GEN PRP 35V 50MA D0-35	28480	1901-0376
A1CR7	1901-0376	6		DIODE-GEN PRP 35V 50MA D0-35	28480	1901-0376
A1CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS D0-35	28480	1901-0050
A1CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS D0-35	28480	1901-0050
A1CR10	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS D0-35	28480	1901-0050
A1CR11	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS D0-35	28480	1901-0050
A1CR12	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS D0-35	28480	1901-0050
A1CR13	1901-0731	7	8	DIODE-PWR RECT 400V 1A	28480	1901-0731
A1CR14	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731
A1CR15	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS D0-35	28480	1901-0050
A1CR16	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731
A1CR17	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731
A1CR18	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731
A1CR19	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731
A1CR20	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731
A1CR21	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731
A1CR22	1902-3110	4	1	DIODE-ZNR 5.9V 2% D0-35 PD=.4W TC+.017%	28480	1902-3110
A1CR23	1901-0877	2	1	DIODE-PWR RECT 40V 3A	04713	MBR340P
A1CR24	1884-0221	2	1	THYRISTOR, SCR VRRM=300	04713	MCR106-5
A1CR25	1902-0244	9	1	DIODE-ZNR 30V 5% PD=1W IR=5UA	28480	1902-0244
A1CR26	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS D0-35	28480	1901-0050
A1CR27	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS D0-35	28480	1901-0050
A1F1	2110-0303	3	1	FUSE 2A 250V TD 1.25X.25 UL	28480	2110-0303
A1F2	2110-0201	0	1	FUSE .25A 250V TD 1.25X .25 UL	28480	2110-0201
A1J1	1250-1782	9	1	CONNECTOR-RF BNC FEM PCH-PNL 50-OHM	28480	1250-1782
J2	1250-0083	1	1	CONNECTOR-FC BNC FEM SGL-HOLE-FR 50-OHM	28480	1250-0083
A1J2	1251-8304	7	1	CONNECTOR-POST TYPE .100-PIN SPCG 8-CONT	28480	1251-8304
A1J3	1200-0607	0	1	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A1J4	1200-0548	8	1	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0548
A1J5	1251-7684	4	1	CABLE ASSY, 14-POST	28480	1251-7684
A1K1	0490-1317	3	1	RELAY-REED 1C 250MA 200VDC 5VDC-COIL 3VA	28480	0490-1317
A1L1	9100-2562	6	1	INDUCTOR, RF-CH-MLD 100UH +-10%	28480	9100-2562
A1L2	9100-1788	6	4	CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A1L3	9100-1788	6		CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A1L4	9100-3060	1	1	INDUCTOR 260 UH	28480	9100-3060
A1L5	9140-0718	4	1	INDUCTOR-FXD NORM IND: 230UH 1.5ADC	28480	9140-1788
A1L6	9100-1788	6		CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A1L7	9100-1788	6		CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A1L8	9100-1788	6		CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A1MP1	1205-0462	5	2	HEAT SINK SGL TO-220 CS	28480	1205-0462
A1Q1	1853-0354	7	1	TRANSISTOR PNP SI TO-92 PD=350MW	28480	1853-0354
A1Q2	1855-0327	8	1	TRANSISTOR J-FET 2N446 N-CHAN D-MODE	01295	2N4416
A1Q3	1854-0215	1	3	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
A1Q4	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
A1Q5	1855-0414	4	1	TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A1Q6	1853-0015	7	2	TRANSISTOR PNP SI PD=200MW FT=500MHZ	28480	1853-0015
A1Q7	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A1Q8	1853-0015	7		TRANSISTOR PNP SI PD=200MW FT=500MHZ	28480	1853-0015
A1Q9	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
A1Q10	1843-0635	1		TRANSISTOR NPN SI PD=50W FT=20MHZ	03508	D44H5
A1Q11	1853-0363	8	2	TRANSISTOR PNP SI PD=50W FT=20MHZ	03508	X45H281
A1Q12	1853-0363	8		TRANSISTOR PNP SI PD=50W FT=20MHZ	03508	X45H281
A1Q13	1854-0013	7	1	TRANSISTOR NPN 2N2218A SI TO-5 PD=800MW	04713	2N2218A
A1R1	2100-0554	5	1	RESISTOR TRMR 500 10% C TOP-ADJ 1-TRN	28480	2100-0554
A1R2	0757-0419	0	1	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A1R3	0757-0420	3	3	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A1R4	0837-0412	1		THERMISTOR-TUB AXL LEADS 10K-OHM +-10%	12930	MSB103K
A1R5	0698-0083	8	10	RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R6	0698-3152	8	3	RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A1R7	1810-0488	8	1	NETWORK RESISTOR 8-SIP 4.7K OHM X 4	28480	1810-0488
A1R8	0698-3156	2	2	RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A1R9	0757-0465	6	3	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A1R10	0757-0421	4	3	RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F

See introduction to this section for ordering information  
\*Indicates factory selected value

Table 6-2. A1 Motherboard Assembly Replaceable Parts (Continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1R11	0757-0382	6	1	RESISTOR 16.2 1% .125W TC=0+-100	28480	0757-0382
A1R12	0698-3132	4	5	RESISTOR 261 1% .125 W F TC=0+-100	24546	0698-3132
A1R13	0699-0071	6	2	RESISTOR 4.64M 1% .125W F TC=0+-100	28480	0699-0071
A1R14	0698-8827	4	2	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A1R15	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A1R16	0757-0706	8	1	RESISTOR 51.1 1% .25W F TC=0+-100	24546	C5-1/4-T0-51R1-F
A1R17	1810-0368	3	1	NETWORK-RES 6-SIP 10.0K OHM X 5	01121	206A103
A1R18	0698-3162	0	1	RESISTOR 46.4 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F
A1R19	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F
A1R20	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F
A1R21	0757-0346	2	2	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A1R22	0757-0420	3	3	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A1R23	0757-0280	3	6	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A1R24	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R25	0757-0401	0	3	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A1R26	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A1R27	0698-3132	4		RESISTOR 261 1% .125 W F TC=0+-100	24546	0698-3132
A1R28				NOT ASSIGNED		
A1R29	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R30	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A1R31	1810-0219	3	1	NETWORK RES 8-SIP 220.0 OHM X 4	01121	208B221
A1R32	0698-3441	8	3	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A1R33				NOT ASSIGNED		
A1R34	0698-3136	8	1	RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F
A1R35	0698-3447	4	3	RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A1R36	0698-3447	4		RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A1R37	1810-0541	4	1	NETWORK RES 6-SP MULTI-VALUE	28480	1810-0541
A1R38	2100-0558	9	1	RESISTOR-TRMR 20K 10% C TOP-ADJ 1-TRN	28480	2100-0558
A1R39	0698-0082	7	5	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A1R40	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A1R41	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A1R42	1810-0370	7	1	NETWORK RES 8-SIP 220.0 OHM X 7	01121	208A221
A1R43	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A1R44	0757-0421	4		RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A1R45	0757-0421	4		RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A1R46	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A1R47	0757-0416	7	5	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1R48	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A1R49	0698-3445	2	1	RESISTOR 348 1% .125W F TC=0+-100	28480	0698-3445
A1R50	0698-3132	4		RESISTOR 261 1% .125 W F TC=0+-100	24546	0698-3132
A1R51	0698-3460	1	1	RESISTOR 422K 1% .125W F TC=0+-100	28480	0698-3460
A1R52	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1R53	0698-3132	4		RESISTOR 261 1% .125 W F TC=0+-100	24546	0698-3132
A1R54	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A1R55	0757-0405	4	2	RESISTOR 162 1% .125W F TC=0+-100	24546	C4-1/8-T0-162R-F
A1R56	0757-0405	4		RESISTOR 162 1% .125W F TC=0+-100	24546	C4-1/8-T0-162R-F
A1R57	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1R58	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1R59	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R60	0698-3151	7	2	RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
A1R61	0698-3132	4		RESISTOR 261 1% .125 W F TC=0+-100	24546	0698-3132
A1R62	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R63	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A1R64	0698-6360		2	RESISTOR-FXD 10K 1% .125W F TC=0+-25	05524	CMF-55-1, T-9
A1R65	0698-6360			RESISTOR 1K .1% .125W F TC=0+-50	05524	CMF-55-1, T-9
A1R66	0698-6630		1	RESISTOR-FXD 20K 1% .125W F TC=0+-25	05524	CMF-55-1, T-9
A1R67	0699-0533	5	3	RESISTOR 4.64K .1% .125W F TC=0+-25	28480	0699-0533
A1R68	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A1R69	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A1R70	0698-3151	7		RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
A1R71	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A1R72	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
A1R73	0757-0420	3		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A1R74	0698-3150	6	2	RESISTOR 2.347K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A1R75	0757-0438	3	2	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1R76	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1R77	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R78	0698-3150	6		RESISTOR 2.347K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A1R79	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R80	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F

See introduction to this section for ordering information  
\*Indicates factory select-d value

Table 6-2. A1 Motherboard Assembly Replaceable Parts (Continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1R81	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R82	0757-0399	5	1	RESISTOR 82.5 1% .125W F TC=0+-100	24546	C4-1/8-T0-82R5-F
A1R83	0699-0533	5		RESISTOR 4.64K 1% .125W F TC=0+-25	28480	0699-0533
A1R84	0699-0533	5		RESISTOR 4.64K 1% .125W F TC=0+-25	28480	0699-0533
A1R85	0698-3400	9	1	RESISTOR 147 1% .5W F TC=0+-100	28480	0698-3400
A1R86	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A1R87	0699-0071	6		RESISTOR 4.64M 1% .125W F TC=0+-100	28480	0699-0071
A1R88	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1R89	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A1R90	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A1R91	0757-0289	2	1	RESISTOR 13.3K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-1332-F
A1R92				NOT ASSIGNED		
A1R93	0812-0021	8	1	RESISTOR .47 5% 3W PW TC=0+-90	91637	CWB1-3 T2-47/100-J
A1R94	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1R95	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1R96	0757-0403	2	1	RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R-F
A1R97	0757-0417	8	1	RESISTOR 562 1% .125W F TC=0+-100	24546	C4-1/8-T0-562R-F
A1R98	0698-3447	1	1	RESISTOR 422 1% .125W F	05524	CMF-55-1 F
A1S1	3101-2644	1	1	SWITCH PB DPOT ALTNQ .5A 100VAC	28480	3101-2644
A1S2	3101-0528	6	1	SWITCH-TGL SUBMIN SPDT .02A 20VAC/DC	28480	3101-0528
A1S3	3101-2656	5	1	SWITCH-SLIDE LINE SEL 90PC	28480	3101-2656
A1TP1	1251-0600	0	7	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A1TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A1TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A1TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A1TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A1TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A1TP9	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A1U1	1826-0393	7	1	IC V RGLTR-ADJ POS 1.2/37V T0-220 PKG	28480	1826-0393
A1U2	1820-4466	1	2	MK3870/42N MICROPROCESSOR	28480	1820-4466
A1U3	1820-4466	1		MK3870/42N MICROPROCESSOR	28480	1820-4466
A1U4	1826-0346	0	1	IC OP AMP GP DUAL 8-DIP-P PKG	27014	LM358N
A1U5	1820-2848	9	1	IC RCVR ECL/10KH LINE RCVR TPL	02037	MC10H116P
A1U6	1820-2096	9	1	IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N
A1U7	1820-2312	2	2	IC MISC	28480	1820-2312
A1U8	1820-1425	6	1	IC SCHMITT-TRIGGER TTL LS NAND QUAD 2-INP	01295	SN74LS132N
A1U9	1858-0054	4	1	TRANSISTOR ARRAY 16-PIN PLASTIC DIP	28480	1858-0054
A1U10	1858-0040	8	1	TRANSISTOR ARRAY 16-PIN PLASTIC DIP	3L585	CA3127E
A1U11	1826-0501	9	1	IC MULTIPLEXER 2-CHAN-ANALOG TRIPLE 16-DIP	04713	MC14053BCP
A1U12	1826-0065	0	1	IC COMPARATOR PRCN 8-DIP P PKG	50545	UPC311C
A1U13	1826-0315	3	1	IC OP AMP GP QUAD 14-DIP-P PKG	27014	LM348N
A1U14	1826-0122	0	2	IC 7805 V RGLTR T0-220	07263	7805UC
A1U15	1826-0544	0	1	IC V RGLTR V-REF FXD 2.5V U-DIP-C PKG	28480	1826-0544
A1U16	1826-0428	9	1	IC 3524 MODULATOR 16-DIP C	01295	SG3524J
A1W1	8159-0005		1	RESISTOR, ZERO-OHM	28480	8159-0005
A1XF1	2110-0642	3	1	FUSEHOLDER-EXTR POST 6.3A 250V BAY CAP	28480	2110-0642
A1XF2	2110-0528	4	1	FUSE 10A 125V NTO 1.25X.25	75915	312010
A1XF1X1	2110-0565	9	2	FUSEHOLDER CAP 12A MAX FOR UL	28480	2110-0565
A1XF1X1	2110-0565	9		FUSEHOLDER CAP 12A MAX FOR UL	28480	2110-0565
A1XU7	1200-0654	7		SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A1Y1A	0960-0612	6	1	CRYSTAL OSCILLATOR 10.0 MHZ: 0-55-DEG C	28480	0960-0612
A1Y1B	0960-0636	4	1	OVEN OSCILLATOR MODULE, FREQ 10 MHZ	28480	0960-0636
	0340-1133	4	1	INSULATOR, TRANSISTOR	28480	0340-1133
	0361-1215	7	3	RIVET, PLASTIC UNIV HEAD .118-DIA	28480	0361-1215
	0370-2862	1	1	SWITCH CAP, WHITE 0.23" SQ	28480	0370-2862
	0403-0424	1	1	BUMPER FOOT (for S1)	28480	0403-0424
	0515-0407	4	2	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
	0515-0886	3	4	SCREW-MACH M3 X 0.5 6MLM-LG PAN-HD	00000	ORDER BY DESCRIPTION
	0515-1286	9	4	SCREW-MACH M3 X 0.6 47MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
	1400-0249	0	1	CABLE TIE	28480	1400-0249
	9100-4493	6	1	TRANSFORMER, POWER	28480	9100-4493
	05386-00003	4	1	BRACKET-TRANSFORMER	28480	05386-00003

See introduction to this section for ordering information  
\*Indicates factory selected value

Table 6-3. A2 Front Panel Display Assembly Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A2				DISPLAY ASSEMBLY		
H13	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI	28480	0624-0333
MP28	5061-1190	0	1	LIQUID CRYSTAL DISPLAY	28480	5061-1190
MP29	05386-20205	0	1	KEY CLAMP	28480	05386-20205

See introduction to this section for ordering information  
 \*Indicates factory selected value

Table 6-4.A3 Hybrid Assembly Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Descriptor	Mfr Code	Mfr Part Number
A3	05386-60002	0	1	3 GHZ PRESCALER BOARD	28480	05386-60002
A3C1	0160-4554	7	7	CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C2	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C3	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C4	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C5	0160-4556	9	11	CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C6	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C7	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C8	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C9	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C10	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C11	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C12	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C13	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C14	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C15	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C16	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C17	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C18	0160-4556	9		CAPACITOR-FXD 1000PF +-20% 100VDC CER	16299	CAC02X7R102M100A
A3C19	0160-4031	5	1	CAPACITOR-FXD 330PF +-5% 100VDC CER	28480	0160-4031
A3C20				NOT ASSIGNED		
A3C21	0160-3879	7	1	CAPACITOR-FXD .01UF 20% 100V CER	16299	C320C103M1R5CA
A3DS1	1990-0665	3	1	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665
A3J1	1200-0548	8	1	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0548
A3J2	1251-7112	3	1	CONNECTOR 4-PIN M POST TYPE	28480	1251-7112
A3J3	1251-3172	7	8	CONNECTOR-SGL CONT SKT .03-IN-BSC SZ RND	28480	1251-3172
A3J4	05386-20202	7	1	CONNECTOR N-TYPE MODIFIED	28480	05386-20202
A3L1	9140-0543	3	1	INDUCTOR RF-CH-MLD 4.3UH 5% .105DX.26LG	28480	9140-0543
A3L2	9140-0551	3	1	INDUCTOR RF-CH-MLD 10UH 5% .105DX.26LG	28480	9140-0551
A3L3	9100-1788	6	4	CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A3L4	9100-1788	6		CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A3L5	9100-1788	6		CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A3L6	9140-0566	0	1	INDUCTOR RF-CH-MLD 47UH 5%	91637	IM2 47UH
A3L7	9100-1788	6		CORE-FERRITE CHOKE-WIDEBAND; IMP:>680	28480	9100-1788
A3L8	9140-0453	4	1	INDUCTOR-RF-CH-MLD 6.8UH 5% .166DX.385LG	28480	9140-0453
A3MP1	05386-20201	6	1	BRACKET, FRONT	28480	05386-20201
A3R1	0698-7236	7	2	RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A3R2	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A3R3	0698-8827	4	1	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A3R4	0698-7260	7	7	RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R5	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R6	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R7	0698-7258	3	1	RESISTOR 8.25K 1% .05W F TC=0+-100	24546	C3-1/8-T0-8251-F
A3R8	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R9	0698-7205	0	2	RESISTOR 51.1 1% .05W F TC=0+-100	24546	C3-1/8-T0-51R1-F
A3R10	2100-3352	7	1	RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN	28480	2100-3352
A3R11	0698-7205	0		RESISTOR 51.1 1% .05W F TC=0+-100	24546	C3-1/8-T0-51R1-F
A3R12	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R13	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R14	2100-3351	6	1	RESISTOR-TRMR 500 10% C SIDE-ADJ 1-TRN	28480	2100-3351
A3R15	0698-7243	6	1	RESISTOR 1.96K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1961-F
A3R16	0698-7253	8	2	RESISTOR 5.11K 1% .05W F TC=0+-100	24546	C3-1/8-T0-5111-F
A3R17	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R18	0698-7253	8		RESISTOR 5.11K 1% .05W F TC=0+-100	24546	C3-1/8-T0-5111-F
A3R19	2100-3349		1	RESISTOR-TRMR 100 10% TKF SIDE-ADJ 1-TRN	03744	3386X-Y46-101
A3R20	0698-7210		1	RESISTOR 82.5 1% .05W TF TC=0+-100	05524	CMF-50-2
A3R21	0698-7218		1	RESISTOR 178 1% .05W TF TC=0+-100	24546	C3-1/8-T0-178R-F
A3R22	0698-7233	4	1	RESISTOR 750 1% .05W F TC=0+-100	24546	C3-1/8-T0-750R-F
A3R23	0698-7244	7	1	RESISTOR 2.15K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2151-F
A3R24				NOT ASSIGNED		
A3R25	0699-1738	4	2	RESISTOR 27 1% .125W F TC=0+-50	28480	0699-1738
A3R26	0199-1768	0	1	RESISTOR 39 1% .1W	28480	0699-1768
A3R27	0699-1738	4		RESISTOR 27 1% .125W F TC=0+-50	28480	0699-1738
A3R28	2100-3426		1	RESISTOR-TRMR 20 10% C SIDE-ADJ 1-TRN	03744	3386X-746-200
A3TP1	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-11M-BSC-SZ SQ	28480	1251-0600

See introduction to this section for ordering information  
\*Indicates factory selected value

Table 6-4.A3 Hybrid Assembly Replaceable Parts (Continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3U1	1820-0493	6	1	IC OP AMP GP D-DIP PKG	27014	LM307N
A3U2	1826-0544	0	1	IC V-RGLTR V-REF FXD 2.5V 8-DIP-C PKG	28480	1826-0544
A3U3	1826-0161	7	1	IC OP AMP GP QUAD 14-DIP P PKG	04713	MLM324P
A3U4	1820-2904	8	1	IC PRESCALER ECL	28480	1820-3904
A3U5				HYBRID (Not replaceable; see Note below)		
				NOTE. AN EXCHANGE ASSEMBLY FOR THE A3 PRESCALER IS AVAILABLE. REFER TO EXCHANGE ASSEMBLY ORDERING INFORMATION AT THE BEGINNING OF SECTION VI.		

See introduction to this section for ordering information  
\*Indicates factory selected value

Table 6-5. A5 HP-IB Assembly Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5	05384-60005	0	1	HP-IB BOARD ASSEMBLY	28480	05384-60005
ASC1	0180-4135	2	1	CAPACITOR-FXD 33UF 105 10V TA	28480	0180-4135
ASC2	0160-4554	7	1	CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
ASC3	0160-4557	0	2	CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
ASC4	0160-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
ASC5	0180-0210	6	1	CAPACITOR-FXD 3.3UF +-20% 15VDC TA	56289	150D335X0015A2
ASCR1	1901-0050	3	1	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
ASJ1	1252-0268	9	1	CONNECTOR HP-IB MICRORIBBON 24-CKT	28480	1252-0268
ASL1	9100-1788	6	1	CORE-FERRITE CHOKE-WIDEBAND, IMP:>680	28480	9100-1788
ASL2	9100-1637	4	1	INDUCTOR RF-CH-MLD 120UF 5% .166DX.385LG	28480	9100-1637
ASR1	0698-3155	1	2	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
ASR2	0698-0082	7	2	RESISTOR 464K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
ASR3	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
ASR4	0698-0082	7		RESISTOR 464K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
ASR5	1810-0247	7	1	NETWORK-RES 16-DIP 220.0 OHM X 8	01121	316B221
ASR6	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
ASR7	0698-3441	8	2	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
ASR8	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
ASS1	3101-2215	2	1	SWITCH-RKR DIP-RKR ASSY 7-1A .05A 30VDC	28480	3101-2215
ASTP1	1251-8096	4	1	HEADER ASSY 7-PIN	28480	1251-8096
ASU1	1820-2461	2	2	IC MISC TTL OCTL	04713	MC3447P3
ASU2	1820-2461	2		IC MISC TTL OCTL	04713	MC3447P3
ASU3	1820-1198	0	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS03N
ASU4	1820-1440	5	1	IC LCH TTL LS QUAD	01295	SN74LS279N
ASU5	1820-3970	0	1	IC MCU 4MHZ W/ROM & RAM	28480	1820-3970
ASW1	8120-3671	1	1	FLAT RIBBON ASSY, 14-COND	28480	8120-3671
ASXU5	1200-0654	7	1	SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
	0361-0079	9	2	RIVET SEMI-TUB OVH .125-DIA .188-LG	28480	0361-0079
	3050-0016	8	2	WASHER, FLAT MTL NO. 6 .147-ID	00000	ORDER BY DESCRIPTION

See introduction to this section for ordering information  
\*Indicates factory selected value



Table 6-6. Replaceable Mechanical Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
CHASSIS PARTS						
A1W1	8120-4168	0	1	LIQUID CRYSTAL DISPLAY (PART OF A2)	28480	5061-1190
A2W1	5061-1190		1	CABLE, RIBBON 8-COND 2.5-IN-LG	28480	8120-4038
H1	8120-4038		1			
H1	0590-0505	1	1	NUT-KNURLED 5/8-24-THD .125-IN-THK	00000	ORDER BY DESCRIPTION
H2	0515-0886	3	7	SCREW-MACH M3 X 0.5 6MM-LG PAN-HD	28480	0515-0886
H3	0515-0887	4	4	SCREW-MACH M3 X 0.6 6MM-LG PAN-HD	28480	0515-0887
H4	0515-0889	6	6	SCREW-MACH M3 X 0.6 6MM-LG	28480	0515-0889
H5				NOT ASSIGNED		
H6				NOT ASSIGNED		
H7	0515-1286	9	4	SCREW-MACH M3.5 X 0.6 47MM-LG PAN-HD	28480	0515-1286
H8	0515-1331	5	8	SCREW-METRIC SPECIALTY M4 X 0.7 THD 6	28480	0515-1331
H9	0535-0006	1	2	NUT-HEX DBL-CHAM M4 X 0.7 3.2MM-THK	00000	ORDER BY DESCRIPTION
H10	0535-0081	2	1	NUT-HEX W/EXT T-LKWR M5 X 0.8 3.3MM THK	28480	0535-0081
H11	0590-0038	5	1	NUT-HEX DBL-CHAM 1/2-32 THD .094-IN-THK	00000	ORDER BY DESCRIPTION
H12	0590-1251	6	1	NUT-SPLCLTY 15/32-32-THD .1-IN-THK .562 WD	00000	ORDER BY DESCRIPTION
H13	0624-0333	6	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD POZI (A2)	28480	0624-0333
H14	2190-0016	3	2	WASHER-LK INTL T 3/8-IN .377-IN-ID	28480	2190-0016
H15	2190-0027	6	1	WASHER-LK INTL T 1/4-IN .256-IN-ID	28480	2190-0027
H16	2190-0577	1	2	WASHER-LK HLCL NO. 10 .194-9N-ID	28480	2190-0577
H17				NOT ASSIGNED		
H18	2190-0646	5	2	WASHER-LK EXT T-B 4.0MM 4.15-MM-ID	28480	2190-0646
H19	2950-0001	8	1	NUT-HEX DBL-CHAM 3/8-32-THD .094-IN-THK	00000	ORDER BY DESCRIPTION
H20	2950-0072	3	1	NUT-HEX DBL-CHAM 1/4-32-THD .062-IN-THK	00000	ORDER BY DESCRIPTION
H21	3050-0893	9	2	WASHER-FL MTLCL 4.0MM 4.4-MM-ID	28480	3050-0893
J2	1250-0083	1	1	CONNECTOR RF BNC PLUG 4-HOLE-FLG-R	28480	1250-0083
MP1	5041-8803		1	TRIM, TOP HALF	28480	5041-8803
MP2	5041-8820		1	STRAP HANDLE CAP, REAR	28480	5041-8820
MP3	5062-3864		1	COVER, BOTTOM	28480	5061-9564
MP4	5041-8822		2	FOOT, NON-SKID	28480	5041-8822
MP5	5041-8801		2	FOOT	28480	5041-8801
MP6	1460-1345	5	2	TILT STAND, STAINLESS STEEL	28480	1460-1345
MP7	0403-0373	6	3	GUIDE-PC BOARD, BLACK	28480	0403-0373
MP8	5062-3703		1	STRAP HANDLE ASSEMBLY	28480	5062-3703
MP9	5001-0519		1	COVER, TOP	28480	5001-0519
MP10	5001-0538		2	TRIM, SIDE	28480	5001-0538
MP11	5041-8820		1	STRAP HANDLE CAP, REAR	28480	5041-820
MP12	05386-00004	5	1	SPACER	28480	05386-00004
MP13	5021-5831	6	2	STRUT, SIDE	28480	5021-5831
MP14	05386-00002	3	1	PANEL, REAR	28480	05386-00002
MP15	05386-00001	3	1	PANEL, FRONT	28480	05386-00001
MP16	5021-8413		1	FRAME, FRONT	28480	5021-8413
MP17	5021-5814		1	FRAME, REAR	28480	4021-5814
MP18	05386-00003	4	1	BRACKET, TRANS	28480	05386-00003
MP19	05386-00007	8	1	SHIELD, AC	28480	05386-00007
MP20	5040-5448	1	1	WINDOW, DISPLAY	28480	5040-5448
MP21	0340-1133	4	1	INSULATOR, TRANSISTOR	28480	0340-1133
MP22	0370-1005	2	1	KNOB-BASE PTR 3/8 JGK .125-IN-ID	28480	0370-1005
MP23	5040-8816		1	PUSHBUTTON CAP, GRAY	28480	0370-2862
MP24	0380-1332	9	2	STANDOFF-HEX M/F	28480	0380-1332
MP25	0380-1582	1	1	SPACER, SNAP-IN 1.25-IN-LG .28-IN DIA	28480	0380-1582
MP26	0380-1749	2	1	STANDOFF-FEM 22-MM-LG M3.0 X 0.5 THD	28480	0380-1749
MP27	7120-3530	0	1	LABEL, WARNING HIGH VOLTAGE	28480	7120-3530
MP28	5061-1190	0	1	LIQUID CRYSTAL DISPLAY	28480	5061-1190
MP29	05386-20205	0	1	KEY CLAMP	28480	05386-20205
MP30	0360-1190	5	1	TERMINAL, SLDR LUG PL-MTG FOR #3/8-SCR	28480	0360-1190
MP31	1400-0249	0	1	CABLE TIE .062- .625-DIA .091-2D NYL	06383	PLT1M-8
R1	2100-2083	9	1	RESISTOR-VAR CONTROL CCP 20K 20% LIN	28480	2100-2083
T1	9100-4493	6	1	TRANSFORMER, POWER	28480	9100-4493

See introduction to this section for ordering information  
\*Indicates factory selected value

Table 6-6. Replaceable Mechanical Parts (Continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
W1	8120-1378	1	1	CABLE ASSY, POWER	28480	8120-1378
W2	8120-0572	5	1	CABLE ASSY, 26AWG 14-COND	28480	8120-0572
W3	8120-4168	3	1	CABLE ASSY, RIBBON 16-COND .063-M-LG	28480	8120-4168
XW2	1200-0547	7	2	SOCKET-LOCKING 14-PIN	28480	1200-0547
Y1	0960-0612	6	1	CRYSTAL OSCILLATOR 10MHZ	28480	0960-0612
Y1B	0960-0636	4	1	CRYSTAL OSCILLATOR 10MHZ (OPTION 004)	28480	0960-0636
	0361-1215	7	3	RIVET, PLASTIC UNIV HD .118 DIA	28480	0361-1215
	0380-1749	1	1	STANDOFF-HEX 22-MM-LG ALUM	28480	0380-1749
	0403-0424	8	1	BUMPER FOOT-ADH MOUNTING 20.5-MM-WD	28480	0403-0424
	0510-1152	8	9	RETAINER, PUSH-ON CIRC .156-IN-DIA	28480	0510-1152
	0510-1212	1	6	FASTENER, PUSH-ON RND .072-IN-DIA	28480	0510-1212
	0515-0407	4	2	SCREW-M3 X 0.5 10-MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
	1200-0547	7	2	SOCKET-LOCK DIP 14-PIN	28480	1200-0547
	3101-2669	2	1	SWITCH, KEYBOARD 14-SWITCH	28480	3101-2669

See introduction to this section for ordering information.  
\*Indicates factory selected value

HP 5386A  
Replaceable Parts

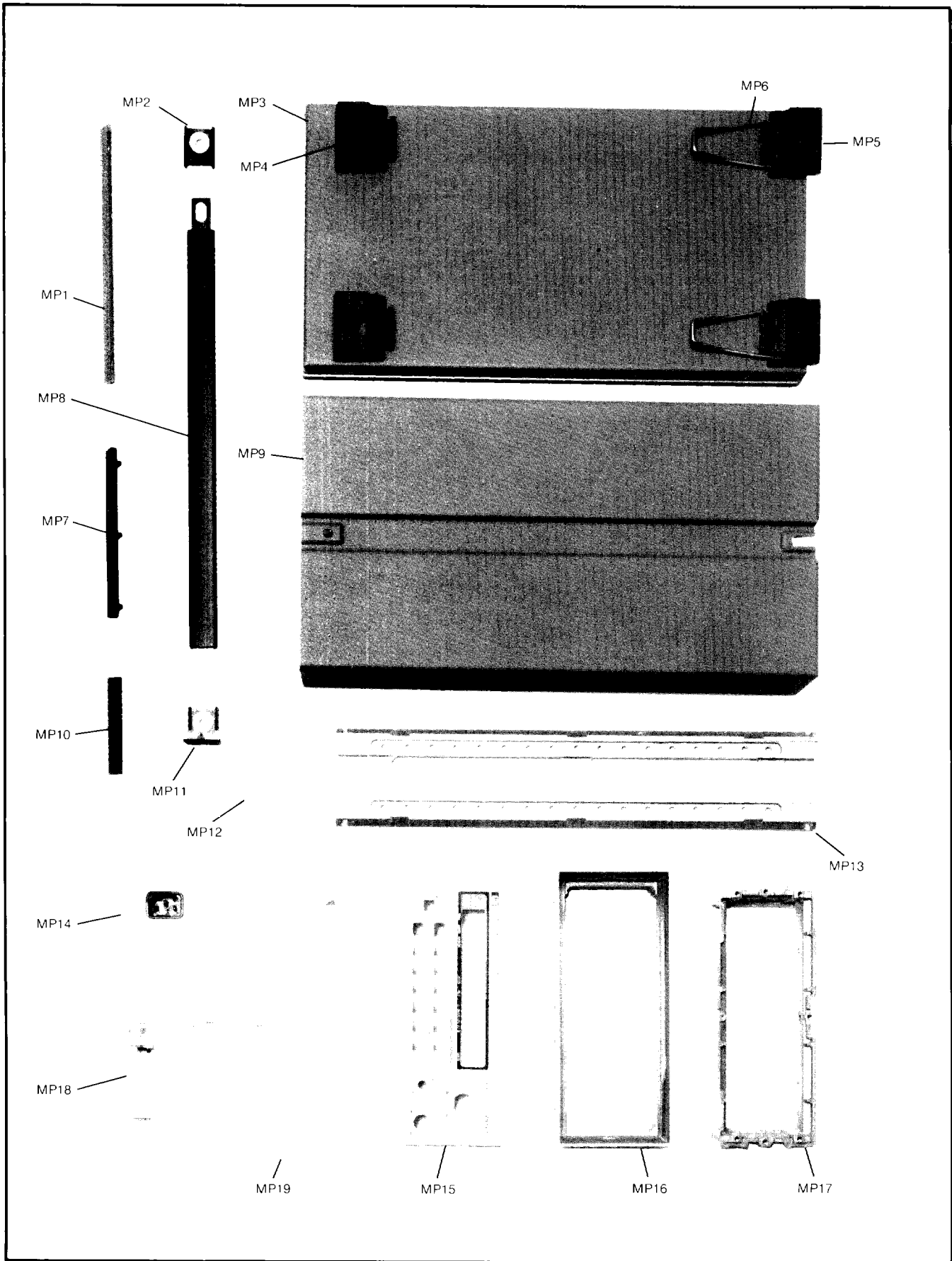


Figure 6-1. HP 5386A Mechanical Parts

Table 6-7. Code List of Manufacturers

MFR. NO.	MANUFACTURER NAME	ADDRESS	ZIP CODE
00000	Any Satisfactory Supplier		
00853	Westin Incorporated	Norcross, GA	30071
01121	Allen Bradley Company	Milwaukee, WI	79935
01295	Texas Instr. Semicond. Cmpnt Div.	Dallas, TX	75265
03508	GE Co. Semiconductor Prod. Dept.	Auburn, NY	13201
04713	Motorola Incorporated	Roselle, IL	04713
06383	Panduit Corporation	Tinley Park, IL	60477
06665	Precision Monolithics, Inc.	Santa Clara, CA	95054
07263	Fairchild Semiconductor Corporation	Cupertino, CA	95014
16299	Corning Glass Works Elec Cmpnt Div	Raleigh, NC	27604
19701	Mepco/Electra Corporation	Mineral Wells, TX	76067
24546	Corning Glass Works (Bradford)	Corning, NY	14830
27014	National Semiconductor Corporation	Santa Clara, CA	95052
28480	Hewlett-Packard Co. Corporate Hq	Palo Alto, CA	94304
3L585	RCA Corporation	New York, NY	10112
51642	Centre Engineering	State College, PA	16801
56289	Sprague Electric Co	Lexington, MA	01273
75915	Littlefuse Incorporated	Des Plaines, IL	60016
91637	Dale Electronics, Inc.	Columbus, NE	68601

## SECTION VII MANUAL CHANGES

### 7-1. INTRODUCTION

7-2. This section contains information necessary to adapt this manual to older versions of the HP 5386A for which the contents of the manual may not directly apply. The manual changes necessary for a particular instrument configuration are determined by the serial number prefix or complete serial number on the rear panel of the instrument.

### 7-3. MANUAL CHANGES

7-4. This manual applies directly to HP 5386A Frequency Counters with serial number prefix 3206A.

7-5. As engineering changes are made, newer instruments may have a serial number prefix higher than 3206A. Manuals for these instruments will be supplied with Manual Updating Change sheets containing the required information. Replace affected pages or modify existing manual information as directed in the Manual Updating Change pages. Contact the nearest Hewlett-Packard Sales and Support Office (listed at the back of this manual) if the change information is missing.

### 7-6. OLDER INSTRUMENTS

7-7. To adapt (backdate) this manual to older instruments having a serial number prefix lower than 3206A refer to *Table 7-1* and make the changes indicated for your instrument's serial number prefix, or complete serial number as applicable.

*Table 7-1. Manual Backdating*

If your instrument has serial number prefix or serial number	Make the following changes to your manual
2946A	1
2704A00930 & above	2
2704A	3
2621A	4

#### CHANGE 1 (Series 3206A to 2946A)

The following Series 2946A instrument includes changes for Series 3206A and does not require backdating:

2946A03051

PAGES 6-11/6-12, TABLE 6-6. HP 5386A REPLACEABLE MECHANICAL PARTS:

- Change MP1 from 5041-8803 to 5040-7203 TRIM-TOP 1/2.
- Change MP2 from 5041-8819 to 5041-6819 STRAP HANDLE CAP-FRONT.
- Change MP4 from 5041-8822 to 5040-7222 FOOT-NON-SKID.
- Change MP5 from 5041-8801 to 5040-7201 FOOT.
- Change MP8 from 5062-3703 to 5060-9803 STRAP-HANDLE ASSY.
- Change MP9 from 5001-0519 to 5001-0419 COVER-U TOP.
- Change MP10 from 5001-0538 to 5001-0438 TRIM-SIDE.
- Change MP11 from 5041-8820 to 5041-6820 STRAP HANDLE CAP-REAR.
- Change MP16 from 5021-8413 to 5021-5813 FRAME-FRONT.
- Change MP23 from 5040-8816 to 0370-2862 (push-button cap changes from gray to white).

#### CHANGE 2 (Series 2946A to 2704A00930 and above)

PAGES 6-8/6-9, TABLE 6-3. A3 3-GHz PRESCALER BOARD ASSEMBLY REPLACEABLE PARTS:

- Change A3R19 from 2100-3349 to 2100-3273 to RESISTOR-TRMR 2K 10% C SIDE-ADJ 1-TRN.
- Change A3R20 from 0698-7210 (82.5 ohms) to 0698-7245 RESISTOR 2.37K 1% .05W TF TC=0+-100.
- Change A3R21 from 0698-7218 (178 ohms) to 0698-7252 RESISTOR 4.64K 1% .05W TF TC=0+-100.

PAGES 8-42/8-43, FIG 8-47. A3 PRESCALER ASSY COMPONENT LOCATOR/SCHEMATIC DIAGRAM:

- Change A3R20 value from 82.5 ohms to 2.37K ohms.
- Change A3R21 value from 178 ohms to 4.64K ohms.

#### CHANGE 3 (Serial Numbers 2704A00930 and above to 2704A)

The following Series 2704A also include changes indicated for Serial Number 2704A00930 and above:

2704A00912, 2704A00916, 2704A00924,  
2704A00926

PAGES 6-3/6-6, TABLE 6-2. A1 MOTHERBOARD  
REPLACEABLE PARTS:

- Change A1 (05386-60001) SERIES to 2704.
- Change A1R98 from 0698-3447 (422 ohms) to 0757-0424 RESISTOR-FXD 1.1K 1% .12W F.

PAGES 8-39/8-41. A1 MOTHERBOARD ASSY  
SCHEMATIC DIAGRAM/COMPONENT LOCATOR:

- Change A1 (05386-60001) SERIES 2704.
- Change A1R98 value from 422 ohms to 1.10K ohms.
- CHANGE 4 (Series 2704A to 2621A)

PAGES 6-3/6-6, TABLE 6-2. A1 MOTHERBOARD  
REPLACEABLE PARTS:

- Add (SERIES 2621) to A1 board description.
- Change C36 from 0180-0291 (1UF) to 0160-4557 CAP-FXD .1UF  $\pm 1\%$  50VDC CER.
- Change A1C50 from 0180-3280 (1800UF) to 0180-2846 CAP FXD 1600UF +75-10% 40VDC AL.
- Change A1R64, R65 from 0698-6360 (10K) to 0698-3491 RESISTOR-FXD 1K 1% .125W F TC=0+-50.
- Change A1R66 from 0698-6630 (20K) to 0698-6612 (2K) to RESISTOR-FXD 2K .1% .125W FTC=0+-50.

PAGES 6-8/6-9, TABLE 6-3. A3 3-GHz PRESCALER  
BOARD ASSEMBLY REPLACEABLE PARTS:

- Change A3R20 from 0698-7242 (1.78K) to 0698-7245 RES FXD 2.37K 1% .05W F TC=0+-100.

Change A3R21 from 0698-7250 (3.83K) 0698-7252 to RES-FXD 4.64K 1% .05 W F TC=0+-100.

Delete A3R28 2100-3426 RESISTOR-TRMR 20 10% C SIDE-ADJ 1-TRN.

PAGES 8-39/8-41. A1 MOTHERBOARD ASSEMBLY  
SCHEMATIC DIAGRAM/COMPONENT LOCATOR:

- Change A1 (05386-60001) SERIES to 2621.
- Change A1C36 value from 1UF to .1UF.
- Change A1R64, R65 values from 10K ohms to 1K ohm.
- Change A1R66 value from 20K ohms to 2K ohms.

PAGES 8-42/8-43, FIG 8-47. A3 PRESCALER ASSY COM-  
PONENT LOCATOR/SCHEMATIC DIAGRAM:

- Change A3R20 value from 1.78K ohms to 2.37K ohms.
- Change A3R21 value from 3.83K ohms to 4.64K ohms.
- Delete A3R28 , 20 ohm Variable resistor.
- Delete A3R28 from the right of R26, near center right of component locator.

## SECTION VIII SERVICE

### 8-1. INTRODUCTION

8-2. This section provides service information and symbol descriptions, component locators, and schematic diagrams. The arrangement of the content of this section is described in detail below. Refer to the Table of Contents for specific page and paragraph numbers.

a. **SCHEMATIC DIAGRAM SYMBOLS AND REFERENCE DESIGNATIONS.** Describes the symbols used on schematic diagrams and reference designators used for parts, subassemblies and assemblies.

b. **IDENTIFICATION MARKINGS.** Describes the method used by Hewlett-Packard for identifying printed circuit boards and assemblies.

c. **SAFETY CONSIDERATIONS.** Describes the safety considerations applicable during maintenance, adjustments, and repair.

d. **SAFETY SYMBOLS.** Lists and describes the safety symbols used on equipment and in manuals.

e. **RECOMMENDED TEST EQUIPMENT.** Refers to test equipment specified in *Table 1-2*.

f. **SERVICE AIDS.** Information provided to assist service personnel.

g. **LOGIC SYMBOLS.** Description of logic symbols used on schematics.

h. **THEORY OF OPERATION.** Presents the theory of operation for the HP 5386A on two levels.

1. First, the Overall Counter Operation is described using the block diagram. This discussion introduces the major functional circuits and briefly explains their purpose and operation during normal measurements.

2. Second, the Detailed Theory of Operation gives an in-depth explanation of each assembly; its function and operation with respect to measurement cycles. These paragraphs reference the schematic diagrams.

i. **TROUBLESHOOTING.** Provides the troubleshooting information for the HP 5386A in the following forms:

1. **DIAGNOSTICS**, which are built into the instrument. They serve to verify, by self-check, various functional subsections of the counters' circuitry.
2. **MANUAL TESTS**, which refer to block diagrams, a flowchart and schematics. Schematic diagrams for

all assemblies are provided at the end of this section. They are arranged in numerical order according to the assembly number.

### 8-3. SCHEMATIC DIAGRAM SYMBOLS AND REFERENCE DESIGNATORS

8-4. *Figure 8-1* shows the symbols used on the schematic diagrams. At the bottom of *Figure 8-1*, the system for reference designators, assemblies, and subassemblies is shown.

#### 8-5. Reference Designations

8-6. Assemblies such as printed circuits are assigned numbers in sequence, A1, A2, etc. As shown in *Figure 8-1*, subassemblies within an assembly are given a subordinate A number. For example, rectifier sub-assembly 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.

### 8-7. IDENTIFICATION MARKINGS ON PRINTED CIRCUIT BOARDS

8-8. HP printed circuit boards (see *Figure 8-1*) have four identification numbers: an assembly part number, a series number, a revision letter, and a production code.

8-9. The assembly part number has 10 digits (such as 05386-60001) 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 2436) 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 VII for backdating information. If it is higher, refer to the looseleaf manual change sheets for this manual. If the manual change sheets are missing,

contact your local Hewlett-Packard Sales and Support Office. See the listing on the back cover of this manual.

8-10. 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.

## 8-11. SAFETY CONSIDERATIONS

8-12. Although this instrument has been designed in accordance with international safety standards, this manual contains information, cautions, and warnings which must be followed to ensure safe operation and to retain the instrument in safe condition. Service and adjustments should be performed only by service-trained personnel.

### WARNING

**ALL PROTECTIVE EARTH TERMINALS, EXTENSION CORDS, AUTOTRANSFORMERS AND DEVICES CONNECTED TO THE INSTRUMENT SHOULD BE CONNECTED TO A PROTECTIVE EARTH GROUNDED SOCKET. ANY INTERRUPTION OF THE PROTECTIVE EARTH GROUNDING WILL CAUSE A POTENTIAL SHOCK HAZARD THAT COULD RESULT IN PERSONAL INJURY.**

**ONLY THE 250V FUSES WITH THE REQUIRED RATED CURRENT AND SPECIFIED TYPE SHOULD BE USED. DO NOT USE REPAIRED FUSES OR SHORT CIRCUITED FUSEHOLDERS. TO DO SO COULD CAUSE A SHOCK OR FIRE HAZARD.**

8-13. Any adjustments, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible and, when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

8-14. Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of power.

### WARNING

**LINE VOLTAGE IS ALWAYS PRESENT AT THE POWER CORD CONNECTOR, AC LINE FUSE AND TRANSFORMER WHENEVER THE LINE CORD IS ATTACHED. UNPLUGGING THE POWER CORD IS NECESSARY TO REMOVE ALL POWER FROM THE INSTRUMENT.**

8-15. Whenever it is likely that grounding or fuse protection has been impaired, the HP 5386A must be made inoperative and secured against any unintended operation.

### WARNING

**THE SERVICE INFORMATION IS OFTEN USED WITH POWER SUPPLIED AND PROTECTIVE COVERS REMOVED FROM THE 5386A. ENERGY AVAILABLE AT MANY POINTS MAY, IF CONTACTED, RESULT IN PERSONAL INJURY.**

## 8-16. Safety Symbols

8-17. The following safety symbols shown in *Figure 8-1* are used on equipment and in manuals:

## 8-18. RECOMMENDED TEST EQUIPMENT

8-19. Test equipment and test equipment accessories required to maintain the HP 5386A are listed in *Table 1-2*. Equipment other than that listed may be used if it meets the critical specifications.

## 8-20. SERVICE AIDS

### 8-21. Pozidriv Screwdrivers

8-22. Many screws in the counter appear to be Phillips, but are not. To avoid damage to the screw slots, pozidriv screwdrivers should be used.

### 8-23. Nut Drivers

8-24. The BNC input connectors on the front panel have ring nuts to hold them in place. To remove or tighten the nuts without damaging the panel, place tape on the end of the nut driver to act as a cushion.



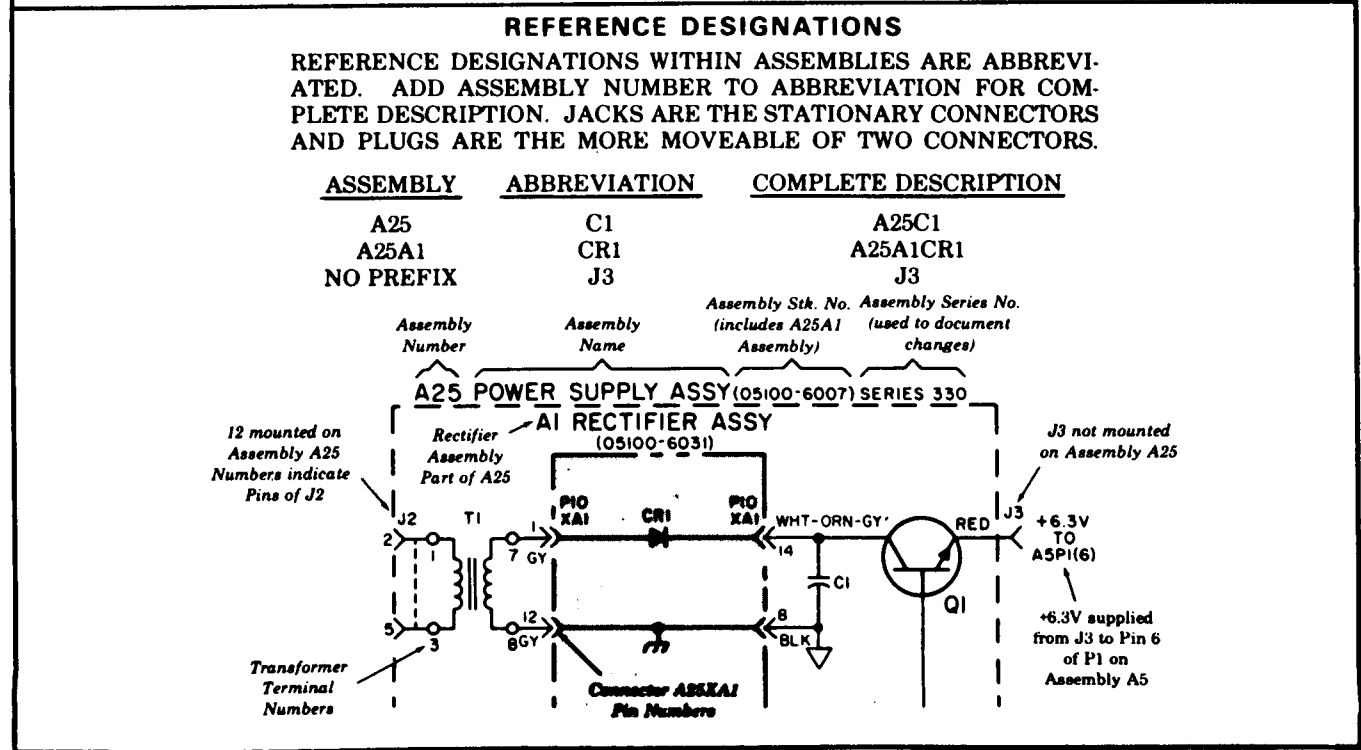
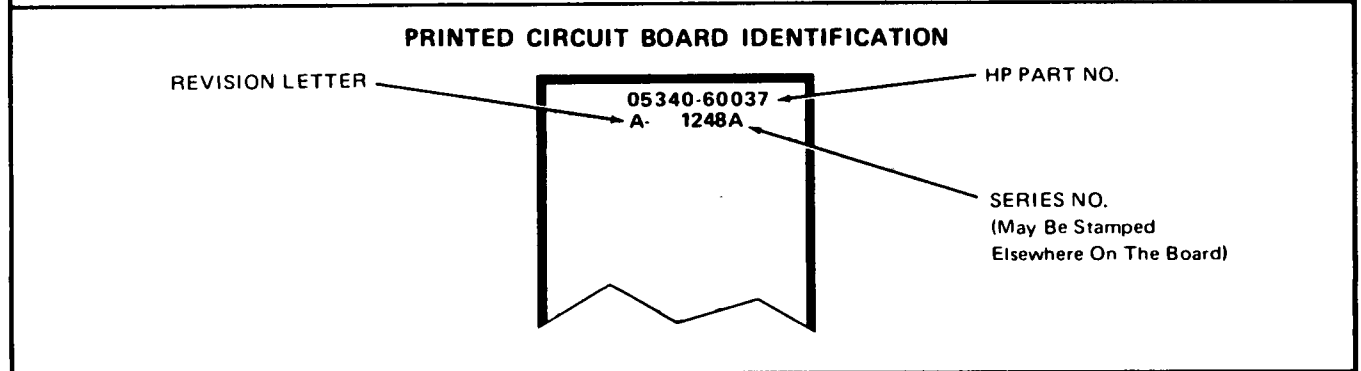
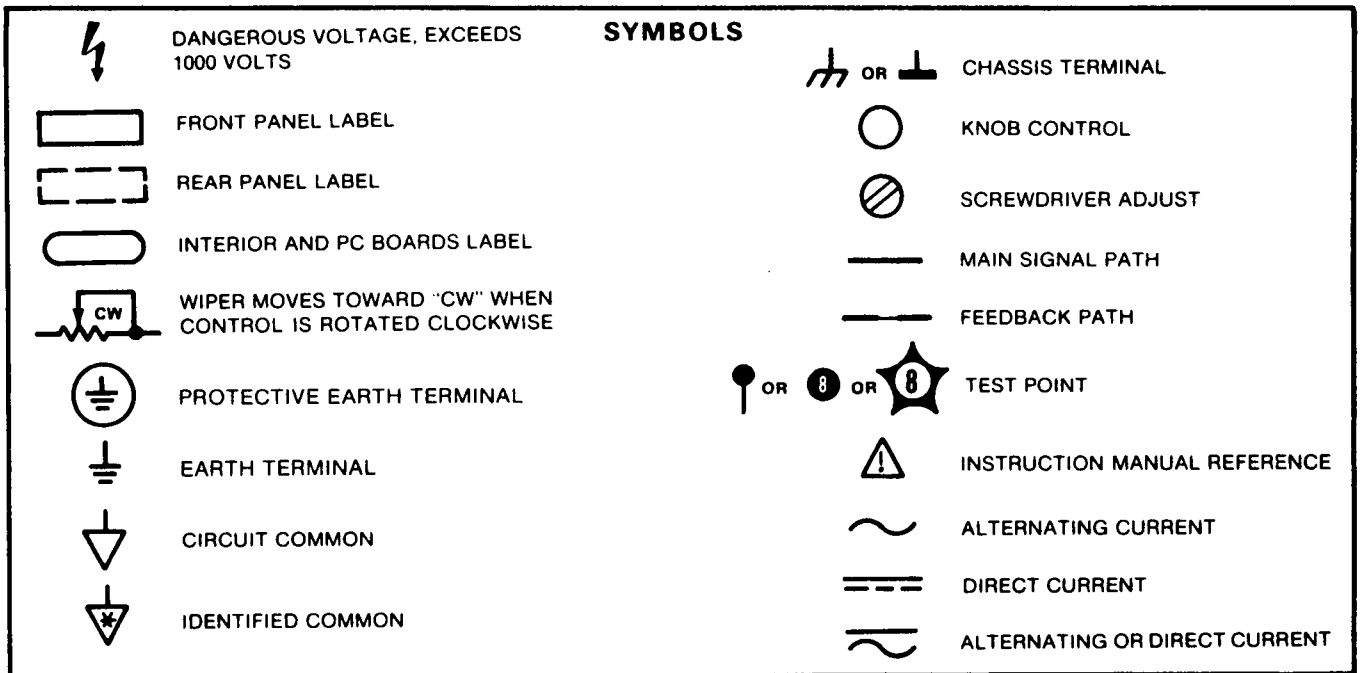


Figure 8-1. Schematic Diagram Notes

### 8-25. Service Aids on Printed Circuit Boards

8-26. The servicing aids include test points, transistor and integrated circuit designations, adjustment call-outs, and assembly stock numbers.

### 8-27. After Service Safety Checks

8-28. Visually inspect interior of instrument for any signs of abnormal internally generated heat, such as discolored printed circuit boards or components, damaged insulation, or evidence of arcing. Determine and remedy the cause of any such condition.

8-29. Using a suitable ohmmeter, check resistance from the front and rear panels to ground pin on power cord plug. The reading must be less than one ohm. Flex the power cord while making this measurement to determine whether intermittent discontinuities exist.

8-30. Check resistance from the front and rear panel BNC connector shells and neutral (tied together) with the power switch on and the power source disconnected. The minimum acceptable resistance is two megohms. Replace any component which results in a failure.

8-31. Check line fuse(s) to verify that a correctly rated fuse is installed.

### 8-32. HP 5386A Disassembly Procedures

8-33. The following procedures describe how to disassemble the HP 5386A counter.

- a. Remove ac power cord from rear of instrument.
- b. Remove BNC nut from Channel A connector.
- c. Remove type N knurled nut from Channel B connector.
- d. Remove knob and hex nut from MAN LEVEL A control.
- e. Remove top cover by:
  1. Loosening screw at rear of cover.
  2. Slide cover toward rear of instrument, lift off.

8-34. If there is an interface board in the instrument, follow the next three steps for disassembly. If there is no interface board present, skip the following three steps and continue with step "i".

f. Disconnect HP-IB ribbon cable from A1 Motherboard.

g. Remove hex screws at HP-IB connector on rear panel.

h. Remove HP-IB board from instrument by pressing in plastic catch near top of support post; lift off.

i. Remove bottom cover in similar manner as top cover.

j. Remove screws holding power transformer mounting bracket to side frame.

k. Remove screws holding A3 Pre-scaler board to side frame.

l. Unplug ribbon cable connecting A3 Pre-scaler board to A1 Motherboard; remove board.

m. Remove screws at rear of instrument in top and bottom of both side frames.

n. Gently slide out A1 Motherboard.

o. Unsolder 10 MHz Reference ground and IN/OUT wires from A1 Motherboard.

p. Unsolder ac input power wires (2) from A1 Motherboard.

q. Remove both side frames from front panel.

r. Remove front panel keyboard/LCD assembly by removing two lock nuts.

s. Lift out front panel keyboard/LCD assembly.

t. Remove LCD assembly by removing two self-tapping screws.

u. Lift out LCD assembly.

v. Disassembly is complete.

### 8-35. Assembly Identification

8-36. The name, assembly number, and Hewlett-Packard part number of the HP 5386A assemblies are listed in *Table 8-1*.

*Table 8-1. Assembly Usage*

REF. DES.	PART NAME	HP PART NUMBER
A1	MotherBoard Assembly	05386-60001
A2	Display Assembly	
	Keyboard Assembly	05384-60102
	Liquid Crystal Display Assembly	05384-60104
A3	Pre-scaler Assembly	05386-60002
A4	Not Assigned	
A5	HP-IB Board Assembly	05384-60005

## 8-37. LOGIC SYMBOLS

8-38. The electronic symbology used in this book is explained starting in paragraphs 8-39.

## 8-39. EXPLANATION OF NEW LOGIC SYMBOLS (by F. A. Mann)\*

### 8-40. Introduction

8-41. The International Electrotechnical Commission (IEC) has been developing a very powerful symbolic language that can show the relationship of each input of a digital logic circuit to each output without showing explicitly the internal logic. At the heart of the system is dependency notation, which will be explained in a later paragraph.

8-42. The system was introduced in the USA in a rudimentary form in IEEE/ANSI Standard Y32.14-1973. Lacking at that time a complete development of dependency notation, it offered little more than a substitution of rectangular shapes for the familiar distinctive shapes for representing the basic functions of AND, OR, negation, etc. This is no longer the case.

8-43. Internationally, Working Group 2 of IEC Technical Committee TC-3 is preparing a new document (Publication 617-12) that will consolidate the original work started in the mid 1960's and published in 1972 (Publication 117-15) and the amendments and supplements that have followed. Similarly for the USA, IEEE Committee SCC 11.9 is revising the publication IEEE Standard 91/ANSI Y32.14. Texas Instruments (and Hewlett-Packard) is participating in the work of both organizations and (a) Supplement to the (Texas Instruments) TTL Data Book introduces new logic symbols in anticipation of the new standards. When changes are made as the standards develop, future editions of the TTL Data Book will take those changes into account.

8-44. The following explanation of the new symbolic language is necessarily brief and greatly condensed from what the standards publications will finally contain. This (description) is not intended to be sufficient for those people who will be developing symbols for new devices. It is primarily intended to make possible the understanding of the symbols used in this book; comparing the symbols with functional block diagrams and/or function tables will further help that understanding.

## 8-45. Symbol Composition

8-46. A symbol comprises an outline or a combination of outlines together with one or more qualifying symbols (characters). The shape of the symbols (outline) is not significant. As shown in *Figure 8-2*, general qualifying symbols are used to tell exactly what logical operation is performed by the elements. *Table 8-2* shows the general qualifying symbols used in the T.I. TTL data book. Input lines are placed on the left and output lines are placed on the right. When an exception is made to that convention, the direction of signal flow is indicated by an arrow as shown in *Table 8-3*.

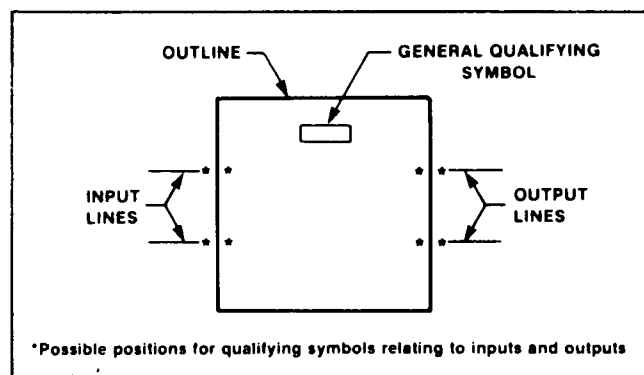


Figure 8-2. Symbol Composition

8-47. All outputs of a single, unsubdivided element always have identical internal logic states determined by the function of the element except when otherwise indicated by an associated qualifying symbol or label inside the element.

8-48. The outlines of elements may be abutted (adjoining) or embedded (enclosed) in which case the following conventions apply. There is no logic connection between the elements when the line common to their outlines is in the direction of signal flow. There is at least one logic connection between the elements when the line common to their outlines is perpendicular to the direction of signal flow. The number of logic connections between elements will be clarified by the use of qualifying symbols and this is discussed further under that topic. If no indications are shown on either side of the common line, it is assumed there is only one connection.

8-49. When a circuit has one or more inputs that are common to more than one element of the circuit, the common-control block may be used. This is the only distinctively shaped outline used in the IEC system.

\*From "1981 Supplement to the TTL Data Book for Design Engineers", copyright © 1981 Texas Instruments Incorporated. Reproduced by permission.

8-50. Figure 8-3 shows that unless otherwise qualified by dependency notation, an input to the common-control block is an input to each of the elements below the common-control block.

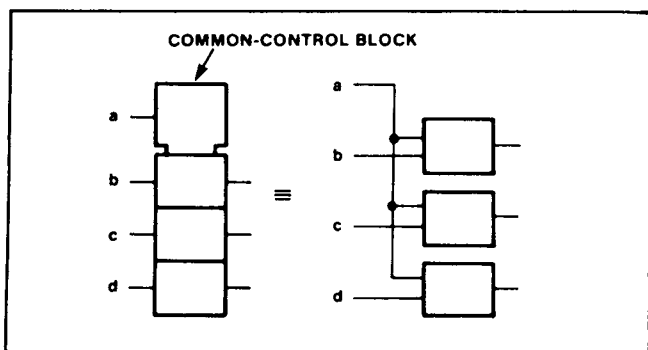


Figure 8-3. Illustration of Common-Control Block

output element. Its distinctive visual feature is the double line at its top. In addition the common-output element may have other inputs as shown in Figure 8-4. The function of the common-output element must be shown by use of a general qualifying symbol.

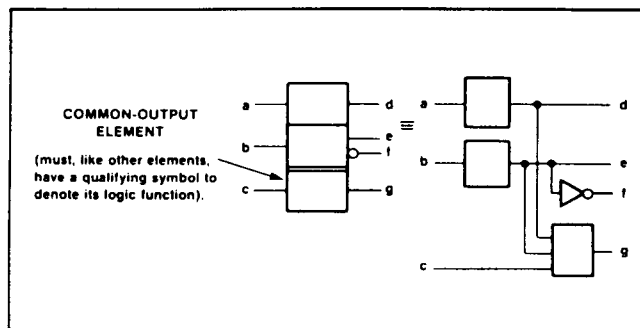


Figure 8-4. Illustration of Common-Output Element

8-51. A common-output depending on all elements of the array can be shown as the output of a common-

Table 8-2. General Qualifying Symbols

SYMBOL	DESCRIPTION	EXAMPLE
&	AND gate or function.	SN7400
$\geq 1$	OR gate or function. The symbol was chosen to indicate that at least one active input is needed to activate the output.	SN7402
$=1$	Exclusive OR. One and only one input must be active to activate the output.	SN7486
=	Logic identity. All inputs must stand at same state.	SN74180
2k	An even number of inputs must be active.	SN74180
2k+1	An odd number of inputs must be active.	*
1	The one input must be active.	SN7404
$\equiv$ or -	A buffer or element with more than usual output capability (symbol is oriented in the direction of signal flow).	SN74S436
$\square$	Schmitt trigger; element with hysteresis.	SN74LS18
X/Y	Coder, code Converter (DEC/BCD, BIN/OCT, BIN/7-SEG, etc.).	SN74LS347
MUX	Multiplexer/data selector.	SN74150
DMUX or DX	Demultiplexer.	SN74138
$\Sigma$	Adder.	SN74LS385
P-Q	Subtractor.	SN74LS385
CPG	Look-ahead carry generator.	SN74182
$\pi$	Multiplier.	SN74LS384
COMP	Magnitude Comparator.	SN74LS682
ALU	Arithmetic logic unit.	SN74LS381
	Retriggerable monostable.	SN74LS422
1	Nonretriggerable monostable (one-shot)	SN74121

\*Not all of the general qualifying symbols have been used in this book, but they are included here for the sake of completeness.

Table 8-2. General Qualifying Symbols (Continued)

SYMBOL	DESCRIPTION	EXAMPLE
G	Astable element. (Showing waveform is optional.)	SN74LS320
!G	Synchronously starting astable.	SN74LS624
G!	Astable element that stops with a completed pulse.	SN74LS624
SRGm	Shift register. m = number of bits.	SN74LS595
CTRm	Counter. m = number of bits; cycle length = 2m.	SN54LS590
CTR DIVm	Counter with cycle length = m.	SN74LS668
ROM	Read-only memory.	SN74187
RAM	Random-access read/write memory.	SN74170
FIFO	First-in, first-out memory.	SN74LS222

**8-52. Qualifying Symbols**

8-53. GENERAL QUALIFYING SYMBOLS. Table 8-2 shows the general symbols used in this data book. These characters are placed near the top center or the geometric center of a symbol or symbol element to define the basic function of the device represented by the symbol or of the element.

8-54. QUALIFYING SYMBOLS FOR INPUTS AND OUTPUTS. Qualifying symbols for inputs and outputs are shown in Table 8-3 and will be familiar to most users with the possible exception of the logic polarity and analog signal indicators. The older logic negation indicator means that the external 0 (zero) state produces the internal 1 state. The internal 1 state means the active state. Logic negation may be used in pure logic diagrams; in order to tie the external 1 and 0 logic states to the level H (high) and L (low), a statement of whether positive logic (1=H, 0=L) or

negative logic (1=L, 0=H) is being used is required or must be assumed. Logic polarity indicators eliminate the need for calling out the logic convention and are used in this (T.I.) data book in the symbology for actual devices. The presence of the triangular polarity indicator indicates that the Low logic level will produce the internal 1 state (the active state) or that, in the case of an output, the internal 1 state will produce the external Low level. Note how the active direction of transition for a dynamic input is indicated in positive logic, negative logic, and with polarity indication.

8-55. The internal connections between logic elements abutted together in a symbol may be indicated by the symbols shown. Each logic connection may be shown by the presence of qualifying symbols at one or both sides of the common line and if confusion can arise about the numbers of connections, use can be made of one of the internal connection symbols.

Table 8-3. Qualifying Symbols for Inputs and Outputs

	Logic negation at input. External 0 produces internal 1.
	Logic negation at output. Internal 1 produces external 0.
	Active-low input. Equivalent to  in positive logic.
	Active-low output. Equivalent to  in positive logic.
	Active-low input in the case of right-to-left signal flow.
	Active-low output in the case of right-to-left signal flow.
	Signal flow from right-to-left. If not otherwise indicated, signal flow is from left-to-right.
	Bidirectional signal flow.

Table 8-3. Qualifying Symbols for Inputs and Outputs (Continued)

		POSITIVE LOGIC	NEGATIVE LOGIC	POLARITY INDICATION
	Dynamic inputs active on indicated transition			NOT USED
		NOT USED	NOT USED	H
				L
	Nonlogic connection. A label inside the symbol will usually define the nature of this pin.			
	Input for analog signals.			
	Internal connection. 1 state on left produces 1 state on right.			
	Negated internal connection. 1 state on left produces 0 state on right.			
	Dynamic internal connection. Transition from 0 to 1 on left produces transitory 1 state on right.			
	Internal input (virtual input). It always stands at its internal 1 state unless affected by an overriding dependency relationship.			
	Internal output (virtual output). Its effect on an internal input to which it is connected is indicated by dependency notation.			

8-56. The internal (virtual) input is an input originating somewhere else in the circuit and is not connected directly to a terminal. The internal (virtual) output is likewise not connected directly to a terminal.

8-57. The application of internal inputs and outputs requires an understanding of dependency notation, which is explained in paragraph 8-66.

8-58. In an array of elements, if the same general qualifying symbol and the same qualifying symbols associated with inputs and outputs would appear inside each of the elements of the array, these qualifying symbols are usually shown only in the first element. This is done to reduce clutter and to save time in recognition. Similarly, large identical elements that are subdivided into smaller elements may each be represented by an unsubdivided outline. The SN54LS440 symbol illustrates this principle.

8-59. SYMBOLS INSIDE THE OUTLINE. Table 8-4 shows some symbols used inside the outline. Note particularly that open-collector, open-emitter, and three-state outputs have distinctive symbols. Also note that an EN input affects all the outputs of the circuit and has no effect on inputs. When an enable input affects only certain outputs and/or affects one or more inputs, a form of dependency notation will

indicate this (see paragraph 8-101). The effects of the EN input on the various types of outputs are shown.

8-60. It is particularly important to note that a D input is always the data input of a storage element. At its internal 1 state, the D input sets the storage element to its 1 state, and at its internal 0 state it resets the storage element to its 0 state.




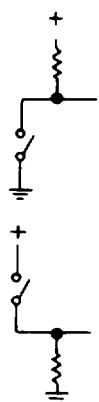







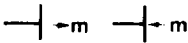
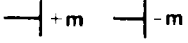


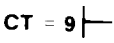



8-61. The binary grouping symbol will be explained more fully in paragraph 8-137. Binary-weighted inputs are arranged in order and the binary weights of the least-significant and the most-significant lines are indicated by numbers. In this data book weights of input and output lines will be represented by powers of two usually only when the binary grouping symbol is used, otherwise, decimal numbers will be used. The grouped inputs generate an internal number on which a mathematical function can be performed or that can be an identifying number for dependency notation. See Figure 8-30. A frequent use is in addresses for memories.

8-62. Reversed in direction, the binary grouping symbol can be used with outputs. The concept is analogous to that for the inputs and the weighted outputs will indicate the internal number assumed to be developed within the circuit.

8-63. Other symbols are used inside the outlines in this data book in accordance with the IEC/IEEE standards but are not shown here. Generally these are associated with arithmetic operations and are self-explanatory.

8-64. When nonstandardized information is shown inside an outline, it is usually enclosed in square brackets [like these].

Table 8-4. Symbols Inside the Outline

	Postponed output (of a pulse-triggered flip-flop). The output changes when input initiating change (e.g., a C input) returns to its initial external state or level.	
	Bi-threshold input (input with hysteresis).	
	NPN open-collector or similar output that can supply a relatively low-impedance L level when not turned off. Requires external pull-up. Capable of positive-logic wired-AND connection.	
	Passive-pull-up output is similar to NPN open-collector output but is supplemented with a built-in passive pull-up.	
	NPN open-emitter or similar output that can supply a relatively low-impedance H level when not turned off. Requires external pull-down. Capable of positive-logic wired-OR connection.	
	Passive-pull-down output is similar to NPN open-emitter output but is supplemented with a built-in passive pull-down.	
	Three-state output.	
	Enable input When at its internal 1-state, all outputs are enabled. When at its internal 0-state, open-collector and open-emitter outputs are off, three-state outputs are at normally defined internal logic states and at external high-impedance state, all other outputs (e.g., totem-poles) are at the internal 0-state.	
J, K, R, S, T	Usual meanings associated with flip-flop (e.g., R = reset, T = toggle).	
	Data input to a storage element equivalent to: 	
	Shift right (left) inputs, m = 1, 2, 3, etc. If m = 1, it is usually not shown.	
	Counting up (down) inputs, m = 1, 2, 3, etc. If m = 1, it is usually not shown.	
	Binary grouping. m is highest power of 2.	
	The contents-setting input, when active, causes the content of a register to take on the indicated value.	
	The content output is active if the content of the register is as indicated.	
	Input line grouping .... indicates two or more terminals used to implement a single logic input.  e.g., The paired expander inputs of SN7450 	
	Fixed-state output always stands at its internal 1 state. For example, see SN74185.	

**8-65. Dependency Notation**

8-66. GENERAL EXPLANATION. Dependency notation is the powerful tool that sets the IEC symbols apart from previous systems and makes compact, meaningful, symbols possible. It provides the means of denoting the relationship between inputs, outputs, or inputs and outputs without actually showing all the elements and interconnections involved. The information provided by dependency notation supplements that provided by the qualifying symbols for an element's function.

8-67. In the convention for the dependency notation, use will be made of the terms "affecting" and "affected".

In cases where it is not evident which inputs must be considered as being the affecting or the affected ones (e.g., if they stand in an AND relationship), the choice may be made in any convenient way.

8-68. So far, 11 types of dependency have been defined and 10 of these are used in the Texas Instruments data book. They are listed below in the order in which they are presented and are summarized in *Table 8-5*.

*Table 8-5. Summary of Dependency Notation*

TYPE OF DEPENDENCY	LETTER SYMBOL*	AFFECTING INPUT AT ITS 1-STATE	AFFECTING INPUT AT ITS 0-STATE
Address	A	Permits action (address selected)	Prevents action (address not selected)
Control	C	Permits action	Prevents action
Enable	EN	Permits action	Prevents action of inputs. ◇ outputs off. ▽ outputs at external high impedance, no change in internal logic state. Other outputs at internal 0 state.
AND	G	Permits action	Imposes 0 state
Mode	M	Permits action (mode selected)	Prevents action (mode not selected)
Negate (X-OR)	N	Complements state	No effect.
RESET	R	Affected output reacts as it would to S = 0, R = 1	No effect
SET	S	Affected output reacts as it would to S = 1, R = 0	No effect
OR	V	Imposes 1 state	Permits action
Transmission	X	Bidirectionally connected input to output	Input to output bidirectionally not connected
Interconnection	Z	Imposes 1 state	Imposes 0 state

\*These letter symbols appear at the AFFECTING input (or output) and are followed by a number. Each input (or output) AFFECTED by that input is labeled with that same number. When the labels EN, R, and S appear at inputs without the following numbers, the descriptions above do not apply. The action of these inputs is described under "Symbols Inside the Outline".



**Paragraph Dependency Type or Other Subject**

8-68	G, AND
8-72	General rules for dependency notation
8-80	V, OR
8-82	N, Negate, (Exclusive OR)
8-84	Z, Interconnection
8-87	X, Transmission
8-91	C, Control
8-94	S, Set and R, Reset
8-100	EN, Enable
8-104	M, Mode
8-117	A, Address

8-70. In Figure 8-5 input **b** is ANDed with input **a** and the complement of **b** is ANDed with **c**. The letter G has been chosen to indicate AND relationships and is placed at input **b**, inside the symbol. A number considered appropriate by the symbol designer (1 has been used here) is placed after the letter G and also at each affected input. Note the bar over the 1 at input **c**.

8-71. In Figure 8-6, output **b** affects input **a** with an AND relationship. The lower example shows that it is the internal logic state of **b**, unaffected by the negation sign, that is ANDed. Figure 8-7 shows input **a** to be ANDed with a dynamic input **b**.

8-72. The rules for G dependency can be summarized thus:

When a  $G_m$  input or output ( $m$  is a number) stand at its internal 1 state, all inputs and outputs affected by  $G_m$  stand at their normally defined internal logic states. When the  $G_m$  input or output stands at its 0 state, all inputs and outputs affected by  $G_m$  stand at their internal 0 states.

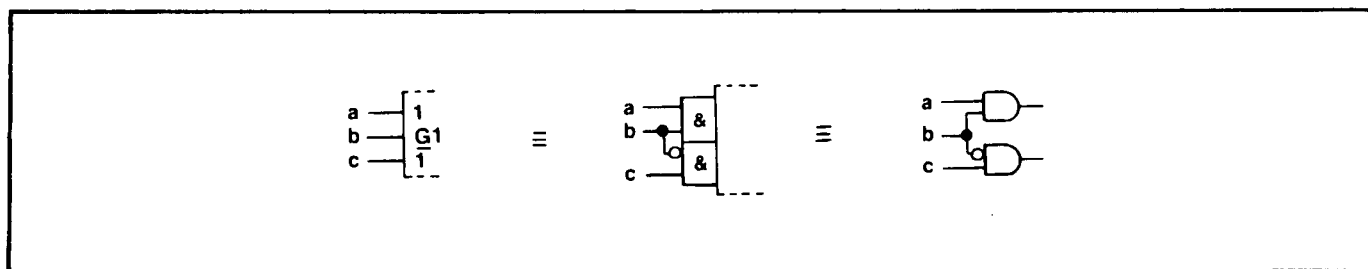


Figure 8-5. G Dependency Between Inputs

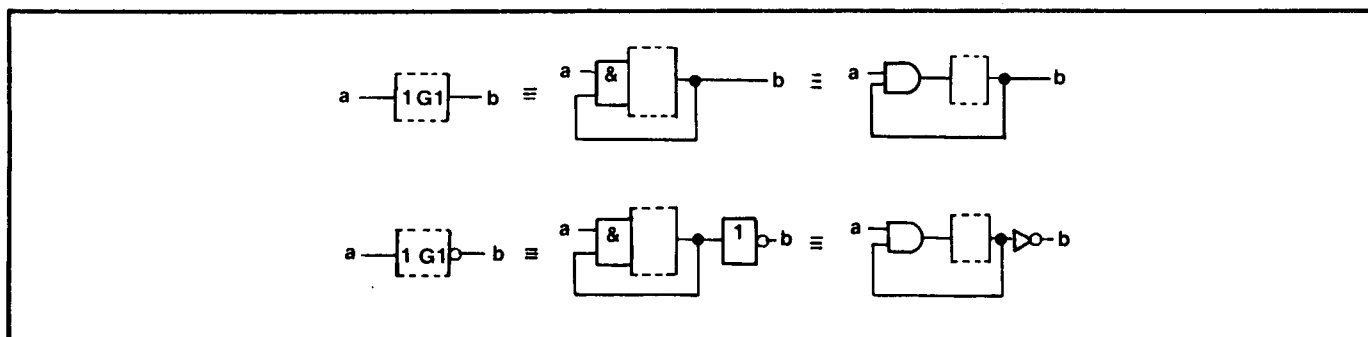


Figure 8-6. G Dependency Between Outputs and Inputs

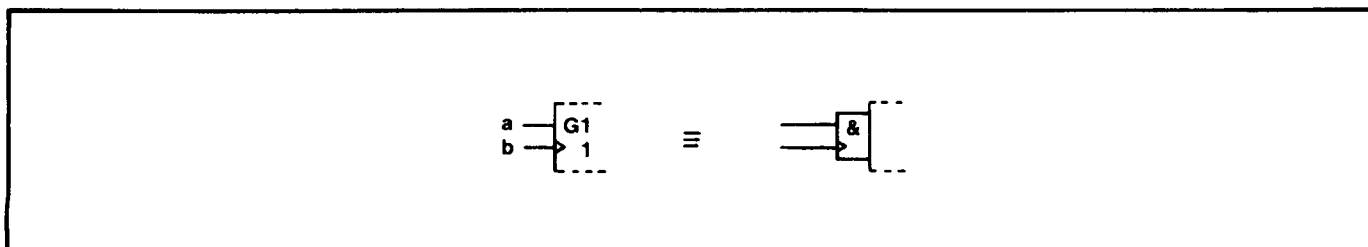


Figure 8-7. G Dependency with A Dynamic Input

8-73. CONVENTIONS FOR THE APPLICATION OF DEPENDENCY NOTATION IN GENERAL. The rules for applying dependency relationships in general follow the same pattern as was illustrated for G dependency.

8-74. Application of dependency notation is accomplished by:

a. Labeling the input (or output) affecting other inputs or outputs with the letter symbol indicating the relationship involved (e.g., G for AND) followed by an identifying number, appropriately chosen, and;

b. Labeling each input or output affected by that affecting input (or output) with the same number.

8-75. If it is the complement of the internal logic state of the affecting input or output that does the affecting, then a bar is placed over the identifying numbers at the affected inputs or outputs. See Figure 8-5.

8-76. If two affecting inputs or outputs have the same letter and same identifying number, they stand in an OR relationship to each other. See Figure 8-8.

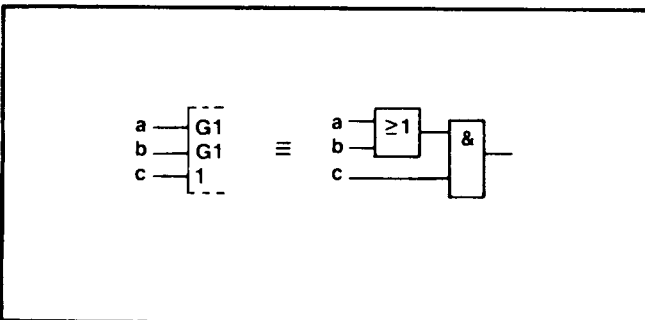


Figure 8-8. OR'ed Affecting Inputs

8-77. If the affected input or output requires a label to denote its function (e.g., "D"), this label will be prefixed by the identifying number of the affecting input. See Figure 8-14.

8-78. If an input or output is affected by more than one affecting input, the identifying numbers of each of the affecting inputs will appear in the label of the affected one, separated by commas. The normal reading order of these numbers is the same as the sequence of the affecting relationships. See Figure 8-14.

8-79. If the labels denoting the functions of affected inputs or outputs must be numbers (e.g., outputs of a coder), the identifying numbers to be associated with both affecting inputs and affected inputs or outputs will be replaced by another character selected to avoid ambiguity, e.g., Greek letters. See Figure 8-9.

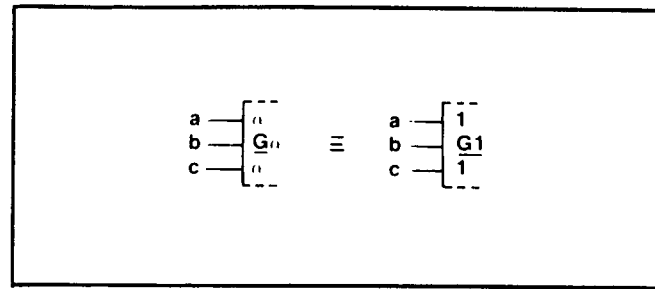


Figure 8-9. Substitution for Numbers

8-80. V (OR) DEPENDENCY. The symbol denoting OR dependency is the letter V. See Figure 8-10.

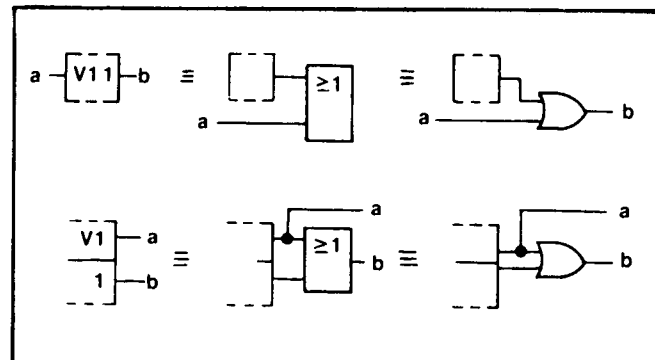


Figure 8-10. V (OR) Dependency

8-81. When a  $V_m$  input or output stands at its internal 1 state, all inputs and outputs affected by  $V_m$  stand at their internal 1 states. When the  $V_m$  input or output stands at its internal 0 state, all inputs and outputs affected by  $V_m$  stand at their normally defined internal logic states.

8-82. N (NEGATE, X-OR) DEPENDENCY. The symbol denoting negate dependency is the letter N. See Figure 8-11. Each input or output affected by an  $N_m$  input or output stands in an exclusive-OR relationship with the  $N_m$  input or output.

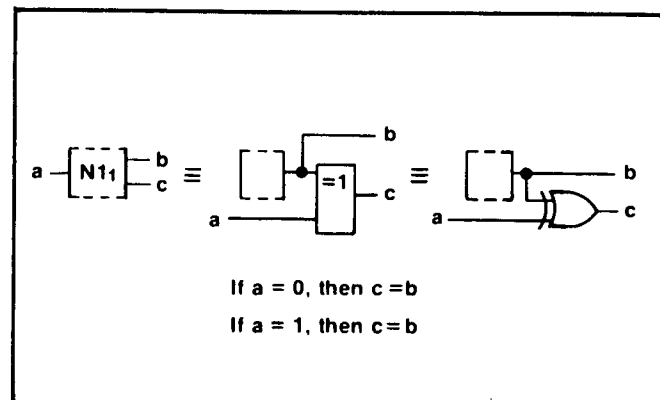


Figure 8-11. N (Negate, X-OR) Dependency

8-83. When an  $N_m$  input or output stands at its internal 1 state, the internal logic state of each input and each output affected by  $N_m$  is the complement of what it would otherwise be. When an  $N_m$  input or output stands at its internal 0 state, all inputs and outputs affected by  $N_m$  stand at their normally defined internal logic states.

8-84. Z (INTERCONNECTION) DEPENDENCY. The symbol denoting interconnection dependency is the letter Z.

8-85. Interconnecting dependency is used to indicate the existence of internal logic connections between inputs, outputs, internal inputs, and/or internal outputs.

8-86. The internal logic state of an input or output affected by a  $Z_m$  input or output will be same as the internal logic state of the  $Z_m$  input or output, unless modified by additional dependency notation. See Figure 8-12.

**NOTE**

Paragraphs 8-87 to 8-90 and Figure 8-13 are not taken from Texas Instruments publications.

8-87. X (TRANSMISSION) DEPENDENCY. The symbol X denotes transmission dependency.

8-88. When an  $X_m$  input or an  $X_m$  output stands at its internal 1 state, all input-output lines affected by this  $X_m$  input or  $X_m$  output are bidirectionally connected together and stand at the same internal logic state or analog signal level.

8-89. When a  $X_m$  input or  $X_m$  output stands at its internal 0 state, the connection associated with this set of dependency notation is broken.

8-90. If  $a$  stands at its 1 state, there is a bidirectional connection between  $b$  and  $c$ . If  $a$  stands at its 0 state, there is a bidirectional connection between  $c$  and  $d$ . See Figure 8-13.

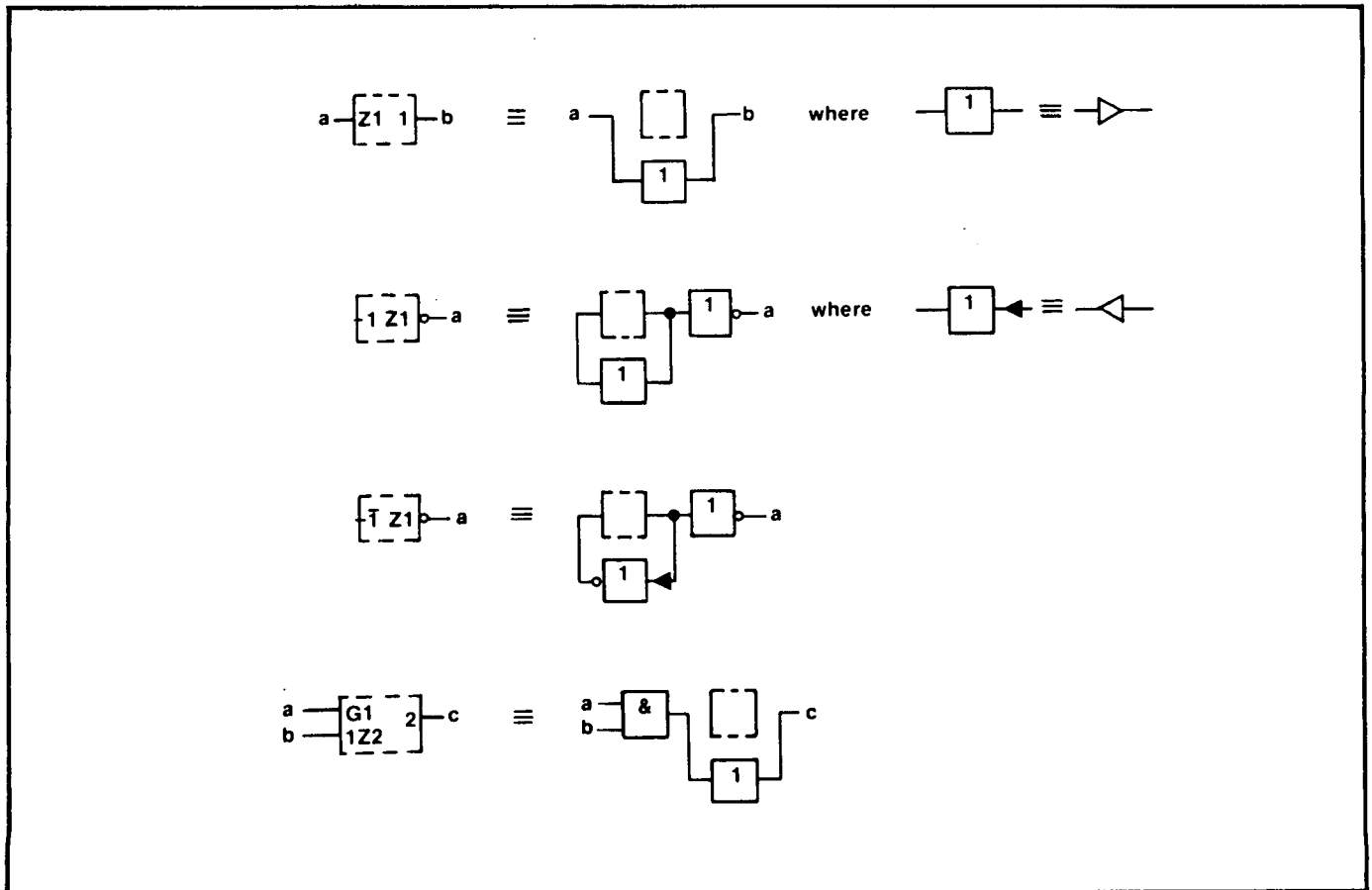


Figure 8-12. Z (Interconnection) Dependency

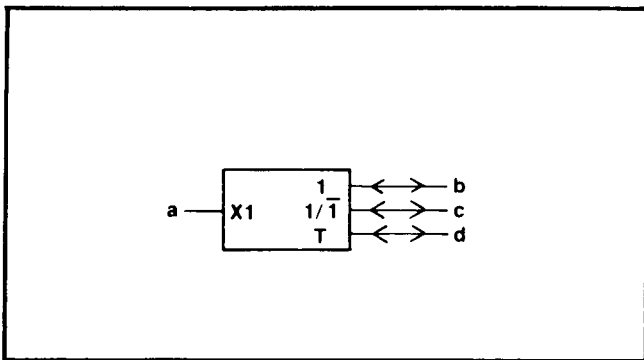


Figure 8-13. X (Transmission) Dependency

8-91. C (CONTROL) DEPENDENCY. The symbol denoting control dependency is the letter C.

8-92. Control inputs are usually used to enable or disable the data (D, J, K, R, or S) inputs of storage elements. They may take on their internal 1 states (be active) either statically or dynamically. In the latter case the dynamic input symbol is used as shown in the third example of Figure 8-14.

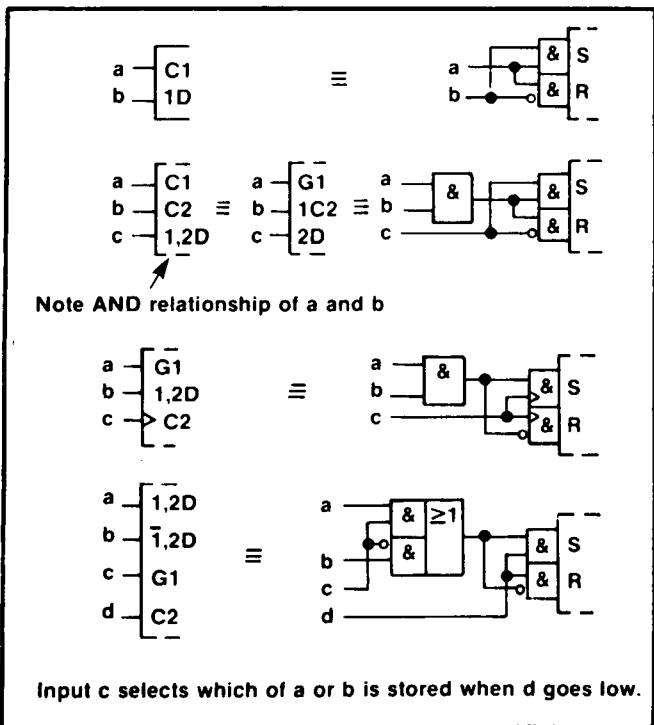


Figure 8-14. C (Control) Dependency

8-93. When a  $C_m$  input or output stands at its internal 1 state, the inputs affected by  $C_m$  have their normally defined affect on the function of the element, i.e., these inputs are enabled. When a  $C_m$  input or output stands at its internal 0 state, the inputs affected by  $C_m$  are disabled and have no effect on the function of the element.

8-94. S (SET) and R (RESET) DEPENDENCIES. The symbol denoting set dependency is the letter S. The symbol denoting reset dependency is the letter R.

8-95. Set and reset dependencies are used if it is necessary to specify the effect of the combination  $R=S=1$  on a bistable element. Case 1 in Figure 8-15 does not use S or R dependency.

8-96. When an  $S_m$  input is at its internal 1 state, outputs affected by the  $S_m$  input will react, regardless of the state of an R input, as they normally would react to the combination  $S=1, R=0$ . See cases 2, 4, and 5 in Figure 8-15.

8-97. When an  $R_m$  input is at its internal 1 state, outputs affected by the  $R_m$  input will react, regardless of the state of an S input, as they normally would react to the combination  $S=0, R=1$ . See cases 3, 4, and 5 in Figure 8-15.

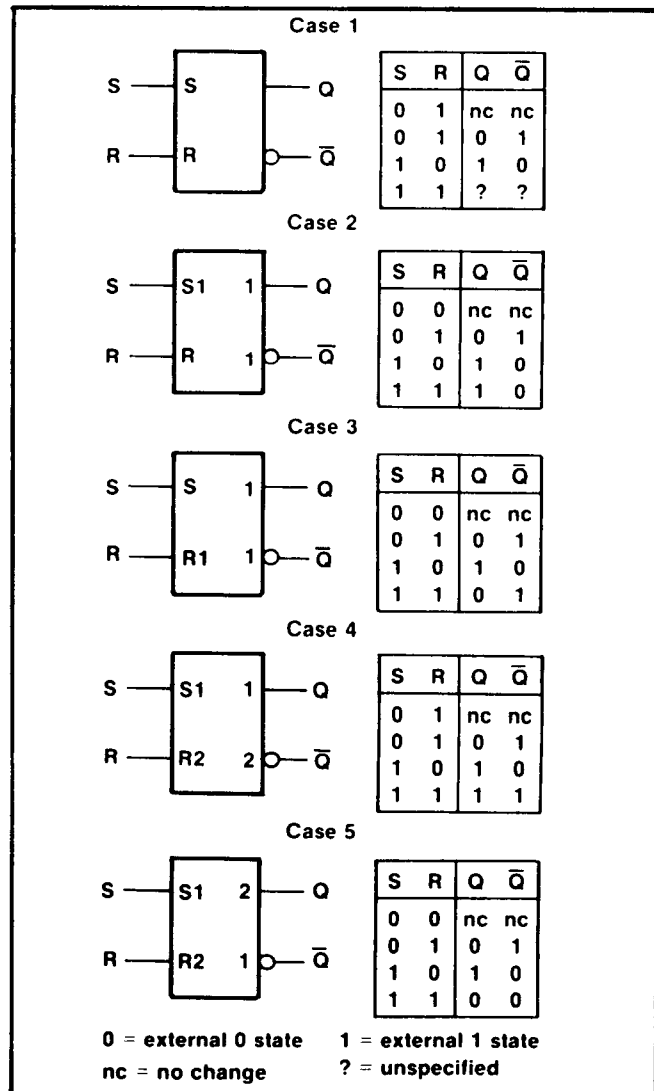


Figure 8-15. S (Set) and R (Reset) Dependencies

8-98. When an  $S_m$  or  $R_m$  input is at its internal 0 state, it has no effect.

8-99. Note that the noncomplementary output patterns in cases 4 and 5 are only pseudostable. The simultaneous return of the inputs to  $S=R=0$  produces an unforeseeable stable and complementary output pattern.

8-100. EN (ENABLE) DEPENDENCY. The symbol denoting enable dependency is the combination of letters EN.

8-101. An  $EN_m$  input has the same effect on outputs as an EN input, see paragraph 8-52, but it affects only those outputs labeled with the identifying number  $m$ . It also affects those inputs labeled with the identifying number  $m$ . By contrast an EN input affects all outputs and no inputs. The effect of an  $EN_m$  input on an affected input is identical to that of a  $C_m$  input. See Figure 8-16.

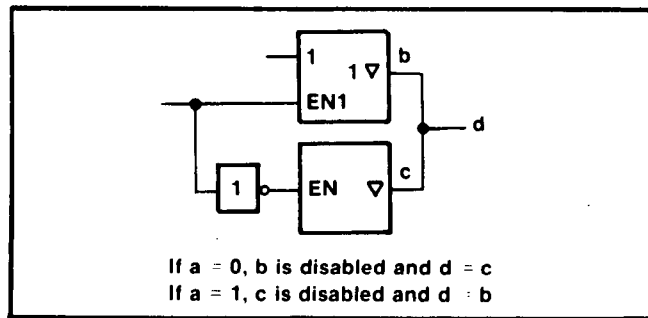


Figure 8-16. EN (Enable) Dependency

8-102. When an  $EN_m$  input stands at its internal 1 state, the inputs affected by  $EN_m$  have their normally defined effect on the function of the element and the outputs affected by this input stand at their normally defined internal logic states, i.e., these inputs and outputs are enabled.

8-103. When an  $EN_m$  input stands at its internal 0 state, the inputs affected by  $EN_m$  are disabled and have no effect on the function of the element, and the outputs affected by  $EN_m$  are also disabled. Open-collector outputs are turned off, three-state outputs stand at their normally defined internal logic states but externally exhibit high impedance, and all other outputs (e.g., totem-pole outputs) stand at their internal 0 states.

8-104. M (MODE) DEPENDENCY. The symbol denoting mode dependency is the letter M.

8-105. Mode dependency is used to indicate that the effects of particular inputs and outputs of an element depend on the mode in which the element is operating.

8-106. If an input or output has the same effect in different modes of operation, the identifying numbers of the relevant affecting  $M_m$  inputs will appear in the label of that affected input or output between parentheses and separated by solidi. See Figure 8-21.

8-107. M DEPENDENCY AFFECTING INPUTS. M dependency affects inputs the same as C dependency. When an  $M_m$  input or  $M_m$  output stands at its internal 1 state, the inputs affected by this  $M_m$  input or  $M_m$  output have their normally defined effect on the function of the element, i.e., the inputs are enabled.

8-108. When an  $M_m$  input or  $M_m$  output stands at its internal 0 state, the inputs affected by this  $M_m$  input or  $M_m$  output have no effect on the function of the element. When an affected input has several sets of labels separated by solidi (e.g.,  $C4/2- /3+$ ), any set in which the identifying number of the  $M_m$  input or  $M_m$  output appears has no effect and is to be ignored. This represents disabling of some of the functions of a multifunction input.

8-109. The circuit in Figure 8-17 has two inputs,  $b$  and  $c$ , that control which one of four modes (0, 1, 2, or 3) will exist at any time. Inputs  $d$ ,  $e$ , and  $f$  are D inputs subject to dynamic control (clocking) by the  $a$  input. The numbers 1 and 2 are in the series chosen to indicate the modes so inputs  $e$  and  $f$  are only enabled in mode 1 (for parallel loading) and input  $d$  is only enabled in mode 2 (for serial loading). Note that input  $a$  has three functions. It is the clock for entering data. In mode 2, it causes right shifting of data, which means a shift away from the control block. In mode 3, it causes the contents of the register to be incremented by one count.

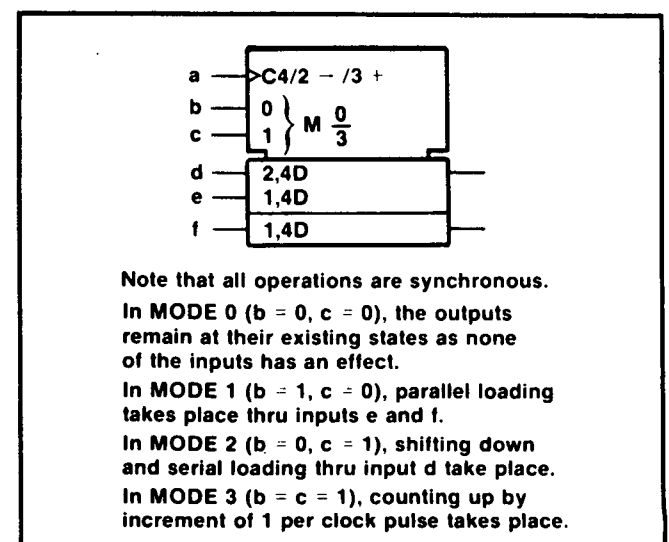


Figure 8-17. M (Mode) Dependency

8-110. **M DEPENDENCY AFFECTING OUTPUTS.** When an *Mm* input or *Mm* output stands at its internal 1 state, the affected outputs stand at their normally defined internal logic states, i.e., the outputs are enabled.

8-111. When an *Mm* input or *Mm* output stands at its internal 0 state, at each affected output any set of labels containing the identifying number of that *Mm* input or *Mm* output has no effect and is to be ignored. When an output has several different sets of labels separated by solidi (e.g., 2, 4/3, 5), only those sets in which the identifying number of this *Mm* input or *Mm* output appears are to be ignored.

8-112. In *Figure 8-18*, mode 1 exits when the *a* input stands at its internal 1 state. The delayed output symbol is effective only in mode 1 (when input *a* = 1) in which case the device functions as a pulse-triggered flip-flop. See paragraphs 8-125 through 8-129. When input *a* = 0, the device is not in mode 1 so the delayed output symbol has no effect and the device functions as a transparent latch.

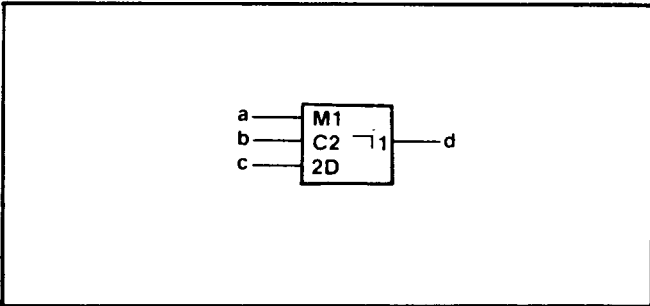


Figure 8-18. Type of Flip-Flop Determined by Mode

8-113. In *Figure 8-19*, if input *a* stands at its internal 1 state establishing mode 1, output *b* will stand at its internal 1 state only when the content of the register equal 9. Since output *b* is located in the common-control block with no defined function outside of mode 1, this output will stand at its internal 0 state when input *a* stands at its internal 0 state, regardless of the register content.

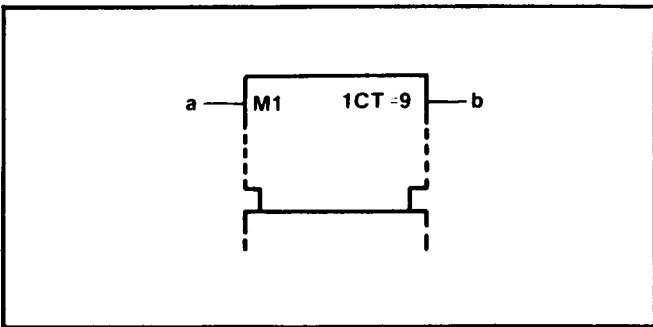


Figure 8-19. Disabling an Output of the Common Control Block

8-114. In *Figure 8-20*, if input *a* stands at its internal 1 state establishing mode 1, output *b* will stand at its internal 1 state only when the content of the register equals 15. If input *a* stands at its internal 0 state, output *b* will stand at its internal 1 state only when the content of the register equals 0.

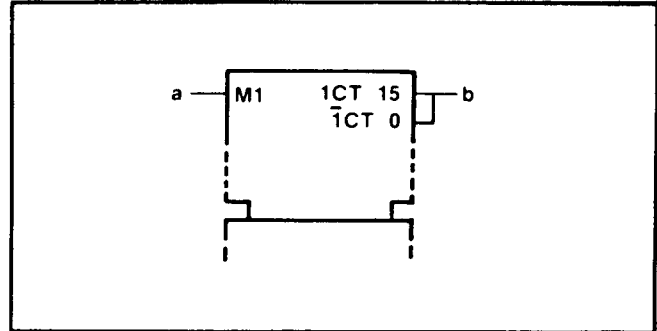


Figure 8-20. Determining an Output Function

8-115. In *Figure 8-21* inputs *a* and *b* are binary weighted to generate the numbers 0, 1, 2, or 3. This determines which one of the four modes exists.

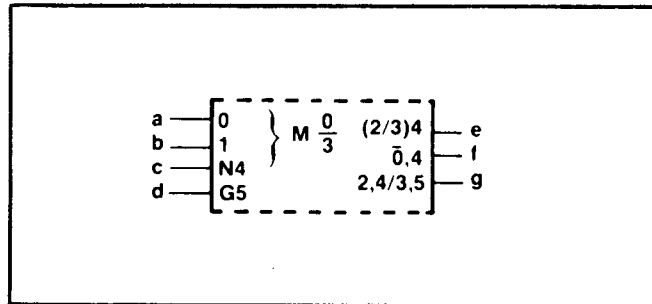


Figure 8-21. Dependent Relationship Affected by Mode

8-116. At output *e* the label set causing negation (if *c* = 1) is effective only in modes 2 and 3. In modes 0 and 1 this output stands at its normally defined state as if it had no labels. At output *f* the label set has effect when the mode is not 0 so output *e* is negated (if *c* = 1) in modes 1, 2, and 3. In mode 0 the label set has no effect so the output stands at its normally defined state. In this example 0, 4 is equivalent to (1/2/3)4. At output *g* there are two label sets. the first set, causing negation (if *c* = 1), is effective only in mode 2. The second set, subjecting *g* to AND dependency on *d*, has effect only in mode 3.

8-117. **A (ADDRESS) DEPENDENCY.** The symbol denoting address dependency is the letter A.

8-118. Address dependency provides a clear representation of those elements, particularly memories, that use address control inputs to select specified sections of a multidimensional array. Such a section of a memory array is usually called a word. The purpose

of address dependency is to allow a symbolic presentation of the entire array. An input of the array shown at a particular element of this general section is common to the corresponding elements of all selected sections of the array. An output of the array shown at a particular element of this general section is the result of the OR function of the outputs of the corresponding elements of selected sections. If the label of an output of the array shown at a particular element of this general section indicates that this output is an open-circuit output or a three-state output, then this indication refers to the output of the array and not to those of the sections of the array.

8-119. Inputs that are not affected by any affecting address input have their normally defined effect on all sections of the array, whereas inputs affected by an address input have their normally defined effect only on the section selected by that address input.

8-120. An affecting address input is labeled with the letter A followed by an identifying number that corresponds with the address of the particular section of the array selected by this input. Within the general section presented by the symbol, inputs and outputs affected by an  $A_m$  input are labeled with the letter A, which stands for the identifying numbers, i.e., the addresses, of the particular sections.

8-121. Figure 8-22 shows a 3-word by 2-bit memory having a separate address line for each word and uses EN dependency to explain the operation. To select word 1, input a is taken to its 1 state, which establishes mode 1. Data can now be clocked into the inputs marked "1, 4D". Unless words 2 and 3 are also selected, data cannot be clocked in at the inputs marked "2, 4D" and "3, 4D". The outputs will be the OR functions of the selected outputs, i.e., only those enabled by the active EN functions.

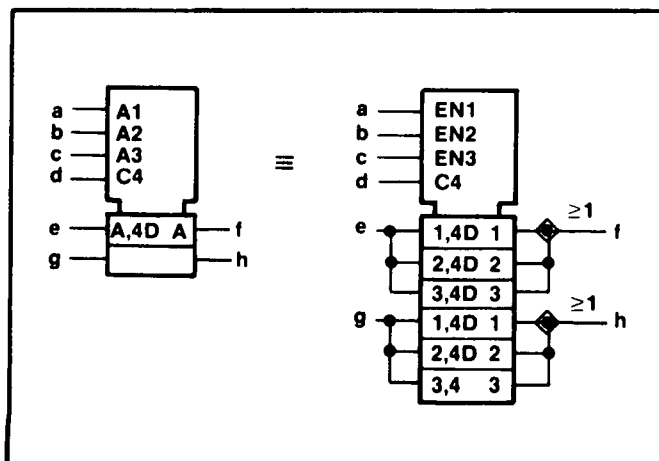


Figure 8-22. A (Address) Dependency

8-122. The identifying numbers of affecting address inputs correspond with the addresses of the sections selected by these inputs. They need not necessarily differ from those of other affecting dependency-inputs (e.g., G, V, N, ...), because in the general section presented by the symbol they are replaced by the letter A.

8-123. If there are several sets of affecting  $A_m$  inputs for the purpose of independent and possibly simultaneous access to sections of the array, then the letter A is modified to 1A, 2A, ..., because they have access to the same sections of the array, these sets of A inputs may have the same identifying numbers.

8-124. Figure 8-23 is another illustration of the A (Address) dependency.

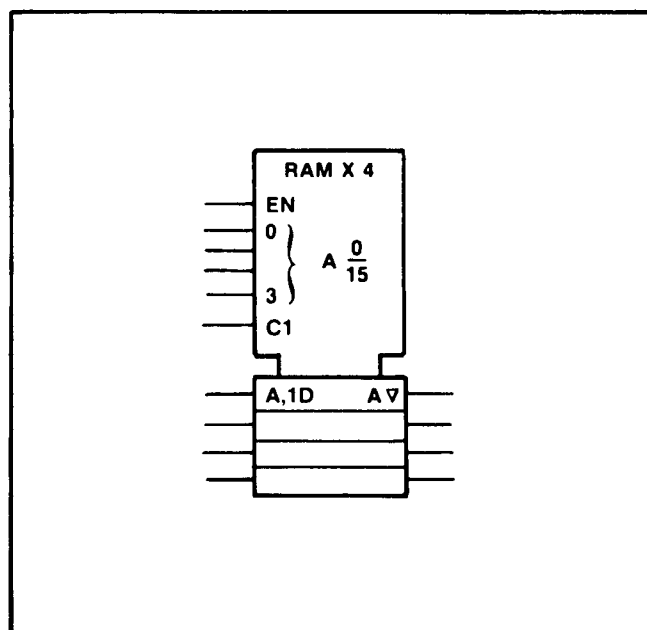


Figure 8-23. RAM Example\*

\*Array of 16 sections of four transparent latches with three-state outputs comprising a 16-word by four-bit random access memory.

### 8-125. Bistable Elements

8-126. The dynamic input symbol, the postponed output symbol, and dependency notation provide the tools to differentiate four main types of bistable elements and make synchronous and asynchronous inputs easily recognizable. See Figure 8-24. The first column shows the essential distinguishing features; the other columns show examples.

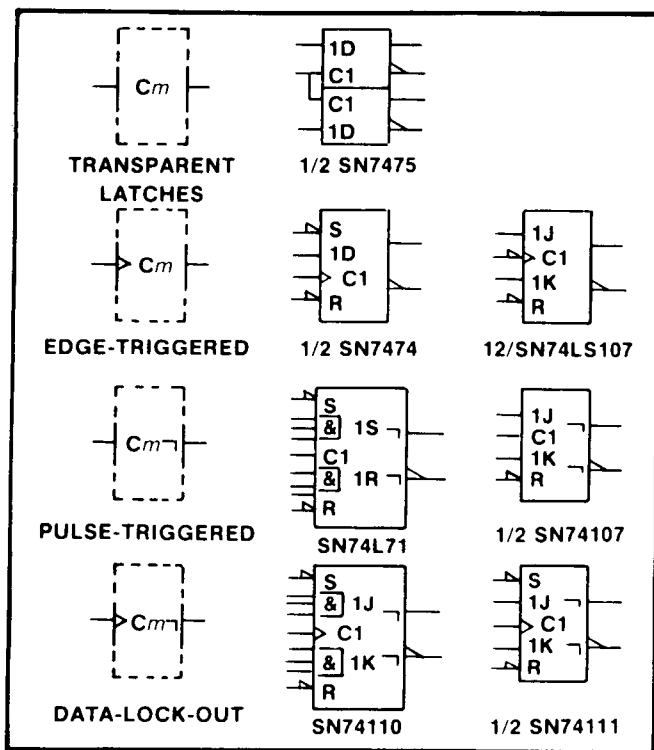


Figure 8-24. Four Types of Bistable Circuits

8-127. Transparent latches have a level-operated control input. The D input is active as long as the C input is at its internal 1 state. The outputs respond immediately. Edge-triggered elements accept data from D, J, K, R, or S inputs on the active transition of C. Pulse-triggered elements require the setup of data before the start of the control pulse; the C input is considered static since the data must be maintained as long as C is at its 1 state. The output is postponed until C returns to its 0 state. The data-lock-out element is similar to the pulse-triggered version except that the C input is considered dynamic in that shortly after C goes through its active transition, the data inputs are disabled and data does not have to be held. However, the output is still postponed until the C input returns to its initial external level.

8-128. Notice that synchronous inputs can be readily recognized by their dependency (1D, 1J, 1K, 1S, 1R) compared to the asynchronous inputs (S,R), which are not dependent on the C inputs.

**8-129. Coders**

8-130. The general symbol for a coder or code converter is shown in Figure 8-25. X and Y may be replaced by appropriate indications of the code used to represent the information at the inputs and at the outputs, respectively.

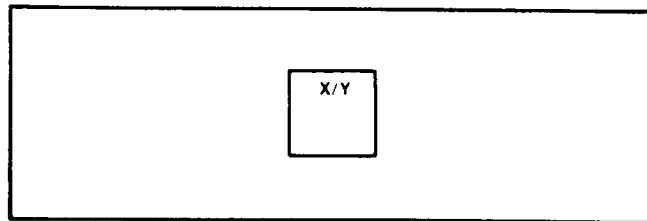


Figure 8-25. Coder General Symbol

8-131. Indication of code conversion is based on the following rule:

Depending on the input code, the internal logic states of the inputs determine an internal value. This value is reproduced by the internal logic states of the outputs, depending on the output code.

8-132. The indication of the relationships between the internal logic states of the inputs and the internal value is accomplished by:

- a. Labeling the inputs with numbers. In this case the internal value equals the sum of the weights associated with those inputs that stand at their internal 1 state, or by;
- b. Replacing X by an appropriate indication of the input code and labeling the inputs with characters that refer to this code.

8-133. The relationships between the internal value and the internal logic states of the outputs are indicated by:

- a. Labeling each output with a list of numbers representing those internal values that lead to the internal 1 state of that output. These numbers shall be separated by solidi (slant:/) as in Figure 8-26. This labeling may also be applied when Y is replaced by a letter denoting a type of dependency (see paragraphs 8-135 and 8-136). If a continuous range of internal values produces the internal 1 state of an output, this can be indicated by two numbers that are inclusively the beginning and the end of the range, with these two numbers separated by three dots, e.g., 4...9 = 4/5/6/7/8/9, or by;

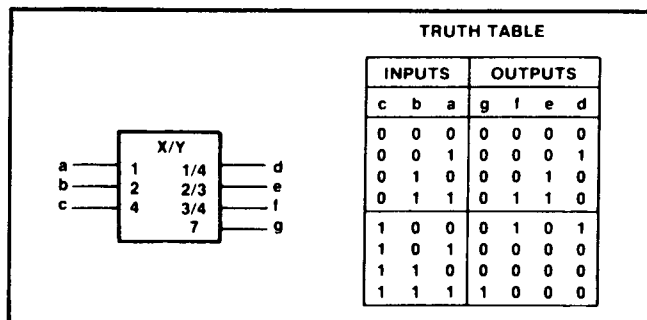


Figure 8-26. An X-Y Code Converter



b. Replacing Y by an appropriate indication of the output code and labeling the outputs with characters that refer to this code as in *Figure 8-27*.

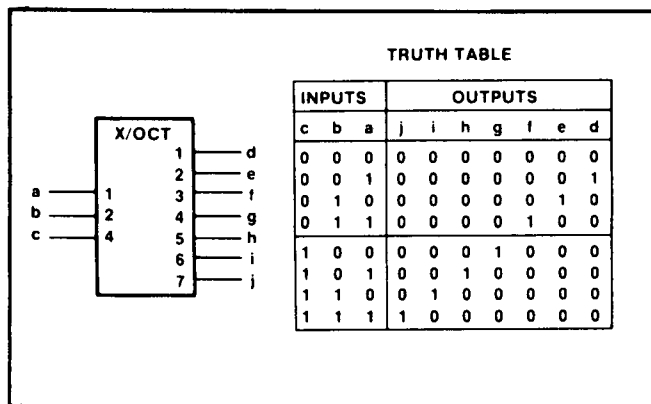


Figure 8-27. An X-Octal Code Converter

8-134. Alternatively, the general symbol may be used together with an appropriate reference to a table in which the relationship between the inputs and outputs is indicated. This is a recommended way to symbolize a PROM after it has been programmed.

8-135. USE OF A CODER TO PRODUCE AFFECTING INPUTS. If often occurs that a set of affecting inputs for dependency notation is produced by decoding the signals on certain inputs to an element. In such a case use can be made of the symbol for a coder as an embedded symbol. See *Figure 8-28*.

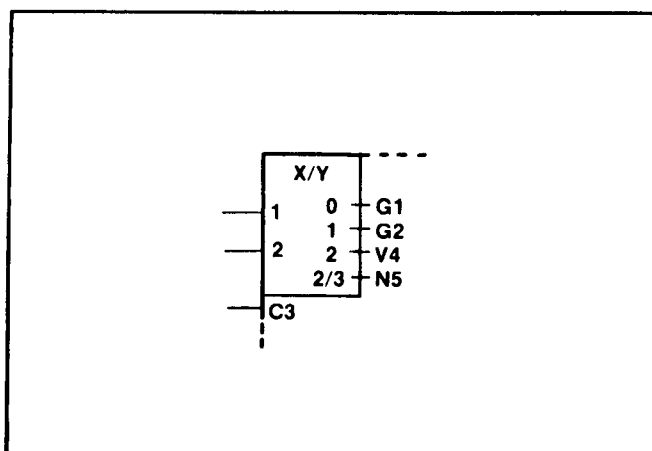


Figure 8-28. Coder Producing Several Dependencies

8-136. If all affecting inputs produced by a coder are of the same type and their identifying numbers correspond with the numbers shown at the outputs of the coder, Y (in the qualifying symbol X/Y) may be replaced by the letter denoting the type of dependency. The indications of the affecting inputs should then be omitted. See *Figure 8-29*.

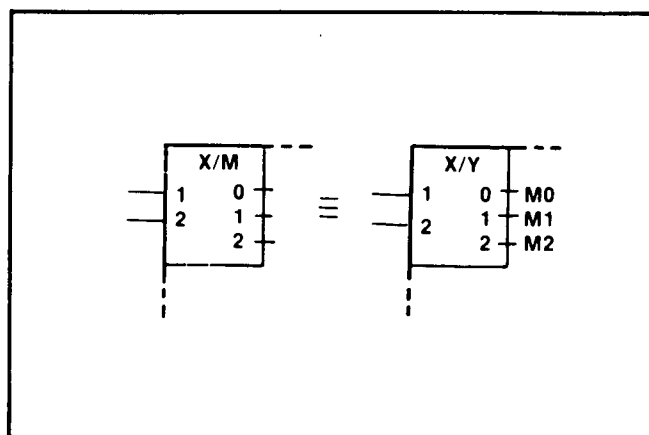


Figure 8-29. Coder Producing One Type of Dependency

### 8-137. Use of Binary Grouping to Produce Affecting Inputs

8-138. If all affecting inputs produced by a coder are of the same type and have consecutive identifying numbers not necessarily corresponding with the numbers that would have been shown at the outputs of the coder, use can be made of the binary grouping symbol (see paragraph 8-61).  $k$  external lines effectively generate  $2k$  internal inputs. The bracket is followed by the letter denoting the type of dependency followed by  $m1/m2$ . The  $m1$  is to be replaced by the smallest identifying number and the  $m2$  by the largest one, as shown in *Figure 8-30*.

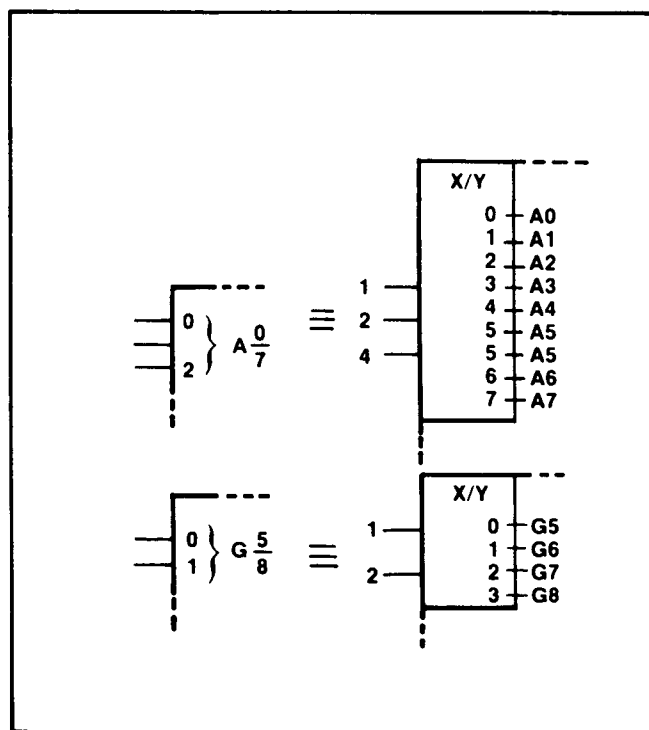


Figure 8-30. Use of Binary Grouping Symbol

### 8-139. Sequence of Input Labels

8-140. If an input having a single functional effect is affected by other inputs, the qualifying symbol (if there is any) for that functional effect is preceded by the labels corresponding to the affecting inputs. The left-to-right order of these preceding labels is the order in which the effects or modifications must be applied. The affected input has no functional effect on the element if the logic state of any one of the affecting inputs, considered separately, would cause the affected input to have no effect, regardless of the logic states of other affecting inputs.

8-141. If an input has several different functional effects or has several different sets of affecting inputs, depending on the mode of action, the input may be shown as often as required. However, there are cases in which this method of presentation is not advantageous. In those cases the input may be shown once with the different sets of labels separated by solidi. See Figure 8-31. No meaning is attached to the order of these sets of labels. If one of the functional effects of an input is that of an unlabeled input of the element, a solidus will precede the first set of labels shown.

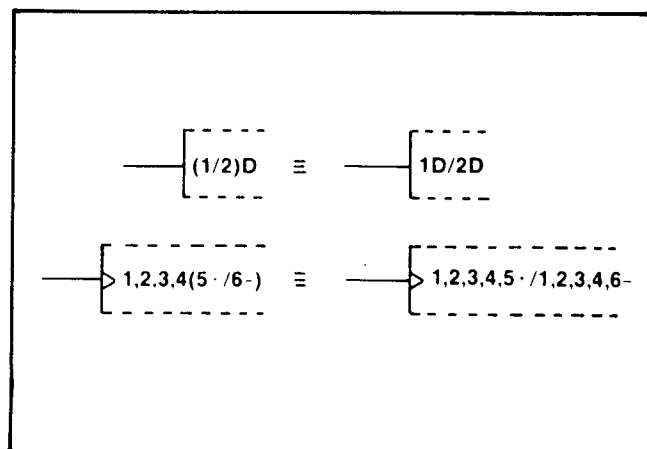


Figure 8-32. Factoring Input Labels

### 8-144. Sequence of Output Labels

8-144. If an output has a number of different labels, regardless of whether they are identifying numbers of affecting inputs or outputs or not, these labels are shown in the following order:

- a. If the postponed output symbol has to be shown, this comes first, if necessary preceded by the indications of the inputs to which it must be applied;
- b. Followed by the labels indicating modifications of the internal logic state of the output, such that the left-to-right order of these labels corresponds with the order in which their effects must be applied;
- c. Followed by the label indicating the effect of the output on inputs and other outputs of the element.

8-146. Symbols for open-circuit or three-state outputs, where applicable, are placed just inside the outside boundary of the symbol adjacent to the output line. See Figure 8-33.

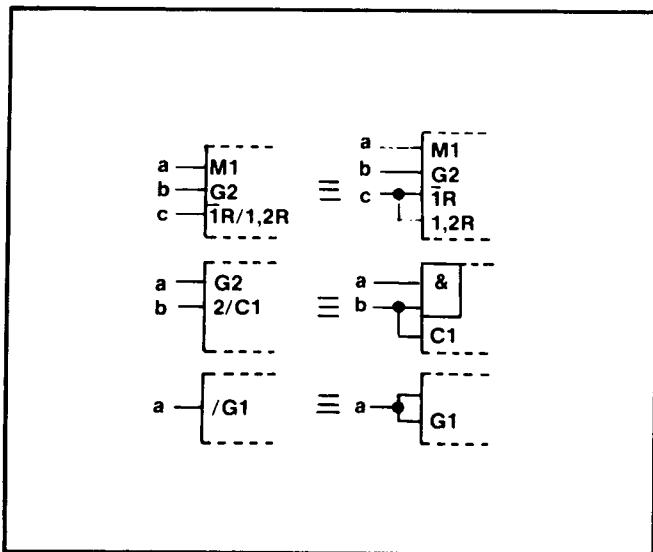


Figure 8-31. Input Labels

8-142. If all inputs of a combinational element are disabled (caused to have no effect on the function of the element), the internal logic states of the outputs of the element are not specified by the symbol. If all inputs of a sequential element are disabled, the content of this element is not changed and the outputs remain at their existing internal logic states.

8-143. Input labels may be factored using algebraic techniques. See Figure 8-32.

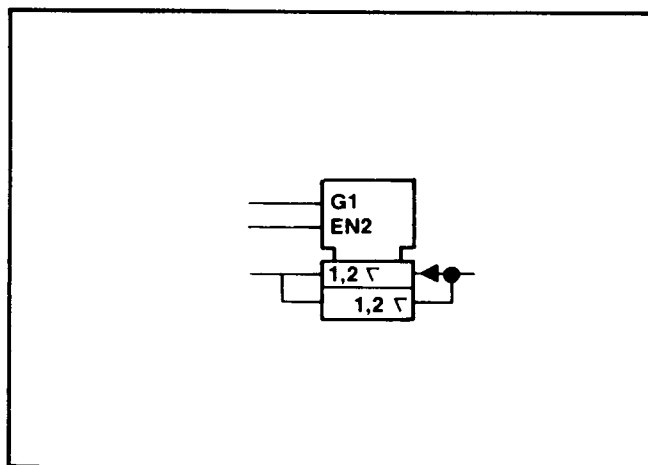


Figure 8-33. Placement of Three-State Symbols

8-147. If an output needs several different sets of labels that represent alternative functions (e.g., depending on the mode of action), these sets may be shown on different output lines that must be connected outside the outline. However, there are cases in which this method of presentation is not advantageous. In those cases the output may be shown once with the different sets of labels separated by solidi. See *Figure 8-34*.

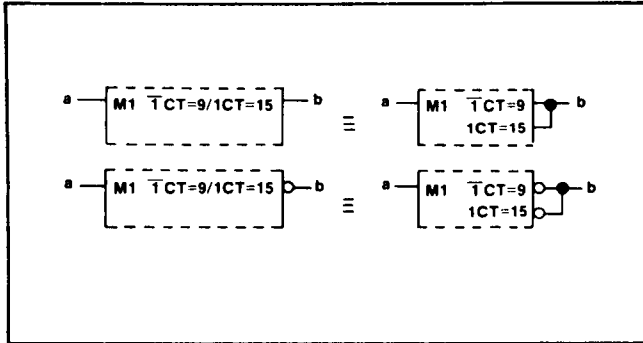


Figure 8-34. Output Labels

8-148. Two adjacent identifying numbers of affecting inputs in a set of labels that are not already separated by a nonnumeric character should be separated by a comma.

8-149. If a set of labels of an output not containing a solidus contains the identifying number of an affecting  $Mm$  input standing at its internal 0 state, this set of labels has no effect on that output.

8-150. Labels may be factored using algebraic techniques. See *Figure 8-35* for output label factoring.

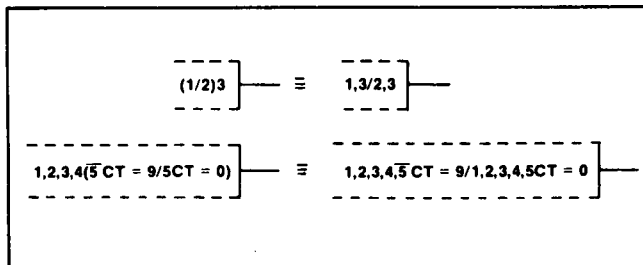


Figure 8-35. Factoring Output Labels

## 8-151. THEORY OF OPERATION

### 8-152. Overall Counter Operation

8-153. Refer to *Figure 8-36* HP 5386A Block Diagram for the following general description.

8-154. There are two input channels that condition and shape the input signals.

8-155. In channel A of the HP 5386A the signal may be attenuated by a X20 attenuator (ATTN) and filtered by a 100 KHz low pass filter (LPF). The trigger level is automatically centered at the average signal level of the input signal or the trigger level may be manually set. The conditioned signal is then input to the Multiple Register Counter (MRC) A1U7.

8-156. Channel B of the HP 5386A is mounted on the A3 Pre-scaler board. It has an automatic gain control amplifier circuit and a divide by 1024 circuit. The conditioned signal is then input to the MRC.

8-157. The MRC receives the input signals from channel A and B. Under the control of the 3870 microprocessor (A1U2), the MRC processes the data for the function specified by the function switches.

8-158. To make measurements, the 3870 routinely scans and stores the position of the function switches and then configures the MRC to the desired measurement mode. The 3870 then "arms" the MRC, which allows the measurement to begin. The input signal to the MRC starts the measurement, and when the Gate-Time determined by the microprocessor has elapsed, the next input signal pulse completes the measurement. The 3870 will then read the measurement data from the MRC, manipulate the data mathematically and direct it to the display assembly (A2). The display assembly receives, decodes, and displays the data. The exponent, exponent sign, units designators and decimal point are computed within the 3870 at the same time as the measurement data. The 3870 will continue to repeat the measurement cycle until the switches are changed.

8-159. For increased measurement accuracy, Oven Oscillator (Option 004) may be used in place of the TCXO. An external 10 MHz time base may also be used as a reference oscillator.

8-160. In digital frequency counters, there is always a possible error of  $\pm 1$  count. For increased measurement resolution in the HP 5386A, an interpolator circuit is used. An interpolator circuit measures the possible time difference between the opening and closing of the counting gate and clock pulses from the internal time base. If the counting gate does not open at the same time a clock pulse occurs and close at the same time a clock pulse occurs ( $n$  number of events later), a difference occurs. The difference is measured and the information is sent to the microprocessor and used in calculating the input frequency, eliminating the  $\pm 1$  count uncertainty.

8-161. For remote control, the HP-IB (A5 board) is used. The board makes use of a 3870 microprocessor to communicate with the 3870 and the MRC on the A1 motherboard. The input/output (I/O) interface assembly contains the bus transceivers, address switches, and buffers. The A5 I/O assembly interfaces directly with the cable connectors on the rear panel of the instrument.

8-162. The built-in power supply consists of three linear power supplies (+10V, +5V, +3V, -5V) and a variable pulse width, switching supply. In the switching supply, the greater the duty cycle of the pulse width, the higher the output power. The supply is regulated for +5 volts out. The power supplies are protected by a crowbar circuit and a 2 amp fuse in the power transformer center tap. The regulated +5 volts is used as a reference for the +10 volts and -5 volts. If the +5 volts shuts down, the +10 volt supply and -5 volt

supply also turn off. If either the input or the output voltage from the supplies goes too high, the crowbar circuit latches on and causes the fuse to open. The open fuse protects the rest of the circuitry from the excessive voltage.

8-163. The function select keys on the front panel keyboard (A2) selects functions by sending a command to the microprocessor (A1U2) when pressed. The microprocessor responds by configuring the MRC (A1U7) to perform a function according to which key on the front panel has been pressed.

8-164. The 12-character, 14-segment Liquid Crystal Display (LCD) contains built-in temperature compensated display drivers. The display shows the results of frequency or period calculations made by the microprocessor. The display information is updated a maximum of four times per second.

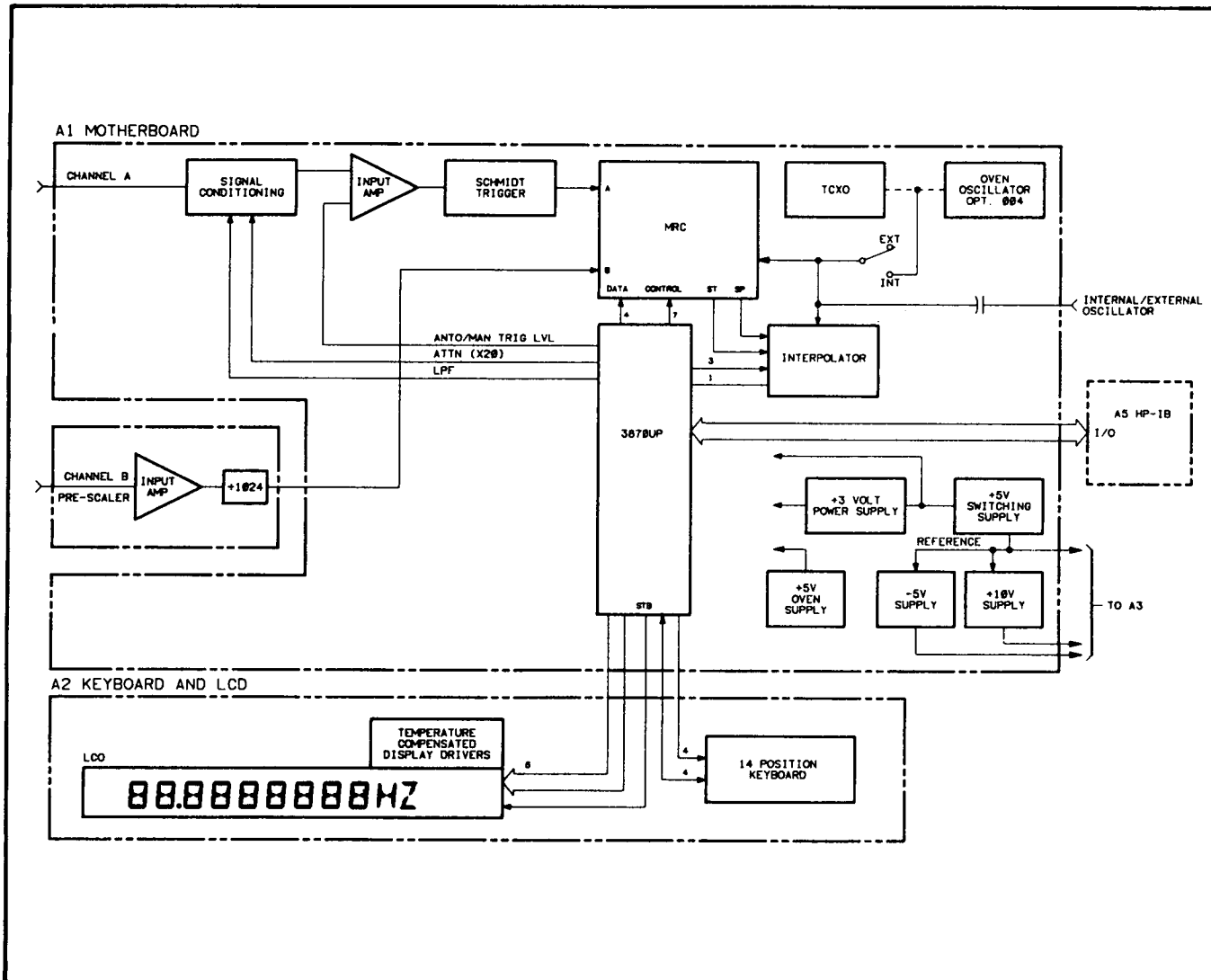


Figure 8-36. HP 5386A Block Diagram

## 8-165. SIGNAL DESCRIPTIONS

8-166. Table 8-6 is a list of the signals used in the HP 5386A. The list is in alphabetical order and includes the mnemonics for cross-reference with the schematic diagrams. A description of the function of each signal is included in the table.

Table 8-6. Signal Descriptions

MNEMONIC	DESCRIPTION
CS	Chip Select Enable line. When enabled, allows the ROM to respond to its addresses.
DAV	Data valid line. One of the three lines used in the handshake. The line is controlled by the data source.
DIR	Determines the direction of data flow between the motherboard microprocessor and the I/O microprocessor.
DREC	Data Received line between the two microprocessors.
DVAL	Data Valid line.
EOI	End or Identify. Indicates the last data byte of a multibyte sequence; also used with ATN (attention) to parallel poll devices for their status bit.
INA	Data line for the display.
ISA	Instruction line for the display.
MR	Reset for the interpolator counter.
NDAC	Not Data Accepted line. One of the three handshake lines. The line is controlled by the device (s) receiving data.
NDACEN	Not Data Accepted Enable. The line determines whether the microprocessor or the ATN line will control the NDAC line.
NRFD	Not Ready for Data line. One of three handshake lines.
PATT	Pattern is used for generating test patterns on lines. The line is controlled by the device (s) receiving data.
PWO	Enable line for the display.
RG0	Register Control Select line.
RG1	Register Control Select line.
RS	Register Select. Controls which register data will be read from or written to.
RXD0	Receive Data.
SENSE	I/O Board Detector line.
SI	Serial Input line.
S/L	Shift Load. Data is loaded into the register when the line goes from high to low.

Table 8-6. Signal Descriptions (Continued)

MNEMONIC	DESCRIPTION
S/R	Send not Receive. These are direction control lines.
SRQ	Service Request. The line is used to indicate a need for attention and can act as an interrupt of the current sequence of events.
STB	Strobe for display clocking.
ST/SP/CLK	Signature Analysis controls only.
SYNC	Synchronizing line for the display.
TA	Talk Addressed. This line controls the direction of data flow through the data and handshake buffers.
TEST	Mostek's own internal manufacturing test. Do not use.
TXD0	Transmit Data.

## 8-167. Detailed Theory of Operation

8-168. Use Figure 8-46, HP 5386A A1 Motherboard Assembly for reference for circuit description of the HP 5386A input Channel A.

8-169. A signal is applied through input connector A1J1 and dc blocking capacitor C1. The signal passes through a frequency compensated attenuator. The attenuator is made up of R13, R15, R18 and C7, and C10. Relay K1 selects the circuitry for either X1 or X20 attenuation. In X1 attenuation, the signal is divided by R15, R18 and C7, and pins 14 and 8 of K1, then routed to Q2. In X20 attenuation, the signal flows through R15, (with high frequency impedance compensation through C7 and R13) then through Pin 8 and Pin 1 of K1. The signal continues from K1 Pin 1 through R18 and C10 to ground. Relay K1 is driven by Q3. Q3 is used as a switch and is controlled by an active low level from the microprocessor. CR8 is used to protect Q1 from voltage spikes generated by the collapsing magnetic field around the winding of K1.

8-170. The limiter circuit CR6 and CR7 together with R13, R15, R16 and C7 form an input protection circuit.

8-171. The high input impedance is converted to a low impedance by Q2 and Q1 connected together as a unity gain buffer.

8-172. A 100 kHz low pass filter (LPF) can be inserted into the signal path between the output of the impedance converter and the input of the first gain stage U5A. The filter is a single pole filter with series resistor R22 and shunt capacitor C16 connected to

ground through Q4. The filter is turned off by applying a TTL low signal from the microprocessor to the base of Q4. Q4 turns off causing the collector to go high which turns on Q5. When Q5 turns on, an ac path through C13 and Q5 is created.

8-173. The first gain stage U5A is a differential line receiver with the signal applied to pin 10. A manually adjustable dc bias voltage (controlled by MAN LEVEL A) or a preset bias level (set by R38) is applied to the other input (pin 9). At power-up, the preset bias level is on the input at pin 9. To switch to manual adjustment and activate the front panel MAN LEVEL A control, a TTL high is placed on pin 11 of switch U11. The TTL low, labeled "A MAN LEVEL" on the schematic, is generated by the microprocessor when the MAN LEVEL key on the front panel is pressed.

8-174. The first gain stage U5A is connected to U5B as a differential amplifier. U5C is a Schmitt trigger with the positive feedback provided by R31B. C17 and C23 provide frequency peaking to compensate for the roll off caused by the input buffer. Transistor array U10B is connected as a differential amplifier to drive the A channel input of the MRC (U1).

#### 8-175. HP 5386 Channel B

8-176. A signal is applied through the input connector A3J3. Signal attenuation is achieved through an automatic gain circuit (AGC) inside the hybrid A3U5 on the A3 pre-scaler board (see *Figure 8-47*).

8-177. The AGC voltage on pin 6 of U3 ranges from +8 volts (no attenuation) to +1.6 volts (maximum attenuation). The detector output at pin 2 of U5 drives the AGC circuitry via U3. The output voltage range at U1 pin 2 ranges from approximately 0 volts (no input) to -1 volt (maximum input amplitude).

8-178. A3U5 also divides the input signal by 4. The clock bias (U5 pin 5) for the divide-by-4 circuit ranges from -.6 volts to -1.2 volts. The clock bias is set for maximum sensitivity at 90 MHz.

8-179. The divided signal leaves hybrid U5 through pin 4 into a 10 dB attenuator. The attenuator consists of R25, 26, 27, and C19.

8-180. The attenuated signal enters A3U4 where it is divided by 256. From U4, the signal leaves the A3 Pre-scaler board through A3J1 and W2. From W2 and A1J4 the signal enters transistor array U10B. Transistor array U10B is connected as a level shifter to drive the B channel input of the MRC.

#### 8-181. 3870 Microprocessor

8-182. The 3870 microprocessor A1U2 runs at an internal clock rate of approximately 3.5 MHz as set by L1. It continually cycles through programmed routines, which are stored in ROM within the IC. The block of front panel switches in the A2 Assembly are routinely polled via the Switch Status bus and the status is stored in internal RAM. Any change in the status is detected and verified. A new function switch contact must remain stable for 32 scans to be accepted.

8-183. The 3870 controls the operation of the MRC via the Address/Control bus. Address lines RG0 and RG1 select one of four internal registers of the MRC. NS0, NS1, and NS2 are nibble select lines (nibble = 4 bits) which address data within the various registers.

8-184. Command line R/W (Read/Write) controls the direction of data transfer on the bidirectional Data/Control Bus.

8-185. The Data/Strobe bus contains four bidirectional data lines, D0-D3, and the command line STR. STR indicates an address or command is valid.

8-186. The Multiple Register Counter (MRC), a counter on a chip, is an LSI bipolar IC utilizing both EFL and I<sup>2</sup>L circuitry. The reference oscillator drives the MRC via pin 21. The reference oscillator may be monitored at TP5 located on the A1 Motherboard. Inputs from channels A and B are fed into the MRC at pins 30 and 28 respectively.

8-187. Within the MRC are four addressable registers. The Events Register and Time Register are counting registers; thus they are Read Only. The Status Register monitors the operation of the MRC, and the Control Register receives the commands from the 3870 and determines the MRC's configuration.

**8-188. Interpolator Technique**

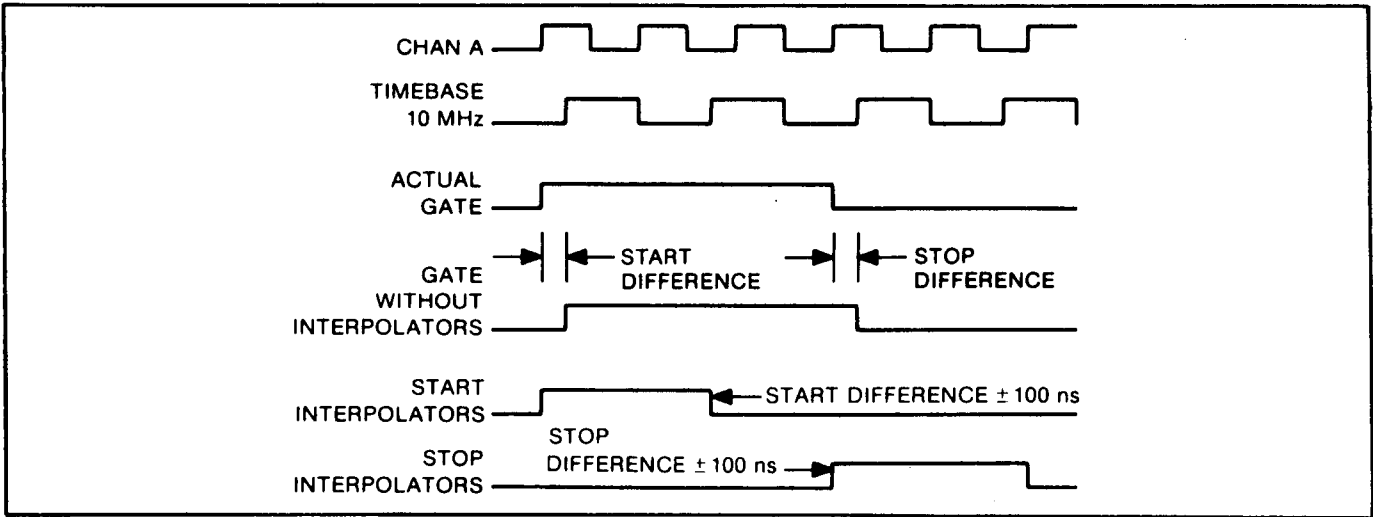
8-189. A major feature of the HP 5386A is the pulse count interpolators.

8-190. Without interpolators, the gate signal during a measurement would normally be synchronous with the main clock (time base). The slight time difference between the actual events of channel A triggering, and the opening and closing of the gate, would represent an unrecoverable error factor, limiting the accuracy of the measurement. The start and stop interpolators within the counter provide a method of determining the amount of time difference for both start and stop events. Refer to *Figure 8-37*.

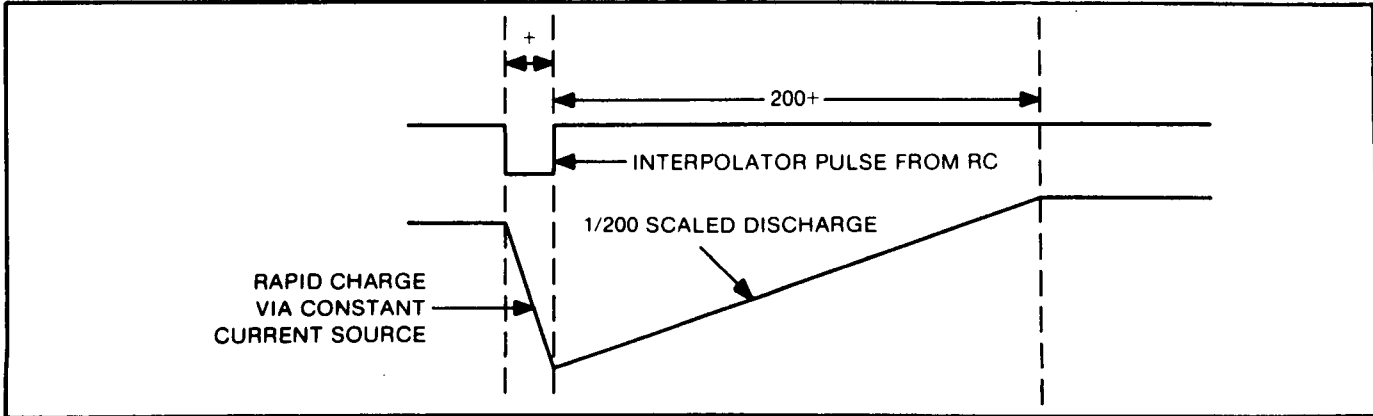
8-191. The MRC provides start and stop interpolator pulses, representing the time difference (error factor) between channel A trigger events and the time base. A dual slope integration scheme is used. Basically, a short interpolation pulse (between 100 and 200 ns) from the MRC, is used to rapidly charge a capacitor via a constant current source. When the pulse ends, the

capacitor begins a scaled discharge at about 1/200th of the charge rate. This proportionally expands the interpolator error pulse by a factor of 200. This integrated waveshape is then squared and used to gate a time base signal into the interpolator counter. The count in the counter will proportionally reflect the length of the interpolator pulse. Refer to *Figure 8-38*.

8-192. To convert the count in the interpolator to real nanoseconds, the MRC provides two calibration pulses; a short calibration pulse of 100 ns and a long calibration pulse of 200 ns. By inputting each of these known length pulses into the same integrator and noting the number of counts produced, a mathematical proportion is established, with which the true time for any pulse length can be interpolated. For example, if the short (100 ns) calibration pulse produced 200 counts, and the long (200 ns) calibration pulse produced 400 counts, a pulse of 150 ns would produce 300 counts. Inversely, if 300 was the number of counts accumulated during the interpolator pulse integrator cycle, then the error factor would be 150 ns. Refer to *Figure 8-39*.



*Figure 8-37. Interpolator Timing Diagram*



*Figure 8-38. Expanded Interpolator Error Pulse*

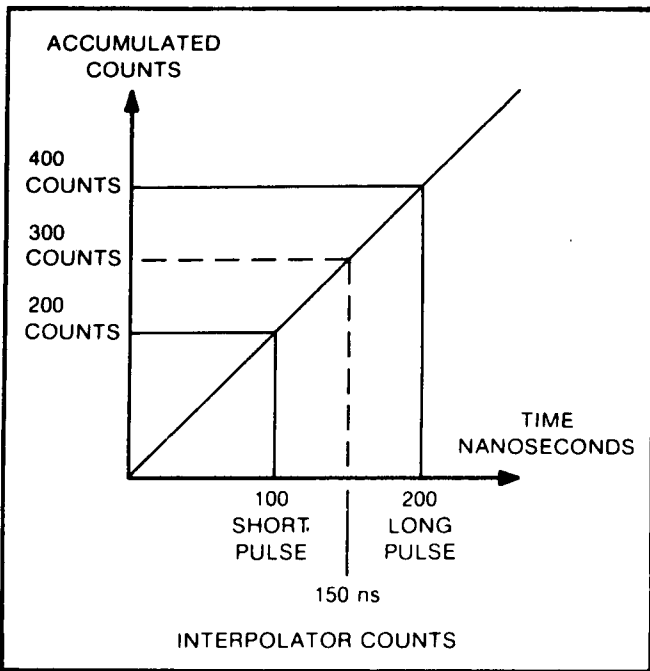


Figure 8-39. Short and Long Calibration Pulses Example

8-193. The final equation for determining the actual gate time is:

$$\text{MEASUREMENT TIME} = (\text{counts in T-register}) \times 100 \text{ ns}$$

$$+ \frac{\text{Count X} - \text{Count S}}{\text{Count L} - \text{Count S}} \times 100 \text{ ns}$$

(for the Start Interpolator)

$$- \frac{\text{Count X} - \text{Count S}}{\text{Count L} - \text{Count S}} \times 100 \text{ ns}$$

(for the Stop Interpolator)

where:

- Count X = effective counts from interpolation pulse
- Count S = effective counts from short calibration pulse
- Count L = effective counts from long calibration pulse

For example, given the following values:

Count in MRC T register	= 10
Count from Start Interpolator	= 100 (+256)
Count from Stop Interpolator	= 230
Count from short calibration pulse	= 200
Count from long calibration pulse	= 150 (+256)

$$\begin{aligned} \text{GATE TIME} &= (10 \times 100 \text{ ns}) + \frac{356 - 200}{406 - 200} \times 100 \text{ ns} - \frac{230 - 200}{406 - 200} \times 100 \text{ ns} \\ &= 1000 \text{ ns} + 75.7 \text{ ns} - 14.6 \text{ ns} = 1061.1 \text{ ns} \end{aligned}$$

8-194. The general measurement program routing is to make a measurement, read the MRC registers, read the interpolator counter, perform the calculations, and display the results. One interpolator counter is used for both Start and Stop interpolation. So, the Start count must be read out during the measurement cycle.

### 8-195. HP-IB

8-196. The HP-IB, A5 board of the HP 5386A counter (Figure 8-48) consists of two line transceivers (U1 and U2), a quad nand gate (U4) and a 3870 microprocessor (U5), and a few other discrete components.

8-197. The line transceiver ICs are bidirectional buffer amplifiers. Each transceiver buffers 8 of the 16 data lines used in HP-IB. (Eight lines are used as a data bus for information transfer, 5 lines for general bus management, and three lines for the handshake sequence.) Direction of data flow is controlled by disabling the undesired direction buffer. The buffers are controlled by TTL logic level inputs to U1(4, 8, 11, 17) and U2(17). A logic high on these pins causes data to be transmitted onto the interface bus. A logic low causes data to be received from the interface bus. The transceivers are switched by U3.

8-198. U3 also pulls the NDAC line low to start the handshake for the information which is sent by the controller with the line true (0).

8-199. The latch (U4) receives short pulses from the Remote Enable (REN) and the Interface Clear (IFC) lines and holds the information until the software in the microprocessor reads them.

8-200. The HP-IB microprocessor (U5) receives commands from the bus, interprets them, and sends them to the motherboard. It also receives measurement data from the motherboard, formats it, and sends it out on the bus when addressed to talk. The bus protocol that performs these tasks is generated by instructions contained in the program ROM of the microprocessor.

### 8-201. POWER SUPPLY

8-202. Refer to Figure 8-46 (sheet 2 of 2), A1 Motherboard Power Supply Assembly for the following discussion on the theory of operation.



8-203. The HP 5386A power supply consists of a +10 volt, +5 volt, -5 volt linear type supply and a +5 volt dc to dc converter type supply having a constant frequency and variable pulse width modulator.

8-204. In the dc to dc down converter type power supply, power is pulsed into an output filter that smooths the large pulses into very small changes that are acceptable and can be called dc. By modifying the ratio of on to off time of the switch transistor, (pulse width modulation) the output voltage can be adjusted.

8-205. When the switch transistor is saturated, current ramps up in L5. Some of the energy is dissipated in the load, and some energy is stored in the magnetic field of L5 and the electric field of C48 and C52. When the switch transistor turns off, the magnetic field around L5 collapses and transfers the energy in L5 to the load and filter capacitor via CR23.

8-206. Power is applied to the primary of T1 through noise filter L8 (and L7 in the return line). Fuse F2 is a .250 amp slow blow fuse which is accessible from the rear panel and is intended to open in the case of catastrophic failure of the +10 volt, +5 volt, and -5 volt power supply. All other failures should result in the 2 amp slow blow fuse F1 opening. The 2 amp fuse is accessible from the rear panel.

8-207. The ON/STBY switch connects the power supply to the counter circuitry. The ON/STBY switch controls the dc to dc converter. The optional oven oscillator, when installed, is connected to +5 volt linear regulator U14. Regulator U14 remains powered whenever the ac line cord is attached. The oven oscillator remains powered whenever the ac line cord is attached.

8-208. The rectified output of the full wave rectifiers CR16 and CR17 goes to C49, a 3900 uf filter capacitor for the +5 volt regulator U14.

8-209. To protect the counter circuitry from overvoltage, a crowbar circuit will fire and cause F1 or F2 to open. The crowbar circuit is formed by series resistor R93 and SCR CR24, Zener diodes CR22 and CR25, diode CR15, and U13. The voltage on C50 is monitored by CR25 and the power supply output voltage of Q12 is monitored by CR22. Capacitor C59 shorts noise spikes to ground so they do not cause the SCR to fire. The -5 volt supply is protected from overvoltage by R67, R79, U13C, and CR15. R79 is connected to a +2.5 volt reference. If the -5 volt supply goes to <-5.9 volts, the op amp output of U13C will go positive and fire CR24 through CR15.

8-210. Diode CR15 and Zener diodes CR22 and CR25 are connected together in a discrete, wired OR configuration. The SCR will fire if the voltage on the filter capacitors rises to approximately 30 volts or if the power supply output voltage rises to approximately 6.0 volts.

8-211. Once the SCR fires, it latches and causes either slow blow fuse to open. The crowbar circuit is intended primarily for protection against shorting of the switching transistor Q12 or using too high a line voltage.

8-212. The 5 volt regulator U14 provides power to switching regulator U16 and the oven oscillator option. U15 outputs a 2.5 volt reference to U16. U16 uses the 2.5 volts for a reference to regulate the power supply output voltage over temperature with no adjustments required. U15 is connected to the reference input of U16 (pin 2), and to -5 volt crowbar voltage detector U13.

8-213. Inside the U16 regulator is an oscillator operating at 87 kHz, a comparator, and an error amplifier. The oscillator is used to generate a ramp signal that is input to the comparator. The error voltage from L5 is fed through the voltage divider R83 and R84, into the inverting amplifier and comparator of U16.

8-214. When the amplified error signal is greater than the oscillator ramp level, the comparator output (pins 11 and 14) turns on the switching transistor Q12 raising the output voltage. If the amplified error signal is below the oscillator ramp level the comparator commands Q12 to turn off.

## 8-215. TROUBLESHOOTING

### 8-216. Introduction

8-217. The HP 5386A is a microprocessor based system. Part of the instrument circuitry consists of digital logic controlled by the microprocessor. Troubleshooting is accomplished by using built-in diagnostics and manual tests.

8-218. The troubleshooting philosophy for the counter is to divide the counter into five main blocks so the problem can be more easily isolated. Once the faulty block has been isolated, refer to the appropriate schematic diagram. If the repaired circuit requires adjustment after being repaired, refer to Section V and perform the adjustments as described.

**CAUTION**

**Proper static handling techniques must be employed when servicing semiconductor products. The voltage susceptibility of all IC and transistor families are well below levels commonly found in service environments. Exercise care and observe standard static precautions.**

8-219. Listed below are some special considerations and helpful hints to keep in mind when troubleshooting the 5386A. They will help avoid potential problems when troubleshooting.

a. When making measurements at IC sockets (with the IC removed), avoid inserting the probe tip into the sockets. This may cause contact problems when the IC is re-inserted. Attach a piece of 26-gauge wire to the probe and insert the wire into the socket.

b. When an LSI IC is removed, it should be placed in conductive foam to avoid static damage. If conductive foam is not available, handle the IC by the ends of the package.

**8-220. Built-in diagnostics**

8-221. The HP 5386A provides six built-in diagnostic routines, including the Power-Up Self Check that occurs automatically when power is applied to the counter. If your instrument has an optional interface installed, the interface is also automatically tested during Power-Up. The built-in diagnostics may be accessed from the front panel or through the interface. The diagnostics are:

Power-Up Self-Check	Occurs automatically when power is applied.
CPU	Checks the ROM and RAM of the microcomputer memory.
I/O Address	Checks the interface option, bus lines and the ports on the microcomputer.
Interpolator Short Cal	Checks the circuitry that produces a short calibration pulse used in the calculation of the two least significant digits of the display.

Interpolator Long Cal Checks the circuitry that produces a long calibration pulse used in the calculation of the two least significant digits of the display.

Microprocessor Port Test Checks all 32 microprocessor port lines. Some manual probing required.

**8-222. Accessing The Built-In Diagnostics**

8-223. The front panel CHECK key is used for manual access to the diagnostic routines. Command codes provide access to the diagnostics from a controller. The following paragraphs describe the key press sequences and the command codes required to execute the various diagnostics.

8-224. After power-up occurs, the diagnostic mode is entered by pressing the CHECK key twice. If the CHECK key is pressed only once, the 10 MHz internal oscillator frequency is displayed. If no other key is pressed, and the CHECK key is pressed a second time, the first diagnostic mode, CPU, is selected automatically. Once a diagnostic routine is selected, the routine will run continuously until another routine is selected or the routine is aborted by pressing the RESET key.

8-225. If the CHECK key is pressed once and any other front panel key is pressed, the counter goes into the Power-Up Initialize State.

**8-226. Power-Up Self-Check**

8-227. When power is applied to the counter, a "star-burst" pattern is sent to the display, turning on all of the LCD segments. In this manner the display driver circuits and the LCD segments on the A2 assembly are tested. The routine is not accessible through the interface.

8-228. While the "star-burst" is displayed, the microprocessor also performs the CPU check. The CPU diagnostic checks the ROM and RAM of the microprocessor A1U1.

**8-229. CPU Check**

8-230. The 64-byte scratch-pad RAM of the A1U1 microprocessor is checked for read/write errors. The routine also performs a check-sum operation that tests the ROM of the microprocessor for bit errors. All 4032 bytes of ROM are scanned and their hexadecimal values are accumulated and compared with a pre-determined check-sum value.

8-231. To access the CPU Check from the front panel, press the CHECK key twice. To access the CPU Check from a controller, use the command code FN11.

Example: wrt703, "FN11"  
(703 is an arbitrary HP-IB address selected for the purpose of illustration)

**8-232. I/O Address**

8-233. In the I/O Address diagnostic, the HP-IB address setting of the interface will be displayed continuously. A typical display would be "ADDRESS 03". If the interface is not installed, the display will be "ADDRESS --". If the address switches are changed while the I/O Address diagnostic is running, the new setting will be displayed automatically.

8-234. To access the I/O Address Check from the front panel, press the CHECK key twice and the PER (period) key once. To access the I/O Address Check from a controller, use the command code FN12.

Example: wrt703, "FN12"

**8-235. Interpolator, Long and Short Calibration**

8-236. The interpolator circuitry, which provides the two least significant digits of resolution, is tested by either the long or the short calibration routine. Both routines are identical except for the absolute value of the numbers displayed and the access code/key press sequence. In both routines, the "start" and "stop" calibration numbers are displayed simultaneously. The calibration numbers are each three digits long. They can range from 000 to 255 with four spaces separating the two numbers. The value of the numbers is not critical as long as they are neither 000 nor 255 and the values do not vary more than three counts. If the calibration values are 000, or 255, or vary more than three counts, the interpolator (consisting of A1U9 and A1U12) is faulty.

8-237. The calibration numbers can be read out over the interface. The numbers are combined into a single 12-digit string which may be read continuously. The

Short Cal number displayed should appear larger than the Long Cal number since the interpolation counter overflows for Long Cal. Firmware adds 256 to the number displayed during Long Cal.

8-238. To access the Short Interpolator Calibration check from the front panel, press the CHECK key twice and the FREQ (B) key once. To access the Long Interpolator Calibration check, press the CHECK key twice and the 0.1S (GATE) key once.

8-239. To access the Short Interpolator Calibration check from a controller use the command code FN13 (FN14 for long calibration).

Example (access): wrt703, "FN14"  
(read): red703, Y\$

**NOTE**

Y\$, if displayed as a string variable without some formatting would not be as convenient to interpret as it would if one of the following controller programming examples were used.

```
HP 85
ENTER 703; Y$
A=100*VAL (Y$|3,6|)
B=VAL (Y$|12,14|); B
DISP A,B
```

```
HP 9825A
red 703,Y$
100val (Y$|3,6|)-A
val (Y$|12,14|)-B
dsp A,B
```

**8-240. Microprocessor Port Check**

8-241. The Microprocessor Port Check diagnostic sends a shifting pattern of ones and zeroes to all 32 lines of the microprocessor ports. The same pattern appears on all ports. One pin on each of the four ports will be low at any given time; the rest will be high. The low will be shifted from the port least significant digit (LSD) to the most significant digit (MSD) and then back to the LSD in a continuous sequence. The resulting port activity may then be checked with a logic probe, oscilloscope, or voltmeter. The test is useful in searching for a stuck, shorted or open portline.

8-242. Access the Microprocessor Port Check by shorting Test Point 1 and Test Point 2 together on the A1 Motherboard then power-up the instrument. The diagnostic routine is automatically entered and will

continue until the short between test points 1 and 2 is removed and a power-up reset is initiated by recycling the power switch from STBY to ON. The Microprocessor Port Check is not accessible by any other method than described above.

### 8-243. MANUAL TROUBLESHOOTING

8-244. For troubleshooting purposes, the counter can be divided into the following sections. The sections are listed in the general sequence that should be used in troubleshooting the counter. Refer to the appropriate flowchart to aid in troubleshooting. With experience, you can recognize fault symptoms that will lead you directly to the faulty section.

- a. Power Supply
  - 1. +3 Volt Supply
  - 2. +5 Volt Supply
  - 3. -5 Volt Supply
  - 4. +10 Volt Supply
- b. Timebase
  - 1. Standard TCXO
  - 2. Oven Oscillator Option 004
- c. Core Counter
  - 1. A1U2 Microprocessor Multiple Counter Register (MRC)
  - 2. Interpolators

- d. Channel A Input
  - 1. Input Conditioning stages
  - 2. Input amplifier stages
  - 3. Channel A selectable features
- e. Channel B Input
- f. Display
- g. HP-IB

### 8-245. POWER SUPPLY TROUBLESHOOTING

8-246. Use *Figure 8-40. Power Supply Troubleshooting Flowchart* to aid in troubleshooting the power supplies on the A1 board. *Table 8-7* shows which assemblies are powered by each voltage of the power supply.

8-247. The power supply voltages should be within the voltages specified below. As shown in *Figure 8-40*, the +3 Volt supply, if out of tolerance, should be adjusted. Use A1R1 to adjust the voltage to within the limits shown.

+3 Volts	±6 mV
+5 Volts	±10 mV
-5 Volts	±10 mV
+10 Volts	±20 mV

*Table 8-7. Power Supplies and Associated Assemblies*

Power Supply	Associated Assembly
+3Volts	A1, A3
+5 Volts	All Assemblies
+10 Volts	A1, A3

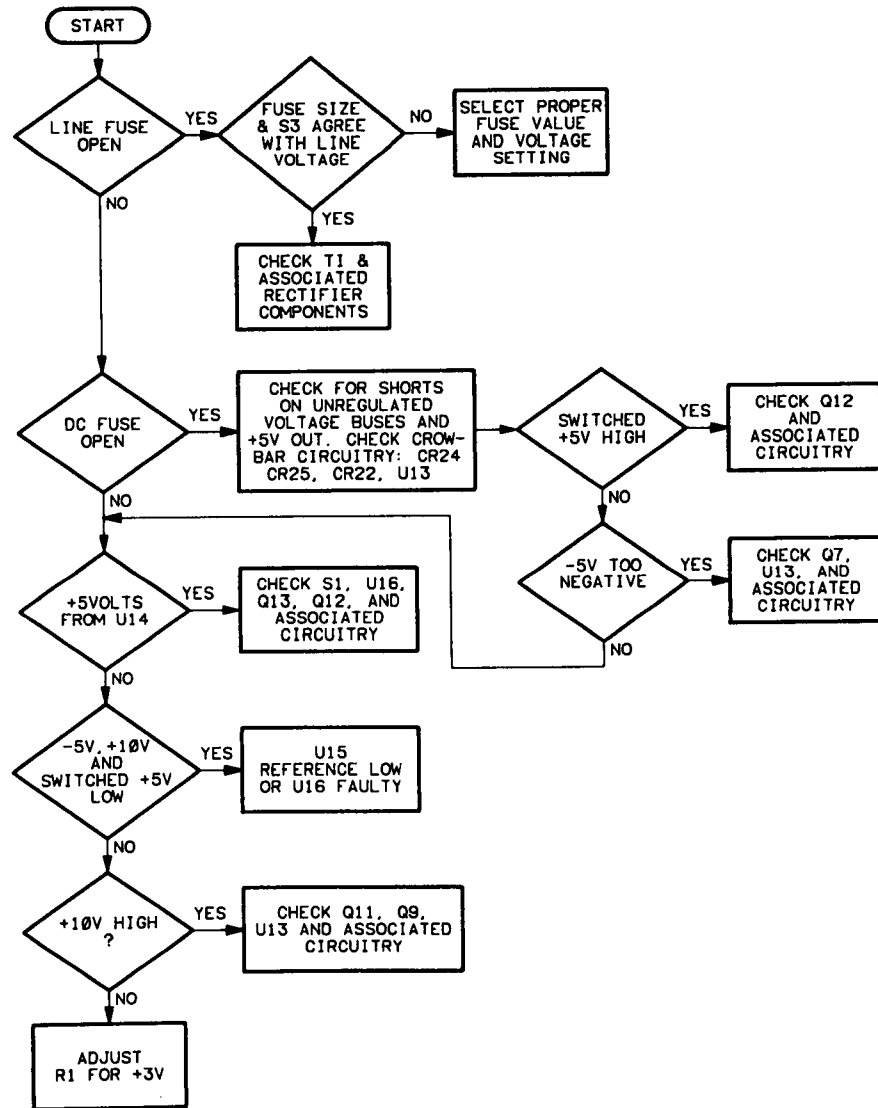


Figure 8-40. POWER SUPPLY TROUBLESHOOTING Flowchart

### 8-248. TIMEBASE TROUBLESHOOTING

8-249. The following paragraphs describe how to troubleshoot the internal oscillator of the HP 5386A. The internal oscillator is either the standard Temperature Compensated Crystal Oscillator (TCXO) or an optional oven oscillator. The TCXO will be discussed first, followed by the oven oscillator.

#### 8-250. Standard Oscillator (TCXO)

8-251. Use the following troubleshooting steps after determining the counter operates with an external 10 MHz signal applied via J2 on the rear panel.

1. Power-up counter.
2. Set INT/EXT switch on rear panel to INT.
3. Check for oscillator output at J2 on rear panel with oscilloscope probe. (Correct waveform for the TCXO is shown in *Figure 8-41*.)
4. Set counter to STBY, remove cover.
5. Power-up counter.
6. Probe C62 with voltmeter for +5V.

8-252. If +5V is measured at C62 with no output at J2, the TCXO is most likely defective. Other components that could cause the same problem (though unlikely) are, C60 or R98 are open, or R97 shorted.

7. Replace the TCXO module; it is not repairable.

#### 8-253. Oven Oscillator (Option 004)

8-254. Troubleshooting the oven oscillator is very similar to troubleshooting the TCXO. Use the following troubleshooting steps after determining the counter operates with an external 10 MHz signal applied via J2 on the rear panel.

1. Power-up counter.
2. Set INT/EXT switch on rear panel to INT.
3. Check for oscillator output at J2 on rear panel with oscilloscope probe. (Correct waveform for the oven oscillator is shown in *Figure 8-41*.)
4. Set counter to STBY, remove cover.
5. Power-up counter.
6. Probe C44 with voltmeter for +5V. (If +5V not present, check L3, it may be open.)

8-255. If +5V is measured at C44, with no output at J2, the oven oscillator is most likely defective. Other components that could cause the same problem (though unlikely) are, C60 open, or R96 or 97 shorted.

7. Replace the oven oscillator module; it is not repairable.

#### 8-256. CORE COUNTER TROUBLESHOOTING

8-257. Use the troubleshooting flowchart shown in *Figure 8-42* to aid in troubleshooting the microprocessor, MRC, and interpolator circuitry.

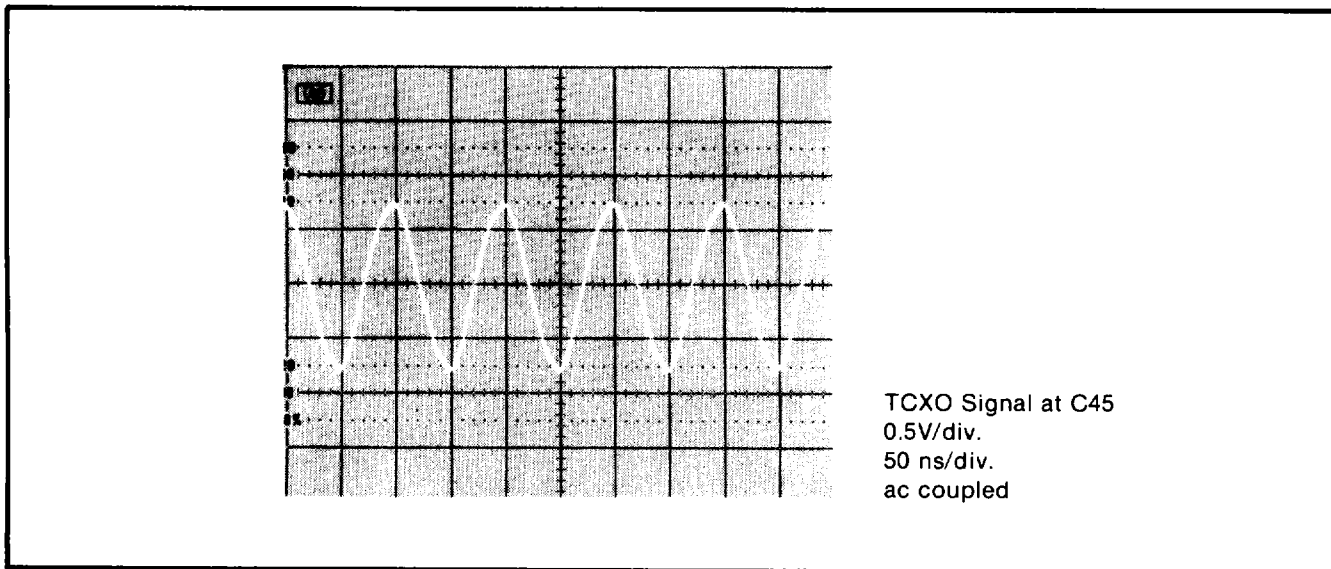


Figure 8-41. TCXO and Option 004 Oven Oscillator Waveform

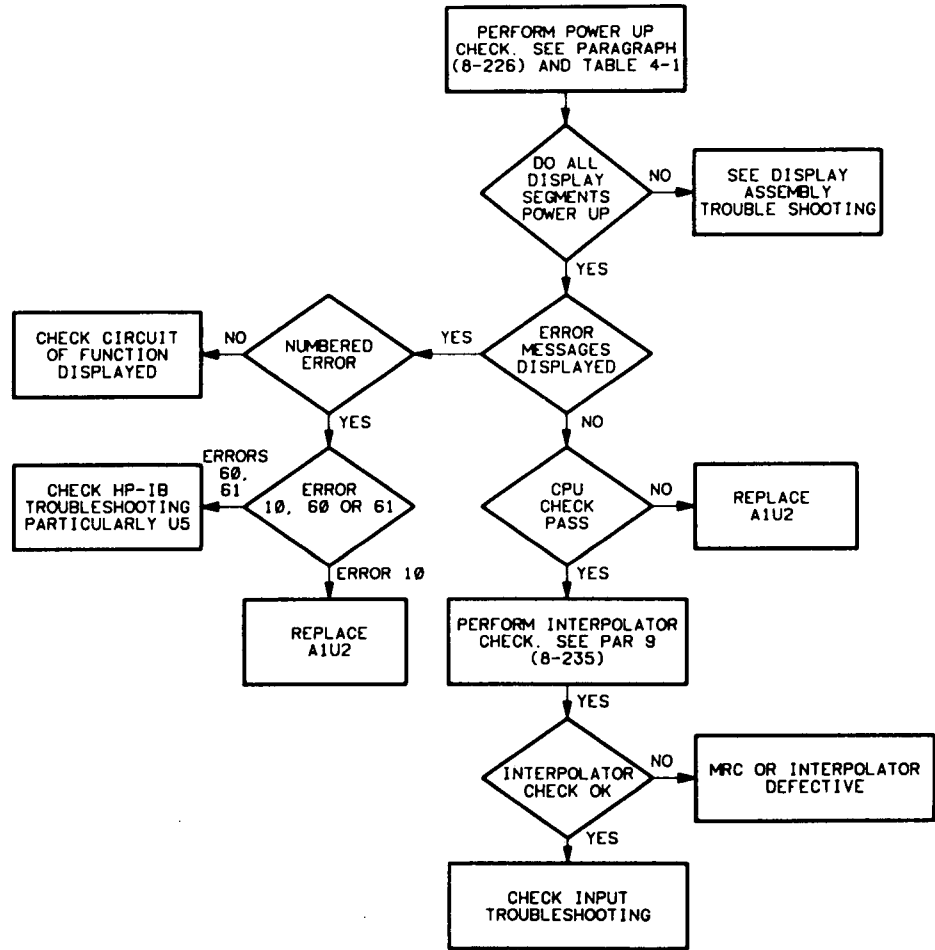


Figure 8-42. Core Counter Troubleshooting Flowchart

**8-258. CHANNEL A INPUT TROUBLESHOOTING**

8-259. Troubleshoot the Channel A input amplifier and conditioning circuitry by using the following procedures, *Table 8-8. Circuit Nodes*, and *Table 8-9. Selectable Features and Related Circuitry*.

8-260. The Input section runs from the input BNC to the signal input to the MRC. By signal tracing, the faulty areas of the input circuitry can be found.

- a. Apply a 10 MHz signal at 25 mV rms (70 mV p-p) to Input A.
- b. Select **FREQ** or **PER A** on the counter.
- c. Use an oscilloscope and probe A1U7(30). If you do not observe a 10 MHz signal at this point, then probe appropriate points in the signal path from the input BNC to the MRC.

8-261. Use *Table 8-8. Circuit Nodes*, in the order shown or use the half-splitting technique and start from A1U5(10). At various points along the input section, the waveform will not retain the exact shape as the input waveform. However, the frequency of the observed signal should still be 10 MHz.

*Table 8-8. Circuit Nodes*

CIRCUIT NODE	CIRCUITRY
A1CR6 (cathode)	Channel A conditioning section
A1U5(10)	Channel A 1st gain stage input
A1U5(5)	Channel A 2nd gain stage input
A1U5(13)	Channel A Schmitt trigger input
A1U10(14)	Channel A Level Translator input
A1U7(30)	Channel A signal line to the MRC

8-262. After repairs are made, perform the adjustments required as described in Section V.

*Table 8-9. Selectable Features and Related Circuitry*

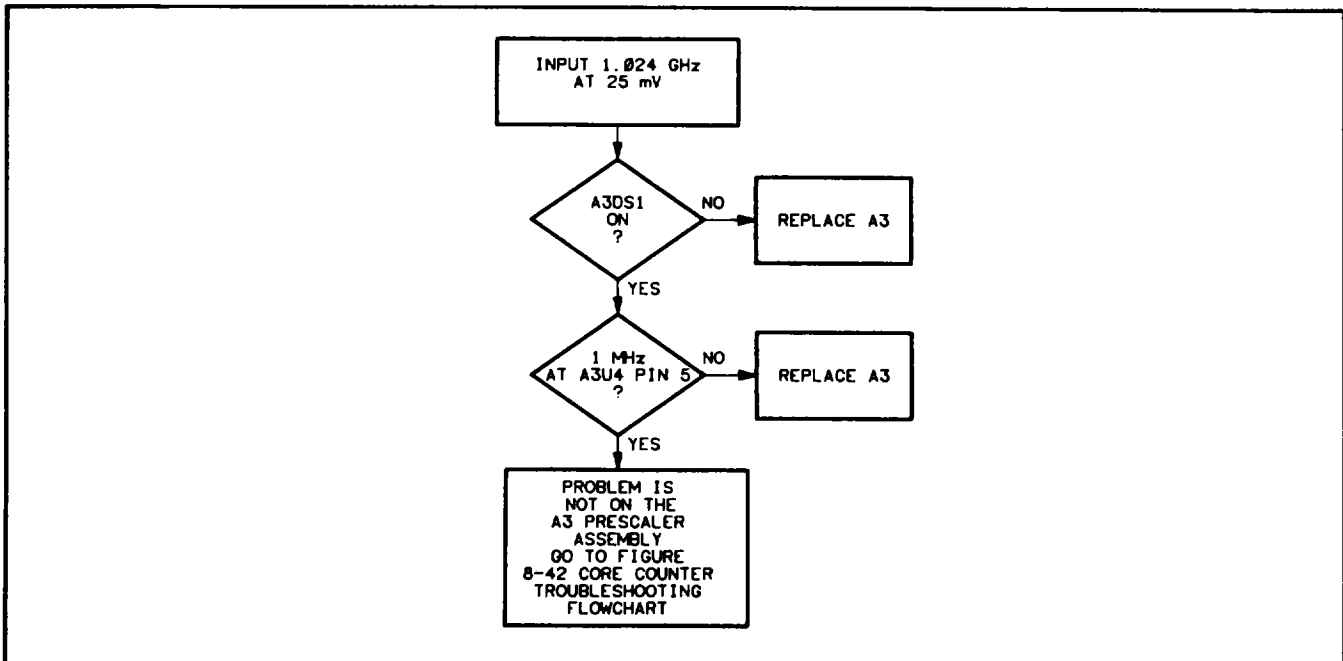
CHANNEL A SELECTABLE FEATURE MALFUNCTIONING	NODES AND COMPONENTS TO BE CHECKED
X20 Attenuator	ATTN line from A1U2(4) A1Q3, K1, R13, R15, R18, C7 and C10.
Low Pass Filter	LPF line from A1U2(3) A1Q4, Q5, R22, C13, C15, C16.
Channel A MAN LEVEL control	MAN LEVEL line A1U2(5) A1U11, R1, R24, R34, R35, R36, R38, R39, C21 and C22.

**8-263. CHANNEL B INPUT TROUBLESHOOTING**

8-264. Channel B Input consists of primarily the (A3) Pre-scaler board. Since the A3 Pre-scaler board is a non-repairable exchange item, troubleshooting consists of determining whether the board functions properly or not. Use *Figure 8-43. Channel B Troubleshooting Flowchart* to troubleshoot Channel B.

**8-265. DISPLAY ASSEMBLY TROUBLESHOOTING**

8-266. Use *Figure 8-44. Display Assembly Troubleshooting Flowchart* to aid in troubleshooting the display assembly.



*Figure 8-43. Channel B Troubleshooting Flowchart*



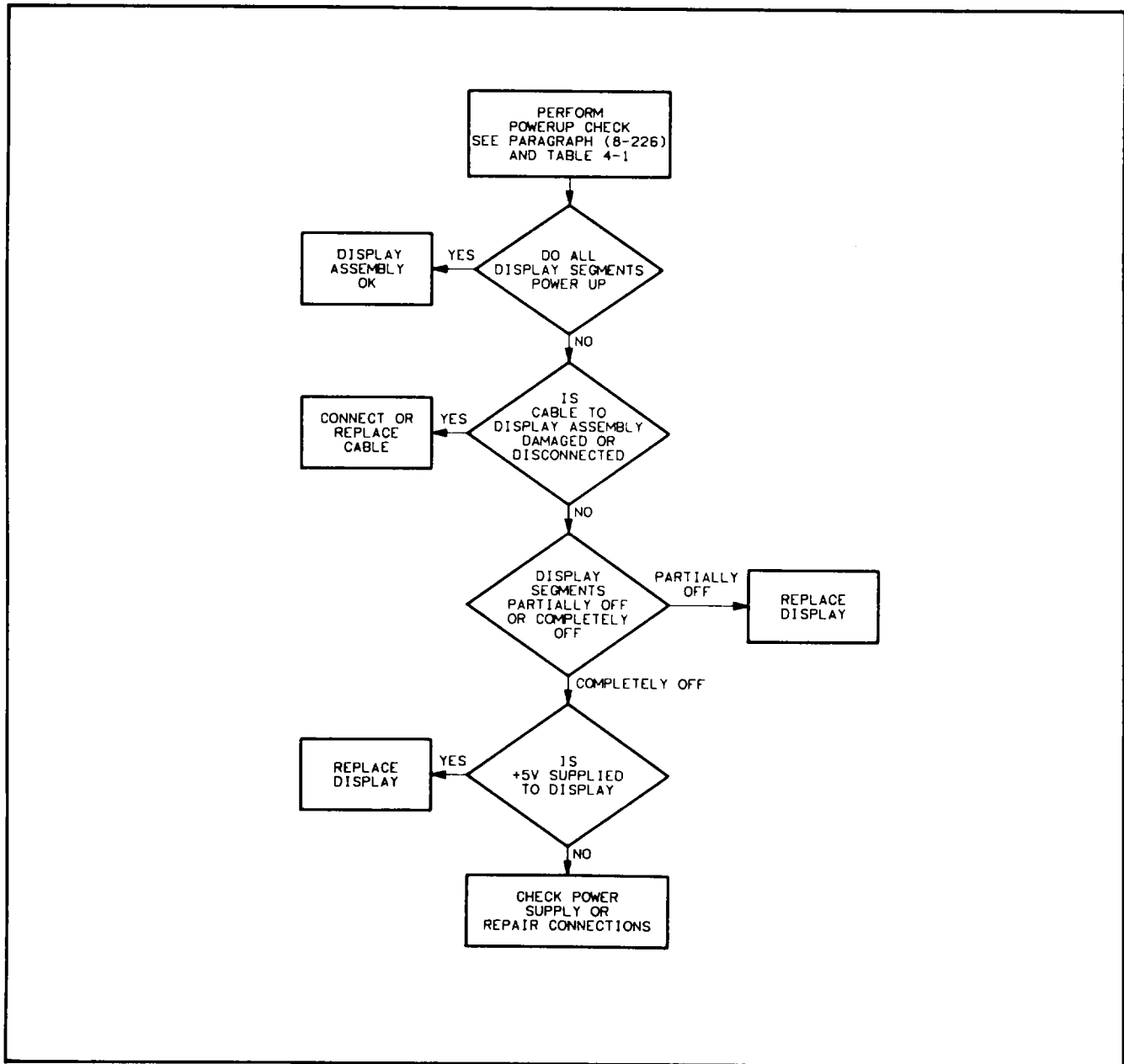


Figure 8-44. Display Assembly Troubleshooting Flowchart

**8-267. HP-IB INTERFACE ASSEMBLY (A5 Board) TROUBLESHOOTING**

8-268. At Power-Up, the HP-IB interface is tested. An ERROR:I/O message will appear on the display if the test did not pass. If the test passes, the address of the interface will appear on the display.

**NOTE**

If all the switches on the DIP switch, A5S1, are set to 1 (open or upward) the error message will appear on the display.

8-269. If the I/O address diagnostic fails and the counter passes all other diagnostics, verify that the ribbon cable A5W1 is properly seated in its motherboard connector A1J5.

8-270. Verify the following voltages on the A5 board assembly:

SIGNAL NAME	TEST POINT	RANGE
+5 volts	+5 (TP1)	±0.2 volts
+5 volts cmc	U2, pin 24	±0.2 volts

8-271. Verify that a 3.5 MHz (nominal) clock signal is present at U5 pin 2.

8-272. A signature analysis mode is available for the A5 board assembly. This technique is helpful to determine failed components on the A5 assembly. For problems involving a particular controller, it is recommended that an HP 59401A Bus Analyzer and logic analyzer be used to determine the cause of the problem. As an initial test, verify that the interface responds properly to the HP-IB test program found in Section IV. Also verify that the controller interface is functioning properly. An HP-IB test tape (HP part Number 59300-10002, Revision G) is available for use with the HP85 desk top controller.

8-273. To perform signature analysis for the A5 assembly, proceed as follows:

- a. Remove the ac power cord from the rear panel of the counter.
- b. Set all of the switches on the DIP switch, A5S1, to 1 (open or upward).
- c. Disconnect the ribbon cable connecting A5J2 to the motherboard.
- d. Connect +5 Volts to A5TP1.
- e. Connect ground to A5TP2.

**NOTE**

The +5V source can be either the +5V from the counter or an external power supply that has as good or better regulation than the counter's power supply. Convenient points are TP9 for +5 volts and the ground test pin near A1J4.

f. Connect a signature analyzer such as the HP 5005B to the A5 assembly as follows:

<b>TIMING POD</b>	<b>TEST POINT</b>
START/ST/SP (green lead)	ST (TP2)
STOP/QUAL (red lead)	SP (TP3)
CLOCK (yellow lead)	CK (TP4)
(black lead)	(TP5)

g. Make the following settings to the HP 5005B:

CLOCK	negative slope
START	negative slope
STOP	negative slope

h. Connect a test lead between PAT (TP1) of the A5 assembly and ground. If the counter is used as a +5 volt supply for the A5 assembly, reconnect the line cord to the rear panel and switch the counter on.

i. Remove the test lead from the PAT test point. The microprocessor checks this line at Power-Up and then goes into the signature analysis mode. The PAT point must be grounded on Power-Up to generate START and STOP signals, however, a valid signature can only be taken at this point with the grounding clip removed. All other signatures on the A5 board should remain identical regardless of the status of PAT (TP1).

j. After verifying the characteristic signatures, V<sub>cc</sub> and ground, verify the signatures shown in *Figure 8-45*. It is recommended that signatures on the HP-IB microprocessor, U5 be checked first as this is where the signal activity is generated.

8-274. The signature analysis routine does not verify the  $\overline{\text{REN}}$  line and the I/O lines between the A5 microprocessor and the main microprocessor on the motherboard. Install the A5 assembly into the instrument and reset the A5S1 DIP switch to its original setting. Enter the following program into an HP85 and connect the HP-IB interface to the counter. Note that for line 10 in the program, the appropriate address for the counter should be entered (714 is used as an example only).

```

10 Remote 714
20 Local 7
30 Go to 10
40 End

```

8-275. Run this program and verify activity at A5U5(27). If there is no activity at this point, trace back through U4D, U4A, and U2 to locate the fault. Also, verify activity on U5, pins 3, 4, 5, 6, 16, 17, and 18. If there is no activity on these lines, a problem may exist in the interface between the A1 Microprocessor assembly and the A5 HP-IB Interface Assembly.

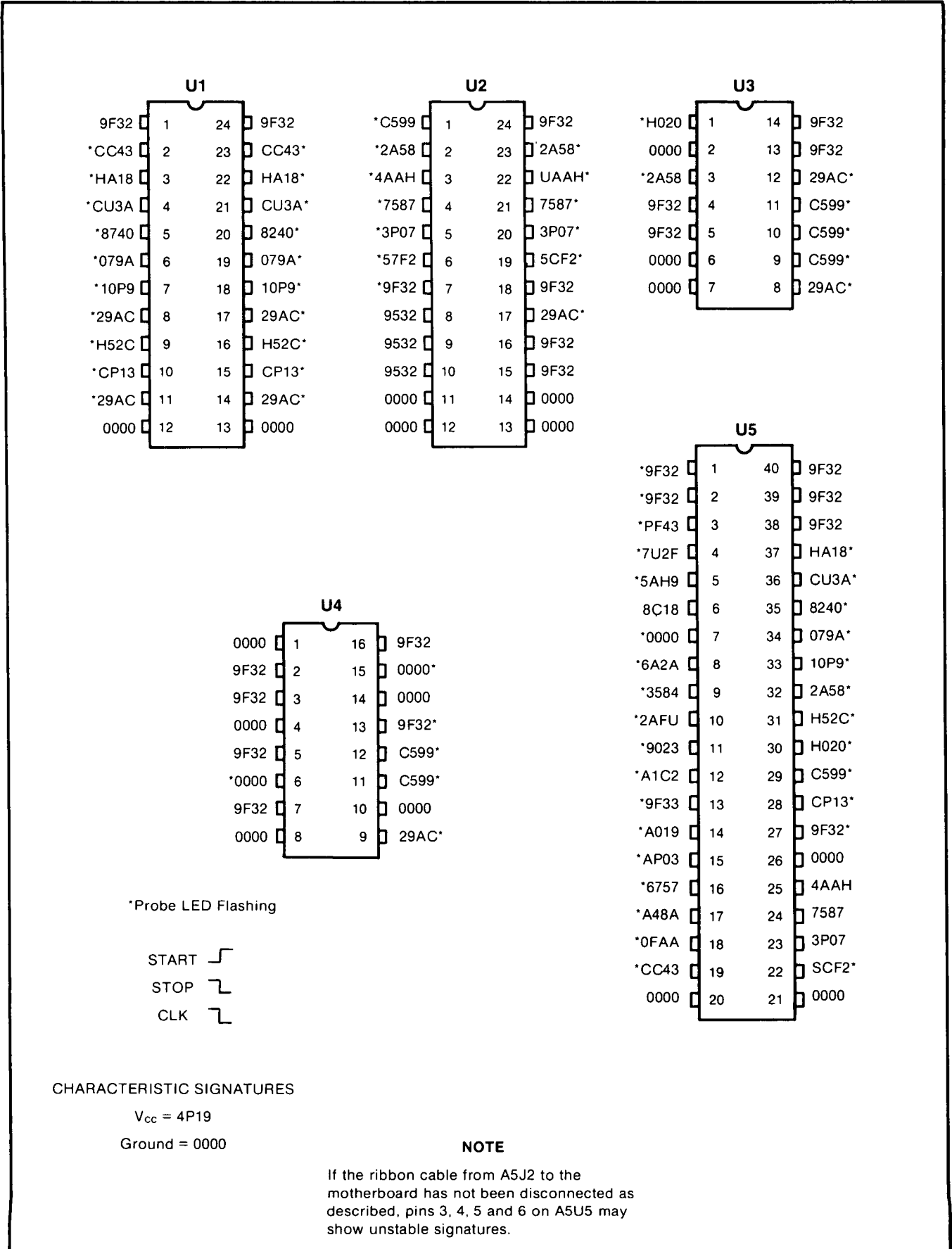
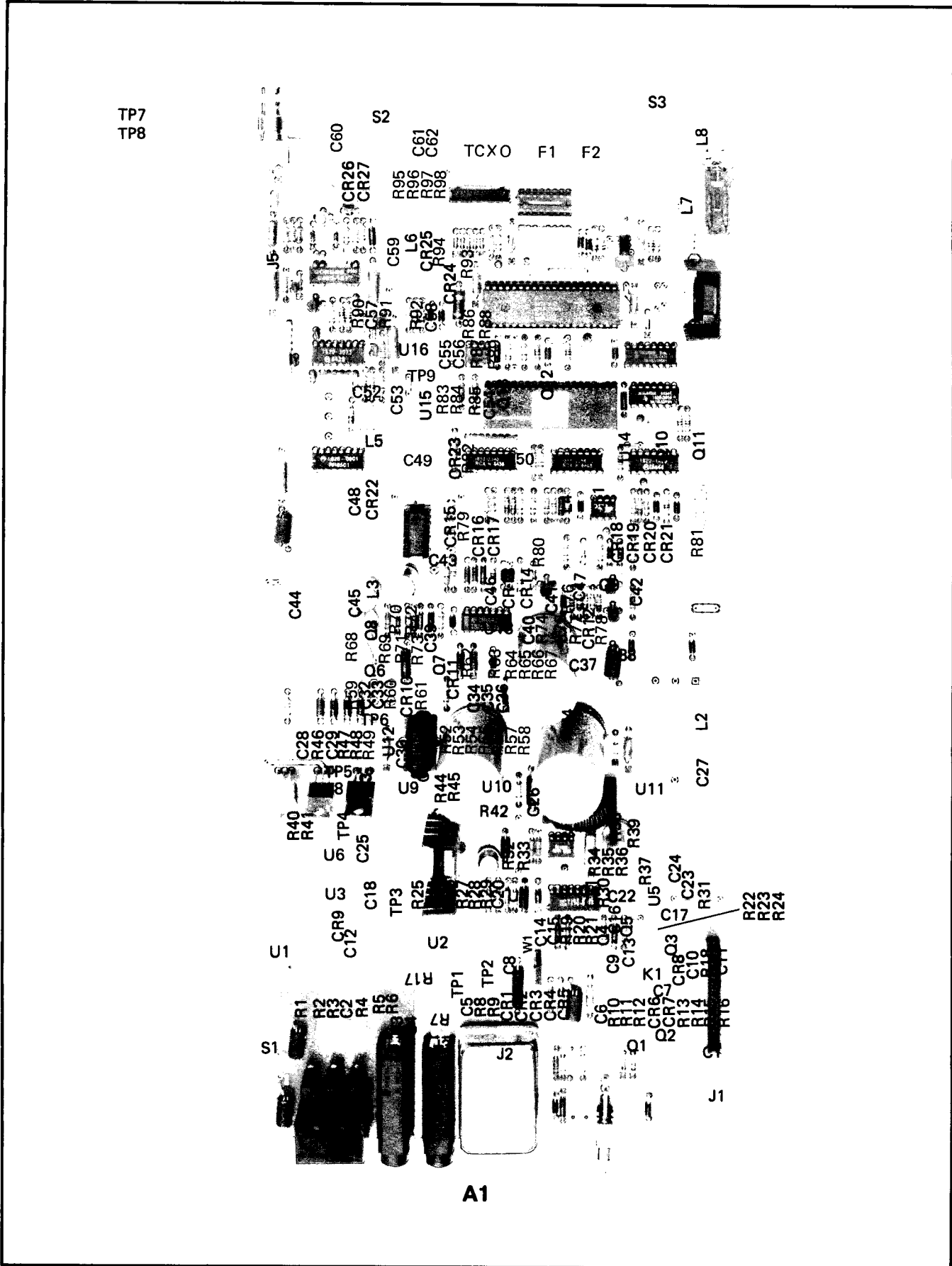


Figure 8-45. All Signatures for the HP 5386A HP-IB Board



Part of Figure 8-46. A1 Motherboard Component Locator



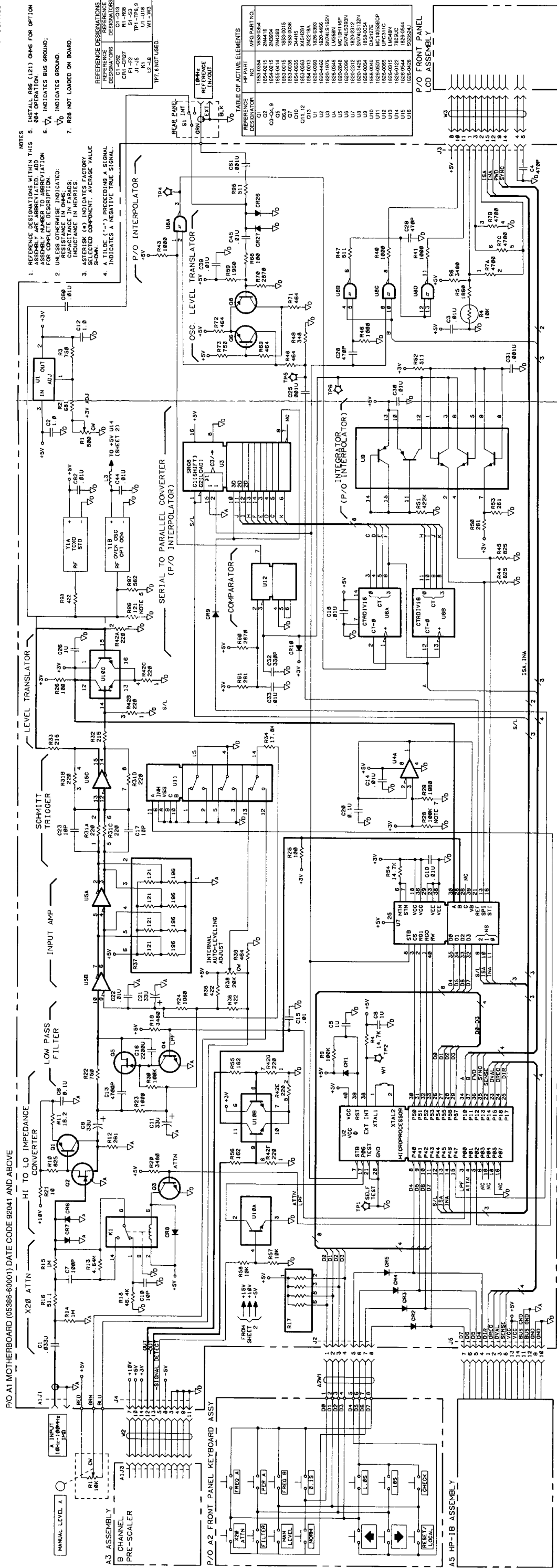
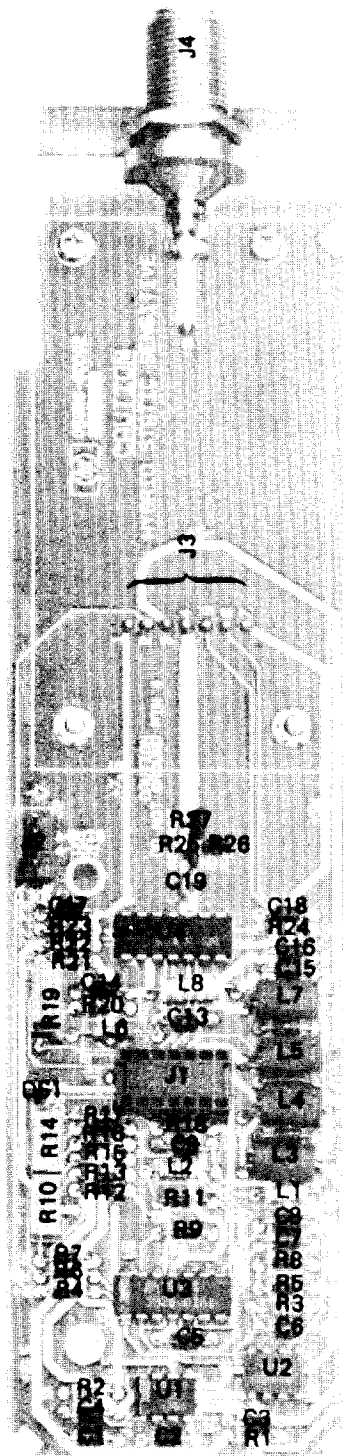


Figure 8-46. A1 Motherboard Assembly (Sheet 1 of 2)

Figure 8-46  
**A1 MOTHERBOARD ASSEMBLY (SHEET 2 OF 2)**  
(See Page 8-41)





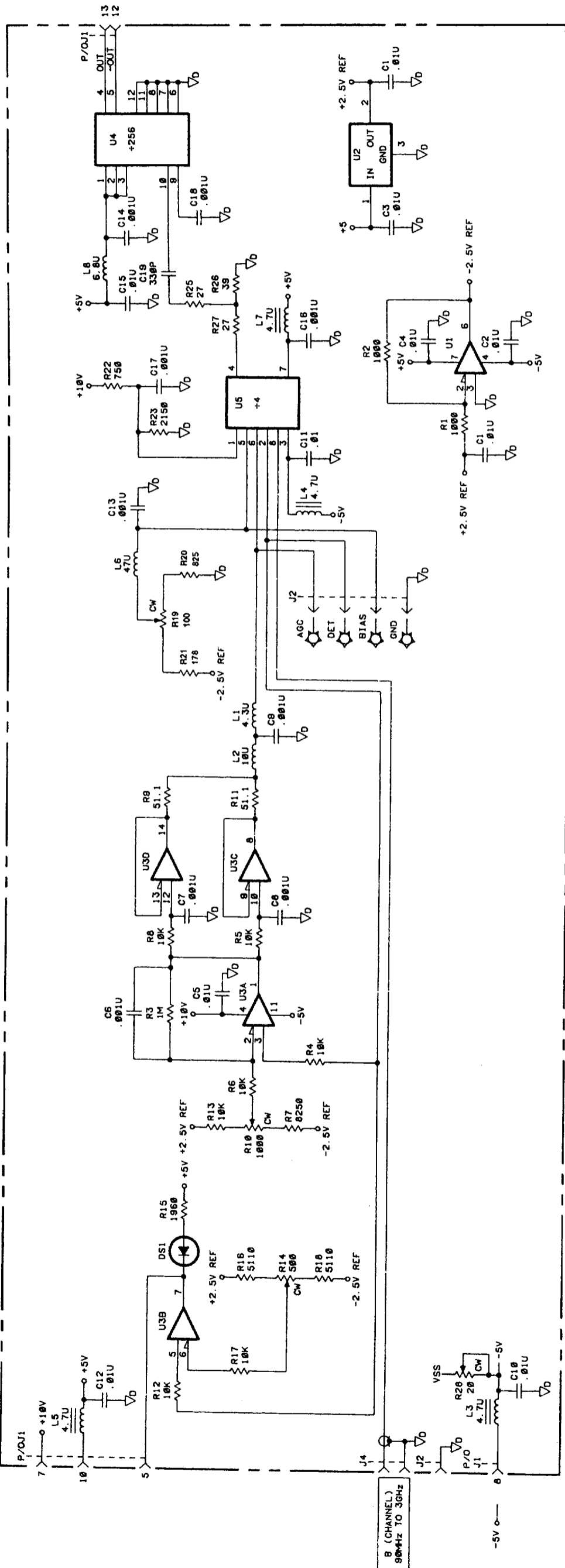


A3

Part of Figure 8-47. A3 Pre-Scaler Component Locator

Figure 8-47  
**A3 PRE-SCALER ASSEMBLY**  
(See Page 8-43)

A3 3 GHz PRESCALER (05386-60002) SERIAL NUMBER 2704A00930 AND ABOVE



- 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 FACTORY SELECTED COMPONENT. AVERAGE VALUE SHOWN.
  4. A TILDE ("~") PRECEEDING A SIGNAL INDICATES A NEGATIVE TRUE SIGNAL.

REFERENCE DESIGNATIONS

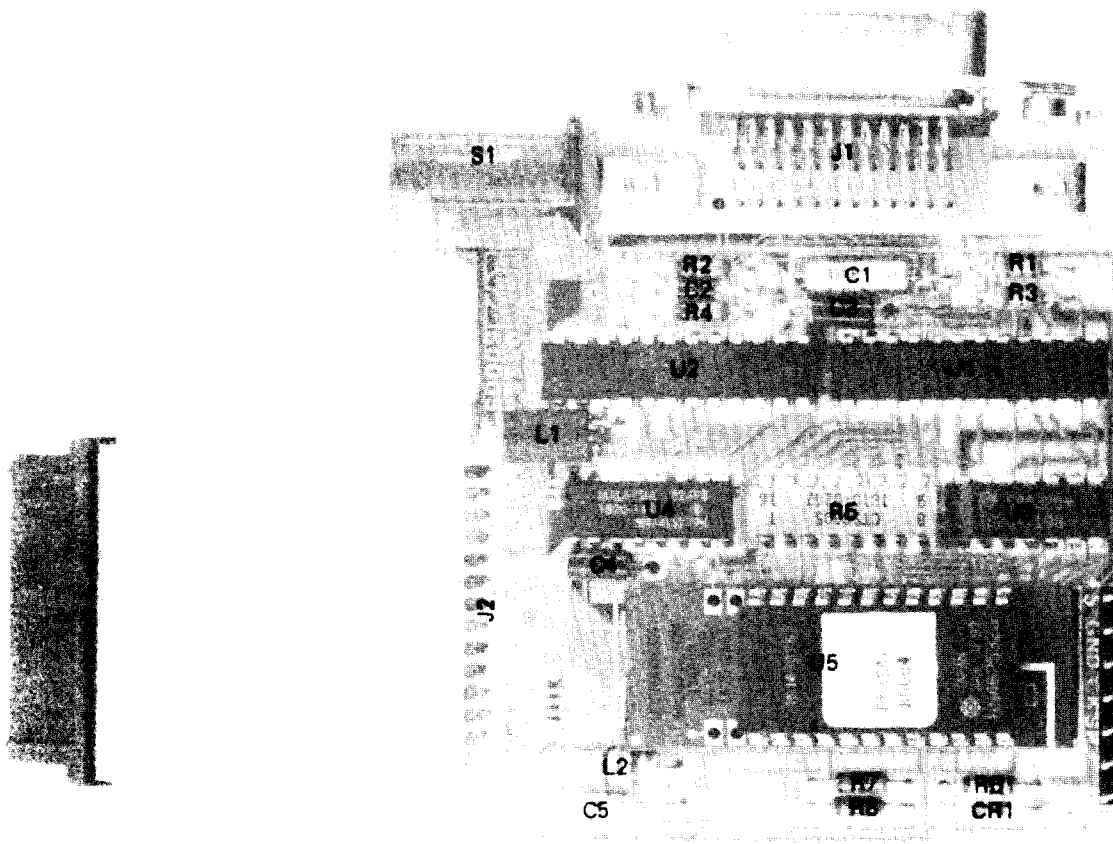
REFERENCE DESIGNATORS	REFERENCE DESIGNATORS
C1-C19	L1-L8
DS1	R1-R23
J1-J4	R25-R28

R24 NOT USED.

TABLE OF ACTIVE ELEMENTS

REFERENCE DESIGNATOR	HP PART NO.	MFG PART NO.
U1	1820-0493	LM507N
U2	1826-0544	1826-0544
U3	1826-0161	MLM524P
U4	1820-2504	1820-2504
U5	Not Replaceable	

Figure 8-47. A3 Pre-Scaler Assembly

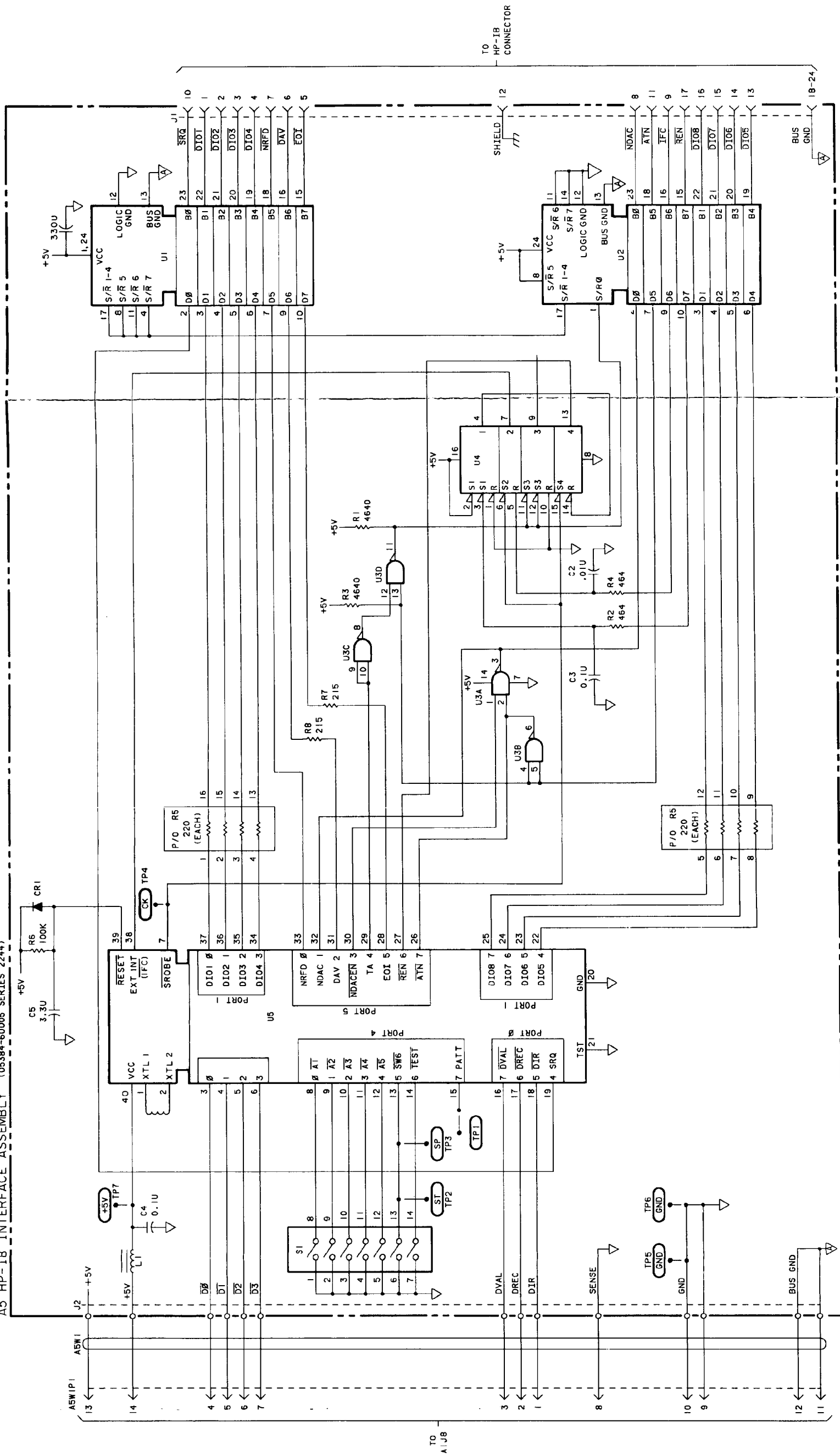


A5

Part of Figure 8-48. A5 HP-IB Interface Component Locator

Figure 8-48  
**A5 HP-IB INTERFACE ASSEMBLY**  
(See Page 8-45)

A5 HP-IB INTERFACE ASSEMBLY (05384-60005 SERIES 2244)



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 FACTORY SELECTED COMPONENT, AVERAGE VALUE SHOWN.
4.  $\nabla$  INDICATES BUS GND.

REFERENCE DESIGNATIONS

A5 ASSY	
CI-CS	
CR1	
J1-J2	
L1, L2	
R1-R8	
S1	
TP1-TP7	
U1-U5	
W1	

TABLE OF ACTIVE ELEMENTS

REFERENCE DESIGNATIONS	HP PART NUMBER	MFR. PART NUMBER
CR1	1901-0050	MC3447P3
U1,2	1820-2461	SN74LS03N
U3	1820-1198	SN74LS279N
U4	1820-1440	
U5	1820-3687	

Figure 8-48. A5 HP-IB Interface Assembly



9282-1077

**Binder Only Part No.**

**Made in U.S.A.**