This document has been ocr'd with text under the original Agilent/HP scanned images.
The Power Supply and Controller schematics were also rescanned at higher resolution and are appended at the end of the orignal document. The original schemaic scans are still included in body of document
Tim Hughes

# Errata

**Title & Document Type:** 3488A Switch/Control Unit Service Manual

**Manual Part Number:** 03488-90012

**Revision Date:** February 1, 2005

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## HP References in this Manual

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

## About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

## Support for Your Product

Agilent no longer sells or supports this product. You will find any other available product information on the Agilent Test & Measurement website:

www.tm.agilent.com

Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

## SERVICE MANUAL

# MODEL 3488A
# SWITCH/CONTROL UNIT

HEWLETT PACKARD

**Manual Part No. 03488-90012**

**Microfiche Part No. 03488-99012**

Printed in Singapore

03488-90012

SUPERSEDES
3488A-11

# HP MODEL 3488A Switch/Control Unit

## Serial Numbers: All

## Line Fuse Clarification

Following are the correct part numbers for HP 3488A line fuses. These fuse sizes are correct for all units, regardless of what size is silkscreened on the back panel. Please correct the replaceable parts list in your service manual.

| | | | |
|---|---|---|---|
| 115 Vac operation: | P/N | 2110-0044 | 300 mAT |
| 230 Vac operation: | P/N | 2110-0448 | 160 mAT |

In addition, units between Serial Numbers 2719A10500 and 2719A10580 were inadvertently shipped with a 2A line fuse installed. Testing has shown that this is not a safety concern, but transformer damage is possible. If you repair one of the above units, please check the line fuse.

Please discard any copies of Service Note 3488A-11 you may have.

REF: 09-27508

I/OF/WO

2/88-09 CWS

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3488A-11B

HEWLETT PACKARD

FOR MORE INFORMATION, CALL YOUR LOCAL HP SALES OR SERVICE OFFICE • East (201) 265-5000 • Midwest (312) 255-9800 • South (404) 955-1500 • West (213) 970-7500 or (415) 968-9200; OR WRITE, Hewlett-Packard, 1820 Embarcadero, Palo Alto, California 94303. IN EUROPE, CALL YOUR HP SALES OR SERVICE OFFICE OR WRITE, Hewlett-Packard S.A.7, rue du Bois-du-Lan, P.O. Box CH-1217 MEYRIN 2-Geneva, Switzerland. IN JAPAN, Yokogawa-Hewlett-Packard Ltd. 1-27-15, Yabe Sagamihara City, Kanagawa Prefecture, Japan 229.

SUPERSEDES
NONE

# HP MODEL 3488A Switch/Control Unit

## Power Supply Failures

The voltage regulator module used on the HP 3488A power supply board has had a high failure rate due to a fabrication process fault. The vendor has corrected the fault and many of the faulty modules have been replaced in the field. LID would like to help protect HP customers from this problem by extending the warranty on HP 3488A's which fail due to a faulty regulator.

### SYMPTOMS:

The problem is easy to detect by monitoring the +5 Vdc output at TP4 on the A31 power supply assembly using an oscilloscope. The voltage should be +5.1 Vdc, ±0.25 Vdc. (Complete procedure is described in Section 6-26 of the Service Manual.) If the voltage regulator has failed, the oscilloscope will show a dirty square wave of varying duty cycle, not a clean DC voltage.

### PROCEDURE:

Replace the voltage regulator, A31 U300 (P/N 1813-0544). If the date code stenciled on the regulator is lower than "8727", then charge the repair to warranty.

NOTE: The Warranty Always condition for this Service Note expires 1 June 1990.

OF/WA

4 88-09 CWS

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3488A-12

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SUPERSEDES
NONE

# HP MODEL 3488A Switch/Control Unit

## Serial Numbers: 2719A13650 and below

## HPIB Communication Problem

The HP 3488A Switch/Control Unit may interrupt HPIB communication between a controller and another instrument. This situation occurs if the power to the HP 3488A is turned off while the controller and another instrument on the bus are communicating. All three instruments must be connected by the HPIB bus at the time.

### Solution:

The transceiver chip, A40U427, has been changed to prevent this problem. A40U427 is now HP part number 1820-6045. 03488-66540 control boards with ERCs (Engineering Revision Codes) of 2822 and above contain the new component. Make a note of this change in your HP 3488A Service Manual.

### Action:

Replace A40U427 with the new component ONLY upon customer complaint of the problem described in this service note.

Ref: PCO 09-27663

W/OF/WA 6/88-09/MBO

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SUPERSEDES
NONE

# HP MODEL 3488A Switch/Test Unit

## Serial Numbers: 2719A12795 and Below

## FIRMWARE UPDATE

The firmware of the HP 3488A Switch/Test Unit has recently been updated. The new firmware, Rev. B, is present in instruments with serial numbers above 2719A12795. These units contain controller boards (HP part number 03488-66540) with an Engineering Revision Code of 2814 and above. Rev. B firmware corrects the following problems.

### HP 44472A VHF Module Channel Shorting

The center conductor and outer conductor of a channel of the VHF card are temporarily shorted together when "CLOSE" commands are executed.

This phenomena can be observed by connecting a power supply high to the VHF card's channel 0 center conductor and the power supply low to channel 0's outer conductor. Set the power supply voltage to +4 Vdc and monitor the supply output with an oscilloscope. Execute "CLOSE 0" on the HP 3488A. Next execute a "CLOSE 1" and watch for a low going pulse on the oscilloscope.

### 3488A Execution Speed Reduced After Basic Reset

The execution speed of the HP 3488A slows down 40% to 50% of the normal operating speed when remotely programmed.

This anomaly can be seen when the HP 3488A is in the TALK mode and a Basic RESET is executed on the controller. At this time the HP 3488A execution speed is visibly reduced. The HP 3488A continues to operate at the slower speed regardless of where the program execution resumes. This phenomena is most noticeable with the HP 44474A Digital I/O Module, however, all modules may exhibit some reduced

D/OF/WA 10/88-09/MBO

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3488A-15

HEWLETT PACKARD

execution speed.

This problem is due to the HP 3488A setting a false error bit indicating a bus error. The HP 3488A constantly requests service in this case, thus reducing the speed of program execution.

### Action

If the HP 3488A is experiencing either of these failures, replace the HP 3488A ROM, A40U401, with the updated firmware, HP part number 1818-3830 Rev. B. Please specify Rev. B when ordering the latest ROM. Refer to Service Note 3488A-6 for instructions on installing a new ROM.

### Warranty

The warranty policy for this update is warranty always ONLY if one or both of these failures is experienced.

Ref: PCO 09-27658

# SERVICE MANUAL

# MODEL 3488A
# SWITCH/CONTROL UNIT

This manual applies to instruments with a serial number prefix of:

2719A

This manual applies to the electronic assemblies marked with the Engineering Revision Codes indicated. A description of the ERC as it applies to the 3488A is given in Chapter 6. Refer to Chapter 7 for information concerning instrument serial number prefixes or ERCs lower than those listed on this title page.

| Part Number | ERC |
|---|---|
| 03488-66510 | 2718 |
| 03488-66531 | 2718 |
| 03488-66540 | 2642 |
| 44470-66501 | 2608 |
| 44471-66501 | 2709 |
| 44472-66501 | 2605 |
| 44473-66501 | 2712 |
| 44474-66501 | 2609 |

**WARNING**

*The information in this manual is to be used by qualified service-trained personnel only. To avoid personal injury, do not perform any procedure explained in this manual, or perform any servicing of the 3488A, unless you are qualified to do so.*

*The 3488A uses latching relays. This is an advantage in the sense that, under most conditions of failure, the relays will remain in whatever state you set them. However, in case of power or equipment failure any application requiring a failsafe method of insuring that the circuits under control are in a known state must be provided by the installer.*

**Manual Part No. 03488-90012**

**Microfiche Part No. 03488-99012**



**Printed: May 1987**

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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 Bureau of Standards, to the extent allowed by the Bureau'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 materials and workmanship for a period of one year from date of shipment [,except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period]. 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.

Duration and conditions of warranty for this instrument may be superceded when the instrument is integrated into (becomes a part of) other -hp- instrument products.

Hewlett-Packard 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. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

## LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

## EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

## 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.*

HEWLETT PACKARD

**Herstellerbescheinigung**

Hiermit wird bescheinigt, daß das Gerät/System HP 3488A
in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/Systems angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

**Zusatzinformation fur Meß- und Testgeräte**

Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

**Manufacturer's declaration**

This is to certify that the equipment HP 3488A
is in accordance with the Radio Interference Requirements of Directive FTZ 1046/84. The German Bundespost was notified that this equipment was put into circulation, the right to check the series for compliance with the requirements was granted.

**Additional Information for Test- and Measurement Equipment**

If Test- and Measurement Equipment is operated with unscreened cables and/or used for measurements on open set-ups, the user has to assure that under operating conditions the Radio Interference Limits are still met at the border of his premises.

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## SAFETY SUMMARY

**The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.**

### GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

### DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

### KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

### DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

### DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

### DO NOT OPERATE A DAMAGED INSTRUMENT

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

### DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

**WARNING**

**Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.**

## SAFETY SYMBOLS

**General Definitions of Safety Symbols Used On Equipment or In Manuals.**

⚠ Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).

⏚ OR ⏚ Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.

OR Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

∼ Alternating current (power line).

⎓ Direct current (power line).

Alternating or direct current (power line).

**WARNING** The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

**CAUTION** The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition 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.

NOTE: The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

## TABLE OF CONTENTS

## TABLE OF CONTENTS (Cont'd)

## TABLE OF CONTENTS (Cont'd)

## LIST OF TABLES



## LIST OF ILLUSTRATIONS

## LIST OF ILLUSTRATIONS (Cont'd)

# Chapter I
# GENERAL INFORMATION

# CHAPTER I

## TABLE OF CONTENTS



## LIST OF TABLES

# CHAPTER I
# GENERAL INFORMATION

## 1-1 INTRODUCTION

This manual contains the information necessary to install, test, and maintain the Hewlett-Packard Model 3488A Switch/Control Unit. This manual is intended for use only by Service Trained Personnel. Operating and Programming Personnel should refer to the Operating Manual. The Hewlett-Packard part number for the Operating Manual is 03488-90002.

## 1-2 HOW TO USE THIS MANUAL

This manual is divided into 12 chapters. This chapter, General Information, describes the use of the manual, gives a brief description of the 3488A and the Plug-in Cards, lists the specifications of the 3488A and the Plug-in Cards, and describes accessories available. The remainder of this manual consists of the following chapters:

### 1-3 Chapter II Installation

This chapter provides installation instructions for the HP 3488A Switch/Control Unit. Also included in this section are instructions for initial inspection, damage claims, preparation for use, packaging and shipment.

### 1-4 Chapter III Operating Information

This chapter contains a condensed description of the operating instructions contained in the Operators Manual. It is provided to give a quick overview of the operating modes and functions of the 3488A. Complete operating information is given in a separate Operating Manual (Hewlett-Packard part number 03488-90002).

### 1-5 Chapter IV Operation Verification

This chapter contains procedures used to gain a high confidence level that the unit and the Plug-in Cards are operating within the defined specifications. This chapter should be used for incoming inspection, post repair evaluation, and to help diagnose failures.

### 1-6 Chapter V Replaceable Parts

This chapter contains assembly and disassembly instructions. Included with the instructions are the mechanical part numbers used in the instrument. A list of the electrical assembly part numbers and component part numbers is also provided. Plug-in Card part lists are not included in this section. They are provided in each Plug-in Card chapter.

### 1-7 Chapter VI Service

This chapter contains procedures and information about problem isolation to an assembly level. Once the problem has been isolated to the assembly level, additional troubleshooting procedures are provided to isolate the problem to the component level. This chapter provides theory of operation and troubleshooting information for the mainframe only. Plug-in Card theory of operation and troubleshooting is provided in each Plug-in Card chapter.

## 1-8 Chapter VII Backdating

This chapter provides information to make this manual apply to earlier serial number prefixes or ERC's than those listed on the title page. A definition of the ERC is is given in Chapter 6.

## 1-9 Chapter VIII 44470A 10 Channel Relay Multiplexer

This chapter contains installation instructions, performance tests, troubleshooting information, and parts lists for the 44470A 10 Channel Relay Multiplexer card.

## 1-10 Chapter IX 44471A 10 Channel General Purpose Relay

This chapter contains installation information, performance tests, troubleshooting information, and parts lists for the 44471A 10 Channel General Purpose Relay card.

## 1-11 Chapter X 44472A Dual 4 Channel VHF Switch

This chapter contains installation information, performance tests, troubleshooting information, and parts lists for the 44472A Dual 4 Channel VHF Switch card.

## 1-12 Chapter XI 44473A 4X4 Matrix Switch

This chapter contains installation information, performance tests, troubleshooting information, and parts lists for the 44473A 4X4 Matrix Switch card.

## 1-13 Chapter XII 44474A 16 Channel Digital Input/Output

This chapter contains installation information, performance tests, troubleshooting information, and parts lists for the 44474A 16 Channel Digital Input/Output card.

## 1-14 DESCRIPTION

The 3488A Switch/Control Unit consists of a mainframe, a keyboard, a display, a power supply, a controller, and a computer interface. The mainframe provides 5 slots for optional plug-in cards. The Unit can be operated either from a remote computer program or manually from the front panel.

In either case, one or more plug-in cards are required. There are six plug-in cards available. Each card is designed for a specific application in either switching or control.The plug-in cards available are:

| | |
|---|---|
| 44470A | 10 Channel Relay Multiplexer Card |
| 44471A | 10 Channel General Purpose Relay Card |
| 44472A | Dual 4 Channel VHF Card |
| 44473A | 4 X 4 Matrix Switch Card |
| 44474A | 16 Channel Digital I/O Card |
| 44475A | Breadboard Card |
| 44476A/B | Microwave Switch Module |
| 44477A | Form C Relay Module |

## 1-15 SPECIFICATIONS

Specifications for the 3488A and the plug-in cards are given in Table 1-1. Specifications are the performance standards or limits against which the 3488A and plug-in cards are tested.

## 1-16 INSTRUMENT IDENTIFICATION

Hewlett-Packard instruments are identified by a two part, ten digit instrument serial number of the form 0000A00000. This serial number is in two parts. The first four digits, called the serial number prefix, is the same for all identical instruments, it changes only when a change is made to the instrument. The letter indicates the country of origin, A indicates that the instrument was made in the United States of America. The last five digits, called the serial number suffix, are unique for each instrument.

The serial number for the 3488A can be found on the bottom cover of the instrument. Please include the entire serial number (both prefix and suffix) in any correspondence about your instrument.

## 1-17 MANUAL IDENTIFICATION

This manual applies to mainframes with serial number prefix(es) listed on the title page. Additionally, this manual applies to electrical assemblies with the Engineering Revision Codes listed on the title page. Section 6-4 describes the Engineering Revision Code as it applies to the electrical assemblies.

This manual is periodically updated, either by revision or change sheets.

## 1-18 OPTIONS

The following list of equipment is available as options to the 3488A.

| | |
|---|---|
| Option 010 | 44470A 10 Channel Relay Multiplexer Card |
| Option 011 | 44471A 10 Channel General Purpose Relay Card |
| Option 012 | 44472A Dual 4 Channel VHF Switch Card |
| Option 013 | 44473A 4 x 4 Matrix Switch Card |
| Option 014 | 44474A 16 Channel Digital Input/Output Card |
| Option 015 | 44475A Breadboard Card |
| Option 016 | 44476A Microwave Switch Card |
| Option 017 | 44477A Form C Relay Card |
| Option 018 | 44476B Microwave Switch Card (User configurable) |
| Option 401 | Side Handle Kit |
| Option 907 | Front Handle Kit |
| Option 908 | Rack Flange Kit |
| Option 909 | Rack Flange And Front handle Kit |
| Option 910 | Extra Operating And Service Manuals |

## 1-19 ACCESSORIES

The following equipment is available as field installation kits for the 3488A.

| | |
|---|---|
| 44470A | 10 Channel Relay Multiplexer Card |
| 44471A | 10 Channel General Purpose Relay Card |
| 44472A | Dual 4 Channel VHF Switch Card |
| 44473A | 4 X 4 Matrix Switch Card |

| | |
|---|---|
| 44474A | 16 Channel Digital Input/Output Card |
| 44475A | Breadboard Card |
| 44476A/B | Microwave Switch Module |
| 44477A | Form C Relay |

Other accessories available include:

| | |
|---|---|
| 44480A | Screw Terminal Connector Block for 44470A |
| 44481A | Screw Terminal Connector Block for 44471A |
| 44483A | Screw Terminal Connector Block for 44473A |
| 44484A | Screw Terminal Connector Block for 44474A |
| 44485A | Screw Terminal Connector Block for 44475A |
| 44487A | Screw Terminal Connector Block for 44477A |
| 10833A | HP-IB Cable, 1 metre |
| 10833B | HP-IB Cable, 2 metre |
| 10833C | HP-IB Cable, 4 metre |
| 10833D | HP-IB Cable, 0.5 metre |
| 10502A | BNC - BNC Cable, 23 cm (9 in) |
| 10503A | BNC - BNC Cable, 122 cm (48 in) |
| 1251-2816 | Dual Banana Plug |
| 1250-0781 | BNC Tee (female-male-female) |
| 5061-1173 | Service Extender Board |
| 5061-1174 | Service Extender Cable |
| 03488-66501 | Test Fixture |

## Table 1-1 3488A Specifications & Information

### GENERAL INFORMATION

**ENVIRONMENTAL**

**Operating:** 0 - 55°C (32 - 130°F);
**Storage:** −40 - 75°C (−40 - 165°F);
**Humidity:** 95%, 0 - 40°C (32 - 104°F)

**POWER**

**Line Voltage (Mains):** 86-132V (115V) or 195-250V (230V) switch selectable, 48 - 440 Hz. Fused at 0.5A (115V) or 0.25A (230V).

**Consumption:** 6 VA (mainframe); 18 VA (maximum).

**SIZE**

89mm H (without removable feet) x 425mm W x 292mm D (3.5" x 16.75" x 11.5").
Height (with removable feet): 100mm (4").
Allow 76mm ( 3") additional depth for wiring.

**WEIGHT**

| | Net | | Shipping | |
|---|---|---|---|---|
| | kg. | lbs. | kg. | lbs. |
| 3488A mainframe– | 5.0 | 11.0 | 8.5 | 19.0 |
| Modules (ea.)– | 0.7 | 1.5 | 1.5 | 3.5 |
| Maximum Total– | 8.5 | 18.5 | 16.0 | 36.5 |

**HP-IB (IEEE-488) Capabilities:**

SH1 AH1 T6 TEO L4 LEO SR1 RL1 PPO DC1 DT1 E2

### OPTION 010 44470A 10 CHANNEL RELAY MULTIPLEXER MODULE

**INPUT CHARACTERISTICS**

**Maximum Voltage** (Terminal-terminal or terminal-chassis):
250 VDC, 250 VAC RMS, 350 VAC Peak

**Maximum Current:** (Per channel or module): 2 ADC, 2 AAC RMS

**Maximum Power** (Per channel or module): 60 W DC, 500 VA AC

**Maximum power dissipated by user added components:** 2 W

**Thermal Offset:** $< 3\mu V$ differential or single ended

**Closed Channel Resistance:** $<2\ \Omega$ (end of relay life)

**DC ISOLATION**

| | <(40°C,60% RH) | <(40°C,95% RH) |
|---|---|---|
| Open Channel, Channel-Channel* | $> 10^{11}\Omega$ | $> 5\times10^{9}\Omega$ |
| Hi-Lo* | $> 5\times10^{10}\Omega$ | $> 10^{9}\Omega$ |
| Channel-Chassis* | $> 5\times10^{10}\Omega$ | $> 10^{9}\Omega$ |

(* with 1 channel closed)

**AC ISOLATION/PERFORMANCE****

**Capacitance:**

| | |
|---|---|
| Open Channel, Channel-Channel* | < 5 pF |
| Hi-Lo* | <27 pF |
| Channel-Chassis* | <80 pF |

(* with 1 channel closed)

| (50Ω termination) | 100 kHz | 1 MHz | 10 MHz |
|---|---|---|---|
| Insertion Loss (dB) | < 0.20 | < 0.25 | < 0.50 |
| Crosstalk (dB) | < −73 | < −53 | < −33 |

**With chassis of all equipment connected, and with low of input lines connected to low of output lines (either directly or via 3488A switched channel).

### OPTION 011 44471A 10 CHANNEL GENERAL PURPOSE RELAY MODULE

**INPUT CHARACTERISTICS**

**Maximum Voltage** (Terminal-terminal or terminal-chassis):
250 VDC, 250 VAC RMS, 350 VAC Peak

**Maximum Current** (Per channel): 2 ADC, 2 AAC RMS
(Per module): 20 ADC, 20 AAC RMS

**Maximum Power** (Per channel): 60 W DC, 500 VA AC
(Per module): 600 W DC, 5000 VA AC

**Maximum power dissipated by user added components:** 2 W

**Thermal Offset** $< 3\ \mu V$ per channel

**Closed Channel Resistance:** $< 2\ \Omega$ (end of relay life)

**DC ISOLATION**

| | <(40°C,60% RH) | <(40°C,95% RH) |
|---|---|---|
| Open Channel, Channel-Channel* | $> 10^{11}\Omega$ | $> 10^{9}\Omega$ |
| Channel-Chassis* | $> 5\times10^{11}\Omega$ | $> 10^{10}\Omega$ |

(* with 1 channel closed)

## Table 1-1. 3488A Specifications & Information (Cont'd)

### OPTION 011 44471A 10 CHANNEL GENERAL PURPOSE RELAY MODULE (Cont'd)

**AC ISOLATION/PERFORMANCE****

**Capacitance:**

| | |
|---|---|
| **Open Channel** | < 7 pF |
| **Channel-Channel*** | <10 pF |
| **Channel-Chassis*** | <25 pF |

(* with 1 channel closed)

| (50Ω termination) | 100 kHz | 1 MHz | 10 MHz |
|---|---|---|---|
| **Insertion Loss** (dB) | < 0.20 | < 0.25 | < 0.50 |
| **Crosstalk** (dB) | < −73 | < −53 | < −33 |

**With chassis of all equipment connected, and with low of input lines connected to low of output lines (either directly or via 3488A switched channel).

### OPTION 012 44472A DUAL 4 CHANNEL VHF SWITCH MODULE

**INPUT CHARACTERISTICS**

**Maximum Voltage** (Center-center, center-low): 250 VDC, 30 VAC RMS,42 VAC Peak*; (Low-chassis, low-low): 42 VDC

**Maximum Current** (Per channel): 30 mA DC, 300 mA AC RMS*

**Thermal Offset:** < 15 $\mu$V per channel

**Characteristic Impedance:** 50Ω

**Closed Channel Resistance:** < 1 Ω (end of relay life)

*To maintain compliance with VDE class B or FTZ 1115/83 radiation limits, use semi-rigid or equivalent coax cable and limit signal to < $2x10^7$ V*Hz.

**AC ISOLATION/PERFORMANCE**

| (50Ω termination) | 30 MHz | 100 MHz | 300 MHz |
|---|---|---|---|
| Insertion Loss (dB) | < 0.5 | < 0.75 | < 1.25 |
| Crosstalk (dB) Channel-Channel, Channel-Common | < −100 | < −85 | < −65 |
| Cross talk group to group (dB) | < −85 | < −85 | < −50 |
| VSWR | < 1.06 | < 1.12 | < 1.43 |

**Capacitance:**

| | |
|---|---|
| **Center-Center, Center-Common** | <0.002 pF |
| **Center-Low** | < 70 pF |
| **Low-Chassis** | < 0.2 $\mu$F |

**Rise Time:** < 0.7 nsec
**Signal Delay:** < 2.5 nsec; Channel match < 90 psec

**DC ISOLATION**

<(40°C,95% RH), between any 2 points: >$10^7$Ω

**GENERAL**

All channels break-before-make within a group of 4 channels. When all channels in a group are opened, the last channel opened (or channel 00 or 13 following a group RESET) has channel-common isolation of >80 dB @ 30 MHz, >60 dB @ 100 MHz, & >40 dB @ 300 MHz.

**Connectors:** BNC's

### OPTION 013 44473A 4 X 4 MATRIX SWITCH MODULE

**INPUT CHARACTERISTICS**

**Maximum Voltage** (Terminal-terminal or terminal-chassis): 250 VDC, 250 VAC RMS, 350 VAC Peak

**Maximum Current** (Per channel): 2 ADC, 2 AAC RMS
(Per module): 8 ADC, 8 AAC RMS

**Maximum Power** (Per channel): 60 W DC, 500 VA AC
(Per module): 240 W DC, 2000 VA AC

**Thermal Offset:** <3 $\mu$V differential

**Closed Channel Resistance:** < 3 Ω (end of relay life)

**DC ISOLATION**

| | <(40°C,60% RH) | <(40°C,95% RH) |
|---|---|---|
| **Open Channel, Channel-Channel** | > $10^{11}$Ω | > $10^9$Ω |
| **Hi-Lo** | > $10^{10}$Ω | > $10^8$Ω |
| **Channel-Chassis** | > $10^{10}$Ω | > $5x10^8$Ω |

## Table 1-1. 3488A Specifications & Information (Cont'd)

### OPTION 013 44473A 4 x 4 MATRIX SWITCH MODULE (Cont'd)

**AC ISOLATION/PERFORMANCE****

**Capacitance:**

| | |
|---|---|
| **Open Channel, Channel-Channel** | < 5 pF |
| **Hi-Lo** | <40 pF |
| **Channel-Chassis** | <70 pF |

| (50Ω termination) | 100 kHz | 1 MHz | 10 MHz |
|---|---|---|---|
| **Insertion Loss** (dB) | < 0.30 | < 0.35 | < 0.90 |
| **Crosstalk** (dB) | < −76 | < −56 | < −36 |

**With chassis of all equipment connected, and with low of input lines connected to low of output lines (either directly or via 3488A switched channel).

### OPTION 014 44474A 16 BIT DIGITAL I/O MODULE

**I/O LINES**

**Maximum Voltage** = +30V DC (Line-Chassis)

**Output Characteristics**

Vout(high) ≥2.4V @ I ≤ 8 mA output
Vout(low) ≤ 0.4V @ I ≤ 16 mA input
I(low) = 125mA @ Vout(low) ≤ 1.25V
I(low) fused at 250 mA

**Input Characteristics**

Vin(high) ≥ 2V; Vin(low) ≤ 0.8V

**HANDSHAKE LINES**

**Maximum Voltage** = +5V DC (Line-Chassis)

**Output Characteristics**
Vout(high) ≥ 2.4V @ I ≤ 400 μA output
Vout(low) ≤ 0.5V @ I ≤ 2 mA input

**Input Characteristics**
Vin(high) ≥ 2.0V; Vin(low) ≤ 0.8V

**External Increment:** Advances 3488A to next programmed configuration on falling edge of TTL pulse, 0.25 μsec minimum width.

**Channel Closed:** Indicates completion of new configuration; TTL pulse, 10 μsec minimum width.

### OPTION 015 44475A BREADBOARD MODULE

**Component Areas Available:** 104mm x 74mm (4.1" x 2.9") and 79mm x 74mm (3.1" x 2.9")

**Mounting Holes** – Center Spacing: 2.54mm x 2.54mm (0.1" x 0.1"); Inside Diameter: 1.17mm (0.046")

**Maximum Component Height** (above board): 12.7 mm (0.5 ")

**Maximum Lead Length** (below board): 3.2mm (0.125")

**Maximum Voltage:** 42 VDC, 30 VAC RMS, 42 VAC Peak

**Maximum Power dissipation per module:** 2 W

**Signal Buses:** On edge of component areas and between component areas.

**Connectors Supplied:** Screw terminal connector with 22 terminals for field wiring, and edge connectors for 3488A backplane and screw terminals.

# Chapter II
# INSTALLATION

# CHAPTER II

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF ILLUSTRATIONS

# CHAPTER II
# INSTALLATION

## 2-1 INTRODUCTION

This chapter contains information and instructions required to install the Hewlett-Packard 3488A Switch/Control Unit. Included in this section are: initial inspection, power requirements, environmental requirements, information about accessories and options, and instructions for repacking and shipping the unit and plug-in cards.

**WARNING**

*The information in this service manual is for service trained personnel only. To avoid electrical shock do not perform any procedures in this manual or do any servicing to the HP 3488A unless you are qualified to do so.*

## 2-2 INITIAL INSPECTION

**WARNING**

*To avoid potentially hazardous elecrical shock, do not perform electrical tests when there are signs of damage to any portion of the outer enclosure.*

The 3488A was carefully inspected, both mechanically and electrically, before shipment. It should be free of any mars or scratches and in perfect electrical order upon receipt. You should inspect the Unit for any damage that may have occurred in transit. If the shipping container or packing material shows any signs of damage or stress, it should be kept until the unit has been mechanically and electrically checked. Procedures to check the electrical performance of the 3488A are given in Chapter IV. If mechanical damage is found, the shipment is incomplete, or the unit does not pass the electrical tests, notify the nearest Hewlett-Packard Sales and Service Office (a list of Sales and Service Offices is given at the back of this manual). If the shipping container or packing material shows any signs of damage or stress, notify both the carrier and the nearest Hewlett-Packard Sales and Service Office. Save the shipping material for the carrier's inspection.

Included with the 3488A should be:

1 Operating, Programming and Configuration Manual
1 Service Manual (this manual)
2 fuses and fuse caps (see Section 2-5)
1 line power cable

## 2-3 POWER REQUIREMENTS

**CAUTION**

*Ensure that the 3488A is set to the correct line voltage before installing the line power cable. Equipment damage may result if line power is applied and the 3488A is incorrectly set.*

The 3488A may be set to operate at either 115 Vac or 230 Vac . When set to the 115 Vac position, the unit may be operated with an input voltage ranging from 86 Vac to 132 Vac. When set to the 230 Vac position the unit may be operated with an input voltage ranging from 195 Vac to 250 Vac. The line power frequency must be between 48 Hz and 440 Hz, single phase. Total power consumption is less than 6 VA (3488A mainframe only), 2.4 VA per option plug-in card, or a total of 18 VA (mainframe and 5 plug-in cards).

### 2-4 Line Voltage Selection

The line voltage selector switch is located on the rear of the unit inside the card cage. It is necessary to set the line voltage selector switch to correspond to the local power line voltage. Figure 2-1 shows the switch set to operate with 115 Vac line input. To set the unit to operate with 230 Vac input, slide the switch to the 230 V position.

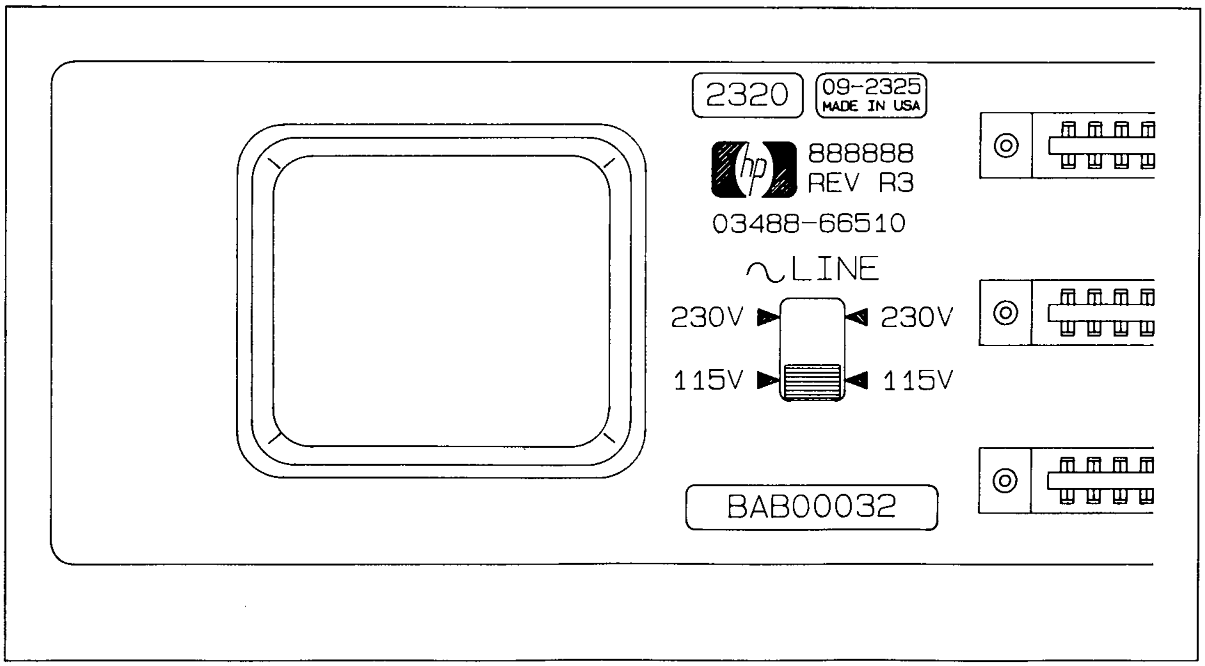



**Figure 2-1 Line Voltage Selection Switch**

### 2-5 Fuses

The 3488A does not have a fuse installed when shipped from the factory. Two fuses and fuse-caps are provided with the unit. The two fuses are electrically and physically different sizes. The two fuse-caps are different colors. Each fuse-cap will accept only one physical size of fuse. The line voltage selected (as described in section 2-4) determines which of the two fuses and fuse-caps to install.



In Apr. '96 - the 500mA fuse only was installed. This is fine for both settings
pn 2110-0907

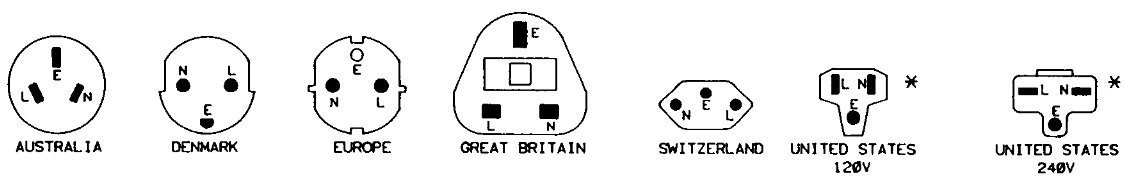
For 115 Vac operation install the 500 mA fuse and the grey fuse-cap. For 230 Vac operation install the 250 mA fuse and the black fuse-cap. Included with each fuse and fuse-cap set is a self-adhesive label identifying the size of fuse and line voltage selected. Affix this label to the 3488 as a permanent identification of the line voltage selected and the fuse type installed.

To install a fuse, first, place the fuse in the fuse-cap. Insert the fuse and fuse-cap assembly in the fuse holder located in the lower right corner of the rear panel. Use a small blade screwdriver to turn the fuse-cap ¼ turn clockwise. To remove a fuse, reverse the procedure.

## 2-6 Power Cables

The 3488A is supplied with a three conductor power cable. The type of primary power plug installed on this cable should be the correct type for local installation. Figure 2-2 shows the various primary power plugs available and lists a Hewlett-Packard part number for each. The Hewlett-Packard part number specifies the entire cable, including the primary power plug. If the cable received with the 3488A does not have the correct primary power plug for your area, contact the nearest Hewlett-Packard Sales and Service Office. A listing of the Hewlett Packard Sales and Service Offices is given at the back of this manual.

**POWER CORDS**




| Country | Part Number | Opt. | Voltage |
|---|---|---|---|
| Australia | 8120-1369 | 901 | 250V 6A |
| Denmark | 8120-2956 | 912 | 250V 6A |
| Europe | 8120-1689 | 902 | 250V 6A |
| Great Britain | 8120-1351 | 900 | 250V 6A |
| Switzerland | 8120-2104 | 906 | 250V 6A |
| *United States | 8120-1376 | 903 | 120V 10A |
| *United States | 8120-0698 | 904 | 240V 10A |

Power cords supplied by HP have polarities matched to the power input socket on the instrument:

- L = Line or Active Conductor (also called "live" or "hot").
- N = Neutral or Identified Conductor
- E = Earth or Safety Ground

**NOTE:** Plugs are viewed from connector end. Shape of molded plug may vary within country.

* CSA certification includes only these Power Plugs

**Figure 2-2 Line Power Cables**

## 2-7 Grounding Requirements

The power cable supplied with the 3488A is a three conductor power cable. When properly connected to a grounded receptacle the third conductor in the cable grounds the 3488A chassis. Under no circumstances should this grounding be defeated. If the primary power receptacle is of the type with only two conductors, the third conductor of the power cable must be routed to a safe earth ground. On adapters designed to mate a three conductor power cable to a two conductor receptacle the earth ground connection is typically a short green wire.

Chassis ground is also available at the rear panel of the unit and can be connected to a reliable earth ground when the power cable ground is unavailable. This ground terminal can also be used to shield input or output cabling to the 3488A or to connect other instruments in the system to a common ground. The ground connection is a silver colored terminal, located in the lower center of the rear panel. The terminal will accept a standard banana plug in the center or, by using the knurled nut, spade lugs and tinned wires.

## 2-8 ENVIRONMENTAL REQUIREMENTS

### 2-9 Temperature

The 3488A may be operated in environments with a temperature range from 0° C to 55° C (32° F to 131° F). The 3488A may be stored in environments with a temperature range from -40° C to 75° C (-40° F to 167° F).

### 2-10 Humidity

The 3488A may be stored or operated in environments where the humidity is less than 95% over the temperature range of 0° C to 40° C (32° F to 104° F).

In moist environments the 3488A should be protected from temperature extremes which can cause condensation within the instrument.

**CAUTION**

*The instrument covers are not water or dust proof. In environments where excessive moisture, dust, or corrosive elements are present, the instrument should be protected in some type of enclosure.*

## 2-11 CARD INSTALLATION

Up to five plug-in cards can be installed in the 3488A. Six different cards are available and any combination of these cards may be used. The plug-in cards are available as Options to the 3488A (Section 1-18) or as field installation kits (Section 1-19).

### 2-12 Slot Numbering

The five available slots are numbered 1 through 5. Figure 2-3 shows the location of these slots. Any plug-in card can be installed in any slot. When installing the cards, make a note of the card type and slot number used. This information is required by the system designer, system programmer, and operator.

### 2-13 Card Insertion

To insert one of the plug-in cards into the 3488A mainframe:

1. Remove power from the 3488A.

2. Remove the black connector block and grey support from the card.

3. Lift the two white 'ears' on the card. These ears have a detent that holds the ear in a closed position.

4. Hold the card so that the ears are pointing out, with the component side of the printed circuit board down. Gently slide the card into one of the slots in the rear of the 3488A. The side edges of the card should positively engage in the slots. Gently push the card into the 3488A until it stops.

5. Fold the ears down until they engage the detent. As the ears are folded down the card will be pulled into the connector in the backplane. This action both engages the connector and locks the card into place.

The black connector block can now be wired to suit the system needs. Detailed instructions to wire the card and install the connector and grey housing are given in appropriate chapter of this manual.

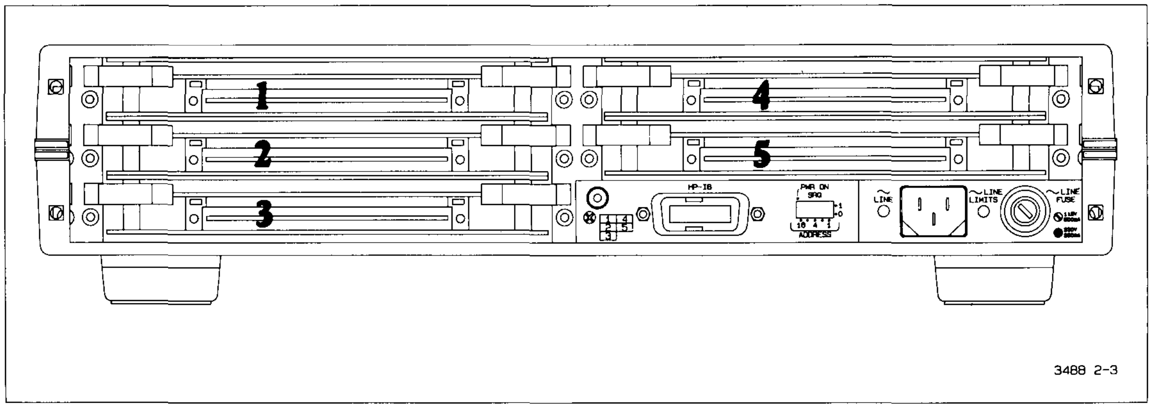



**Figure 2-3 Slot Numbers**

## 2-14 HP-IB INSTALLATION

Installing the 3488A in a computer system requires two steps; connecting the HP-IB cable and setting the HP-IB address.

## 2-15 HP-IB Cable

The HP-IB Cable attaches to the connector on the rear panel of the 3488A mainframe. The connector is tapered to ensure proper orientation. The two screws on the cable connector should be finger tightened to provide mechanical integrity to the connection.

Other instruments may be connected to the bus in any manner desired (i.e., series connections, parallel connections, or a combination of both). Only one requirement must be met when installing the HP-IB cables. This requirement is a maximum length requirement. In general, the maximum length of the HP-IB cables must not exceed 20 metres or 2 metres per device, whichever is less.

HP-IB cables are listed by part number in Section 1-19 of this manual.

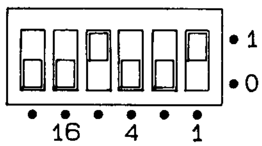
## 2-16 HP-IB Address

The 3488A is shipped from the factory set to an address of 09. This address is set on a series of small switches located on the rear panel of the instrument. The switches set a five bit binary code. This binary code is referred to by its decimal equivalent. For example, the factory set binary code of 01001, is equivalent to a decimal 9.

The five switches that set the address are accessible through a rectangular hole in the rear panel. Setting the switch to the up position sets the '1' state, setting the switch down sets the '0' state. Each switch is marked with the decimal weight of the bit. The address is the sum of the weighted bits.

To select an address place the switches in the desired pattern. Table 2-1 shows all allowable combinations of the switches and the resulting decimal address code.

**Table 2-1 HP-IB Addresses**




Shown at Factory Default Address (09).

| ASCII Code Character | | Address Switches | | | | | 5-bit |
|---|---|---|---|---|---|---|---|
| Listen | Talk | A5 | A4 | A3 | A2 | A1 | Decimal Code |
| 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 |

## 2-17 Power On SRQ

The Power On SRQ switch is located next to the HP-IB address switches. This switch is set at the factory to the off (down) position. If it is desired that the 3488A assert an HP-IB service request at each power up cycle, set the switch to the on (up) position. The 3488A Operating Manual contains additional information about power on SRQ.

## 2-18 SHIPPING THE 3488A

Should it become necessary to ship the 3488A or any of the plug-in cards to Hewlett-Packard, follow these guidelines:

1. Remove all plug-in cards from the mainframe before shipment. This should be done even if both the plug-in cards and the mainframe are to be shipped.

2. Use clean handling and anti-static techniques when removing and packaging the plug-in cards. Anti-static handling procedures are described in Section 6-3.

3. Wrap the plug-in cards in anti-static bags before packaging. A part number for anti-static bags is given in Table 5-1.

4. Attach a tag to the 3488A and any plug-in cards that are to be shipped. Mark the tag with the owners name, the model number of the unit or plug-in, the unit serial number, and the repair or service desired.

5. Carefully package the unit or plug-in card with an ample amount of cushioning material. Hewlett-Packard cannot assume any liability for damage caused in transit due to poor packaging. Preferrably, use the original shipping container and cushioning material

6. Attach a tag to the outside of the shipping container. Mark this tag with the owners name, the model number of the unit or plug-in, the serial number, and the repair or service desired.

## 2-19 Where To Ship The 3488A

For replacement or repair of defective assemblies, send the correctly packaged assembly to the nearest Hewlett-Packard Service Office. Hewlett-Packard Service Offices are listed at the back of this manual.

# Chapter III
# OPERATING INFORMATION

# CHAPTER III

## TABLE OF CONTENTS



## LIST OF TABLES

# CHAPTER III
# OPERATING INFORMATION

## 3-1 INTRODUCTION

This section provides a general overview of the 3488A's operating commands and front panel keys. An (RO) following a command description indicates that the command can be executed from Remote Only (from the computer). An (LO) following a command description indicates that the command can be executed from Local Only (from the 3488A keyboard). Commands that are not followed by (RO) or (LO) can be both remotely and locally executed.

## 3-2 CARD COMMANDS

The following commands apply to all plug-in cards with the exception of the 44475A Breadboard Card. The commands that apply to the Breadboard Card (SREAD and SWRITE) can be found in Sections 3-13 and 3-14.

## 3-3 Close

CLOSE <ch. address>[,<ch. address>,<ch. address>, . . .]

The CLOSE command can be used to (1) close one or more channels on the 44470A, 44471A, 44472A, or 44473A cards and (2) "clear" (logic 0) one or more bits on the 44474A Digital I/O card.

When CLOSE is used with the Digital I/O card, the card must be in digital mode 1 or 2. An error condition will occur if the card is in digital mode 3, 4 or 5, and a CLOSE command is issued to it (refer to Digital Mode, Section 3-16).

Several channels or bits can be closed using one CLOSE command by listing their addresses in a series separated by commas. Channels or bits will be closed successively in the order that they appear in the list.

As an example of the CLOSE command, executing the following line will close channels or bits 2, 3 and 5 in slot 1 and channel or bit 5 in slot 3.

OUTPUT 709;"CLOSE 102,103,105,305"

## 3-4 Open

OPEN <ch. address>[,<ch. address>,<ch. address>...]

The OPEN command can be used to (1) open one or more channels on the 44470A, 44471A, 44472A, or 44473A cards and (2) "set" (logic 1) one or more bits on the 44474A Digital I/O card.

When OPEN is used with the Digital I/O card, the card must be in digital mode 1 or 2. An error condition will occur if the card is in digital mode 3, 4 or 5, and an OPEN command is issued to it (refer to Digital Mode, Section 3-16).

Several channels or bits can be opened using one OPEN command by listing their addresses in a series separated by commas. Channels or bits will be opened successively in the order that they appear in the list.

As an example of the OPEN command, executing the following line will open channels or bits 3 and 5 in slot 1 and channel or bit 7 in slot 3.

OUTPUT 709;"OPEN 103,105,307"

## 3-5 View

VIEW <ch. address>

The VIEW command can be used to verify the state of a particular channel on the 44470A, 44471A, 44472A, or 44473A cards and to verify the state of a particular bit on the 44474A Digital I/O card.

If the VIEW command is asserted from the 3488A's front panel, the 3488A displays the slot/channel address followed by the term "OPEN 0" or "CLOSED 1". If the VIEW command is asserted from the computer, only "OPEN 0" or "CLOSED 1" is returned (the slot/channel address is not returned).

For example, line 10 of the following program will view channel or bit 5 in slot 1. Line 20 will input the alphanumeric response from the 3488A into a string variable in the computer. Line 30 displays the string (either "OPEN 1" or "CLOSED 0")

```
10 OUTPUT 709;"VIEW 105"
20 ENTER 709; A$
30 DISP A$
```

## 3-6 Card Type

CTYPE <slot>

The CARD TYPE command causes the 3488A to output the model name and number of the plug-in card in the specified slot. If the CARD TYPE command is executed from the 3488A's front panel, the display shows the slot in addition to the card's name and model number. Table 3-1 shows all possible card types and the corresponding 3488A responses to the CARD TYPE command.

**Table 3-1 CARD TYPE Command Responses**

| CARD TYPE | DESCRIPTION |
|---|---|
| Slot is empty | NO CARD 00000 |
| 10 Channel Multiplexer | RELAY MUX 44470 |
| General Purpose Card | GP RELAY 44471 |
| High Frequency Scanner | VHF SW 44472 |
| Matrix Card | MATRIX SW 44473 |
| Digital I/O Card | DIGITAL IO 44474 |
| Breadboard Card | BREADBOARD 44475 |

For example, line 10 of the following program will verify the type of card in slot 3. Line 20 will enter the alphanumeric response from the 3488A into a string in the computer. Line 30 will display the string.

```
10 OUTPUT 709;"CTYPE 3"
20 ENTER 709; A$
30 DISP A$
```

## 3-7 Card Reset

CRESET <slot>[,<slot>...]

The CARD RESET command can be used to reset (open) all channels or bits on a card in a particular slot. Only the card specified in the command will be reset. All other cards remain in their previous states.

Several cards can be reset using one CARD RESET command by listing their addresses in a series separated by commas. Cards will be reset successively in the order that they appear in the list.

When the 44474A Digital I/O Card is reset, it returns to its default mode and state. This means that the 16 data lines are set open (high state) and the card is in digital mode 1 (refer to Digital Mode, Section 3-16).

For example, executing the following line will reset the card in slot 2.

```
OUTPUT 709;"CRESET 2"
```

## 3-8 Card Pair

CPAIR <slot>,<slot>

The CARD PAIR command is used to group two cards of the same type together — effectively assigning both cards to both slot numbers. When a command is sent to one of the paired cards, that command is executed on both cards in succession — lowest slot number first. The card pair feature is especially useful when doing 4-wire scanning with 44470A 10 Channel Multiplexers.

Executing a CARD PAIR command will cancel any previous CARD PAIR command involving either of the two cards. It is possible, however, to have two sets of card pairs (e.g., 44470As in slots 1 and 2, and 44474As in slots 3 and 4).

As an example of the CARD PAIR command, line 10 in the following program will group the cards in slots 1 and 3. Line 20 will successively close channel or bit 5 on the cards in slots 1 and 3.

```
10 OUTPUT 709; "CPAIR 1,3"
20 OUTPUT 709; "CLOSE 105"
```

## 3-9 Card Monitor

CMON<slot>

The CARD MONITOR command causes the 3488A's display to monitor the state of the card in the specified slot. The display is updated whenever a command is issued to the specified slot.

Specifying slot 0 causes the card monitor mode to be cancelled.

Specifying a negative slot number (e.g., -1) initiates the monitor tracking mode. In this mode, the card in the slot where the last operation was performed will be monitored. Upon initiating the monitor tracking mode, the display will monitor the slot specified in the command (-1 = slot 1) until an operation is performed on another card.

Table 3-2 summarizes the various cards and their corresponding displays in the card monitor mode.

**Table 3-2 Card Monitor Mode**

| CARD TYPE | DISPLAY |
|---|---|
| 44470A Multiplexer | s:n,n,n,n,n,n,n,n,n,n |
| 44471A General Purpose | s:n,n,n,n,n,n,n,n,n,n |
| 44472A VHF Multiplexer | s: n,n,n,n,n,n,n,n, |
| 44473A Matrix (monitoring rows) | s: ROW r ;c,c,c,c |
| 44473A Matrix (monitoring columns) | s: r,r,r,r; COL c |
| 44474A Digital I/O (monitoring decimal bytes) | s: H:bbb L:bbb |
| 44474A Digital I/O (monitoring hexadecimal bytes) | s: H:bbbH L:bbbH |
| 44474A Digital I/O (monitoring decimal word) | s: W:wwwwww |
| 44474A Digital I/O (monitoring hexadecimal word) | s: W:wwwwH |
| where:<br>s = slot number<br>n = channel number<br>r = row number<br>c = column number<br>bbb = digital data byte<br>www = digital data word | |

As an example of the CARD MONITOR command, executing the following line will cause the 3488A to monitor the card in slot 1.

OUTPUT 709;"CMON 1"

## 3-10 Scan List

SLIST [<ch. address>(,or -)<ch. address>...<ch. address>]

The SCAN LIST command establishes a list of up to 85 channels or bits and/or stored setups (see STORE, Section 3-30) to be stepped through in sequence. Addresses and stored setups in the list are separated by commas. A series of contiguous channels or bits may be specified by entering the first address and the last address separated by a hyphen. Any gaps or improper card types included in this list will be ignored as long as the two numbers specified are valid.

After a scan list has been established, the STEP command will sequence through the list opening the previous channel or bit and closing the next.

In most cases, if the STEP command is executed after reaching the end of the scan list, a wraparound to the beginning of the list will occur. The number 0, however, may be inserted into the list to act as a "stop channel". When 0 is reached, the 3488A will open the last channel closed but will not close another channel. Also, the Channel Closed pulse will not be generated following the number 0 (refer to Digital Mode, Section 3-16)

The CHAN command may be used to specify a particular channel to close. If CHAN is used, any channel previously closed in the scan list will open and the channel specified in the CHAN command will close. Also, if the channel closed by the CHAN command is specified in the scan list, subsequent scanning with the STEP command will start with that channel. If the CHAN command is used to close a channel outside of the scan list and a STEP command is executed, the 3488A will open the channel closed by the CHAN command and close the first channel or bit specified in the scan list.

The commands OPEN, CLOSE, CRESET, and RECALL have no effect on the scan list although these commands can change the state of particular channels or bits included in the scan list. Conversely, STEP, CHAN and SLIST have no effect on channels closed by CLOSE, or RECALL if those channels do not exist in the scan list.

As an example, executing the following line will specify a scan list that starts with channel or bit 104, followed by 205, 300 through 309 and finally channel or bit 410.

```
OUTPUT 709;"SLIST 104,205,300-309,410"
```

## 3-11 Step

The STEP command is used to sequence through a scan list, opening the previous channel or bit in the list and closing the next. If STEP is executed and no scan list exists, the 3488A will generate an execution error; ERR 2.

As an example, line 10 of the following program sets up a scan list for channels or bits 00 through 09 on the card in slot number 1. Lines 20 and 40 establish a for/next loop which, in this case, will cycle through line 30 ten times. Line 30 executes the STEP command which will increment through the scan list one channel or bit at a time.

```
10 OUTPUT 709;"SLIST100-109"
20 FOR I=1 TO 10
30 OUTPUT 709;"STEP"
40 NEXT I
```

## 3-12 Channel

CHAN [<ch. address>]

The CHAN command opens the last channel or bit closed by either the STEP command or the CHAN command and close the specified channel or bit. If no channel or bit is specified with CHAN, the 3488A will display or output to the interface the number of the last channel or bit closed by either STEP or CHAN. If no channel or bit has been closed since the last reset, executing the CHAN command will return the number 0.

As an example, executing the following line will open any channel or bit previously closed by CHAN or STEP and will close channel or bit 105.

OUTPUT 709;"CHAN 105"

## 3-13 System Read (RO)

SREAD <slot><register>

The SREAD command allows any register on the Breadboard Card (44474A) to be read. The <slot><register> specifier is a three-digit number where the slot and register specifiers are each one digit and are separated by a 0 (e.g., 405 corresponds to register 5 on the card in slot 4). The only error checks that are performed are on the slot number (must be 1 through 5) and the register number (must be 0 through 7). Reading a non-existent register will cause the instrument to respond with the value 255 which is the result of reading a floating data bus.

## 3-14 System Write (RO)

SWRITE <slot><register>,<8-bit data>

This command allows the user to write to any register on the Breadboard card (44475A). This command is subject to the same range-checking as discussed in the SREAD discussion above. Writing to a non-existent register is allowed — the data will be written to the backplane.

## 3-15 DIGITAL I/O CARD COMMANDS

The following commands apply only to the 44474A Digital I/O card.

## 3-16 Digital Mode

DMODE <slot>[,<mode>][,<polarity>][,<EI>]

The digital mode command is used to establish the handshake mode and polarity of the 44474A Digital I/O Card. It is also used to enable the External Increment and Channel Closed control line functions. The mode and polarity specifiers are shown in Table 3-3.

The External Increment and Channel Closed lines are enabled by a 1 in the EI specifier. They are disabled with an EI specifier of 0.

The contents of the DMODE register can be read by deleting the parameters and executing only: DMODE <slot>.

At power on, any 44474A Digital I/O cards will revert to the default static mode with high true logic levels on all data and control lines and with the External Increment and Channel Closed lines disabled.

**Table 3-3 Mode and Polarity Specifiers**

| MODE TYPE | VALUE |
|---|---|
| Static 1 | 1 |
| Static 2 | 2 |
| R/W & Strobe | 3 |
| Read & Write Strobe | 4 |
| Handshake (no ext. incr.) | 5 |
| **POLARITY** | **VALUE** |
| Lower Byte | 1 = low true |
| Upper Byte | 2 = low true |
| PCTL Line | 4 = low ready |
| PFLG Line | 8 = low ready |
| I/O direction line | 16 = low input mode |

As an example of the DMODE command, executing the following line will place the Digital I/O card in slot 1 in the static 2 mode, with positive true logic (0), and EI/CC enabled (1).

OUTPUT 709;"DMODE1,2,0,1"

## 3-17 Digital Write

DWRITE <slot><port>, <data>[,<data>]...

The Digital Write command establishes the port configuration of the 44474A Digital I/O card and writes data to a port. The port configuration is determined by the two digit number following the slot address in the Digital Write command. The port configurations are; port 00 — the low order eight bit byte (LO BYTE), port 01 — the high order eight bit byte (HI BYTE), and port 02 — the entire 16 bit word.

When writing to either of the 8-bit ports (port 00 or 01), the decimal value of the data must be between 0 and 255. When writing to the 16-bit port (port 02) the data must be between -32768 and +32767. Positive decimal values are written in standard binary format. Negative decimal values are written in 2's complement format.

As an example of writing to an 8-bit port, executing the following line will cause the decimal value 124 to be written to the HI BYTE.

OUTPUT 715; "DWRITE 501,124"

As an example of writing to the 16-bit port, executing the following line will write the decimal value 24561.

OUTPUT 715; "DWRITE 502,24561"

## 3-18 Digital Read

DREAD <slot><port>[,# of times to read]

The Digital Read command reads the current status of the 44474A ports designated as inputs. The decimal value read back is equal to the sum of the weighted values of the bits that are set. Refer to the Digital Write command for an explanation of the port specifier.

When in static mode 1 (see DMODE, Section 3-16), the Digital Read command reads the data being input to the data lines. When in static mode 2, the Digital Read command reads the data line outputs.

When reading an 8-bit port, the value read back will be between 0 and 255. When reading the 16-bit port, the value read back will be between -32768 and +32767.

If no value is specified for the number of readings, the specified port will be read only once. The maximum number of times a port can be read with one DREAD command is 32767. The 3488A must be in the overlap mode (see Section 3-35) in order to perform multiple readings.

As an example of the DREAD command, executing the following line will read the low order 8-bit port (on the 44474A card in slot 5) 10 times.

OUTPUT 709;"DREAD 500,10"

## 3-19 Delay

DELAY [<time in milliseconds>]

The DELAY command inserts a delay between the time that a channel is closed and the time that the next command is executed or the Channel Closed pulse is generated. This command is executed immediately after executing a CHAN or STEP command. The delay time may be specified from 0 to 32,767ms (32.767 seconds) in 1ms increments.

When the Channel Closed line is enabled (refer to Digital Mode, Section 3-16), the 44474A card will output a TTL-compatible pulse on this line immediately after a channel (on another card) or a bit has been closed. This is true whether the channel or bit was closed by the STEP or CHAN command, the interface TRIGGER command, or by the External Increment line.

If no time value is specified in the DELAY command, the 3488A will respond by displaying the current value of the delay time.

As an example, executing the following line will initiate a delay of 45ms (.045 seconds).

OUTPUT 715;"DELAY 45"

## 3-20 Digital Binary Write (RO)

DBW <slot><port>,#I<block data>

When the DBW command is received, the 3488A will interpret the data bytes that follow as a block of binary data. This data will be output according to the format setup for that card by the slot/port and the DMODE command. In 16-bit mode (port 2), the incoming data is interpreted as being most significant byte first. The transfer is completed by setting the HP-IB EOI line true at the same time as the last byte of data is transferred.

As an example, line 30 of the following program sets EOI true concurrent with the final character transfer. It is important to remember that the EOI formatting (line 30) varies according to the computer used. The program shown works only on an HP series-80 computer. Line 40 contains the commands that will be sent to the 3488A. In this example, the ASCII values of A and B will be written to port 2 of the 44474A card in slot 5.

```
10 DIM A$[40]
20 IOBUFFER A$
30 CONTROL 7,16;128
40 A$="DBW 502,#IAB"
50 TRANSFER A$ TO 709 FHS
60 END
```

### 3-21 Digital Binary Read (RO)

DBR <slot><port>[,<number of items>]

In binary digital read mode, data items are read and output according to the format setup for the specified card by the slot/port and the DMODE command. If the 16-bit mode is specified, the data is sent most significant byte first. The data transfer is terminated by setting the HP-IB EOI line true concurrently with the last byte of data output. The maximum number of data items that may be specified by this command is 32,767. If more than one data item is specified, the 3488A must be in the overlap mode (see Section 3-35).

As an example, lines 30 and 40 of the following program reads port 2 of the 44474A card in slot 5. Line 50 uses the image specifiers % and K to set EOI true concurrent with the last character transfer. It is important to remember that the EOI formatting (line 50) varies according to the computer used. The program shown works only on an HP series-80 computer.

```
10 DIM A$[40]
20 IOBUFFER A$
30 A$="DBR 502,1"
40 TRANSFER A$ TO 709 FHS
50 ENTER 709 USING "%,K";B$
60 DISP B$
70 END
```

## 3-22 3488A SYSTEM COMMANDS

### 3-23 Reset

The RESET command is used to reset the 3488A to its power-on (default) state. This includes the following sequence:

1. Identify all option cards and reset them (all channels or bits open).

2. Set all parameters to their default conditions.

If RESET is executed from the 3488A's front panel, the 3488A reads the HP-IB address switches to establish the talk and listen addresses.

If RESET is executed from the system computer, the HP-IB interface functions are not affected (i.e., the 3488A remains in the remote mode). If the front panel RESET key is pressed, the interface functions are reset.

The RESET command does not erase stored states (refer to STORE, Section 3-30).

As an example, executing the following line will reset the 3488A.

OUTPUT 709;"RESET"

## 3-24 Test

The Test command causes the 3488A to perform a series of self-tests. When the TEST key is pressed on the 3488A's front panel, the display test and the internal self-tests are performed. The display test turns-on every display segment (with the exception of the top dot on the colons) for the operator's inspection. It is up to the operator to verify proper display operation - no failure message exists for the display test. After the display test, the internal self-tests are performed. If all tests pass, the message "SELF TEST OK" appears in the display. If any tests fail, the message "FAILED nn" is displayed (where nn is the sum of the binary weighted values of the failed tests).

When TEST is executed from the system computer, only the internal tests are performed. The displayed messages indicating whether the tests passed or failed are the same as those described above. The results of the tests can also be read by the system computer — a value of 0 read by the computer indicates that all tests passed. Table 3-4 shows the possible self-test failures and their corresponding binary weighted values.

**Table 3-4 Self-Test Failures**

| FAILURE | WEIGHTED VALUE |
|---|---|
| RAM | 1 |
| ROM | 2 |
| TIMER | 4 |
| HP-IB CHIP | 8 |

As an example, line 10 of the following program initiates a remote self-test in the 3488A. Line 20 reads the numerical results of the tests, and line 30 displays those results.

```
10 OUTPUT 709;"TEST"
20 ENTER 709;A
30 DISP A
```

## 3-25 Local (LO)

This front panel key returns the 3488A to local operation. This causes any pending remote operations to be aborted. In addition, this command will reactivate the display if it has been turned off (see Display On/Off, Section 3-39).

## 3-26 Address (LO)

This front panel key causes the 3488A's address switch settings to be read and displayed and the address register to be updated. It is important to note that the 3488A will not automatically update its address register whenever the rear panel address switch settings are changed. This register will only be updated following a front panel RESET or ADDRESS command or when power is cycled to the 3488A.

## 3-27 Service Request (LO)

This front panel key asserts an SRQ over the HP-IB bus if the SRQ function is enabled (see MASK, Section 3-34). This key is active even when the 3488A is in the remote mode of operation.

## 3-28 Identify (RO)

If the 3488A is addressed to talk after receiving the ID? command, it will output the string "HP3488A". This allows the HP-IB address of the 3488A to be remotely identified.

As an example, line 10 of the following program will send the ID? command to the device at address 709. Line 20 reads the response of the unknown device. If the device is a 3488A, line 30 will display HP3488A.

```
10 OUTPUT 709;"ID?"
20 ENTER 709; A$
30 DISP A$
```

## 3-29 Status

The STATUS command reads the 3488A's status byte. The STATUS command returns a decimal value which is the sum of the binary weighted values of the individual bits that are set (condition is true).

Bits 0, 2, and 3 will be cleared after the STATUS command is executed. Bit 1 will be cleared only after the data is read from the 3488A, new data is requested, or the 3488A is reset. The Ready for Instructions bit (bit 4) will be cleared whenever the 3488A is busy executing instructions. For this reason, bit 4 will always be clear when STATUS is executed. The SPOLL command should be used to determine when the 3488A is ready for instructions. The Error bit (bit 5) will only be cleared after the Error Register is read. Bit 6, RQS, will be cleared after a STATUS command if the condition that caused bit 6 to be set is cleared. Table 3-5 shows the various bits of the status byte and their corresponding descriptions and binary weighted values.

**Table 3-5 Status Byte Values**

| BIT | WEIGHTED VALUE | DEFINITION |
|---|---|---|
| 0 | 1 | End of scan sequence |
| 1 | 2 | Output available |
| 2 | 4 | Power-on SRQ asserted |
| 3 | 8 | Front panel SRQ key pressed |
| 4 | 16 | Ready for instructions |
| 5 | 32 | Error |
| 6 | 64 | RQS |
| 7 | 128 | Not used (always 0) |

As an example, line 10 of the following program will read the 3488A's status byte. Line 20 enters that reading into the computer. Line 30 displays the reading.

```
10 OUTPUT 709; "STATUS"
20 ENTER 709; A
30 DISP A
```

## 3-30 Store

STORE <register number 1 to 40>

The STORE command is used to record the current state of the 3488A and any plug-in cards it contains (closed channels, static digital output states, etc.). The state is stored in the register number specified in the command. The stored setup can be used to easily return the 3488A to a particular state and it can be used as part of a scan list.

The states of 44474A Digital I/O cards that are not in the static mode will be ignored.

Resetting the 3488A does not affect stored setups.

As an example of storing a state, executing the following line will close channels or bits 3 and 5 in slot 1 and channels or bits 3, 4 and 5 in slot 2. After closing these channels, the state of the 3488A will be stored in register 25. The state can be recalled by using the RECALL command (see Section 3-31).

```
OUTPUT 709;"CLOSE 103,105,203,204,205;STORE 25"
```

## 3-31 Recall

RECALL <register number 1 to 40>

Once a setup has been stored, the RECALL command can be used to re-initiate that setup. When a stored state is recalled, the 3488A reconfigures itself, one slot at a time, beginning with slot 1 channel or bit 00. Only the states of channels and static digital outputs are recalled.

If no state has been stored in the recalled register, an error will result and the 3488A will send a Service Request if SRQ is enabled (see MASK, Section 3-34). In this situation, the 3488A will remain in its previous state.

As an example of the RECALL command, executing the following line will recall the contents of register number 25.

```
OUTPUT 709;"RECALL 25"
```

## 3-32 Error

The ERROR command allows the 3488As error register to be read. The decimal value read is equal to the sum of the binary weighted values of the error conditions as defined in Table 3-6.

As an example, line 10 in the following program reads the 3488A's error register. Line 20 enters the error register value into a variable in the computer. Line 30 displays the value.

```
10 OUTPUT 709;"ERROR"
20 ENTER 709;A
30 DISP A
```

**Table 3-6 Error Conditions**

| WEIGHTED VALUE | ERROR CONDITION |
|---|---|
| 1 | Syntax Error |
| 2 | Execution Error<br>possible meanings include:<br>a. Parameter out of range<br>b. Card type mismatch<br>c. Attempt to access a nonexistent stored state or scan list |
| 4 | Hardware Trigger Too Fast |
| 8 | Logic Failure |
| 16 | Power Supply Failure |

## 3-33 Revison (RO)

REV

This command outputs the current ROM revision date using a four-digit code. The first two digits specify the year or the latest update minus 60 (since this coding scheme was introduced in 1960), and the next two digits specify the week of the update. Thus, the code for ROM's updated in week 34 of 1983 would be 2334.

As an example, line 10 of the following program reads the current ROM code. Line 20 inputs that code into the computer and line 30 displays the code.

```
10 OUTPUT 709"REV"
20 ENTER 709;A
30 DISP A
```

## 3-34 Mask

MASK <decimal value>

The MASK command allows the SRQ mask to be set for various conditions. The decimal value loaded into the mask is equal to the sum of the binary weighted values of the condition that will cause an SRQ interrupt. The possible conditions and their corresponding binary weighted values are shown in Table 3-7.

**Table 3-7 SRQ Mask**

| MASK BIT | WEIGHTED VALUE | DESCRIPTION |
|---|---|---|
| 0 | 1 | End of scan sequence |
| 1 | 2 | Output available |
| 2 | 4 | Power-on SRQ true |
| 3 | 8 | Front panel SRQ key pressed |
| 4 | 16 | Ready for instructions |
| 5 | 32 | Error |
| 6 | 64 | RQS (request service) |
| 7 | 128 | Not used |

If no value is included with the MASK command, the 3488A will display or output to the computer the current value of its SRQ mask.

As an example, executing the following line will set the mask enabling the front panel SRQ key function.

OUTPUT 709;"MASK 8"

## 3-35 Overlap (RO)

OLAP <1 or 0>

In the overlap disabled mode (default, OLAP 0), the 3488A holds up HP-IB I/O communications while it processes received messages. If overlap is enabled, (OLAP 1), the 3488A will release the HP-IB as soon as the command message is received. Overlap enabled allows faster I/O throughput but does not guarantee sequential operation of other devices on the bus (as normally occurs when overlap is disabled). When overlap is enabled, the user should monitor bit 4 in the 3488A's status register (using the serial poll command) to help ensure sequential operation of other instruments on the HP-IB interface.

The overlap function only applies to commands received by the 3488A, not to data sent by the 3488A. The 3488A must be in the overlap mode in order to perform multiple readings using the DREAD and DBR commands.

## 3-36 Error Halt (RO)

EHALT <0 or 1>

This command is used to enable (EHALT 1) the stop-on-error mode of the 3488A. When in this mode, the 3488A will lock-up the HP-IB interface whenever it discovers that an error has occurred (see ERROR, Section 3-32).

**NOTE**

*Once the HP-IB has locked-up the user must press the local key followed by the reset key or cycle power to the 3488A. The computer and the HP-IB interface must also be reset.*

The default error condition (EHALT 0) allows normal HP-IB communication following an error.

## 3-37 DISPLAY AND KEYBOARD COMMANDS

## 3-38 Display (RO)

DISP <ASCII character string>

The DISP command allows messages up to 127 characters long to be written to the 3488A's display. Any characters in excess of 127 will be discarded. Any printable ASCII character (decimal value of 32 and greater) can be displayed except for colons (:), semicolons (;), pound signs (#), line feeds (lf), and carriage returns (cr) which will cause errors. Quotation marks within the ASCII string are ignored.

### 3-39 Display On/Off (RO)

The DOFF command allows the 3488A display to be disabled. This allows the 3488A to operate faster since it no longer needs to update the display. After DOFF has been executed, the display will show a series of hyphens and will eventually turn off. The hyphen series may stay in the display for as long as 15 minutes before the display actually clears.

The display can be re-enabled by executing the DON command or by pressing the LOCAL key.

The DON command also can be used to clear the display from remote.

### 3-40 Key Mode (RO)

When in the key mode the 3488A displays the term "KEY:" and scans the front panel keyboard matrix in search of a key closure. When a key is pressed, the 3488A sends a two-digit code to its display and to its output buffer. The first digit corresponds to the row and the second digit corresponds to the column of the key closure. To prevent a potential interface hangup, the user should monitor the Output Available bit in the status register (using the serial poll command) to determine when a key has been closed. The 3488A will not read a new key closure until the previous closure has been read by the controller.

### 3-41 Lockout (RO)

The LOCK command is equivalent to sending the local lockout command from the computer. Locking out the keyboard prevents the keyboard from being scanned thus permitting faster operation.

## 3-42 INTERFACE DEFINED COMMANDS

The 3488A will respond to the following HP-IB commands.

### 3-43 Group Execute Trigger

The GET command is interpreted as a STEP command by the 3488A (see STEP, Section 3-11).

### 3-44 Device Clear

The DCL and SDC commands are interpreted as a RESET command by the 3488A.

# Chapter IV

# OPERATION VERIFICATION

# CHAPTER IV

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF ILLUSTRATIONS

# CHAPTER IV
# OPERATION VERIFICATION

## 4-1 INTRODUCTION

Properly executing the following Operation Verification Tests will provide a high confidence level (approximately 90%) that the 3488A and its associated plug-in cards are operating within their published specifications.

The primary purpose of these tests is to provide a relatively fast and easy method to determine the operability of the 3488A and any plug-in cards it may contain (with the exception of the 44475A Breadboard card, for which there are no tests).

**NOTE**

*A more in-depth, higher confidence level procedure for testing an individual plug-in card can be found in that card's chapter of this manual.*

A secondary purpose of the Operation Verification Tests is to serve as the "main directory" to the 3488A service documentation. The test results will direct the user to the appropriate supplemental service documentation - whether that be troubleshooting information or merely more extensive specification testing.

## 4-2 GENERAL INFORMATION

The Operation Verification Tests should be performed whenever it is desired to determine whether the 3488A and its plug-in cards are actually operating. For example, these tests can be used as an "incoming inspection procedure" when the 3488A Switch/Control Unit is initially received, or they can be used to verify a suspected failure after the unit has been installed into the system. Additionally, after a failure has been detected and repaired, these tests can be used to confirm that the repairs have accomplished their purpose. Whatever the case, the Operation Verification Tests must always be performed prior to conducting any of the plug-in card performance tests (located in Chapters 8, 9, 10, 11, and 12).

A "test fixture" is required for each plug-in card (with the exception of the VHF Switch card) to simplify testing and to act as an interface between the card and a multimeter. This fixture can be either of the following two types:

a. A test fixture is available from Hewlett-Packard as an accessory to the 3488A (HP part number 03488-66501). This fixture can be used to test any of the four plug-in cards (one card at a time) that require a test fixture.

b. A test fixture can be made for each plug-in card using a removable wiring block configured as described in the appropriate card's Test Fixture section. This method requires that a separate test fixture be configured for each type of plug-in card to be tested.

The procedures in this section are written to be compatible with either type of test fixture.

## 4-3 EQUIPMENT REQUIRED

Digital Multimeter - Hewlett Packard 3478A or equivalent

Test Fixture (refer to Section 4-2)

Computer - Hewlett Packard Series-80

HP-IB Interface - Hewlett Packard 82937A

## 4-4 OPERATION VERIFICATION TESTS

The Operation Verification Tests are divided into the following seven subsections:

Mainframe Self-Test, Section 4-5

HP-IB Test, Section 4-7

44470A 10 Channel Multiplexer Tests, Section 4-13

44471A 10 Channel General Purpose Card Test, Section 4-14

44472A Dual 4 Channel VHF Switch Card Test, Section 4-16

44473A 4x4 Matrix Switch Card Test, Section 4-18

44474A 16 Channel Digital I/O Card Tests, Section 4-20

Always perform the mainframe self-test (Section 4-5) and the HP-IB test (Section 4-7) before performing any of the remaining plug-in card tests. Doing so will ensure the most comprehensive approach toward isolating a problem — should a problem exist.

## 4-5 Mainframe Self-Test

The mainframe self-test verifies the operation of the display circuitry and a large part of the micro-processor related circuitry (RAM, ROM, etc) on the Controller pc board. It does not, however, assess the operability of the backplane or the drivers contained in the mainframe. The operability of the backplane and drivers will not be tested until the individual plug-in card tests are performed.

It is important to remember that if the self-test passes, it does not, in itself, ensure proper instrument operation. A self-test failure, however, does indicate an instrument malfunction.

1. Use the 3488A's front panel keys to initiate a self-test as follows:

   a. Press the LOCAL key.

   b. Press the TEST key.

The self-test should start by turning on all display segments (with the exception of the top dot of the colon). Following the display test, the internal tests are performed. If all internal tests pass, SELF TEST OK will be displayed. If a test fails, FAILED nn will be displayed (where nn is the sum of the binary weighted values of the failed tests). For example, a FAILED 05 display indicates that the RAM test (value = 1) and the TIMER test (value = 4) have failed. The self-test failure modes and their corresponding binary weighted values are shown in Table 4-1.

**Table 4-1 Self-Test Failure Modes**

| FAILURE | WEIGHTED VALUE |
|---|---|
| RAM | 1 |
| ROM | 2 |
| TIMER | 4 |
| HP-IB CHIP | 8 |

### 4-6 Corrective Action

If, during the display test, a segment or segments malfunctioned, a problem exists on the Controller pc board or the Display assembly. Refer to Chapter 6 for problem isolation information.

If any of the internal tests failed, the Controller pc board is malfunctioning. Refer to Chapter 6 for problem isolation information.

## 4-7 HP-IB Test

1. Connect the computer and the HP-IB interface to the 3488A.

2. Load and run the following program:

```
10 A=709
20 SET TIMEOUT 7;2000
30 ON TIMEOUT 7 GOTO 370
40 RESET 7
50 OUTPUT A ;"TEST"
60 ENTER A ; B
70 IF B#0 THEN 290
80 OUTPUT A ;"MASK 0"
90 OUTPUT A ;"MASK"
100 ENTER A ; B
110 IF B#0 THEN 350
120 OUTPUT A ;"MASK 128"
130 OUTPUT A ;"MASK"
140 ENTER A ; B
150 IF B#128 THEN 350
160 ON INTR 7 GOTO 220
170 ENABLE INTR 7;8
180 OUTPUT A ;"MASK2"
190 OUTPUT A ;"ID?"
200 WAIT 1000
```

(CONTINUED ON NEXT PAGE)

```
210 GOTO 390
220 OFF INTR 7
230 STATUS 7,1 ; B
240 ENTER A ; A$
250 OUTPUT A ;"STATUS"
260 ENTER A ; B
270 PRINT "HP3488A PASSED HP-IB TEST"
280 END
290 PRINT "HP3488A HAS FAILED;","SELF-TEST"
300 IF BIT(B,0) THEN PRINT "FAIL CODE 1 (RAM)"
310 IF BIT(B,1) THEN PRINT "FAIL CODE 2 (ROM)"
320 IF BIT(B,2) THEN PRINT "FAIL CODE 4 (TIMER)"
330 IF BIT(B,3) THEN PRINT "FAIL CODE 8 (I/O CHIP)"
340 END
350 PRINT "HP3488A HAS FAILED THE SERVICE REQUEST MASK TEST"
360 END
370 PRINT "HP3488A DID NOT RESPOND. HP-IB TIMEOUT ERROR OCCURRED."
380 END
390 PRINT "HP3488A HAS FAILED THE SRQ TEST."
400 END
```

### 4-8 Program Description

Line 10 defines the 3488A's address (the factory preset address,709, is shown).

Lines 20 and 30 set a time limit in which the HP-IB can respond. If no response occurs within 2 seconds, line 370 will print the HP-IB timeout error.

Lines 50 through 70 initiate a remote self-test and read the results. In case of a self-test failure, lines 290 through 330 decode and print the failure information.

Lines 80 through 150 check the service request mask by setting the mask to a certain state, reading the state back, and comparing the two states. A service request mask failure is printed by line 350.

Lines 160 through 260 check the SRQ function. A failure is printed by line 390.

If the remote self-test, the service request mask test, and the SRQ test pass, line 270 prints a message indicating that all of the HP-IB tests have passed.

### 4-9 Corrective Action

If any of the HP-IB tests fail, the HP-IB circuitry on the Controller pc board is malfunctioning (assuming that the computer and HP-IB interface are operating properly). Contact an HP Sales and Service Office for Controller board replacement information.

## 4-10 Keyboard Test

This test takes advantage of the 3488A's keymode feature. When in the keymode, the 3488A displays the term KEY: and scans the front panel keyboard matrix in search of a key closure. After a key is closed, a two digit number will be sent to the 3488A's output buffer and will appear following the term KEY: in the display. The first digit of this number represents the row, and the second digit represents the column of the closed key. Thus, by (1) placing the 3488A in the keymode, (2) pressing the front panel keys and, (3) observing the displayed number, the operation of the keyboard can be tested.

1. Load and run the following computer program:

```
10 OUTPUT 709"KEY1"
20 ENTER 709;A
30 GOTO 20
```

2. Successively press every key on the 3488A's keyboard and verify that the displayed response corresponds to the number shown in Table 4-2.

**Table 4-2 3488A Keyboard Test**

| KEY CLOSURE | DISPLAYED RESPONSE | KEY CLOSURE | DISPLAYED RESPONSE |
|---|---|---|---|
| BACK SPACE | 11 | CARD PAIR | 36 |
| 9 | 12 | STORE | 37 |
| 8 | 13 | VIEW | 38 |
| 7 | 14 | EXEC | 41 |
| WRITE | 15 | – | 42 |
| SCAN LIST | 16 | , | 43 |
| CARD RESET | 17 | 0 | 44 |
| CLOSE | 18 | DELAY | 45 |
| CLEAR DISPLAY | 21 | STEP | 46 |
| 6 | 22 | RECALL | 47 |
| 5 | 23 | CARD MON | 48 |
| 4 | 24 | → | 54 |
| READ | 25 | ← | 51 |
| CHAN | 26 | SYNTAX | 57 |
| CARD TYPE | 27 | TEST | 56 |
| OPEN | 28 | RESET | 58 |
| ERROR REG | 31 | SRQ | 64 |
| 3 | 32 | MASK | 61 |
| 2 | 33 | STATUS | 67 |
| 1 | 34 | ADRS | 66 |
| MODE | 35 | LOCAL | 68 |

3. Use the HP 80-series controller to remove the 3488A from the keymode as follows:

a. Press the PAUSE key (it may be necessary to press one of the 3488A's keys to regain control of the computer).

b. Type: OUTPUT 709 "KEY 0".

c. Press the ENDLINE key.

### 4-11 Corrective Action

If one or more keys failed the above test, a problem exists in either the Keyboard Assembly or the Controller Assembly. Refer to Chapter 6 for problem isolation information.

## 4-12 44470A 10 Channel Multiplexer Test

The 10 Channel Multiplexer contains a 10 channel array of double-pole single-throw (DPST) relays.* Each channel has a low line and a high line which are switched in unison. The test fixture (see Figure 4-1) consists of (1) a short circuit between all of the low lines, (2) a short circuit between all of the high lines, and (3) a short circuit between the two common lines. With the test fixture installed, and an ohmmeter connected between the shorted common lines and either the shorted low lines or the shorted high lines, the card is tested by successively closing each relay while checking for an indication of the closure on the ohmmeter.

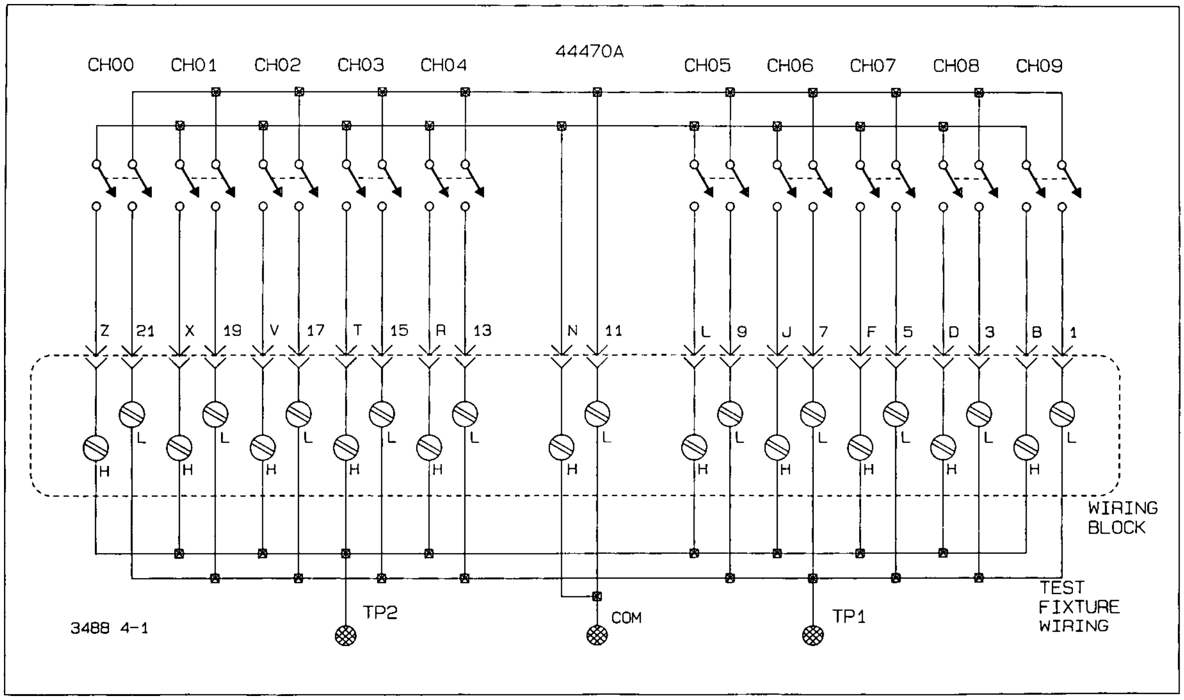



**Figure 4-1 44470A Test Configuration**

**WARNING**

*If the Switch/Control Unit is currently installed in a system, it must be disconnected from the system in the following procedure. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected.*

*The user must take the necessary precautions to prevent the above from happening before disconnecting the wiring or the wiring block.*

* These relays also contain a separate set of "sense contacts" that are used by the 3488A to verify relay states.

1. Remove the wiring block from the 44470A's rear edge connector.

2. Install the test fixture onto the 44470A's rear edge connector.

**NOTE**

*If the HP 03488-66501 test fixture is being used, set its switch to the 1 position.*

3. Set the multimeter to measure ohms. ''Zero'' the multimeter.

4. Using the 3488A's front panel keys, specify the card monitor mode and the scan list as follows:

a. Press the LOCAL key.

b. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the card under test.

c. Press the EXECUTE key.

d. Press the SCAN LIST key followed by X00-X09 (where X is the slot occupied by the card under test and 00-09 are the relays to be scanned).

e. Press the EXECUTE key.

5. LOW LINES TEST: Connect the multimeter between the COM terminal and the TP1 terminal on the test fixture.

6. Using the 3488A's front panel keys, reset the 44470A as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44470A.

b. Press the EXECUTE key.

The multimeter should indicate that all relays are open (very high resistance or overload indication).

**NOTE**

*If the multimeter is indicating a very low resistance, one or more of the relays is remaining closed. In this situation, the 3488A should generate an error condition (ERR 8: LOGIC) signifying that one or more of its relay sense lines is closed. Refer to Chapter 6 for problem isolation information.*

7. Successively press the STEP key while observing the displays on the 3488A and the multimeter. The 3488A's display should show a number corresponding to the closed relay. This number will be incremented one digit every time the step key is pressed (one full cycle starts at 0 and ends at 9). The multimeter should display a resistance reading of less than 2 ohms for each relay.

**NOTE**

*The 3488A will generate an error condition (ERR 8: LOGIC) if one or more of its sense contacts is indicating that an improper relay state exists during the execution of the scan list.*

8. LOW LINES TEST: Connect the multimeter between the COM terminal and the TP2 terminal on the test fixture. Repeat steps 6 and 7.

### 4-13 Corrective Action

a. If during step 7, one or more relays did not close as described, a problem exists either in the mainframe or the 44470A. Refer to Chapter 6 for problem isolation information.

b. If during step 7, the appropriate relays closed, but one or more of the resistances was greater than 2 ohms, the corresponding relay(s) are failing. Refer to Chapter 8 for relay replacement information.

If the above test passed, and further specification testing is desired, refer to the 44470A Performance Tests in Chapter 8.

## 4-14 44471A General Purpose Card Test

The General Purpose Relay Card contains a 10 channel array of single-pole single-throw (SPST) relays.* The test fixture (see Figure 4-2) short circuits all of the inputs together and short circuits all of the outputs together. Thus, by connecting an ohmmeter between the shorted inputs and the shorted outputs, the card is tested by successively closing each relay while checking for an indication of the closure on the ohmmeter.

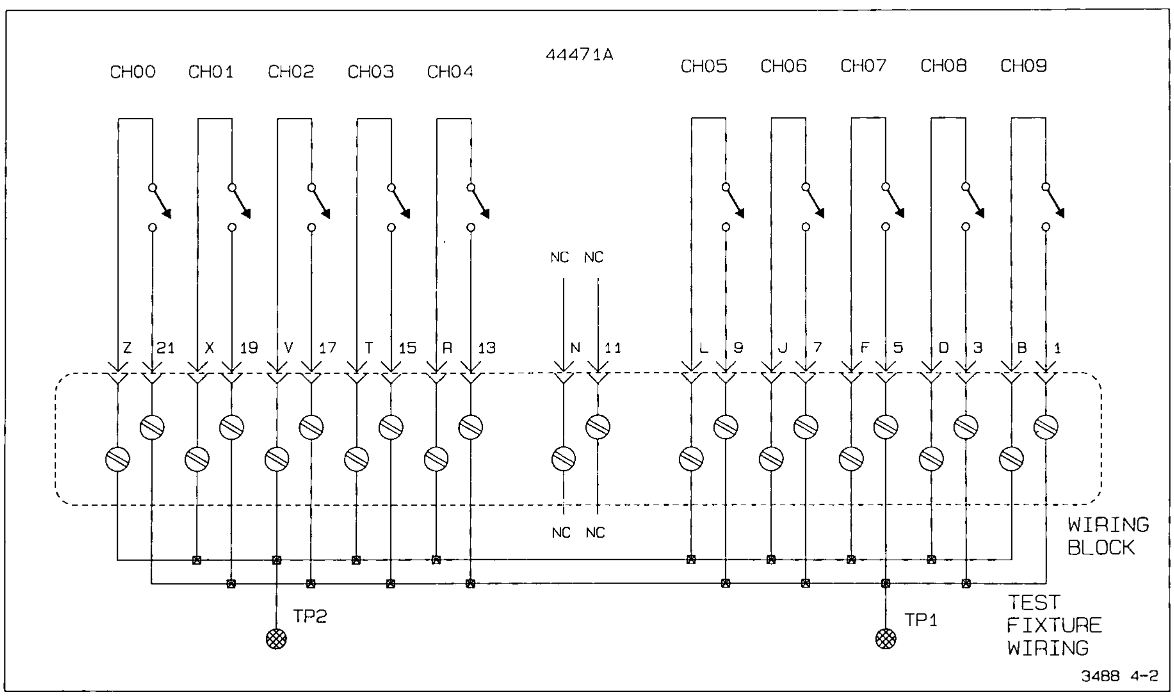



**Figure 4-2 44471A Test Configuration**

* These relays also contain a separate set of "sense contacts" that are used by the 3488A to verify relay states.

**WARNING**

*If the Switch/Control Unit is currently installed in a system, it must be disconnected from the system in the following procedure. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected.*

*The user must take the necessary precautions to prevent the above from happening before disconnecting the wiring or the wiring block.*

1. Remove the wiring block from the 44471A's rear edge connector.

2. Install the test fixture onto the 44471A's rear edge connector.

**NOTE**

*If the HP 03488-66501 test fixture is being used, its switch must be set to the 1 position.*

3. Set the multimeter to measure ohms. ''Zero'' the multimeter. Connect the multimeter between the TP1 terminal and the TP2 terminal on the test fixture.

4. Using the 3488A's front panel keys, reset the 44471A as follows:

a. Press the LOCAL key.

b. Press the CARD RESET key followed by the numeral key (1-5) corresponding to the slot occupied by the 44471A.

c. Press the EXECUTE key.

The multimeter should indicate that all relays are open (very high resistance or an overload indication).

**NOTE**

*If the multimeter is indicating a very low resistance, one or more of the relays is remaining closed. In this situation, the 3488A should generate an error condition (ERR 8: LOGIC) signifying that one or more of its relay sense lines is closed. Refer to Chapter 6 for problem isolation information.*

5. Using the 3488A's front panel, specify card monitor mode and the scan list as follows:

a. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the card under test.

b. Press the EXECUTE key.

c. Press the SCAN LIST key followed by X00-X09 (where X is the slot occupied by the card under test and 00-09 are the relays to be scanned).

d. Press the EXECUTE key.

6. Successively press the STEP key while observing the displays on the 3488A and the multimeter. The 3488A's display should show a number corresponding to the closed relay. This number will be incremented one digit every time the step key is pressed (starting at 0 and incrementing up to 9). The multimeter should display a resistance reading of less than 2 ohms for each relay.

**NOTE**

*The 3488A will generate an error condition (ERR 8:LOGIC) if one or more of its sense contacts is indicating an improper relay state during execution of the scan list.*

### 4-15 Corrective Action

a. If during step 6, one or more relays did not open or close as described, a problem exists either in the mainframe or the 44471A. Refer to Chapter 6 for problem isolation information.

b. If during step 6, the relays closed as described, but one or more of the resistances was greater than 2 ohms, the corresponding relay(s) are failing. Refer to Chapter 9 for relay replacement information.

If the preceding test passed, and further specification testing is desired, refer to the 44471A Performance Tests in Chapter 9.

## 4-16 44472A VHF Switch Card Test

The VHF Switch Card consists of two 4 channel to 1 channel multiplexers with BNC connections. Only the center conductor of each channel is switched. The outer conductors (shield) of all channels in a particular multiplexer are connected together and unswitched. Each channel is tested by (1) connecting an ohmmeter between the center conductor of the common connector and the center conductor of the channel to be tested, (2) closing the channel, and (3) checking for the indication of the closure on the ohmmeter. This process is repeated until all channels of both multiplexers have been tested.

**WARNING**

*If the Switch/Control Unit is currently installed in a system, it must be disconnected from the system in the following procedure. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected.*

*The user should take the necessary precautions to prevent the above from happening before disconnecting any wiring.*

1. Remove any external wiring from the rear of the 44472A.

2. Set the multimeter to measure ohms. "Zero" the multimeter.

3. Using the 3488A front panel keys, reset the 44472A, establish the card monitor mode, and setup a scan list as follows:

a. Press the LOCAL key.

b. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44472A.

c. Press the EXECUTE key.

d. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the 44472A.

e. Press the EXECUTE key.

f. Press the SCAN LIST key followed by X00-X13 (where X is the slot occupied by the card under test and 00 through 13 are the channels to be scanned).

g. Press the EXECUTE key.

4. MULTIPLEXER #0 TEST: Connect the multimeter between the center conductor of the COM 0 connector and the center conductor of the channel under test (channel 00 to start). The multimeter should indicate that the channel is open (very high resistance or an overload indication).

**NOTE**

*If the multimeter is indicating a very low resistance, the channel is remaining closed for some reason. Refer to Chapter 6 for problem isolation informaltion.*

5. Press the STEP key. The multimeter should display a resistance reading of less than 1 ohm.

6. Repeat steps 4 and 5 for channels 01, 02, and 03.

7. Use the 3488A front panel keys to reset the 44472A as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44472A.

b. Press the EXECUTE key.

8. MULTIPLEXER #1 TEST: Connect the multimeter between the center conductor of the COM 1 connector and the center conductor of the channel under test (channel 10 to start). The multimeter should indicate that the channel is open (very high resistance).

NOTE

*If the multimer is indicating a very low resistance, the channel is remaining closed for some reason. Refer to Chapter 6 for problem isolation information.*

9. Press the STEP key until the channel under test appears in the 3488A's display. The multimeter should display a resistance reading of less than 1 ohm.

10. Repeat steps 8 and 9 for channels 11, 12, and 13.

### 4-17 Corrective Action

a. If during steps 5 or 9, one or more channels did not close as described, a problem exists in either the mainframe or the 44472A plug-in card. Refer to Chapter 6 for problem isolation information.

b. If during steps 5 or 9, the channels closed but one or more of the resistances was greater than 1 ohm, the relays in the corresponding channel(s) are failing. Refer to Chapter 10 for relay replacement information.

If the preceding test passed, and further specification testing is desired, refer to the 44472A Performance Tests in Chapter 10.

## 4-18 44473A Matrix Card Test

The Matrix Card consists of 16 double-pole single-throw (DPST) relays arranged in a 4 channel by 4 channel switching matrix.* As shown in Figure 4-3, each channel has a low line and a high line which are switched in unison. The test fixture (see Figure 4-3) consists of (1) a short circuit between all of the low line inputs, (2) a short circuit between all of the low line outputs, (3) a short circuit between all of the high line inputs, and (4) a short circuit between all of the high line outputs. With the test fixture installed, and an ohmmeter connected between the inputs and outputs of either the low lines or high lines, the card is tested by successively closing each relay while checking for the indication of a closure with the ohmmeter.

**WARNING**

*If the Switch/Control Unit is currently installed in a system, it must be disconnected from the system in the following procedures. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected.*

*The user should take the necessary precautions to prevent the above from happening before disconnecting the wiring or the wiring block.*

* These relays also contain a separate set of "sense contacts" that are used by the 3488A to verify relay states.

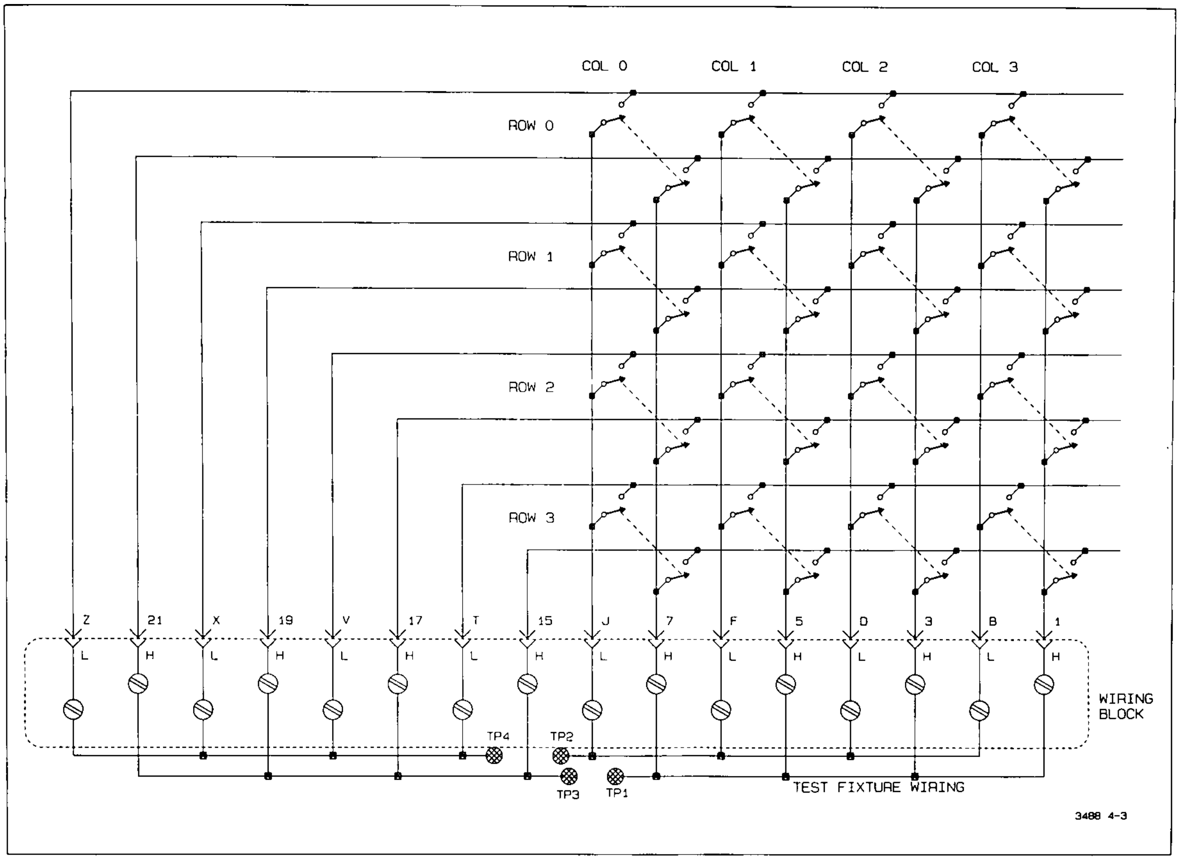



**Figure 4-3 Matrix Card Test Configuration**

1. Remove the wiring block from the 44473A's rear edge connector.

2. Install the test fixture onto the 44473A's rear edge connector.

**NOTE**

*If the HP 03488-66501 test fixture is being used, set its switch to the 0 position.*

3. Set the multimeter to measure ohms. "Zero" the multimeter.

4. Using the 3488A's front panel, reset the 44473A as follows:

a. Press the LOCAL key.

b. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44473A.

c. Press the EXECUTE key.

5. LOW LINES TEST: Connect the multimeter between the TP2 terminal and the TP4 terminal on the test fixture. The multimeter should indicate that all relays are open (very high resistance or overload indication).

**NOTE**

*If the multimeter is indicating a very low resistance, one or more of the relays is remaining closed. In this situation, the 3488A should generate an error condition (ERR 8: LOGIC) signifying that one or more of its relay sense lines is closed. Refer to Chapter 6 for problem isolation information.*

6. Using the 3488A's front panel keys, place the 3488A in the card monitor mode and specify the scan list as follows:

a. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the card under test.

b. Press the EXECUTE key.

c. Press the SCAN LIST key followed by X00-X33 (where X is the slot occupied by the card under test).

d. Press the EXECUTE key.

7. Successively press the STEP key while observing the displays on the 3488A and the multimeter. The 3488A's display should show a two digit number corresponding to the closed relay. The first digit indicates the row and the second digit indicates the column of the relay matrix. The column digit will be incremented by one every time the STEP key is pressed (starting at 0 and ending at 3). After stepping through every column in a row, the column digit will reset to 0 and the row digit will be incremented by one (starting at 0 and ending at 3). Thus, every relay in the matrix can be checked by repeatedly pressing the STEP key. The multimeter should display a resistance reading of less than 3 ohms for each relay.

**NOTE**

*The 3488A will generate an error condition (ERR 8: LOGIC) if one or more of its sense contacts indicate an improper relay state during the execution of the scan list.*

8. Use the 3488A front panel keys to reset the 44473A as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44473A.

b. Press the EXECUTE key.

9. HIGH LINES TEST: Connect the multimeter between the TP1 terminal and the TP3 terminal on the test fixture. The multimeter should indicate that all relays are open (infinite resistance).

**NOTE**

*If the multimeter is indicating a very low resistance, one or more of the relays is remaining closed for some reason. Refer to Chapter 6 for problem isolation information.*

10. Successively press the STEP key while observing the displays on the 3488A and the multimeter (as was done in step 7). The 3488A's display should show a number corresponding to the closed relay. The multimeter should display a resistance reading of less than 3 ohms for each relay.

#### 4-19 Corrective Action

a. If during steps 7 or 10, one or more relays did not open or close as described, a problem exists either in the mainframe or the 44473A. Refer to Chapter 6 for problem isolation information.

b. If during steps 7 or 10, the relays closed as described but one or more of the resistances was greater than 3 ohms, the corresponding relay(s) are failing. Refer to Chapter 11 for relay replacement information.

If the preceding test passed, and further specification testing is desired, refer to the 44473A Performance Tests in Chapter 11.

### 4-20 44474A Digital I/O Card Tests

The 44474A Digital I/O card is made up of 16 bidirectional data lines and 4 control lines. The test for this card consists of (1) a data line input/output test, (2) a Channel Closed/External Increment test, and (3) an IO/WR and PCTL/RD line test. The first test uses the test fixture to connect the eight LO BYTE data lines to the eight HI BYTE data lines. Thus, by writing to one set of data lines and reading the data from the other set, the operation of the data lines and the continuity of the fuses and connectors can be verified. The second test uses the test fixture to connect the CHAN CLOSED line to the PFLG/EXT INC line. This test relys on the self-triggering action of these lines to continuously advance through a scan list - thereby testing the lines. The third test checks the operation of the IO/WR and PCTL/RD control lines by individually connecting each line to a dc voltmeter, using the 3488A front panel keys to change the state of the line, and verifying the state change on the voltmeter.

**NOTE**

*Whenever the term X is encountered in the following steps, it must be replaced by the number corresponding to the 3488A slot occupied by the 44474A.*

1. INPUT AND OUTPUT TESTS: Install the test fixture onto the 44474A's rear edge connector.

2. Reset the 44474A as follows:

a. Press the LOCAL key.

b. Press the CARD RESET key followed by X.

c. Press the EXECUTE key.

3. Write a binary 10101010 to the LO BYTE (in order to open every other line) as follows:

a. Press the WRITE key followed by X00,170.

b. Press the EXECUTE key.

4. Verify that the data has been transferred to the HI BYTE as follows:

a. Press the READ key followed by X01.

b. Press the EXECUTE key.

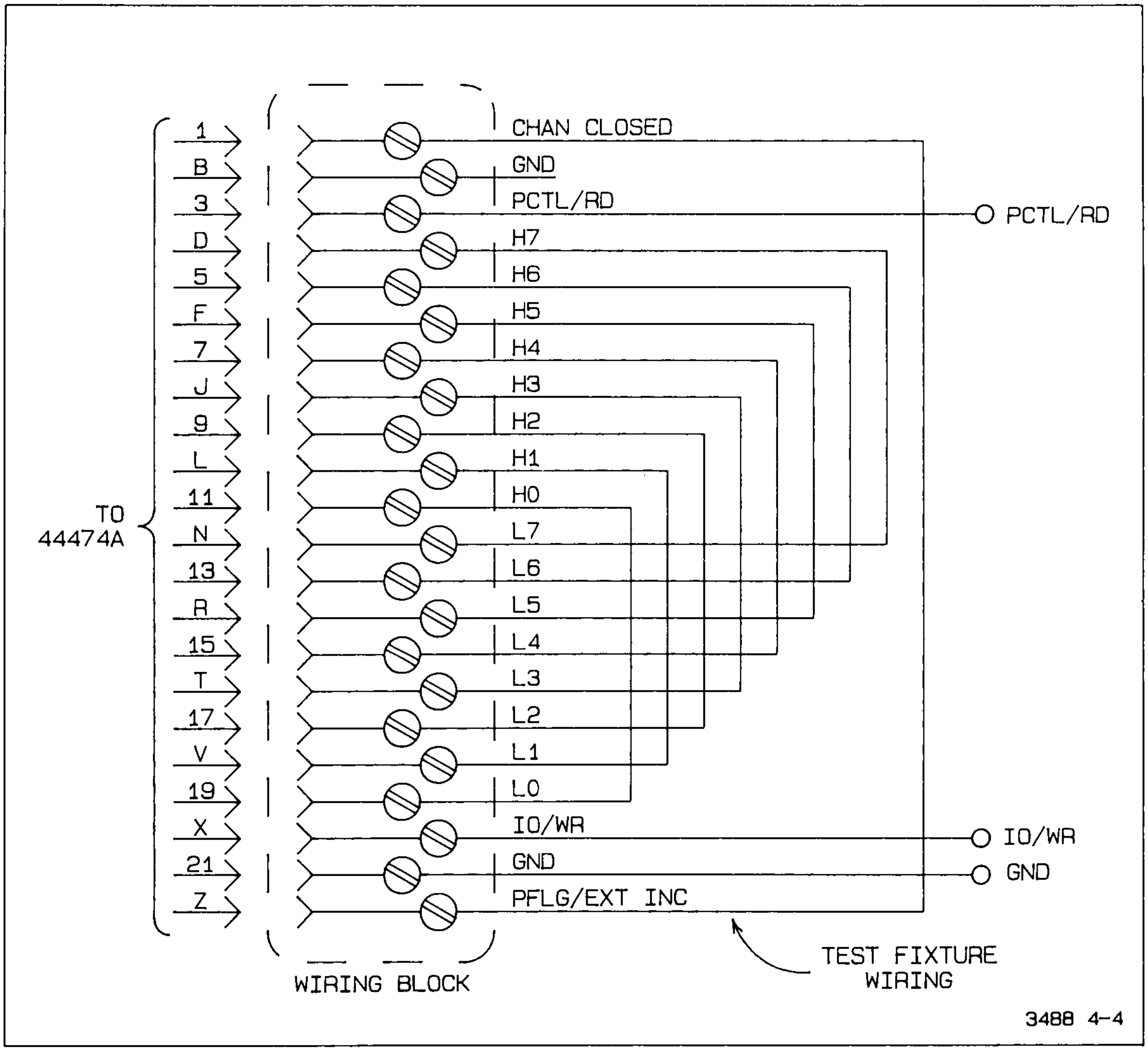



**Figure 4-4 44474A Test Fixture**

The 3488A display should read +00170 (a binary 10101010). If it does not, refer to Chapter 6 for problem isolation information.

5. Write a binary 01010101 to the LO BYTE (in order to open every other line) as follows:

a. Press the WRITE key followed by X00,85.

b. Press the EXECUTE key.

6. Verify that the data has been transferred to the HI BYTE as follows:

   a. Press the READ key followed by X01.

   b. Press the EXECUTE key.

The 3488A display should read +00085 (a binary 01010101). If it does not, refer to Chapter 6 for problem isolation information.

7. Write a binary 10101010 to the HI BYTE (in order to open every other line) as follows:

   a. Press the WRITE key followed by X01,170.

   b. Press the EXECUTE key.

8. Verify that the data has been transferred to the LO BYTE as follows:

   a. Press the READ key followed by X00.

   b. Press the EXECUTE key.

The 3488A display should read +00170 (a binary 10101010). If it does not, refer to Chapter 6 for problem isolation information.

9. Write a binary 01010101 to the HI BYTE (in order to open every other line) as follows:

   a. Press the WRITE key followed by X01,85.

   b. Press the EXECUTE key.

10. Verify that the data has been transferred to the LO BYTE as follows:

   a. Press the READ key followed by X00.

   b. Press the EXECUTE key.

The 3488A display should read +00085 (a binary 01010101). If it does not, refer to Chapter 6 for problem isolation information.

11. CHANNEL CLOSED AND EXTERNAL INCREMENT TEST: Reset the 44474A and set up a scan list as follows:

   a. Press the CARD RESET key followed by X.

   b. Press the EXECUTE key.

   c. Press the MODE key followed by X,2,0,1.

   d. Press the EXECUTE key.

   e. Press the SCAN LIST key followed by X00-X15,0.

f. Press the EXECUTE key.

g. Press the DELAY key followed by 1000.

h. Press the EXECUTE key.

i. Press the CARD MONITOR key followed by X.

j. Press the EXECUTE key.

12. Press the STEP key. If the CHAN CLOSED and PFLG/EXT lines are functioning, the 3488A will begin stepping through the scan list, opening each data line as it closes the previous line. This will be shown on the 3488A's display as the LO BYTE being successively decremented by the binary weighted value of each data line. In other words, the display will start with the value of 255, step to 254 (binary 1), step to 253 (binary 2), step to 251 (binary 4), step to 247 (binary 8), step to 239 (binary 16), step to 223 (binary 32), step to 191 (binary 64) and finally, step to 127 (binary 128). When all eight LO BYTE lines have been stepped through, the LO BYTE will reset to 255 and the process will repeat with the HI BYTE .

If the scan list will not automatically advance as described above, the CHAN CLOSED line, the PFLG/EXT INC line, or both are malfunctioning. Refer to Chapter 12 for problem isolation information.

13. CONTROL LINES TESTS: Set the IO/WR and the PCTL/RD lines to the high state as follows:

a. Press the CARD RESET key followed the numeral key corresponding to the slot occupied by the 44474A.

b. Press the EXECUTE key.

14. Set the multimeter to measure dc voltage. Connect the multimeter between the GND and the PCTL/RD terminals on the test fixture. The PCTL/RD line should be in the high state (between +2.4Vdc and +5Vdc).

15. Connect the multimeter between the GND and the IO/WR terminals on the test fixture. The IO/WR line should be in the high state (between +2.4Vdc and +5Vdc).

16. Set the IO/WR and the PCTL/RD lines to the low state as follows:

a. Press the MODE key followed by X,1,20,0 (where X is the slot occupied by the 44474A).

b. Press the EXECUTE key.

The IO/WR line should be go to the low state (between 0Vdc and +0.4Vdc).

17. Connect the multimeter between the GND and the PCTL/RD terminals on the test fixture. The PCTL/RD line should be in the low state (between 0Vdc and +0.4Vdc).

If either or both control lines failed to achieve either or both states, a problem exists in either the mainframe or the 44474A. Refer to Chapter 6 for problem isolation information.

If the above 44474A tests passed, and further specification testing is desired, refer to the 44474A Performance Tests in Chapter 12.

# Chapter V
# REPLACEABLE PARTS

# CHAPTER V

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF ILLUSTRATIONS

# CHAPTER V
# REPLACEABLE PARTS

## 5-1 INTRODUCTION

This chapter contains:
- Disassembly/assembly instructions
- Mechanical and electrical replaceable parts (Tables 5-1 & 5-3).

## 5-2 DISASSEMBLY/ASSEMBLY

**WARNING**

*The line power cable and all other interconnections must be removed before performing any disassembly procedures.*

**CAUTION**

*To prevent static damage, observe static handling procedures during disassembly (see section 6-3).*

### 5-3 Cover Removal

It is necessary to remove the top cover to access any of the major assemblies within the 3488A mainframe. The cover is secured by six captive screws. To remove the cover:

1. Remove all power cables, interconnections, and plug-in cards from the 3488A.

2. Turn the 3488A upside down. Loosen the six screws in the bottom cover. The screws are captive in the bottom cover. Do not attempt to completely remove the screws.

3. DO NOT ATTEMPT TO REMOVE THE BOTTOM COVER FIRST. When the screws are loosened, turn the entire unit upright. The top cover can now be lifted off.

4. To reinstall the top cover, reverse the procedure.

### 5-4 Front Panel Removal

This procedure describes how to remove the front panel assembly from the mainframe.

1. Depress the line power switch to the on position.

2. The front panel is now held captive in the slot in the bottom cover. Gently pry the right side of the bottom cover until the keyboard can be released from the slot. The keyboard assembly will then swing out and clear the line power switch knob.

3. Lift the front panel up and out. The cable that attaches the front panel to the controller board has enough slack to allow the front panel to be removed. If it is desired to completely remove the front panel, disconnect the grey cable at the controller board connection by pulling the white plastic tab installed on the connector. The cable removal is shown in Figure 5-1.

**CAUTION**

*The two connectors attached to the front panel are delicate connectors. These connectors should only be removed if it necessary to replace either the display assembly or keyboard assembly.*

4. If necessary, the connectors can now be removed from the display assembly and keyboard assembly. These connectors are difficult to remove and are fragile. Removal is best accomplished by gently prying up each edge of the connector a very small amount with a small blade screwdriver.

5. To reinstall the front panel, reverse the procedure.

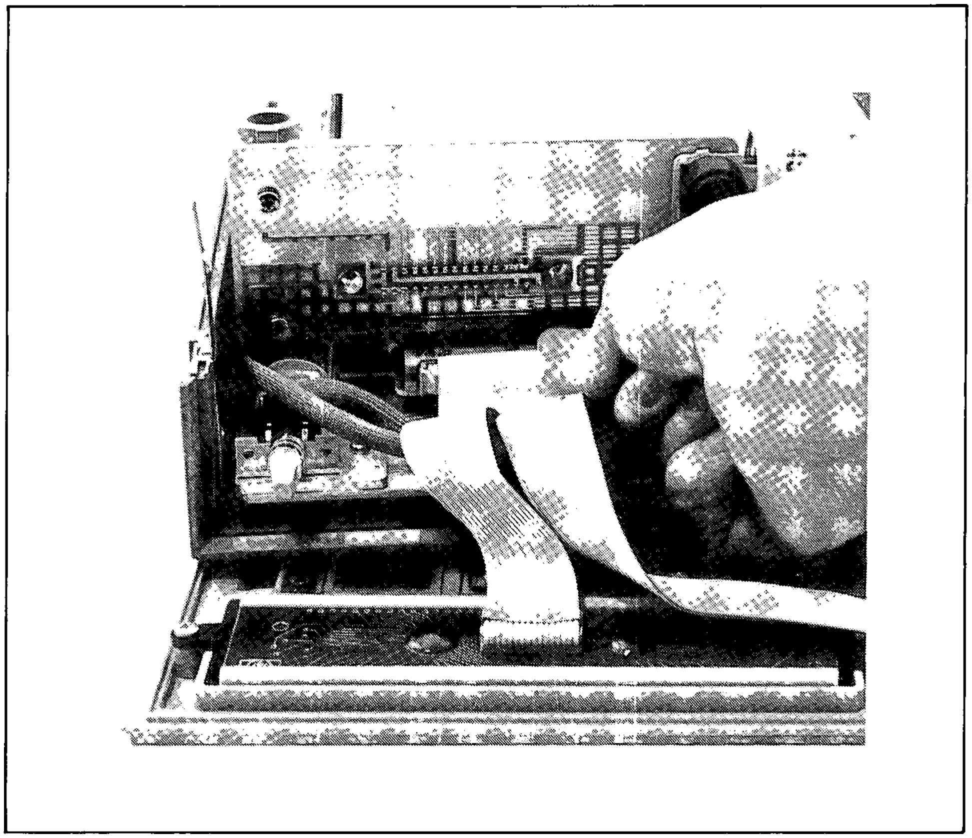


**Figure 5-1 Cable Removal**

## 5-5 Controller Board Access

To access the controller printed circuit board, remove the four screws in the shield over the board. The shield will lift up and off. The controller printed circuit board is now accessable for troubleshooting or testing. Shield removal is shown in Figure 5-2.

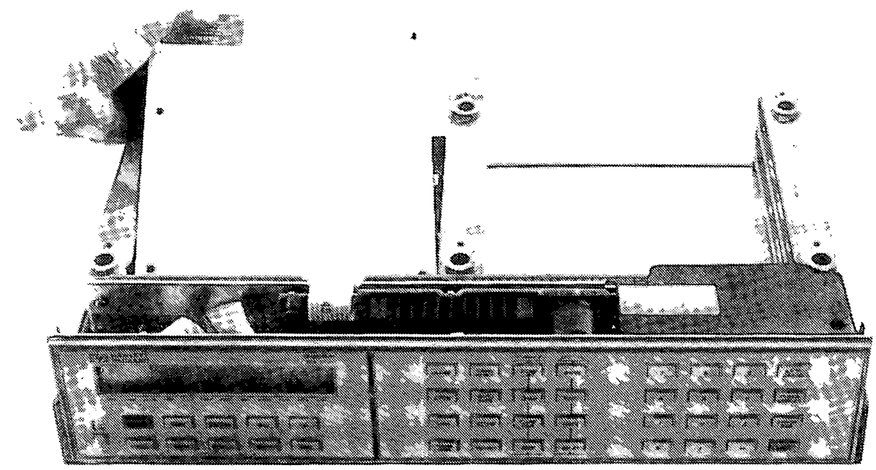


Figure 5-2 Shield Removal

## 5-6 Controller Board Removal

To remove the controller printed circuit board from the mainframe:

1. Remove the front panel assembly as described in Section 5-4.

2. Disconnect the front panel cable from the controller by pulling the white tab installed on the connector (see Figure 5-1).

3. Remove the four screws in the controller board shield and lift the shield up and out (see Figure 5-2).

4. Remove the posi-drive screw located on the rear panel below the silver ground terminal.

5. Gently pull the controller board up and toward the rear of the unit to disconnect the controller board from the backplane board. The HP-IB connector and rear panel will be removed with the controller board assembly. Lift the controller assembly up and out.

6. To reinstall the controller board, reverse the procedure.

## 5-7 Power Supply Removal

The power supply for the 3488A and the plug-in cards is located on a printed circuit board just behind the keyboard. To remove the power supply printed circuit board from the mainframe:

1. Remove the front panel as described in Section 5-4.

2. Disconnect the front panel cable from the controller board by pulling the white tab installed on the connector (see Figure 5-1).

3. Disconnect the power supply printed circuit board from the line power transformer by removing the white three conductor connector located near the right edge of the circuit board (see Figure 5-3).

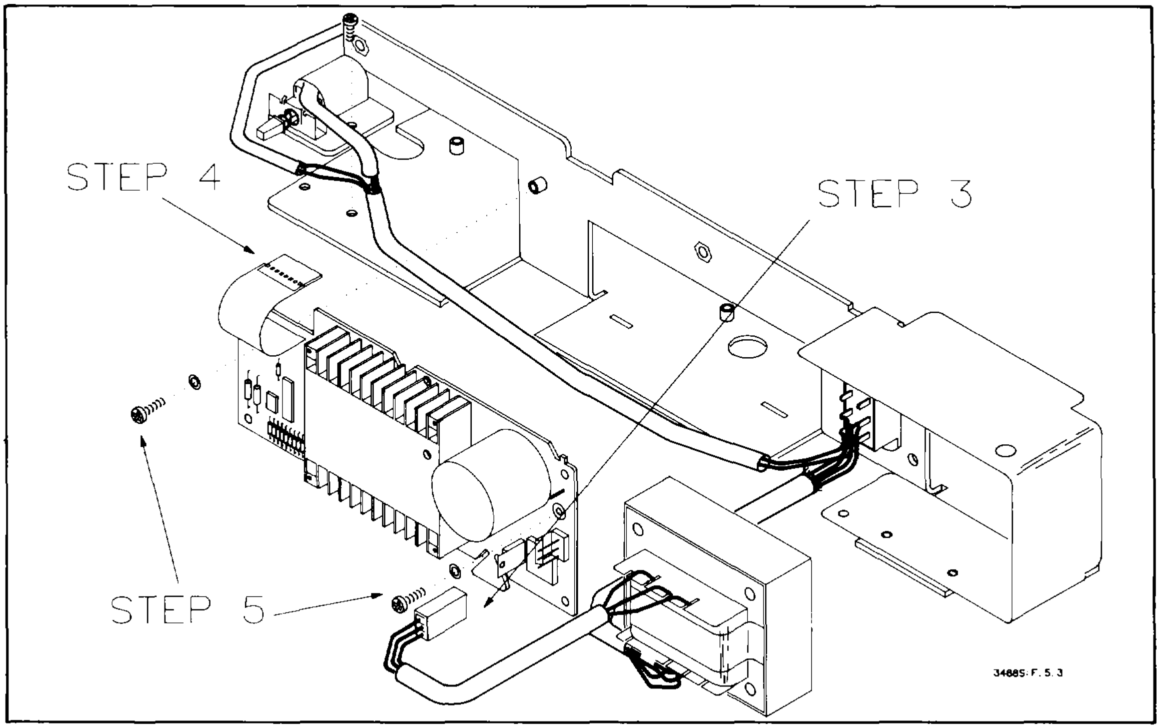



**Figure 5-3 Power Supply Removal**

4. Disconnect the power supply from the backplane circuit board by removing the connector on the top of the backplane board (see Figure 5-3). DO NOT excessively flex the cable.

5. The power supply printed circuit board can now be removed from the mainframe by removing the two Pozi-drive screws holding it in place. Figure 5-3 shows the location of these screws. Lift the power supply assembly straight up so that the bottom tabs on the circuit board clear the slots in the sheet metal.

6. To replace the power supply assembly, reverse the procedure.

## 5-8 REPLACEABLE PARTS

Table 5-1 lists mechanical replaceable parts available for the 3488A. The reference designators used in Table 5-1 are keyed to Figures 5-4 and 5-5. These figures also provide assembly and disassembly information.

Table 5-2 lists manufacturers code numbers as they apply to the electrical parts lists provided in Table 5-3. Table 5-3 is divided by electrical assembly number and reference designator. The assembly number and reference designator appear on the component locator and schematic of the assembly.

Replaceable parts for the plug-in assemblies are not listed in this section. Refer to the specific plug-in card chapter of this manual for plug-in card replaceable parts.

## 5-9 Part Ordering Information

To order a listed part in Table 5-1 or Table 5-3, quote the Hewlett-Packard part number, the check digit (abbreviated CD), and the quantity desired. Address the order to the nearest Hewlett-Packard Sales Office. Hewlett-Packard Sales Sales Offices are listed at the back of this manual.

## 5-10 Direct Mail Order System

Within the U.S.A. only, Hewlett-Packard can supply parts through a direct mail order system. Mail order forms and specific ordering information are available through your local Hewlett-Packard Sales Office.

**Table 5-1 Mechanical Replaceable Parts**

| REF | PART NUMBER | QTY | CD | DESCRIPTION |
|---|---|---|---|---|
| A10 | 03488-66510 | 1 | 5 | BACKPLANE BOARD |
| A31 | 03488-66531 | 1 | 9 | POWER SUPPLY BOARD |
| A40 | 03488-66540 | 1 | 1 | CONTROLLER BOARD |
| F1 | 2110-0012 | 1 | 1 | FUSE 500 MA FOR 115V |
| | 2110-0489 | 1 | 6 | FUSE 250 MA FOR 230V |
| MP1* | 5040-5196 | 1 | 6 | TOP SHELL, MOLDED |
| MP2 | 03488-00601 | 1 | 7 | CONTROLLER SHIELD |
| MP3 | 0515-0844 | 4 | 3 | SCREW 2.5 X 22 |
| MP4 | 2190-0577 | 2 | 1 | WASHER, LOCK |
| MP5 | 0380-1270 | 2 | 4 | STANDOFF, HEX |
| MP6 | 03488-00202 | 1 | 4 | REAR PANEL |
| MP7 | 1510-0038 | 1 | 8 | BINDING POST |
| MP8 | 2190-0060 | 1 | 1 | WASHER, LOCK |
| MP9 | 2950-0072 | 1 | 3 | NUT |
| MP10 | 0515-0408 | 1 | 5 | SCREW 3.0 X 12 |
| MP12 | 2110-0565 | 1 | 9 | FUSE CAP GREY FOR 115V |
| | 2110-0567 | 1 | 1 | FUSE CAP BLACK FOR 230V → no longer used See pg. 2-2 |
| MP13 | 2110-0564 | 1 | 8 | FUSE HOLDER BODY |
| MP14 | 2110-0569 | 1 | 3 | FUSE HOLDER NUT |
| MP15 | 0515-0406 | 2 | 3 | SCREW 3.0 X 8 |
| MP16 | 3050-0891 | 2 | 7 | WASHER, FLAT |
| MP18 | 2190-0004 | 1 | 9 | WASHER, LOCK |
| MP19 | 03488-62701 | 1 | 8 | LINE FILTER ASSEMBLY |
| MP20 | 1600-1185 | 2 | 9 | RACK MOUNT FASTENER |
| MP21* | 0515-1325 | 6 | 7 | SCREW 4 X .7MM |
| MP23 | 03488-64102 | 1 | 6 | BOTTOM PLATE |
| MP24* | 5040-5195 | 1 | 5 | BOTTOM SHELL, MOLDED |
| MP25 | 5180-0223 | 4 | 6 | SIDE TRIM |
| MP26 | 5040-7201 | 2 | 8 | FRONT FOOT |
| MP27 | 1460-1345 | 2 | 5 | TILT STAND |
| MP28 | 5040-7222 | 2 | 3 | REAR FOOT |
| MP29 | 03488-60202 | 1 | 9 | FRONT PANEL ASSEMBLY |
| MP30 | 5061-1190 | 1 | 6 | DISPLAY ASSEMBLY |
| MP31 | 0624-0333 | 2 | 6 | SCREW 4-20 X .25 |
| MP32 | 0370-0603 | 1 | 4 | KNOB, PUSH BUTTON |
| MP33 | 03488-04103 | 1 | 1 | SWITCH ASSEMBLY |
| MP37 | 0515-0408 | 4 | 5 | SCREW 3.0 X 12 |
| MP38 | 0515-0211 | 6 | 8 | SCREW 3.0 X 6 |
| MP39 | 5041-5209 | 3 | 4 | PC GUIDE |

* Refer to Chapter 7 for additional information.

## Table 5-1 Mechanical Replaceable Parts (Cont'd)

| REF | PART NUMBER | QTY | CD | DESCRIPTION |
|---|---|---|---|---|
| MP40 | 0515-0306 | 4 | 2 | SCREW 4.0 X 40 |
| MP41 | 7102-0081 | 1 | 4 | TRANSFORMER COVER |
| MP42 | 0390-0006 | 8 | 3 | INSULATOR |
| MP43 | 3050-0893 | 4 | 0 | WASHER, FLAT |
| MP44 | 2190-0586 | 4 | 2 | WASHER, LOCK |
| MP46 | 0515-0845 | 2 | 4 | SCREW 3.0 X 18 |
| MP54 | 03478-49301 | 1 | 4 | WINDOW-DISPLAY ASSEMBLY |
| T1 | 9100-4347 | 1 | 9 | TRANSFORMER |
| W2 | 8120-4208 | 1 | 2 | FRONT PANEL CABLE ASSEMBLY |
| W5 | 8150-4563 | 1 | 5 | JUMPER (WHT/BLK/GRY) |
| W6 | 8150-4696 | 1 | 5 | JUMPER (WHT/RED/GRY) |
| W7 | 8150-4707 | 1 | 9 | JUMPER (GRAY) |
| | 03488-90002 | | 9 | OPERATORS MANUAL |
| | 03488-90012 | | 8 | SERVICE MANUAL |
| | 9222-0698 | | 0 | ANTI-STATIC BAG |
| | 03488-66501 | | 4 | TEST FIXTURE |
| | 5061-1173 | | 5 | EXTENDER BOARD |
| | 5061-1174 | | 6 | EXTENDER CABLE |

## Table 5-2 Code List of Manufacturers

| Mfr. No. | Manufacturer Name | Address | | Zip Code |
|---|---|---|---|---|
| S4013 | Hitachi America Ltd. | Sunnyvale | CA | 94086 |
| 01121 | Allen-Bradley Co, Inc | El Paso | TX | 79935 |
| 01295 | Texas Instruments Inc | Dallas | TX | 75265 |
| 04713 | Motorola Inc Semi-Cond Prod | Phoenix | AZ | 85008 |
| 1B546 | Varo Semiconductor Inc | Garland | TX | 75046 |
| 11236 | CTS Corp Berne Div | Berne | IN | 46711 |
| 19701 | Mepco/Centralab Inc | W Palm Beach | FL | 33407 |
| 2M627 | Rohm Corp | Irvine | CA | 92716 |
| 24546 | Corning Electronics | Santa Clara | CA | 95050 |
| 26654 | Varadyne Inc | Santa Monica | CA | 90404 |
| 27014 | National Semiconductor Corp | Santa Clara | CA | 95052 |
| 28480 | Hewlett-Packard Co Corporate Hq | Palo Alto | CA | 94304 |
| 50088 | Mostek Corp | Carrollton | TX | 75006 |
| 56289 | Sprague Electric Co | North Adams | MA | 01247 |
| 9N171 | Unitrode Corp | Lexington | MA | 02173 |
| 91637 | Dale Electronics Inc | El Paso | TX | 79936 |

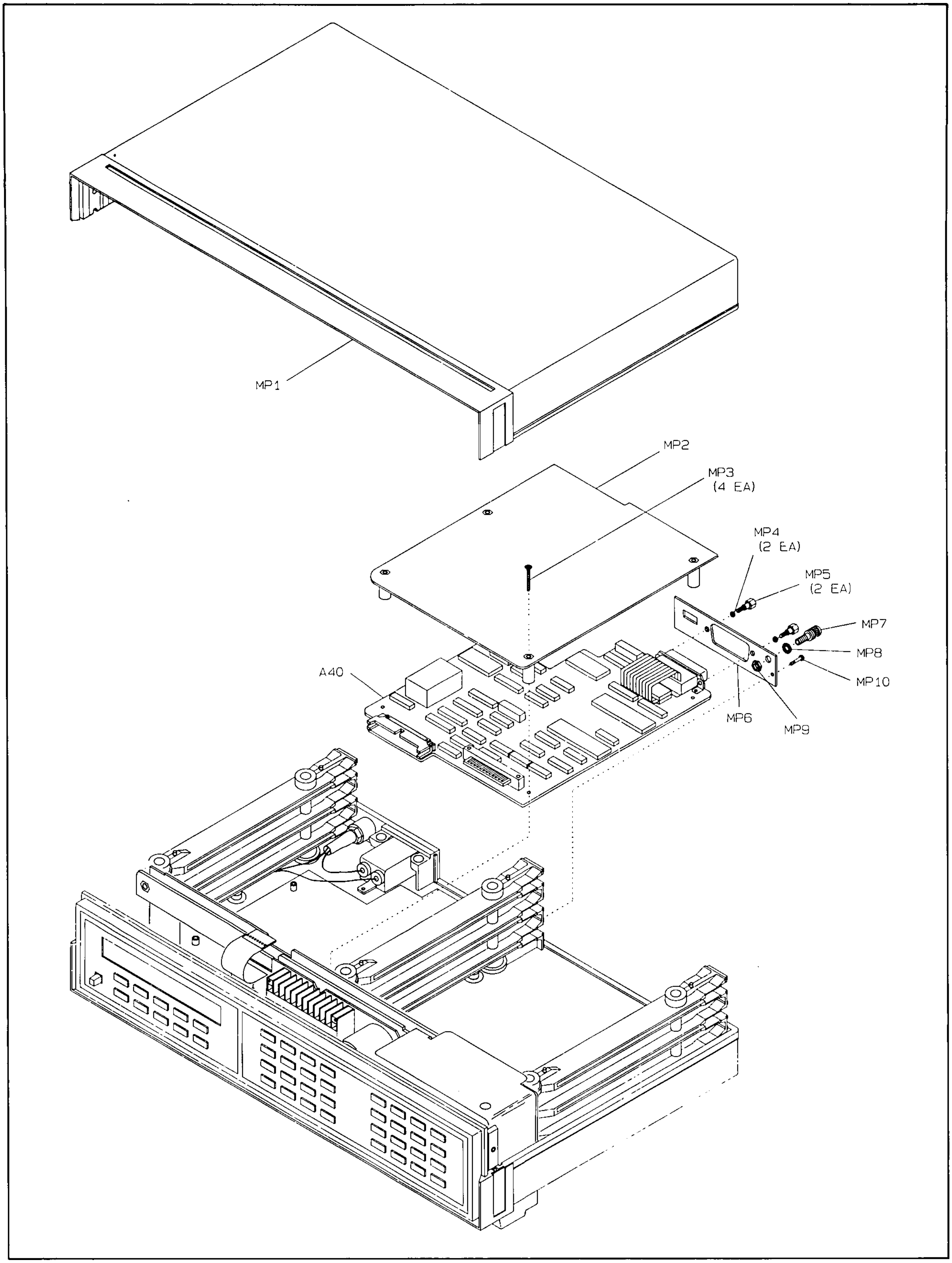



**Figure 5-4 3488A Disassembly**

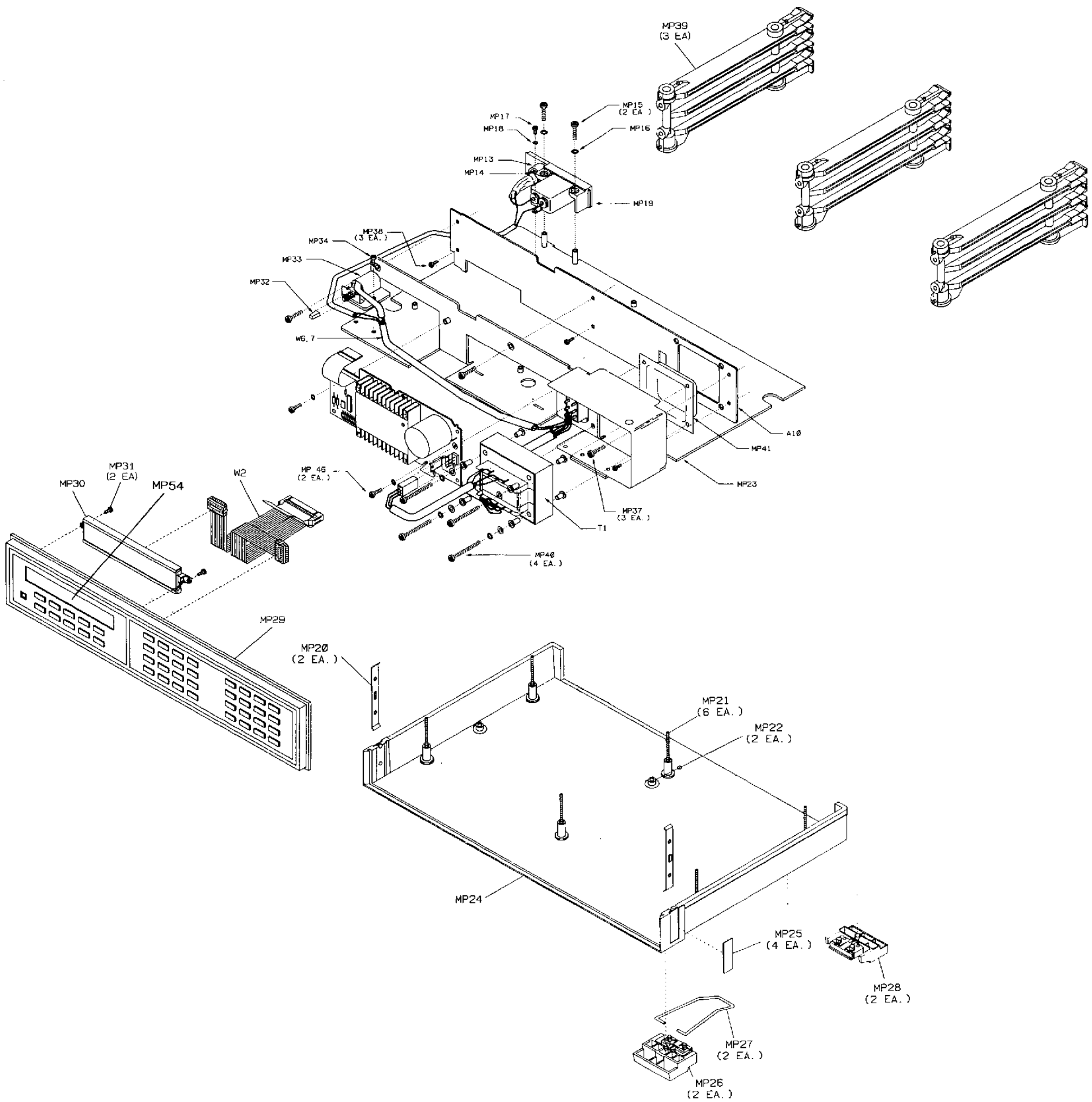



Figure 5-5 3488A Disassembly

## Table 5-3 Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A10 | 03488-66510 | 5 | 1 | BACKPLANE ERC: 2718 | 28480 | 03488-66510 |
| A10J101 | 5180-8211 | 8 | 6 | CONN-EDGE 2X15 | 28480 | 5180-8211 |
| A10J102 | 5180-8211 | 8 | | CONN-EDGE 2X15 | 28480 | 5180-8211 |
| A10J103 | 5180-8211 | 8 | | CONN-EDGE 2X15 | 28480 | 5180-8211 |
| A10J104 | 5180-8211 | 8 | | CONN-EDGE 2X15 | 28480 | 5180-8211 |
| A10J105 | 5180-8211 | 8 | | CONN-EDGE 2X15 | 28480 | 5180-8211 |
| A10J106 | 5180-8211 | 8 | | CONN-EDGE 2X15 | 28480 | 5180-8211 |
| A10J107 | 1251-5287 | 9 | 1 | CONNECTOR 8-PIN M POST TYPE | 28480 | 1251-5287 |
| A31 | 03488-66531 | 0 | 1 | POWER SUPPLY ERC: 2718 | 28480 | 03488-66531 |
| A31C300 | 0160-3622 | 8 | 1 | CAPACITOR-FXD .1UF +80-20% 100VDC CER | 26654 | 2130Y5V100R104Z |
| A31C301 | 0180-3880 | 2 | 1 | CAPACITOR-FXD 4700UF+-20% 50VDC AL | 28480 | 0180-3880 |
| A31C302 | 0180-0230 | 0 | 1 | CAPACITOR-FXD 1UF+-20% 50VDC TA | 56289 | 150D105X0050A2 |
| A31C316 | 0180-1745 | 4 | 2 | CAPACITOR-FXD 1.5UF+-10% 20VDC TA | 56289 | 150D155X9020A2 |
| A31C317 | 0180-1745 | 4 | | CAPACITOR-FXD 1.5UF+-10% 20VDC TA | 56289 | 150D155X9020A2 |
| A31CR302 | 1906-0079 | 6 | 1 | DIODE-FW BRDG 100V 10A | 1B546 | VJ148X |
| A31CR304 | 1901-0025 | 2 | 1 | DIODE-GEN PRP 100V 200MA DO-7 | 9N171 | 1N645 |
| A31J300 | 1251-4246 | 8 | 1 | CONNECTOR 3-PIN M POST TYPE | 28480 | 1251-4246 |
| A31P302 | 03488-61601 | 5 | 1 | CBL-ASSY PWRSPLY | 28480 | 03488-61601 |
| A31Q302 | 1853-0016 | 8 | 1 | TRANSISTOR PNP SI TO-92 PD=300MW | 28480 | 1853-0016 |
| A31R300 | 0698-3160 | 8 | 1 | RESISTOR 31.6K 1% .125W F TC=0+-100 | 24546 | CT4-1/8-T0-3162-F |
| A31R303 | 0698-3548 | 6 | 1 | RESISTOR 732 1% .125W F TC=0+-100 | 24546 | CT4-1/8-T0-732R-F |
| A31R304 | 0757-0408 | 7 | 1 | RESISTOR 243 1% .125W F TC=0+-100 | 24546 | CT4-1/8-T0-243R-F |
| A31R334 | 0683-1035 | 1 | 2 | RESISTOR 10K 5% .25W CF TC=0-400 | 01121 | CB1035 |
| A31R336 | 0698-4202 | 1 | 1 | RESISTOR 8.87K 1% .125W F TC=0+-100 | 24546 | CT4-1/8-T0-8871-F |
| A31R337 | 0698-8162 | 0 | 1 | RESISTOR 11.8K .25% .125W F TC=0+-50 | 19701 | 5033R-1/8-T2-1182-C |
| A31R341 | 0698-4478 | 3 | 1 | RESISTOR 10.7K 1% .125W F TC=0+-100 | 24546 | CT4-1/8-T0-1072-F |
| A31R345 | 0757-0465 | 6 | 2 | RESISTOR 100K 1% .125W F TC=0+-100 | 24546 | CT4-1/8-T0-1003-F |
| A31R346 | 0757-0465 | 6 | | RESISTOR 100K 1% .125W F TC=0+-100 | 24546 | CT4-1/8-T0-1003-F |
| A31R347 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W CF TC=0-400 | 01121 | CB1035 |
| A31R348 | 0683-3645 | 3 | 1 | RESISTOR 360K 5% .25W CF TC=0-800 | 01121 | CB3645 |
| A31R350 | 0683-3015 | 1 | 2 | RESISTOR 300 5% .25W CF TC=0-400 | 01121 | CB3015 |
| A31R351 | 068 | | | | | |
| A31SP300 | 0960-0561 | 4 | 1 | AUDIO TRANSDUCER 1-3VDC; 85DB AT 1.5V | 28480 | 0960-0561 |
| A31TP003 | 1251-0600 | 0 | 2 | CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ | 28480 | 1251-0600 |
| A31TP004 | 1251-0600 | 0 | | CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ | 28480 | 1251-0600 |
| A31U300 | 1813-0544 | 3 | 1 | SWG VOLTAGE REG | 28480 | 1813-0544 |
| A31U301 | 1826-0393 | 7 | 1 | IC V RGLTR-ADJ-POS 1.2/37V TO-220 PKG | 28480 | 1826-0393 |
| A31U303 | 1826-0412 | 1 | 1 | IC COMPARATOR PRCN DUAL 8-DIP-P PKG | 27014 | LM393N |
| A31U304 | 1820-1202 | 7 | 2 | IC GATE TTL LS NAND TPL 3-INP | 01295 | SN74LS10N |
| A31U305 | 1820-1932 | 0 | 1 | IC MV CMOS MONOSTBL RETRIG/RESET DUAL | 04713 | MC14538BCP |
| A40 | 03488-66540 | 1 | 1 | CONTROLLER ERC: 2642 | 28480 | 03488-66540 |
| A40C401 | 0180-0224 | 2 | 2 | CAPACITOR-FXD 10UF+75-10% 16VDC AL | 56289 | 30D106G016BA2 |
| A40C402 | 0160-4808 | 4 | 1 | CAPACITOR-FXD 470PF +-5% 100VDC CER | 28480 | 0160-4808 |
| A40C403 | 0160-3847 | 9 | 12 | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C404 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C405 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C406 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C407 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C408 | 0160-4822 | 2 | 1 | CAPACITOR-FXD 1000PF +-5% 100VDC CER | 28480 | 0160-4822 |
| A40C409 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C410 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C411 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C412 | 0160-4825 | 5 | 1 | CAPACITOR-FXD 560PF +-5% 100VDC CER | 28480 | 0160-4825 |
| A40C413 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C414 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C415 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C416 | 0160-4787 | 8 | 1 | CAPACITOR-FXD 22PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4787 |
| A40C417 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A40C418 | 0180-0224 | 2 | | CAPACITOR-FXD 10UF+75-10% 16VDC AL | 56289 | 30D106G016BA2 |
| A40CR401 | 1901-0033 | 2 | 3 | DIODE-GEN PRP 180V 200MA DO-35 | 9N171 | 1N645 |
| A40CR402 | 1901-0033 | 2 | | DIODE-GEN PRP 180V 200MA DO-35 | 9N171 | 1N645 |
| A40CR403 | 1901-0033 | 2 | | DIODE-GEN PRP 180V 200MA DO-35 | 9N171 | 1N645 |
| A40DP401 | 1906-0229 | 8 | 3 | DIODE-ARRAY 50V 400MA | 01295 | TID133 |
| A40DP402 | 1906-0229 | 8 | | DIODE-ARRAY 50V 400MA | 01295 | TID133 |
| A40DP403 | 1906-0229 | 8 | | DIODE-ARRAY 50V 400MA | 01295 | TID133 |

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

## Table 5-3 Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A40J401 | 1251-5615 | 7 | 1 | CONNECTOR 34-PIN M POST TYPE | 28480 | 1251-5615 |
| A40JM401 | 7175-0057 | 5 | 3 | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A40JM403 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A40JM404 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A40L401 | 9140-0748 | 0 | 1 | INDUCTOR 250UH 25% .28D-INX.53LG-IN Q=3 | 28480 | 9140-0748 |
| A40P401 | 1251-8645 | 9 | 1 | CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS | 28480 | 1251-8645 |
| A40Q401 | 1854-0071 | 7 | 1 | TRANSISTOR NPN SI TO-92 PD=300MW | 2M627 | CP4071 |
| A40R400 | 0683-2025 | 1 | 1 | RESISTOR 2K 5% .25W CF TC=0-400 | 01121 | CB2025 |
| A40R401 | 0698-3359 | 7 | 1 | RESISTOR 12.7K 1% .125W F TC=0+-100 | 24546 | CT4-1/8-T0-1272-F |
| A40R402 | 0698-8827 | 4 | 1 | RESISTOR 1M 1% .125W F TC=0+-100 | 28480 | 0698-8827 |
| A40R403 | 0683-1025 | 9 | 1 | RESISTOR 1K 5% .25W CF TC=0-400 | 01121 | CB1025 |
| A40R404 | 0683-4715 | 0 | 1 | RESISTOR 470 5% .25W CF TC=0-400 | 01121 | CB4715 |
| A40R405 | 0683-3335 | 8 | 1 | RESISTOR 33K 5% .25W CF TC=0-400 | 01121 | CB3335 |
| A40RP401 | 1810-0560 | 7 | 1 | NETWORK-RES 16-DIP5.6K OHM X 8 | 28480 | 1810-0560 |
| A40RP402 | 1810-0280 | 8 | 4 | NETWORK-RES 10-SIP 10.0K OHM X 9 | 91637 | CSC10A01-103G/MSP10A01- |
| A40RP403 | 1810-0280 | 8 | | NETWORK-RES 10-SIP 10.0K OHM X 9 | 91637 | CSC10A01-103G/MSP10A01- |
| A40RP404 | 1810-0265 | 9 | 1 | NETWORK-RES 16-DIP 680.0 OHM X 8 | 01121 | 316B681 |
| A40RP405 | 1810-0280 | 8 | | NETWORK-RES 10-SIP 10.0K OHM X 9 | 91637 | CSC10A01-103G/MSP10A01- |
| A40RP406 | 1810-0280 | 8 | | NETWORK-RES 10-SIP 10.0K OHM X 9 | 91637 | CSC10A01-103G/MSP10A01- |
| A40RP407 | 1810-0286 | 4 | 1 | NETWORK-RES 16-DIP 10.0K OHM X 15 | 11236 | 761-1-R10K |
| A40RP408 | 1810-0201 | 3 | 1 | NETWORK-RES 14-DIP 100.0K OHM X 13 | 11236 | 760-1-R100K |
| A40RP409 | 1810-0307 | 0 | 1 | NETWORK-CNDCT MODULE DIP; 16 PINS; 0.100 | 28480 | 1810-0307 |
| A40RT401 | 0837-0220 | 1 | 1 | THERMISTOR ROD 10K-OHM TC=-3.83%/C-DEG | 28480 | 0837-0220 |
| A40SWP401 | 3101-2094 | 5 | 1 | SWITCH-RKR DIP-RKR-ASSY 8-1A .05A 30VDC | 28480 | 3101-2094 |
| A40SWP402 | 3101-2696 | 3 | 1 | SWITCH-RKR DIP-RKR-ASSY 6-1A .05A 30VDC | 28480 | 3101-2696 |
| A40U401 | 1818-3830 | 6 | 1 | IC NMOS 262144 (256K) ROM 250-NS 3-S | 50088 | MK38000N-25 MASKED |
| A40U402 | 1818-1611 | 7 | 1 | IC CMOS 16384 (16K) STAT RAM 150-NS 3-S | S4013 | HM6116P-3 |
| A40U403 | 1820-1281 | 2 | 1 | IC DCDR TTL LS 2-TO-4-LINE DUAL | 01295 | SN74LS139AN |
| A40U404 | 1820-1794 | 2 | 5 | IC BFR TTL LS NON-INV OCTL | 27014 | DM81LS95N |
| A40U405 | 1820-2216 | 5 | 2 | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A40U406 | 1820-2216 | 5 | | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A40U407 | 1820-1794 | 2 | | IC BFR TTL LS NON-INV OCTL | 27014 | DM81LS95N |
| A40U408 | 1820-1794 | 2 | | IC BFR TTL LS NON-INV OCTL | 27014 | DM81LS95N |
| A40U409 | 1820-1208 | 3 | 1 | IC GATE TTL LS OR QUAD 2-INP | 01295 | SN74LS32N |
| A40U410 | 1820-2702 | 4 | 1 | IC DIVR CMOS DIVIDE-BY-24 | 04713 | MC14521BCP |
| A40U411 | 1820-1445 | 0 | 2 | IC LCH TTL LS 4-BIT | 01295 | SN74LS375N |
| A40U412 | 1820-1445 | 0 | | IC LCH TTL LS 4-BIT | 01295 | SN74LS375N |
| A40U413 | 1820-1216 | 3 | 2 | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| A40U414 | 1820-1216 | 3 | | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| A40U415 | 1820-1199 | 1 | 1 | IC INV TTL LS HEX 1-INP | 01295 | SN74LS04N |
| A40U416 | 1820-1197 | 9 | 2 | IC GATE TTL LS NAND QUAD 2-INP | 01295 | SN74LS00N |
| A40U417 | 1820-1197 | 9 | | IC GATE TTL LS NAND QUAD 2-INP | 01295 | SN74LS00N |
| A40U418 | 1820-2469 | 0 | 1 | IC-MICROPROCESSOR | 28480 | 1820-2469 |
| A40U419 | 1820-1794 | 2 | | IC BFR TTL LS NON-INV OCTL | 27014 | DM81LS95N |
| A40U420 | 1820-1201 | 6 | 1 | IC GATE TTL LS AND QUAD 2-INP | 01295 | SN74LS08N |
| A40U421 | 1820-2102 | 8 | 1 | IC LCH TTL LS D-TYPE OCTL | 01295 | SN74LS373N |
| A40U422 | 1820-1794 | 2 | | IC BFR TTL LS NON-INV OCTL | 27014 | DM81LS95N |
| A40U423 | 1820-2490 | 7 | 1 | IC-MPU; CLK FREQ=1 MHZ, ENHANCED 6800 | 28480 | 1820-2490 |
| A40U424 | 1820-2549 | 7 | 1 | IC-8291A P HPIB | 28480 | 1820-2549 |
| A40U425 | 1820-2485 | 0 | 1 | IC TRANSCEIVER TTL LS INSTR-BUS IEEE-488 | 01295 | SN75160AN |
| A40U426 | 1820-1202 | 7 | | IC GATE TTL LS NAND TPL 3-INP | 01295 | SN74LS10N |
| A40U427 | 1820-2483 | 8 | 1 | IC RCVR TTL LS BUS OCTL | 01295 | SN75161AN |
| A40W401 | 8120-4206 | 0 | 1 | FLAT RIBBON ASSY 28-AWG 24-COND | 28480 | 8120-4206 |
| A40X400 | 1200-0853 | 8 | 1 | SOCKET-IC 16-CONT DIP DIP-SLDR | 28480 | 1200-0853 |
| A40Y401 | 0410-1493 | 8 | 1 | CRYSTAL-QUARTZ 4.0000 MHZ HC-18/U-HLDR | 28480 | 0410-1493 |

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

# Chapter VI
# SERVICE

# CHAPTER VI

## TABLE OF CONTENTS



## LIST OF ILLUSTRATIONS

# CHAPTER VI
# SERVICE

## 6-1 INTRODUCTION

This chapter is divided into three parts. The first part (sections 6-1 through 6-6) give general service related information for the HP3488A. This includes safety considerations, static handling procedures, and printed circuit board identification.

Sections 6-7 through 6-15 contain information to aid in the isolation of a problem to a particular assembly in the HP 3488A. There are two problem isolation discussions: one discussion (beginning at section 6-7) provides information to aid problem isolation to either a plug-in card or the mainframe, the other discussion (beginning at section 6-10) will aid in isolating a problem in the mainframe to a particular mainframe assembly.

The remaining sections of this chapter contain specific information pertaining to the two main subsections of the mainframe: the power supply (A30) and the controller (A40). This specific information is presented as a detailed theory of operation, a troubleshooting information section, and a schematic of the assembly.

## 6-2 SAFETY CONSIDERATIONS

Only service trained personnel should attempt to repair the 3488A. There are two places in the unit where dangerous voltages may exist. The ac line voltage exists in the mainframe around the areas of the line input filter, line power switch, and transformer primary. This potentially lethal voltage can only be contacted if the covers are removed.

The other potentially lethal voltage may exist at the plug-in card wiring block. This voltage is generated externally to the 3488A. Consult the system installer or documentation worksheet (given in the 3488A Operation Manual) before attempting to remove the 3488A and plug-in cards from the system.

**WARNING**

*Only personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make any repairs to this instrument or assembly.*

**CAUTION**

*To prevent equipment circuit damage, always set the line power switch to off before removing or replacing any assembly. To prevent static zap of IC's, always observe anti-static techniques when assemblies are handled or serviced.*

## 6-3 Static Handling

Static electricity is a familiar phenomenon which, except for an occasional shock, doesn't seem very serious. However, it has been proven that in the electronics industry electrostatic discharge (ESD) is a major cause of component failure. In many cases, the component damaged may not immediately fail, causing low instrument reliability and unnecessary repairs at a later time. ESD damage can occur at static levels too low for human perception. Additionally, it has been shown that ESD can affect both passive and active devices.

Any assembly or subassembly removed from the mainframe MUST be handled in accordance with anti-static handling procedures. This specifically includes plug-in cards.

The following guidelines are the minimum requirements for a static safe service environment.

- The work bench should be equipped with a conductive table mat. The mat should be grounded to earth ground through a 1 megohm resistor. The mat should be equipped with at least one swivel conector for connecting wrist straps.

- All service and handling personnel should wear a conductive wrist strap in contact with bare skin. This strap should be connected to the swivel connector on the conductive table mat through a 1 megohm resistor.

- All metal equipment at a work station must be grounded. This includes soldering irons, solder suckers, shelving, and equipment stands.

- Only one common ground should be provided at a workstation.

- The workstation must be kept free of nonconductors. No common plastics, polybags, cardboard, cigarette or candy wrappers should be allowed. There should not be rugs or carpet on the floor, shelving, or bench top.

- Only proper containers should be used for shipping, storing and transporting assemblies.

## 6-4 PRINTED CIRCUIT BOARD IDENTIFICATION

The printed circuit boards contained in the 3488A and the plug-in cards are identified by the board part number and the engineering revision code. These two sequences of numbers are used to exactly identify the electrical characteristics of the printed circuit board. In this manual the engineering revision code and board part number are given on the schematics, component locators, and electrical parts lists.

In any correspondance with a service office or service representative it is necessary to exactly identify the printed circuit board configuration. This is done in a standard format using the board part number followed by the engineering revision code. For example:

03488-66510-2310

would describe a particular backplane printed circuit board assembly in the 3488A. The board part number is 03488-66510 and the engineering revision code is 2310. The information given in this example can be seen, although it may not be identical, by removing any plug-in cards from slots 1, 2, and 3 of the mainframe and looking at the backplane printed circuit board just above the line voltage selector switch.

## 6-5 Board Part Number

The Hewlett-Packard part number of the printed circuit board is etched on the board. This is a ten digit number, separated by a hyphen into two groups of five digits. The first five digits generally identify the model number or assembly number of which the printed circuit board is a part. The last five digits are a unique part number for identifying the the printed circuit board.

## 6-6 Engineering Revision Code

Figure 6-1 shows a typical Engineering Revison Code label. This four digit code is in the form of YYWW, where YY is the last two digits of the year minus year 60 and WW is the week code. For example, an engineering revision code of 2310 would identify a change made in the tenth week of 1983.

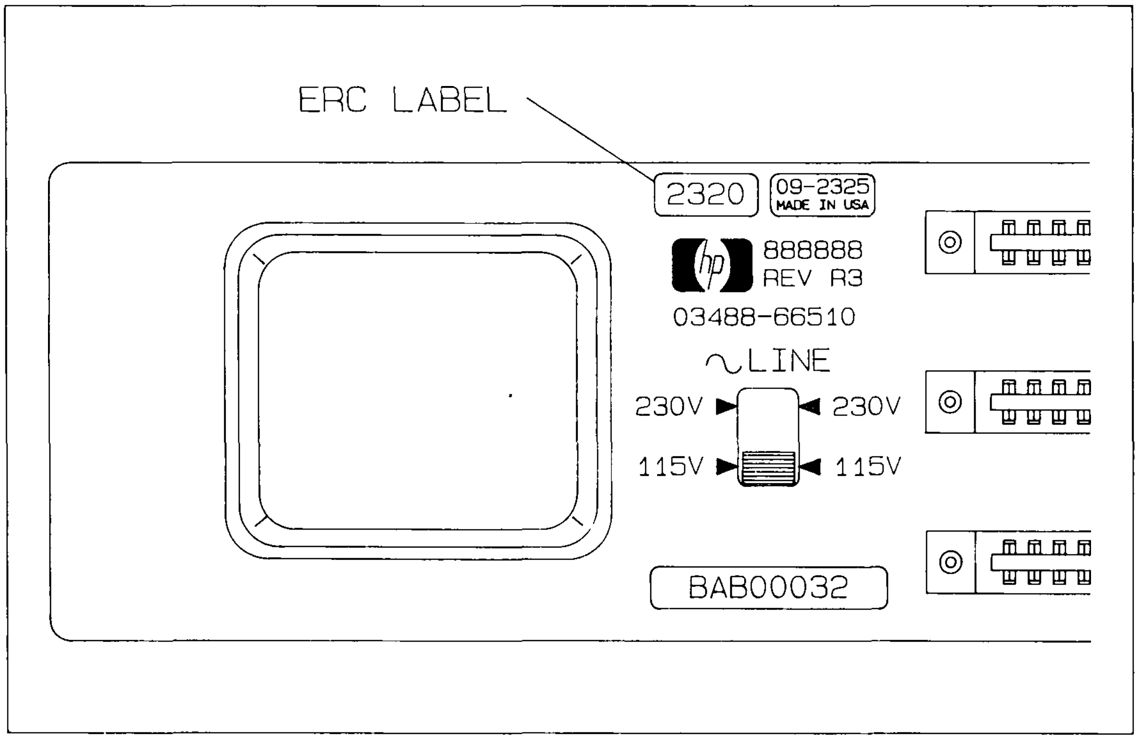



**Figure 6-1 Typical ERC Label**

The engineering revision code is updated whenever a change is made to the assembly. This change may be a printed circuit board revision, a component value change, added or deleted components, a component part number change, or a revised test and assembly procedure.

The engineering revision code should be checked against schematics, component diagrams, and parts lists to ensure compatibility. Engineering revison codes with lower values than noted on the schematics, component diagrams, and part lists are described in the backdating section. Engineering revision codes with values higher than that noted on the schematics, component diagrams, and parts lists will be covered by manual change sheets or manual revisions.

In this manual and in other literature about the 3488A, the engineering revision code may be designated by the abbreviation ERC.

## 6-7 PROBLEM ISOLATION

These procedures assume that reasonable steps have been taken to isolate the system problem to the 3488A. These steps may include checking the system controller, input devices, and output devices. If the 3488A is on a common HP-IB interface with other instruments, a bus failure can sometimes be isolated to a particular instrument by disconnecting the instruments from the interface one at a time.

### 6-8 Preliminary Tests

**WARNING**

*The following procedure requires that the system controller be stopped and disconnected and that the 3488A be removed from the system. Ensure that no damage to other parts of the system will be caused by these actions.*

Once the 3488A is suspected of a failure:

1. Stop the system controller. This is to prevent the 3488A from receiving any local lockout, display off, or other commands that may confuse the problem isolation procedure.

2. Cycle power on the 3488A. The display should show the lazy T ( ⊢ ). If the 3488A display appears "dead", press any front panel device function key (any key in the center keypad) and check if the command is shown in the display. If the 3488A does not respond, check the power fuse. Fuses are described in section 2-5. If the fuse and primary power are good and the 3488A still won't display any characters:

   a. Turn off the 3488A and remove the power cord. Disconnect the HP-IB interface. Remove any plug-in cards installed in the 3488A.

   b. Replace the power cord and turn on the 3488A. The lazy T ( ⊢ ) should appear in the display and the 3488A should respond to any key closure of the device function keys by displaying the key command.

If the 3488A does not respond, a problem exists in the mainframe. The problem may be further isolated within the mainframe by performing the procedures described in section 6-10.

If the 3488A responds to the front panel keys and the display functions, the problem most likely exists on one of the plug-in cards or the HP-IB interface. Replace the plug-in cards one at a time, cycling power each time. If a card is installed and the 3488A no longer responds, the plug-in card is faulty. If all the plug-in cards are re-installed and the 3488A still functions, re-install the HP-IB connector. If the 3488A does not respond now, a problem is indicated on the HP-IB interface. The computer or interface manual will contain a procedure to verify the correct operation of the HP-IB.

3. If the 3488A display works but the 3488A does not seem to function properly, perform the Operation Verification tests describe in Chapter 4. These tests provide a quick and simple method to determine if the 3488A and plug-in cards are functioning properly.

## 6-9 Board Substitution

The easiest and fastest method to isolate a failure to a particular printed circuit board is the board substitution technique. The technique calls for the suspected bad board to be replaced with a known good board. If the problem is solved, the replaced board or assembly had the problem. One drawback to this technique is the need for known good circuit boards.

A limited board substitution may be performed to isolate a faulty plug-in card. To use this method, first, determine which plug-in card is suspected of the failure. The Operation Verification procedures in Chapter 4 may be used as a troubleshooting aid. Then try the failing card in another mainframe slot. If the card functions normally in the other slot, a mainframe failure is indicated. If the card still fails, try another card. This other card does not have to be the type as the failing card. If the other card does not function properly, a mainframe failure is indicated. If the new card does function properly, a failure in the suspected card is indicated.

# 6-10 MAINFRAME PROBLEM ISOLATION

Once the 3488A is suspected of a failure the problem may be further isolated within the mainframe to a particular assembly. Isolating a problem within the mainframe requires that the 3488A be at least partially disassembled. A disassembly procedure is given in Chapter 5.

There are five main electronic assemblies within the 3488A. These assemblies are: (1) the power supply, (2) the controller, (3) the display, (4) the keyboard, and (5) the backplane board. Because of the interaction of some of these assemblies problem isolation is limited to replacement of the suspected assembly.

## 6-11 Power Supply

To determine if a problem exists within the power supply it will be necessary to remove the 3488A top cover. Chapter 5 provides a procedure to remove the cover. A voltmeter is also required. A recommended voltmeter is the Hewlett-Packard Model 3478A.

The power supply printed circuit board is located behind the keyboard. Connect the voltmeter common lead to TP3 (GND) on the power supply board (shown in Figure 6-2). Connect the voltmeter positive test lead to TP4 on the power supply board (shown in Figure 6-2).

Apply power to the 3488A. The voltmeter should indicate +5.1 Vdc (±0.1 Vdc).

If the voltmeter reading is correct, the problem exists in one of the other assemblies. If the voltmeter reading is incorrect, remove power from the 3488A and disconnect the white cable between the power supply board and the backplane board (refer to Figure 5-3). Take care not to excessively flex the cable. This isolates the power supply from the rest of the unit.

Re-apply power to the 3488A. If the voltmeter reading is correct, the problem exists in one of the other assemblies. If the voltmeter reading is still incorrect, the problem exists in the power supply or the power supply input. The input to the power supply, as measured at the secondary of the transformer (the the two brown wires in white connector shown in Figure 5-3) should be approximately 25 Vac.

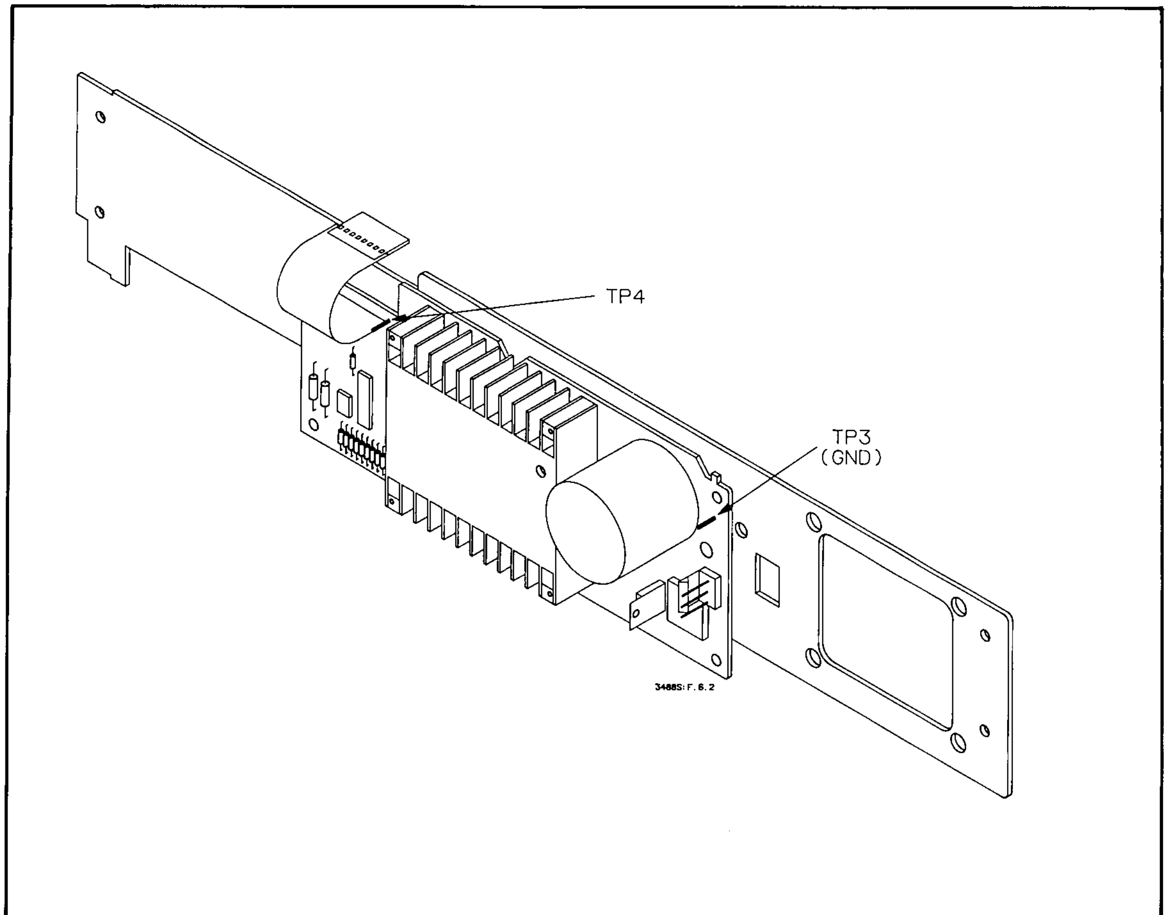



**Figure 6-2 TP3 (GND) and TP4 Test Points**

## 6-12 Controller

Isolating a problem to the controller is best accomplished by the substitution of a known good controller. The signature analysis procedures in Section 6-43 may also be used to verify correct controller operation. Failures in the controller will, for the most part, be readily apparent. Symptoms of a failure in the controller include: a confused, incorrect, or dead display, an interface bus hang-up, front panel command response but no HP-IB command response, a failure of all plug-in cards or slots, or an incorrect response to a command.

Access to the controller printed circuit board is described in Section 5-5.

## 6-13 Display

Problems in the display can usually be detected by performing the display test described in Section 4-5. Typically, a failing display will exhibit missing segments. Display removal is depicted in Chapter 5.

## 6-14 Keyboard

Problems in the keyboard can usually be isolated by performing the keyboard test described in Section 4-10. No response to a key closure is the typical failure mode of the keyboard. No response to any key closure would indicate a controller failure. Procedures to remove the front panel are given in Section 5-4.

## 6-15 Backplane

The backplane board has no active components. Failures of the backplane board will, typically, be visually identifiable. If a plug-in card will not function in only one slot, the backplane board should be suspected. Connector failure on the backplane board will be the most common form of backplane failures. Because the plug-in card slots are all in parallel on the backplane, a shorted connector on the backplane board may appear to be a controller failure.

## 6-16 POWER SUPPLY THEORY OF OPERATION

This theory of operation references the power supply schematic, Figure 6-14. The power supply for the 3488A and all the option cards is contained on the A31 circuit board assembly. The power supply used is a switching mode type supply.

Primary power can be either 115 Vac or 230 Vac, 48 to 440 Hz. The primary power is applied through a line filter that is an integral part of the line power input connector. Fuse F1 protects the 3488A from damage. F1 is rated at 500 mA for 115 Vac operation and 250 mA for 230 Vac operation. Both fuses are normal blow type fuses.

Switch S2 selects the transformer (T1) primary windings to match the line input voltage. S2 is accessible through the option card slots on the rear of the 3488A.

A simplified schematic of power supply operation is shown in Figure 6-3. The secondary voltage of the transformer is applied to CR302, a full wave rectifier. The rectifier produces a DC output of approximately 31 volts. The 31 Vdc is applied to regulator U301. This is a 5-volt regulator and provides the operating voltage for the comparator and the logic on the power supply board. The +5 VR is only used on the power supply assembly. It is not routed to other assemblies in the instrument.

The 31 Vdc is applied to the switching regulator U300. U300 is a step down switching mode regulator. U300 provides all of the necessary output filtering. The output of U300 is the +5V supply.

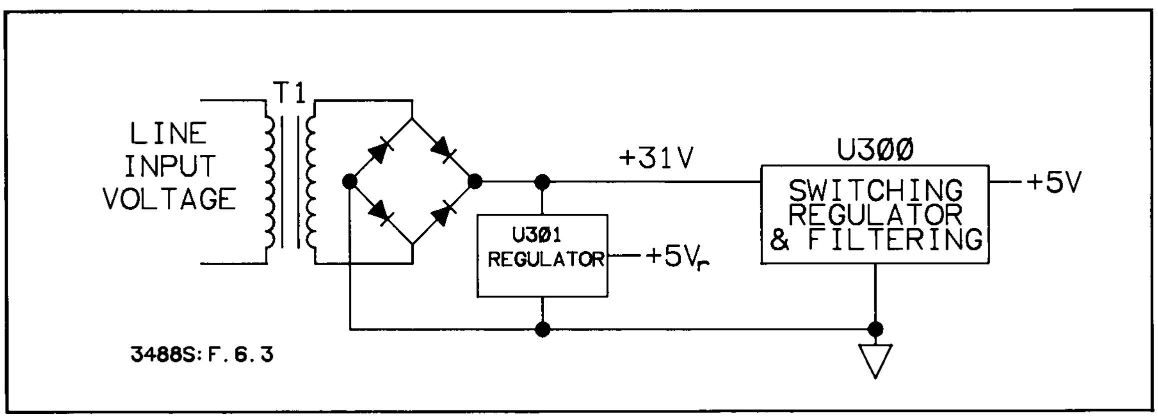



**Figure 6-3. Simplified Power Supply**

## 6-17 Power Supply Protection

Switching Regulator U300 provides three types of protection.

1. **Thermal Protection:** U300 has a thermal protection inside. When the internal junction temperature of active components reaches 150°C, U300 is switched off. Normal operation is restored when the internal junction temperature falls below 130°C.

2. **Short Circuit Protection:** U300 is protected against temporary and permanent short circuits of the output pin (pin 8) to ground or against output current overloads.

3. **Load Protection:** U300 protects the load connected to its output against overvoltages by a crowbar circuit. If the output of U300 exceeds the nominal value by +20%, a crowbar protection is activated; this shorts the output to ground.

## 6-18 Controller Signals

There are two signals output from the power supply to the controller (A40). These are PON and POK.

## 6-19 PON

The PON line provides a wake-up signal to the controller. PON is output from nand-gate U304C at pin 8. The pin 9 input to the gate is tied high, the pin 10 input is controlled by U300 pin 2. Initially, the output of U300 will be low. This holds PON high through the pin 10 input to U304C.

The output of U300 also is applied to U305 at pin 12. U305 is a dual one-shot multivibrator. Pin 12 controls the A portion of the one-shot. A transition on pin 12 from low to high triggers the multivibrator. The duration of the output pulse is determined by R346 and C316. The Q output of the multivibrator is applied to pin 11 of nand-gate U304C.

PON is thus controlled by two sources. Initially, PON is held high by the low input from U300. After a brief interval, U300 output will go high. This transition triggers the multivibrator, U305, and the Q output goes low. The low output holds PON high through U304C pin 11. After the multivibrator has timed out (approximately 0.47 seconds) the Q output returns high and PON goes low. The controller then takes PON low to be the wake-up signal. This action ensures that all the power supplies are operating before the controller begins operation.

## 6-20 POK

The controller uses the POK line to indicate problems with the line input power. The POK line is held low during normal operation. If the POK line should go high, the controller will generate ERROR 16: POWER.

When power is first applied to the 3488A, POK is held high until the +5V supply is operating. The output of U300 holds pin 2 of U304B low, keeping POK high. This will not generate an error condition because the controller has not yet been powered up and PON will be low.

Because line power problems may occur too quickly for the controller to respond, the POK pulse is stretched. This stretching of the pulse occurs through the action of U304A and the B portion of U305. The output of U304A is connected to pin 5 of U305. A high to low transition on this pin will trigger the one shot. The Q output of the one shot is connected to pin 3 of U304B. The duration of the output pulse is set by timing components R345 and C317. The output pulse width is nominally 0.15 seconds.

Two of the three inputs to U304A are also inputs to U304B. A low input on either of these lines will cause the POK line to be set high and also trigger the one shot and stretch the pulse through pin 3 of U304B. The third input to U304C is tied high through R334.

Line input power problems are detected by U303A. The inverting input to U303A is +2.15V, derived by dividing the +5VREF supply through resistors R337 and R336. The non-inverting input to U303A is proportional to the raw DC output of rectifier CR302. This raw DC voltage (approximately 31 Vdc) is divided through resistors R300 and R341. For normal operation the non-inverting input to U303A is held at +7.84 volts. This holds the output of the comparator at + 5 V. A drop in the line voltage will cause a corresponding drop in the raw DC voltage. When the raw DC voltage drops to approximately 8.5 Vdc, the output of U303A will go low, indicating a power line problem.

## 6-21 BEEP

The audible output of the 3488A is also contained on the power supply board. This circuit is composed of Q302, R343, CR304 and SP300. SP300 is connected in the collector lead of Q302. The emitter lead of Q302 is connected directly to the +5V supply. The base of Q302 is driven by a signal, called BEEP, from the controller. This signal is a gated 1 kHz square wave. Q302 will conduct during the negative portion of the signal and so allow current to flow through the coil of SP300. CR304 protects the circuit from inductive kickback when Q302 is turned off.

## 6-22 POWER SUPPLY TROUBLESHOOTING

To troubleshoot the power supply the top cover and the keyboard should be removed (the keyboard need not be disconnected). A procedure to remove the top cover and the keyboard is given in Chapter 5. Once the top cover and keyboard has been removed it is not necessary to remove the power supply printed circuit board from the mainframe to troubleshoot the supply.

The power supply provides +5 Vdc to the rest of the instrument. Additionally, two signals to the controller originate on the power supply board (POK and PON). The power supply receives one input from the controller (BEEP).

### 6-23 Test Equipment Required

These troubleshooting procedures require the use of the following test equipment.

| | |
|---|---|
| Multimeter | HP 3478A or equivalent |
| Oscilloscope | HP 1741A or equivalent |

## 6-24 Isolating The Power Supply

The power supply can be isolated from the rest of the instrument and still operate. To isolate the power supply, remove the line input power and disconnect the white cable between the power supply printed circuit board and the backplane printed circuit board (refer to Figure 5-3). Take care not to excessively flex the cable. This action completely isolates the power supply from the instrument. The line input power may now be reapplied.

## 6-25 Loading The Power Supply

When disconnected, the power supply may be loaded by placing a 39 ohm resistor between TP3 and TP4. A correctly operating supply will drive this load.

## 6-26 Initial Checks

1. Turn on the instrument and check the display. At turn-on, the display should show the lazy T. Pressing any key in the center keypad of the keyboard should result in that key name appearing in the display.

If the display shows ERROR 16, the instrument beeps continuously, or the instrument beeps periodically a problem may exist in the POK circuitry. Troubleshooting the POK circuitry is described in Section 6-30.

If the display shows undefined characters, fading characters, or intermittent characters a problem may exist in the PON circuitry. Troubleshooting the PON circuitry is described in Section 6-29.

If no display is present, the power supply may not be functioning. Check the fuse. A procedure for checking the fuse is given in Chapter 2. If the fuse continuously blows when power is applied, perform the Blown Fuse troubleshooting procedure in Section 6-29. If the fuse is good and no display is present, perform Step 2.

2. Check the +5 Vdc output of the power supply. It will be necessary to remove the 3488A top cover to check the power supply. A cover removal procedure is given in Chapter 5. Figure 6-2 shows the ground and TP4 test points. Connect the positive lead of the voltmeter to TP4 and the negative lead to ground (TP3). The voltmeter should indicate +5.1 Vdc, ±0.10 Vdc. If the voltage indicated is within the specification, check the +5 Vdc output (at TP4) with an oscilloscope for noise on the supply. Noise should be less than 65 mV peak-to-peak.

If the voltage is not +5.1 Vdc, proceed to step 3.

3. Isolate the power supply from the instrument by removing the white cable connecting the power supply to the backplane. Be careful not to excessively flex the cable. This cable is shown in Figure 5-3. If the +5.1 Vdc output, at TP4, is now +5.1 Vdc go to Step 4. If the supply is still not +5.1 Vdc, perform the Failing +5.1 Vdc procedure in Section 6-27.

4. Load the power supply by installing a 39 ohm resistor between TP3 and TP4 on the power supply board. If the +5.1 Vdc output at TP4 is bad, perform the Failing +5.1 Vdc procedure in Section 6-27 with the supply loaded. If the +5.1 Vdc output is good, the problem does not exist on the power supply board. The power supply output is being excessively loaded by something external to the supply.

## 6-27 Failing +5 Vdc

1. When the + 5 Vdc output has been determined to be at fault, as described in Initial Checks Section 6-26, check the raw dc voltage. This is the output of CR302. The raw dc should be +31 Vdc. If the raw dc is not present, check the ac input to CR302 at J300 (the white three-pin connector). The two brown leads in J300 should have approximately 25 Vac rms across them. If not, troubleshoot CR302, T1, S2, S1, and the line input filter. If the raw dc is present, proceed to step 2.

2. Check the +5 VR supply. This supply is output from U301. The +5 VR supply should be checked at pin 2 of U301. The supply should be +5 Vdc, ±0.05 Vdc. This +5 V is only used on the power supply board. If the voltage is not +5 Vdc, troubleshoot U301, R304, R303 and C302. If the supply is +5 Vdc, proceed to step 3.

3. At this point, the power supply internal voltage has been determined to be operational. It is now necessary to determine if the switching regulator is operational. Measure the voltage level at pin 3 of U300. The voltage level should be 31 Vdc. If pin 3 of U300 is at 31 Vdc, check the level at pin 1 of U300. Pin 1 should be at ground potential. If pin 1 is at ground potential, and pin 3 is at 31 Vdc, and there is not a short on the output of U300, then U300 needs to be replaced.

## 6-28 Blown Fuse

Check for direct shorts in the primary and secondary of T1 with an ohm meter. If no shorts are found, remove J300 from the power supply board and check for shorts in C300, CR302, and C301.

## 6-29 PON Troubleshooting

PON is a wake-up signal to the controller. When functioning correctly, PON is held high for approximately 0.47 seconds after the power supply is operating. The controller begins operation when PON goes low. A detailed description of the operation of the PON circuitry is given in the Theory Of Operation, beginning at Section 6-19.

1. Apply power to the instrument. Check the voltage at pin 8 of U304C. This voltage should be 0 Vdc. If the voltage is 0 Vdc and the controller will not wake-up, use an oscilloscope to check pin 8. The line should be high for approximately 0.47 seconds after line power has been cycled. If the line never goes high the controller cannot wake-up correctly. Troubleshoot the circuitry associated with U300 and U305 while cycling power.

If the voltage is not 0 Vdc, proceed to Step 2.

2. Check the voltage at pin 10 of U304C. This voltage should be +5 Vdc. If it is not + 5 Vdc, troubleshoot U300. If the voltage is + 5 Vdc, proceed to step 3.

3. Check the voltage at pin 11 of U304C. This voltage should be +5 Vdc. If it is not + 5 Vdc, troubleshoot C316, R346, and U305. If the voltage is +5 Vdc, troubleshoot U304C and R334.

## 6-30 POK Troubleshooting

POK is a status line to the controller. POK indicates the status of the reference voltage (+5 VREF) and the line input power. When POK is low, the controller assumes the power supply is functioning normally. If POK is high the controller will display ERROR 16. Because POK is used to indicate line input power problems such as brown-outs, the POK pulse is stretched to allow the controller time to scan the status line.

1. Apply power to the instrument and measure the voltage at pin 6 of U304B. This voltage should be 0 V. If the voltage is 0 V, POK is probably functioning correctly. If the voltage is not 0 V, proceed to Step 2.

2. Check the voltage at pin 4 of U304B. This voltage should be +5 Vdc. If the voltage is +5 Vdc, proceed to Step 3.

3. Check the voltage at pin 5 of U304B. This voltage should be +5 Vdc. If the voltage is not +5 Vdc, troubleshoot R347, U303A, R348, R300, R337, R338, C302, R304, R303, U301 and R341. If the voltage is +5 Vdc, proceed to Step 4.

4. Check the voltage at pin 3 of U304B. This voltage should be +5 Vdc. If the voltage is not +5 Vdc, troubleshoot U305, C317, R345, U300, U304A and R334. If the voltage is +5 Vdc, troubleshoot U304B.

# 6-31 CONTROLLER THEORY OF OPERATION

## 6-32 Introduction

A basic block diagram for the controller is shown in Figure 6-4. The Oscillator provides a 4MHz square wave to the Primary Functions and the HP-IB section. In the Primary Functions the 4MHz square wave is divided by four and used as the master clock for the rest of the controller.

The Backplane Interface section controls the flow of data and commands between the controller and the backplane. All option cards are controlled through the backplane. By latching the data and commands, the Backplane Interface allows the use of a static backplane. This reduces radiated noise from the HP3488A.

The Interrupt Logic interfaces devices generating interrupts with the microprocessor. Interrupts are generated for periodic keyboard scans, periodic display updates, external increments from a digital I/O card, from the HP-IB circuitry, or from the power supply.

The Keyboard, Display, and Address Logic allows the microprocessor to scan the keyboard, control the display, and read the current HP-IB address.

The Primary Functions section contains the minimum set of hardware required to fetch and execute instructions. The microprocessor, ROM, and RAM is contained in this section.

The type of microprocessor used in the Primary Functions requires that all devices on the data bus be memory mapped. To facilitate this type of system an Address Decoding section is used. Address Decoding selects the active devices based upon the address information output from the microprocessor.

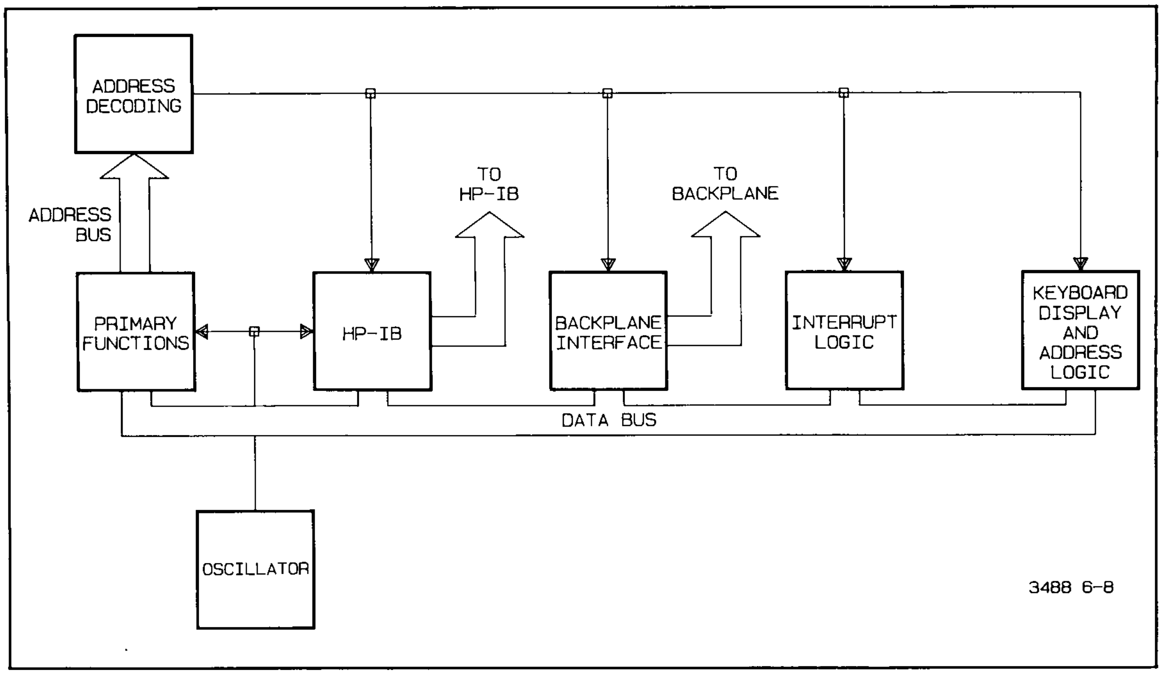



**Figure 6-4 Controller Basic Block Diagram**

The HP-IB section interfaces the HP3488A to the system controller. This section is bidirectional. Both data and control information is handled by this section. The HP-IB section is clocked by the 4MHz clock from the Oscillator. The HP-IB section is controlled by the output of the Address Decoding section.

## 6-33 Primary Functions

A simplified schematic of the Primary Functions is shown in Figure 6-5. At the center of the Primary Functions is the microprocessor, U423. This IC will be referred to as the mpu in this discussion. The mpu communicates over a 16 bit address bus and an 8 bit data bus. The address bus provides 64 Kilobytes of addressable memory space.

The mpu is driven by a 4 MHz square wave provided by the oscillator. From this input the mpu derives two clocks. These clocks operate at a 1 MHz rate and are identical. The two clocks are labeled Q and E. The Q clock (quadrature clock) leads the E clock (main clock) by 90°. For operations within the controller, the E clock is a read operation clock and the Q clock is a write operation clock.

The E clock is gated with the R/W line from the processor to generate the READ strobe. The Q clock is gated with the E clock and the inverted R/W line to generate the WRITE strobe. These two strobes are used throughout the controller to set the read or write operations on the data bus.

The instruction set for the mpu is contained in the ROM. This ROM is enabled by two lines from the Address Decoding section; CE1 and ROM. The ROM output is buffered before it is sent on the data bus. This buffering is necessary because the ROM cannot source enough current to drive the data bus. The ROM Buffer is also enabled by the ROM line from the Address Decoding section. The READ line controls the output timing of the ROM Buffer.

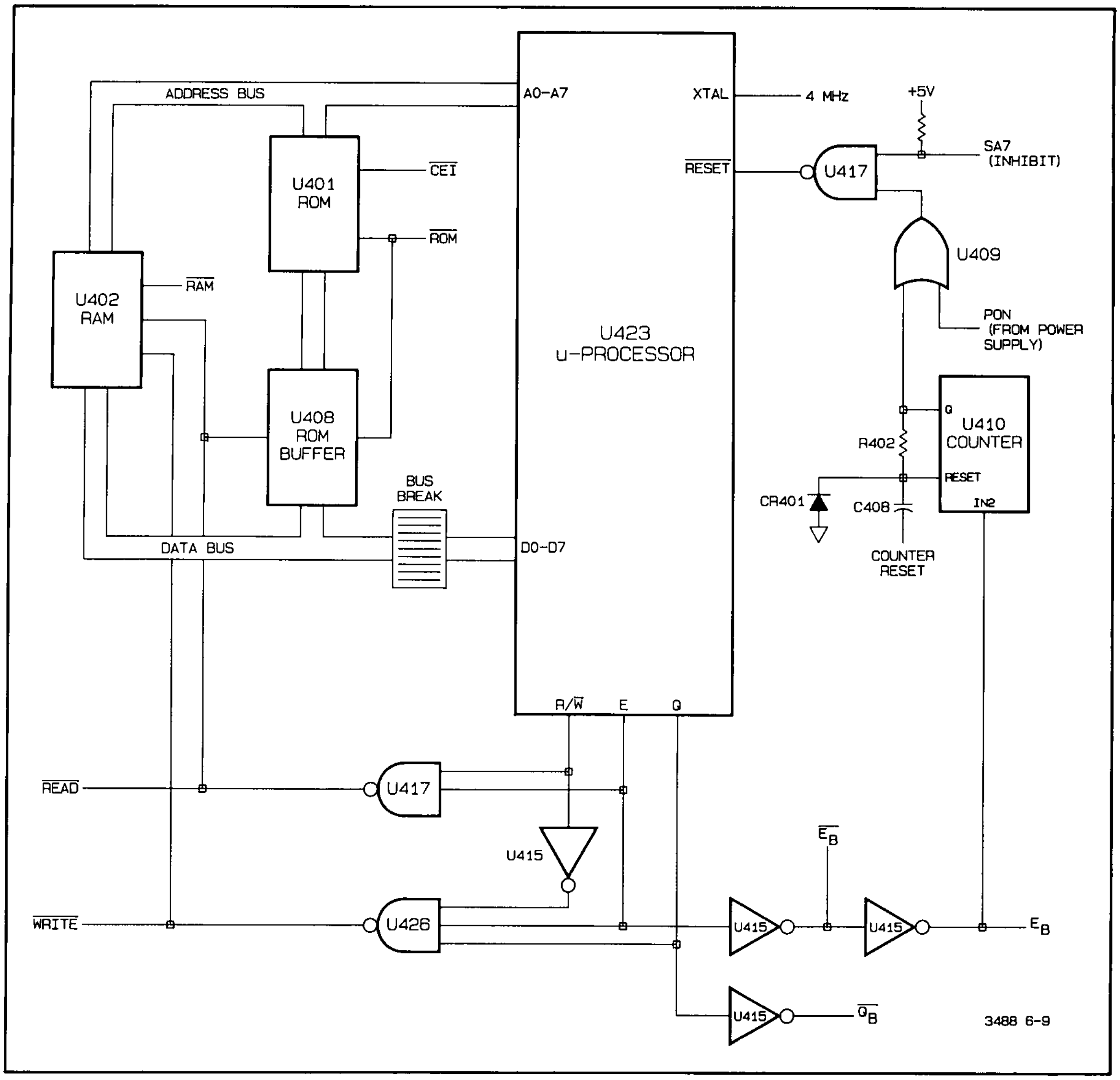



**Figure 6-5 Primary Functions Simplified Schematic**

The RAM is used to store time delay constants, stored set-ups and scan lists for the mpu. The RAM is enabled by the RAM line from the Address Decoding section. The RAM also uses the READ and WRITE lines to control the direction of the data flow.

The Bus Break is used for service purposes. This is a series of jumpers, packaged in a DIP and installed in an IC socket. The Bus Break is removed to isolate the mpu from the data bus. This will allow the mpu to cycle through all addresses to permit testing of the other devices on the bus.

The mpu has an input labeled RESET. A low on this line caused the mpu to perform an initial power on reset. This line can be set low by two sources; PON from the power supply and a line from the counter.

The PON line is a pulsed-high signal from the power supply. It indicates that all the power supplies are up and operating. The pulse is at least 150 milliseconds in duration. This is the initial power-on wake up cycle for the controller. The high pulse is inverted by the action of the nand gate, U417, and applied to the mpu.

The counter, U410, output can also force the mpu to perform a power-on reset. This counter is a simple up-counter and is driven by the buffered E clock (Eb). The counter increments at each E clock. The counter provides a reset in the case of a software failure. In normal operation, the mpu periodically sends a pulse to the counter on the line marked COUNTER RESET. This resets the counter and begins the up-count over. Should the mpu become lost, the counter reset pulse will not occur. The counter will then reach the maximum count and set the Q output high. This high will cause a power-on reset of the mpu through U409 and U417. The periodic reset of the counter is coupled through a capacitor. This coupling prevents a stuck line from continually resetting the counter and preventing a required mpu reset. The diode is provided to prevent negative overshoot of the counter reset line. By connecting the counter reset and Q output through a resistor, R402, the reset line is held low as long as the Q output is low.

## 6-34 Address Decoding

A simplified schematic of the Address Decoding is shown in Figure 6-6. A memory map is also shown on that figure. The type of mpu used in the controller requires that all devices be memory mapped. As shown on the memory map, memory is divided into two large portions of 32 Kilobytes each. The first portion is reserved for ROM. The remaining 32 Kilobytes is divided into four equal portions of 8 Kilobytes each. The first of these subdivisions is not used in the current instrument revision. The remaining three portions allocate memory for the RAM, the backplane, and other peripherals to the mpu.

The most significant address line, A15, selects either of the two large 32 Kilobyte portions of the memory. When A15 is high the ROM portion of the memory is selected.

The ROM requires two enabling inputs to be selected; ROM and CE1. The upper portion of U403 generates the CE1 pulse. U403 is a dual 2 to 4 decoder. The A15 line is connected to both the A and B inputs of the first half of U403. The Y0, Y1 and Y2 outputs are not used. When A15 is high The Y3 output is selected. The output is gated by the E clock. The Y3 output is the CE1 line.

A15 is inverted by U415 and used as the ROM enable line. When A15 is high, the ROM line is set low and enables the ROM and ROM Buffer.

When address line A15 is set low, the lower portion of the memory map is selected. The second half of U403, a 2 to 4 decoder, divides the lower portion of the memory into four 8 Kilobyte pieces. The A input is connected to address line A13 and the B input is connected to address line A14. When both A13 and A14 are set high, the 2Y3 output is active. This output is not connected. On the memory map this area is marked NOT USED.

When A14 is high and A13 is low the 2Y2 output is active. This output is the line RAM and enables the RAM, U402.

When A14 is low and A13 is high the 2Y1 output is active. This address selects the backplane portion of the memory. The 2Y1 output is routed to three places; the back plane data buffer as BP, to U413 as an enable, and to U409. At U409 the line is combined with the Qb clock, inverted by U417, and output as BPS. BPS enables the backplane data latch and address latch for write operations to the backplane.

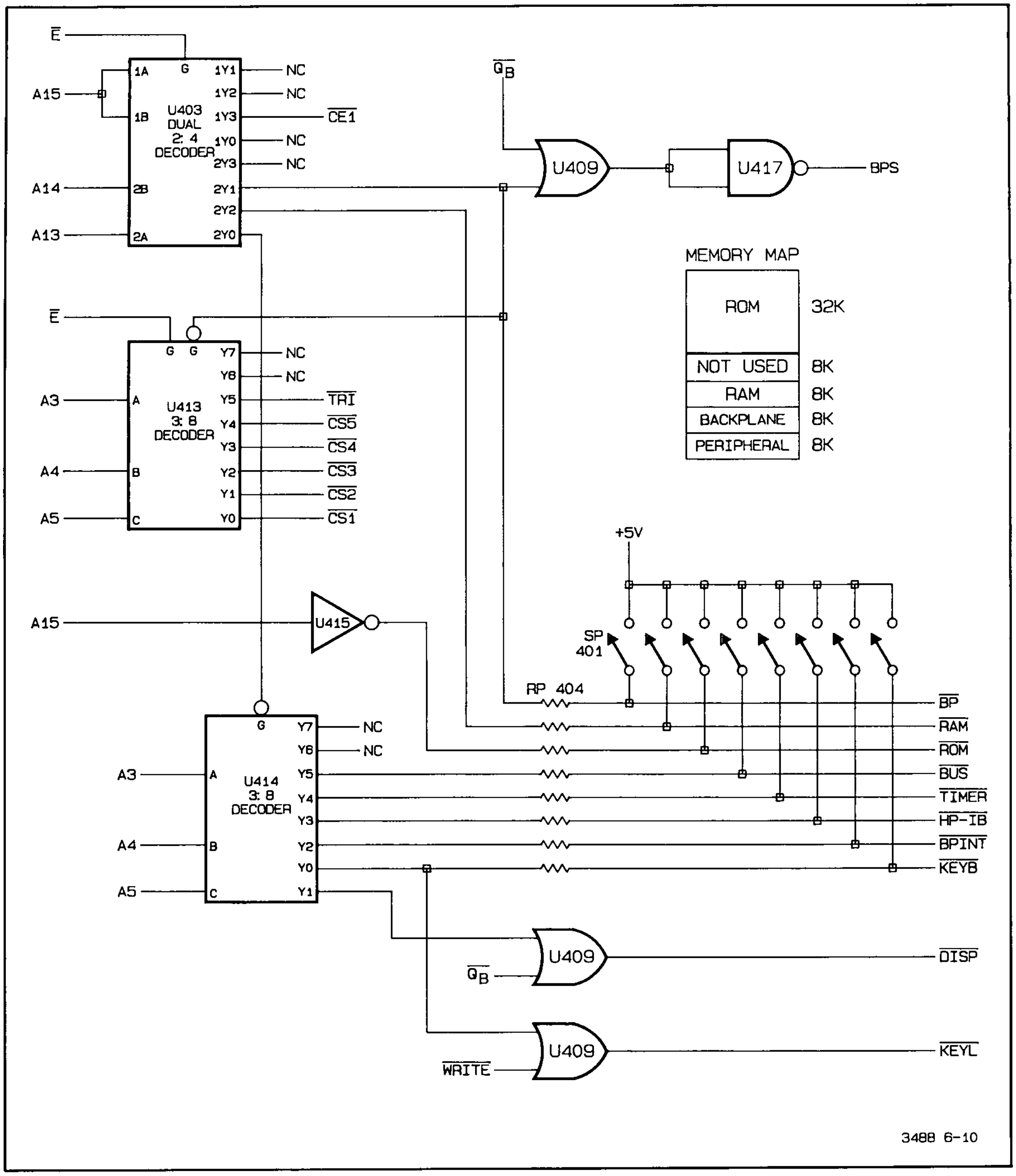



**Figure 6-6 Address Decoding Simplified Schematic**

U413 decodes the A3, A4, and A5 address lines into option card slot select lines. U403 is enabled when the backplane portion of memory is selected and by the E clock. The outputs of U413 enable specific option card slots for read operations. These outputs, CS1, CS2, CS3, CS4 and CS5, are used as enable lines to each specific option card slot. Additionally, the line TRI is output from this decoder. TRI is used to enable the outputs of the option cards for read operations.

When A14 and A13 are low the 2Y0 output of U403 is active. This selects the peripheral portion of memory. This output is used as an enable line for the 3 to 8 decoder, U414. U414 decodes the A3, A4 and A5 address lines into enabling strobes for peripheral devices on the bus.

The peripheral devices enabled by U414 and the associated enabling lines are; the HP-IB Address Buffer by BUS, the Timer by TIMER, the HP-IB Encoder by HP-IB, The Backplane Interrupt Buffer by BPINT, and the Keyboard Buffer by KEYB. The Y0 output of U414 (KEYB) is also gated with WRITE and generates the KEYL strobe. KEYL controls the keyboard scan drive lines. The Y0 output of U414 is gated with the Qb clock and generates the DISP strobe. DISP controls the transfer of data to the display during write operations.

RP404 and SP401 are included for troubleshooting purposes. By closing one of the switches in SP401, the connected strobe line is forced to the high state. This action disables the selected strobe and prevents the device reading from or writing to the bus. One device at a time may be disabled or all devices but one may be disabled. RP404 prevents damage to U403, U413 or U414 when troubleshooting.

## 6-35 Backplane Interface

A simplified schematic of the backplane interface is shown in Figure 6-7. The Backplane Interface controls the direction and timing of data flow on the backplane, addresses the option card registers, and sets read, write or 3-state operations of the option cards.

U421 and U422 latch and buffer the backplane data bus from the controller data bus. This action permits the backplane data bus to be static and results in a decreased radiated noise level from the backplane. When not following other commands, however, the controller will periodically scan all backplane slots.

U422 is the buffer and is enabled by the BP line from the Address Decoding section and the READ strobe. When both BP and READ are low, data is transferred from the backplane data bus to the controller data bus.

U421 is a latch. U421 latches the controller data bus on the backplane data bus. The latch is enabled by the R/W strobe from the mpu and the BPS line. The BPS line will be set high when the backplane portion of memory has been specified. The R/W strobe is set low by the mpu for write operations. This strobe is inverted by U415 and applied to U420. The output of U420 will be high, enabling U421, when both the BPS and R/W are high.

U421 output is also controlled by an output enable strobe. This strobe is generated by combining SERV and R/Wb in U420. The output is enabled when the OE input is low. The R/Wb will be high for read operations and low for write operations. The SERV line is tied high. This line can only be set low by the deliberate placement of a service test jumper. The OE input of U421, then, follows the R/Wb line. When R/Wb is low the output of U421 is enabled. Grounding the SERV line forces the mpu into a firmware service routine. This routine is used to check backplane and option cards. Grounding SERV enables the output of U421.

U411 and U412 latch the three least significant address lines, A0, A1 and A2, and the R/W line on the backplane. These three lines and the R/W line are latched in U411 by the Q clock. The three latched address lines are output from U411 to control register selection in the HP-IB Encoder.

U412 latches the four lines to the backplane. U412 latches the data when the BPS line is set high (set high by Address Decoding to select the backplane portion of memory).

On the backplane, the three address lines and the R/W line are used by each option card to select appropriate IC's to send or receive data.

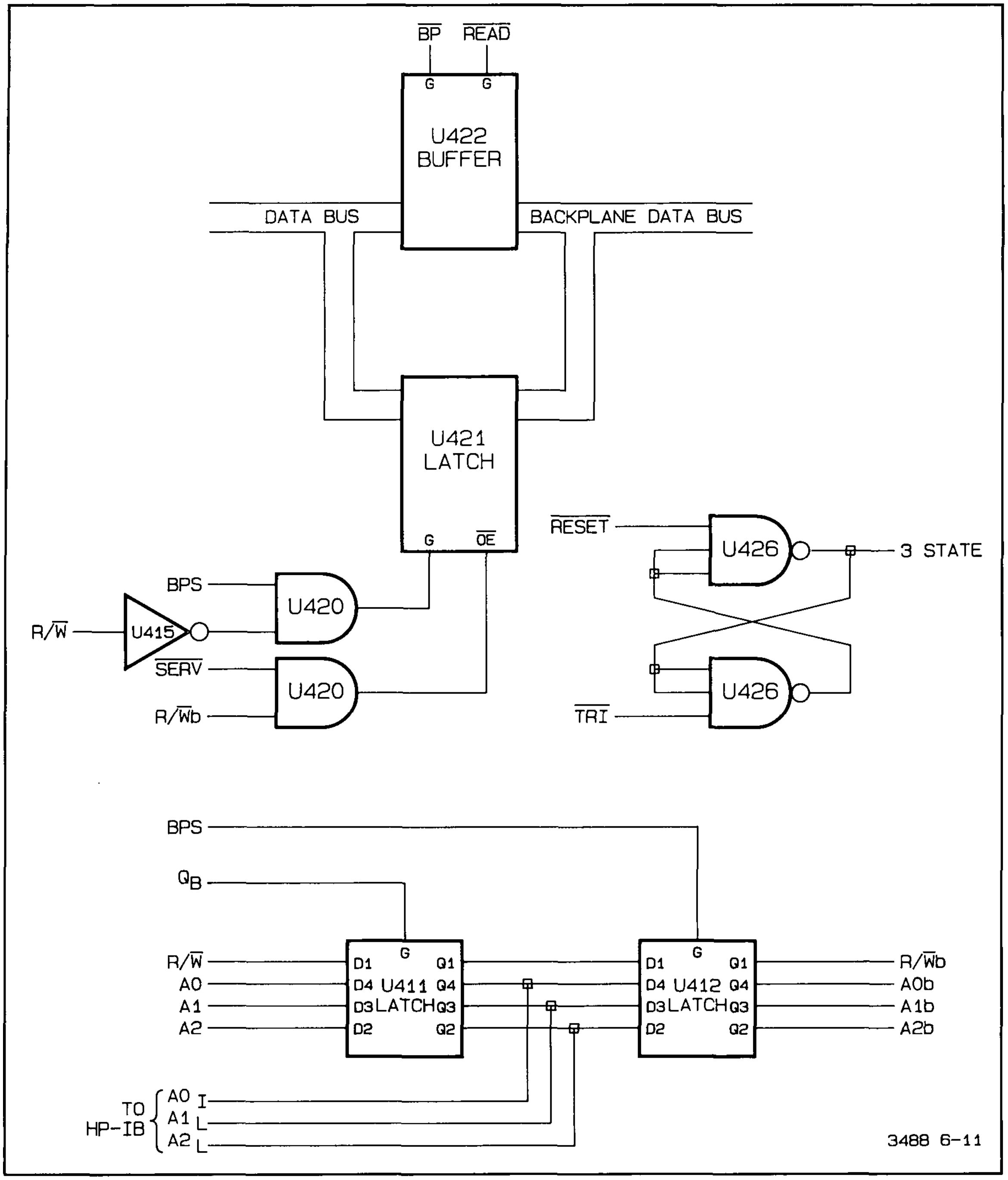



**Figure 6-7 Backplane Interface Simplified Schematic**

Also latched on the backplane is the 3-STATE line. The two portions of U426 operate as a S-R flip-flop. There are two signals used to control the flip-flop; RESET and TRI. RESET holds the 3-STATE line high at instrument wake-up to ensure that all option cards are in the three state mode and can not send data on the bus. Ultimately, RESET is controlled by the PON line from the power supply. The TRI line forces 3-STATE low and enables the option card drivers for write operations. Once 3-STATE has been set low it remains low unless primary power is cycled, U410 interrupts the mpu, or test point SA7 is grounded.

## 6-36 Interrupt Logic

A simplified schematic of the Interrupt Logic is shown in Figure 6-8. There are two types of interrupt that can be generated; a hardware interrupt and a firmware interrupt.

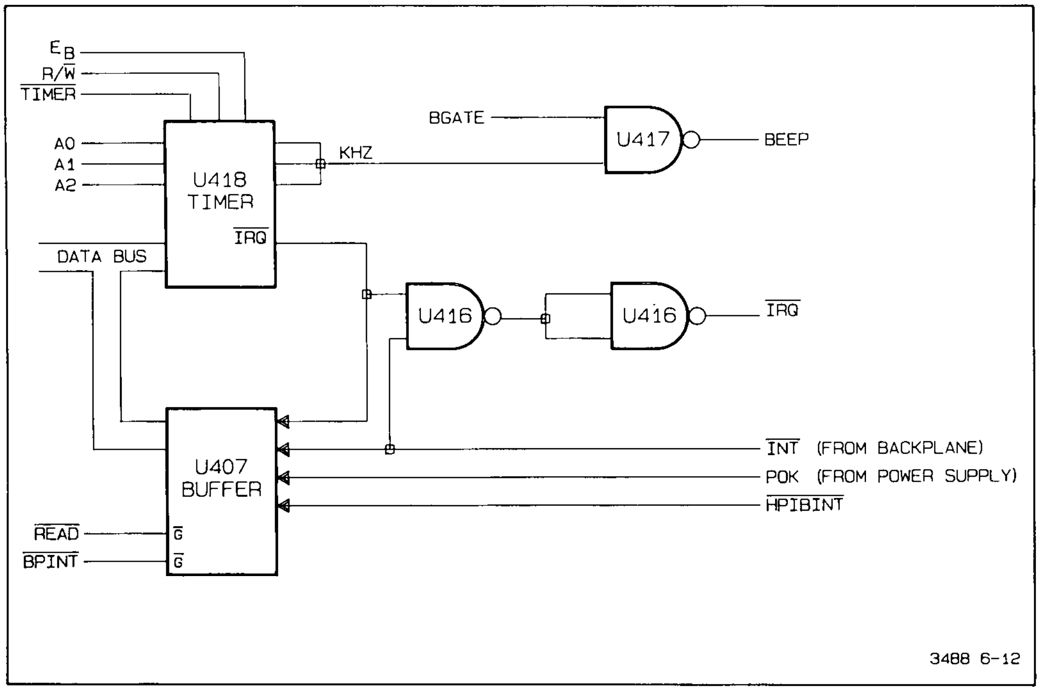



**Figure 6-8 Interrupt Logic Simplified Schematic**

U418 is a programmable timer module that provides variable system time intervals. Contained in U418 are three 16 bit binary counter, three corresponding control registers, and a status register. U418 is enabled by the TIMER strobe from the Address Decoding section. The R/W strobe is used to control the read and write operations of the timer. The three least significant address lines are used to address the control registers.

The timer performs several tasks in the controller. It provides periodic interrupts to the mpu that are used to initiate keyboard scans and display updates. The timer also controls the software delay function (see section 3-19 Delay). Another output from the timer is a 1 KHz square wave used to drive the beeper.

The KHz output of the timer is gated with BGATE at U417. BGATE is set high to allow the beeper to operate. When BGATE is high the KHz signal is sent directly to the beeper. The beeper is located on the Power Supply circuit board.

The timer interrupt is transmitted to the mpu through nand-gate U416. The IRQ output is set low to indicate the interrupt. Another interrupt to the mpu comes from the backplane. This signal is labeled INT and is generated by the external increment function on a 44474A 16 Channel Digital I/O Card.

U407 acts as a source interrupt buffer. The buffer is active when BPINT and READ are low. There are four inputs to the buffer; IRQ from the timer, INT from the backplane, POK from the power supply, and HPIBINT from the HP-IB encoder. U407 allows the mpu to identify devices that are interrupting or to poll devices for a possible interrupt.

## 6-37 Keyboard, Display, and Address Logic

The keyboard, display, and address logic is shown on Figure 6-11, the controller schematic.

The keyboard is a 6X8 matrix. Two ICs are used to scan the keyboard; U405 and U404. U405 is a latch. This latch is enabled by KEYL during write operations. The latch is used to strobe across the 6 lines of the keyboard.

U404 is a buffer. U404 is enabled by KEYB and READ. This buffer reads the 8 keyboard lines onto the data bus. By the action of the latch and the buffer, the mpu can tell which key has been pressed.

U405 also outputs the BGATE signal. This signal is used to control the beeper on the power supply board. When BGATE is high the beeper will operate.

U406 is the display latch. U406 is enabled by the DISP line. U406 latches the data bus to the display. Additionally, two outputs of U406 are used for signature analysis.

U419 is the address buffer. U419 is enabled by the BUS and READ lines. U419 buffers the status of the five address switches and SRQ switch in SP402. Additionally, the SERVICE FUNCTIONS test point is buffered by U419. When SERVICE FUNCTIONS test point is grounded, the mpu will enter a special service routine designed to test the plug-in cards. The use of this test point is described in each plug-in card's troubleshooting section.

## 6-38 CONTROLLER TROUBLESHOOTING

Service access to the Controller printed circuit board assembly requires that the instrument top cover be removed. Cover removal is described in Chapter 5. The controller board shield must also be removed (all option cards must be removed from slots 4 and 5 to access the shield). The shield removal is depicted in Figure 5-2.

## 6-39 Initial Set-Up

The following troubleshooting procedures require that the Controller be set to a known state. Before applying power to the Controller ensure that the bus break is installed in its socket (RP409). All switches on SP401 should be in the OPEN position. The HP-IB address should be set to the factory address of 9. Setting the HP-IB address is described in Section 2-16. The power on SRQ switch should be set off, as described in Section 2-17. All plug-in option cards should be removed from the mainframe.

## 6-40 Test Equipment Required

These troubleshooting procedures require the following test equipment.

| | |
|---|---|
| Signature Multimeter | HP 5005A or equivalent |

The HP 5005A Signature Multimeter is a multipurpose instrument. In addition to signature analysis this instrument has the capability of measuring frequency, voltages, time intervals, and resistance. If an HP 5005A is not available, it will be necessary to have a digital multimeter, a frequency counter, and a signature analyzer to troubleshoot the controller board.

## 6-41 Initial Checks

Front panel display symptoms of a failing controller include no display, fading displays, or randomly lit segments in the display. If one or more segments in the display are consistently missing, suspect the display itself. If the instrument does not respond to any front panel keys, a controller problem could exist. If one or more keys (typically a row or column) do not function, the keyboard should be suspected.

1. Measure the +5 Vdc on the controller board. Connect the multimeter between ground at test point SA4 and the positive end of C401. The voltage should measure +5 Vdc ±0.5 Vdc. If the voltage is not +5 Vdc, troubleshoot the power supply, the supply interconnections to the controller board, or A40L401. If the voltage is within the limits, proceed to Step 2.

2. Check the controller main clock (E). Connect the frequency counter between ground (SA4) and test point SA5. This test point should show a clock at a frequency of 1 MHz. If the clock is present, proceed to Step 3. If the clock is not present, connect the frequency counter to U416 pin 8. This should be clock at a frequency of 4 MHz. If this clock is not present, troubleshoot U416, Q401, R404, R405, R403, C412, C416 , and Y401. If the 4 Mhz clock is present, check for the presence of a clock at U423 pin 34. This should be a 1 MHz clock. If the clock is present, troubleshoot the Q and E clocks from the microprocessor through the buffers in U415. If the clock is not present, U423 is probably at fault.

3. Check the controller quadrature clock (Q). Measure the frequency of this clock at U415 pin 2. This clock should be 1 MHz. If the clock is not present, troubleshoot U415 and U423. If the clock is present proceed to Step 4.

4. Check the microprocessor interrupts. Measure the voltage at U423 pin 2. This point is driven low by grounding test point SA8 and forces the microprocessor into a service routine. This voltage should be +5 Vdc. If the voltage is not +5 Vdc, troubleshoot RP403, DP402, and U420.

Measure the voltage at pin 37 of U423. This voltage should be a steady +5 Vdc. Check for any transitions on this line (when failing, some transitions take up to a second to occur). If the voltage is not +5 Vdc or there are transitions occurring, troubleshoot RP406, U417, U409, U410, R402, CR401, C408, or U405. A detailed discussion of the operation of U410 is given in the Theory Of Operation, Section 6-31.

5. At this point, the power supply to the controller, the basic clocks in the controller, and the microprocessor interrupts have been checked. Be sure the controller is set up as described in Section 6-39. Cycle power to the instrument and probe the 16 address lines and 8 data lines for activity (transitions). This is easily accomplished with the HP 5005A probe. The light in the probe tip will blink when activity is present (the HP 5005A should be set to either kHz or signature function). An oscilloscope may also be used to check for transitions.

The 16 address lines can be accessed at pins 8 through 23 of U423. All 16 address lines should show activity.

The 8 data lines are easily accessed at the pins of the bus break (RP409). All eight lines should show activity.

If either a data line or address line appears stuck (no transitions), troubleshoot the stuck line. This is a difficult task since there are many devices on each line. One method of finding stuck lines is described in Section 6-44, Stuck Line Troubleshooting.

If activity is found on each line, proceed to Step 6.

6. Measure the frequency of the timer output at U418 pin 27. This output should be 1 kHz. If this signal is present, although not conclusive, it indicates that the timer is able to function (the timer initiates mpu scans of keyboard, display, etc.) If the timer output is not present, troubleshoot the timer circuitry (U418).

7. At this point the common failures of the controller have been identified. If the problem has still not been isolated it will be necessary to use signature analysis procedures. These procedures begin in Section 6-42.

## 6-42 Controller Signature Analysis

The following pages describe the signature analysis procedures. Each page contains the set up procedure, the area of the controller being checked, the appropriate signatures, and general notes about the test.

The procedure has been designed to be either followed in a step by step fashion, or, if the symptoms indicate a particular area of the controller, specific signatures can be observed. In each case the set-up procedure must be followed exactly to assure compatible signatures. If the procedure is used in a step by step manner, the changes in the set-up procedure between the steps are highlighted.

During the step-by-step portion of the signature analysis tests, specific devices are enabled and their output checked. If the signatures obtained are incorrect, the device or the inputs to the device could be at fault. In the NOTES section of each signature analysis procedure step, a note directs the user to a separate sheet, labeled FAILED, where input signatures to the device are given. Between the output signatures given in the STEP and the input signatures given in FAILED, a failing device can be isolated.

In general, the signature analysis procedures described in this section make use of SWP401. This switch pack allows specific devices to be disabled. The procedures record signatures on the data bus in the controller while adding devices to the bus one at a time. For this reason, if the procedures are not followed in a step-by-step manner, the procedure itself should be half-split to isolate incorrect signatures.

Also used in the first set of procedures (SA1) is RP409. This is a series of jumpers packaged in a DIP package and installed in an IC socket. Removing RP409 from the circuit isolates the microprocessor from the data bus. Note that removing RP409 also removes the pull-up resistors from the data bus.

The Initial Checks listed in Section 6-41 should be performed prior to using signature analysis. Be sure that no option cards are installed in the mainframe during the signature analysis tests.

### 6-43 SA1 and SA2

There are two main signature analysis tests. These tests are labeled SA1 and SA2. The tests in SA1 test the basic hardware in the controller. SA2 tests the read and write devices in the controller. The signatures in SA1 must be correct for the SA2 tests to work. SA2 testing begins at step 7 in the procedure. Signature analysis testing of the option cards and backplane board is given in each option card chapter of this manual.

## 6-44 Stuck Line Troubleshooting

A common problem in digital circuits is a stuck line. A line may be stuck high, stuck low, or stuck at some arbitrary value. When a stuck line is part of an address or data bus, finding the source of the problem can be difficult. The difficulty increases as the number of devices in common with the line increases.

Isolating the sources of the stuck line (typically by unsoldering a lead of an IC), one at a time, is time consuming and may damage good parts or the circuit board. This method is, ultimately, the only real proof of a failing part. The following paragraphs describe a method that may be used to reduce the number of devices suspected of the failure to a few that can then be isolated by unsoldering.

The method described here requires the use of a high resolution, high input impedance voltmeter. A recommended voltmeter is the Hewlett-Packard Model 3456A.

This method of isolation takes advantage of the physical location of the parts on the printed circuit board. The stuck line is provided with a current source (or sink) and the voltage drop across the trace resistance is measured.

Lines that are stuck low will need a current source. Typically, a 10 Kohm resistor connected between the stuck line and the +5 Vdc supply will provide an adequate source. Lines that are stuck high will require a current sink. A 10 Kohm resistor connected between the stuck line and circuit board ground will provide a sink.

Once the necessary current paths have been provided (some paths are automatically provided by pull-up resistors on the board), each device output connected to the stuck line is probed with the voltmeter. The voltage measurements should be recorded. A change in the voltages measured can give an indication of the failing device.

For example, suppose a line in the controller data bus is stuck low. A current path is provided (through RP408) by installing RP409. The voltmeter common is connected to circuit board ground. The voltage at each device output on the stuck line is now measured. The most likely device causing the problem is the device exhibiting the lowest voltage reading to ground (due to the voltage drops across the printed circuit board traces).

A line stuck high is checked in a similar manner. In this case an external resistor is connected between the stuck line and ground. Each device output is checked. The device exhibiting the highest voltage reading is the suspect device.

This method can only assist in the isolation of the bad device. The device must still be disconnected from the stuck line by unsoldering to prove the malfunction.

| **STEP 1** | **CHECKING: SA1**<br>**ADDRESS LINES (U423)** |
|---|---|

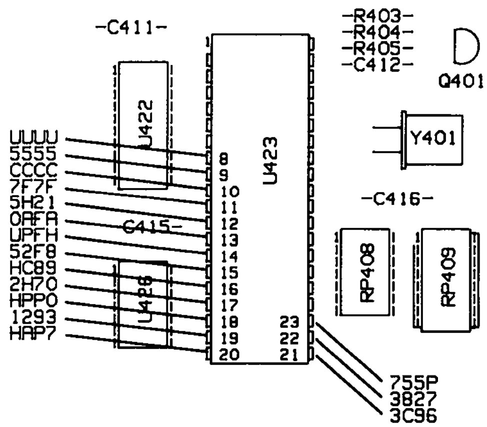
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK START STOP
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | CLOSED |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




## NOTES

1. Pins 8 through 23 of U423 are address lines AØ through A15 respectively
2. If signatures are correct, perform Step 2.
3. If signatures are incorrect, troubleshoot U423.

# STEP 2

**CHECKING: SA1**

## ROM OUTPUT (U401, U408)

03488-66540 ERC: 2642

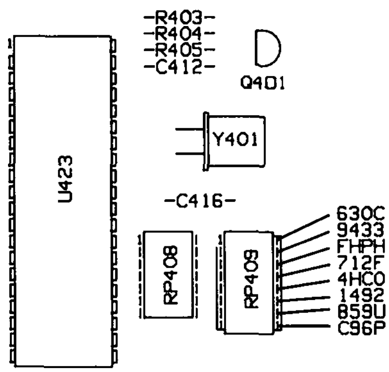
SET-UP

1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK START STOP
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | CLOSED |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




### NOTES

1. Signatures represent the ROM output to the data bus.
2. If signatures are correct, perform Step 3.
3. If signatures are incorrect, troubleshoot ROM, ROM buffer, and ROM address decoding. See Failed ROM Output (SA1) for additional troubleshooting information.

| STEP 3 | CHECKING: SA1 ADDRESS BUFFER (U419) |
|---|---|

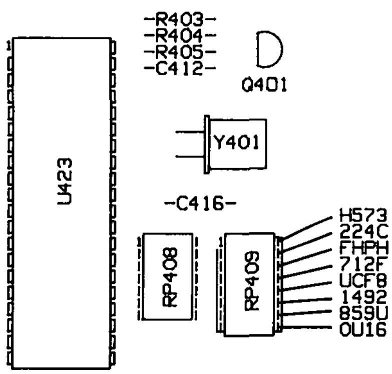
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK ⌝_ START ⌝_ STOP ⌝_
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




## NOTES

1. Signatures will be incorrect if SWP402 not correctly set.
2. If signatures are correct, perform Step 4.
3. If signatures are incorrect, troubleshoot U419 (address buffer) and address decoding. See Failed Address Buffer (SA1) for additional troubleshooting information.

# STEP 4

**CHECKING: SA1**
**BACKPLANE INTERRUPT BUFFER (U407)**

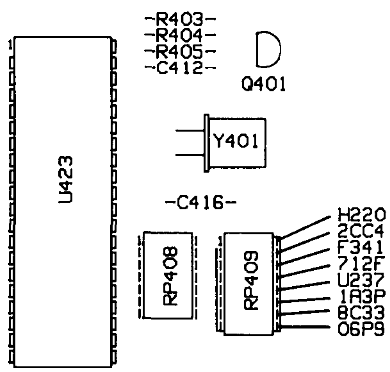
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK ⏷ START ⏷ STOP ⏷
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | OPEN |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




**NOTES**

1. If signatures are correct, perform Step 5.
2. If signatures are incorrect, troubleshoot U407 and address decoding. See Failed Backplane Interrupt Buffer (SA1) for additional troubleshooting information.

# STEP 5

**CHECKING: SA1**
**BACKPLANE BUFFER (U422)**

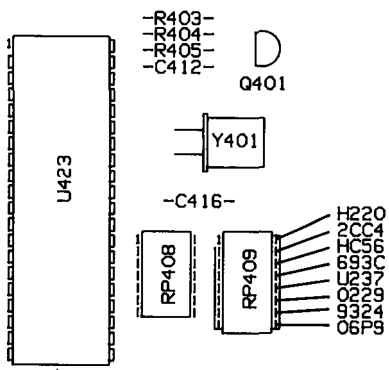
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK ⌝_ START ⌝_ STOP ⌝_
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




**NOTES**

1. If signatures are correct, perform Step 6.
2. If signatures are incorrect, troubleshoot U422 and address decoding. See Failed Backplane Buffer (SA1) for additional troubleshooting information.

# STEP 6

**CHECKING:** SA1
**KEYBOARD BUFFER (U404)**

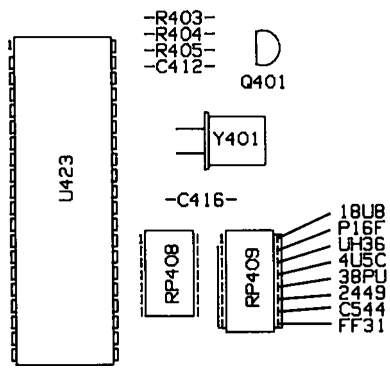
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK ⏷ START ⏷ STOP ⏷
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | OPEN |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




**NOTES**

1. If signatures are correct, perform Step 7.

2. If signatures are incorrect, troubleshoot U404 and address decoding. See Failed Keyboard Buffer (SA1) for additional troubleshooting information.

| FAILED ROM OUTPUT | CHECKING: SA1 ROM OUTPUT (U401, U408) |
|---|---|

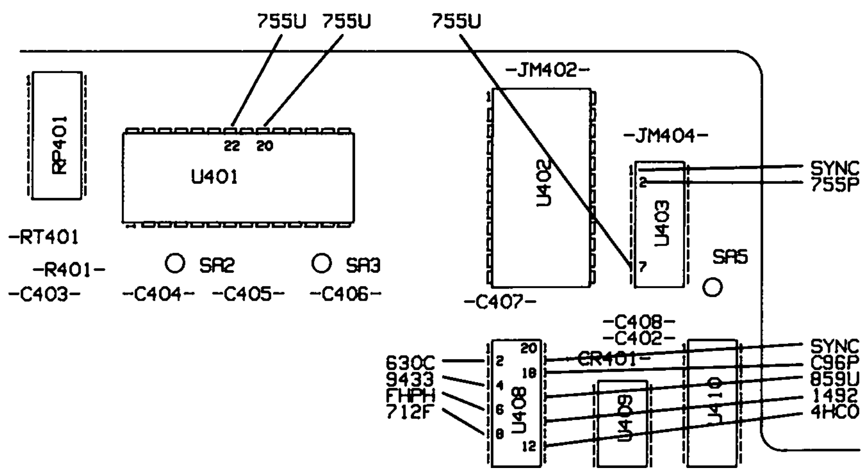
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK START STOP
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | CLOSED |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




### NOTES

1. "sync" indicates a node with no meaningful signature. These nodes are synchronous with the SA clock. Check for activity only.

2. For failing signatures, troubleshoot using Figure 6-11 (Controller Schematic).

| FAILED ADDRESS BUFFER | CHECKING: SA1 ADDRESS BUFFER (U419) |
|---|---|

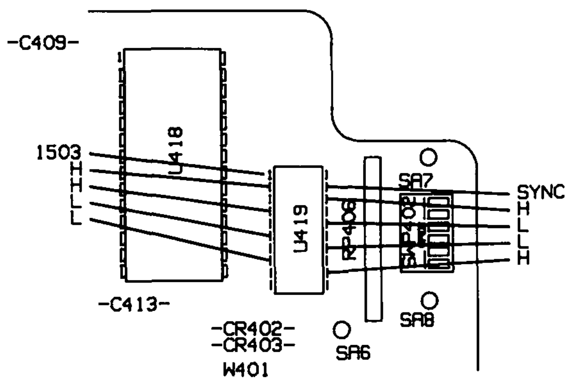
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK ⌐_ START ⌐_ STOP ⌐_
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




## NOTES

1. "sync" indicates a node with no meaningful signature. These nodes are synchronous with the SA clock. Check for activity only.
2. "H" indicates pin is high.
3. "L" indicates pin is low.
4. Troubleshoot using Figure 6-11 (Controller Schematic).

| **FAILED BACKPLANE INTERRUPT BUFFER** | **CHECKING: SA1** **BACKPLANE INTERRUPT (U407)** |
|---|---|

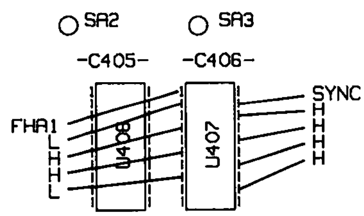
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK ⏋_ START ⏋_ STOP ⏋_
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | OPEN |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




## NOTES

1. "sync" indicates a node with no meaningful signature. Node is synchronous with the SA clock. Check for activity only.
2. "H" indicates pin is high.
3. "L" indicates pin is low.
4. Troubleshoot using Figure 6-11 (Controller Schematic).

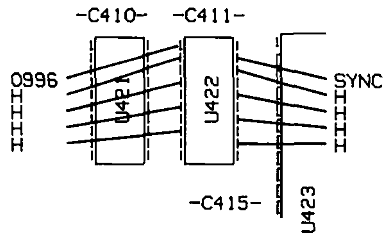
| FAILED BACKPLANE BUFFER | CHECKING: SA1 BACKPLANE BUFFER (U422) |
|---|---|

03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK START STOP
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

| SWP401 TABLE | |
|---|---|
| **SWITCH** | **POSITION** |
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




## NOTES

1. "sync" indicates a node with no meaningful signature. Node is synchronous with the SA clock. Check for activity only.

2. "H" indicates pin is high.

3. "L" indicates pin is low.

4. Troubleshoot using Figure 6-11 (Controller Schematic).

| FAILED KEYBOARD BUFFER | CHECKING: SA1 KEYBOARD BUFFER (U404) |
|---|---|

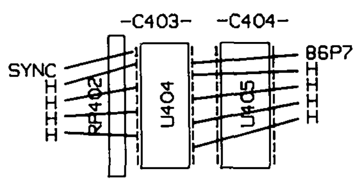
03488-66540 ERC: 2642

SET-UP
1. REMOVE ALL OPTION CARDS
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA1
5. STOP/QUAL: SA1
6. CLOCK: SA5
7. GROUND: SA4
8. JUMPER SA7 TO GROUND (SA4)
9. POLARITY: CLOCK ⏋_ START ⏋_ STOP ⏋_
10. REMOVE RP409
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | OPEN |
| SWP401-8 | CLOSED |

+5 Vdc: 0001




### NOTES

1. "sync" indicates a node with no meaningful signature. Node is synchronous with the SA clock. Check for activity only.
2. "H" indicates pin is high.
3. "L" indicates pin is low.
4. Troubleshoot using Figure 6-11 (Controller Schematic).

# STEP 7

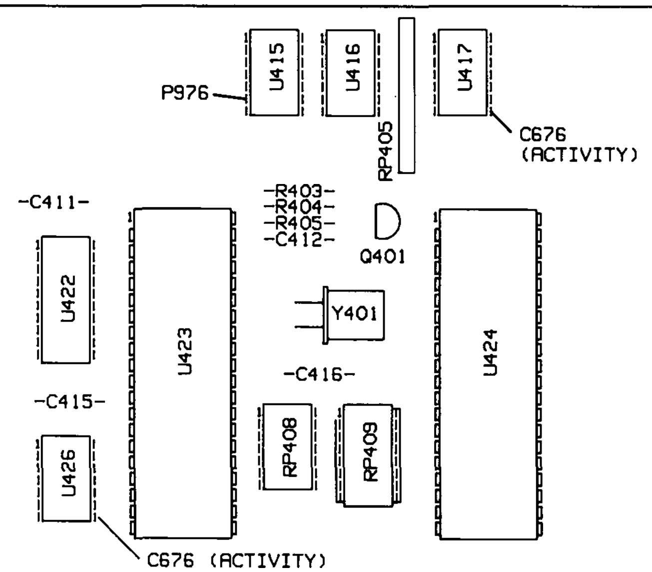
**CHECKING: SA2**
## $\overline{\text{READ}}$, $\overline{\text{WRITE}}$, R/$\overline{\text{W}}$

03488-66540 ERC: 2642

SET-UP
1. SET ALL SWP401 SWITCHES OPEN
2. INSTALL RP409
3. HP-IB ADDRESS SET TO 09
4. POWER ON SRQ SET TO OFF
5. START/ST/SP:SA2
6. STOP/QUAL: SA3
7. CLOCK: SA5
8. GROUND: SA4
9. POLARITY: CLOCK ⎺\⎽ START ⎺\⎽ STOP ⎽/⎺
10. APPLY POWER THEN GROUND SA8
11. SET SWITCHES SWP401-1 THRU 8 (see Table)

| SWP401 TABLE | |
|---|---|
| **SWITCH** | **POSITION** |
| SWP401-1 | OPEN |
| SWP401-2 | CLOSED |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




### NOTES

1. Initially, all SWP401 switches must be set open and power must be applied before grounding SA8.
2. Signatures on U415 represents R/$\overline{\text{W}}$.
3. Signature on U417 represents $\overline{\text{READ}}$, probe should show activity at this node.
4. Signature on U426 represents $\overline{\text{WRITE}}$, probe should show activity at this node.
5. If signatures are correct, perform Step 8.
6. If signatures are incorrect, troubleshoot the $\overline{\text{READ}}$, $\overline{\text{WRITE}}$ and R/$\overline{\text{W}}$ circuits, additional troubleshooting information is given in Failed $\overline{\text{READ}}$, $\overline{\text{WRITE}}$, R/$\overline{\text{W}}$ (SA2).

# STEP 8

**CHECKING: SA2**

## TIMER (U418)

03488-66540 ERC: 2642

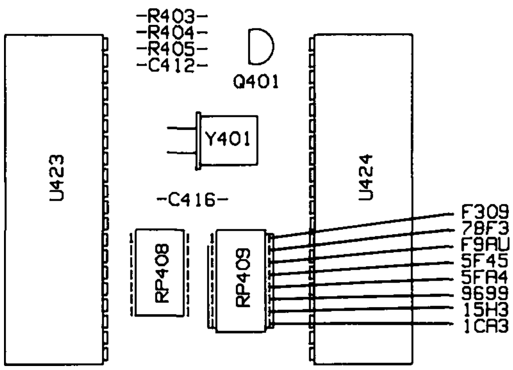
SET-UP

1. INSTALL RP 409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌐_ START ⌐_ STOP _/¯
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




### NOTES

1. Power must be applied before grounding SA8.
2. If signatures are correct, perform Step 9.
3. If signatures are incorrect, troubleshoot U418. See Failed Timer (SA2) for additional troubleshooting information.

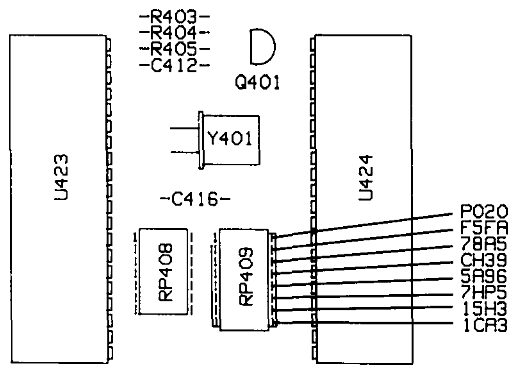
| STEP 9 | CHECKING: SA2<br>**HP-IB (U424)** |
|---|---|

03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌐_ START ⌐_ STOP_/¯
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

| SWP401 TABLE | |
|---|---|
| **SWITCH** | **POSITION** |
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




## NOTES

1. Power must be applied before grounding SA8.
2. If signatures are correct, perform Step 10.
3. If signatures are incorrect, troubleshoot U424, U425 and U427. See Failed HP-IB (SA2) for additional troubleshooting information.

# STEP 10

**CHECKING: SA2**
## BACKPLANE LATCH (U421)

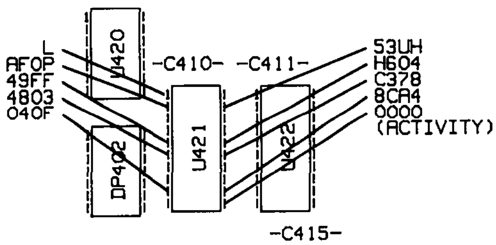
03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌐_ START ⌐_ STOP _/¯
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




### NOTES

1. Power must be applied before grounding SA8.
2. If signatures are correct, perform Step 11.
3. If signatures are incorrect, troubleshoot U421 using Figure 6-11 (Controller Schematic). Input signatures to U421 pins, 3, 4, 7, 8, 13, 14, 17, and 18 are the same as the signatures obtained in Step 9.
4. "L" indicates pin is low.

# STEP 11

**CHECKING: SA2**
## ADDRESS LATCH (U412)

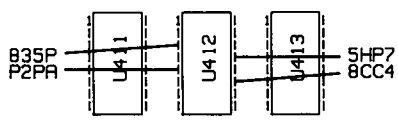
03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌐_ START ⌐_ STOP _/¯
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




**NOTES**

1. Power must be applied before grounding SA8.
2. If signatures are correct, perform Step 12.
3. If signatures are incorrect, troubleshoot U411 and U412. See Failed Address Latch (SA2) for additional troubleshooting information.

| STEP 12 | CHECKING: SA2<br>**BACKPLANE BUFFER (U422)** |
|---|---|

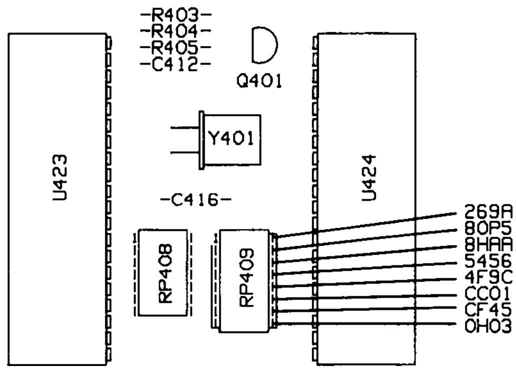
03488-66540 ERC: 2642

SET-UP

1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌐_ START ⌐_ STOP _/‾
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

| SWP401 TABLE | |
|---|---|
| **SWITCH** | **POSITION** |
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




## NOTES

1. Power must be applied before grounding SA8.
2. If signatures are correct, perform Step 13.
3. If signatures are incorrect, troubleshoot U422. See Failed Backplane Buffer (SA2) for additional troubleshooting information. The Backplane Buffer was statically tested in SA1 Step 5.

| **STEP 13** | **CHECKING: SA2**<br>**RAM (U402)** |
|---|---|

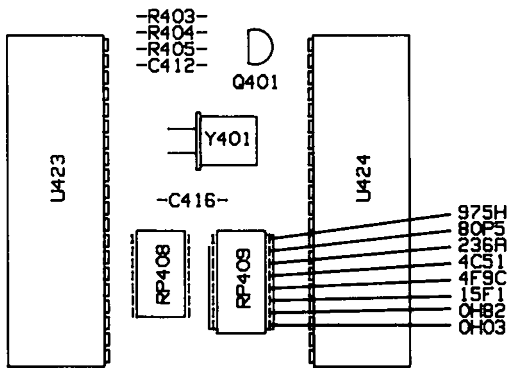
03488-66540 ERC: 2642

SET-UP

1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌝_ START ⌝_ STOP _/⌜
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

| SWP401 TABLE | |
|---|---|
| **SWITCH** | **POSITION** |
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | OPEN |
| SWP401-8 | OPEN |

+5 Vdc: C676




**NOTES**

1. Power must be applied before grounding SA8.
2. If signatures are correct, perform Step 14.
3. If signatures are incorrect, troubleshoot U402. See Failed RAM (SA2) for additional troubleshooting information.

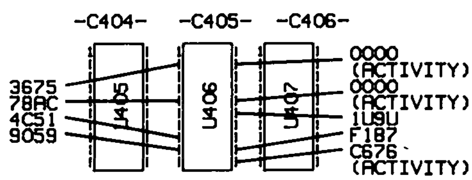
| STEP 14 | CHECKING: SA2<br>DISPLAY DRIVER (U406) |
|---|---|

03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌝_ START ⌝_ STOP _/¯
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

| SWP401 TABLE | |
|---|---|
| **SWITCH** | **POSITION** |
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | OPEN |
| SWP401-8 | OPEN |

+5 Vdc: C676




## NOTES

1. Power must be applied before grounding SA8.
2. If signatures are correct and display does not work, display or display cable should be suspected.
3. Input signatures to U406 are the same as signatures obtained in Step 13.
4. If display works and signatures are correct, perform Step 15.

# STEP 15

**CHECKING: SA2**

## KEYBOARD DRIVER (U405)

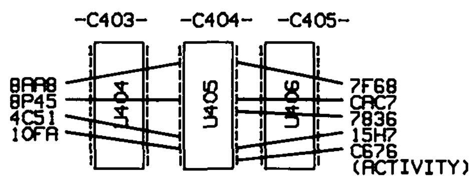
03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌐_ START ⌐_ STOP_/¯
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | OPEN |
| SWP401-8 | OPEN |

+5 Vdc: C676




**NOTES**

1. Power must be applied before grounding SA8.
2. Correct signatures may be traced to the inputs of U404 through the keyboard. Use Figure 6-11 (Controller Schematic) to identify the signature, U404 input, and key to press.
3. Input data bus signatures are the same as signatures obtained in Step 13.
4. If signatures are correct and keyboard functions, perform Step 16.

# STEP 16

**CHECKING: SA2**
**BEEP DRIVE (U417)**

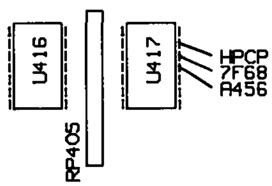
03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌐_ START ⌐_ STOP_/¯
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | OPEN |
| SWP401-8 | OPEN |

+5 Vdc: C676




## NOTES

1. Power must be applied before grounding SA8.
2. Pin 11 is output to Power Supply circuit board to drive beeper. If signature at pin 11 is correct and beep does not function, troubleshoot beep circuitry on Power Supply.

| **FAILED READ, WRITE, R/W** | **CHECKING: SA2 READ, WRITE, R/W** |
|---|---|

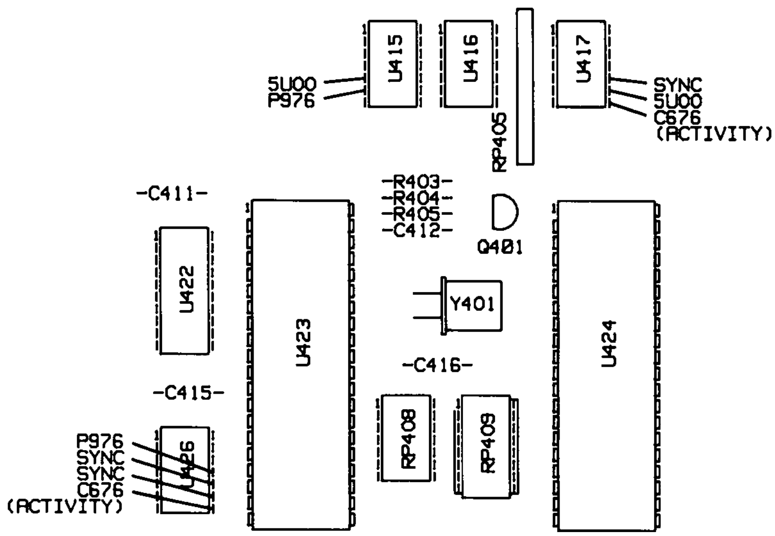
03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ‾_ START ‾_ STOP _/‾
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | CLOSED |
| SWP401-3 | CLOSED |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




**NOTES**

1. Power must be applied before grounding SA8.
2. Check signatures on U415 first, the other signatures require that these be correct.
3. Troubleshoot using Figure 6-11 (Controller Schematic).
4. ''sync'' indicates a node with no meaningful signature. Node is synchronous with the SA clock. Check for activity only.

| FAILED TIMER | CHECKING: SA2 TIMER (U418) |
|---|---|

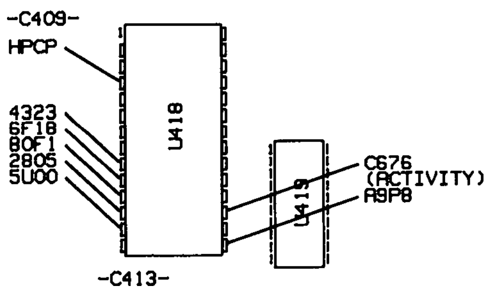
03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⏋_ START ⏋_ STOP _/‾
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | CLOSED |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




**NOTES**

1. Power must be applied before grounding SA8.
2. Inputs are pins 10, 11, 12, 13, 15 and 17. These signatures must be correct for other signatures to be correct.
3. Troubleshoot using Figure 6-11 (Controller Schematic).

| **FAILED HP-IB** | **CHECKING: SA2 HP-IB (U424)** |
|---|---|

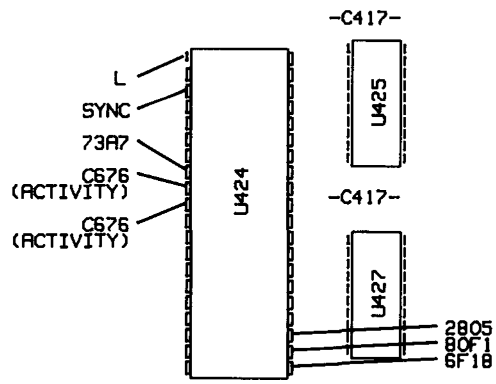
03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌝_ START ⌝_ STOP _/⌝
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




**NOTES**

1. Power must be applied before grounding SA8.
2. "sync" indicates a node with no meaningful signature. Node is synchronous with SA clock. Check for activity only.
3. "L" indicates pin is low.
4. If signatures at pins 21, 22, and 23 are incorrect, see Failed Address Latch for additional troubleshooting information.

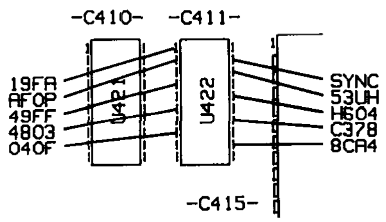
| **FAILED BACKPLANE BUFFER** | **CHECKING: SA2**<br>**BACKPLANE BUFFER (U422)** |
|---|---|

03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌐_ START ⌐_ STOP_/‾
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

| **SWP401 TABLE** | |
|---|---|
| **SWITCH** | **POSITION** |
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

+5 Vdc: C676




## NOTES

1. Power must be applied before grounding SA8.
2. "sync" indicates a node with no meaningful signature. Node is synchronous with SA clock. Check for activity only.
3. Troubleshoot using Figure 6-11 (Controller Schematic).

| FAILED RAM | CHECKING: SA2 RAM (U402) |
|---|---|

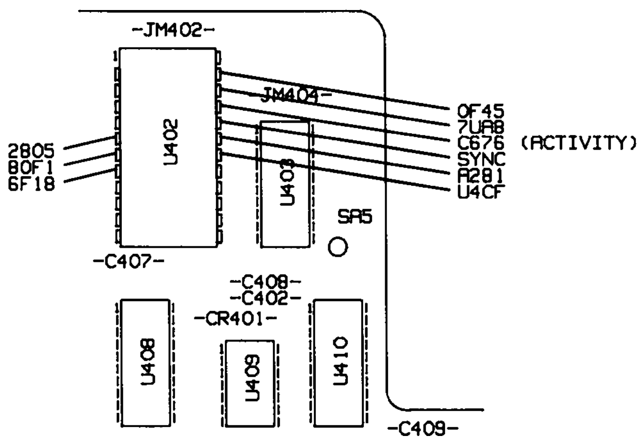
03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⌝_ START ⌝_ STOP _/⌐
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

**SWP401 TABLE**

| SWITCH | POSITION |
|---|---|
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | OPEN |
| SWP401-6 | OPEN |
| SWP401-7 | OPEN |
| SWP401-8 | OPEN |

+5 Vdc: C676




## NOTES

1. Power must be applied before grounding SA8.
2. RAM outputs are given in Step 13.
3. Pins 18, 20 and 21 are enable inputs.
4. ''sync'' indicates a node with no meaningful signature. Node is synchronous with SA clock. Check for activity only.
5. Troubleshoot using Figure 6-11 (Controller Schematic).

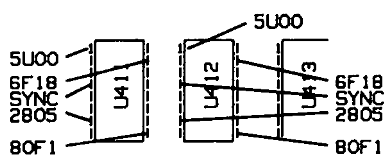
| FAILED ADDRESS LATCH | CHECKING: SA2 ADDRESS LATCHES (402, U412) |
|---|---|

03488-66540 ERC: 2642

SET-UP
1. INSTALL RP409
2. HP-IB ADDRESS SET TO 09
3. POWER ON SRQ SET TO OFF
4. START/ST/SP:SA2
5. STOP/QUAL: SA3
6. CLOCK: SA5
7. GROUND: SA4
8. POLARITY: CLOCK ⏋_ START ⏋_ STOP _⌈
9. APPLY POWER THEN GROUND SA8
10. SET SWITCHES SWP401-1 THRU 8 (see Table)

| SWP401 TABLE | |
|---|---|
| **SWITCH** | **POSITION** |
| SWP401-1 | OPEN |
| SWP401-2 | OPEN |
| SWP401-3 | OPEN |
| SWP401-4 | OPEN |
| SWP401-5 | CLOSED |
| SWP401-6 | CLOSED |
| SWP401-7 | CLOSED |
| SWP401-8 | CLOSED |

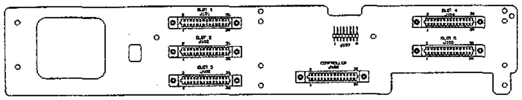
+5 Vdc: C676




### NOTES

1. Power must be applied before grounding SA8.
2. Check U411 first, signatures on U412 require correct signatures on U411.
3. Troubleshoot using Figure 6-11 (Controller Schematic).
4. ''sync'' indicates a node with no meaningful signature. Node is synchronous with SA clock. Check for activity only.

Backplane
Schematic



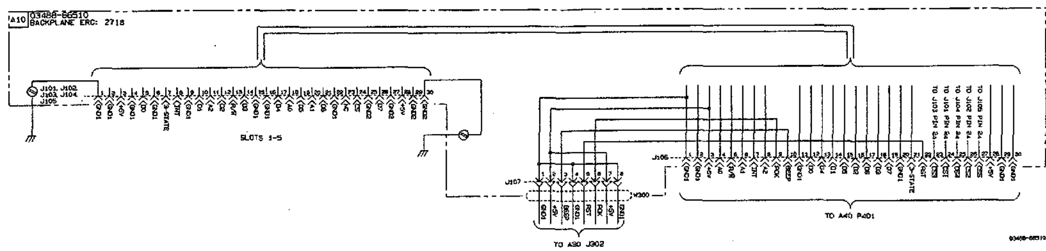
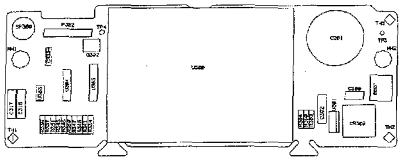


Figure 6-9 Backplane Schematic

Power Supply Schematic (See also high resolution scan at end of document)



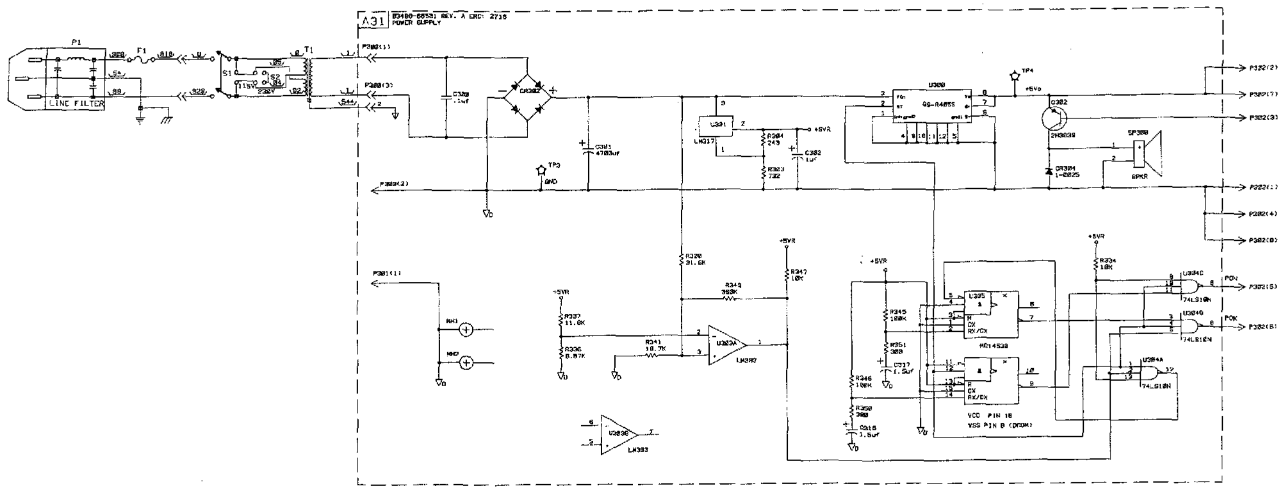
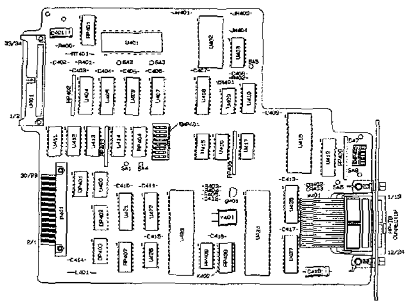
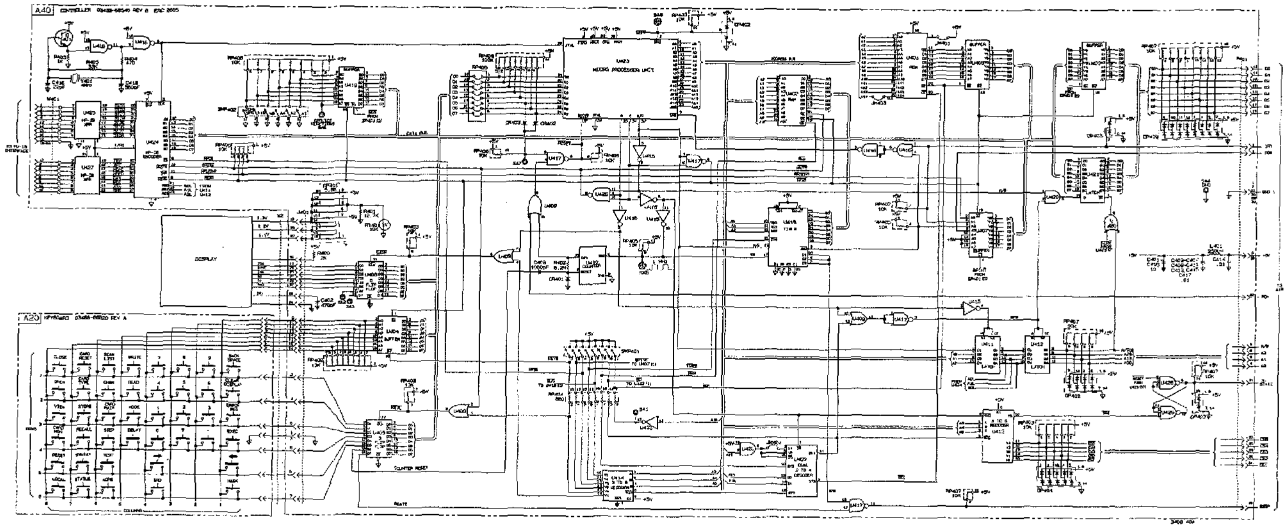


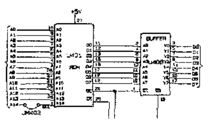
Figure 6-10 Power Supply Schematic

Controller Board Schematic (See also high resolution scan at end of document)





For 03488-66540 Rev. B ERC 2341 the following component locator and schematic change to U401 apply:



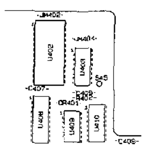


Figure 6-11 Controller Schematic

# Chapter VII
# BACKDATING

# CHAPTER VII

## TABLE OF CONTENTS

# CHAPTER VII
# BACKDATING

## 7-1 INTRODUCTION

This chapter contains information required to adapt this manual to instruments with serial numbers and engineering revision codes lower than the ones listed on the title page. The instrument serial number is used to identify changes to the mechanical aspects of the HP 3488A. The engineering revision code is used on each electrical assembly to identify changes to that assembly. A complete description of the engineering revision code is given in Section 6-6 of this manual.

## 7-2 MECHANICAL CHANGES

### 7-3 3488A Top Cover Change

Beginning with serial number 2240A1858 the top cover, bottom cover and fasteners were changed. The change occurred because the plating on the fasteners was found to flake off when the covers were attached, leaving metal particles inside the instrument. The new covers use a larger diameter, shorter screw fastener and a longer threaded insert in the top cover. To accommodate the longer threaded insert, the printed circuit board guides had to be modified slightly. If replacing the top cover or bottom cover on instruments with serial numbers 2240A1857 or below, order Enclosure Retrofit Kit, part number 03488-68701. This kit contains all the necessary hardware to retrofit the instrument covers. The original fasteners can be obtained by ordering HP part number 0515-0754.

### 7-4 3488A Switch Assembly Mounting Change

Serial number unknown. The line power switch assembly (MP33 in Figure 5-6) was mounted to the power supply bracket (MP35 in Figure 5-6) using a screw (MP34 in Figure 5-6) into a threaded insert. On later instruments, the threaded insert was replaced by a nut (MP53 in Figure 5-6). The change was incorporated to aid production assembly procedures.

## 7-5 ELECTRICAL CHANGES

### 7-6 03488-66540 Controller

Controller printed circuit boards with ERC codes 2338 used a socket to mount U401. This socket was later removed and the IC soldered directly into the board. The printed circuit board traces were also changed. The change is NOT retrofitable. If the IC socket should fail, a replacement socket can be obtained by ordering part number 1200-0469. The ERC was changed to 2341 and the printed circuit board revision was changed to revision B.

New ROM code was added and a different ROM pin-out was used on printed circuit boards with ERC of 2605. The new ROM code eliminates the possibility of HP-IB hangup under certain unique application/timing situations. The new ROM is not retrofitable. To use the new ROM on boards with ERC 2338 or 2341, order service kit 03488-68702 which contains the new memory device with installation instructions.

Figure 7-1 contains the signature changes corresponding to the 1818-3306 ROM. The SET-UP and NOTES for each SA test do not change. Those tests not listed here are valid in section VI for either the 1818-3306 ROM or the ERC 2605 ROM (1818-3830).

## 7-7 44470A 10-Channel Relay Multiplexer

HP 44470A printed circuit boards with ERC codes 2338 used a 1.8 Kohm resistor (part number 0683-1825) for R901, R902, R903, R912, R914, R915 and R916. This resistor was changed to a 2.7 Kohm resistor (part number 0683-2725). The resistor value was increased to decrease the base drive current of transistors Q901, Q903, Q904, Q905, Q906, Q907 and Q908 and so decrease the power dissipation.

If a failure is encountered in these resistors on boards with ERC 2338, it is recommended that all the resistors be changed to the new value. If this modification is performed, mark the letter "A" on the board, next to the ERC label, with permanent ink. The letter "A" will indicate that this modification has been performed. When this change was implemented on new boards, the engineering revision code was changed to 2340.

Prior to ERC 2601, a different connector was used. Form, fit and function of the previous connector is identical to that used on ERC 2601. If a connector needs replacing, replace with 5180-6636 regardless of ERC. Prior to ERC 2608, a different capacitor was used for C905 (5180-0254). Replace with part number listed in Section VI regardless of ERC.

## 7-8 44471A 10 Channel General Purpose Relay

HP 44471A printed circuit boards with ERC codes 2338 used a 1.8 Kohm resistor (part number 0683-1825) for R901, R902, R903, R912, R914, R915 and R916. This resistor was changed to a 2.7 Kohm resistor (part number 0683-2725). The resistor value was increased to decrease the base drive current of transistors Q901, Q903, Q904, Q905, Q906, Q907 and Q908 and so decrease the power dissipation.

If a failure is encountered in these resistors on boards with ERC 2338, it is recommended that all the resistors be changed to the new value. If this modification is performed, mark the letter "A" on the board, next to the ERC label, with permanent ink. The letter "A" will indicate that this modification has been performed.

When this change was implemented on new boards, the engineering revision code was changed to 2340.

## 7-9 44473A 4X4 Matrix Switch

HP 44473A printed circuit boards with ERC codes 2338 used a 1.8 Kohm resistor (part number 0683-1825) for R901, R902, R903, R912, R914, R915 and R916. This resistor was changed to a 2.7 Kohm resistor (part number 0683-2725). The resistor value was increased to decrease the base drive current of transistors Q901, Q903, Q904, Q905, Q906, Q907 and Q908 and so decrease the power dissipation.

If a failure is encountered in these resistors on boards with ERC 2338, it is recommended that all the resistors be changed to the new value. If this modification is performed, mark the letter "A" on the board, next to the ERC label, with permanent ink. The letter "A" will indicate that this modification has been performed.

When this change was implemented on new boards, the engineering revision code was changed to 2340.

## 7-10 44474A 16 Channel Digital Input/Output

HP 44474A printed circuit boards with ERC 2338 used part number 1855-0423 for FETs Q901 through Q916. An improved part was later used. If a failure is encountered with Q901 through Q916, it is recommended that the new part number be used as a replacement. The new part number is 1855-0564.

If all 16 of the FETs on the printed circuit board have been replaced by the new part number, mark the board, next to the ERC label, with the letter "B". The letter "B" will indicate that the modification has been performed.

When this change was implemented on new boards, the engineering revision code was changed to 2429.

Prior to ERC 2609, pins 1 of U903 and U904 (Output Enable) were grounded. This allowed these two IC's to be enabled in an unknown state for 250 milliseconds at power-up after which time the instrument initializes the card to a known state. During this momentary enable, certain I/O lines were pulled low. The ERC 2609 board connects U903 and U904 pin 1 to U902 pin 1 which is controlled by line "3-state" which prevents enable at power-up and assures a tri-state condition on the I/O lines.

## 7.11 03488-66510 Backplane

Prior to ERC 2551, different card edge connectors were used. Form, fit and function of the previous connector is identical to that used on ERC 2551. If a connector needs replacing, replace with 5180-8211 regardless of ERC.

## 7.12 03488-66530 Power Supply

Prior to serial numbers prefixed 2719A, a different power supply board was used. The old power supply, 03488-66530, used discrete components for regulation and protection. The newer power supply, 03488-66531, has a self-contained regulator which replaces much of the old circuitry. The new power supply is compatible with all older instruments.

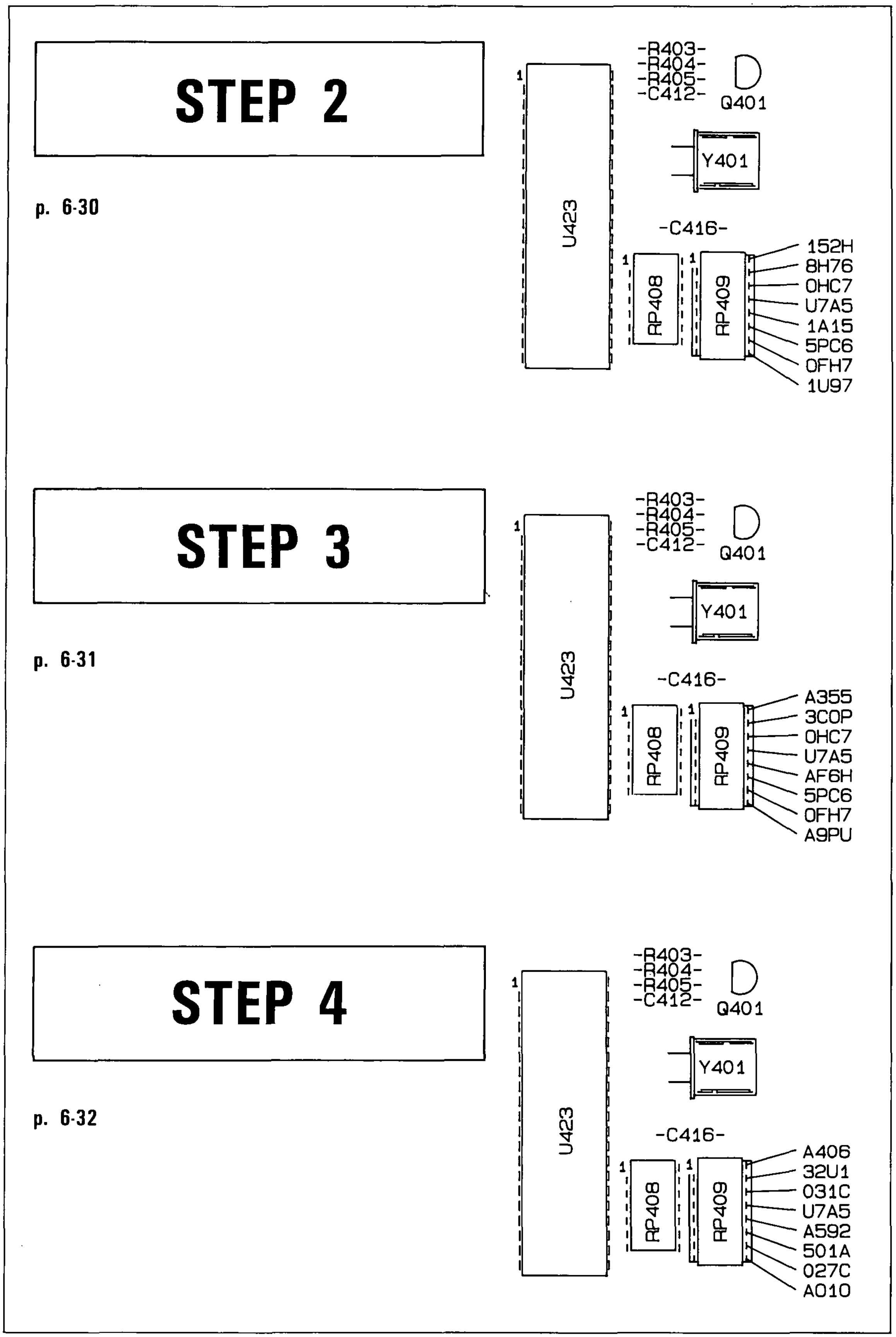
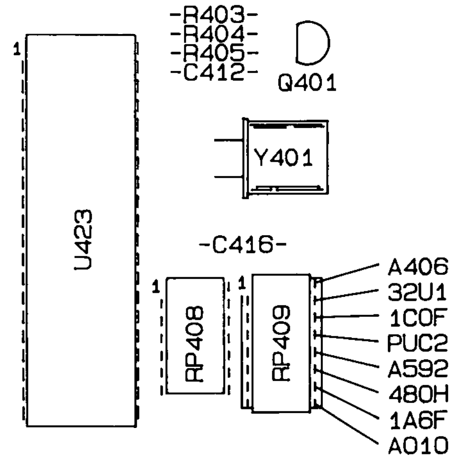



**Figure 7-1. Signature Changes for 1818-3306 ROM (ERC 2338 and 2341)**

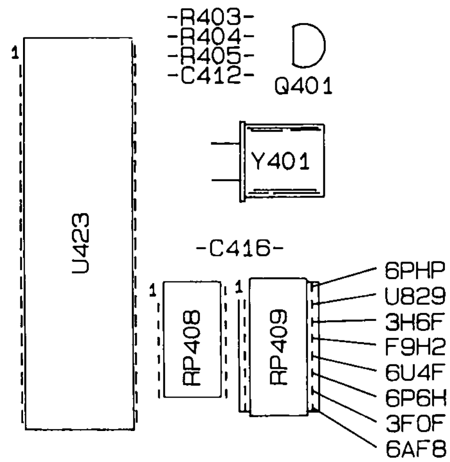
## STEP 5

p. 6-33




## STEP 6

p. 6-34




## FAILED ROM OUTPUT

p. 6-35

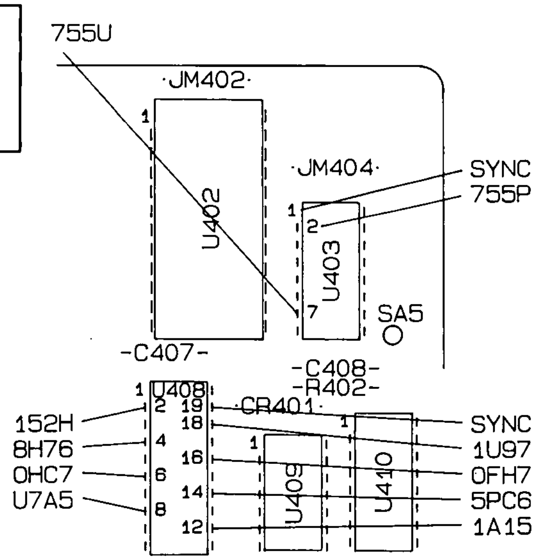



**Figure 7-1. Signature Changes for 1818-3306 ROM (ERC 2338 and 2341) (Cont'd)**

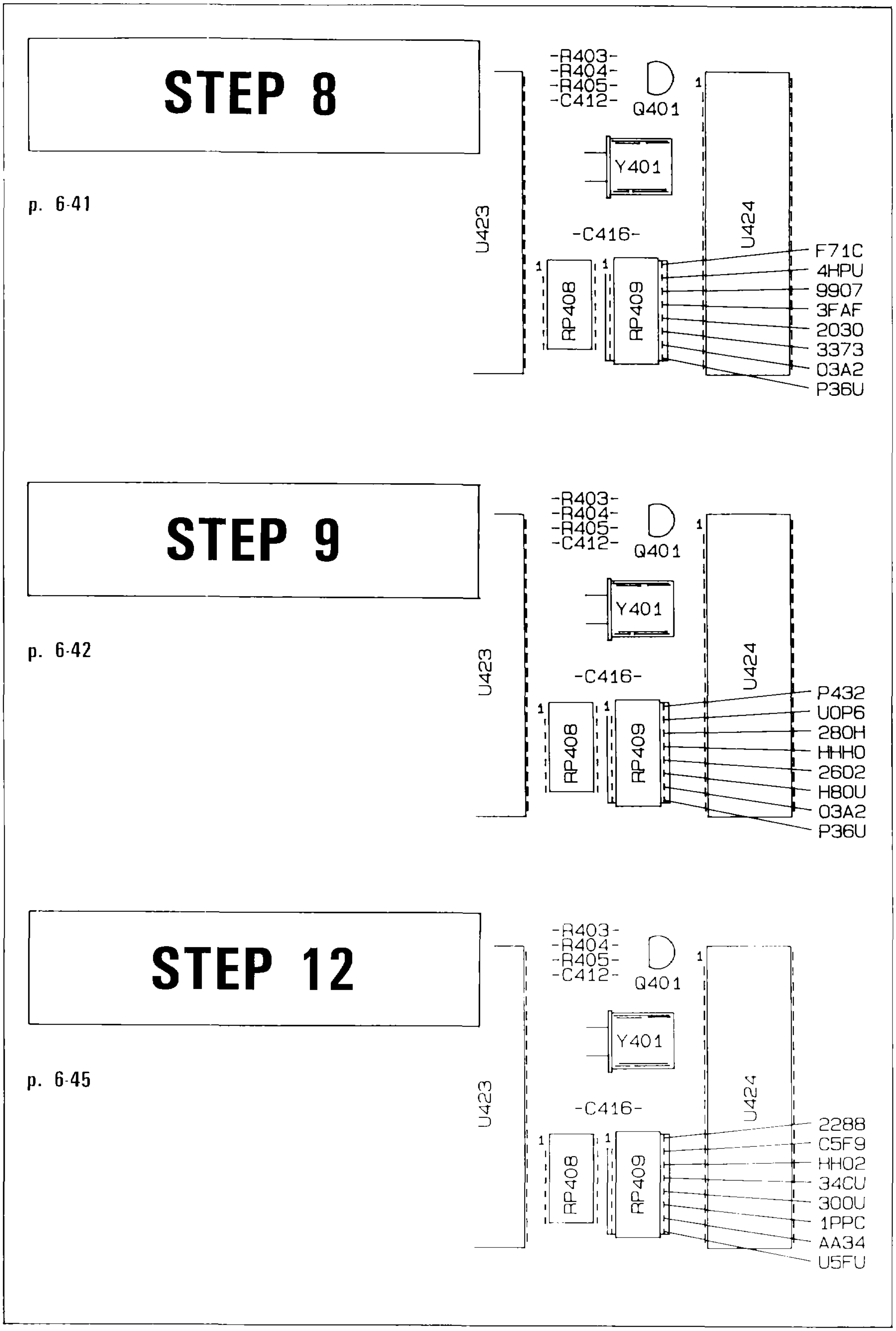
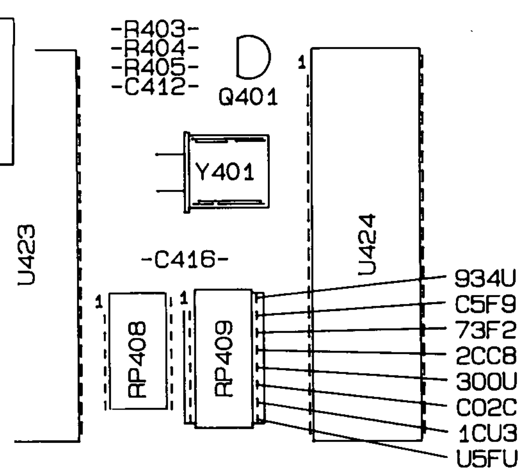



**Figure 7-1. Signature Changes for 1818-3306 ROM (ERC 2338 and 2341) (Cont'd)**

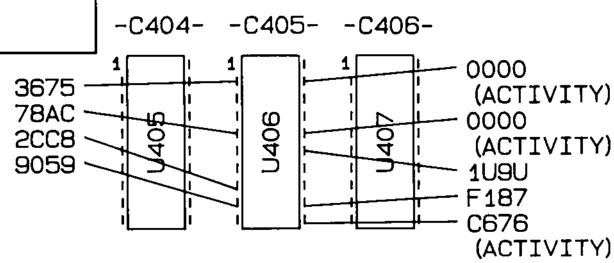
## STEP 13

p. 6-46



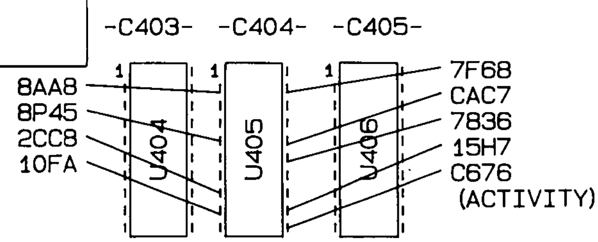

## STEP 14

p. 6-47




## STEP 15

p. 6-48




## FAILED TIMER

p. 6-51

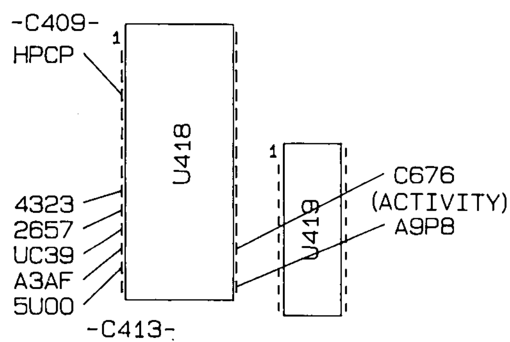



Figure 7-1. Signature Changes for 1818-3306 ROM (ERC 2338 and 2341) (Cont'd)

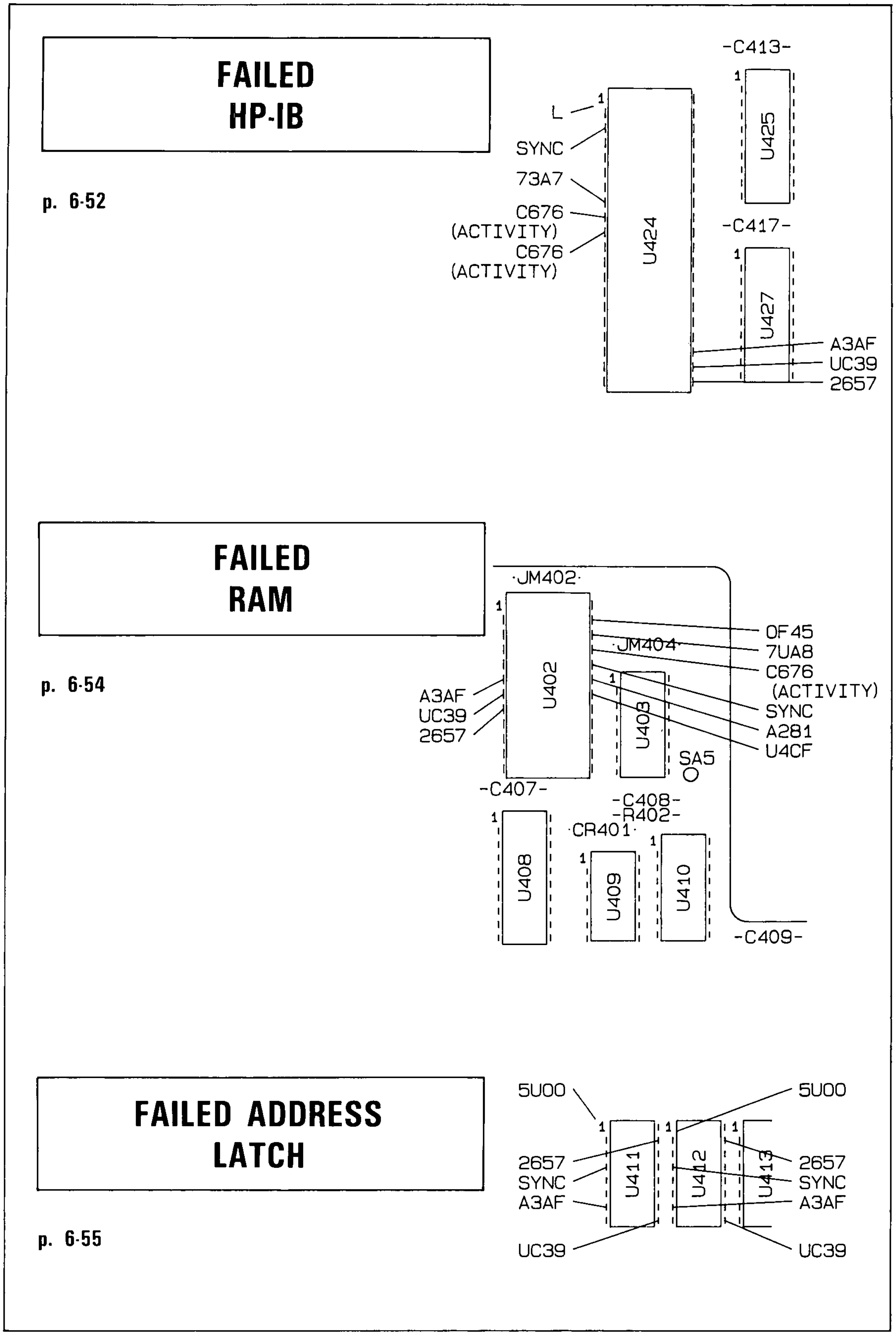



**Figure 7-1. Signature Changes for 1818-3306 ROM (ERC 2338 and 2341) (Cont'd)**

## Table 7-1 Replaceable Parts for 03488-66530 Power Supply

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A30C300 | 0160-3622 | 8 | 1 | CAPACITOR-FXD .1UF +80-20% 100VDC CER | 26654 | 2130Y5V100R104Z |
| A30C301 | 0180-3393 | 2 | 1 | CAPACITOR-FXD 4700UF 50V | 28480 | 0180-3393 |
| A30C303 | 0180-0291 | 3 | 4 | CAPACITOR-FXD 1UF+-10% 35VDC TA | 56289 | 150D105X9035A2 |
| A30C304 | 0180-0291 | 3 | | CAPACITOR-FXD 1UF+-10% 35VDC TA | 56289 | 150D105X9035A2 |
| A30C305 | 0180-0291 | 3 | | CAPACITOR-FXD 1UF+-10% 35VDC TA | 56289 | 150D105X9035A2 |
| A30C306 | 0160-4805 | 1 | 1 | CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4805 |
| A30C307 | 0180-3399 | 8 | 1 | CAPACITOR-FXD 560UF 40V | 28480 | 0180-3399 |
| A30C308 | 0160-5349 | 0 | 3 | CAPACITOR-FXD 200PF +-5% 100VDC CER | 28480 | 0160-5349 |
| A30C309 | 0160-4571 | 8 | 1 | CAPACITOR-FXD .1UF +80-20% 50VDC CER | 28480 | 0160-4571 |
| A30C310 | 0160-5349 | 0 | | CAPACITOR-FXD 200PF +-5% 100VDC CER | 28480 | 0160-5349 |
| A30C311 | 0160-5349 | 0 | | CAPACITOR-FXD 200PF +-5% 100VDC CER | 28480 | 0160-5349 |
| A30C312 | 0160-3847 | 9 | 13 | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A30C313 | 0180-0291 | 3 | | CAPACITOR-FXD 1UF+-10% 35VDC TA | 56289 | 150D105X9035A2 |
| A30C314 | 0160-0207 | 9 | 1 | CAPACITOR-FXD .01UF +-5% 200VDC POLYE | 28480 | 0160-0207 |
| A30C315 | 0160-0889 | 3 | 1 | CAPACITOR-FXD .33UF +-10% 80VDC POLYE | 28480 | 0160-0889 |
| A30C316 | 0180-1745 | 4 | 2 | CAPACITOR-FXD 1.5UF+-10% 20VDC TA | 56289 | 150D155X9020A2 |
| A30C317 | 0180-1745 | 4 | | CAPACITOR-FXD 1.5UF+-10% 20VDC TA | 56289 | 150D155X9020A2 |
| A30CR300 | 1902-0176 | 6 | 1 | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A30CR301 | 1884-0266 | 5 | 1 | THYRISTOR-SCR 2N6400 TO-220AB VRRM=50 | 3L585 | 2N6400 |
| A30CR302 | 1906-0079 | 6 | 1 | DIODE-FW BRDG 100V 10A | 1B546 | VJ148X |
| A30CR303 | 1901-0025 | 2 | 2 | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| A30CR304 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| A30J300 | 1251-4246 | 8 | 1 | CONNECTOR 3-PIN M POST TYPE | 28480 | 1251-4246 |
| A30J301 | 1251-0600 | 0 | 1 | CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ | 28480 | 1251-0600 |
| A30JM300 | 8159-0005 | 0 | 1 | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| A30L300 | 03488-87101 | 4 | 1 | I-F 750UH | 28480 | 03488-87101 |
| A30MP1 | 1205-0531 | 9 | 1 | HEAT SINK | 28480 | 1205-0531 |
| A30Q300 | 1854-0637 | 1 | 1 | TRANSISTOR NPN 2N2219A SI TO-5 PD=800MW | 01295 | 2N2219A |
| A30Q301 | 1853-0036 | 2 | 1 | TRANSISTOR PNP SI PD=310MW FT=250MHZ | 28480 | 1853-0036 |
| A30Q302 | 1853-0016 | 8 | 1 | TRANSISTOR PNP SI TO-92 PD=300MW | 28480 | 1853-0016 |
| A30R300 | 0698-4490 | 9 | 1 | RESISTOR 29.4K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2942-F |
| A30R301 | 0757-0280 | 3 | 2 | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| A30R302 | 0683-3015 | 1 | 3 | RESISTOR 300 5% .25W FC TC=-400/+600 | 01121 | CB3015 |
| A30R303 | 0757-0441 | 8 | 1 | RESISTOR 8.25K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-8251-F |
| A30R304 | 0757-0280 | 3 | | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| A30R305 | 0683-2025 | 1 | 5 | RESISTOR 2K 5% .25W FC TC=-400/+700 | 01121 | CB2025 |
| A30R306 | 0698-4414 | 7 | 1 | RESISTOR 158 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-158R-F |
| A30R307 | 0683-0335 | 2 | 1 | RESISTOR 3.3 5% .25W FC TC=-400/+500 | 01121 | CB33G5 |
| A30R308 | 0683-2025 | 1 | | RESISTOR 2K 5% .25W FC TC=-400/+700 | 01121 | CB2025 |
| A30R310 | 0683-1025 | 9 | 2 | RESISTOR 1K 5% .25W FC TC=-400/+600 | 01121 | CB1025 |
| A30R311 | 0683-2025 | 1 | | RESISTOR 2K 5% .25W FC TC=-400/+700 | 01121 | CB2025 |
| A30R312 | 0699-1074 | 1 | 2 | RESISTOR .05 3% 3W F TC=0+-337 | 28480 | 0699-1074 |
| A30R313 | 0699-1074 | 1 | | RESISTOR .05 3% 3W F TC=0+-337 | 28480 | 0699-1074 |
| A30R314 | 0699-1137 | 7 | 1 | RESISTOR 39 5% 2W F TC=0+-200 | 28480 | 0699-1137 |
| A30R315 | 0698-4157 | 5 | 4 | RESISTOR 10K .1% .125W F TC=0+-50 | 28480 | 0698-4157 |
| A30R316 | 0698-4157 | 5 | | RESISTOR 10K .1% .125W F TC=0+-50 | 28480 | 0698-4157 |
| A30R317 | 0698-4157 | 5 | | RESISTOR 10K .1% .125W F TC=0+-50 | 28480 | 0698-4157 |
| A30R318 | 0698-4157 | 5 | | RESISTOR 10K .1% .125W F TC=0+-50 | 28480 | 0698-4157 |
| A30R319 | 0757-0283 | 6 | 2 | RESISTOR 2K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2001-F |
| A30R320 | 0757-0283 | 6 | | RESISTOR 2K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2001-F |
| A30R321 | 0698-6758 | 6 | 2 | RESISTOR 12.5K .5% .125W F TC=0+-50 | 24546 | NC4-1/8-T2-1252-D |
| A30R322 | 0698-6758 | 6 | | RESISTOR 12.5K .5% .125W F TC=0+-50 | 24546 | NC4-1/8-T2-1252-D |
| A30R323 | 0698-4121 | 3 | 1 | RESISTOR 11.3K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1132-F |
| A30R324 | 0698-3498 | 5 | 1 | RESISTOR 8.66K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-866R-F |
| A30R325 | 0757-0435 | 0 | 1 | RESISTOR 3.92K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-3921-F |
| A30R326 | 0757-0449 | 6 | 2 | RESISTOR 20K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2002-F |
| A30R327 | 0683-1055 | 5 | 1 | RESISTOR 1M 5% .25W FC TC=-800/+900 | 01121 | CB1055 |
| A30R328 | 0698-4532 | 0 | 1 | RESISTOR 280K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2803-F |
| A30R329 | 0757-0465 | 6 | 2 | RESISTOR 100K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1003-F |
| A30R330 | 0683-5125 | 8 | 4 | RESISTOR 5.1K 5% .25W FC TC=-400/+700 | 01121 | CB5125 |

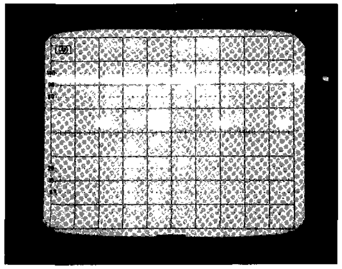
See introduction to this section for ordering information
*Indicates factory selected value

## Table 7-1 Replaceable Parts for 03488-66530 Power Supply (Cont'd)

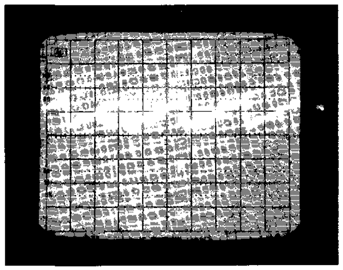
| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A30R331 | 0683-3645 | 3 | 3 | RESISTOR 360K 5% .25W FC TC=-800/+900 | 01121 | CB3645 |
| A30R332 | 0757-0422 | 5 | 1 | RESISTOR 909 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-909R-F |
| A30R333 | 0698-3279 | 0 | 1 | RESISTOR 4.99K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-4991-F |
| A30R334 | 0683-1035 | 1 | 3 | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A30R335 | 0683-5125 | 8 | | RESISTOR 5.1K 5% .25W FC TC=-400/+700 | 01121 | CB5125 |
| A30R336 | 0698-6429 | 8 | 1 | RESISTOR 10.1K .5% .125W F TC=0+-100 | 28480 | 0698-6429 |
| A30R337 | 0698-8162 | 0 | 1 | RESISTOR 11.8K .25% .125W F TC=0+-50 | 19701 | MF4C1/8-T2-1182-C |
| A30R338 | 0683-5125 | 8 | | RESISTOR 5.1K 5% .25W FC TC=-400/+700 | 01121 | CB5125 |
| A30R339 | 0757-0449 | 6 | | RESISTOR 20K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2002-F |
| A30R340 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A30R341 | 0698-4125 | 7 | 1 | RESISTOR 953 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-953R-F |
| A30R342 | 0698-3155 | 1 | 1 | RESISTOR 4.64K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-4641-F |
| A30R343 | 0683-5125 | 8 | | RESISTOR 5.1K 5% .25W FC TC=-400/+700 | 01121 | CB5125 |
| A30R344 | 0683-2025 | 1 | | RESISTOR 2K 5% .25W FC TC=-400/+700 | 01121 | CB2025 |
| A30R345 | 0757-0454 | 3 | 1 | RESISTOR 33.2K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-3322-F |
| A30R346 | 0757-0465 | 6 | | RESISTOR 100K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1003-F |
| A30R347 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A30R348 | 0683-3645 | 3 | | RESISTOR 360K 5% .25W FC TC=-800/+900 | 01121 | CB3645 |
| A30R349 | 0683-3645 | 3 | | RESISTOR 360K 5% .25W FC TC=-800/+900 | 01121 | CB3645 |
| A30R350 | 0683-3015 | 1 | | RESISTOR 300 5% .25W FC TC=-400/+600 | 01121 | CB3015 |
| A30R351 | 0683-3015 | 1 | | RESISTOR 300 5% .25W FC TC=-400/+600 | 01121 | CB3015 |
| A30SP300 | 0960-0561 | 4 | 1 | AUDIO TRANSDUCER 1-3VDC; 85DB AT 1.5V | 28480 | 0960-0561 |
| A30U300 | 1813-0083 | 5 | 1 | IC TO-66 | 12967 | PIC601 |
| A30U301 | 1826-0393 | 7 | 1 | IC V RGLTR TO-220 | 27014 | LM317T |
| A30U302 | 1826-1040 | 3 | 1 | IC V RGLTR-SWG 4.85/5.15V 18-DIP-C PKG | 28480 | 1826-1040 |
| A30U303 | 1826-0138 | 8 | 2 | IC COMPARATOR GP QUAD 14-DIP-P PKG | 01295 | LM339N |
| A30U304 | 1820-1202 | 7 | 2 | IC GATE TTL LS NAND TPL 3-INP | 01295 | SN74LS10N |
| A30U305 | 1820-1932 | 0 | 1 | IC MV CMOS MONOSTBL RETRIG/RESET DUAL | 04713 | MC14538BCP |
| A30U306 | 1826-0138 | 8 | | IC COMPARATOR GP QUAD 14-DIP-P PKG | 01295 | LM339N |
| A30W300 | 03488-61601 | 5 | 1 | CBL-ASSY PWRSPLY | 28480 | 03488-61601 |
| | 03488-01201 | 5 | 1 | POWER SUPPLY BRACKET | | |

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

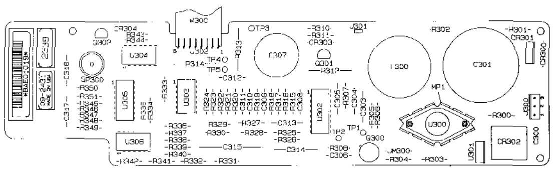
See also high resolution scan
Schematic at end of Document



TP1
10:1 PROBE
INT. TRIGGER
.2 V/DIV. DC
.01 MSEC



U302 PIN 10
10:1 PROBE
INT. TRIGGER
2 V/DIV. DC
.01 MSEC



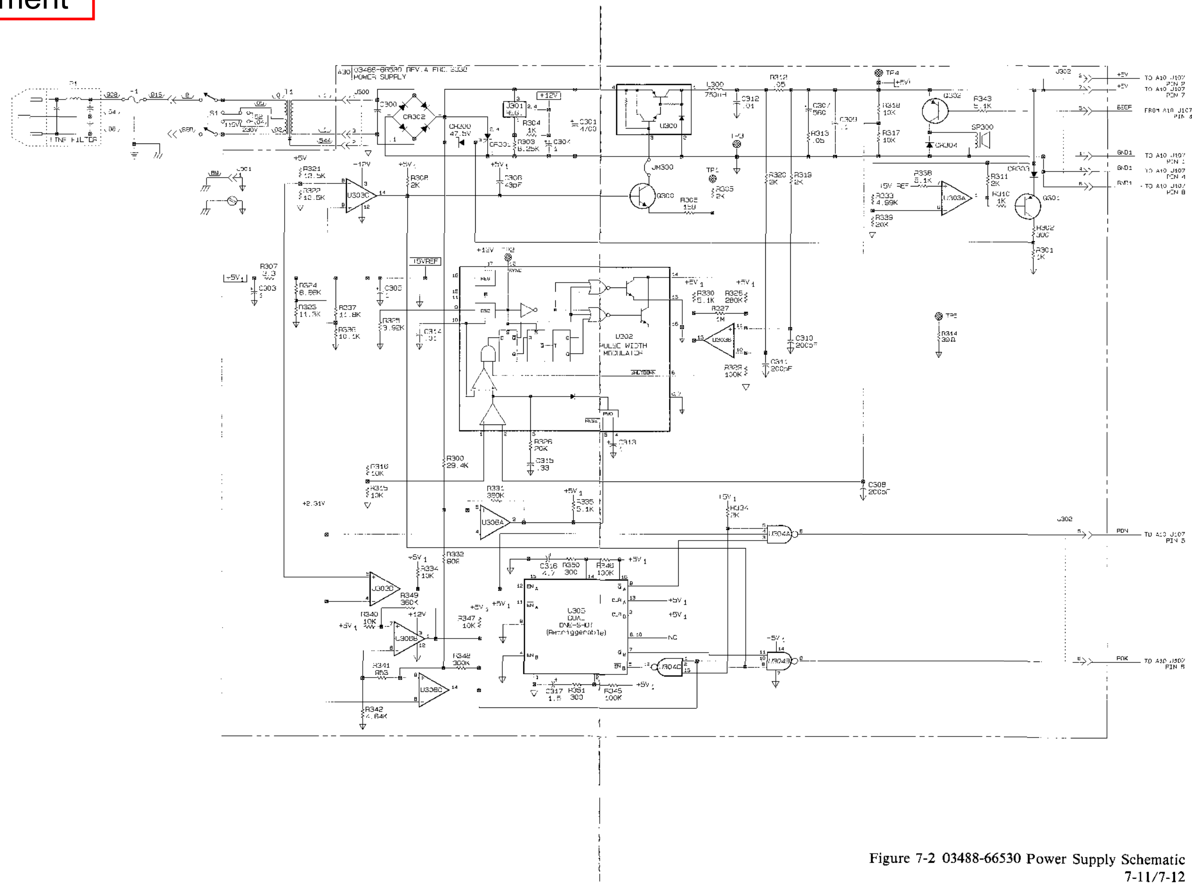


Figure 7-2 03488-66530 Power Supply Schematic

# Chapter VIII

# 44470A 10 CHANNEL RELAY MULTIPLEXER

# CHAPTER VIII

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF ILLUSTRATIONS

# CHAPTER VIII
# 44470A 10 CHANNEL RELAY MULTIPLEXER

## 8-1 INTRODUCTION

This chapter contains installation information, performance testing information, troubleshooting procedures, and replaceable parts lists for the 44470A 10 Channel Multiplexer.

The 44470A 10 Channel Multiplexer contains a 10 channel array of double-pole single-throw (DPST) relays. Each channel has a low line and a high line which are switched in unison. A simplified schematic of the 44470A relay circuitry is shown in Figure 8-1.

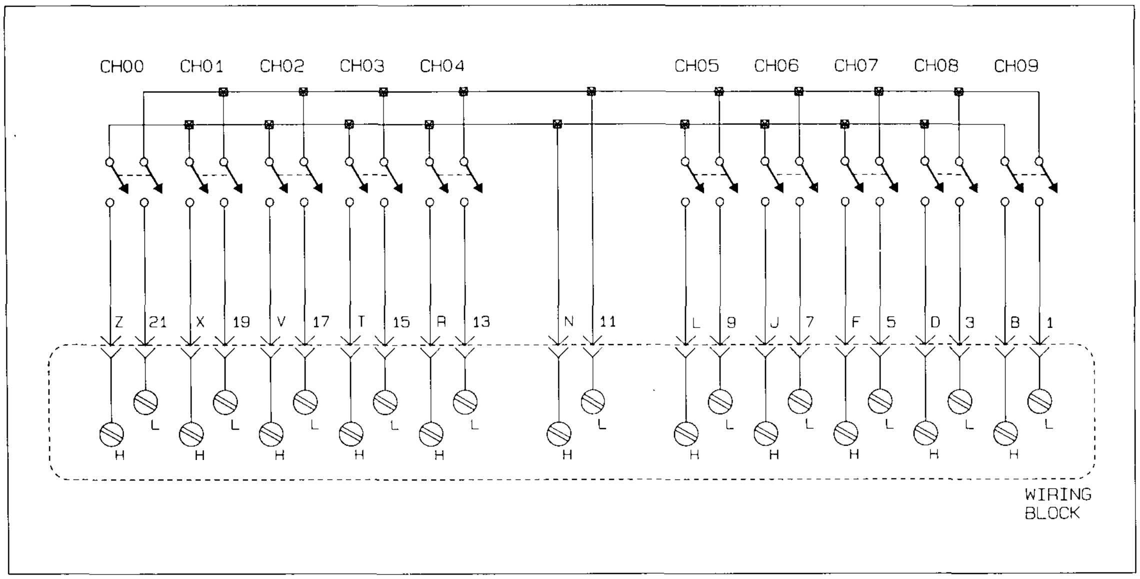



**Figure 8-1 44470A Simplified Schematic**

**NOTE**

*The Performance Test procedures in this chapter are involved and time consuming. Since the most likely parameter to change with time is the series resistance of a channel, and since the series resistance is tested in the Operation Verification procedures (Chapter 4), it is not recommended that the Performance Tests be conducted unless one of the tested specifications is in question.*

## 8-2 PLUG-IN CARD WIRING

Figure 8-2 shows the proper wiring procedures for the 44470A.

**WARNING**

*Hazardous voltages may exist on the wiring and connectors of the 3488A's plug-in cards. Only Service Trained Personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make repairs to the 3488A and/or the plug-in cards.*

## 8-3 PLUG-IN CARD CLEANING

Printed circuit board contamination can affect the dc isolation and the high frequency performance of the plug-in cards. This contamination can come from dust accumulation, fingerprints, condensation, and so on. The plug-in card printed circuit boards are to be cleaned as follows:

**CAUTION**

*Use anti-static pc board handling techniques during the following procedure.*

1. Remove the shields from the plug-in card.
2. Use a stiff bristled camel hair brush (do not use a wire brush) soaked in isopropyl alcohol to wash the pc board.

**CAUTION**

*DO NOT immerse the printed circuit board in any type of fluid.*

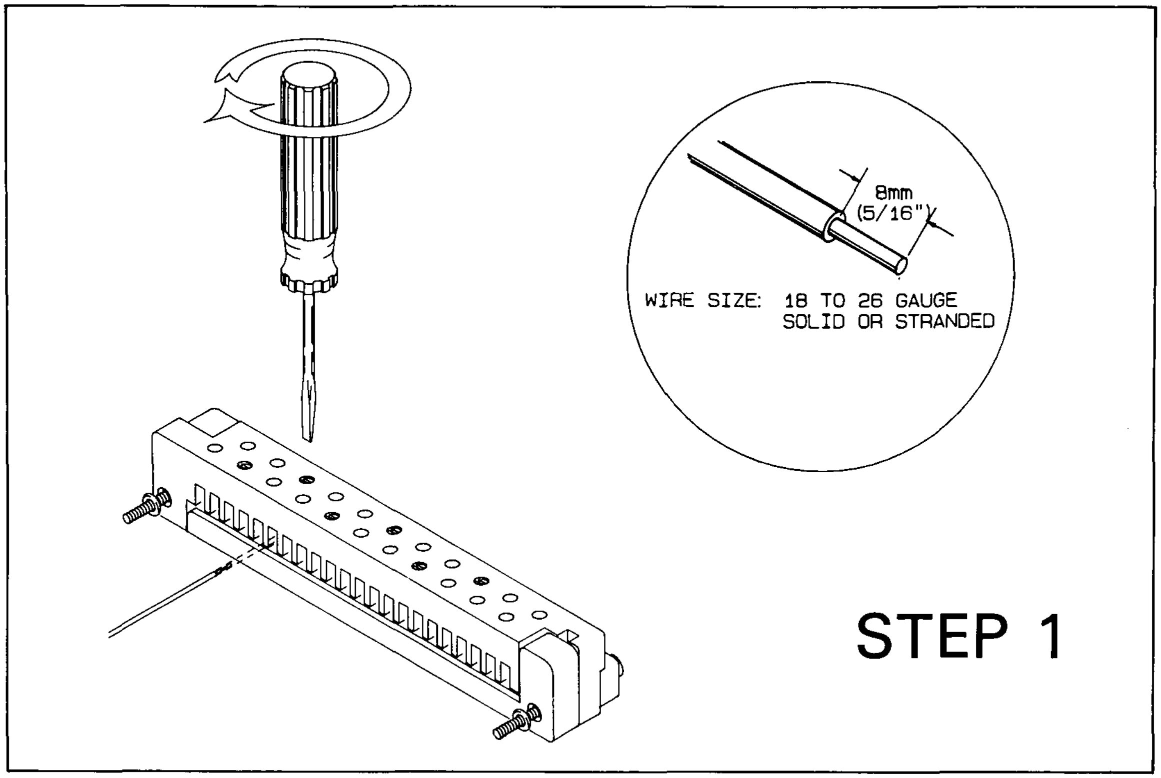
3. Use the stiff bristled brush soaked in deionized or distilled water, to remove any residue left by the alcohol.
4. Allow the printed circuit board to dry thoroughly.
5. Replace the shields.

**WARNING**

*Hazardous voltages may exist on the wiring and connectors of the 44470A plug-in card (see Caution below). Only service trained personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make repairs to the 3488A and/or its plug-in cards.*

⚠ **CAUTION**

*The 44470A's maximum terminal-to-terminal or terminal-to-chassis voltage limits are 250Vdc or 250 Vac rms (350 Vac peak). The maximum current limits are 2Adc or 2Aac rms (per channel or card). The maximum power limits are 60Wdc or 500VAac (per channel or card). Damage to the 44470A and possibly the 3488A will occur if any of the above limits are exceeded.*



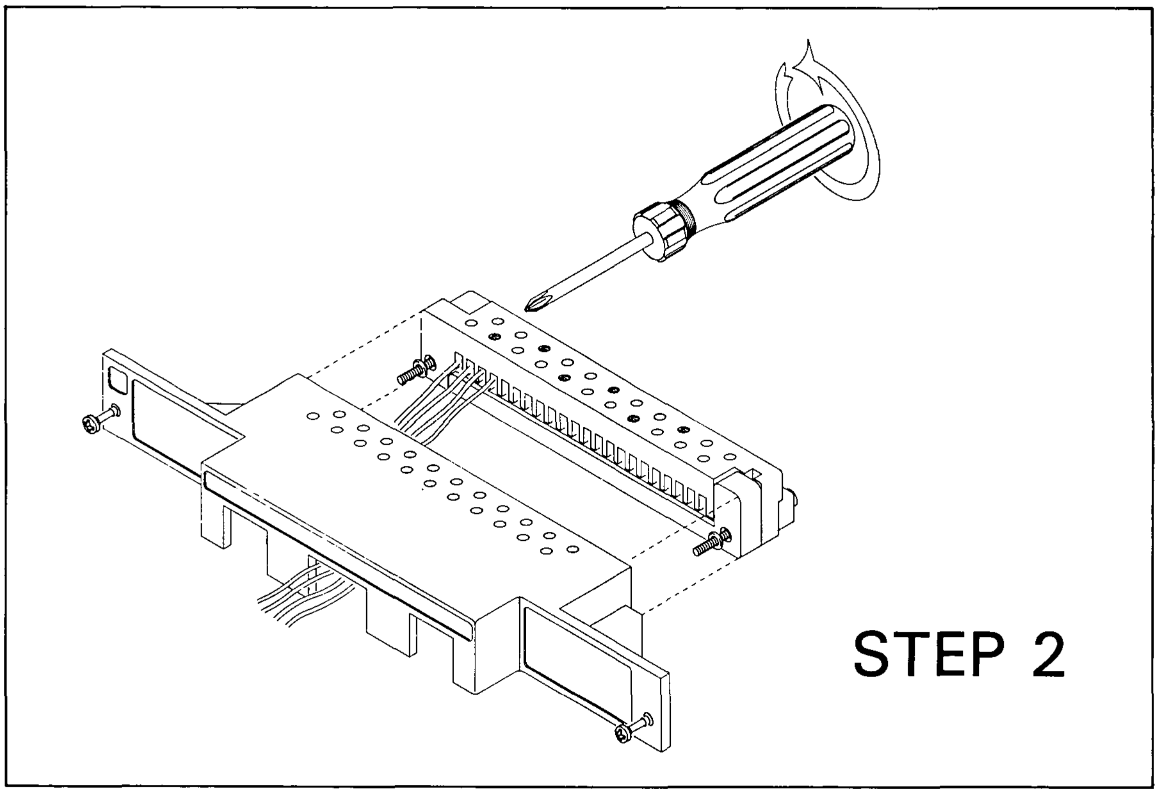




**Figure 8-2 Plug-In Card Wiring**

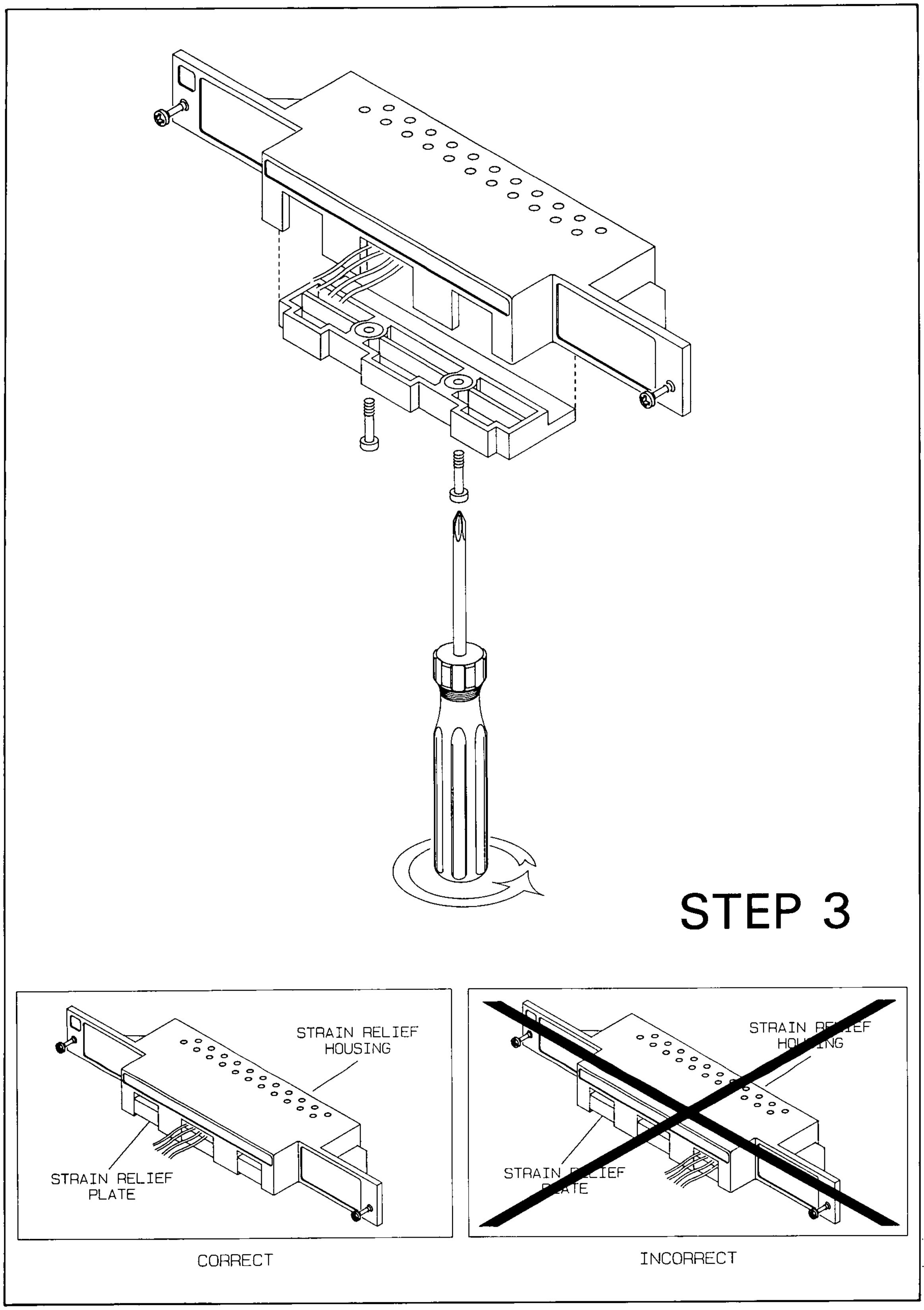
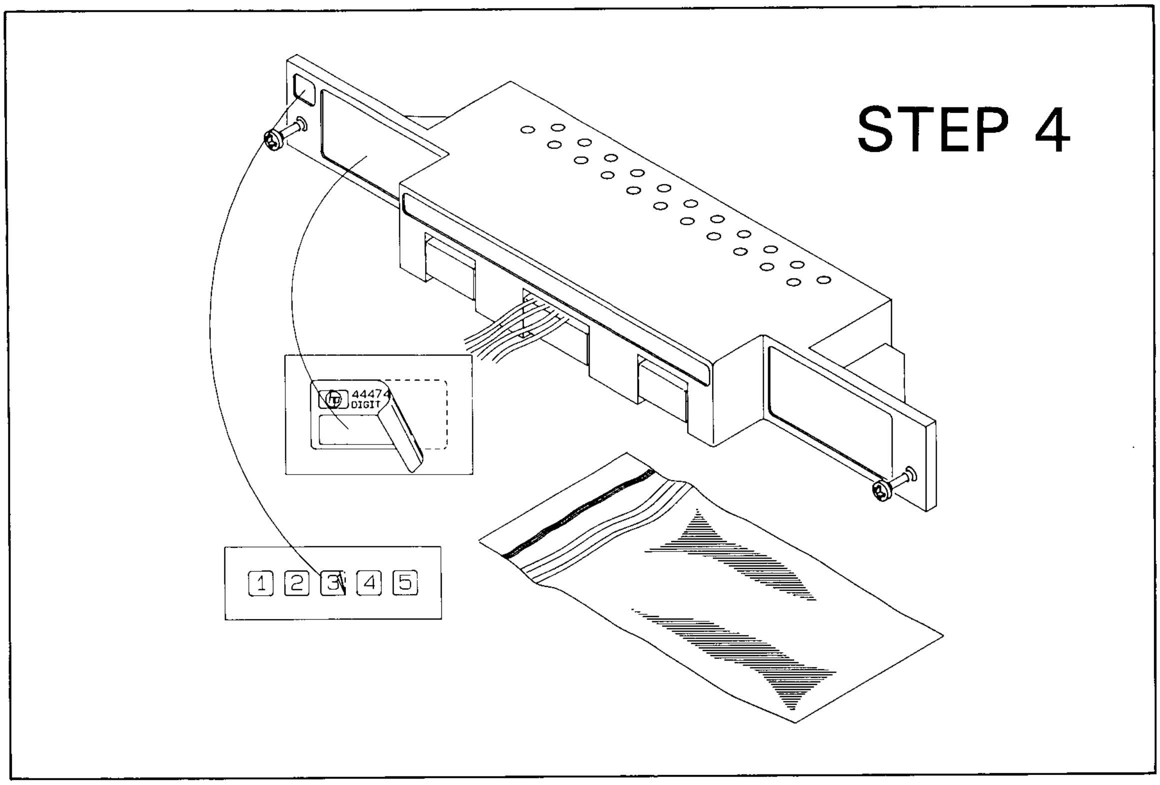



**Figure 8-2. Plug-In Card Wiring (Cont'd)**



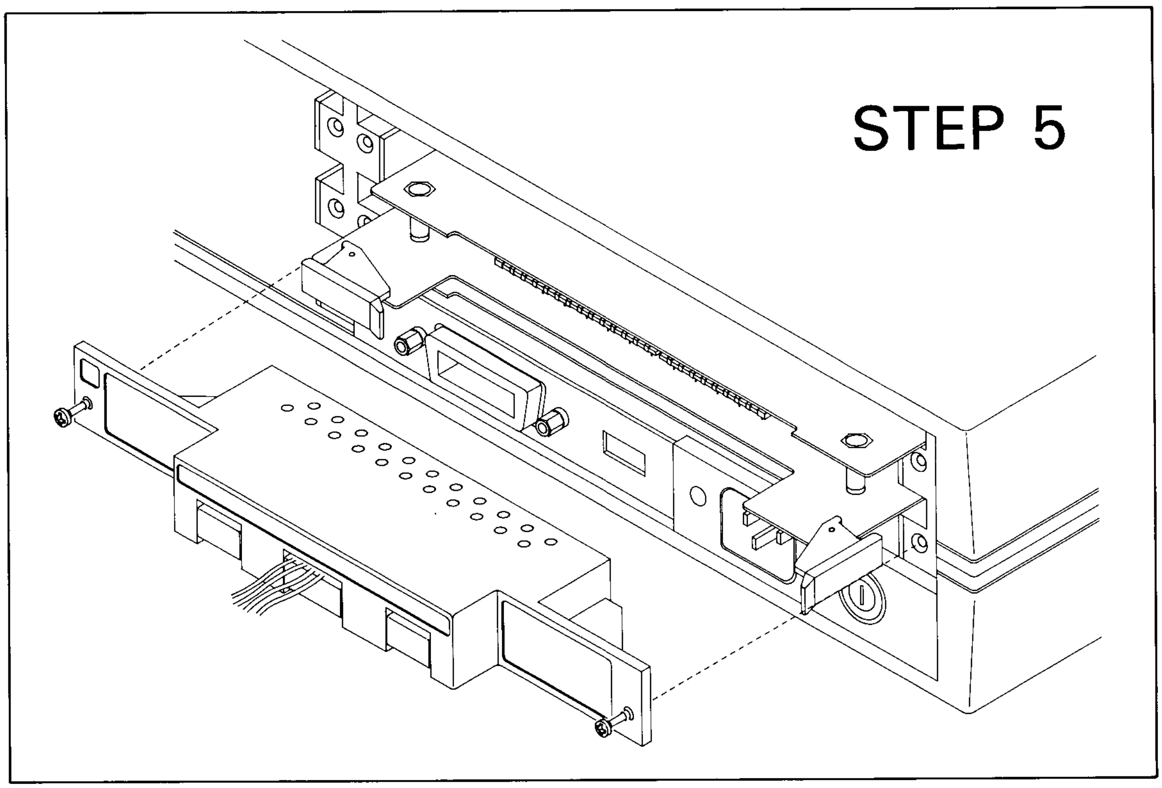




Figure 8-2. Plug-In Card Wiring (Cont'd)

## 8-4 TEST FIXTURE

A test fixture is required in order to perform the Operation Verification Tests for the 44470A (Chapter 4 of this manual). This fixture simplifies testing by eliminating the need to repeatedly connect and disconnect test leads and by acting as an interface between the 44470A and an ohmmeter.

The test fixture can be either of the following two types:

a. A test fixture is available from Hewlett-Packard (HP part number 03488-66501). The advantages of this fixture are (1) it requires no assembly and (2) it can be used to test the 44470A, the 44471A, the 44473A and the 44474A plug-in cards without modification.

b. A test fixture can be constructed by configuring an HP 44480A removable wiring block as shown in Figure 8-3. This particular test fixture can only be used to test the 44470A.

Either type of test fixture contains (1) a short circuit between all of the low lines, (2) a short circuit between all of the high lines, and (3) a short circuit between the two common lines. With the test fixture installed, and an ohmmeter connected between the shorted common lines and either the shorted low lines or the shorted high lines, the card is tested by successively closing each relay while checking for an indication of the closure on the ohmmeter.

## 8-5 PERFORMANCE TESTS

The following Performance Tests check the 44470A's dc isolation and thermal offset specifications. The results of these tests, when coupled with the results of the 44470A Operation Verification Test (Chapter 4), will verify whether or not the 44470A is operating within its critical specifications. Since the 44470A Operation Verification Test assesses the operability of the 44470A, it is important that it be performed prior to performing the Performance Tests.

**WARNING**

*If the 44470A is currently installed into a system, it must be disconnected from the system in order to execute the Performance Tests. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected. The user must take the necessary precautions to prevent the above from happening before disconnecting the 44470A.*

### 8-6 Required Test Equipment

DC Power Supply — HP 6216B or equivalent. The power supply must be able to deliver a stable +20Vdc at low current levels.

10 megohm resistor.

Digital Multimeter — HP 3478A or equivalent. The multimeter must have the resolution and accuracy to measure a 1$\mu$V differential dc voltage.

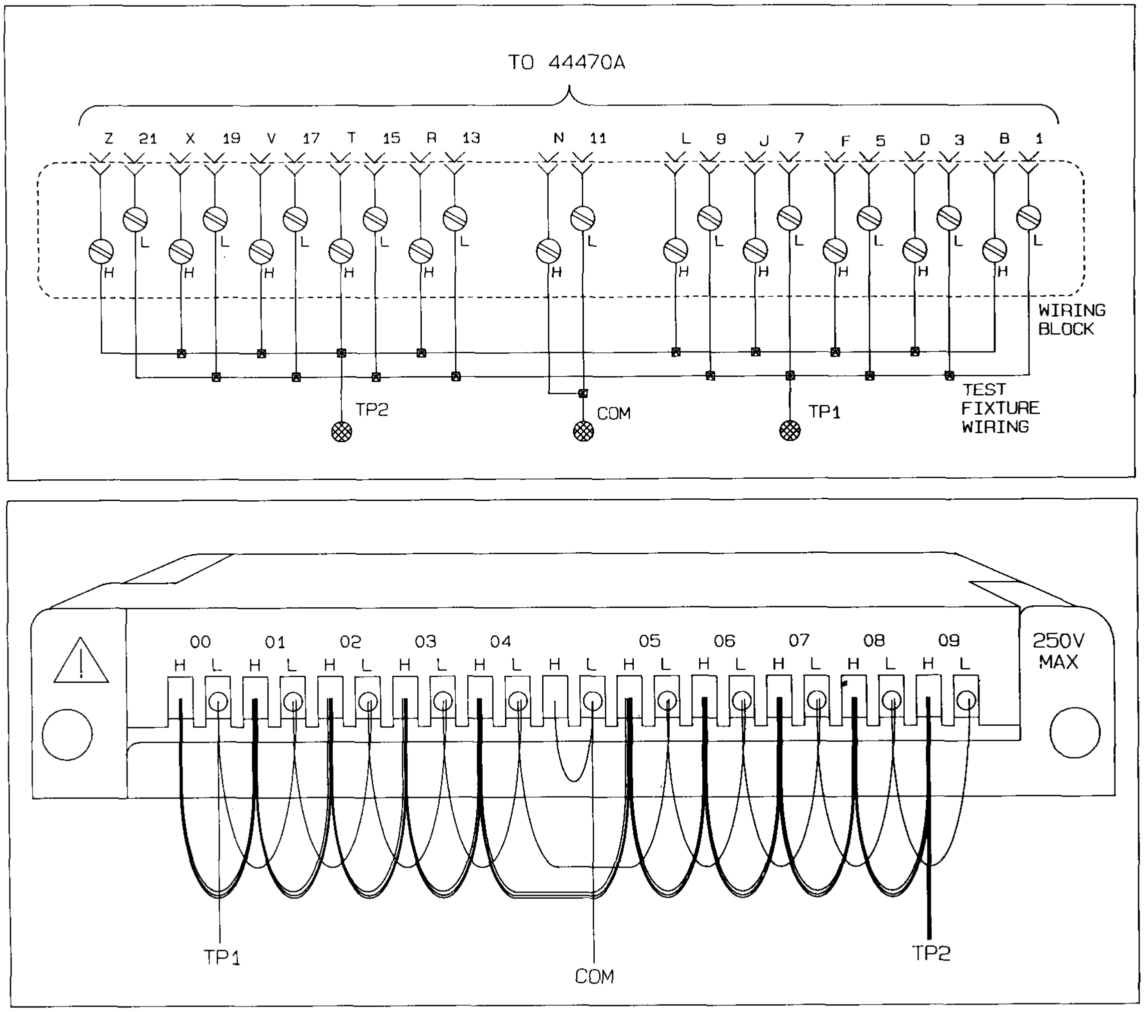



**Figure 8-3 44470 Test Fixture**

## 8-7 44470A DC Isolation Tests

The following dc isolation tests require a dc power supply, a resistor of known value, and a dc voltmeter. The first phase of the tests involves precisely setting the dc power supply's output voltage and connecting the resistor and the dc voltmeter in series with the power supply. In this configuration, the resistor and the internal resistance of the dc voltmeter form a voltage divider. The voltage drop across the dc voltmeter is measured and, with the value of the resistor and the power supply voltage being known, the internal resistance of the dc voltmeter is calculated.

**NOTE**

*The best test results will be obtained when the value of the known resistor is equal to the internal resistance of the dc voltmeter.*

The second phase of the tests consists of (1) placing a channel of the 44470A in parallel with the dc voltmeter, (2) measuring the voltage drop across the dc voltmeter/channel combination, and (3) calculating the channel's dc isolation.

1. SET-UP SEQUENCE: Set the digital multimeter to measure dc voltage. Connect the multimeter to the dc power supply. Set the dc power supply to deliver +20Vdc ±.01Vdc as measured on the multimeter. This voltage will be referred to as V1 in the following steps.

2. Use the multimeter to measure the exact resistance of the 10 megohm resistor. This resistance will be referred to as R1.

3. Connect the test equipment as shown in Figure 8-4.

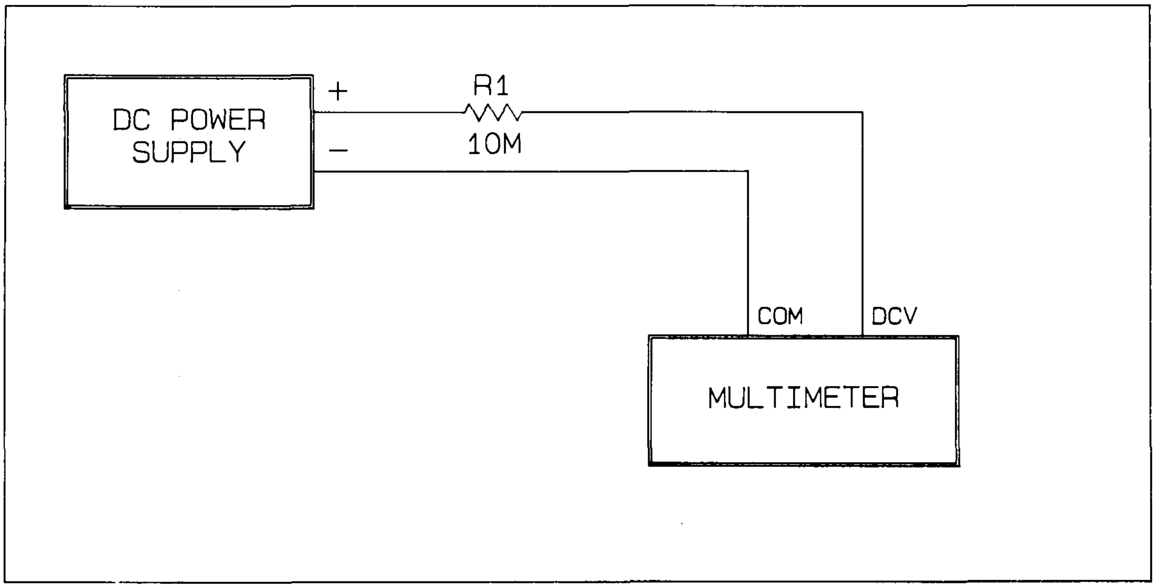



**Figure 8-4 DC Isolation Test Set-Up**

4. Set the multimeter to the 300Vdc range. Record the exact dc voltage reading on the multimeter. This voltage will be referred to as V2 in the following steps.

5. Calculate the internal resistance of the multimeter (Rm) using the following equation:

$$Rm = R1 \bullet V2/(V1 - V2)$$

**NOTE**

*In most cases, the internal resistance of the multimeter depends on its range setting. For this reason, do not change the multimeter's range setting in the following steps.*

6. OPEN CHANNEL TO COMMON DC ISOLATION TEST: use the 3488A front panel keys to establish the card monitor mode and to open all channels as follows:

a. Press the LOCAL key.

b. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the 44470A.

c. Press the EXECUTE key.

d. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44470A.

e. Press the EXECUTE key.

7. Connect the common low line and the low line of the channel under test (channel 00 to start) into the test circuit as shown in Figure 8-5. Record the multimeter's dc voltage reading for this channel. This reading will be referred to as V3.

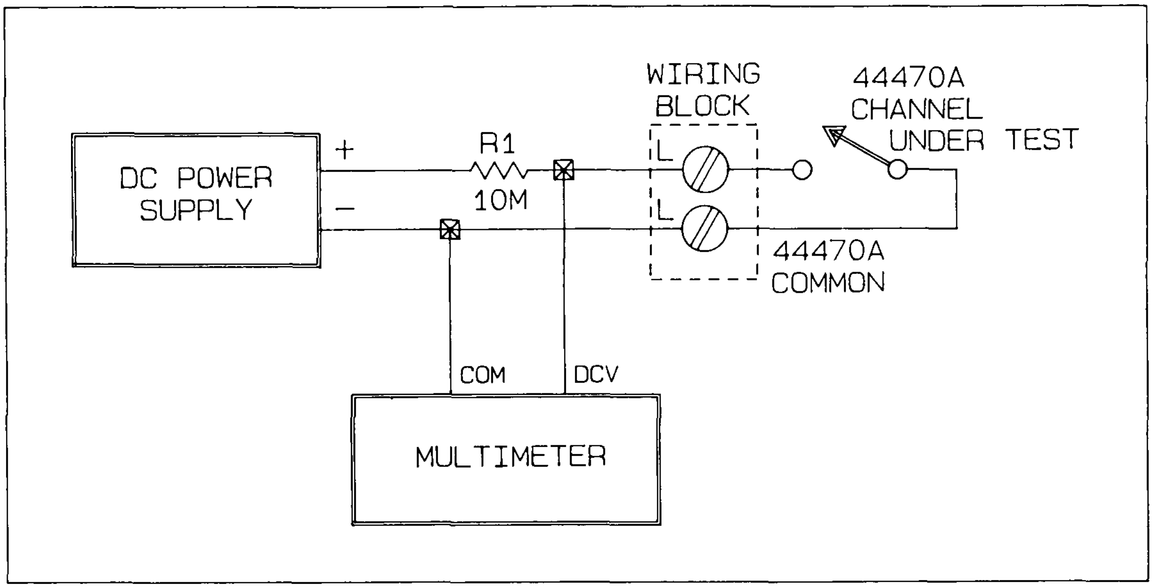



**Figure 8-5 Channel To Common DC Isolation Test**

8. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V3 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V3) - R1 \bullet V3}$$

The open channel to common dc isolation should be greater than 5 gigohms for each channel.

9. Repeat steps 7 and 8 for the low lines of channels 01 through 09.

10. Repeat steps 7 and 8 using the common high line and the high lines of channels 00 through 09.

11. COMMON HIGH TO LOW TEST: Reset the 44470A and establish a scan list as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the card.

b. Press the EXECUTE key.

c. Press the SCAN LIST key followed by X00-X09 (where X is the slot occupied by the 44470A and 00 through 09 are the channels to be scanned).

d. Press the EXECUTE key.

12. Connect the equipment to the common high and common low lines as shown in Figure 8-6.

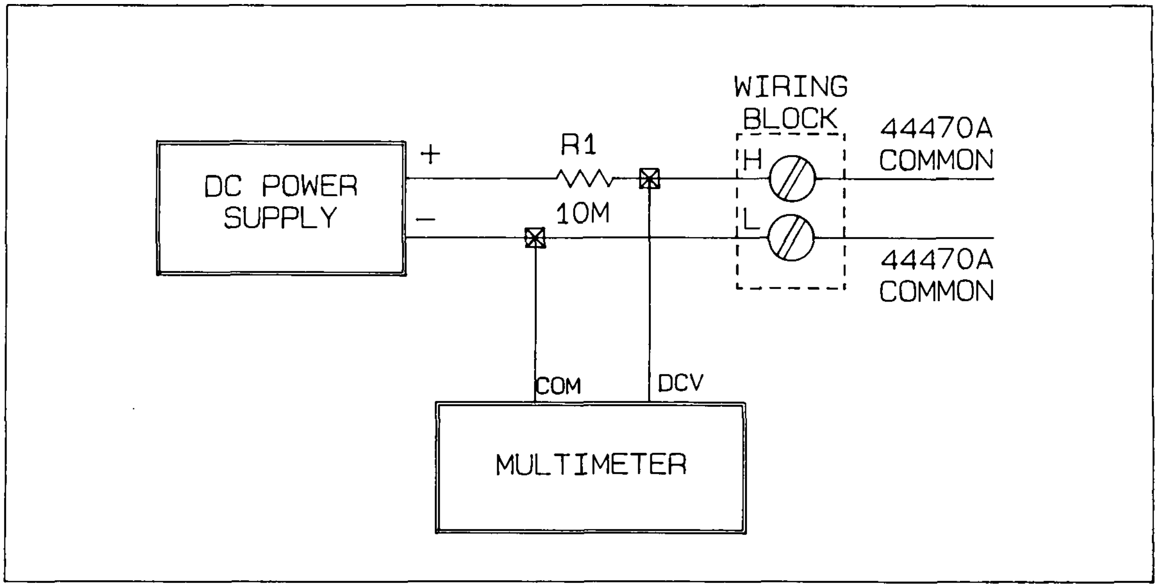



**Figure 8-6 Common High To Low DC Isolation Test**

13. Press the STEP key and record the multimeter reading for the channel under test (channel 00 to start). This voltage will be referred to as V4.

14. Calculate the dc isolation resistance (Rc) using the following equation:

$$Rc = \frac{V4 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V4) \; - \; R1 \bullet V4}$$

With any one channel closed, the common high to low dc isolation resistance should be ≥ 1 gigohm.

15. Repeat steps 13 and 14 for the remaining channels (01 through 09).

16. COMMON TO CHASSIS DC ISOLATION TEST: Connect the equipment to the 3488A back panel ground connector (chassis ground) and to the common low line connector as shown in Figure 8-7.

17. Reset the 44470A and establish a scan list as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the card.

b. Press the EXECUTE key.

c. Press the SCAN LIST key followed by X00-X09 (where X is the slot occupied by the 44470A and 00 through 09 are the channels to be scanned).

d. Press the EXECUTE key.

18. Press the STEP key and record the multimeter reading for the channel under test (chan-

nel 00 to start). This voltage will be referred to as V5.

19. Calculate the dc isolation resistances (Rc) using the following equation:

$$Rc = \frac{V5 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V5) - R1 \bullet V3}$$

With any one channel closed, the common to chassis dc isolation resistance should be ≥ 1 gigohm.

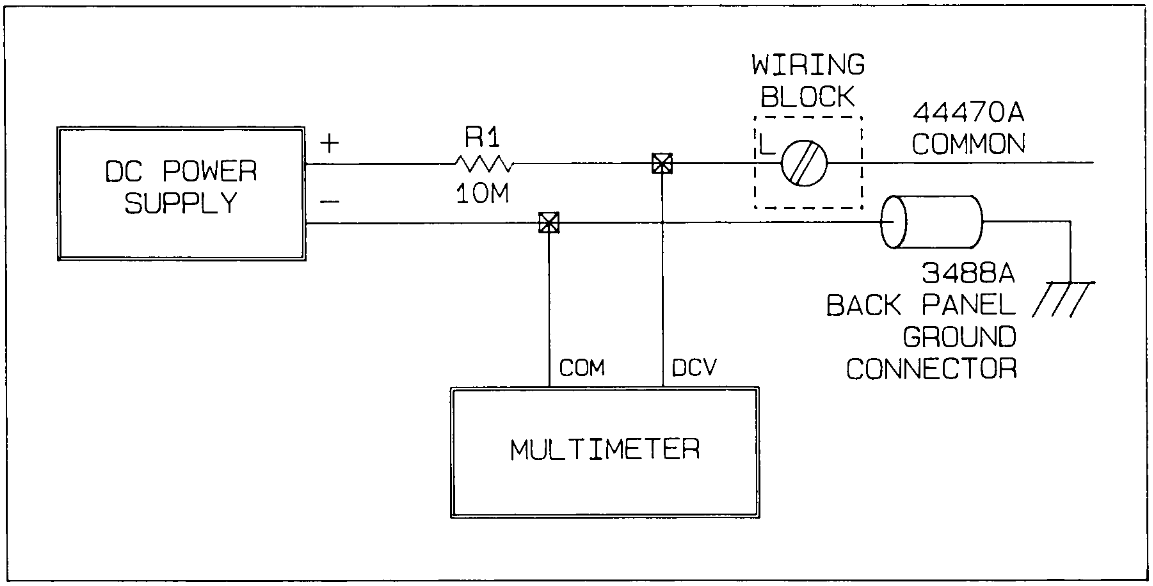



**Figure 8-7 Common To Chassis DC Isolation**

20. Repeat steps 18 and 19 for each of the remaining channels.

21. Remove the test lead from the common low line connector and connect it to the common high line connector. Repeat steps 18 and 19 for the high lines of of channels 00 through 09.

### 8-8 Corrective Action

An open channel to common isolation failure (Step 8) is most likely caused by a failing relay or a damaged or dirty 44470A printed circuit board. Board cleaning is described in Section 8-3. Section 8-17 describes troubleshooting procedures to isolate a damaged relay.

A common high to low isolation failure (Step 14) is most likely caused by a dirty 44470A printed circuit board. Board cleaning is described in Section 8-3.

A common to chassis isolation failure (Step 19) can be caused by electrical leakage from a relay contact through its drive coil to ground, or by a damaged or dirty printed circuit board. Board cleaning is described in Section 8-3. Section 8-17 describes troubleshooting procedures to isolate a damaged relay.

## 8-9 44470A Thermal Offset Test

This is a test of the thermally generated dc voltage present on the 44470A. This test is very sensitive to ambient temperature changes and thermoelectricity generated at the junction of two dissimilar metals. For these reasons, it is important that this test be performed in an environment where the temperature is stable and that the number of test lead connections are kept to a minimum.

1. Set the multimeter to its lowest dc voltage range. Connect the two multimeter test leads together and record the reference offset voltage. This voltage will be referred to as V1 in the following steps.

2. Set up a scan list and the card monitor mode as follows:

a. Press the SCAN LIST key followed by X00-X09 (where X is the slot occupied by the 44470A and 00 through 09 are the channels to be scanned).

b. Press the EXECUTE key.

c. Press the CARD MONITOR key followed by X (where X is the slot occupied by the 44470A).

d. Press the EXECUTE key.

3. Connect the multimeter's common test lead to the 44470A's common L terminal.

4. Press the STEP key. Measure the dc voltage on the L terminal of the channel shown in the display (channel 00 to start). This voltage will be referred to as V2. The difference between V1 and V2 must be less than 3$\mu$V for each channel.

5. Repeat step 4 for channels 01 through 09.

6. Connect the multimeter's common test lead to the 44470A's common H terminal.

7. Repeat step 4 for the H terminals of channels 00 through 09.

### 8-10 Corrective Action

The most likely cause of a thermal offset failure is the relay or a connector. Section 8-17 describes troubleshooting procedures to isolate a failing relay.

## 8-11 REPLACEABLE PARTS

Table 8-1 lists the mechanical and electrical replaceable parts available for the 44470A. The mechanical parts are keyed to Figure 8-8. This figure also provides assembly and disassembly information. The electrical parts are keyed to the schematic and component locator in Figure 8-12. Table 5-2, in Chapter 5, lists manufacturers code numbers as they apply to the parts lists in Table 8-1.

## 8-12 44470A THEORY OF OPERATION

The 44470A Multiplexer Card consists of an input buffer and latch, relay drive and sense circuits, an address decoder, and a card-type/sense buffer. Refer to the 44470A schematic in the following discussions (Figure 8-12).

## 8-13 Input Buffer And Latch

The input buffer (U902 in Figure 8-12) provides isolation between the 44470A and the mainframe's data bus. An input buffer is present on each type of option card and prevents excessive loading of the data bus by the option cards.

The input latch (U903 and U905 in Figure 8-12) holds the output of the input buffer for application to the relay drive and sense circuitry.

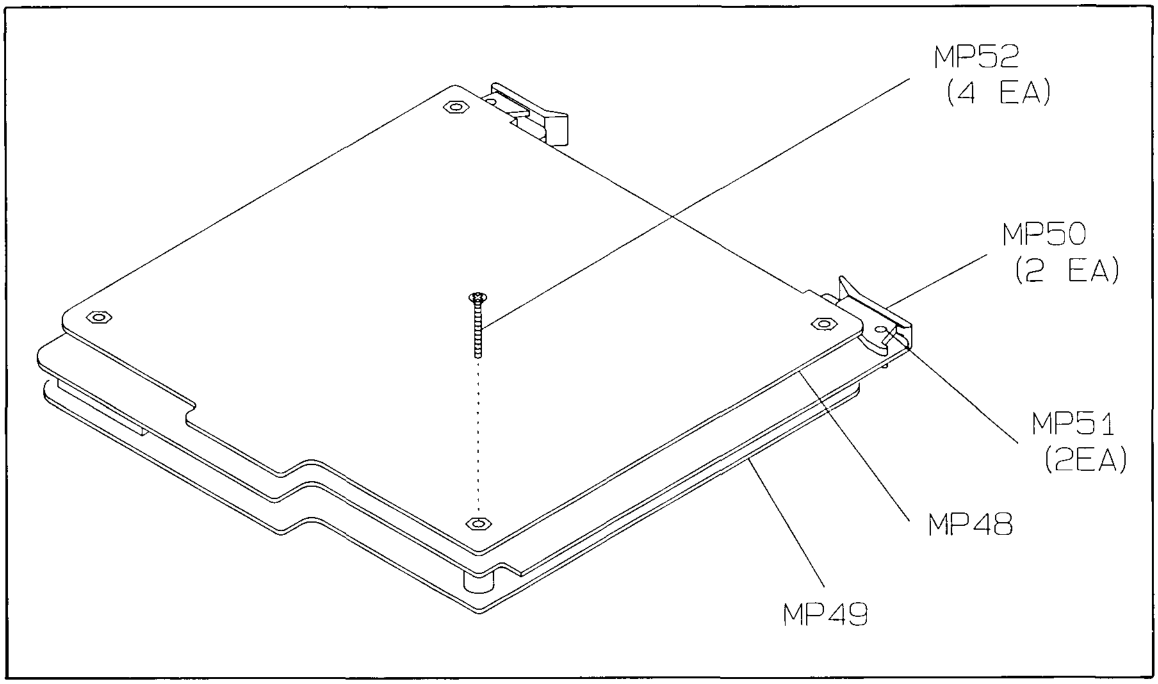



**Figure 8-8 44470A Disassembly**

## 8-14 Relay Drive And Sense Operation

A simplified schematic diagram of one relay drive and sense circuit is shown in Figure 8-9. When instructions are received over the data bus to set a relay (close a channel), a logic high level is applied to the base of Q2 and the input of U2 causing their outputs to go low. A logic low level is applied to the base of Q1 causing its output to go high. CR2 becomes forward biased allowing current to flow through both the set and reset coils of relay K1. The magnetic field generated around the coils interacts with the permanent magnetic field of the relay armature causing it to close the relay contacts. Once closed, the drive current is removed from the relay coil and the permanent magnetic field of the armature latches the contact in the closed state.

When instructions are received over the data bus to reset a relay (open a channel), a logic low level is applied to the base of Q2 and the input of U2 causing their outputs to go high. A logic high level is applied to the input of U1 causing its output to go low. CR1 becomes forward biased allowing current to flow through both the set and reset coils of relay K1. The magnetic field generated around the coils interacts with the permanent magnetic field of the relay armature causing it to open the relay contacts. Once opened, the drive current is removed from the relay coil and the permanent magnetic field of the armature latches the contacts in the opened state.

## Table 8-1 Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1 | 44470-66501 | 0 | 1 | 10-CHANNEL MULTIPLEXER ERC: 2608 | 28480 | 44470-66501 |
| A1C901 | 0160-3847 | 9 | 4 | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C902 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C903 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C904 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C905 | 0160-4844 | 2 | 1 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-4844 |
| A1CR901 | 1901-0050 | 3 | 13 | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR902 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR903 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR904 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR906 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR907 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR908 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR909 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR910 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR911 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR912 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR945 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR946 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1DP901 | 1906-0229 | 8 | 2 | DIODE-ARRAY 50V 400MA | 01295 | TID133 |
| A1DP902 | 1906-0229 | 8 | | DIODE-ARRAY 50V 400MA | 01295 | TID133 |
| A1J901 | 5180-6636 | 1 | 1 | CONN-2X11 RT ANG | 28480 | 5180-6636 |
| A1JM901 | 7175-0057 | 5 | 20 | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM903 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM904 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM906 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM907 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM909 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM910 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM912 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM913 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM915 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM916 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM918 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM919 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM921 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM922 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM924 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM925 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM927 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM928 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM930 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1K901 | 0490-1337 | 7 | 10 | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K902 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K903 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K904 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K905 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K906 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K907 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K908 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K909 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K910 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1P901 | 5180-6697 | 9 | 1 | CONN-RT ANG 2X15 | 28480 | 1251-8645 |
| A1Q901 | 1853-0551 | 6 | 7 | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q903 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q904 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q905 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q906 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q907 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q908 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1R901 | 0683-2725 | 8 | 7 | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R902 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R903 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R904 | 0683-1035 | 1 | 8 | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R905 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R906 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R907 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R908 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R909 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R910 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |

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

## Table 8-1 Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1R912 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R914 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R915 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R916 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R917 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R918 | 0683-4705 | 8 | 3 | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1R919 | 0683-4705 | 8 | | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1R920 | 0683-4705 | 8 | | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1U901 | 1820-2537 | 3 | 2 | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C244N |
| A1U902 | 1820-2537 | 3 | | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C244N |
| A1U903 | 1820-2216 | 5 | 2 | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U904 | 1858-0047 | 5 | 2 | TRANSISTOR ARRAY 16-PIN PLSTC DIP | 13606 | ULN-2003A |
| A1U905 | 1820-2216 | 5 | | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U906 | 1858-0047 | 5 | | TRANSISTOR ARRAY 16-PIN PLSTC DIP | 13606 | ULN-2003A |
| A1U907 | 1820-1216 | 3 | 1 | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| MP48 | 03488-00602 | 8 | 1 | CARD SHIELD - CKT | 28480 | 03488-00602 |
| MP49 | 03488-00603 | 9 | 1 | CARD SHIELD - COMP | 28480 | 03488-00603 |
| MP50 | 0403-0464 | 6 | 2 | PC EXTRACTER WHT | 28480 | 0403-0464 |
| MP51 | 1480-0625 | 4 | 2 | PIN-GRV 3/32 X 1/4 | 28480 | 1480-0625 |
| MP52 | 0515-0843 | 2 | 4 | SCREW M2.5 X 20 LK | 28480 | 0515-0843 |
| | 5040-5193 | 3 | 1 | STRAIN RELIEF HOUSING | 28480 | 5040-5193 |
| | 5040-5194 | 4 | 1 | STRAIN RELIEF PLATE | 28480 | 5040-5194 |
| | | | | NOTE: HP PRODUCT NUMBER 44480A INCLUDES CONNECTOR TERMINAL BLOCK AND STRAIN RELIEF ASSEMBLY. | | |

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

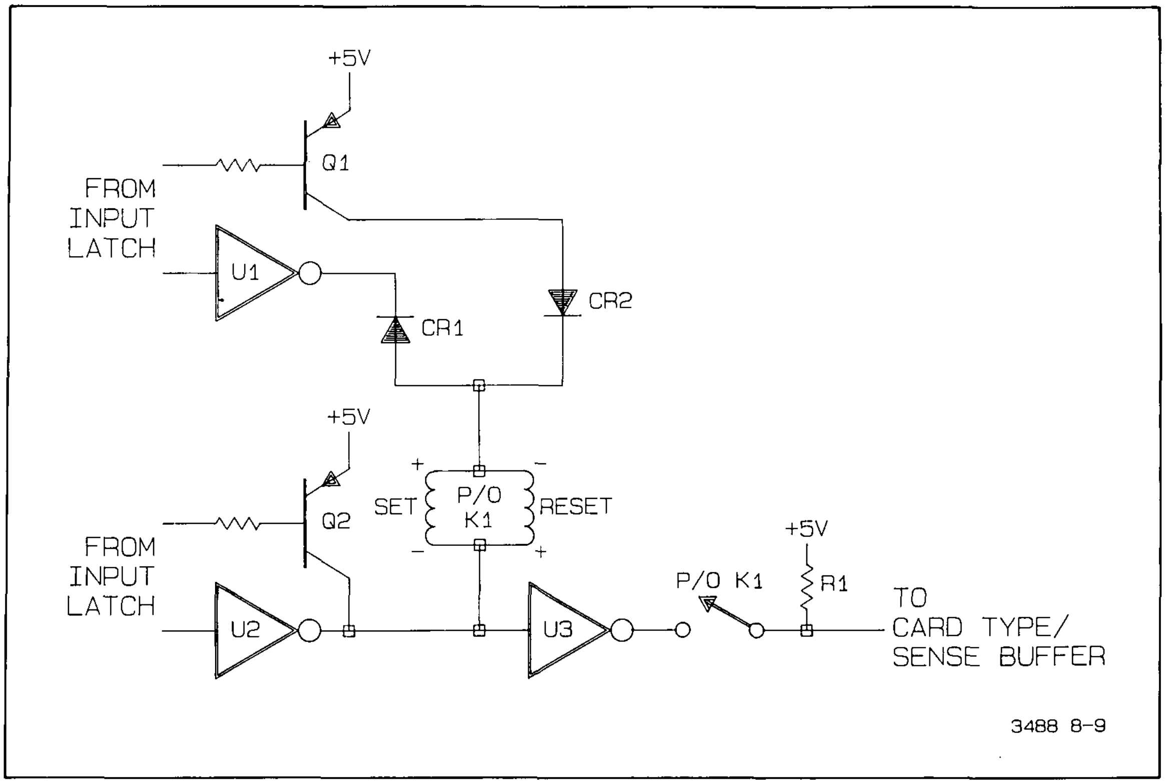



**Figure 8-9 One Relay Drive and Sense Circuit**

Notice that it is necessary to activate one of the upper drive elements (Q1 or U1) and the lower drive elements (Q2 and U2) in order to change a relay's state. If the elements in only the upper or lower drive are activated, no current flows through the relay coils and the relay retains its previous state. This aspect of operation is used by the mainframe in conjunction with the 44470A's relay sense circuitry to verify relay states following relay contact closures, a card reset, and an instrument reset.

When a relay state is being verified following a closure, a low is applied to the base of Q2 and to the input of U2. This causes a high at the input of inverter U3 causing its output to go low. If the sense switch is in the correct state (closed) a low is applied, through the switch contacts, to the card-type/sense buffer. The controller recognizes this signal as being correct and no error message occurs.

If, following a closure, the sense switch is in the incorrect state (open), the pull-up resistor R1 applies a high to the card-type/sense buffer. The controller recognizes this as an incorrect state and displays ERR:8 LOGIC.

Relay sense operation following a card or instrument reset is similar to that described above with the exception that the controller interprets an open sense switch as the correct state and a closed sense switch as the incorrect state.

## 8-15 Card-Type/Sense Buffer

The card-type/sense buffer (U901 in Figure 8-12) indicates to the mainframe that a 44470A is in the particular card slot queried. The card type is determined by the wiring configuration of four of the input lines to the card-type/sense buffer. By connecting all four inputs to ground, a 4-bit code (0000) is created that is recognized by the mainframe as the unique identifier for the 44470A card.

Secondarily, the card-type/sense buffer provides isolation between the outputs of the sense circuits and the mainframe's data bus. This buffer provides the necessary current to drive the data bus.

## 8-16 Address Decoder

The address decoder (U907 in Figure 8-12) is enabled when the $\overline{CS}$ signal from the mainframe goes low. Once enabled, the address decoder is responsible for enabling the various IC's on the board in response to the instructions it receives via the R/$\overline{W}$, A0 and A1 signals from the mainframe. Figures 8-10 and 8-11 show the timing relationships between these control lines for both read and write operations.

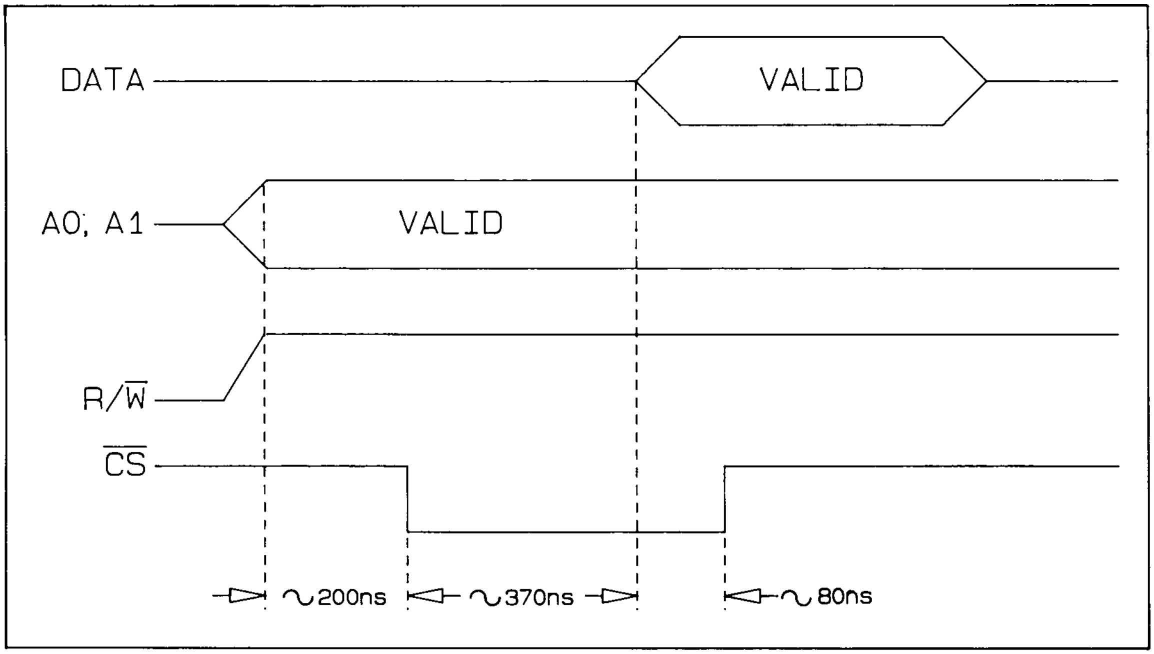



**Figure 8-10 Control Line Timing (Read)**

# 8-17 44470A TROUBLESHOOTING

## 8-18 Introduction

If the Performance Tests (Section 8-5) or Operational Verification tests (Chapter 4) have indicated that a particular relay is failing, that relay is probably at fault. A failure of the relay contact resistance test indicates a bad relay.

If more than one relay failure is indicated, the associated drivers should be suspected. Using Figure 8-12 (44470A Schematic) the problem can be isolated to a few components from the symptoms. The relays on the 44470A circuit board are arranged into three rows and four columns. To close a relay, both a row driver and a column driver must be active. Failures in the drivers, then, will exhibit symptoms that are common to a row or a column.

For example; suppose relays in channels 08 and 09 are failing to close. From the schematic, it is determined that channels 08 and 09 correspond to relays K909 and K910 respectively.

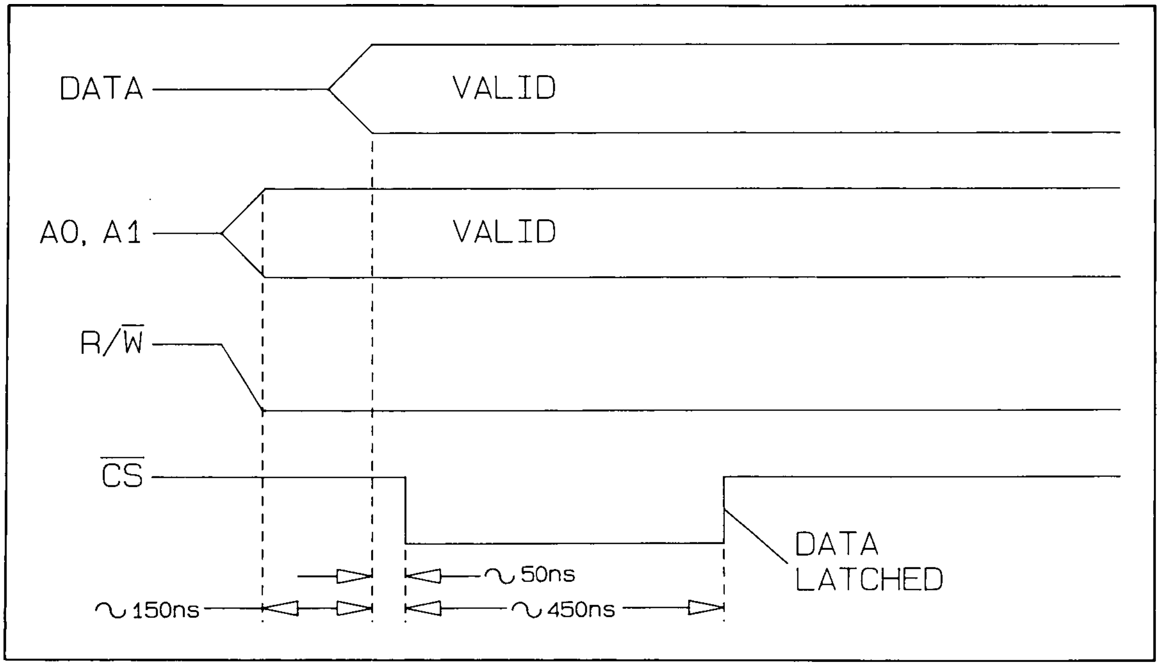



**Figure 8-11 Control Line Timing (Write)**

Further examination of the schematic reveals that both these relays are in the same row. The drivers Q906, U906, and U905 would be suspected.

As a another example; suppose relays in channels 01, 05 and 09 are failing to close. These channels correspond to relays K902, K906 and K910. These three relays are in a common column. The suspected drivers would be Q901, U904 and U903.

## 8-19 ERR 8: LOGIC SLOT X

The mainframe error most associated with the plug-in option cards is the ERROR 8: LOGIC error. This error is generated when the controller checks the relays sense circuitry after changing a relay state. The operation of the relay sense circuitry is described in Section 8-14.

The sense circuitry is used by the controller to indicate that a relay did not close when instructed or did not open when instructed. However, the controller does not always check each state. After a power-on reset, a front panel (or remote) reset, or a card reset, the controller checks the sense circuitry for open contacts. If one or more contacts is indicating the closed position, the controller will beep and display ERR 8: LOGIC. After a close command, the controller checks the sense circuitry to determine if the indicated relay is closed. If the sense circuitry indicates the relay is open the controller beeps and displays ERR 8: LOGIC. This action occurs for each relay closure including scan lists and stored set-ups. Following a relay opening, however, the controller does NOT check the sense circuitry for the open. This means that a relay may stick closed and the controller will not flag an error. This occurs for relays opened through the open command, scan lists, and stored set-ups.

In summary, the controller checks for open relays following power-on resets, front panel or remote resets, and card resets. It checks for closed relays following a close command (whether executed by the close command, a scan list or a stored set-up).

When troubleshooting a plug-in card that is generating ERROR: 8 LOGIC it is important to carefully observe the symptoms. If the error is generated when power is applied to the

3488A (controller checking for openings) check the relay contacts to determine if a relay is stuck closed. If no relay is stuck closed, suspect the sense circuitry. If the error is generated following a close command, check the relay contacts to determine if the relay is closed. If the relay is closed, suspect the sense circuitry.

### 8-20 Equipment Required

| | |
|---|---|
| Signature Multimeter | HP 5005A or equivalent |
| Service Extender Cable | 5061-1174 |
| Service Extender Board | 5061-1173 |

## 8-21 Initial Checks

The initial checks of a suspected plug-in card will require that the plug-in card shields be removed. Removal of the four screws in the plug-in shield allows both shields to be removed from the plug-in printed circuit board.

Once the shields have been removed, the card to be tested should be installed in slot 1 of the mainframe. There are two ways to do this. The first method uses the Service Extender Board (5061-1173) and the Service Extender Cable (5061-1174). With these two service tools the card may be electrically installed in the card slot but be physically located on the test bench.

If the service extender tools are not available, the card may be installed in slot 1 and the 3488A mainframe top cover removed. This will allow access to the non-component side of the plug-in card for servicing. 3488A top cover removal is described in Chapter 5.

Be sure that all other plug-in cards have been removed from the mainframe.

1. Apply power and measure the +5 Vdc on the plug-in board. There are two supplies to this board, both the supplies (and the grounds) are common on the backplane board. Connect the ground lead of the voltmeter to pin 10 of U901. Measure the voltage at pin 20 of U901. The voltage should be +5 Vdc ±0.5 Vdc. Measure the voltage at the emitter of any of the discrete transistors on the board (i.e., Q906). The transistors are mounted with the emitter lead in a square pad on the board. The voltage should be +5 Vdc ±0.5 Vdc.

If the voltages are correct, proceed to Step 2. If either or both of the voltages are incorrect, troubleshoot the +5 Vdc supply in the mainframe (it is possible that the plug-in card is loading the supply).

2. Observe the front panel symptoms to determine if the problem can be isolated to a few components. The Operational Verification tests is Chapter 4 may be used to identify a relay contact or closure problem. If a relay is closing (or opening) correctly, as determined by the relay contact tests, but the mainframe displays ERR 8: LOGIC, the relay sense circuitry is at fault. The mainframe will also display ERR 8: LOGIC if one or more relays are not functioning (refer to Section 8-19 for a discussion of the error message).

If a single relay (channel) is at fault, troubleshoot that relay. If one or more relays indicate a fault, the drivers should be suspected (refer to Section 8-18).

If the problem cannot be isolated easily, proceed to Step 3.

3. Check the mainframe and plug-in card data bus for activity. The data probe of the HP

5005A may be used to indicate activity on the data bus. A blinking probe light indicates state changes. Check the data bus at U902 pins 2, 4, 6, 8, 11, 13, 15 and 17. The plug-in card must be installed in slot 1 and power applied to the mainframe. No special test set-ups should be installed.

All eight data lines should show activity.

If activity is found, proceed to Step 4. If one or more of the lines are stuck, troubleshoot the backplane data bus or the inputs to buffers U901 and U902 on the plug-in card.

4. Check the outputs of U902 at pins 3, 5, 7, 9, 12, 14, 16 and 18 for activity. All eight pins should show activity.

If activity is found, proceed to Step 5. If no activity is found on one or more lines, troubleshoot U902, U905 or U903.

5. Check the backplane card select and decoding lines for activity. Check U907 pins 1, 2, 3, and 4 for activity. All lines should show activity.

If activity is found, proceed to Step 6. If no activity is found, troubleshoot the backplane or the inputs to U907 on the plug-in card.

6. If the problem has not been isolated, signature analysis procedures may be used to test the buffers, drivers, and relay coils. The procedure begins in Section 8-22.

## 8-22 Buffer, Driver, And Relay Signature Analysis

To perform the signature analysis tests the mainframe top cover and the controller shield must be removed. Procedures to remove the cover and shield are located in Chapter 5.

The HP 5005A has been recommended for this signature analysis test because it incorporates adjustable data thresholds. This feature allows signatures to be checked at the relay coils. If a different signature analyzer is being used, the signatures may only be checked up to the drivers.

Ensure the controller is set to the normal operating configuration (RP409 installed and all switches on SP401 set open) before performing these troubleshooting steps. All plug-in cards should be removed from the mainframe. The suspected plug-in card must be installed in slot 1.

The initial checks given in section 8-21 should be performed prior to this signature analysis procedure. Section 8-21 also describes the use of the service extender card and service extender cable.

1. Signature Analyzer set-up. Polarity: START _/‾, STOP and CLOCK ‾_. On the controller printed circuit board (A40), connect START/ST/SP to SA2, STOP/QUAL to SA2, CLOCK to SA3, Ground to SA4.

2. On the controller printed circuit board (A40), connect a jumper between SA6 (SERV FUNC) and ground (SA4).

3. If using the HP 5005A signature analyzer, set the data probe threshold to 2.80 H and 2.00 L.

4. Apply power to the 3488A. Press the TEST key on the front panel. Instead of performing the internal controller self-test, the display will prompt for a number. Enter 2 and press execute.

5. The signature analyzer should now be gating. The test selected cycles all data lines in a fixed pattern. This pattern will produce one of two signatures (depending upon inversion) that may be traced from the relay coils to the backplane data bus. These signature are: 36U6 and 6HPH.

6. The signatures for the inputs and outputs on the 44470A are given in Table 8-2.

## 8-23 Sense Circuit Troubleshooting

Problems with the sense circuitry will typically exhibit ERR 8: LOGIC in the display. A discussion of the error message as it applies to the plug-in card is given is Section 8-19. A theory of operation of the sense circuitry is given in section 8-14.

The drivers for the sense circuit, U904 and U906, are open collector drivers. This means that one of the relays sense contacts must be closed for the driver to operate. The driver may be manually tested by closing an appropriate relay to provide as current path and exercising the input to the driver.

Problems with the sense circuitry can also be isolated with a signature analysis procedure. This procedure begins in Section 8-24.

## 8-24 Sense Circuitry Signature Analysis

This procedure checks the signatures at the input to the buffer, U901. This buffer has three inputs from the sense circuitry, pins 11, 15, and 17. Each of these inputs represents a composite signal obtained through several different relays and drivers. The signature analysis procedure is designed so that one column of relays is driven at a time (i.e., K901, K905, and K909 are in column 0). Each relay in the column is sensed by a separate line. By observing the signatures obtained at the input to U901 and knowing which column is being driven to obtain the signature, a problem may be isolated to one driver and a set of relays. If all the signatures are incorrect for a given column, the drivers should be suspected. If only one signature is incorrect, the relay should be suspected.

To perform the signature analysis tests the mainframe top cover and the controller shield must be removed. Procedures to remove the cover and shield are located in Chapter 5.

Ensure the controller is set to the normal operating configuration (RP409 installed and all switches on SP401 set open) before performing these troubleshooting steps. All plug-in cards should be removed from the mainframe. The suspected plug-in card must be installed in slot 1.

The initial checks given in section 8-21 should be performed prior to this signature analysis procedure. Section 8-21 also describes the use of the service extender card and service extender cable.

1. Signature Analyzer set-up. Polarity: START _/‾, STOP and CLOCK ‾_. On the controller printed circuit board (A40), connect START/ST/SP to SA2, STOP/QUAL to SA2, CLOCK to SA3, Ground to SA4.

2. On the controller printed circuit board (A40), connect a jumper between SA6 (SERV FUNC)

and ground (SA4).

3. Apply power to the 3488A. Press the TEST key on the front panel. Instead of performing the internal controller self-test, the display will prompt for a number. Enter 3 and press execute.

4. The signature analyzer should now be gating. The test drives one column of relays at a time. The 3488A display will show COLUMN 0 SA. Pressing the right arrow key on the front panel increments the column number. Pressing the left arrow key decrements the column number.

This test is very noisy as all the relays are being cycled.

5. The signatures for each column and input of U901 are given in Table 8-3a. Table 8-3b identifies the components that are being used to make up the correct signature.

**Table 8-2 Buffer, Driver, And Relay Signatures (Test 2)**

+5 Vdc signature: 5C1C

U902

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 20 | +5 Vdc |
| 2 | 36U6 | 19 | NA |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 36U6 | 16 | 36U6 |
| 6 | 36U6 | 15 | 36U6 |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 36U6 | 12 | 36U6 |
| 10 | NA | 11 | 36U6 |

U903

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | L | 20 | +5 Vdc |
| 2 | 6HPH | 19 | 6HPH |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 6HPH | 16 | 6HPH |
| 6 | 6HPH | 15 | 6HPH |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 6HPH | 12 | 6HPH |
| 10 | NA | 11 | NA |

U905

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | L | 20 | +5 Vdc |
| 2 | 36U6 | 19 | 36U6 |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 36U6 | 16 | 36U6 |
| 6 | 36U6 | 15 | 36U6 |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 36U6 | 12 | 36U6 |
| 10 | NA | 11 | NA |

U904

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | 36U6 | 16 | NA |
| 2 | 36U6 | 15 | NA |
| 3 | 6HPH | 14 | 36U6 |
| 4 | NA | 13 | NA |
| 5 | 6HPH | 12 | 36U6 |
| 6 | 6HPH | 11 | 36U6 |
| 7 | 6HPH | 10 | 36U6 |
| 8 | NA | 9 | +5 Vdc |

U906

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 16 | NA |
| 2 | 36U6 | 15 | 6HPH |
| 3 | 36U6 | 14 | NA |
| 4 | 36U6 | 13 | NA |
| 5 | 36U6 | 12 | 6HPH |
| 6 | NA | 11 | NA |
| 7 | 36U6 | 10 | 6HPH |
| 8 | NA | 9 | +5 Vdc |

K901 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

K905 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

K908 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

K902 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

K906 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

K909 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

K903 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

K907 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

K910 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

K904 *

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

* these signatures have a data threshold of 2.80 H and 2.0 L.

**Table 8-3a Sense Circuit Signatures**

+5 Vdc signature: 6592

| | column 0 | column 1 | column 2 | column 3 |
|---|---|---|---|---|
| U901 pin 17 | 474A | 474A | 474A | 474A |
| U901 pin 15 | 2P64 | 2P64 | 2P64 | 2P64 |
| U901 pin 13 | PF66 | PF66 | 6592 | 6592 |

**Table 8-3b Components Used For Signatures**

| | column 0 | column 1 | column 2 | column 3 |
|---|---|---|---|---|
| U901 pin 17 | U906<br>K901 | U906<br>K902 | U904<br>K903 | U904<br>K904 |
| U901 pin 15 | U906<br>K905 | U906<br>K906 | U904<br>K907 | U904<br>K908 |
| U901 pin 13 | U906<br>K909 | U906<br>K910 | NONE | NONE |

HP44470A Relay Card Schematic

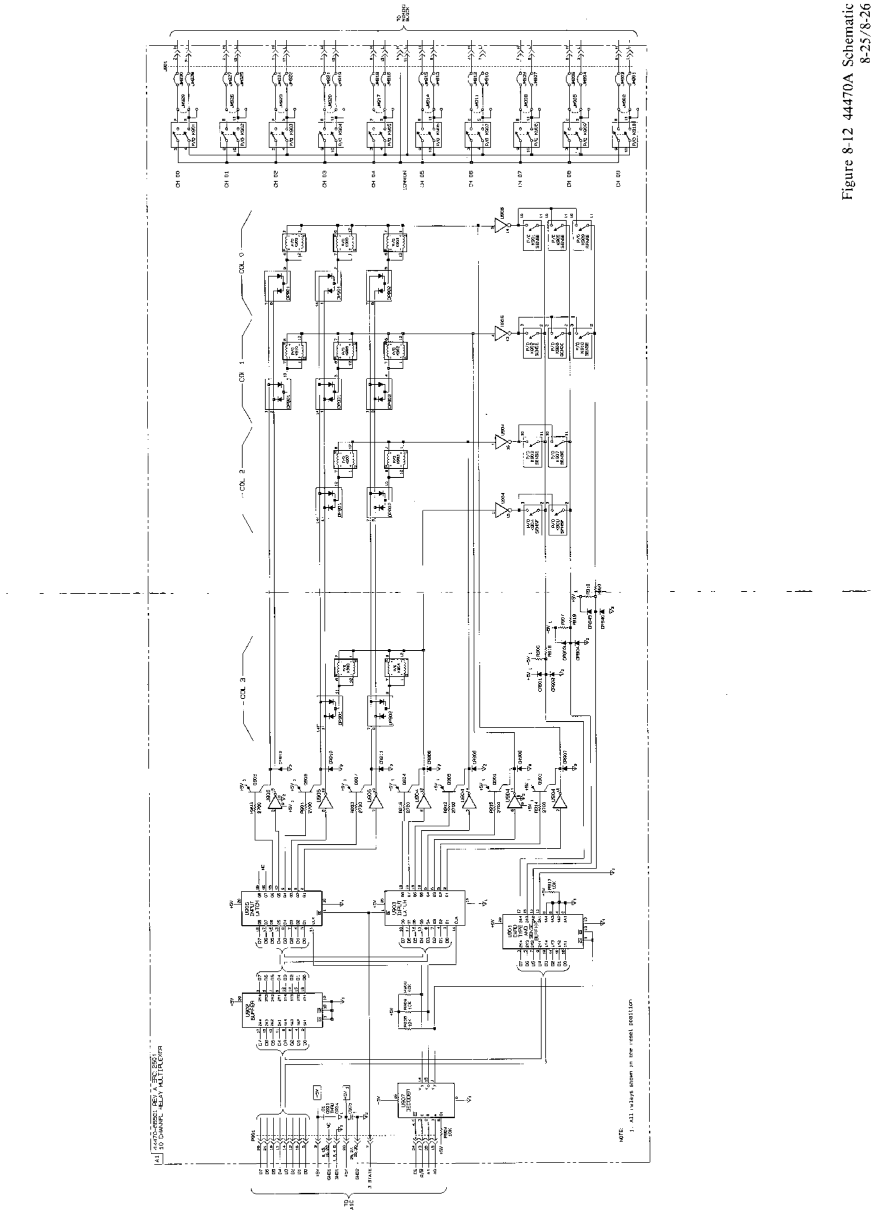
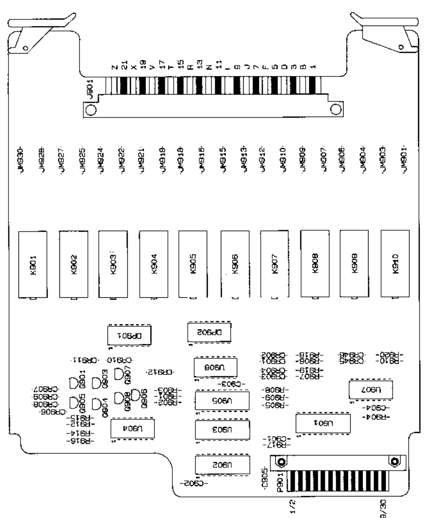


Figure 8-12 44470A Schematic
8-25/8-26



# Chapter IX

# 44471A 10 CHANNEL GENERAL PURPOSE RELAY

# CHAPTER IX

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF ILLUSTRATIONS

# CHAPTER IX
# 44471A 10 CHANNEL GENERAL PURPOSE RELAY

## 9-1 INTRODUCTION

This chapter contains installation information, performance testing information, troubleshooting procedures and replaceable parts lists for the 44471A General Purpose Relay.

The General Purpose Relay contains a 10 channel array of single-pole single-throw (SPST) relays. A simplified schematic of the 44471A switching circuitry is shown in Figure 9-1.

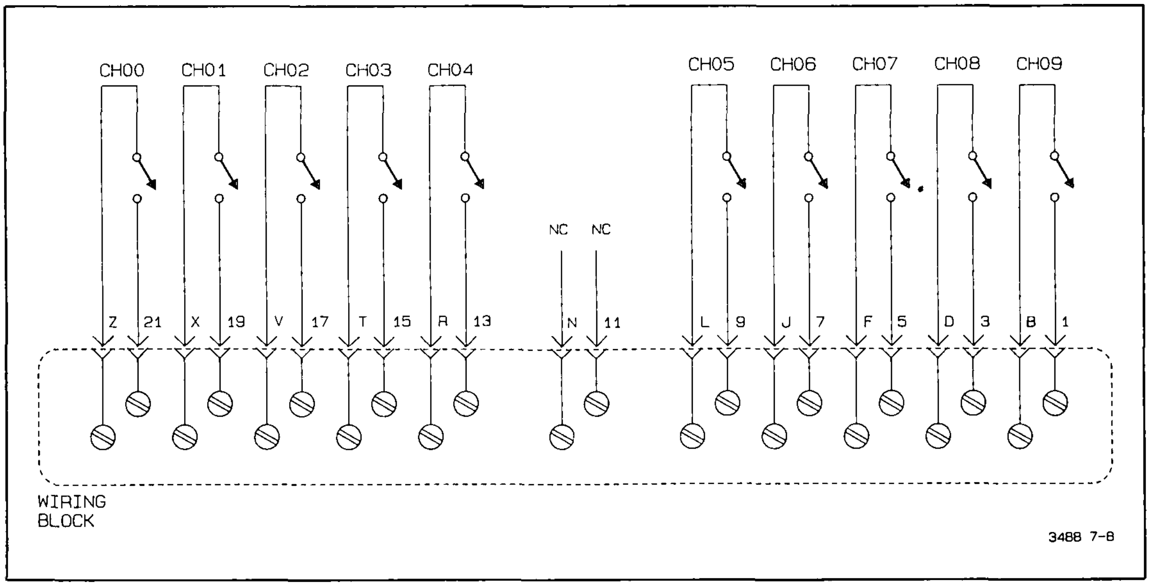



**Figure 9-1 44471A Simplified Schematic**

**WARNING**

*Hazardous voltages may exist on the wiring and connector of the 44471A plug-in card. Only service trained personnel with a knowledge of electronic circuitry and an awareness of the hazard involved should install, reconfigure, or make repairs to the 3488A and/or the plug-in cards.*

**NOTE**

*The Performance Test procedures in this chapter are involved and time consuming. Since the most likely parameter to change with time is the series resistance of a channel, and since the series resistance is tested in the Operation Verification procedures (Chapter 4), it is not recommended that the Performance Tests be conducted unless one of the tested specifications is in question.*

## 9-2 PLUG-IN CARD WIRING

Figure 9-2 shows the proper wiring procedures for the 44471A.

**WARNING**

*Hazardous voltages may exist on the wiring and connectors of the 3488A's plug-in cards. Only Service Trained Personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make repairs to the 3488A and/or the plug-in cards.*

## 9-3 PLUG-IN CARD CLEANING

Printed circuit board contamination can affect the dc isolation and the high frequency performance of the plug-in cards. This contamination can come from dust accumulation, fingerprints, condensation, and so on. The plug-in card printed circuit boards are to be cleaned as follows:

**CAUTION**

*Use anti-static pc board handling techniques during the following procedure.*

1. Remove the shields from the plug-in card.

2. Use a stiff bristled camel hair brush (do not use a wire brush) soaked in isopropyl alcohol to wash the pc board.

**CAUTION**

*DO NOT immerse the printed circuit board in any type of fluid.*

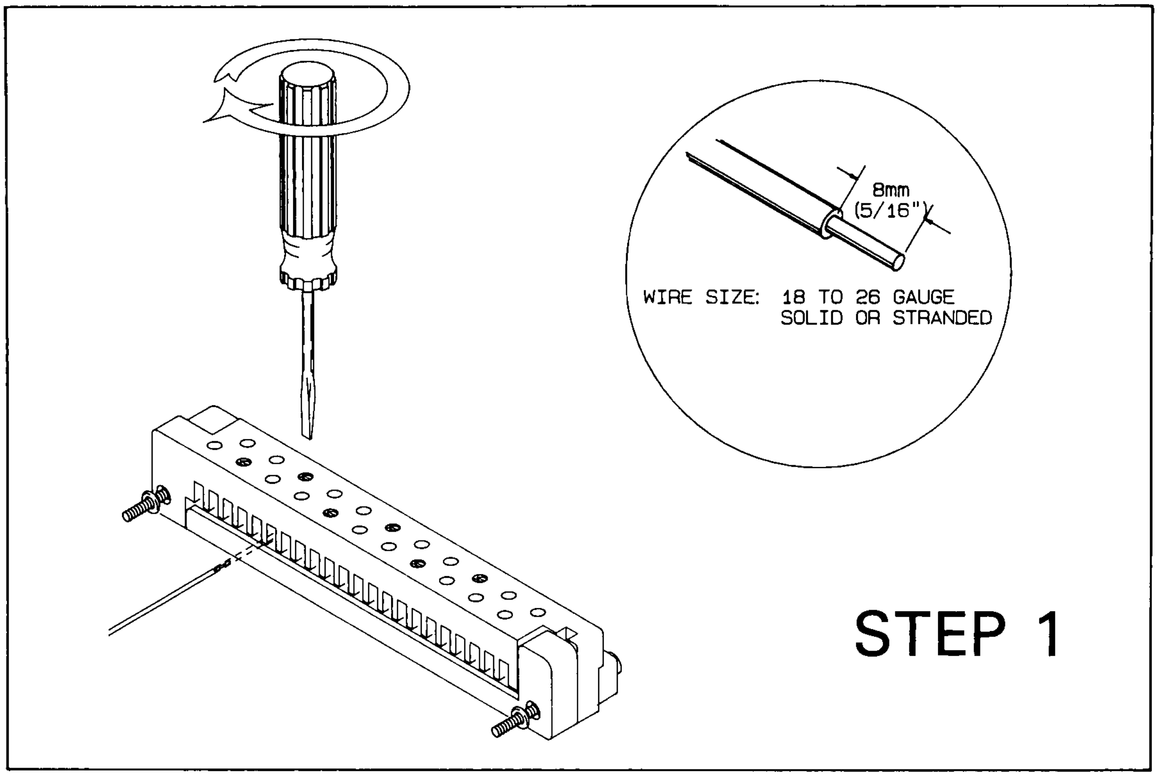
3. Use the stiff bristled brush soaked in deionized or distilled water, to remove any residue left by the alcohol.

4. Allow the printed circuit board to dry thoroughly.

5. Replace the shields.

⚠ **CAUTION**

*The maximum allowable terminal-to-terminal or terminal-to-chassis voltage limits for the 44471A are 250Vdc or 250Vac rms (350Vac peak). The maximum current limits per channel are 2Adc or 2Aac rms. The maximum current limits per card are 20Adc or 20Aac rms. The maximum power limits per channel are 60Wdc or 500VAac. The maximum power limits per card are 600Wdc or 5000VAac. Damage will occur to the 44471A and possibly the 3488A if any of the above limits are exceeded.*



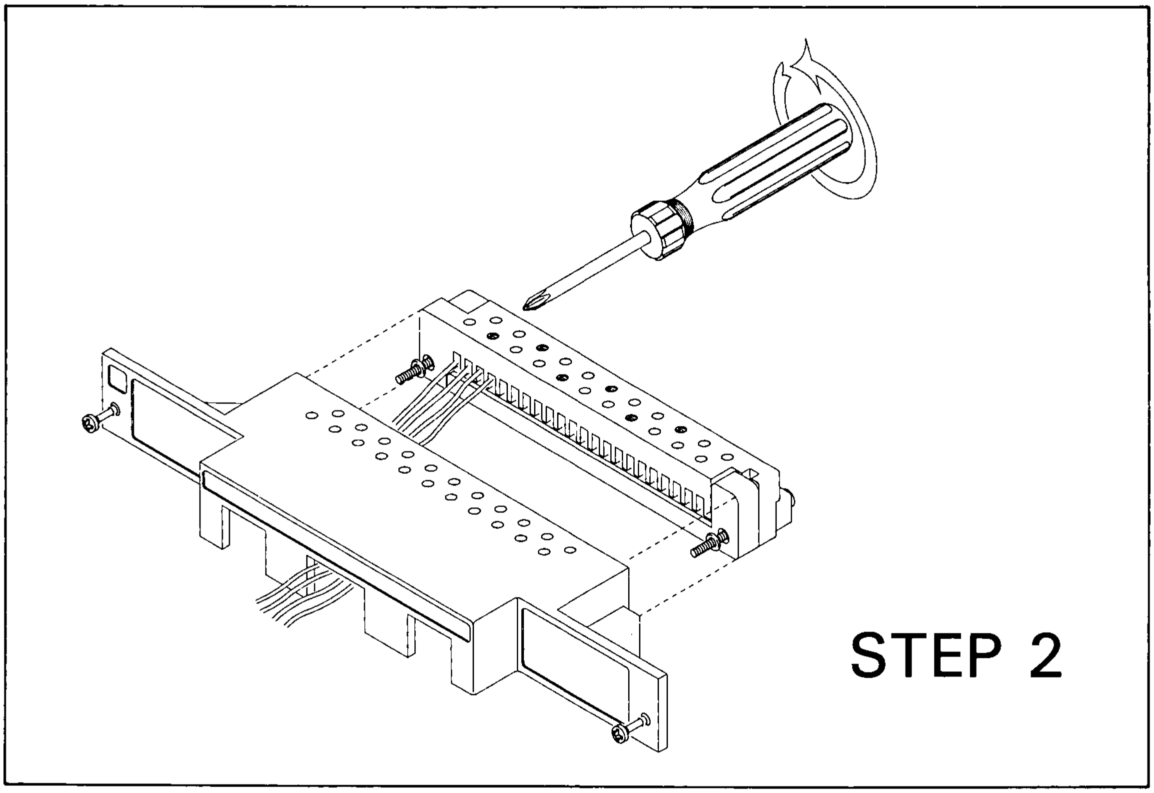




Figure 9-2 Plug-In Card Wiring

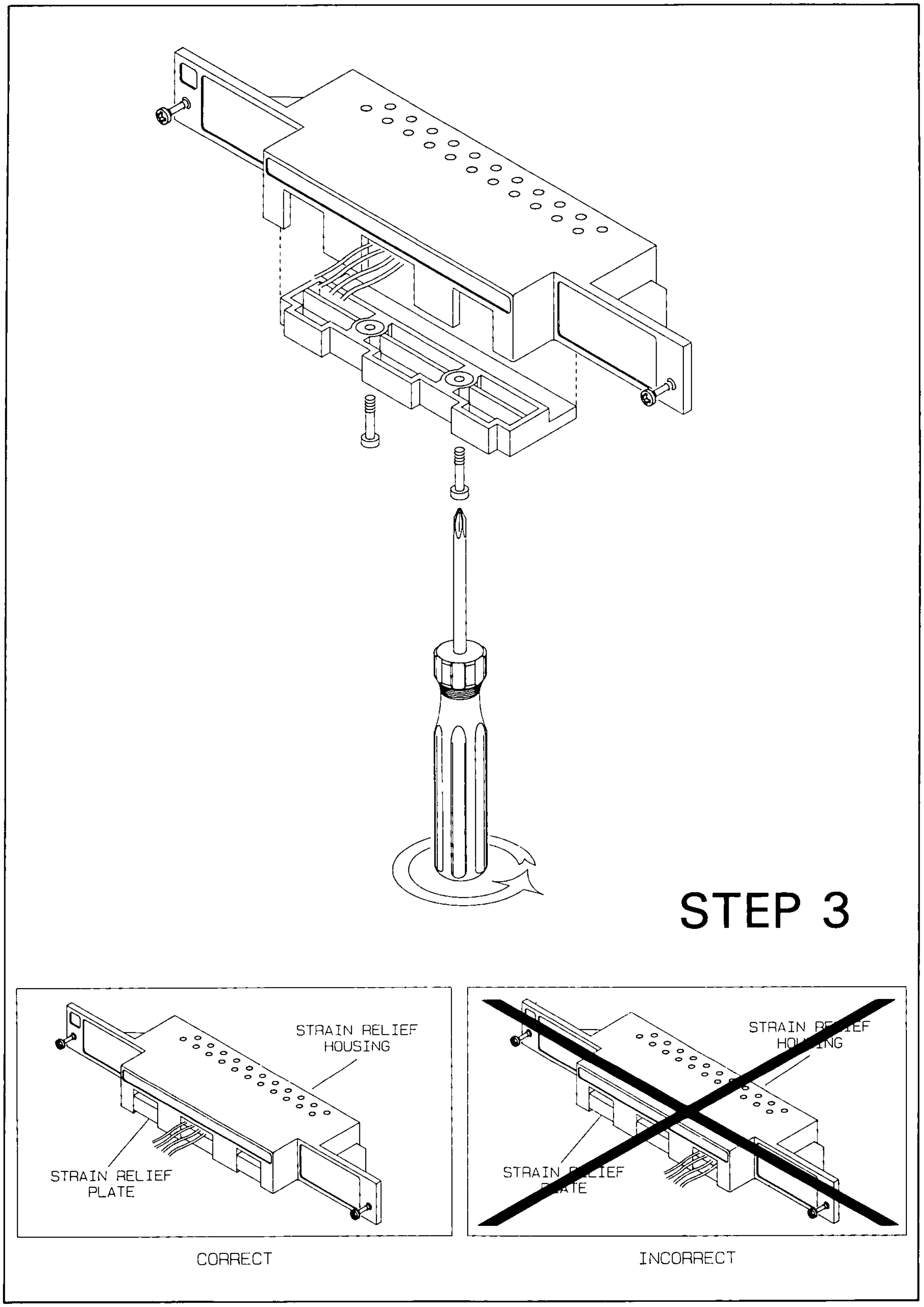
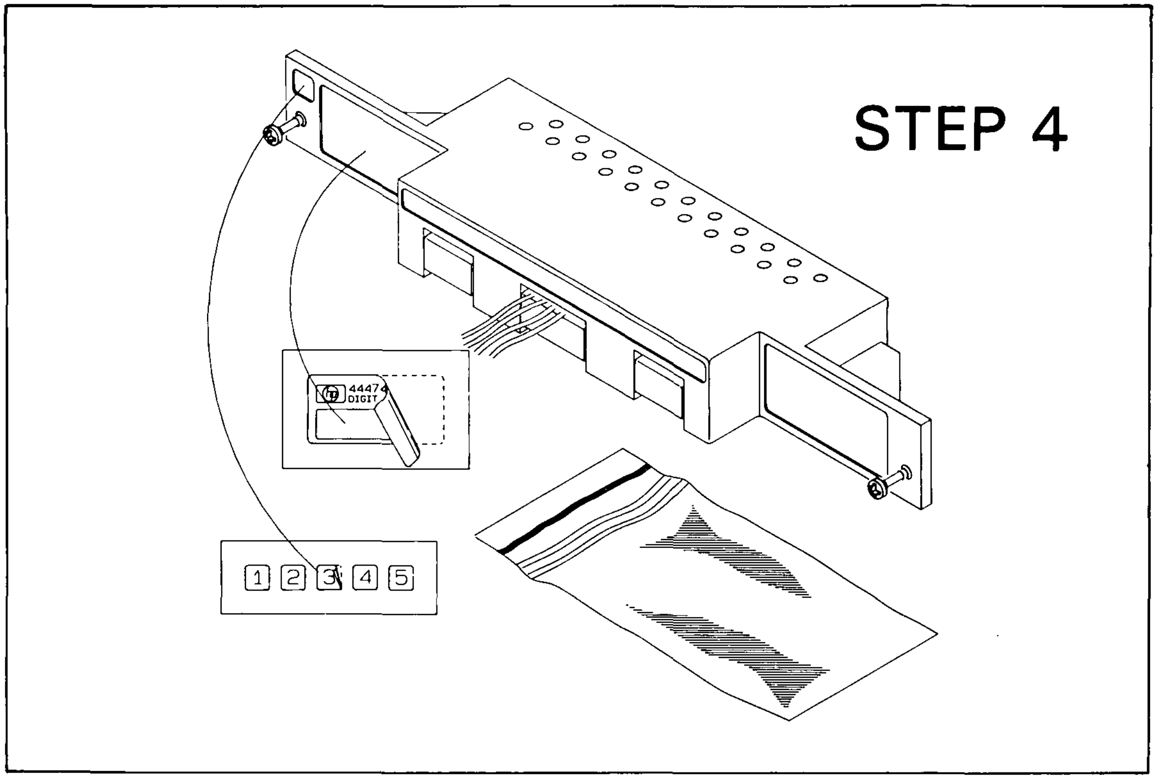



**Figure 9-2. Plug-In Card Wiring (Cont'd)**



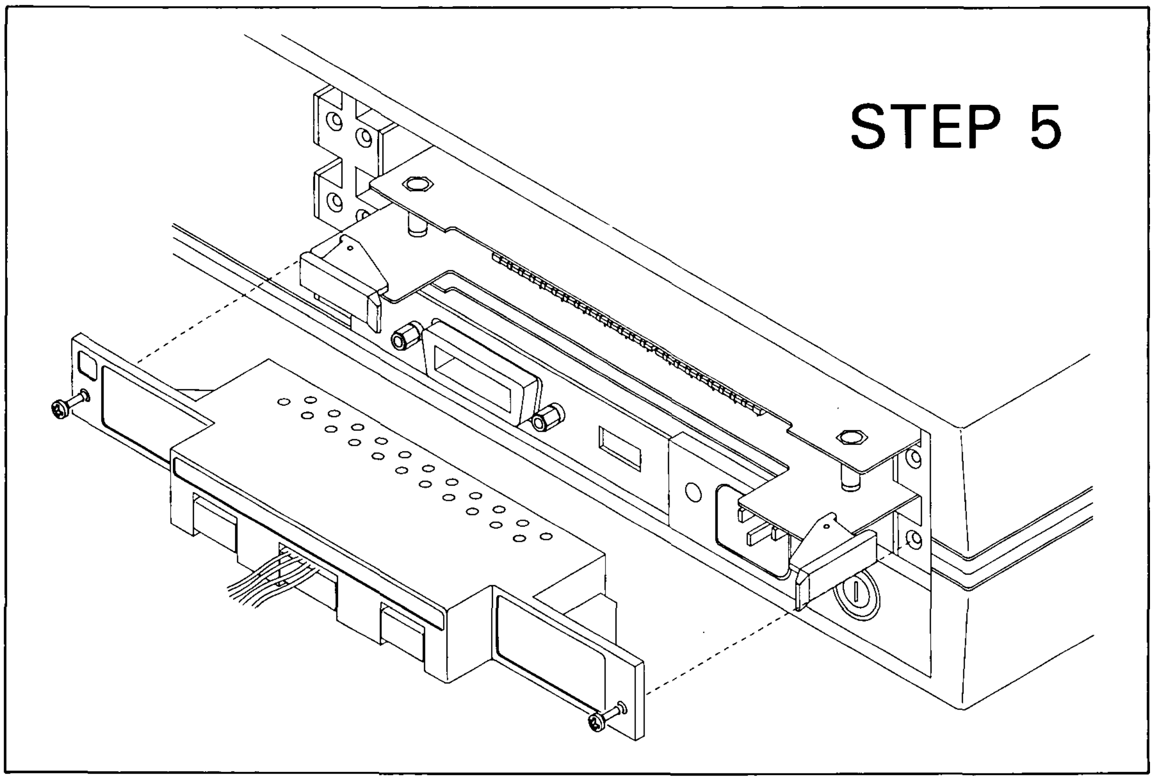




Figure 9-2. Plug-In Card Wiring (Cont'd)

## 9-4 CONTACT PROTECTION

Provision is made on the 44471A printed circuit board for user-installed contact protection. Sometimes called a snubber network, this protection consists of an RC network and a varistor. Contact protection requirements vary greatly from one application to another. With no contact protection whatsoever, the 44471A will switch a maximum of 250V rms (ac or dc), or 2A rms (ac or dc). The maximum power levels that can be switched per channel without contact protection are 60 W (dc), or 500VA (ac). For loads where the voltage, current, or power is greater than the above limits, contact protection is required.

The component values shown in Figure 9-3 are typical of general purpose snubber circuits. Other component values may be better suited to a particular application. The locations for these components are printed directly onto the 44471A pc board using the same symbols as shown in Figure 9-3.

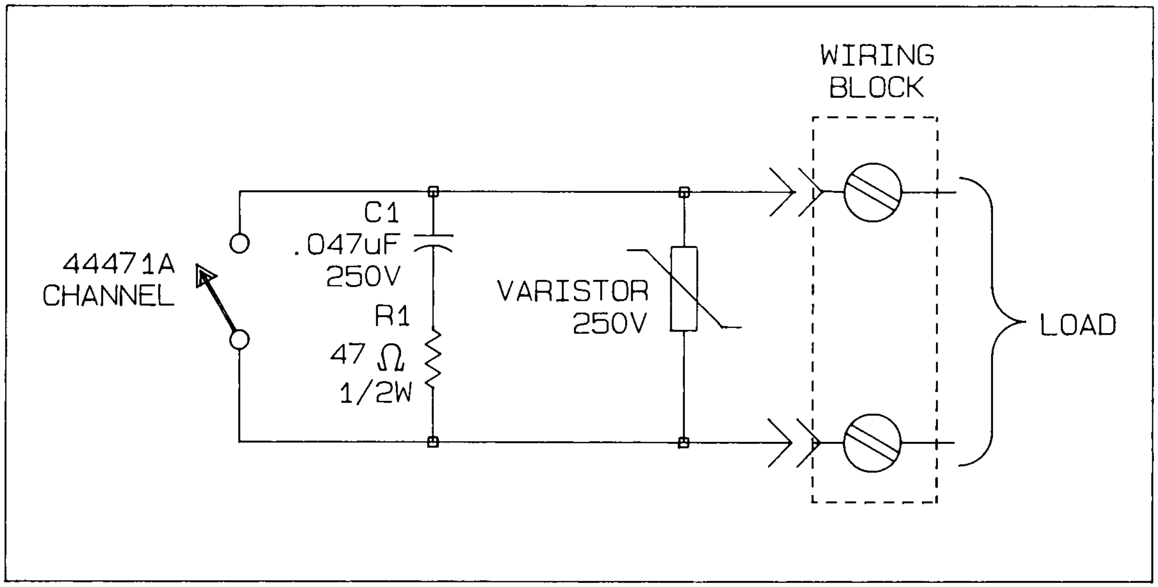



**Figure 9-3 Typical Snubber Circuit**

The protection resistor (R1) is selected as a compromise between two values. The maximum value of R1 is the value of the load resistance. The minimum value of R1 is determined by the equation:

$$R1 = V/Io$$

Where: V is the peak value of the supply voltage and Io is the maximum allowable relay current (2 Amps rms ac or 2 Amps dc for the 44471A).

The value of the protection capacitor (C1) should be such that it does not allow the voltage across the relay contacts to exceed 353 Volts peak (250V rms = 353V peak). The equation for determining the minimum value of C1 is:

$$C1 \geq (Ip/353)^{2L}$$

Where: Ip is the peak current which is equal to Vpeak/R1 and L is the inductance of the load.

The important parameter for the varistor is that its voltage rating is sufficient to handle the supply voltage. A 250V-rated varistor can be purchased from Hewlett-Packard with the part number 0837-0227.

In most cases, external contact protection (at or near the load) is also beneficial, especially with inductive loads.

It is beyond the scope of this manual to discuss the design criteria for all types of contact protection. A very good tutorial on relay contact protection can be found in:

"Practical Relay Circuits," by Frank J. Oliver. Published by the Hayden Book Company, Inc., New York.

## 9-5 TEST FIXTURE

A test fixture is required in order to perform the Operation Verification Tests for the 44471A (Chapter 4 of this manual). This fixture simplifies testing by eliminating the need to repeatedly connect and disconnect test leads and by acting as an interface between the 44471A and an ohmmeter.

The test fixture can be either of the following two types:

a. A test fixture is available from Hewlett-Packard (HP part number 03488-66501). The advantages of this fixture are (1) it requires no assembly and (2) it can be used to test the 44470A, the 44471A, the 44473A and the 44474A plug-in cards without modification.

b. A test fixture can be constructed by configuring an HP 44481A removable wiring block as shown in Figure 9-4. This particular test fixture can only be used to test the 44471A.

Either type of test fixture short circuits all of the 44471A's inputs together and short circuits all of the outputs together. Thus, by connecting an ohmmeter between the shorted inputs and the shorted outputs, the card is tested by successively closing each relay while checking for an indication of the closure on the ohmmeter.

## 9-6 PERFORMANCE TESTS

The following Performance Tests check the 44471A's dc isolation and thermal offset specifications. The results of these tests, when coupled with the results of the 44471A Operation Verification Test (Chapter 4), will verify whether or not the 44471A is operating within its critical specifications. Since the 44471A Operation Verification Test assesses the operability of the 44471A, it is important that it be performed prior to performing the Performance Tests.

**WARNING**

*If the 44471A is currently installed into a system, it must be disconnected from the system in order to execute the Performance Tests. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

**WARNING**

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected. The user must take the necessary precautions to prevent the above from happening before disconnecting the 44471A.*

### 9-7 Required Test Equipment

DC Power Supply — HP 6216B or equivalent. The power supply must be able to deliver a stable +20Vdc at low current levels.

10 megohm resistor.

Digital Multimeter — HP 3478A or equivalent. The multimeter must have the resolution and accuracy to measure a 1$\mu$V differential dc voltage.

## 9-8 44471A DC Isolation Tests

The following dc isolation tests incorporate a dc power supply, a resistor of known value,

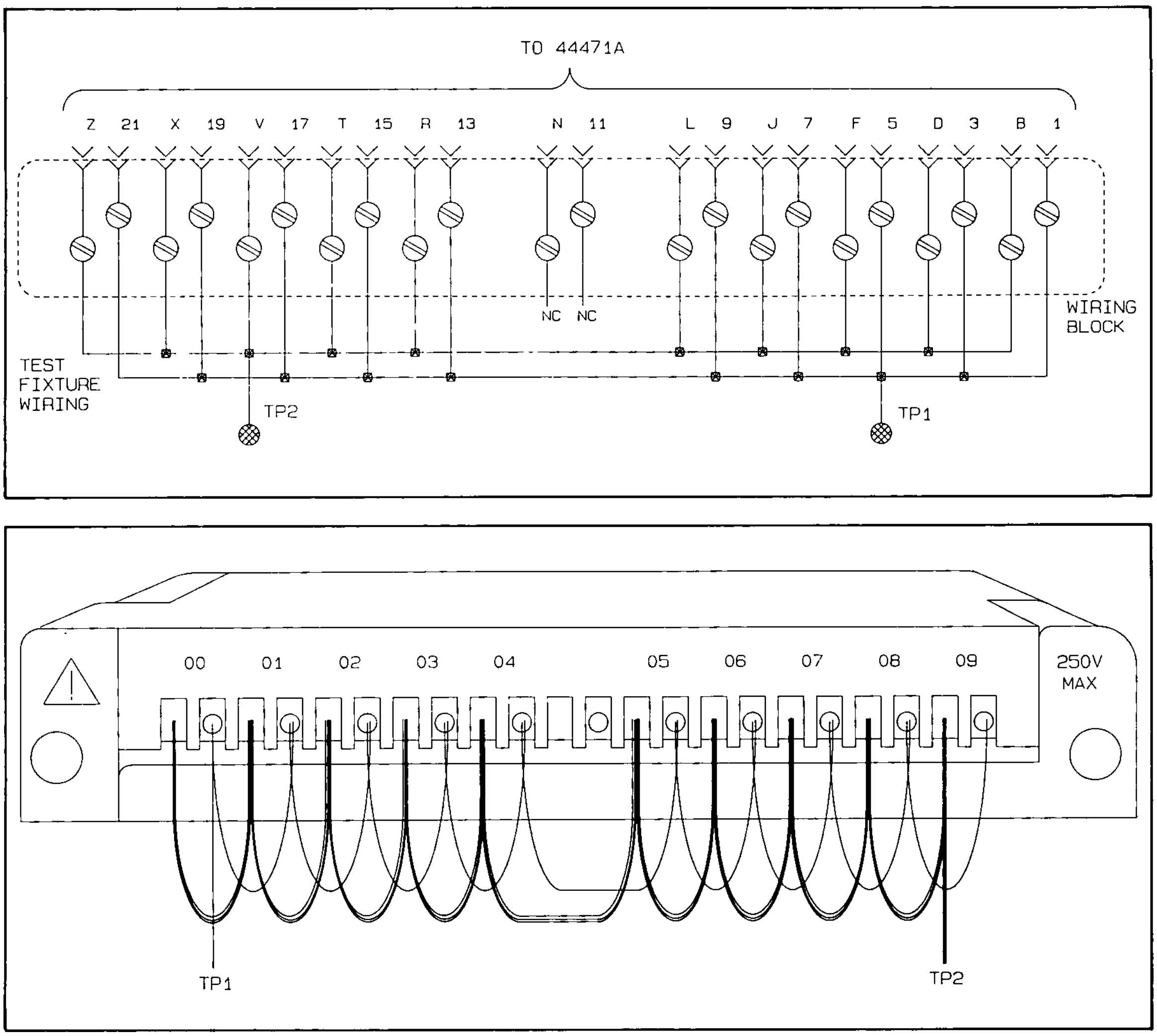



**Figure 9-4 44471A Test Fixture**

and a dc voltmeter. The first phase of the tests involves connecting the resistor and the dc voltmeter in series with the dc power supply. In this configuration, the resistor and the internal resistance of the dc voltmeter form a voltage divider. The voltage drop across the dc voltmeter is measured and, with the value of the resistor and the power supply voltage being known, the internal resistance of the dc voltmeter is calculated.

**NOTE**

*The best test results will be attained when the value of the known resistor is equal to the internal resistance of the dc voltmeter.*

The second phase of the tests consists of (1) placing the appropriate channel of the 44471A in parallel with the dc voltmeter, (2) measuring the voltage drop across the dc voltmeter/channel combination, and (3) calculating the channel's dc isolation.

1. SET-UP SEQUENCE: Set the digital multimeter to measure dc voltage. Connect the multimeter to the dc power supply. Set the dc power supply to deliver +20Vdc ±.01Vdc as measured on the multimeter. This voltage will be referred to as V1 in the following steps.

2. Use the multimeter to measure the exact resistance of the 10 megohm resistor. This value will be referred to as R1.

3. Connect the test equipment as shown in Figure 9-5.

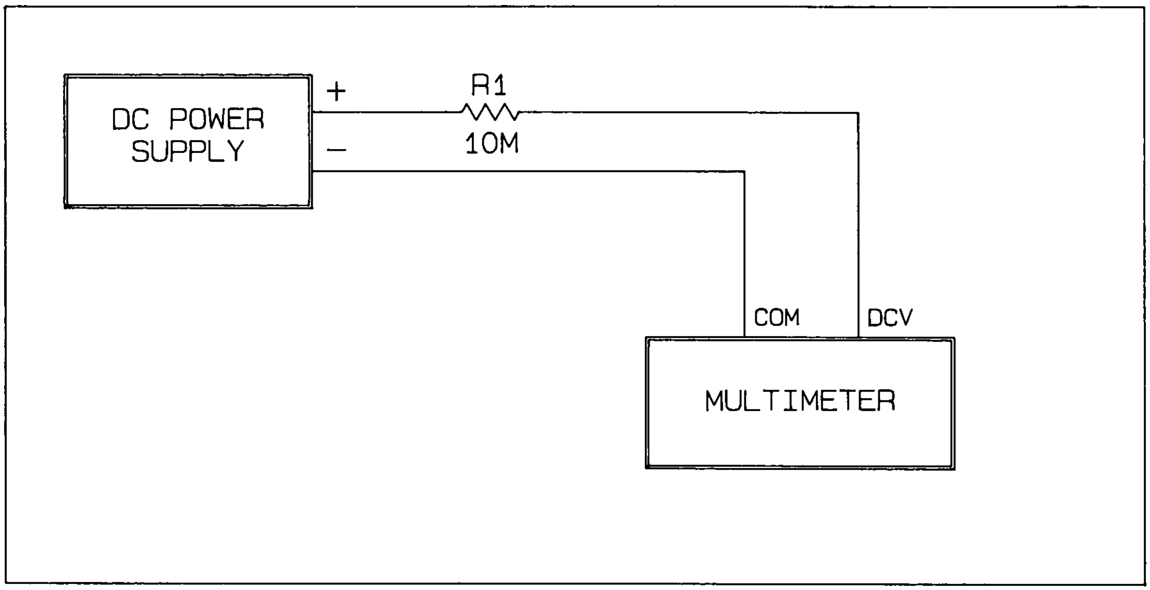



**Figure 9-5 DC Isolation Test Set-Up**

4. Set the multimeter to the 300Vdc range. Record the exact dc voltage reading on the multimeter. This voltage will be referred to as V2 in the following steps.

5. Calculate the internal resistance of the multimeter (Rm) using the following equation:

$$Rm = R1 \bullet V2/(V1 - V2)$$

**NOTE**

*In most cases, the internal resistance of the multimeter is dependent upon the range setting. For this reason, do not change the multimeter's range setting in the following steps.*

6. OPEN CHANNEL DC ISOLATION TEST: Use the 3488A front panel keys to establish the card monitor mode and to open all channels as follows:

a. Press the LOCAL key.

b. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the 44471A.

c. Press the EXECUTE key.

d. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44471A.

e. Press the EXECUTE key.

7. Connect the channel to be tested (channel 00 to start) into the test circuit as shown in Figure 9-6. Record the multimeter's dc voltage reading. This reading will be referred to as V3.

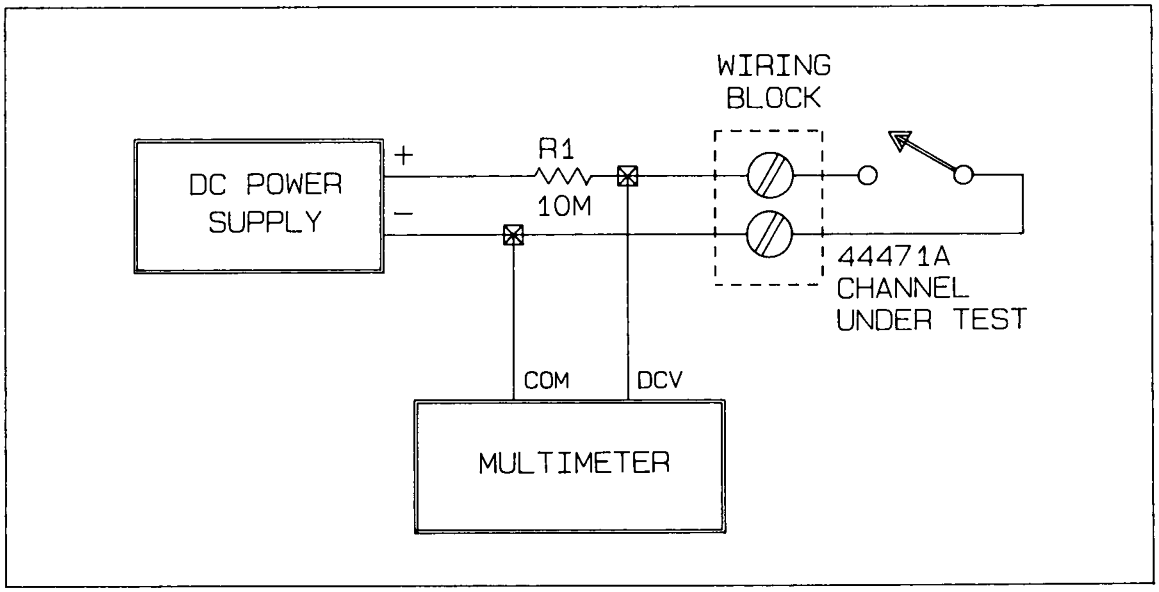



**Figure 9-6 Open Channel DC Isolation Test**

8. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V3 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V3) - R1 \bullet V3}$$

The open channel dc isolation should be greater than 1 gigohm.

9. Repeat steps 7 and 8 for channels 01 through 09.

10. CHANNEL TO CHASSIS DC ISOLATION: Use the 3488A front panel keys to close all channels as follows:

a. Press the CLOSE key followed by X00,X01,X02,X03,X04,X05,X06,X07,X08,X09 (where X is the slot occupied by the 44471A).

b. Press the EXECUTE key.

11. Connect the equipment to the 3488A back panel ground connector (chassis ground) and to the channel under test (channel 00 to start) as shown in Figure 9-7.

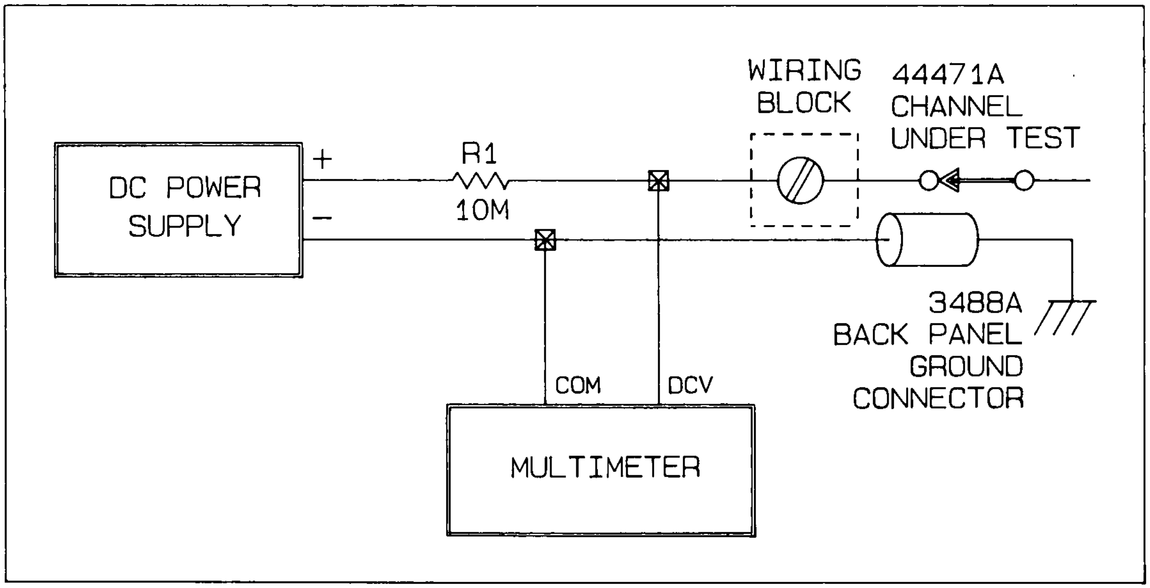



**Figure 9-7 Channel To Chassis DC Isolation**

12. Record the multimeter reading for the channel under test. This voltage will be referred to as V4.

13. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V4 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V4) - R1 \bullet V4}$$

The channel to chassis dc isolation should be greater than 10 gigohms for each channel.

14. Repeat steps 11 through 13 for channels 01 through 09.

15. ADJACENT CHANNEL DC ISOLATION TEST: Close all channels on the 44471A as follows:

a. Press the CLOSE key followed by X00,X01,X02,X03,X04,X05,X06,X07,X08,X09

b. Press the EXECUTE key.

16. Connect the equipment to the adjacent channels under test (channels 00 and 01 to start) as shown in Figure 9-8.

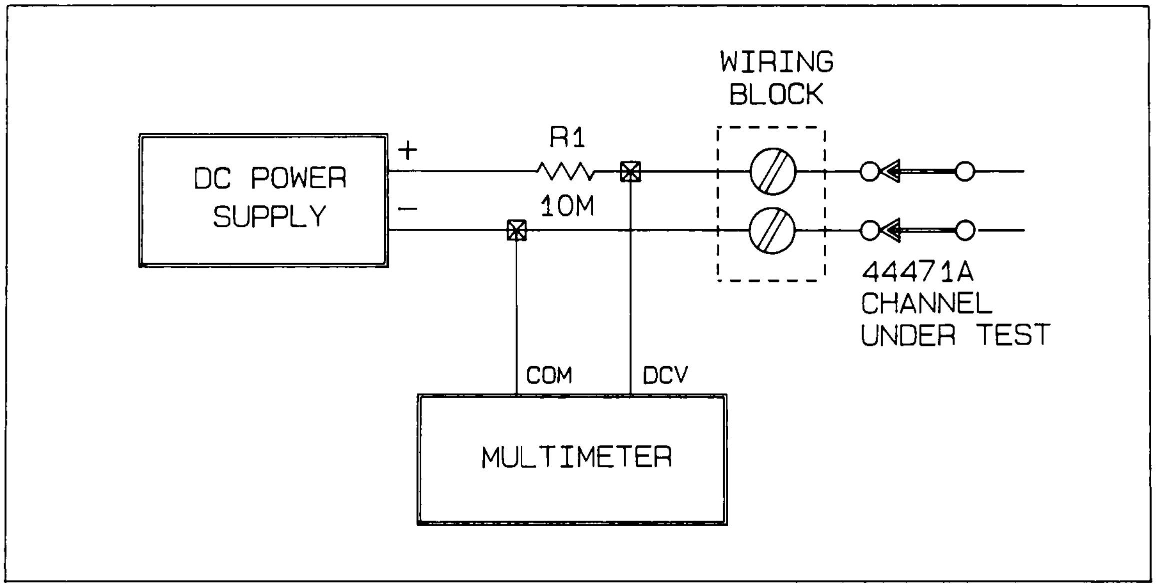



**Figure 9-8 Adjacent Channel DC Isolation**

17. Record the multimeter reading for the adjacent channels under test. This voltage will be referred to as V5.

18. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V5 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V5) - R1 \bullet V5}$$

The adjacent channel dc isolation should be greater than 1 gigohm for any adjacent channels.

19. Repeat steps 16 through 18 for adjacent channels 01 and 02, 02 and 03, 03 and 04, 04 and 05, 05 and 06, 06 and 07, 07 and 08, 08 and 09.

### 9-9 Corrective Action

An open channel isolation failure (step 8) is most likely caused by a failing relay or a damaged or dirty 44471A pc board. If damage is found, contact an HP Sales and Service Office for replacement information. If no damage is found, clean the board thoroughly (see Section 9-3).

A channel to chassis isolation failure (step 13) can be caused by electrical leakage from a relay contact through its drive coil to ground, or by a damaged or dirty 44471A printed circuit board. If damage is found, contact an HP Sales and Service Office for replacement information. If damage is not found, clean the board thoroughly (see Section 9-3).

An adjacent channel isolation failure (step 18) is most likely caused by a damaged or dirty 44471A pc board. If damage is found, contact an HP Sales and Service Office for replacement information. If no damage is found, clean the board thoroughly (see Section 9-3).

## 9-10 44471A Thermal Offset Test

This is a test of the thermally generated dc voltage present on the 44471A. This test is very sensitive to ambient temperature changes and thermoelectricity generated at the junction of two dissimilar metals. For these reasons, it is important that this test be performed in an environment where the temperature is stable and that the number of test lead connections are kept to a minimum.

1. Set the multimeter to its lowest dc voltage range. Connect the two multimeter test leads together and record the reference offset voltage. This voltage will be referred to as V1 in the following steps.

2. Close all channels on the 44471A as follows:

   a. Press the CLOSE key followed by X00,X01,X02,X03,X04,X05,X06,X07,X08,X09

   b. Press the EXECUTE key.

3. Measure the dc voltage between the two terminals of the channel under test (channel 00 to start). This voltage will be referred to as V2. The difference between V1 and V2 must be less than 3$\mu$V for each channel.

4. Repeat step 3 for channels 01 through 09.

#### 9-11 Corrective Action

The most likely cause of a thermal offset failure is the relay. If a failure is found, replace the relay. The relay part number can be found by using the 44471A schematic (Figure 9-13) to determine the component designator for the relay and Table 9-1 to determine the HP part number of the relay. Contact an HP Sales and Service Office for part ordering information.

## 9-12 REPLACEABLE PARTS

Table 9-1 lists the mechanical and electrical replaceable parts available for the 44471A. The mechanical parts are keyed to Figure 9-9. This figure also provides assembly and disassembly information. The electrical parts are keyed to the schematic and component locator in Figure 9-13. Table 5-2, in Chapter 5, lists manufacturers code numbers as they apply to the parts lists in Table 9-1.

## 9-13 44471A THEORY OF OPERATION

The 44471A General Purpose Card consists of an input buffer and latch, relay drive and sense circuits, an address decoder, and a card-type/sense buffer. Refer to the 44471A schematic in the following discussions (Figure 9-13).

### 9-14 Input Buffer And Latch

The input buffer (U902 in Figure 9-13) provides isolation between the 44471A and the mainframe's data bus. An input buffer is present on each type of option card an prevents excessive loading of the data bus by the option cards.

The input latch (U903 and U905 in Figure 9-13) holds the output of the input buffer for application to the relay drive and sense circuitry.

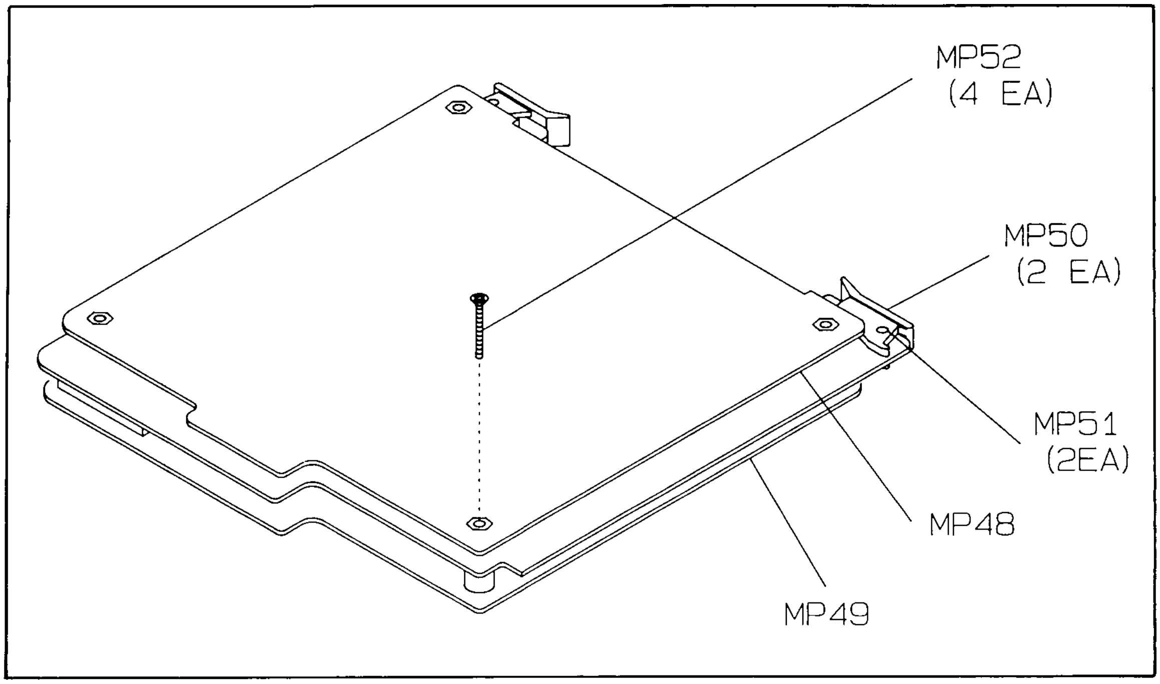



**Figure 9-9 44471A Disassembly**

## 9-15 Relay Drive And Sense Operation

A simplified schematic diagram of one relay drive and sense circuit is shown in Figure 9-10. When instructions are received over the data bus to set a relay (close a channel), a logic high level is applied to the base of Q2 and the input of U2 causing their outputs to go low. A logic low level is applied to the base of Q1 causing its output to go high. CR2 becomes forward biased allowing current to flow through both the set and reset coils of relay K1. The magnetic field generated around the coils interacts with the permanent magnetic field of the relay armature causing it to close the relay contacts. Once closed, the drive current is removed from the relay coil and the permanent magnetic field of the armature latches the contact in the closed state.

When instructions are received over the data bus to reset a relay (open a channel), a logic low level is applied to the base of Q2 and the input of U2 causing their outputs to go high. A logic high level is applied to the input of U1 causing its output to go low. CR1 becomes forward biased allowing current to flow through both the set and reset coils of relay K1. The magnetic field generated around the coils interacts with the permanent magnetic field of the relay armature causing it to open the relay contacts. Once opened, the drive current is removed from the relay coil and the permanent magnetic field of the armature latches the contacts in the opened state.

Notice that it is necessary to activate one of the upper drive elements (Q1 or U1) and the lower drive elements (Q2 and U2) in order to change a relay's state. If the elements in only the upper or lower drive are activated, no current flows through the relay coils and the relay retains its previous state. This aspect of operation is used by the mainframe in conjunction with the 44471A's relay sense circuitry to verify relay states following relay contact closures, a card reset, and an instrument reset.

When a relay state is being verified following a closure, a low is applied to the base of Q2

## Table 9-1 Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1 | 44471-66501 | 1 | 1 | GENERAL PURPOSE CARD ERC: 2709 | 28480 | 44471-66501 |
| A1C901 | 0160-3847 | 9 | 4 | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C902 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C903 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C904 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C905 | 0160-0127 | 2 | 1 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| A1CR901 | 1901-0050 | 3 | 13 | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR902 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR903 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR904 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR906 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR907 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR908 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR909 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR910 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR911 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR912 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR945 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR946 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1DP901 | 1906-0229 | 8 | 2 | DIODE-ARRAY 50V 400MA | 01295 | TID133 |
| A1DP902 | 1906-0229 | 8 | | DIODE-ARRAY 50V 400MA | 01295 | TID133 |
| A1J901 | 5180-6637 | | 1 | CONN-2X11 RT ANG | 28480 | 44471-62102 |
| A1JM901 | 7175-0057 | 5 | 20 | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM903 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM904 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM906 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM907 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM909 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM910 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM912 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM913 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM915 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM916 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM918 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM919 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM921 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM922 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM924 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM925 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM927 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM928 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1JM930 | 7175-0057 | 5 | | RESISTOR-ZERO OHMS SOLID TINNED COPPER | 28480 | 7175-0057 |
| A1K901 | 0490-1337 | 7 | 10 | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K902 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K903 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K904 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K905 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K906 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K907 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K908 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K909 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K910 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1P901 | 5180-6697 | 9 | 1 | CONN-RT ANG 2X15 | 28480 | 1251-8645 |
| A1Q901 | 1853-0551 | 6 | 7 | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q903 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q904 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q905 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q906 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q907 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q908 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1R901 | 0683-2725 | 8 | 7 | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R902 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R903 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R904 | 0683-1035 | 1 | 8 | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R905 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R906 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R907 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R908 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R909 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R910 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |

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

## Table 9-1 Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1R912 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R914 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R915 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R916 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R917 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R918 | 0683-4705 | 8 | 3 | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1R919 | 0683-4705 | 8 | | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1R920 | 0683-4705 | 8 | | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1U901 | 1820-2537 | 3 | 2 | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C244N |
| A1U902 | 1820-2537 | 3 | | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C244N |
| A1U903 | 1820-2216 | 5 | 2 | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U904 | 1858-0047 | 5 | 2 | TRANSISTOR ARRAY 16-PIN PLSTC DIP | 13606 | ULN-2003A |
| A1U905 | 1820-2216 | 5 | | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U906 | 1858-0047 | 5 | | TRANSISTOR ARRAY 16-PIN PLSTC DIP | 13606 | ULN-2003A |
| A1U907 | 1820-1216 | 3 | 1 | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| MP48 | 03488-00602 | 8 | 1 | CARD SHIELD - CKT | 28480 | 03488-00602 |
| MP49 | 03488-00603 | 9 | 1 | CARD SHIELD - COMP | 28480 | 03488-00603 |
| MP50 | 0403-0464 | 6 | 2 | PC EXTRACTER WHT | 28480 | 0403-0464 |
| MP51 | 1480-0625 | 4 | 2 | PIN-GRV 3/32 X 1/4 | 28480 | 1480-0625 |
| MP52 | 0515-0843 | 2 | 4 | SCREW M2.5 X 20 LK | 28480 | 0515-0843 |
| | 5040-5193 | 3 | 1 | STRAIN RELIEF HOUSING | 28480 | 5040-5193 |
| | 5040-5194 | 4 | 1 | STRAIN RELIEF PLATE | 28480 | 5040-5194 |
| | | | | NOTE: *HP PRODUCT NUMBER 44481A INCLUDES* CONNECTOR TERMINAL BLOCK AND STRAIN RELIEF ASSEMBLY | | |

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

and to the input of U2. This causes a high at the input of inverter U3 causing its output to go low. If the sense switch is in the correct state (closed) a low is applied, through the switch contacts, to the card-type/sense buffer. The controller recognizes this signal as being correct and no error message occurs.

If, following a closure, the sense switch is in the incorrect state (open), the pull-up resistor R1 applies a high to the card-type/sense buffer. The controller recognizes this as an incorrect state and displays ERR:8 LOGIC.

Relay sense operation following a card or instrument reset is similar to that described above with the exception that the controller interprets an open sense switch as the correct state and a closed sense switch as the incorrect state.

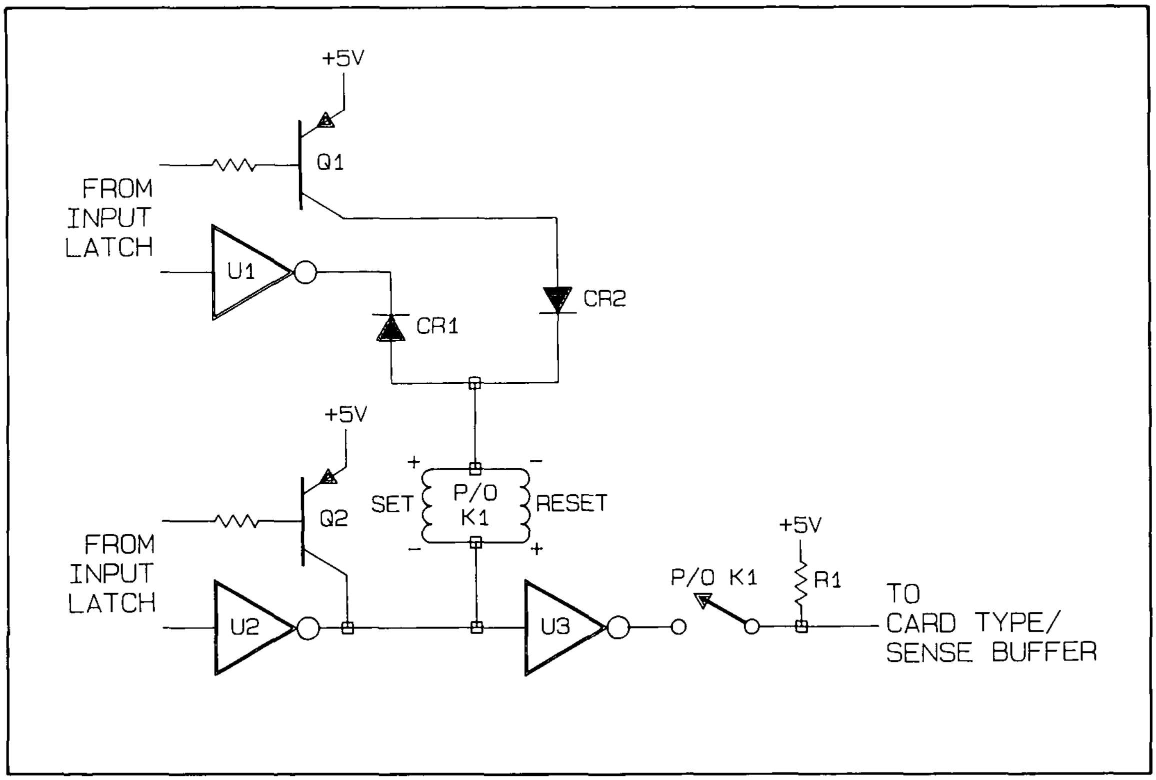



**Figure 9-10 One Relay Drive And Sense Circuit**

## 9-16 Card Type/Sense Buffer

The card-type/sense buffer (U901 in Figure 9-13) indicates to the mainframe that a 44471A is in the particular card slot queried. The card type is determined by the wiring configuration of four of the input lines to the card-type/sense buffer. By connecting one input to + 5 Vdc and three inputs to ground, a 4-bit code (0001) is created that is recognized by the controller as the unique identifier for the 44471A card.

The card-type/sense buffer also provides isolation between the outputs of the sense circuits and the mainframe's data bus. In short, this buffer provides the necessary current to drive the data bus.

## 9-17 Address Decoder

The address decoder (U907 in Figure 9-13) is enabled when the $\overline{\text{CS}}$ signal from the mainframe goes low. Once enabled, the address decoder is responsible for enabling the various IC's on the board in response to the instructions it receives via the R/$\overline{W}$, A0 and A1 signals from the mainframe. Figures 9-11 and 9-12 show the timing relationships between these control lines for both read and write operations.

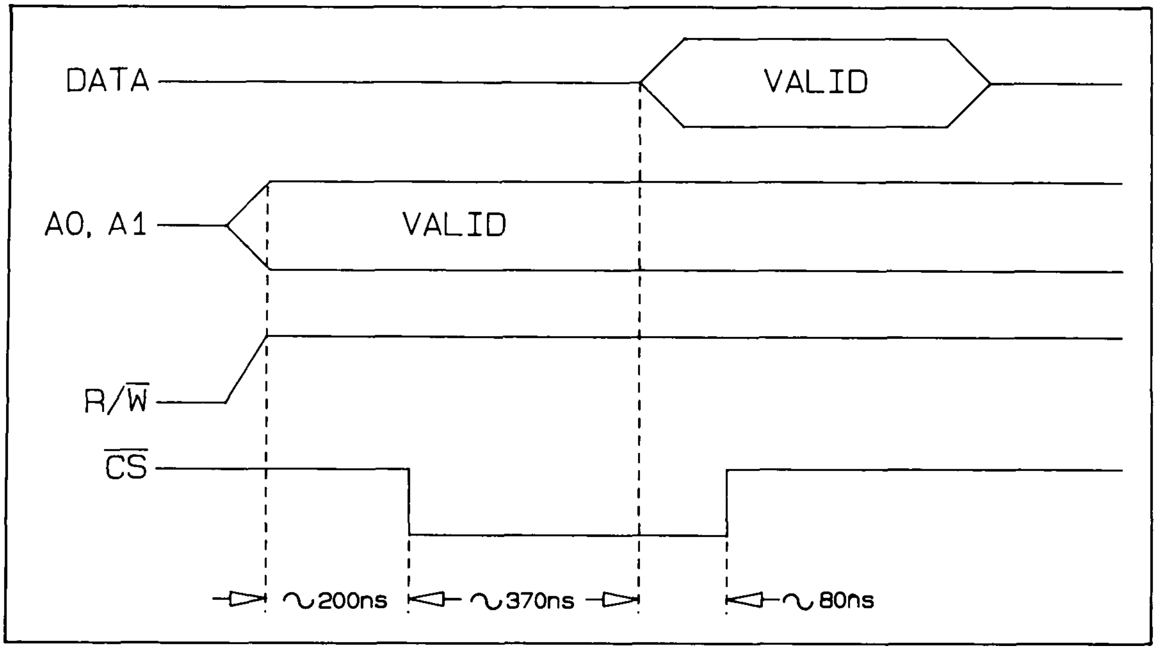



**Figure 9-11 Control Line Timing (Read)**

## 9-18 44471A TROUBLESHOOTING

### 9-19 Introduction

If the Performance Tests (Section 9-6) or Operational Verification tests (Chapter 4) have indicated that a particular relay is failing, that relay is probably at fault. A failure of the relay contact resistance test indicates a bad relay.

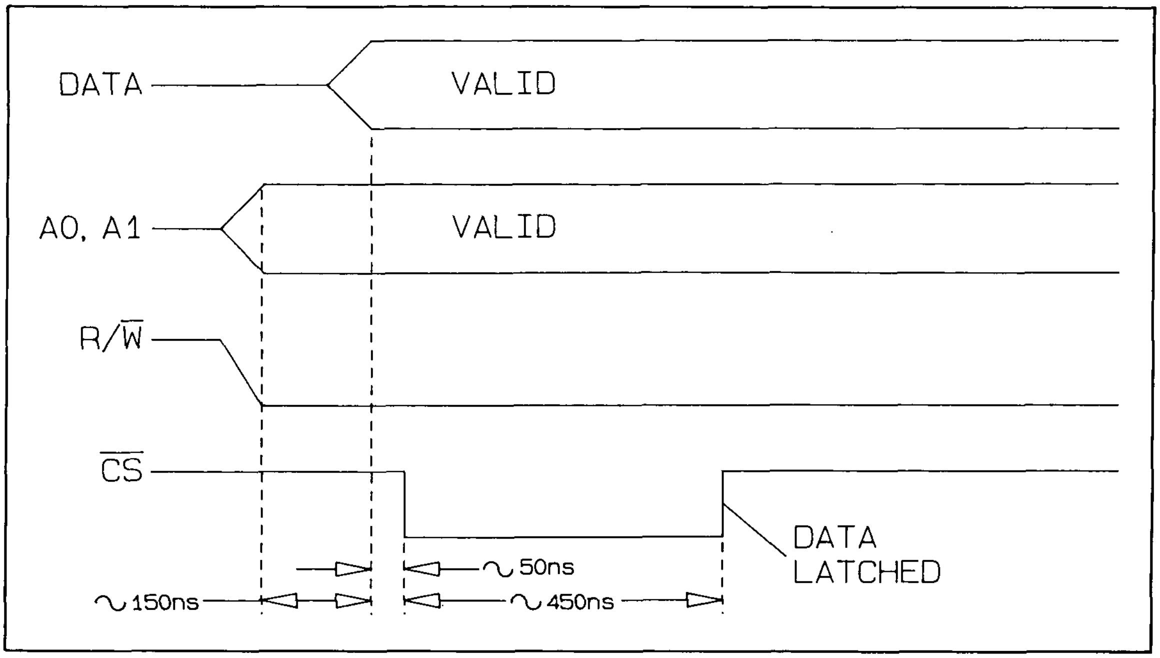



**Figure 9-12 Control Line Timing (Write)**

If more than one relay failure is indicated, the associated drivers should be suspected. Using Figure 9-13 (44471A Schematic) the problem can be isolated to a few components from the symptoms. The relays on the 44471A circuit board are schematically arranged into three rows and four columns. To close a relay, both a row driver and a column driver must be active. Failures in the drivers, then, will exhibit symptoms that are common to a row or a column.

For example; suppose relays in channels 08 and 09 are failing to close. From the schematic, it is determined that channels 08 and 09 correspond to relays K909 and K910 respectively. Further examination of the schematic reveals that both these relays are in the same row. The drivers Q906, U906, and U905 would be suspected.

As a another example; suppose relays in channels 01, 05 and 09 are failing to close. These channels correspond to relays K902, K906 and K910. These three relays are in a common column. The suspected drivers would be Q901, U904 and U903.

## 9-20 ERR 8: LOGIC SLOT X

The mainframe error most associated with the plug-in option cards is the ERROR 8: LOGIC error. This error is generated when the controller checks the relays sense circuitry after changing a relay state. The operation of the relay sense circuitry is described in Section 9-15.

The sense circuitry is used by the controller to indicate that a relay did not close when instructed or did not open when instructed. However, the controller does not always check each state. After a power-on reset, a front panel (or remote) reset, or a card reset, the controller checks the sense circuitry for open contacts. If one or more contacts is indicating the closed position, the controller will beep and display ERR 8: LOGIC. After a close command, the controller checks the sense circuitry to determine if the indicated relay is closed. If the sense circuitry indicates the relay is open the controller beeps and displays ERR 8: LOGIC. This action occurs for each relay closure including scan lists and stored set-ups. Following a relay opening, however, the controller does NOT check the sense circuitry for the open. This means that a relay may stick closed and the controller will not flag an error. This occurs for relays opened through the open command, scan lists, and stored set-ups.

In summary, the controller checks for open relays following power-on resets, front panel or remote resets, and card resets. It checks for closed relays following a close command (whether executed by the close command, a scan list or a stored set-up).

When troubleshooting a plug-in card that is generating ERROR: 8 LOGIC it is important to carefully observe the symptoms. If the error is generated when power is applied to the 3488A (controller checking for openings) check the relay contacts to determine if a relay is stuck closed. If no relay is stuck closed, suspect the sense circuitry. If the error is generated following a close command, check the relay contacts to determine if the relay is closed. If the relay is closed, suspect the sense circuitry.

### 9-21 Equipment Required

| | |
|---|---|
| Signature Multimeter | HP 5005A or equivalent |
| Service Extender Cable | 5061-1174 |
| Service Extender Board | 5061-1173 |

## 9-22 Initial Checks

The initial checks of a suspected plug-in card will require that the plug-in card shields be removed. Removal of the four screws in the plug-in shield allows both shields to be removed from the plug-in printed circuit board.

Once the shields have been removed, the card to be tested should be installed in slot 1 of the mainframe. There are two ways to do this. The first method uses the Service Extender Board (5061-1173) and the Service Extender Cable (5061-1174). With these two service tools the card may be electrically installed in the card slot but be physically located on the test bench.

If the service extender tools are not available, the card may be installed in slot 1 and the 3488A mainframe top cover removed. This will allow access to the non-component side of the plug-in card for servicing. 3488A top cover removal is described in Chapter 5.

Be sure that all other plug-in cards have been removed from the mainframe.

1. Apply power and measure the +5 Vdc on the plug-in board. There are two supplies to this board, both the supplies (and the grounds) are common on the backplane board. Connect the ground lead of the voltmeter to pin 10 of U901. Measure the voltage at pin 20 of U901. The voltage should be +5 Vdc ±0.5 Vdc. Measure the voltage at the emitter of any of the discrete transistors on the board (i.e., Q906). The transistors are mounted with the emitter lead in a square pad on the board. The voltage should be +5 Vdc ±0.5 Vdc.

If the voltages are correct, proceed to Step 2. If either or both of the voltages are incorrect, troubleshoot the +5 Vdc supply in the mainframe (it is possible that the plug-in card is loading the supply).

2. Observe the front panel symptoms to determine if the problem can be isolated to a few components. The Operational Verification tests is Chapter 4 may be used to identify a relay contact or closure problem. If a relay is closing (or opening) correctly, as determined by the relay contact tests, but the mainframe displays ERR 8: LOGIC, the relay sense circuitry is at fault. The mainframe will also display ERR 8: LOGIC if one or more relays are not functioning (refer to Section 9-20 for a discussion of the error message).

If a single relay (channel) is at fault, troubleshoot that relay. If one or more relays indicate a fault, the drivers should be suspected (refer to Section 9-19).

If the problem cannot be isolated easily, proceed to Step 3.

3. Check the mainframe and plug-in card data bus for activity. The data probe of the HP 5005A may be used to indicate activity on the data bus. A blinking probe light indicates state changes. Check the data bus at U902 pins 2, 4, 6, 8, 11, 13, 15 and 17. The plug-in card must be installed in slot 1 and power applied to the mainframe. No special test set-ups should be installed.

All eight data lines should show activity.

If activity is found, proceed to Step 4. If one or more of the lines are stuck, troubleshoot the backplane data bus or the inputs to buffers U901 and U902 on the plug-in card.

4. Check the outputs of U902 at pins 3, 5, 7, 9, 12, 14, 16 and 18 for activity. All eight pins should show activity.

If activity is found, proceed to Step 5. If no activity is found on one or more lines, troubleshoot U902, U905 or U903.

5. Check the backplane card select and decoding lines for activity. Check U907 pins 1, 2, 3, and 4 for activity. All lines should show activity.

If activity is found, proceed to Step 6. If no activity is found, troubleshoot the backplane or the inputs to U907 on the plug-in card.

6. If the problem has not been isolated, signature analysis procedures may be used to test the buffers, drivers, and relay coils. The procedure begins in Section 9-23.

## 9-23 Buffer, Driver, And Relay Signature Analysis

To perform the signature analysis tests the mainframe top cover and the controller shield must be removed. Procedures to remove the cover and shield are located in Chapter 5.

The HP 5005A has been recommended for this signature analysis test because it incorporates adjustable data thresholds. This feature allows signatures to be checked at the relay coils. If a different signature analyzer is being used, the signatures may only be checked up to the drivers.

Ensure the controller is set to the normal operating configuration (RP409 installed and all switches on SP401 set open) before performing these troubleshooting steps. All plug-in cards should be removed from the mainframe. The suspected plug-in card must be installed in slot 1.

The initial checks given in section 9-22 should be performed prior to this signature analysis procedure. Section 9-22 also describes the use of the service extender card and service extender cable.

1. Signature Analyzer set-up. Polarity: START _/‾, STOP and CLOCK‾_ . On the controller printed circuit board (A40), connect START/ST/SP to SA2, STOP/QUAL to SA2, CLOCK to SA3, Ground to SA4.

2. On the controller printed circuit board (A40), connect a jumper between SA6 (SERV FUNC) and ground (SA4).

3. If using the HP 5005A signature analyzer, set the data probe threshold to 2.80 H and 2.00 L.

4. Apply power to the 3488A. Press the TEST key on the front panel. Instead of performing the internal controller self-test, the display will prompt for a number. Enter 2 and press execute.

5. The signature analyzer should now be gating. The 3488A display will show RELAY S.A. The test selected cycles all data lines in a fixed pattern. This pattern will produce one of two signatures (depending upon inversion) that may be traced from the relay coils to the backplane data bus. These signature are: 36U6 and 6HPH.

6. The signatures for the inputs and outputs on the 44471A are given in Table 9-2.

## 9-24 Sense Circuit Troubleshooting

Problems with the sense circuitry will typically exhibit ERR 8: LOGIC in the display. A discussion of the error message as it applies to the plug-in card is given is Section 9-20. A theory of operation of the sense circuitry is given in section 9-15.

The drivers for the sense circuit, U904 and U906, are open collector drivers. This means that one of the relays sense contacts must be closed for the driver to operate. The driver may be manually tested by closing an appropriate relay to provide as current path and exercising the input to the driver.

Problems with the sense circuitry can also be isolated with a signature analysis procedure. This procedure begins in Section 9-25.

## 9-25 Sense Circuitry Signature Analysis

This procedure checks the signatures at the input to the buffer, U901. This buffer has three inputs from the sense circuitry, pins 11, 15, and 17. Each of these inputs represents a composite signal obtained through several different relays and drivers. The signature analysis procedure is designed so that one column of relays is driven at a time (i.e., K901, K905, and K909 are in column 0). Each relay in the column is sensed by a separate line. By observing the signatures obtained at the input to U901 and knowing which column is being driven to obtain the signature, a problem may be isolated to one driver and a set of relays. If all the signatures are incorrect for a given column, the drivers should be suspected. If only one signature is incorrect, the relay should be suspected.

To perform the signature analysis tests the mainframe top cover and the controller shield must be removed. Procedures to remove the cover and shield are located in Chapter 5.

Ensure the controller is set to the normal operating configuration (RP409 installed and all switches on SP401 set open) before performing these troubleshooting steps. All plug-in cards should be removed from the mainframe. The suspected plug-in card must be installed in slot 1.

The initial checks given in section 9-22 should be performed prior to this signature analysis procedure. Section 9-22 also describes the use of the service extender card and service extender cable.

1. Signature Analyzer set-up. Polarity: START _/‾, STOP and CLOCK ‾_. On the controller printed circuit board (A40), connect START/ST/SP to SA2, STOP/QUAL to SA2, CLOCK to SA3, Ground to SA4.

2. On the controller printed circuit board (A40), connect a jumper between SA6 (SERV FUNC) and ground (SA4).

3. Apply power to the 3488A. Press the TEST key on the front panel. Instead of performing the internal controller self-test, the display will prompt for a number. Enter 3 and press execute.

4. The signature analyzer should now be gating. The test drives one column of relays at a time. The 3488A display will show COLUMN 0 SA. Pressing the right arrow key on the front panel increments the column number. Pressing the left arrow key decrements the column number.

This test is very noisy as all the relays are being cycled.

5. The signatures for each column and input of U901 are given in Table 9-3a. Table 9-3b identifies the components that are being used to make up the correct signature.

## Table 9-2 Buffer, Driver, And Relay Signatures (Test 2)

+5 Vdc signature: 5C1C

**U902**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 20 | +5 Vdc |
| 2 | 36U6 | 19 | NA |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 36U6 | 16 | 36U6 |
| 6 | 36U6 | 15 | 36U6 |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 36U6 | 12 | 36U6 |
| 10 | NA | 11 | 36U6 |

**U903**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | L | 20 | +5 Vdc |
| 2 | 6HPH | 19 | 6HPH |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 6HPH | 16 | 6HPH |
| 6 | 6HPH | 15 | 6HPH |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 6HPH | 12 | 6HPH |
| 10 | NA | 11 | NA |

**U905**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | L | 20 | +5 Vdc |
| 2 | 36U6 | 19 | 36U6 |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 36U6 | 16 | 36U6 |
| 6 | 36U6 | 15 | 36U6 |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 36U6 | 12 | 36U6 |
| 10 | NA | 11 | NA |

**U904**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | 36U6 | 16 | NA |
| 2 | 36U6 | 15 | NA |
| 3 | 6HPH | 14 | 36U6 |
| 4 | NA | 13 | NA |
| 5 | 6HPH | 12 | 36U6 |
| 6 | 6HPH | 11 | 36U6 |
| 7 | 6HPH | 10 | 36U6 |
| 8 | NA | 9 | +5 Vdc |

**U906**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 16 | NA |
| 2 | 36U6 | 15 | 6HPH |
| 3 | 36U6 | 14 | NA |
| 4 | 36U6 | 13 | NA |
| 5 | 36U6 | 12 | 6HPH |
| 6 | NA | 11 | NA |
| 7 | 36U6 | 10 | 6HPH |
| 8 | NA | 9 | +5 Vdc |

| Relay | pin | signature | pin | signature |
|---|---|---|---|---|
| K901 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K905 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K908 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K902 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K906 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K909 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K903 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K907 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K910 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K904 * | 1,7 | 6HPH | 6,12 | 36U6 |

* these signatures have a data threshold of 2.80 H and 2.0 L.

## Table 9-3a Sense Circuit Signatures

+5 Vdc signature: 6592

| | column 0 | column 1 | column 2 | column 3 |
|---|---|---|---|---|
| U901 pin 17 | 474A | 474A | 474A | 474A |
| U901 pin 15 | 2P64 | 2P64 | 2P64 | 2P64 |
| U901 pin 13 | PF66 | PF66 | 6592 | 6592 |

## Table 9-3b Components Used For Signatures

| | column 0 | column 1 | column 2 | column 3 |
|---|---|---|---|---|
| U901 pin 17 | U906<br>K901 | U906<br>K902 | U904<br>K903 | U904<br>K904 |
| U901 pin 15 | U906<br>K905 | U906<br>K906 | U904<br>K907 | U904<br>K908 |
| U901 pin 13 | U906<br>K909 | U906<br>K910 | NONE | NONE |

HP44471A Relay Card
See also further below

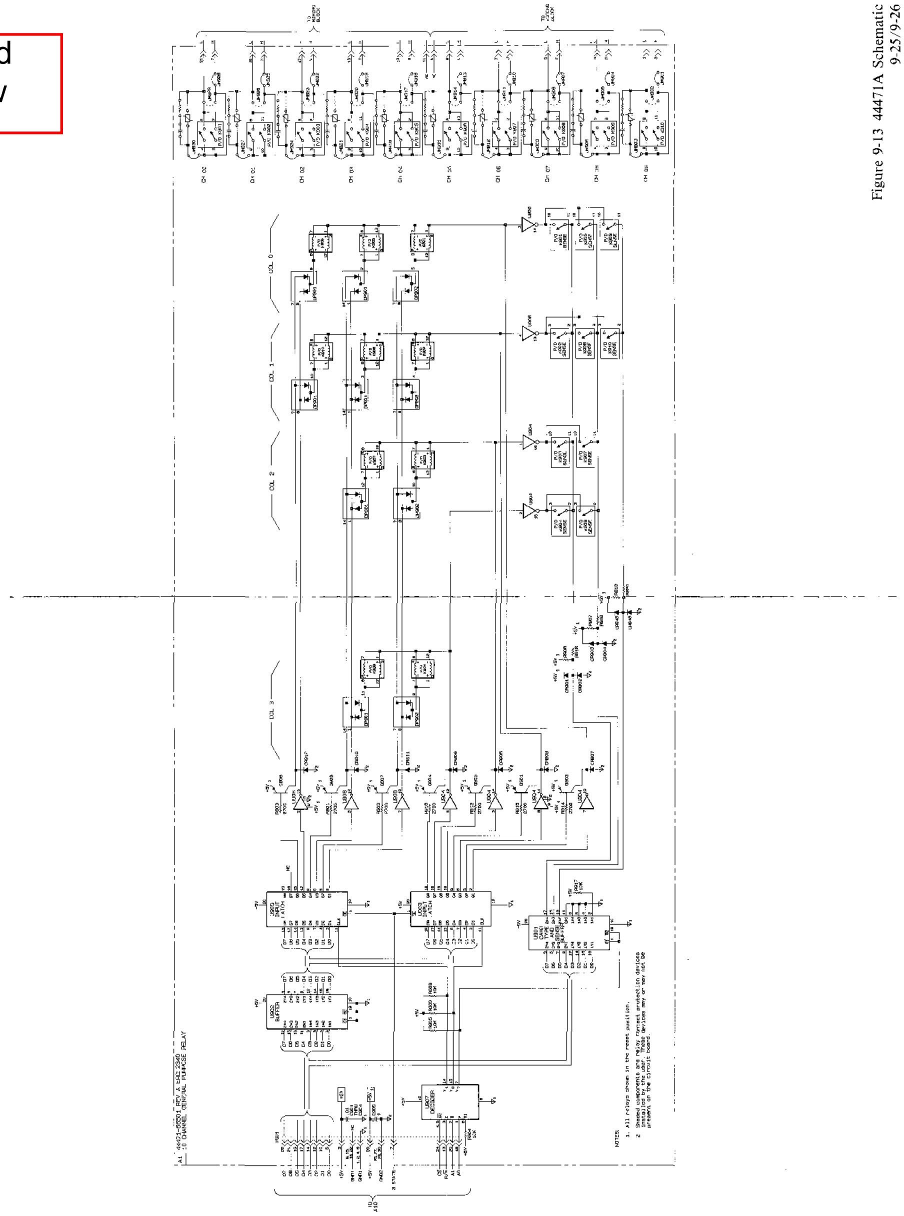
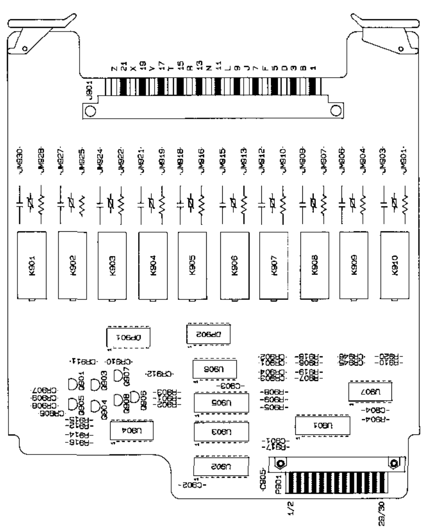


Figure 9-13 44471A Schematic
9-25/9-26



CHAPTER X
44472A DUAL 4 CHANNEL
VHF SWITCH

# Chapter X

# 44472A DUAL 4 CHANNEL VHF SWITCH

# CHAPTER X

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF ILLUSTRATIONS

# CHAPTER X
# 44472A DUAL 4 CHANNEL VHF SWITCH

## 10-1 INTRODUCTION

This chapter contains installation information, performance testing information, troubleshooting information, and replaceable parts lists for the 44472A Dual 4 Channel VHF Switch.

The VHF switch consists of two 4 channel to 1 channel multiplexers with BNC connectors. Only the center conductor of each channel is switched. The outer conductors (shields) of all channels in a particular multiplexer are connected together and unswitched. A simplified schematic of the 44472A is shown in Figure 10-1.

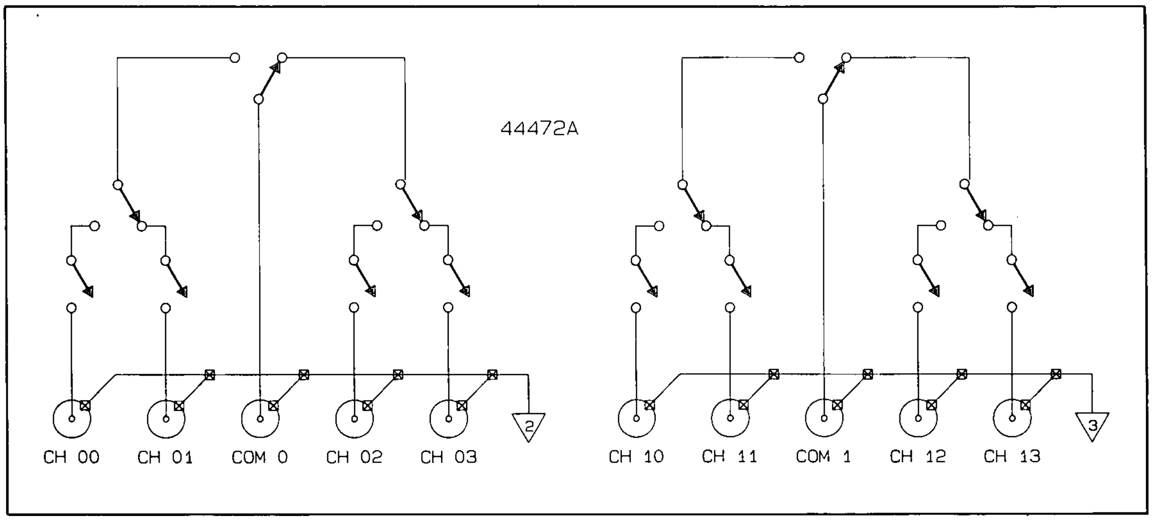



**Figure 10-1 44472A Simplified Schematic**

**WARNING**

*Hazardous voltage may exist on the wiring and connectors of the 44472A plug-in card. Only service trained personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make repairs to the 3488A and or the plug-in cards.*

**NOTE**

*The Performance Test procedures in this chapter are involved and time consuming. Since the most likely parameter to change with time is the series resistance of a channel, and since the series resistance is tested in the Operation Verification procedures (Chapter 4), it is not recommended that the Performance Tests be conducted unless one of the tested specifications is in question.*

## 10-2 PLUG-IN CARD CLEANING

Printed circuit board contamination can affect the dc isolation and the high frequency performance of the plug-in cards. This contamination can come from dust accumulation, fingerprints, condensation, and so on. The plug-in card printed circuit boards are to be cleaned as follows:

**CAUTION**

*Use anti-static pc board handling techniques during the following procedure.*

1. Remove the shields from the plug-in card.

2. Use a stiff bristled camel hair brush (do not use a wire brush) soaked in isopropyl alcohol to wash the pc board.

**CAUTION**

*DO NOT immerse the printed circuit board in any type of fluid.*

3. Use the stiff bristled brush soaked in deionized or distilled water, to remove any residue left by the alcohol.

4. Allow the printed circuit board to dry thoroughly.

5. Replace the shields.

⚠ **CAUTION**

*The maximum allowable voltage limits (center conductor-to-center conductor, or center conductor-to-shield) for the 44472A are 250Vdc or 30Vac rms (42Vac peak).* The maximum allowable dc voltage limit (shield-to-chassis or shield-to-shield) for the 44472A is 42Vdc. The maximum current limits (per channel) are 30mA dc or 300mA ac rms.* Damage will occur to the 44472A and possibly the 3488A if any of the above limits are exceeded.*

## 10-3 PERFORMANCE TESTS

The following Performance Tests check the 44472A's dc isolation, thermal offset, insertion loss, VSWR, and channel to channel crosstalk specifications. The results of these tests, when coupled with the results of the 44472A Operation Verification Test, will verify whether or not the 44472A is operating within its critical specifications. The 44472A Operation Verification Test is located in Chapter 4 of this manual. Since the 44472A Operation Verification Test assesses the operability of the 44472A, it is important that it be performed prior to performing the Performance Tests.

* To maintain compliance with VDE class B or FTZ 1115/83 radiation limits, use semi-rigid or equivalent coax cable and limit the signal to $< 20$ V$\times$Hz.

**WARNING**

*If the 44472A is currently installed into a system, it must be disconnected from the system in order to execute the Performance Tests. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected. The user must take the necessary precautions to prevent the above from happening before disconnecting the 44472A.*

### 10-4 Required Test Equipment

DC Power Supply — HP 6216B or equivalent. The power supply must be able to deliver a stable +20Vdc at low current levels.

10 megohm resistor.

Digital Multimeter — HP 3478A or equivalent. The multimeter must have the resolution and accuracy to measure a 1$\mu$V differential dc voltage.

HP 8505A RF Network Analyzer

HP 8503A (50 Ohm) S-Parameter Test Set

BNC-type Direct Feedthru Connector (Male Barrel)

BNC-type Shorting Connector

BNC-type 50 Ohm Termination

## 10-5 44472A DC Isolation Tests

The following dc isolation tests incorporate a dc power supply, a resistor of known value, and a dc voltmeter. The first phase of the tests involves precisely setting the dc power supply's output voltage and connecting the resistor and the dc voltmeter in series with the power supply. In this configuration, the resistor and the internal resistance of the dc voltmeter form a voltage divider. The voltage drop across the dc voltmeter is measured and, with the value of the resistor and the power supply voltage being known, the internal resistance of the dc voltmeter is calculated.

**NOTE**

*The best test results will be obtained when the value of the known resistor is equal to the internal resistance of the dc voltmeter.*

The second phase of the tests consists of (1) placing the appropriate channel of the 44472A in parallel with the dc voltmeter, (2) measuring the voltage drop across the dc voltmeter/channel combination, and (3) calculating the channel's dc isolation.

1. SET-UP SEQUENCE: Set the digital multimeter to measure dc voltage. Connect the multimeter to the dc power supply. Set the dc power supply to deliver +20Vdc ±.01Vdc as measured on the multimeter. This voltage will be referred to as V1 in the following steps.

2. Use the multimeter to measure the exact resistance of the 10 megohm resistor. This value will be referred to as R1.

3. Connect the test equipment as shown in Figure 10-2.

4. Set the multimeter to the 300Vdc range. Record the exact dc voltage reading on the multimeter. This voltage will be referred to as V2 in the following steps.

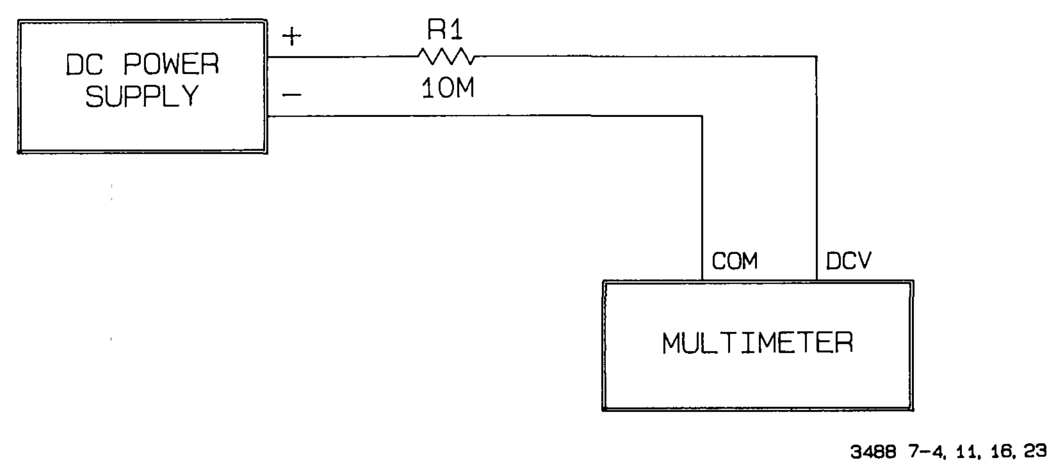



**Figure 10-2 DC Isolation Test Set-Up**

5. Calculate the internal resistance of the multimeter (Rm) using the following equation:

$$Rm = R1 \bullet V2/(V1 - V2)$$

**NOTE**

*In most cases, the internal resistance of the multimeter is dependent upon the range setting. For this reason, do not change the multimeter's range setting in the following steps.*

6. OPEN CHANNEL DC ISOLATION TEST: use the 3488A front panel keys to reset the 44472A and to establish the card monitor mode and a scan list as follows:

a. Press the LOCAL key.

b. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44472A.

c. Press the EXECUTE key.

d. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the 44472A.

e. Press the EXECUTE key.

f. Press the SCAN LIST key followed by X00 through X13 (where X is the slot occupied by the 44472A and 00 through 13 are the channels to be scanned).

g. Press the EXECUTE key.

7. Connect the center conductor of the COM 0 connector into the test circuit as shown in Figure 10-3.

8. Connect the center conductor of the channel under test (channel 00 to start) into the test circuit as shown in Figure 10-3. Successively press the STEP key until the channel adjacent to the channel under test (channel 01 to start) appears in the display. Record the multimeter's dc voltage reading for the channel under test. This reading will be referred to as V3.

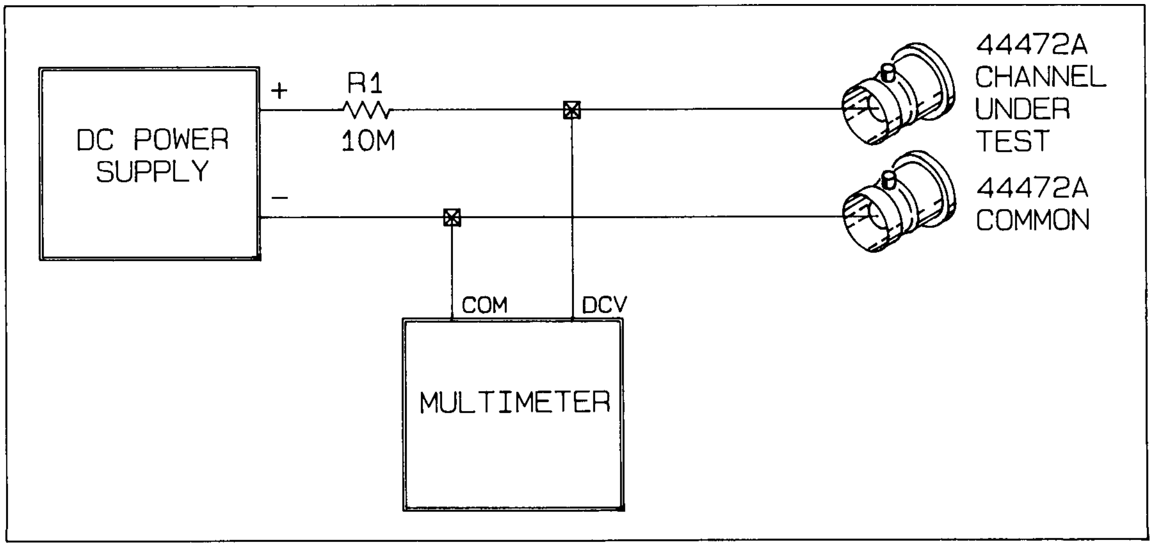



**Figure 10-3 Open Channel DC Isolation Test**

9. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V3 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V3) - R1 \bullet V3}$$

The open channel dc isolation must be greater than 10 megohms.

10. Repeat steps 8 and 9 for the Group 0 channels shown in Table 10-1.

**Table 10-1 Channels Under Test/Adjacent Channels**

| GROUP 0 CHANNELS | | GROUP 1 CHANNELS | |
|---|---|---|---|
| UNDER TEST | ADJACENT | UNDER TEST | ADJACENT |
| 01 | 00 | 10 | 11 |
| 02 | 03 | 11 | 10 |
| 03 | 02 | 12 | 13 |
| | | 13 | 12 |

11. Connect the center conductor of the COM 1 connector into the test circut as was done with COM 0 in step 7. Repeat steps 8 and 9 for the Group 1 channels shown in Table 10-1.

12. CHANNEL TO CHASSIS DC ISOLATION: Use the 3488A front panel keys to establish the card monitor mode and a scan list as follows:

a. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the 44472A.

b. Press the EXECUTE key.

c. Press the SCAN LIST key followed by X00-X13 (where X is the slot occupied by the card under test and 00 through 13 are the channels to be scanned).

d. Press the EXECUTE key.

13. Connect the center conductor of the COM 0 connector and the 3488A backpanel chassis ground terminal into the test circuit as shown in Figure 10-4.

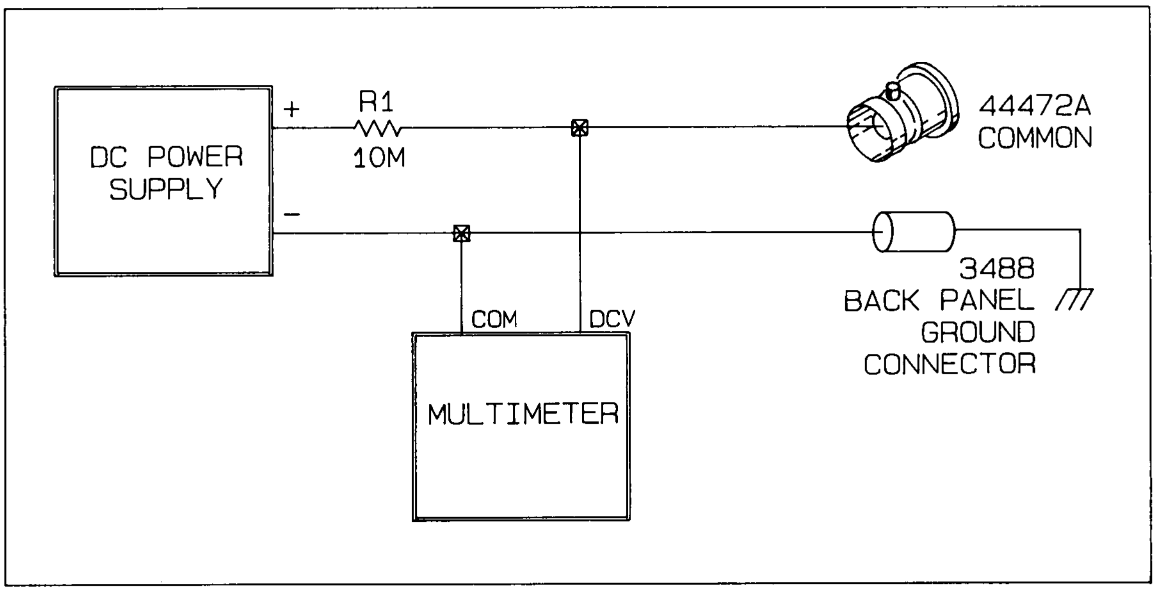



**Figure 10-4 Channel to Chassis DC Isolation**

14. Press the STEP key. Record the multimeter reading for the channel shown in the 3488A's display. This voltage will be referred to as V4.

15. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V4 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V4) - R1 \bullet V4}$$

The channel to chassis dc isolation should be greater than 10 megohms for each channel.

16. Repeat steps 14 and 15 for channels 01 through 03.

17. Connect the center conductor of the COM 1 connector into the test circuit as was done with COM 0 in step 13. Repeat steps 14 and 15 for channels 10 through 13.

18. HIGH TO LOW DC ISOLATION TEST: Use the 3488A front panel keys to establish the card monitor mode and a scan list as follows:

a. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the 44472A.

b. Press the EXECUTE key.

c. Press the SCAN LIST key followed by X00-X13 (where X is the slot occupied by the card under test and 00 through 13 are the channels to be scanned).

d. Press the EXECUTE key.

19. Connect the COM 0 connector the test circuit as shown in Figure 10-5.

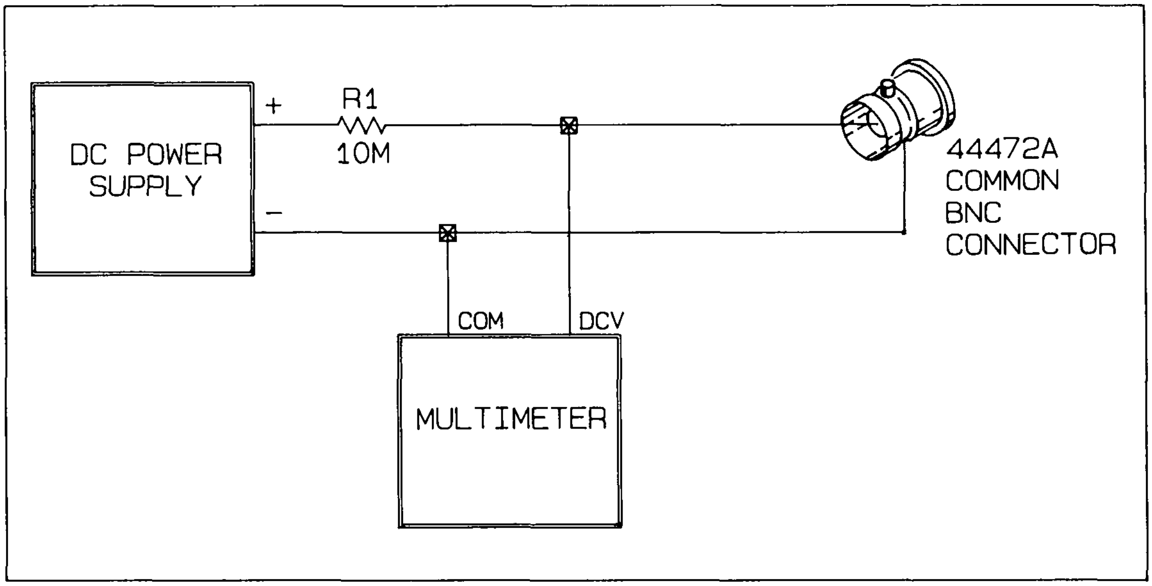



**Figure 10-5 High To Low DC Isolation**

20. Press the STEP key. Record the multimeter reading for the channel shown in the 3488A's display. This voltage will be referred to as V5.

21. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V5 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V5) - R1 \bullet V5}$$

The high to low dc isolation should be greater than 10 megohms for each channel.

22. Repeat steps 20 and 21 for channels 01 through 03.

23. Connect the COM 1 connector into the test circuit as was done with COM 0 in step 19. Repeat steps 20 and 21 for channels 10 through 13.

### 10-6 Corrective Action

An open channel isolation failure (step 9) is most likely caused by a failing relay or a damaged or dirty 44472A printed circuit board. If damage is found, contact an HP Sales and Service Office for replacement information. If no damage is found, clean the board thoroughly (see Section 10-2).

A channel to chassis isolation failure (step 15) can be caused by electrical leakage from a relay contact through its drive coil to ground, or a damaged or dirty 44472A printed circuit board. If damage is found, contact an HP Sales and Service Office for 44472A replacement information. If no damage is found, clean the board thoroughly (see Section 10-2).

A high to low failure (step 21) is most likely caused by a damaged or dirty 44472A printed circuit board. If damage is found, contact an HP Sales and Service Office for 44472A replacement information. If damage is not found, clean the board thoroughly (see Section 10-2).

## 10-7 44472A Thermal Offset Test

This is a test of the thermally generated dc voltage present on the 44472A. This test is very sensitive to ambient temperature changes and thermoelectricity generated at the junction of two dissimilar metals. For these reasons, it is important that this test be performed in an environment where the temperature is stable and that the number of test lead connections are kept to a minimum.

1. Set the multimeter to its lowest dc voltage range. Connect the two multimeter test leads together and record the reference offset voltage. This voltage will be referred to as V1 in the following steps.

2. Establish the card monitor mode and a scan list as follows:

a. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the 44472A.

b. Press the EXECUTE key.

c. Press the SCAN LIST key followed by X00-X13 (where X is the slot occupied by the 44472A and 00-13 are the channels to be scanned.

d. Press the EXECUTE key.

3. Connect the multimeter's common test lead to the center conductor of the COM 0 connector.

4. Press the STEP key.

5. Measure the dc voltage on the center conductor of the channel shown in the display. This voltage will be referred to as V2. The difference between V1 and V2 must be less than $15\mu V$.

6. Repeat steps 4 and 5 for channels 01 through 03.

7. Connect the multimeter's common test lead to the center conductor of the COM 1 connector.

8. Repeat steps 4 and 5 for channels 10 through 13.

### 10-8 Corrective Action

The most likely cause of a thermal offset failure is one or more of the relays in the failed channel. If a failure is found, replace the relay. The relay part number can be found by using the 44472A schematic (Figure 10-11) to determine the component designator for the relay and Table 10-2 to determine the HP part number of the relay. Contact an HP Sales and Service Office for part ordering information.

## 10-9 High Frequency Tests

The following insertion loss, VSWR, and crosstalk tests use an HP 8505A network Analyzer coupled with an HP 8503A S-parameter Test Set. Each test consists of (1) a setup sequence, (2) a calibration sequence, and (3) a measurement sequence. The setup sequence merely establishes the proper switch settings for the ensuing calibration sequence. The calibration sequence is done without the 44472A in the circuit and compensates for the effects caused by the hook-up cabling. After calibration, the 44472A is inserted into the circuit for the measurement sequence. To achieve an accurate test, it is very important that the cabling configuration for the calibration sequence be as similar as possible to the cabling configuration for the measurement sequence. In other words, the major difference in configuration between the calibration and the measurement sequences should be the insertion of the 44472A itself. Additionally, it is important that the shields be installed on the 44472A for these tests.

### 10-10 Insertion Loss Test

1. Set the S-PARAMETER SELECT Switch on the 8503A to the FORWARD position.

2. Set the signal levels on the 8505A as follows:

   a. Set the INPUT LEVEL dBm MAX Switch to the −10 position.

   b. Set the OUTPUT LEVEL dBm Switch to the +10 position.

   c. Set the OUTPUT LEVEL dBm Vernier to the 0 position.

3. Select the measurement on the 8505A as follows:

   a. Set the CHANNEL 1 INPUT Switch to the B/R position (this selects a transmission measurement).

   b. Set the MODE Switch to the MAG position (this selects the magnitude ratio).

   c. Set the SCALE/DIV Switch to the .1dB/division position.

   d. Set the CHANNEL 2 MODE Switch to the OFF position.

   e. Set the ELECTRICAL LENGTH MODE Switch to the OFF position.

4. Set the CRT display on the 8505A as follows:

   a. Press the REF LINE POSN/BEAM CENTER Switch to display the reference line. Rotate the CH1 vernier until the reference line is positioned on the center horizontal graticule.

5. Set the Frequency Sweep on the 8505A as follows:

a. Set the RANGE MHz Switch to the LIN .5-130 range.

b. Set the sweeper MODE Switch to the LIN EXPAND position.

c. Set the sweeper WIDTH Switch to the START/STOP 1 position.

d. Rotate the START FREQUENCY controls until the START FREQUENCY display reads .022.

e. Rotate the STOP FREQUENCY controls until the STOP FREQUENCY display reads 130.0.

6. Calibrate the 8505A as follows:

a. Connect the 8505A and the 8503A together as shown in Figure 10-6. Use a shorting connector to connect Port 1 and Port 2 of the 8503A together as shown in Figure 10-6.

b. Rotate the OUTPUT Vernier counterclockwise until the OVERLOAD light turns off.

c. Set the MARKERS Switch to position 1. Rotate the MARKERS 1 vernier to set the measurement marker to 100MHz.

d. Press the CHANNEL 1 MKR button. Press and hold the the ZRO button until the iterative zero process is complete and the trace moves to the reference line. This establishes the reference at 0dB.

7. Remove any external wiring from the rear of the 44472A.

8. Connect the 44472A's COM 0 connector to Port 1 of the 8503A.

9. Connect the 44472A's channel 00 connector to Port 2 of the 8503A.

10. Using the 3488A's front panel, close channel 00 as follows:

a. Press the LOCAL key.

b. Press the CLOSE key followed by X00 (where X is the slot occupied by the 44472A and 00 is the channel to be closed).

c. Press the EXEC key.

11. Press the MKR button to display the marker displacement (in dB) from the reference line. The marker displacement (insertion loss) should be $<.75$ dB at 100MHz.

12. Repeat steps 9 through 11 for channels 01, 02, and 03.

13. Connect the 44472A's COM 1 connector to Port 1 of the 8503A. Repeat steps 9 through 11 for channels 10, 11, 12, and 13.

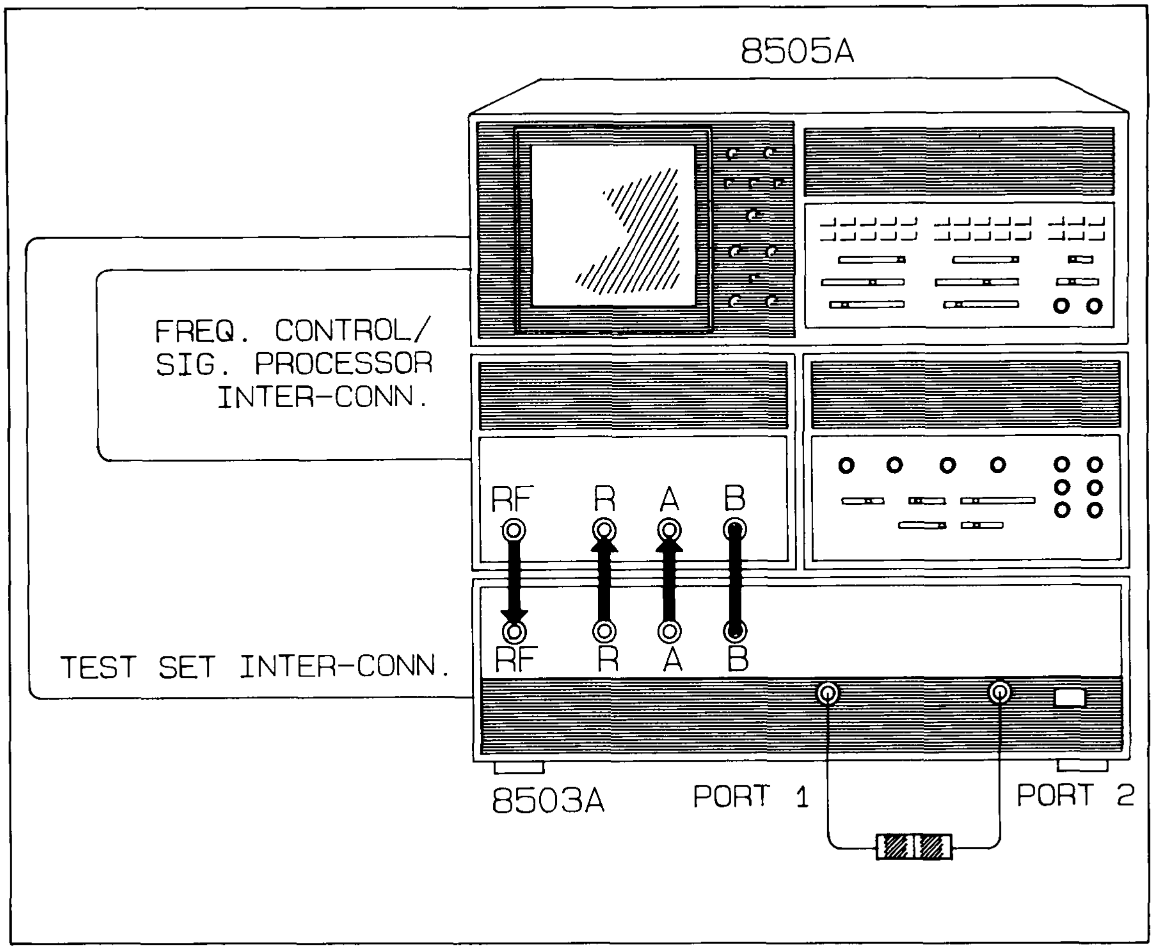



**Figure 10-6 Insertion Loss Calibration Setup**

**NOTE**

*The above test checks insertion loss at 100MHz. Insertion loss can be tested at other frequencies by inserting those frequencies into steps 5a and 6c.*

## 10-11 Corrective Action

An insertion loss failure is most likely caused by a higher than normal series resistance in the failed channel. Relay contact(s) and BNC connectors are the probable suspects. If an insertion loss failure is encountered, use Figure 10-11 (44472A schematic) to determine the component designator of the failing component and Table 10-2 to determine the HP part number of the component. Contact an HP Sales and Service Office for part ordering information.

## 10-12 Voltage Standing Wave Ratio (VSWR) Test

This test measures the return loss of the 44472A from which the voltage standing wave ratio (VSWR) is calculated.

**NOTE**

*Connect the 8505A to the 8503A as shown in Figure 10-6.*

1. Set the S-PARAMETER SELECT Switch on the 8503A to the FORWARD position.

2. Set the signal levels on the 8505A as follows:

   a. Set the INPUT LEVEL dBm MAX Switch to the −10 position.

   b. Set the OUTPUT LEVEL dBm Switch to the +10 position.

   c. Set the OUTPUT LEVEL dBm Vernier to the 0 position.

3. Select the measurement on the 8505A as follows:

   a. Set the CHANNEL 1 INPUT Switch to the A/R position.

   b. Set the MODE Switch to the MAG position (this selects the magnitude ratio).

   c. Set the SCALE/DIV Switch to the 10dB/division position.

   d. Set the CHANNEL 2 MODE Switch to the OFF position.

   e. Set the ELECTRICAL LENGTH MODE Switch to the OFF position.

4. Set the CRT display on the 8505A as follows:

   a. Press the REF LINE POSN/BEAM CENTER Switch to display the reference line. Rotate the CH1 vernier until the reference line is positioned on the center horizontal graticule.

5. Set the Frequency Sweep on the 8505A as follows:

   a. Set the RANGE MHz Switch to the LIN .5-130 range.

   b. Set the sweeper MODE Switch to the LIN EXPAND position.

   c. Set the sweeper WIDTH Switch to the START/STOP 1 position.

   d. Rotate the START FREQUENCY controls until the START FREQUENCY display reads .022.

   e. Rotate the STOP FREQUENCY controls until the STOP FREQUENCY display reads 130.0.

6. Calibrate the 8505A as follows:

   a. Connect a shorting connector to Port 1 of the 8503A.

   b. Rotate the OUTPUT Vernier counterclockwise until the OVERLOAD light turns off.

   c. Set the MARKERS Switch to position 1. Rotate the MARKERS 1 vernier to set the measurement marker to 100MHz.

   d. Press the CHANNEL 1 MKR button. Press and hold the the ZRO button until the iterative zero process is complete and the trace moves to the reference line. This establishes the reference at 0dB.

7. Remove any external wiring from the rear of the 44472A. Remove the shorting connector from Port 1 of the 8503A.

8. Connect the 44472A's COM 0 connector to Port 1 of the 8503A.

9. Connect the 50 Ohm termination to the 44472A's channel 00 connector.

10. Using the 3488A's front panel, close channel 00 as follows:

a. Press the LOCAL key.

b. Press the CLOSE key followed by X00 (where X is the slot occupied by the 44472A and 00 is the channel to be closed).

c. Press the EXEC key.

11. Press the MKR button to display the marker displacement (in dB) from the reference line. This is the return loss for the channel under test.

12. Use the following equation and the return loss measured in step 11 to calculate the VSWR for the channel under test.

$$p = 10^{D} \qquad \text{where } D = \frac{\text{Return Loss (in dB)}}{20}$$

$$\text{VSWR} = \frac{1 + p}{1 - p}$$

The VSWR should be $<$ 1.12 at 100MHz.

13. Repeat steps 9 through 12 for channels 01, 02, and 03.

14. Connect the 44472A's COM 1 connector to Port 1 of the 8503A. Repeat steps 9 through 12 for channels 10, 11, 12, and 13.

**NOTE**

*The above test checks VSWR at 100MHz. VSWR can be tested at other frequencies by inserting those frequencies into steps 5a and 6c.*

### 10-13 Corrective Action

A VSWR failure is most likely caused by a higher than normal series resistance in the failed channel. Relay contact(s) and BNC connectors are the probable suspects. If a VSWR failure is encountered, use Figure 10-11 (44472A schematic) to determine the component designator of the failing component and Table 10-2 to determine the HP part number of the component. Contact an HP Sales and Service Office for part ordering information.

### 10-14 Crosstalk Tests

**NOTE**

*Connect the 8505A and the 8303A together as shown in Figure 10-6.*

1. SET UP SEQUENCE: Set the S-PARAMETER SELECT Switch on the 8503A to the REVERSE position.

2. Set the signal levels on the 8505A as follows:

   a. Set the INPUT LEVEL dBm MAX Switch to the − 10 position.

   b. Set the OUTPUT LEVEL dBm Switch to the + 10 position.

   c. Set the OUTPUT LEVEL dBm Vernier to the 0 position.

3. Select the measurement on the 8505A as follows:

   a. Set the CHANNEL 1 INPUT Switch to the A/R position.

   b. Set the CHANNEL 1 MODE Switch to the MAG position.

   c. Set the CHANNEL 1 SCALE/DIV Switch to the 20dB/division position.

   d. Set the CHANNEL 2 MODE Switch to the OFF position.

   e. Set the ELECTRICAL LENGTH MODE Switch to the OFF position.

4. Set the CRT display on the 8505A as follows:

   a. Press the REF LINE POSN/BEAM CENTER Switch to display the reference line. Rotate the CH1 vernier until the reference line is positioned on the center horizontal graticule.

5. Set the Frequency Sweep on the 8505A as follows:

   a. Set the RANGE MHz Switch to the LIN .5-130 range.

   b. Set the sweeper MODE Switch to the LIN EXPAND position.

   c. Set the sweeper WIDTH Switch to the START/STOP 1 position.

   d. Rotate the START FREQUENCY controls until the START FREQUENCY display reads .022.

   e. Rotate the STOP FREQUENCY controls until the STOP FREQUENCY display reads 130.0.

6. Remove any external wiring from the 44472A.

7. CHANNEL TO CHANNEL CROSSTALK TEST: Using the 3488A's front panel keys, establish the card monitor mode and a scan list as follows:

a. Press the LOCAL key.

b. Press the CARD MONITOR key followed by the numeral corresponding the slot occupied by the 44472A.

c. Press the EXECUTE key.

d. Press the SCAN LIST key followed by X00-X13 (where X is the slot occupied by the 44472A and 00 through 13 are the channels to be scanned).

e. Press the EXECUTE key.

8. Press the STEP key.

9. Calibrate the 8505A as follows:

a. Connect a 50 Ohm matched termination to the closed channel appearing in the 3488A's display (channel 00 to start).

b. Connect the 44472A's COM 0 connector to Port 1 of the 8503A.

c. Rotate the OUTPUT Vernier counterclockwise until the OVERLOAD light turns off.

d. Set the MARKERS Switch to position 1. Rotate the MARKERS 1 vernier to set the measurement marker to 100MHz.

e. Press the CHANNEL 1 MKR button. Press and hold the ZRO button until the iterative zero process is complete and the trace moves to the reference line. This establishes the reference at 0dB.

10. Connect the 44472A's COM 0 connector to Port 1 of the 8503A.

11. Connect one of the open channels in multiplexer group 0 to Port 2 of the 8503A.

12. Press the MKR button to display the marker displacement (in dB) from the reference line. This is the channel to channel crosstalk between the closed channel and the open channel under test. The crosstalk should be $< -85$dB.

13. Repeat steps 11 and 12 for the remaining open channels in group 0.

14. Repeat steps 8 through 13 until all channels in the group 0 multiplexer have been stepped through and tested.

15. Connect the 44472A's COM 1 connector to Port 1 of the 8503A.

16. Press the STEP key.

17. Calibrate the 8505A as follows:

a. Connect a 50 Ohm matched termination to the closed channel appearing in the 3488A's display (channel 10 to start).

b. Connect the 44472A's COM 1 connector to Port 1 of the 8503A.

c. Rotate the OUTPUT Vernier counterclockwise until the OVERLOAD light turns off.

d. Set the MARKERS Switch to position 1. Rotate the MARKERS 1 vernier to set the measurement marker to 100MHz.

e. Press the CHANNEL 1 MKR button. Press and hold the ZRO button until the iterative zero process is complete and the trace moves to the reference line. This establishes the reference at 0dB.

18. Connect the 44472A's COM 1 connector to Port 1 of the 8503A.

19. Connect one of the open channels in multiplexer group 1 to Port 2 of the 8503A.

20. Press the MKR button to display the marker displacement (in dB) from the reference line. The marker displacement (channel to channel crosstalk) should be < −85dB.

21. Repeat steps 19 and 20 for the remaining open channels in group 1.

22. Repeat steps 16 through 21 until all channels in the group 1 multiplexer have been stepped through and tested.

23. GROUP TO GROUP CROSSTALK TEST: Using the 3488A's front panel keys, close channels 03 and 10 as follows:

a. Press the LOCAL key.

b. Press the CARD MONITOR key followed by the numeral key corresponding to the slot occupied by the 44472A.

c. Press the EXECUTE key.

d. Press the CLOSE key followed by X03 (where X is the slot occupied by the 44472A).

e. Press the EXECUTE key.

f. Press the CLOSE key followed by X10 (where X is the slot occupied by the 44472A).

g. Press the EXECUTE key.

24. Calibrate the 8508A as follows:

a. Connect 50 Ohm matched terminations to channels X03 and X10 (these channels should be appearing in the 3488A's display).

b. Connect the 44472A's COM 0 connector to Port 1 of the 8503A.

c. Rotate the OUTPUT vernier counterclockwise until the OVERLOAD light turns off.

d. Set the MARKERS switch to position 1. Rotate the MARKERS vernier to set the measurement marker to 100 MHz.

e. Press the CHANNEL 1 MKR button. Press and hold the ZRO button until the iterative process is complete and the trace moves to the reference line. This establishes the reference at 0dB.

25. Connect the 44472A's COM 0 connector to Port 1 of the 8503A.

26. Connect the 44472A's COM 1 connector to Port 2 of the 8503A.

27. Press the MKR button to display the marker displacement (in dB) from the reference line. This is the group to group crosstalk. It should be <-85 dB.

**NOTE**

*The above test checks the crosstalk at 100MHz. Crosstalk can be tested at other frequencies by inserting those frequencies into steps 5a and 9d.*

### 10-15 Corrective Action

A channel to channel or group to group crosstalk failure is caused by electrical leakage between the failed channels. This can be caused by a dirty or damaged 44472A pc board. If a failure is encountered, inspect the 44472A pc board for damage. If damage is found, contact an HP Sales and Service Office for 44472A replacement information. If no damage is found, clean the board thoroughly (see Section 10-2).

## 10-16 REPLACEABLE PARTS

Table 10-2 lists the mechanical and electrical replaceable parts available for the 44472A. The mechanical parts are keyed to Figure 10-7. This figure also provides assembly and disassembly information. The electrical parts are keyed to the schematic and component locator in Figure 10-11. Table 5-2, in Chapter 5, lists manufacturers code numbers as they apply to the parts lists in Table 10-2.

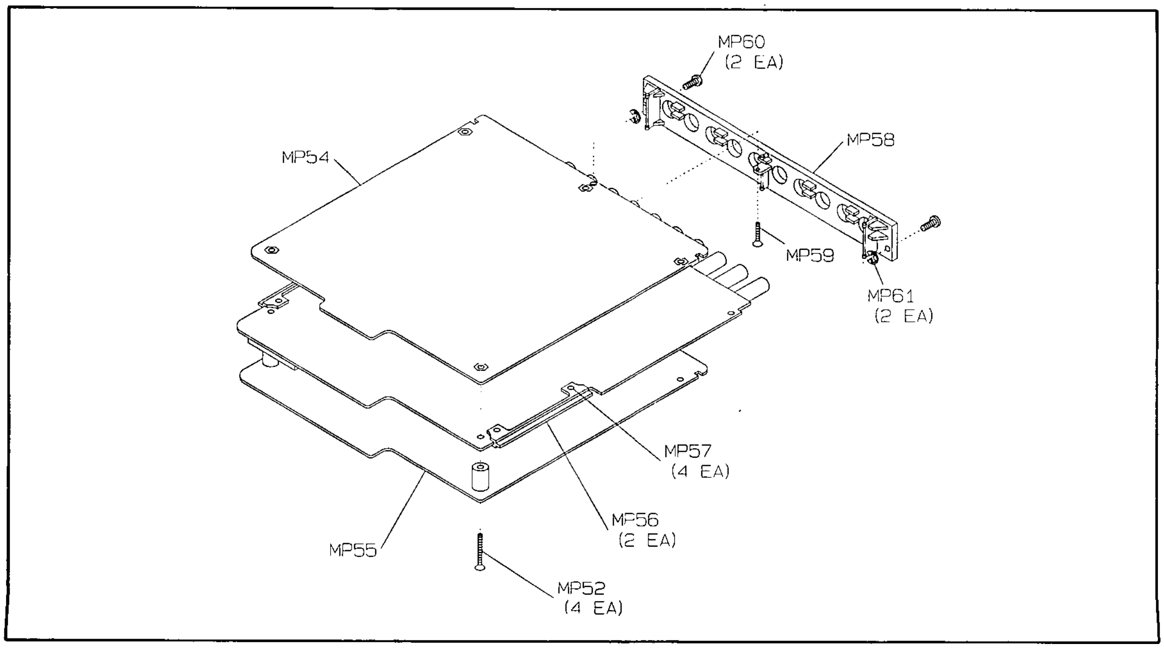



**Figure 10-7 44472A Disassembly**

# Table 10-2 Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1 | 44472-66501 | 2 | 1 | VHF SWITCH ERC: 2605 | 28480 | 44472-66501 |
| A1C901 | 0160-3847 | 9 | 28 | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C902 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C903 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C904 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C905 | 0160-0127 | 2 | 1 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| A1C906 | 0160-5349 | 0 | 2 | CAPACITOR-FXD 200PF +-5% 100VDC CER | 28480 | 0160-5349 |
| A1C907 | 0160-5349 | 0 | | CAPACITOR-FXD 200PF +-5% 100VDC CER | 28480 | 0160-5349 |
| A1C908 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C909 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C910 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C911 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C912 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C913 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C914 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C915 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C916 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C917 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C918 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C919 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C920 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C921 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C922 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C923 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C924 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C925 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C926 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C927 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C928 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C929 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C930 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C931 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1CR905 | 1901-0050 | 3 | 8 | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR906 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR907 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR908 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR909 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR910 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR911 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR912 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1DP901 | 1906-0229 | 8 | 2 | DIODE-ARRAY 50V 400MA | 01295 | TID133 |
| A1DP902 | 1906-0229 | 8 | | DIODE-ARRAY 50V 400MA | 01295 | TID133 |
| A1J901 | 1250-1846 | 6 | 10 | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J902 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J903 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J904 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J905 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J906 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J907 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J908 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J909 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1J910 | 1250-1846 | 6 | | CONNECTOR-RF BNC FEM PC 50-OHM | 28480 | 1250-1846 |
| A1K901 | 0490-1414 | 1 | 8 | RLY-S2M-L2-5VH10 | 28480 | 0490-1414 |
| A1K902 | 0490-1414 | 1 | | RLY-S2M-L2-5VH10 | 28480 | 0490-1414 |
| A1K903 | 0490-1336 | 6 | 6 | RELAY-S2EB-L2-5V | 28480 | 0490-1336 |
| A1K904 | 0490-1336 | 6 | | RELAY-S2EB-L2-5V | 28480 | 0490-1336 |
| A1K905 | 0490-1414 | 1 | | RLY-S2M-L2-5VH10 | 28480 | 0490-1414 |
| A1K906 | 0490-1414 | 1 | | RLY-S2M-L2-5VH10 | 28480 | 0490-1414 |
| A1K907 | 0490-1336 | 6 | | RELAY-S2EB-L2-5V | 28480 | 0490-1336 |
| A1K908 | 0490-1336 | 6 | | RELAY-S2EB-L2-5V | 28480 | 0490-1336 |
| A1K909 | 0490-1414 | 1 | | RLY-S2M-L2-5VH10 | 28480 | 0490-1414 |
| A1K910 | 0490-1414 | 1 | | RLY-S2M-L2-5VH10 | 28480 | 0490-1414 |
| A1K911 | 0490-1336 | 6 | | RELAY-S2EB-L2-5V | 28480 | 0490-1336 |
| A1K912 | 0490-1336 | 6 | | RELAY-S2EB-L2-5V | 28480 | 0490-1336 |
| A1K913 | 0490-1414 | 1 | | RLY-S2M-L2-5VH10 | 28480 | 0490-1414 |
| A1K914 | 0490-1414 | 1 | | RLY-S2M-L2-5VH10 | 28480 | 0490-1414 |

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

# Table 10-2 Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1P901 | 5180-6697 | 9 | 1 | CONN-RT ANG 2X15 | 28480 | 1251-8645 |
| A1Q901 | 1853-0551 | 6 | 8 | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q902 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q903 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q904 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q905 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q906 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q907 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q908 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1R901 | 0683-2725 | 8 | 8 | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R902 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R903 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R904 | 0683-1035 | 1 | 5 | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R905 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R908 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R909 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R912 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R913 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R914 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R915 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R916 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R917 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R918 | 0683-1065 | 7 | 2 | RESISTOR 10M 5% .25W CC TC=-900/+1100 | 01121 | CB1065 |
| A1R919 | 0683-1065 | 7 | | RESISTOR 10M 5% .25W CC TC=-900/+1100 | 01121 | CB1065 |
| A1U901 | 1820-2537 | 3 | 2 | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C244N |
| A1U902 | 1820-2537 | 3 | | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C244N |
| A1U903 | 1820-2216 | 5 | 2 | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U904 | 1858-0047 | 5 | 2 | TRANSISTOR ARRAY 16-PIN PLSTC DIP | 13606 | ULN-2003A |
| A1U905 | 1820-2216 | 5 | | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U906 | 1858-0047 | 5 | | TRANSISTOR ARRAY 16-PIN PLSTC DIP | 13606 | ULN-2003A |
| A1U907 | 1820-1216 | 3 | 1 | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| MP52 | 0515-0843 | 2 | 4 | SCREW M2.5X20 LK | 28480 | 0515-0843 |
| MP54 | 44472-00601 | 5 | 1 | SHIELD-VHF CKT | 28480 | 44472-00601 |
| MP55 | 44472-00602 | 6 | 1 | SHIELD-VHF COMP | 28480 | 44472-00602 |
| MP56 | 5041-5213 | 0 | 2 | GLIDE PC BOARD | 28480 | 5041-5213 |
| MP57 | 1480-0625 | 4 | 4 | PIN-GRV 3/32X1/4 | 28480 | 1480-0625 |
| MP58 | 44472-40201 | 5 | 1 | PANEL-REAR VHF | 28480 | 44472-40201 |
| MP59 | 0515-0403 | 0 | 1 | SCREW M2.5X8 LK | 28480 | 0515-0403 |
| MP60 | 5180-8269 | 9 | 2 | SCREW, CAPTIVE | 28480 | 5957-5138 |
| MP61 | 0510-0043 | 4 | 2 | RING, RETAINER 3.58 | 28480 | 0510-0043 |

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

## 10-17 44472A THEORY OF OPERATION

The 44472A VHF Card consists of an input buffer and latch, relay drive circuits, an address decoder, and a card-type buffer.

### 10-18 Input Buffer And Latch

The input buffer (U902 in Figure 10-11) provides isolation between the 44472A and the mainframe's data bus. An input buffer is present on each type of plug-in card and prevents excessive loading of the data bus by the plug-in cards.

The input latch (U903 and U905 in Figure 10-11) holds the output of the input buffer for application to the relay drive circuitry.

### 10-19 Relay Drive Operation

A simplified schematic diagram of one relay drive circuit is shown in Figure 10-8. When instructions are received over the data bus to set a relay (close a channel), a logic high level is applied to the base of Q2 and the input of U2 causing their outputs to go low. A logic low level is applied to the base of Q1 causing its output to go high. CR2 becomes forward biased allowing current to flow through both the set and reset coils of relay K1. The magnetic field generated around the coils interacts with the permanent magnetic field of the relay armature causing it to close the relay contacts. Once closed, the drive current is removed from the relay coil and the permanent magnetic field of the armature latches the contact in the closed state.

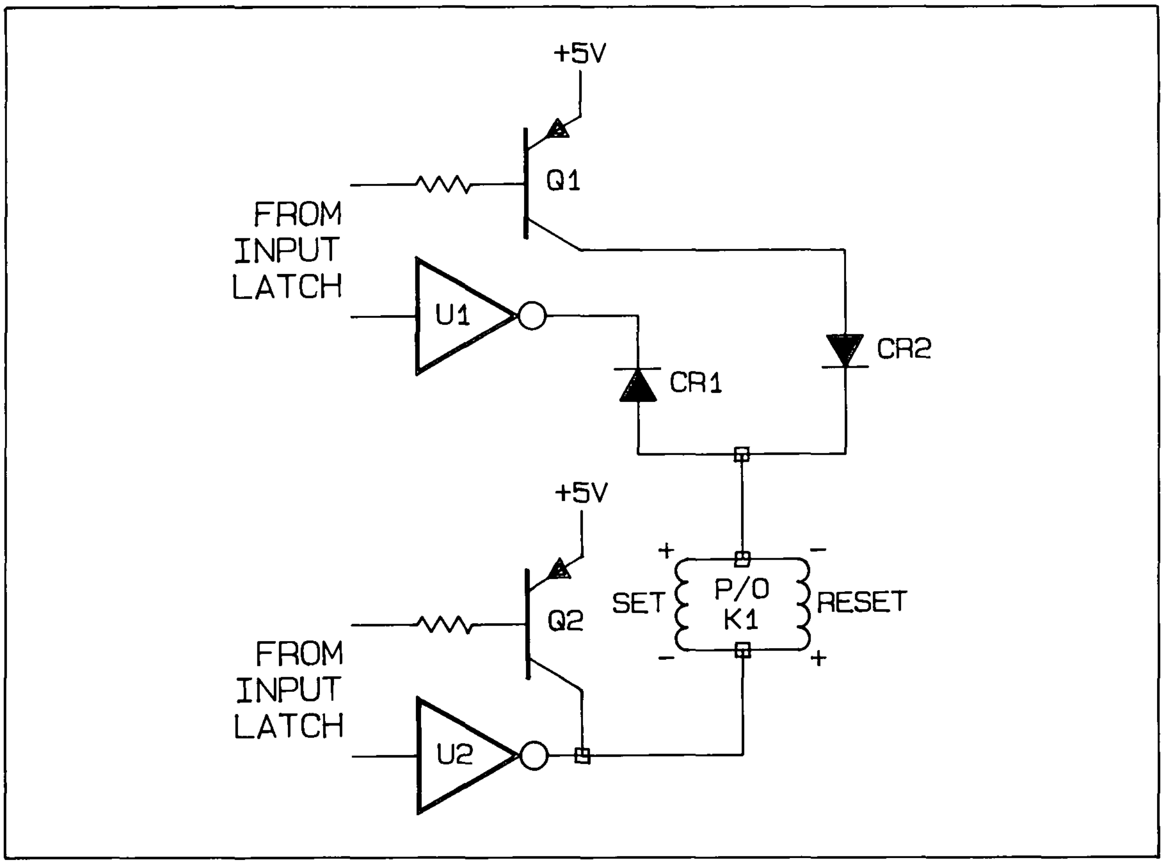



**Figure 10-8 One Relay Drive Circuit**

When instructions are received over the data bus to reset a relay (open a channel), a logic low level is applied to the base of Q2 and the input of U2 causing their outputs to go high. A logic high level is applied to the input of U1 causing its output to go low. CR1 becomes forward biased allowing current to flow through both the set and reset coils of relay K1. The magnetic field generated around the coils interacts with the permanent magnetic field of the relay armature causing it to open the relay contacts. Once opened, the drive current is removed from the relay coil and the permanent magnetic field of the armature latches the contacts in the opened state.

## 10-20 Card-Type Buffer

The card-type buffer (U901 in Figure 10-11) indicates to the mainframe that a 44472A is in the particular card slot queried. The card type is determined by the wiring configuration of four of the input lines to the card-type buffer. By connecting one input to +5Vdc and three inputs to ground, a 4-bit code (0010) is created that is recognized by the mainframe as the unique identifier for the 44472A card.

## 10-21 Address Decoder

The address decoder (U907 in Figure 10-11) is enabled when the $\overline{\text{CS}}$ signal from the mainframe goes low. Once enabled, the address decoder is responsible for enabling the various IC's on the board in response to the instructions it receives via the R/$\overline{\text{W}}$, A0 and A1 signals from the mainframe. Figures 10-9 and 10-10 show the timing relationships between these control lines for both read and write operations.

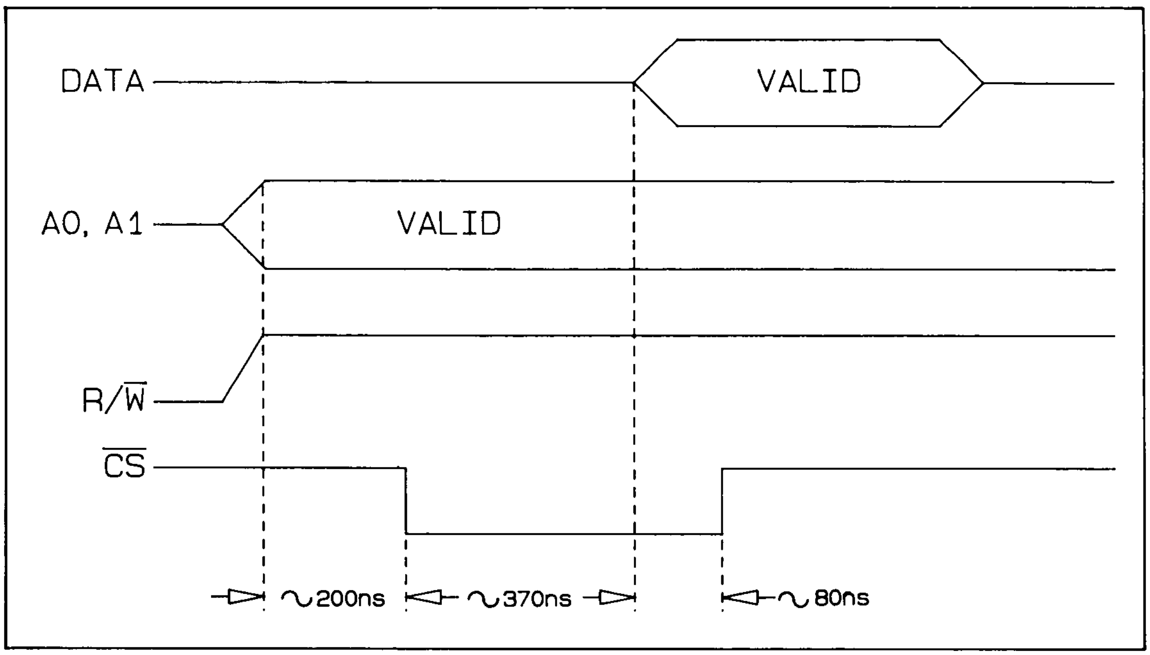



**Figure 10-9 Control Line Timing (Read)**

# 10-22 44472A TROUBLESHOOTING

## 10-23 Introduction

If the Performance Tests (Section 10-3) or Operational Verification tests (Chapter 4) have indicated that a particular relay is failing, that relay is probably at fault. A failure of the relay contact resistance test indicates a bad relay.

If more than one relay failure is indicated, the associated drivers should be suspected. Using Figure 10-11 (44472A Schematic) the problem may be isolated to a few components from the symptoms. The relays on the 44472A circuit board are arranged into four rows and four columns. To close a relay, both a row driver and a column driver must be active. Failures in the drivers, then, will exhibit symptoms that are common to a row or a column. For example; group 0 relays are common to columns 0 and 2. Group 1 relays are common to columns 1 and 3. Relays K913 and K914 are common to row 0. Note that not all relays need to change state to accomplish a channel to common connection.

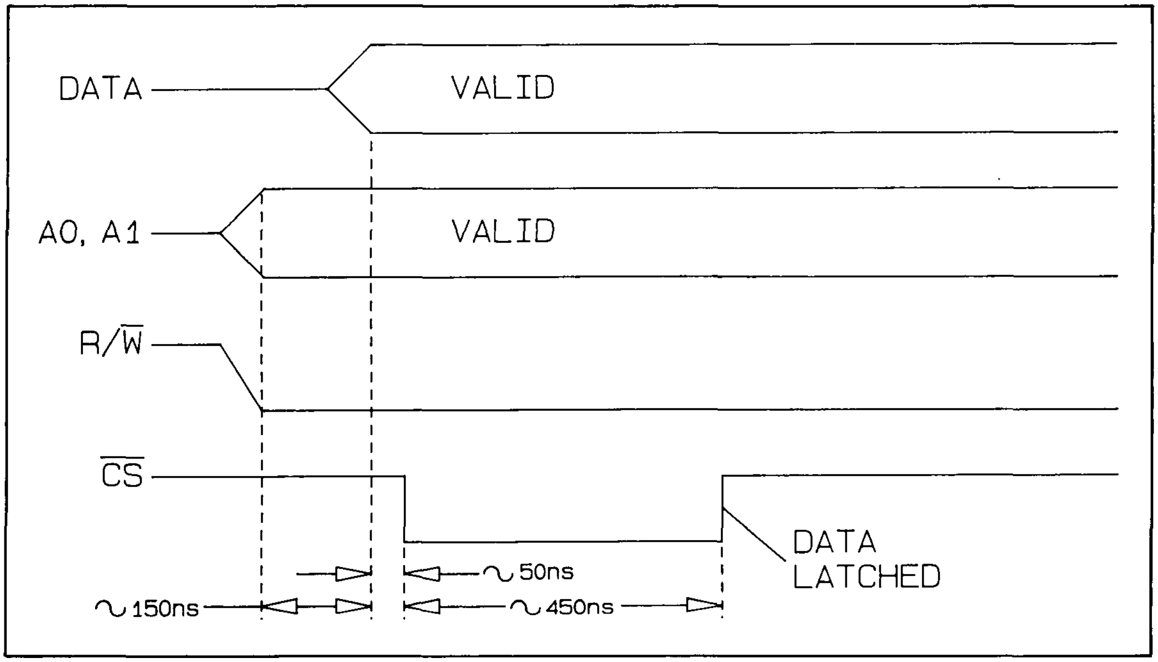



**Figure 10-10 Control Line Timing (Write)**

**10-24 Equipment Required**

| | |
|---|---|
| Signature Multimeter | HP 5005A or equivalent |
| Service Extender Cable | 5061-1174 |
| Service Extender Board | 5061-1173 |

## 10-25 Initial Checks

The initial checks of a suspected plug-in card will require that the plug-in card shields be removed. Removal of the four screws in the plug-in shield allows both shields to be removed from the plug-in printed circuit board.

Once the shields have been removed, the card to be tested should be installed in slot 1 of the mainframe. There are two ways to do this. The first method uses the Service Extender Board (5061-1173) and the Service Extender Cable (5061-1174). With these two service tools the card may be electrically installed in the card slot but be physically located on the test bench.

If the service extender tools are not available, the card may be installed in slot 1 and the 3488A mainframe top cover removed. This will allow access to the non-component side of the plug-in card for servicing. 3488A top cover removal is described in Chapter 5.

Be sure that all other plug-in cards have been removed from the mainframe.

1. Apply power and measure the + 5 Vdc on the plug-in board. There are two supplies to this board, both the supplies (and the grounds) are common on the backplane board. Connect the ground lead of the voltmeter to pin 10 of U901. Measure the voltage at pin 20 of U901. The voltage should be + 5 Vdc ±0.5 Vdc. Measure the voltage at the emitter of any of the discrete transistors on the board (i.e., Q906). The transistors are mounted with the emitter lead in a square pad on the board. The voltage should be + 5 Vdc ±0.5 Vdc.

If the voltages are correct, proceed to Step 2. If either or both of the voltages are incorrect, troubleshoot the + 5 Vdc supply in the mainframe (it is possible that the plug-in card is loading the supply).

2. Observe the front panel symptoms to determine if the problem can be isolated to a few components. The Operational Verification tests is Chapter 4 may be used to identify a relay contact or closure problem.

If a single channel is at fault, troubleshoot the relays in that channel to determine if they will change state. Use the front panel keys to change the state of the relays (described in Chapter 3) and an ohmmeter to determine if the relay actually changed state. If a single relay is failing to change state, the relay is probably at fault. If more than one relay is failing, the drivers should be suspected. Use the 44472A schematic (Figure 10-11) to determine if If the problem cannot be isolated easily, proceed to Step 3.

3. Check the mainframe and plug-in card data bus for activity. The data probe of the HP 5005A may be used to indicate activity on the data bus. A blinking probe light indicates state changes. Check the data bus at U902 pins 2, 4, 6, 8, 11, 13, 15 and 17. The plug-in card must be installed in slot 1 and power applied to the mainframe. No special test set-ups should be installed.

All eight data lines should show activity.

If activity is found, proceed to Step 4. If one or more of the lines are stuck, troubleshoot the backplane data bus or the inputs to buffers U901 and U902 on the plug-in card.

4. Check the outputs of U902 at pins 3, 5, 7, 9, 12, 14, 16 and 18 for activity. All eight pins should show activity.

If activity is found, proceed to Step 5. If no activity is found on one or more lines, troubleshoot U902, U905 or U903.

5. Check the backplane card select and decoding lines for activity. Check U907 pins 1, 2, 3, and 4 for activity. All lines should show activity.

If activity is found, proceed to Step 6. If no activity is found, troubleshoot the backplane or the inputs to U907 on the plug-in card.

6. If the problem has not been isolated, signature analysis procedures may be used to test the buffers, drivers, and relay coils. The procedure begins in Section 10-26.

## 10-26 Buffer, Driver, And Relay Signature Analysis

To perform the signature analysis tests the mainframe top cover and the controller shield must be removed. Procedures to remove the cover and shield are located in Chapter 5.

The HP 5005A has been recommended for this signature analysis test because it incorporates adjustable data thresholds. This feature allows signatures to be checked at the relay coils. If a different signature analyzer is being used, the signatures may only be checked up to the drivers.

Ensure the controller is set to the normal operating configuration (RP409 installed and all switches on SP401 set open) before performing these troubleshooting steps. All plug-in cards should be removed from the mainframe. The suspected plug-in card must be installed in slot 1.

The initial checks given in section 10-25 should be performed prior to this signature analysis procedure. Section 10-25 also describes the use of the service extender card and service extender cable.

1. Signature Analyzer set-up. Polarity: START _/¯, STOP and CLOCK ¯_. On the controller printed circuit board (A40), connect START/ST/SP to SA2, STOP/QUAL to SA2, CLOCK to SA3, Ground to SA4.

2. On the controller printed circuit board (A40), connect a jumper between SA6 (SERV FUNC) and ground (SA4).

3. If using the HP 5005A signature analyzer, set the data probe threshold to 2.80 H and 2.00 L.

4. Apply power to the 3488A. Press the TEST key on the front panel. Instead of performing the internal controller self-test, the display will prompt for a number. Enter 2 and press execute.

5. The signature analyzer should now be gating. The test selected cycles all data lines in a fixed pattern. This pattern will produce one of two signatures (depending upon inversion) that may be traced from the relay coils to the backplane data bus. These signature are: 36U6 and 6HPH.

6. The signatures for the inputs and outputs on the 44472A are given in Table 10-3.

## Table 10-3 Buffer, Driver, And Relay Signatures (Test 2)

+5 Vdc signature: 5C1C

**U902**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 20 | +5 Vdc |
| 2 | 36U6 | 19 | NA |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 36U6 | 16 | 36U6 |
| 6 | 36U6 | 15 | 36U6 |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 36U6 | 12 | 36U6 |
| 10 | NA | 11 | 36U6 |

**U903**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | L | 20 | +5 Vdc |
| 2 | 6HPH | 19 | 6HPH |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 6HPH | 16 | 6HPH |
| 6 | 6HPH | 15 | 6HPH |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 6HPH | 12 | 6HPH |
| 10 | NA | 11 | NA |

**U905**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | L | 20 | +5 Vdc |
| 2 | 36U6 | 19 | 36U6 |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 36U6 | 16 | 36U6 |
| 6 | 36U6 | 15 | 36U6 |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 36U6 | 12 | 36U6 |
| 10 | NA | 11 | NA |

**U904**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 16 | NA |
| 2 | NA | 15 | NA |
| 3 | 6HPH | 14 | 36U6 |
| 4 | 36U6 | 13 | 6HPH |
| 5 | 6HPH | 12 | 36U6 |
| 6 | 6HPH | 11 | 36U6 |
| 7 | 6HPH | 10 | 36U6 |
| 8 | NA | 9 | +5 Vdc |

**U906**

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 16 | NA |
| 2 | 36U6 | 15 | 6HPH |
| 3 | NA | 14 | NA |
| 4 | NA | 13 | NA |
| 5 | 36U6 | 12 | 6HPH |
| 6 | NA | 11 | NA |
| 7 | 36U6 | 10 | 6HPH |
| 8 | NA | 9 | +5 Vdc |

**K901 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

**K906 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

**K911 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

**K902 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

**K907 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

**K912 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

**K903 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

**K908 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

**K913 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

**K904 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

**K909 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

**K914 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 36U6 | 6,12 | 6HPH |

**K905 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

**K910 ***

| pin | signature | pin | signature |
|---|---|---|---|
| 1,7 | 6HPH | 6,12 | 36U6 |

* these signatures have a data threshold of 2.80 H and 2.0 L.

HP44472A Relay Card

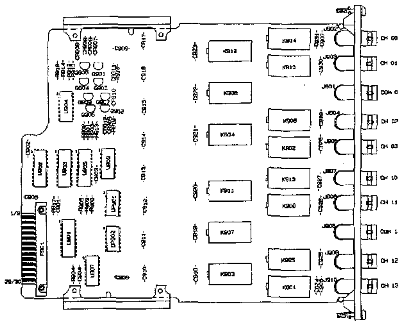
**44472A**
**Relay State Table**

**Group 0**

| | K902 | K904 | K906 | K908 | K910 | K912 | K914 |
|---|---|---|---|---|---|---|---|
| CH00 | RESET | RESET | RESET | RESET | RESET | SET | SET |
| CH01 | RESET | RESET | RESET | RESET | SET | RESET | RESET |
| CH02 | RESET | SET | SET | SET | RESET | SET | RESET |
| CH03 | SET | RESET | RESET | SET | RESET | SET | RESET |

**Group 1**

| | K901 | K903 | K905 | K907 | K909 | K911 | K913 |
|---|---|---|---|---|---|---|---|
| CH10 | RESET | RESET | RESET | RESET | RESET | SET | SET |
| CH11 | RESET | RESET | RESET | RESET | SET | RESET | RESET |
| CH12 | RESET | SET | SET | SET | RESET | SET | RESET |
| CH13 | SET | RESET | RESET | SET | RESET | SET | RESET |



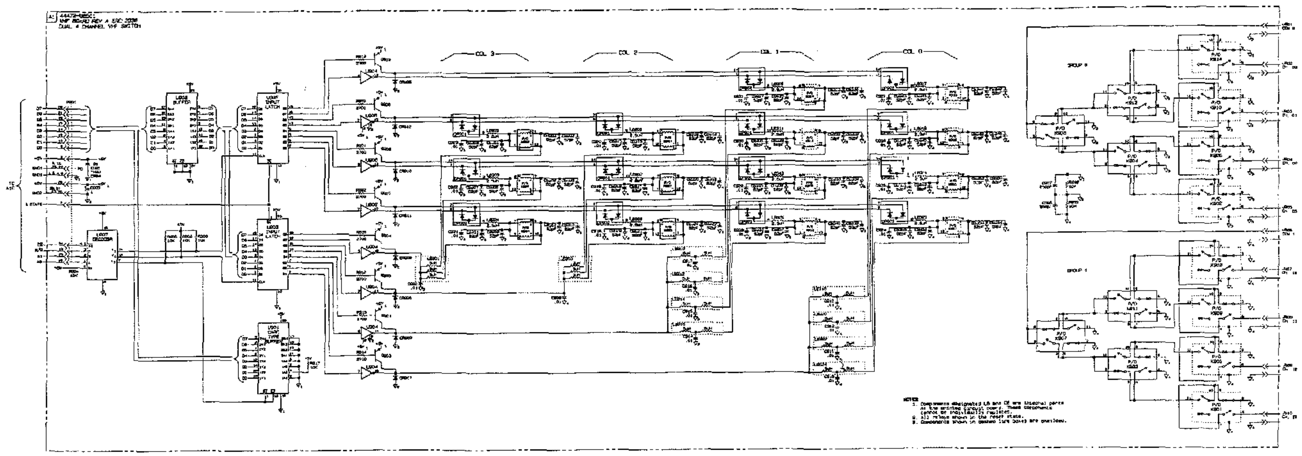


Figure 10-11 44472A Schematic
10-27/10-28

# Chapter XI

# 44473A 4X4 MATRIX SWITCH

# CHAPTER XI

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF ILLUSTRATIONS

# CHAPTER XI
# 44473A 4X4 MATRIX SWITCH

## 11-1 INTRODUCTION

This chapter contains installation information, performance testing information, trouble-shooting information and replaceable parts lists for the 44473A 4X4 Matrix Switch.

The 44473A consists of 16 double-pole single-throw (DPST) relays arranged in a 4 channel by 4 channel switching matrix. Each channel has a low line and a high line which are switched in unison. Figure 11-1 shows a simplified schematic of the 44473A.

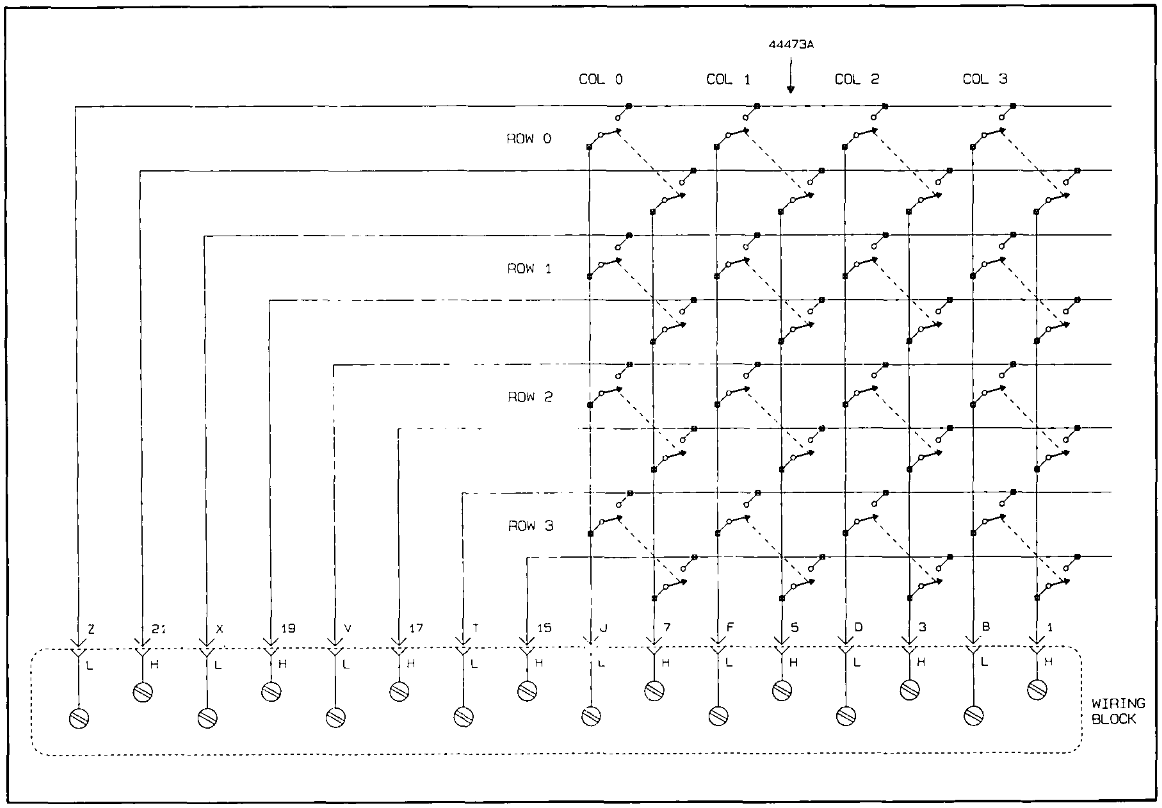



**Figure 11-1 44473A Simplified Schematic**

**WARNING**

*Hazardous voltage may exist on the wiring and connectors of the 44473A plug-in card. Only service trained personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make repairs to the 3488A and or the plug-in cards.*

## 11-2 PLUG-IN CARD WIRING

Figure 11-2 shows the proper wiring procedures for the 44473A.

**WARNING**

*Hazardous voltages may exist on the wiring and connectors of the 3488A's plug-in cards. Only Service Trained Personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make repairs to the 3488A and/or the plug-in cards.*

## 11-3 PLUG-IN CARD CLEANING

Printed circuit board contamination can affect the dc isolation and the high frequency performance of the plug-in cards. This contamination can come from dust accumulation, fingerprints, condensation, and so on. The plug-in card printed circuit boards are to be cleaned as follows:

**CAUTION**

*Use anti-static pc board handling techniques during the following procedure.*

1. Remove the shields from the plug-in card.

2. Use a stiff bristled camel hair brush (do not use a wire brush) soaked in isopropyl alcohol to wash the pc board.

**CAUTION**

*DO NOT immerse the printed circuit board in any type of fluid.*

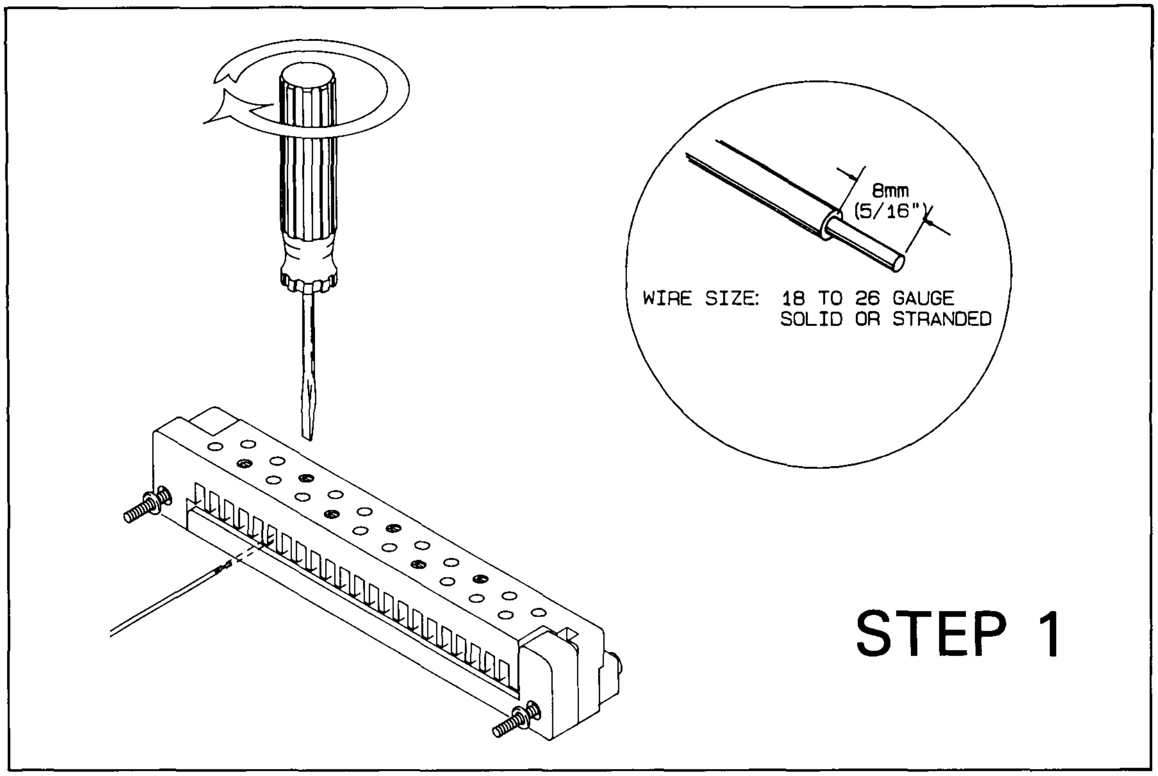
3. Use the stiff bristled brush soaked in deionized or distilled water, to remove any residue left by the alcohol.

4. Allow the printed circuit board to dry thoroughly.

5. Replace the shields.

⚠ **CAUTION**

*The maximum terminal-to-terminal or terminal-to-chassis voltage limits for the 44473A are 250Vdc or 250Vac rms (350Vac peak). The maximum current limits per channel are 2Adc or 2Aac rms. The maximum current limits per card are 8Adc or 8Aac rms. The maximum power limits per channel are 60Wdc or 500VAac. The maximum power limits per card are 240Wdc or 2000VAac. Damage to the 44473A and possibly the 3488A will occur if any of the above limits are exceeded.*



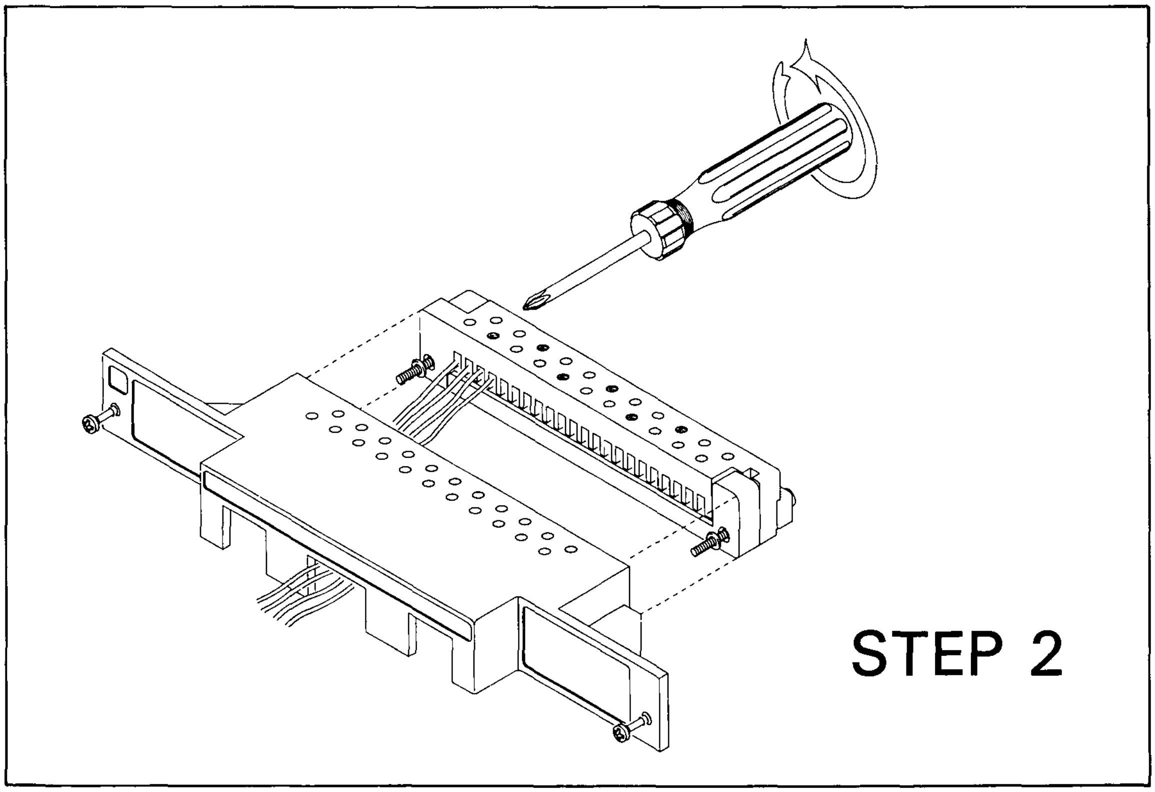




**Figure 11-2 Plug-In Card Wiring**

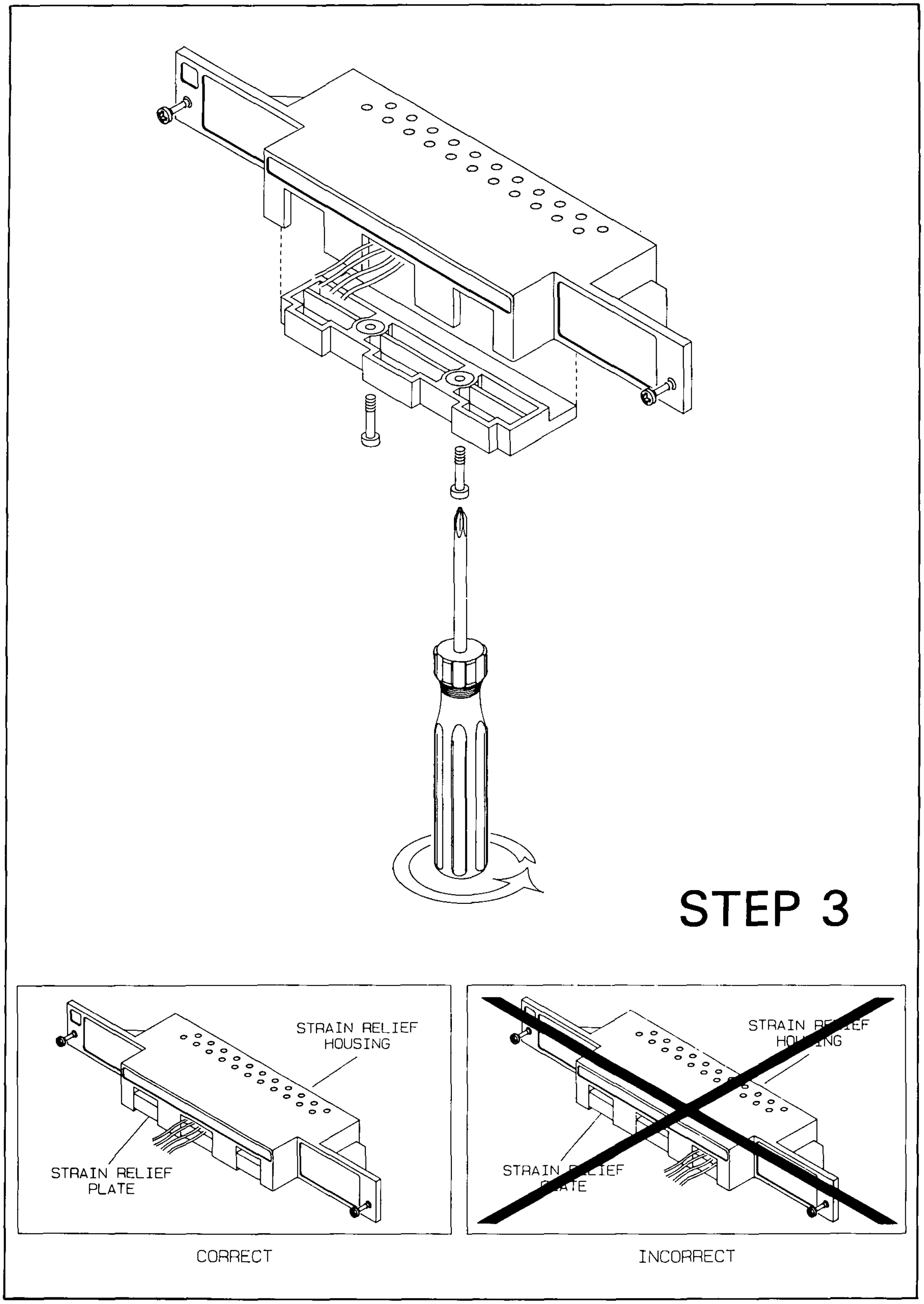
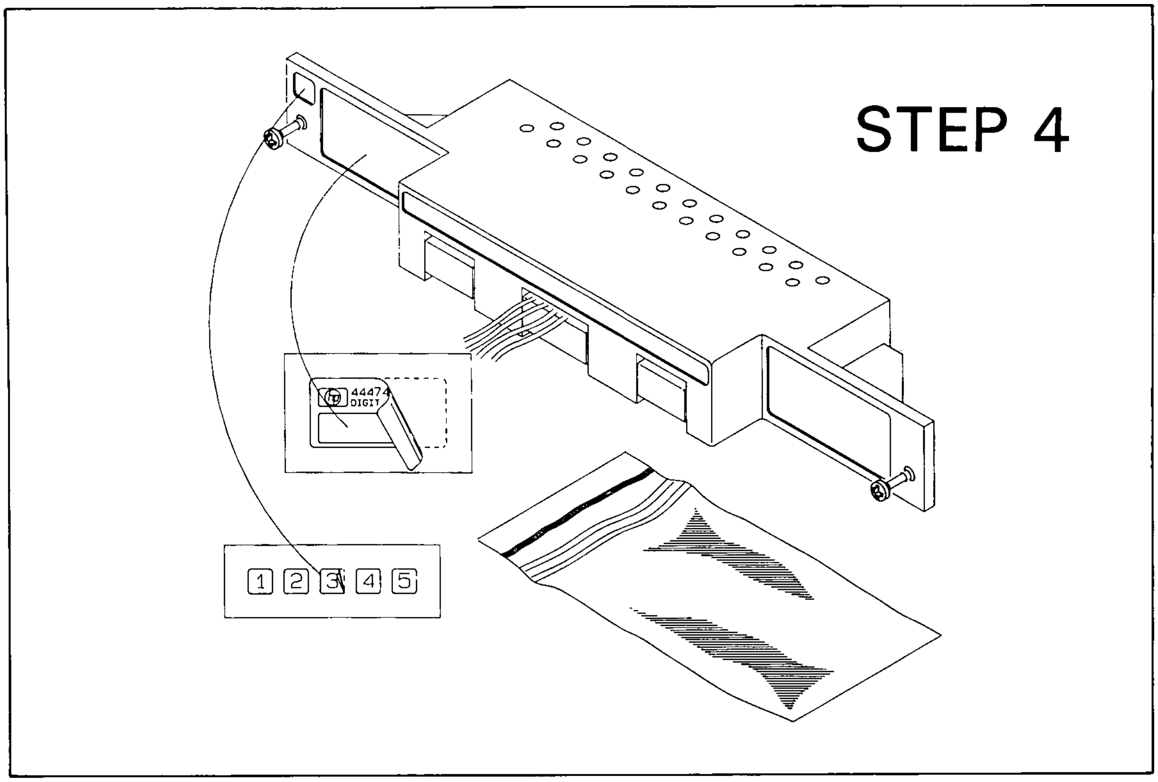



**Figure 11-2. Plug-In Card Wiring (Cont'd)**



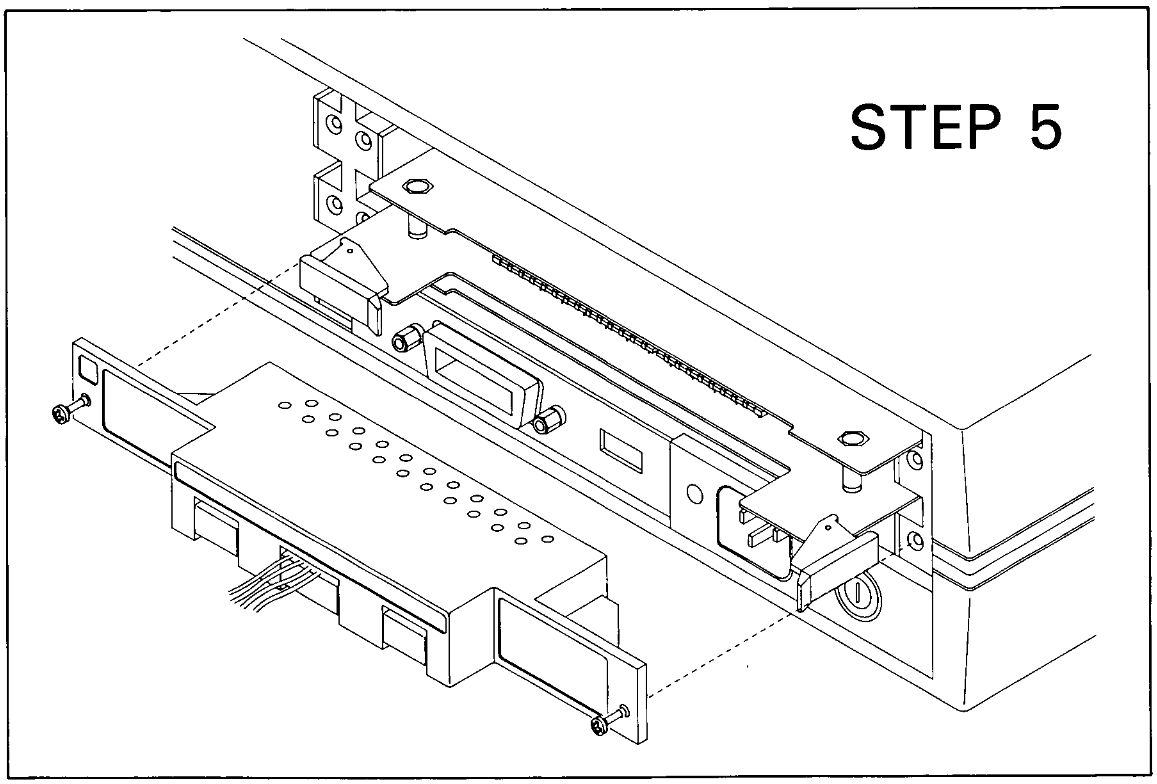




Figure 11-2. Plug-In Card Wiring (Cont'd)

## 11-4 TEST FIXTURE

A test fixture is required in order to perform the Operation Verification Tests for the 44473A (Chapter 4 of this manual). This fixture simplifies testing by eliminating the need to repeatedly connect and disconnect test leads and by acting as an interface between the 44473A and an ohmmeter.

The test fixture can be either of the following two types:

a. A test fixture is available from Hewlett-Packard (HP part number 03488-66501). The advantages of this fixture are (1) it requires no assembly and (2) it can be used to test the 44470A, the 44471A, the 44473A and the 44474A plug-in cards without modification.

b. A test fixture can be constructed by configuring an HP 44483A removable wiring block as shown in Figure 11-3. This particular test fixture can only be used to test the 44473A.

The test fixture consists of (1) a short circuit between all of the low line inputs, (2) a short circuit between all of the low line outputs, (3) a short circuit between all of the high line inputs, and (4) a short circuit between all of the high line outputs. With the test fixture installed, and an ohmmeter connected between the inputs and outputs of either the low lines or high lines, the card is tested by successively closing each relay while checking for the indication of a closure with the ohmmeter.

**NOTE**

*The Performance Test procedures in this chapter are involved and time consuming. Since the most likely parameter to change with time is the series resistance of a channel, and since the series resistance is tested in the Operation Verification procedures (Chapter 4), it is not recommended that the Performance Tests be conducted unless one of the tested specifications is in question.*

## 11-5 PERFORMANCE TESTS

The following Performance Tests check the 44473A's dc isolation and thermal offset specifications. The results of these tests, when coupled with the results of the 44473A Operation Verification Test, will verify whether or not the 44473A is operating within its critical specifications. The 44473A Operation Verification Test is located in Chapter 4 of this manual. Since the 44473A Operation Verification Test assesses the operability of the 44473A, it is important that it be performed prior to performing the Performance Tests.

**WARNING**

*If the 44473A is currently installed into a system, it must be disconnected from the system in order to execute the Performance Tests. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

**WARNING**

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected. The user must take the necessary precautions to prevent the above from happening before disconnecting the 44473A.*

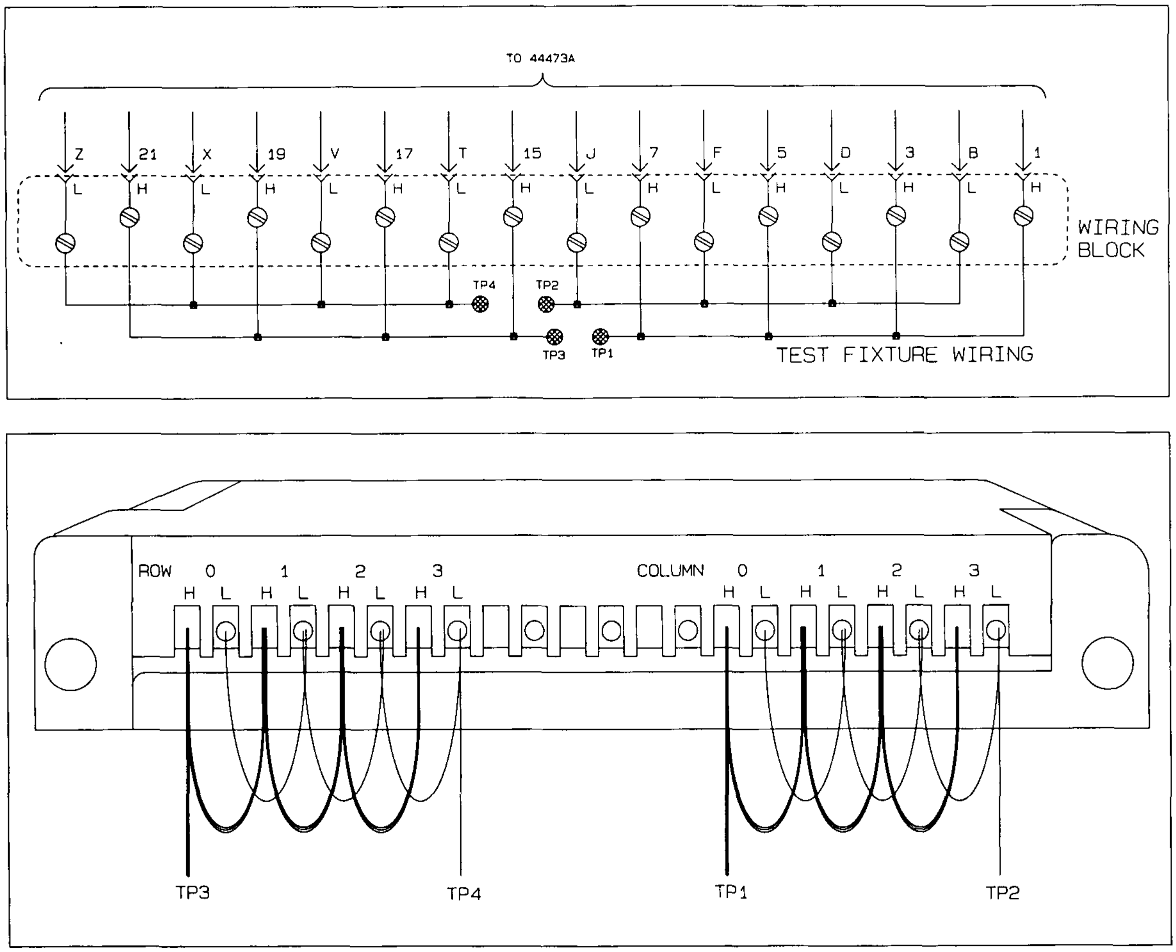



**Figure 11-3 44473A Test Fixture**

### 11-6 Required Test Equipment

DC Power Supply – HP 6216B or equivalent. The power supply must be able to deliver a stable +20Vdc at low current levels.

10 megohm resistor.

Digital Multimeter – HP 3478A or equivalent. The multimeter must have the resolution and accuracy to measure a 1$\mu$V differential dc voltage.

## 11-7 44473A DC Isolation Tests

The following dc isolation tests incorporate a dc power supply, a resistor of known value, and a dc voltmeter. The first phase of the tests involves precisely setting the dc power supply's output voltage and connecting the resistor and the dc voltmeter in series with the dc power supply. In this configuration, the resistor and the internal resistance of the dc voltmeter form a voltage divider. The voltage drop across the dc voltmeter is measured and, with the value of the resistor and the power supply voltage being known, the internal resistance of the dc voltmeter is calculated.

**NOTE**

*The best test results will be obtained when the value of the known resistor is equal to the internal resistance of the dc voltmeter.*

The second phase of the tests consists of (1) placing the appropriate channel of the 44473A in parallel with the dc voltmeter, (2) measuring the voltage drop across the dc voltmeter/channel combination, and (3) calculating the channel's dc isolation.

1. SET-UP SEQUENCE: Set the digital multimeter to measure dc voltage. Connect the multimeter to the dc power supply. Set the dc power supply to deliver +20Vdc ±.01Vdc as measured on the multimeter. This voltage will be referred to as V1 in the following steps.

2. Use the multimeter to measure the exact resistance of the 10 megohm resistor. This resistance will be referred to as R1.

3. Connect the test equipment as shown in Figure 11-4.

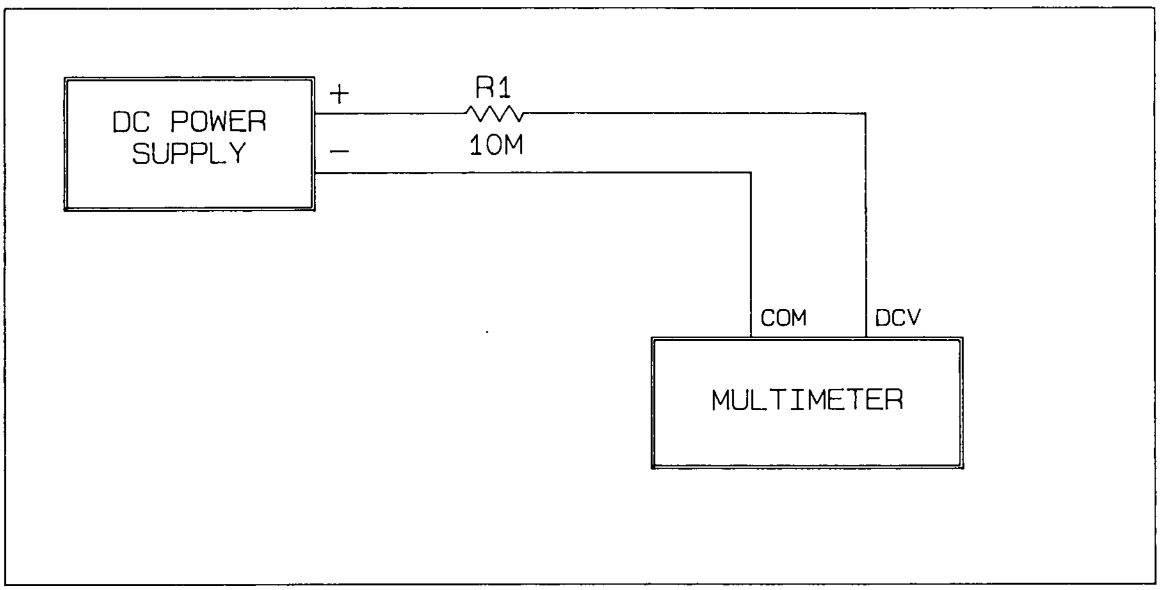



**Figure 11-4 DC Isolation Test Set-Up**

4. Set the multimeter to the 300Vdc range. Record the exact dc voltage reading on the multimeter. This voltage will be referred to as V2 in the following steps.

5. Calculate the internal resistance of the multimeter (Rm) using the following equation:

$$Rm = R1 \bullet V2/(V1 - V2)$$

**NOTE**

*In most cases, the internal resistance of the multimeter is dependent upon the range setting. For this reason, do not change the multimeter's range setting in the following steps.*

6. ROW OR COLUMN TO CHASSIS TEST: Use the 3488A front panel to open all channels as follows:

a. Press the LOCAL key.

b. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44473A.

c. Press the EXECUTE key.

7. Connect the 3488A backpanel ground terminal (chassis ground) and the low line of the channel under test (row 0 to start) into the test circuit as shown in Figure 11-5.

8. Record the multimeter's dc voltage reading. This reading will be referred to as V3.

9. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V3 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V3) - R1 \bullet V3}$$

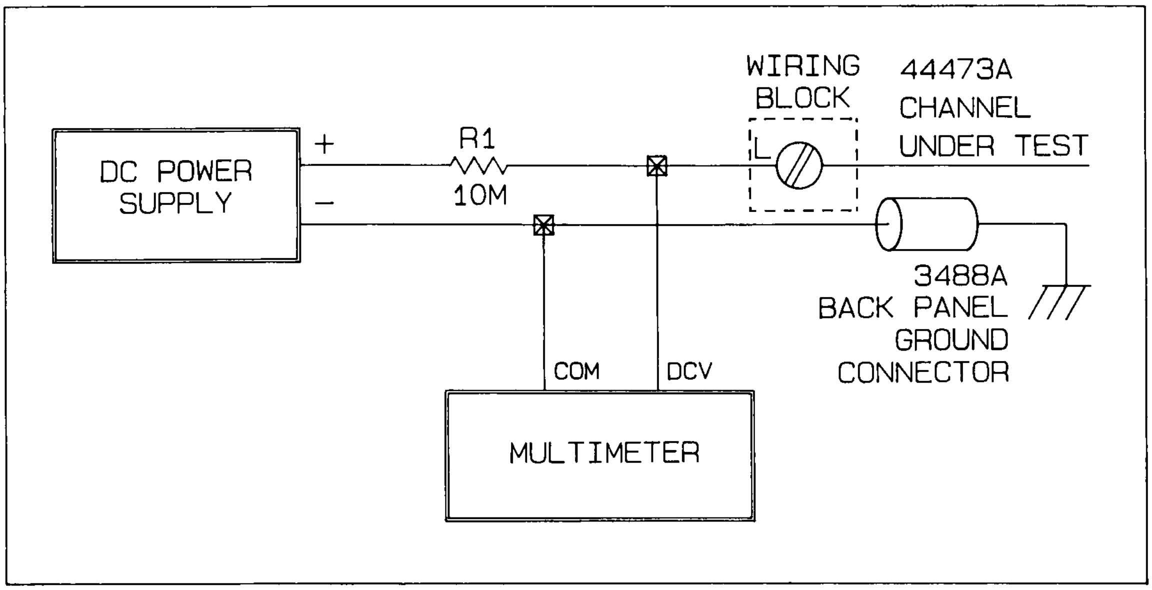



**Figure 11-5 Row Or Column To Chassis DC Isolation Test**

The row or column to chassis dc isolation should be greater than 500 megohms.

10. Repeat steps 7 through 9 for rows 1 through 3 and columns 0 through 3.

11. Connect the 3488A backpanel ground terminal (chassis ground) and the the high line of the channel under test (row 0 to start) into the test circuit as was done in step 7. Repeat steps 8 and 9 for the high lines of rows 0 through 3 and columns 0 through 3.

12. ROW OR COLUMN HIGH TO LOW DC ISOLATION TEST: Use the 3488A front panel keys to open all channels as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44473A.

b. Press the EXECUTE key.

13. Configure a 44483A wiring block so that the high lines of all the rows and columns are shorted together as shown in Figure 11-6.

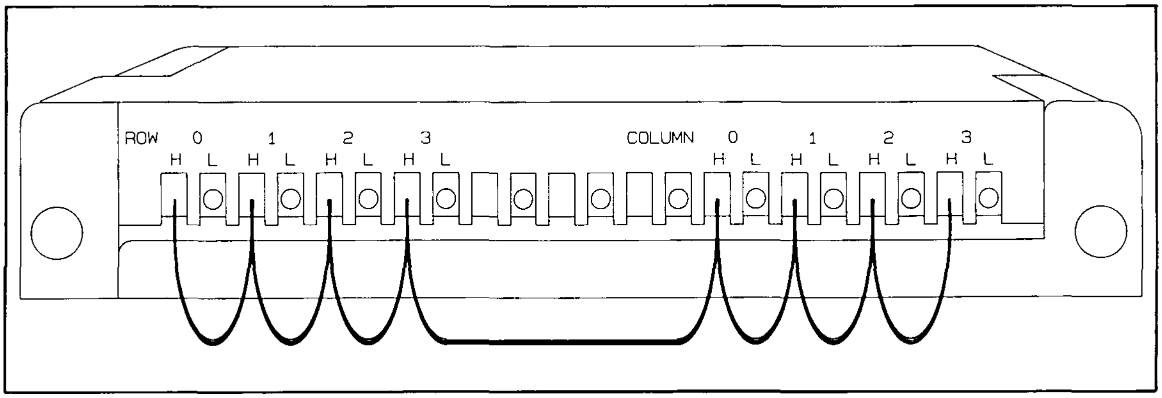



**Figure 11-6 Row Or Column High To Low Test Wiring #1**

14. Connect the shorted lines and the low line of the channel under test (row 0 to start) into the test circuit as shown in Figure 11-7.

15. Record the multimeter's dc voltage reading for the channel under test. This reading will be referred to as V4.

16. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V4 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V4) - R1 \bullet V4}$$

The row or column high to low dc isolation should be greater than 100 megohms.

17. Repeat steps 14 through 16 for the low lines of rows 1 through 3 and columns 0 through 3.

18. Configure a 44483A wiring block so that the low lines of all the rows and columns are shorted together as shown in Figure 11-8.

19. Connect the shorted lines and the high line of the channel under test (row 0 to start) into the test circuit as shown in Figure 11-9.

20. Record the multimeter's dc voltage reading for the channel under test. This reading will be referred to as V5.

21. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V5 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V5) - R1 \bullet V5}$$

The row or column high to low dc isolation should be greater than 100 megohms.

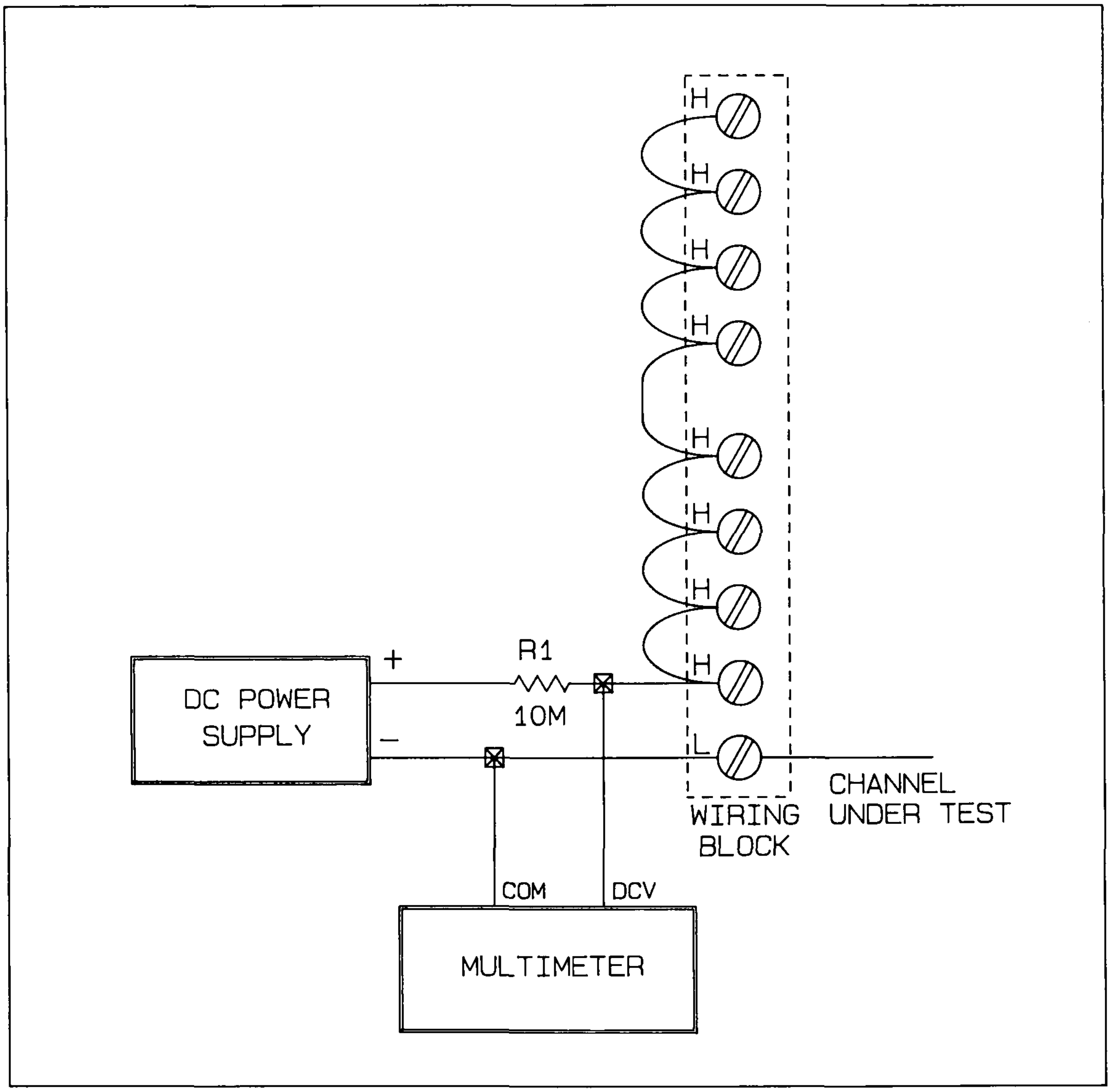



**Figure 11-7 Row Or Column High To Low Test Circuit #1**

22. Repeat steps 19 through 21 for the high lines of rows 1 through 3 and columns 0 through 3.

23. OPEN CONTACT DC ISOLATION TEST: Use the 3488A front panel keys to open all channels as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44473A.

b. Press the EXECUTE key.

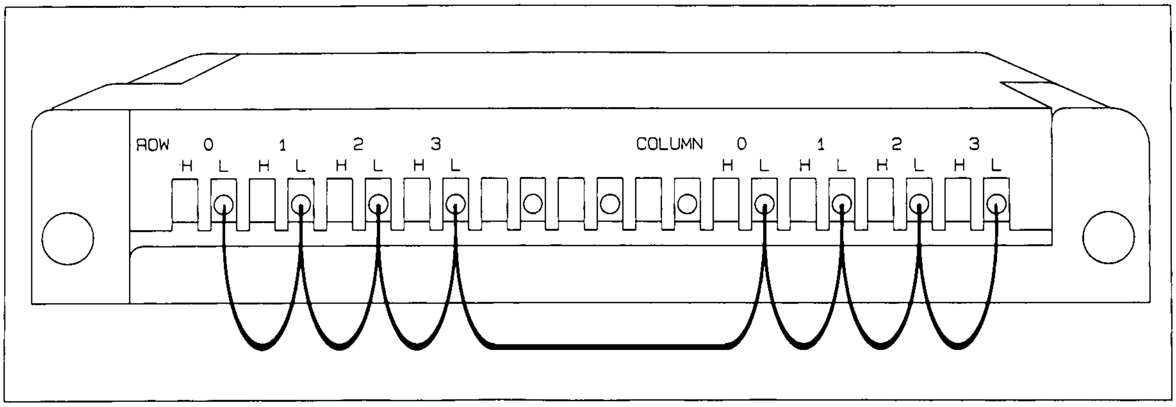



**Figure 11-8 Row Or Column High To Low Test Wiring #2**

24. Connect the low lines of the channels under test (row 0 and row 1 to start) into the test circuit as shown in Figure 11-10.

25. Record the multimeter's dc voltage reading for the channels under test. This reading will be referred to as V6.

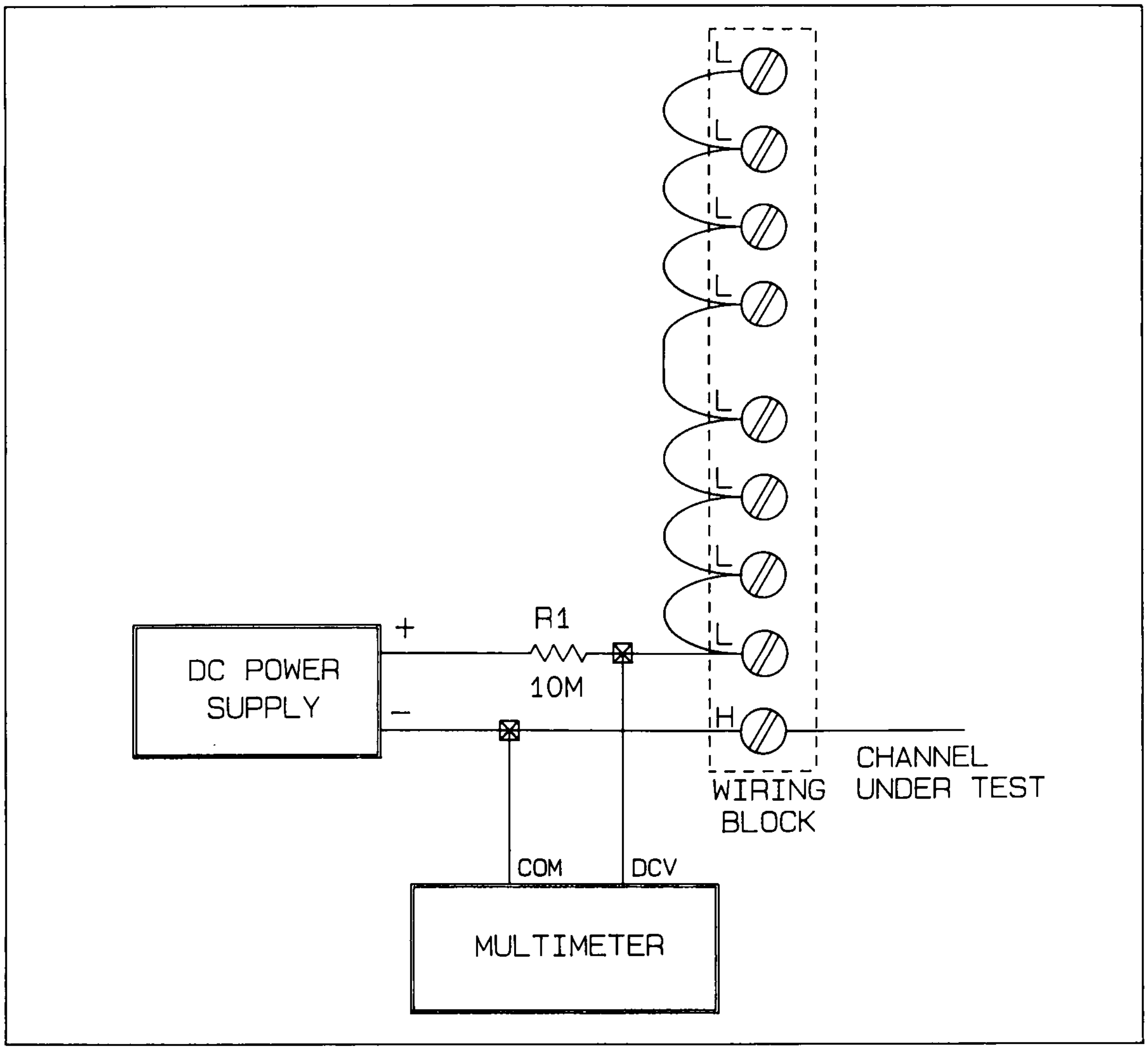



**Figure 11-9 Row Or Column High To Low Test Circuit #2**

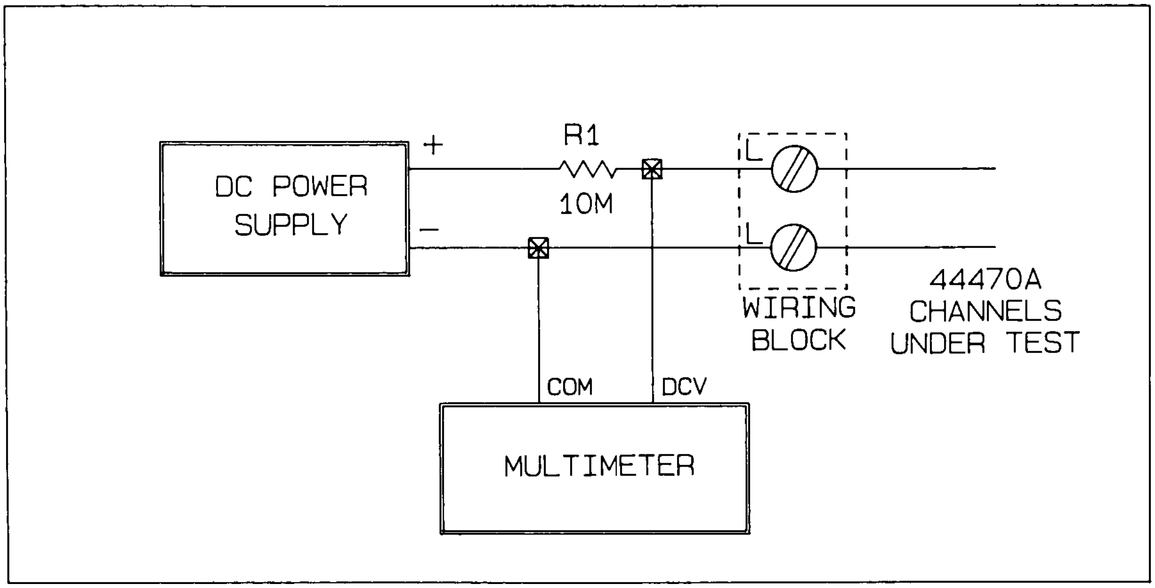



**Figure 11-10 Open Contact DC Isolation Test**

26. Calculate the dc isolation (Rc) using the following equation:

$$Rc = \frac{V6 \bullet R1 \bullet Rm}{Rm \bullet (V1 - V6) - R1 \bullet V6}$$

The open contact dc isolation should be greater than 1 gigohm.

27. Repeat steps 24 through 26 for the low lines of rows 1 and 2, rows 2 and 3, columns 0 and 1, columns 1 and 2, and columns 2 and 3.

28. Repeat steps 24 through 26 for the high lines of rows 0 and 1, rows 1 and 2, rows 2 and 3, columns 0 and 1, columns 1 and 2, and columns 2 and 3.

### 11-8 Corrective Action

A row or column to chassis dc isolation failure (step 9) can be caused by electrical leakage from a relay contact through its drive coil to ground, or by a damaged or dirty pc board. If damage is found, contact an HP Sales and Service Office for 44473A replacement information. If no damage is found, clean the board thoroughly (see Section 11-3).

A row or column high to low dc isolation failure (step 16 or 21) or an open contact dc isolation failure (step 26) is most likely caused by a damaged or dirty 44473A printed circuit board. If damage is found, contact an HP Sales and Service Office for 44473A replacement information. If damage is not found, clean the board thoroughly (see Section 11-3).

## 11-9 Thermal Offset Test

This is a test of the thermally generated dc voltage present on the 44473A. This test is very sensitive to ambient temperature changes and thermoelectricity generated at the junction of two dissimilar metals. For these reasons, it is important that this test be performed in an environment where the temperature is stable and the test lead connections are kept to a minimum.

1. Set the multimeter to its lowest dc voltage range. Connect the two multimeter test leads together and record the reference offset voltage. This voltage will be referred to as V1 in the following steps.

2. Set up a scan list and the card monitor mode as follows:

a. Press the SCAN LIST key followed by X00-X33 (where X is the slot occupied by the 44473A and 00-33 are the relays to be scanned).

b. Press the EXECUTE key.

c. Press the CARD MONITOR key followed by X (where X is the slot occupied by the 44473A).

d. Press the EXECUTE key.

3. Press the STEP key. Connect the multimeter between the low lines of the channels shown in the 3488A's display (row 0 and column 0 to start).

4. Record the dc voltage. This voltage will be referred to as V2. The difference between V1 and V2 must be less than $3\mu V$ for each relay.

5. Repeat steps 3 and 4 until all 16 relays have been tested.

6. Repeat steps 3 and 4 for the high lines of all relays.

### 11-10 Corrective Action

The most likely cause of a thermal offset failure is the relay. If a failure is found, use Figure 11-15 (44473A schematic) to determine the reference designator of the relay and Table 11-1 to determine the HP part number of the relay. Contact an HP Sales and Service Office for part ordering information.

## 11-11 REPLACEABLE PARTS

Table 11-1 lists the mechanical and electrical replaceable parts available for the 44473A. The mechanical parts are keyed to Figure 11-11. This figure also provides assembly and disassembly information. The electrical parts are keyed to the schematic and component locator in Figure 11-15. Table 5-2, in Chapter 5, lists manufacturers code numbers as they apply to the parts lists in Table 11-1.

## 11-12 44473A THEORY OF OPERATION

The 44473A Matrix Card consists of an input buffer and latch, relay drive and sense circuits, an address decoder, and a card-type/sense buffer. Refer to the 44473A schematic in the following discussion (Figure 11-15).

## 11-13 Input Buffer And Latch

The input buffer (U902 in Figure 11-15) provides isolation between the 44473A and the mainframe's data bus. An input buffer is present on each type of plug-in card an prevents excessive loading of the data bus by the plug-in cards.

The input latch (U903 and U905 in Figure 11-15) holds the output of the input buffer for application to the relay drive and sense circuitry.

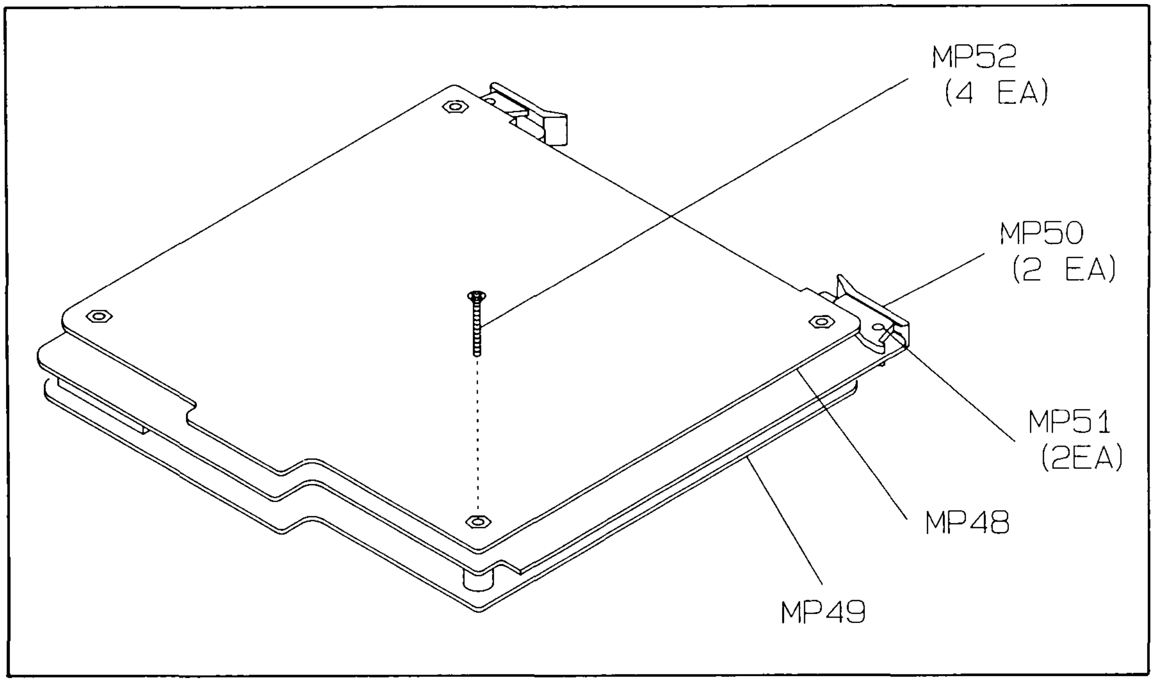



**Figure 11-11 44473A Disassembly**

## 11-14 Relay Drive And Sense Operation

A simplified schematic diagram of one relay drive and sense circuit is shown in Figure 11-12. When instructions are received over the data bus to set a relay (close a channel), a logic high level is applied to the base of Q2 and the input of U2 causing their outputs to go low. A logic low level is applied to the base of Q1 causing its output to go high. CR2 becomes forward biased allowing current to flow through both the set and reset coils of relay K1. The magnetic field generated around the coils interacts with the permanent magnetic field of the relay armature causing it to close the relay contacts. Once closed, the drive current is removed and the permanent magnetic field of the armature latches the contact in the closed state.

When instructions are received over the data bus to reset a relay (open a channel), a logic low level is applied to the base of Q2 and the input of U2 causing their outputs to go high. A logic high level is applied to the input of U1 causing its output to go low. CR1 becomes forward biased allowing current to flow through both the set and reset coils of relay K1. The magnetic field generated around the coils interacts with the permanent magnetic field of the relay armature causing it to open the relay contacts. Once opened, the drive current is removed from the relay and the permanent magnetic field of the armature latches the contacts in the opened state.

Notice that it is necessary to activate one of the upper drive elements (Q1 or U1) and the lower drive elements (Q2 and U2) in order to change a relay's state. If the elements in only the upper or lower drive are activated, no current flows through the relay coils and the relay retains its previous state. This aspect of operation is used by the mainframe in conjunction with the 44473A's relay sense circuitry to verify relay states following relay contact closures, a card reset, and an instrument reset.

When a relay state is being verified following a closure, a low is applied to the base of Q2

# Table 11-1 Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1 | 44473-66501 | 3 | 1 | MATRIX CARD ERC: 2712 | 28480 | 44473-66501 |
| A1C901 | 0160-3847 | 9 | 4 | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C902 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C903 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C904 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C905 | 0160-0127 | 2 | 1 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| A1CR901 | 1901-0620 | 3 | 48 | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR902 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR903 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR904 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR905 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR906 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR907 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR908 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR909 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR910 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR911 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR912 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR913 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR914 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR915 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR916 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR917 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR918 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR919 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR920 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR921 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR922 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR923 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR924 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR925 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR926 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR927 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR928 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR929 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR930 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR931 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR932 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR933 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR934 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR935 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR936 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR937 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR938 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR939 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR940 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR941 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR942 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR943 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR944 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR945 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR946 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR947 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1CR948 | 1901-0620 | 3 | | DIODE-SWITCHING 60V 400MA DO-35 | 9N171 | NDP250 |
| A1J901 | 5180-6638 | 4 | 1 | CONN-2X11 RT ANG | 28480 | 44473-82102 |
| A1K901 | 0490-1337 | 7 | 16 | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K902 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K903 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K904 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K905 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K906 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K907 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K908 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K909 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K910 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K911 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K912 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K913 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K914 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1K915 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |

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

## Table 11-1 Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1K916 | 0490-1337 | 7 | | RELAY-S4EB-L2-5V | 28480 | 0490-1337 |
| A1P901 | 5180-6697 | 9 | 1 | CONN-RT ANG 2X15 | 28480 | 1251-8645 |
| A1Q901 | 1853-0551 | 6 | 8 | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q902 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q903 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q904 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q905 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q906 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q907 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1Q908 | 1853-0551 | 6 | | XSTR-TN4030-237 | 28480 | 1853-0551 |
| A1R901 | 0683-2725 | 8 | 8 | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R902 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R903 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R904 | 0683-1035 | 1 | 9 | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R905 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R906 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R907 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R908 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R909 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R910 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R911 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R912 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R913 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R914 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R915 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R916 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| A1R917 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A1R918 | 0683-4705 | 8 | 4 | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1R919 | 0683-4705 | 8 | | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1R920 | 0683-4705 | 8 | | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1R921 | 0683-4705 | 8 | | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| A1U901 | 1820-2537 | 3 | 2 | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C244N |
| A1U902 | 1820-2537 | 3 | | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C244N |
| A1U903 | 1820-2216 | 5 | 2 | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U904 | 1858-0047 | 5 | 2 | TRANSISTOR ARRAY 16-PIN PLSTC DIP | 13606 | ULN-2003A |
| A1U905 | 1820-2216 | 5 | | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U906 | 1858-0047 | 5 | | TRANSISTOR ARRAY 16-PIN PLSTC DIP | 13606 | ULN-2003A |
| A1U907 | 1820-1216 | 3 | 1 | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| MP48 | 03488-00602 | 8 | 1 | CARD SHIELD - CKT | 28480 | 03488-00602 |
| MP49 | 03488-00603 | 9 | 1 | CARD CHIELD - COMP | 28480 | 03488-00603 |
| MP50 | 0403-0464 | 6 | 2 | PC EXTRACTER WHT | 28480 | 0403-0464 |
| MP51 | 1480-0625 | 4 | 2 | PIN-GRV 3/32 X 1/4 | 28480 | 1480-0625 |
| MP52 | 0515-0843 | 2 | 4 | SCREW M2.5 X 20 LK | 28480 | 0515-0843 |
| | 5040-5193 | 3 | 1 | STRAIN RELIEF HOUSING | 28480 | 5040-5193 |
| | 5040-5194 | 4 | 1 | STRAIN RELIEF PLATE | 28480 | 5040-5194 |
| | | | | NOTE: HP PRODUCT NUMBER 44483A INCLUDES CONNECTOR TERMINAL BLOCK AND STRAIN RELIEF ASSEMBLY. | | |

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

and to the input of U2. This causes a high at the input of inverter U3 causing its output to go low. If the sense switch is in the correct state (closed) a low is applied, through the switch contacts, to the card-type/sense buffer. The controller recognizes this signal as being correct and no error message occurs.

If, following a closure, the sense switch is in the incorrect state (open), the pull-up resistor R1 applies a high to the card-type/sense buffer. The controller recognizes this as an incorrect state and displays ERR:8 LOGIC.

Relay sense operation following a card or instrument reset is similar to that described above with the exception that the controller interprets an open sense switch as the correct state and a closed sense switch as the incorrect state.

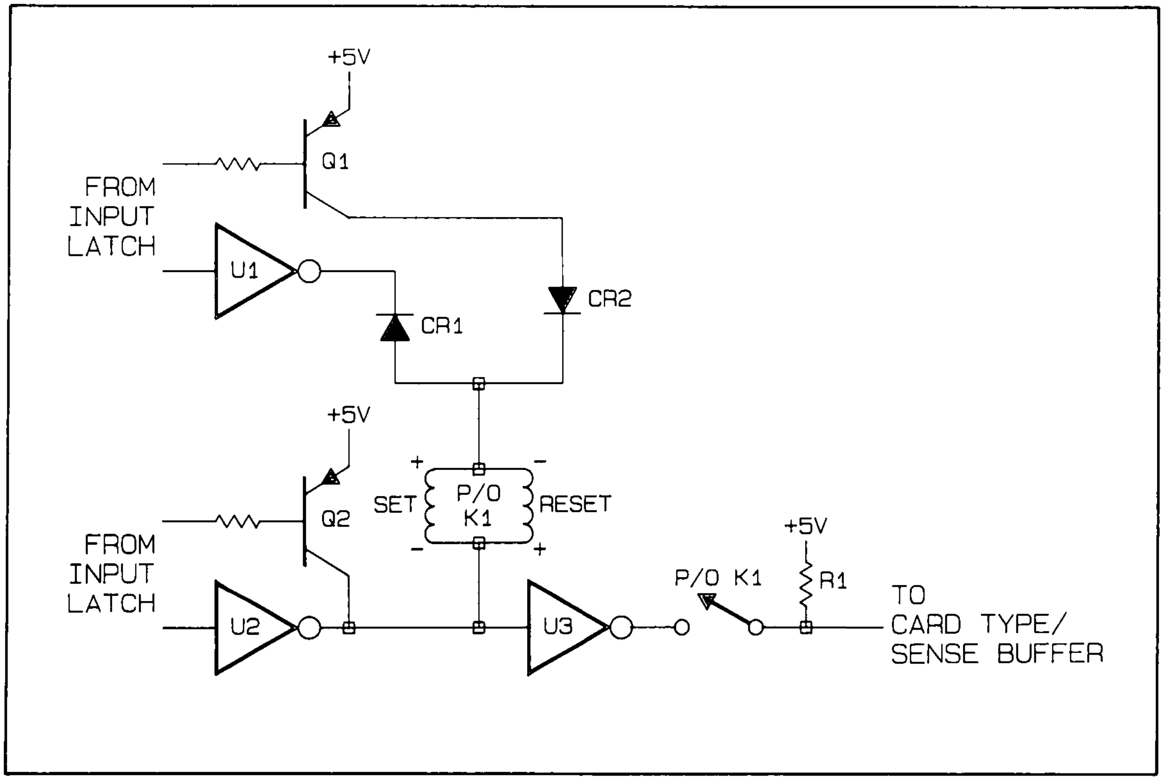



**Figure 11-12 One Relay Drive and Sense Circuit**

## 11-15 Card-Type/Sense Buffer

The card-type/sense buffer (U901 in Figure 11-15) indicates to the mainframe that a 44473A is in the particular card slot queried. The card type is determined by the wiring configuration of four of the input lines to the card-type/sense buffer. By connecting two inputs to +5Vdc and two inputs to ground, a 4-bit code (0011) is created that is recognized by the mainframe as the unique identifier for the 44473A card.

The card-type/sense buffer also provides isolation between the outputs of the sense circuits and the mainframe's data bus. In short, this buffer provides the necessary current to drive the data bus.

## 11-16 Address Decoder

The address decoder (U907 in Figure 11-15) is enabled when the $\overline{CS}$ signal from the mainframe goes low. Once enabled, the address decoder is responsible for enabling the various IC's on the board in response to the instructions it receives via the R/$\overline{W}$, A0 and A1 signals from the controller. Figures 11-13 and 11-14 show the timing relationships between these control lines for both read and write operations.

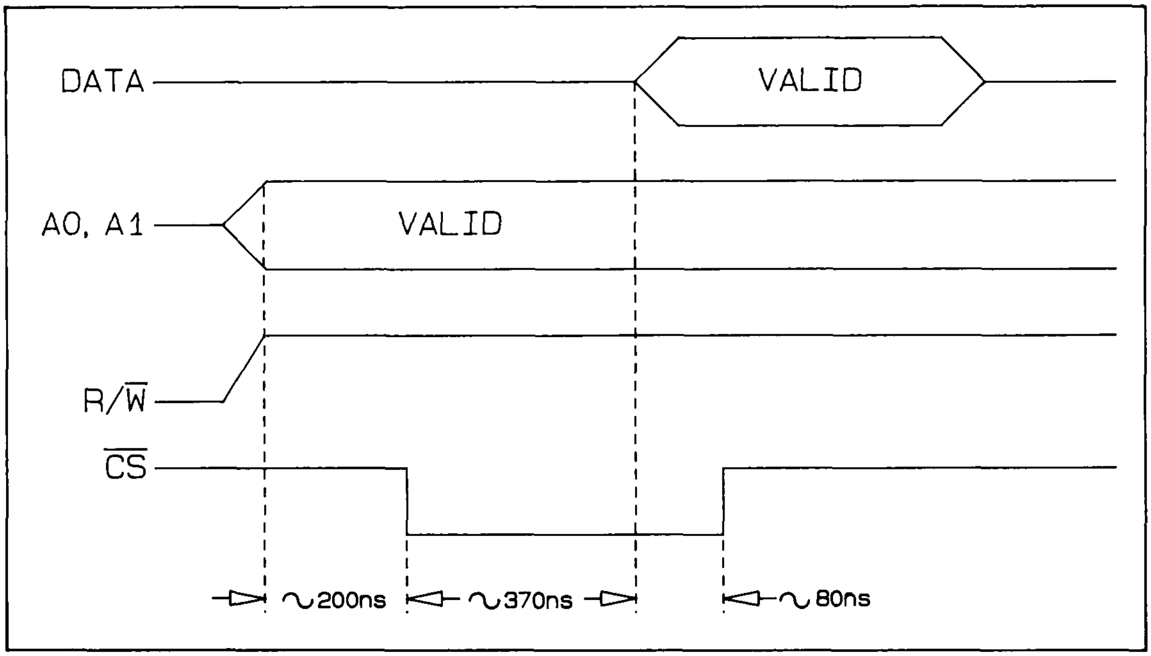



**Figure 11-13 Control Line Timing (Read)**

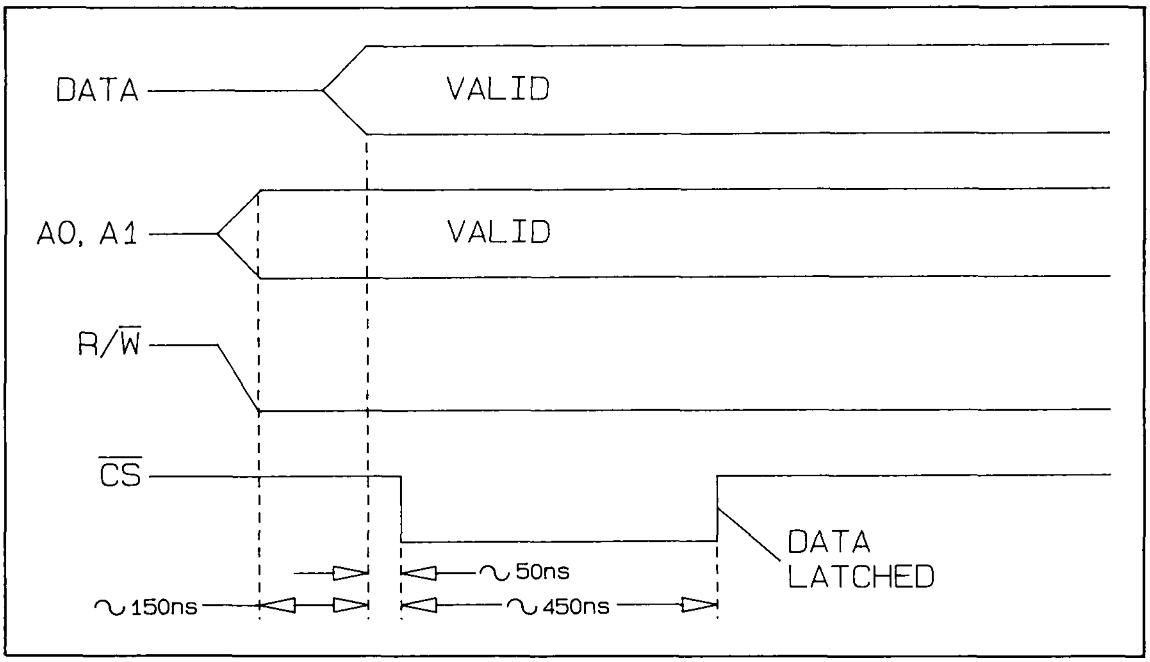



**Figure 11-14 Control Line Timing (Write)**

## 11-17 44473A TROUBLESHOOTING

### 11-18 Introduction

If the Performance Tests (Section 11-5) or Operational Verification tests (Chapter 4) have indicated that a particular relay is failing, that relay is probably at fault. A failure of the relay contact resistance test indicates a bad relay.

If more than one relay failure is indicated, the associated drivers should be suspected. Using Figure 11-15 (44473A Schematic) the problem can be isolated to a few components from the symptoms. The relays on the 44473A circuit board are schematically arranged into four rows and four columns. To close a relay, both a row driver and a column driver must be active. Failures in the drivers, then, will exhibit symptoms that are common to a row or a column.

For example; suppose all relays in column 0 are failing to close. From the schematic, it is determined that column 0 relays correspond to K901, K905, K909 and K913. Further examination of the schematic reveals that all these relays are in the same column (column 0). The drivers Q903, U904, and U903 would be suspected.

As a another example; suppose all relays in row 2 are failing to close. This row corresponds to relays K909, K910, K911 and K912. These three relays are in a common row. The suspected drivers would be Q906, U906 and U905.

## 11-19 ERR 8: LOGIC SLOT X

The mainframe error most associated with the plug-in option cards is the ERROR 8: LOGIC error. This error is generated when the controller checks the relays sense circuitry after changing a relay state. The operation of the relay sense circuitry is described in Section 11-14.

The sense circuitry is used by the controller to indicate that a relay did not close when instructed or did not open when instructed. However, the controller does not always check each state. After a power-on reset, a front panel (or remote) reset, or a card reset, the controller checks the sense circuitry for open contacts. If one or more contacts is indicating the closed position, the controller will beep and display ERR 8: LOGIC. After a close command, the controller checks the sense circuitry to determine if the indicated relay is closed. If the sense circuitry indicates the relay is open the controller beeps and displays ERR 8: LOGIC. This action occurs for each relay closure including scan lists and stored set-ups. Following a relay opening, however, the controller does NOT check the sense circuitry for the open. This means that a relay may stick closed and the controller will not flag an error. This occurs for relays opened through the open command, scan lists, and stored set-ups.

In summary, the controller checks for open relays following power-on resets, front panel or remote resets, and card resets. It checks for closed relays following a close command (whether executed by the close command, a scan list or a stored set-up).

When troubleshooting a plug-in card that is generating ERROR: 8 LOGIC it is important to carefully observe the symptoms. If the error is generated when power is applied to the 3488A (controller checking for openings) check the relay contacts to determine if a relay is stuck closed. If no relay is stuck closed, suspect the sense circuitry. If the error is generated following a close command, check the relay contacts to determine if the relay is closed. If the relay is closed, suspect the sense circuitry.

### 11-20 Equipment Required

| | |
|---|---|
| Signature Multimeter | HP 5005A or equivalent |
| Service Extender Cable | 5061-1174 |
| Service Extender Board | 5061-1173 |

## 11-21 Initial Checks

The initial checks of a suspected plug-in card will require that the plug-in card shields be removed. Removal of the four screws in the plug-in shield allows both shields to be removed from the plug-in printed circuit board.

Once the shields have been removed, the card to be tested should be installed in slot 1 of the mainframe. There are two ways to do this. The first method uses the Service Extender Board (5061-1173) and the Service Extender Cable (5061-1174). With these two service tools the card may be electrically installed in the card slot but be physically located on the test bench.

If the service extender tools are not available, the card may be installed in slot 1 and the 3488A mainframe top cover removed. This will allow access to the non-component side of the plug-in card for servicing. 3488A top cover removal is described in Chapter 5.

Be sure that all other plug-in cards have been removed from the mainframe.

1. Apply power and measure the +5 Vdc on the plug-in board. There are two supplies to this board, both the supplies (and the grounds) are common on the backplane board. Connect the ground lead of the voltmeter to pin 10 of U901. Measure the voltage at pin 20 of U901. The voltage should be +5 Vdc ±0.5 Vdc. Measure the voltage at the emitter of any of the discrete transistors on the board (i.e., Q906). The transistors are mounted with the emitter lead in a square pad on the board. The voltage should be +5 Vdc ±0.5 Vdc.

If the voltages are correct, proceed to Step 2. If either or both of the voltages are incorrect, troubleshoot the +5 Vdc supply in the mainframe (it is possible that the plug-in card is loading the supply).

2. Observe the front panel symptoms to determine if the problem can be isolated to a few components. The Operational Verification tests is Chapter 4 may be used to identify a relay contact or closure problem. If a relay is closing (or opening) correctly, as determined by the relay contact tests, but the mainframe displays ERR 8: LOGIC, the relay sense circuitry is at fault. The mainframe will also display ERR 8: LOGIC if one or more relays are not functioning (refer to Section 11-19 for a discussion of the error message).

If a single relay (channel) is at fault, troubleshoot that relay. If one or more relays indicate a fault, the drivers should be suspected (refer to Section 11-18).

If the problem cannot be isolated easily, proceed to Step 3.

3. Check the mainframe and plug-in card data bus for activity. The data probe of the HP 5005A may be used to indicate activity on the data bus. A blinking probe light indicates state changes. Check the data bus at U902 pins 2, 4, 6, 8, 11, 13, 15 and 17. The plug-in card must be installed in slot 1 and power applied to the mainframe. No special test set-ups should be installed.

All eight data lines should show activity.

If activity is found, proceed to Step 4. If one or more of the lines are stuck, troubleshoot the backplane data bus or the inputs to buffers U901 and U902 on the plug-in card.

4. Check the outputs of U902 at pins 3, 5, 7, 9, 12, 14, 16 and 18 for activity. All eight pins should show activity.

If activity is found, proceed to Step 5. If no activity is found on one or more lines, troubleshoot U902, U905 or U903.

5. Check the backplane card select and decoding lines for activity. Check U907 pins 1, 2, 3, and 4 for activity. All lines should show activity.

If activity is found, proceed to Step 6. If no activity is found, troubleshoot the backplane or the inputs to U907 on the plug-in card.

6. If the problem has not been isolated, signature analysis procedures may be used to test the buffers, drivers, and relay coils. The procedure begins in Section 11-22.

## 11-22 Buffer, Driver, And Relay Signature Analysis

To perform the signature analysis tests the mainframe top cover and the controller shield must be removed. Procedures to remove the cover and shield are located in Chapter 5.

The HP 5005A has been recommended for this signature analysis test because it incorporates adjustable data thresholds. This feature allows signatures to be checked at the relay coils. If a different signature analyzer is being used, the signatures may only be checked up to the drivers.

Ensure the controller is set to the normal operating configuration (RP409 installed and all switches on SP401 set open) before performing these troubleshooting steps. All plug-in cards should be removed from the mainframe. The suspected plug-in card must be installed in slot 1.

The initial checks given in section 11-21 should be performed prior to this signature analysis procedure. Section 11-21 also describes the use of the service extender card and service extender cable.

1. Signature Analyzer set-up. Polarity: START _/¯, STOP and CLOCK ¯_. On the controller printed circuit board (A40), connect START/ST/SP to SA2, STOP/QUAL to SA2, CLOCK to SA3, Ground to SA4.

2. On the controller printed circuit board (A40), connect a jumper between SA6 (SERV FUNC) and ground (SA4).

3. If using the HP 5005A signature analyzer, set the data probe threshold to 2.80 H and 2.00 L.

4. Apply power to the 3488A. Press the TEST key on the front panel. Instead of performing the internal controller self-test, the display will prompt for a number. Enter 2 and press execute.

5. The signature analyzer should now be gating. The 3488A display will show RELAY S.A. The test selected cycles all data lines in a fixed pattern. This pattern will produce one of two signatures (depending upon inversion) that may be traced from the relay coils to the backplane data bus. These signature are: 36U6 and 6HPH.

6. The signatures for the inputs and outputs on the 44471A are given in Table 11-2.

## 11-23 Sense Circuit Troubleshooting

Problems with the sense circuitry will typically exhibit ERR 8: LOGIC in the display. A discussion of the error message as it applies to the plug-in card is given is Section 11-19. A theory of operation of the sense circuitry is given in section 11-14.

The drivers for the sense circuit, U904 and U906, are open collector drivers. This means that one of the relays sense contacts must be closed for the driver to operate. The driver may be manually tested by closing an appropriate relay to provide as current path and exercising the input to the driver.

Problems with the sense circuitry can also be isolated with a signature analysis procedure. This procedure begins in Section 11-24.

## 11-24 Sense Circuitry Signature Analysis

This procedure checks the signatures at the input to the buffer, U901. This buffer has four inputs from the sense circuitry, pins 11, 13, 15, and 17. Each of these inputs represents a composite signal obtained through several different relays and drivers. The signature analysis procedure is designed so that one column of relays is driven at a time (i.e., K901, K905, K909 and K913 are in column 0). Each relay in the column is sensed by a separate line. By observing the signatures obtained at the input to U901 and knowing which column is being driven to obtain the signature, a problem may be isolated to one driver and a set of relays. If all the signatures are incorrect for a given column, the drivers should be suspected. If only one signature is incorrect, the relay should be suspected.

To perform the signature analysis tests the mainframe top cover and the controller shield must be removed. Procedures to remove the cover and shield are located in Chapter 5.

Ensure the controller is set to the normal operating configuration (RP409 installed and all switches on SP401 set open) before performing these troubleshooting steps. All plug-in cards should be removed from the mainframe. The suspected plug-in card must be installed in slot 1.

The initial checks given in section 11-21 should be performed prior to this signature analysis procedure. Section 11-21 also describes the use of the service extender card and service extender cable.

1. Signature Analyzer set-up. Polarity: START _/¯, STOP and CLOCK ¯_. On the controller printed circuit board (A40), connect START/ST/SP to SA2, STOP/QUAL to SA2, CLOCK to SA3, Ground to SA4.

2. On the controller printed circuit board (A40), connect a jumper between SA6 (SERV FUNC) and ground (SA4).

3. Apply power to the 3488A. Press the TEST key on the front panel. Instead of performing the internal controller self-test, the display will prompt for a number. Enter 3 and press execute.

4. The signature analyzer should now be gating. The test selected drives on column of relays at a time. The 3488A display will show COLUMN 0 SA. Pressing the right arrow key on the front panel increments the column number. Pressing the left arrow key decrements the column number.

This test is very noisy as all the relays are being cycled.

5. The signatures for each column and input of U901 are given in Table 11-3a. Table 11-3b identifies the components that are being used to make up the correct signature.

**Table 11-2 Buffer, Driver, And Relay Signatures (Test 2)**

+5 Vdc signature: 5C1C

U902

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 20 | +5 Vdc |
| 2 | 36U6 | 19 | NA |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 36U6 | 16 | 36U6 |
| 6 | 36U6 | 15 | 36U6 |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 36U6 | 12 | 36U6 |
| 10 | NA | 11 | 36U6 |

U903

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | L | 20 | +5 Vdc |
| 2 | 6HPH | 19 | 6HPH |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 6HPH | 16 | 6HPH |
| 6 | 6HPH | 15 | 6HPH |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 6HPH | 12 | 6HPH |
| 10 | NA | 11 | NA |

U905

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | L | 20 | +5 Vdc |
| 2 | 36U6 | 19 | 36U6 |
| 3 | 36U6 | 18 | 36U6 |
| 4 | 36U6 | 17 | 36U6 |
| 5 | 36U6 | 16 | 36U6 |
| 6 | 36U6 | 15 | 36U6 |
| 7 | 36U6 | 14 | 36U6 |
| 8 | 36U6 | 13 | 36U6 |
| 9 | 36U6 | 12 | 36U6 |
| 10 | NA | 11 | NA |

U904

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | 36U6 | 16 | NA |
| 2 | 36U6 | 15 | NA |
| 3 | 6HPH | 14 | 36U6 |
| 4 | 36U6 | 13 | 6HPH |
| 5 | 6HPH | 12 | 36U6 |
| 6 | 6HPH | 11 | 36U6 |
| 7 | 6HPH | 10 | 36U6 |
| 8 | NA | 9 | +5 Vdc |

U906

| pin | signature | pin | signature |
|---|---|---|---|
| 1 | NA | 16 | NA |
| 2 | 36U6 | 15 | 6HPH |
| 3 | 36U6 | 14 | NA |
| 4 | 36U6 | 13 | NA |
| 5 | 36U6 | 12 | 6HPH |
| 6 | NA | 11 | NA |
| 7 | 36U6 | 10 | 6HPH |
| 8 | NA | 9 | +5 Vdc |

| Relay | pin | signature | pin | signature |
|---|---|---|---|---|
| K901 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K902 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K903 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K904 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K905 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K906 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K907 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K908 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K909 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K910 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K911 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K912 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K913 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K914 * | 1,7 | 36U6 | 6,12 | 6HPH |
| K915 * | 1,7 | 6HPH | 6,12 | 36U6 |
| K916 | 1,7 | 36U6 | 6,12 | 6HPH |

* these signatures have a data threshold of 2.80 H and 2.0 L.

**Table 11-3a Sense Circuit Signatures**

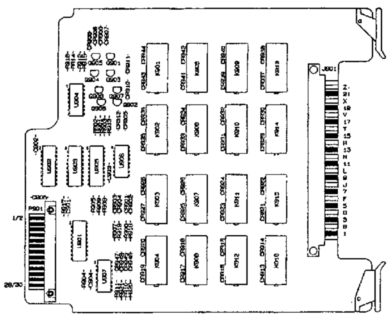
+5Vdc signature: 6592

| | column 0 | column 1 | column 2 | column 3 |
|---|---|---|---|---|
| U901 pin 17 | 474A | 474A | 474A | 474A |
| U901 pin 15 | 2P64 | 2P64 | 2P64 | 2P64 |
| U901 pin 13 | PF66 | PF66 | PF66 | PF66 |
| U901 pin 11 | 003C | 003C | 003C | 003C |

**Table 11-3b Components Used For Signatures**

| | column 0 | column 1 | column 2 | column 3 |
|---|---|---|---|---|
| U901 pin 17 | U906<br>K901 | U906<br>K902 | U904<br>K903 | U904<br>K904 |
| U901 pin 15 | U906<br>K905 | U906<br>K906 | U904<br>K907 | U904<br>K908 |
| U901 pin 13 | U906<br>K909 | U906<br>K910 | U904<br>K911 | U904<br>K912 |
| U901 pin 11 | U906<br>K913 | U906<br>K914 | U904<br>K915 | U904<br>K916 |

HP44473A Relay SW Card



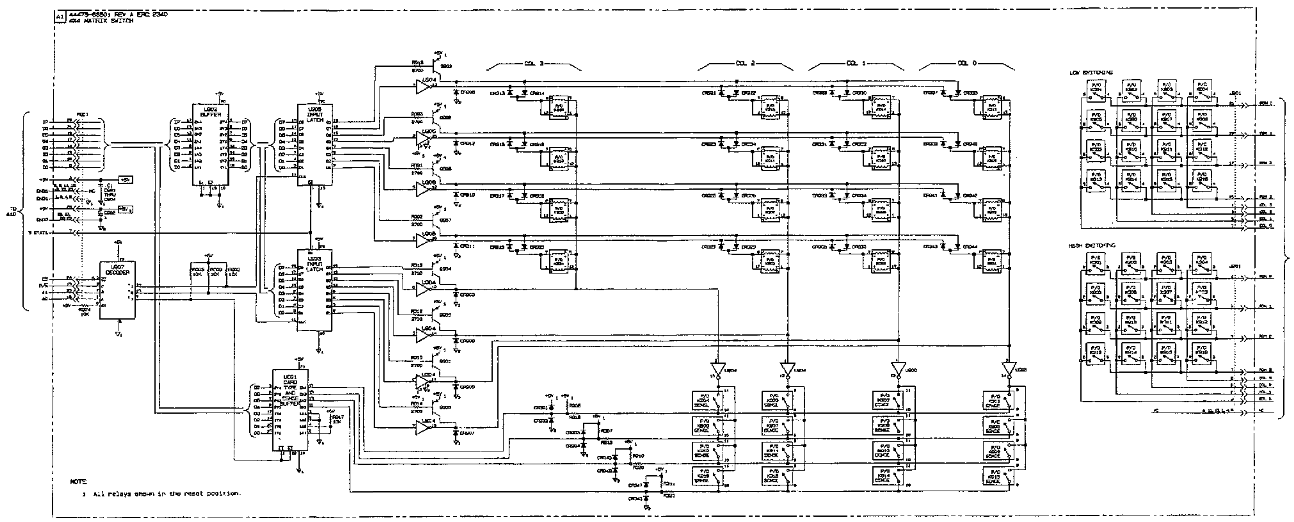



Figure 11-15 44473A Schematic
11-27/11-28

# Chapter XII

# 44474A 16 CHANNEL DIGITAL INPUT/OUTPUT

## CHAPTER XII

### TABLE OF CONTENTS



### LIST OF TABLES



### LIST OF ILLUSTRATIONS

# CHAPTER XII
# 44474A 16 CHANNEL DIGITAL INPUT/OUTPUT

## 12-1 INTRODUCTION

This chapter contains installation information, performance testing information, troubleshooting procedures and replaceable parts lists for the 44474A 16 Channel Digital Input/Output card.

The 44474A is made up of 16 bi-directional data lines and 4 control lines. A simplified schematic of the 44474A is shown in Figure 12-1.

**WARNING**

*Hazardous voltage may exist on the wiring and connectors of the 44474A plug-in card. Only service trained personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make repairs to the 3488A and or the plug-in cards.*

## 12-2 PLUG-IN CARD WIRING

Figure 12-2 shows the proper wiring procedures for the 44474A.

**WARNING**

*Hazardous voltages may exist on the wiring and connectors of the 3488A's plug-in cards. Only Service Trained Personnel with a knowledge of electronic circuitry and an awareness of the hazards involved should install, reconfigure, or make repairs to the 3488A and/or the plug-in cards.*

## 12-3 PLUG-IN CARD CLEANING

Printed circuit board contamination can affect the dc isolation and the high frequency performance of the plug-in cards. This contamination can come from dust accumulation, fingerprints, condensation, and so on. The plug-in card printed circuit boards are to be cleaned as follows:

**CAUTION**

*Use anti-static pc board handling techniques during the following procedure.*

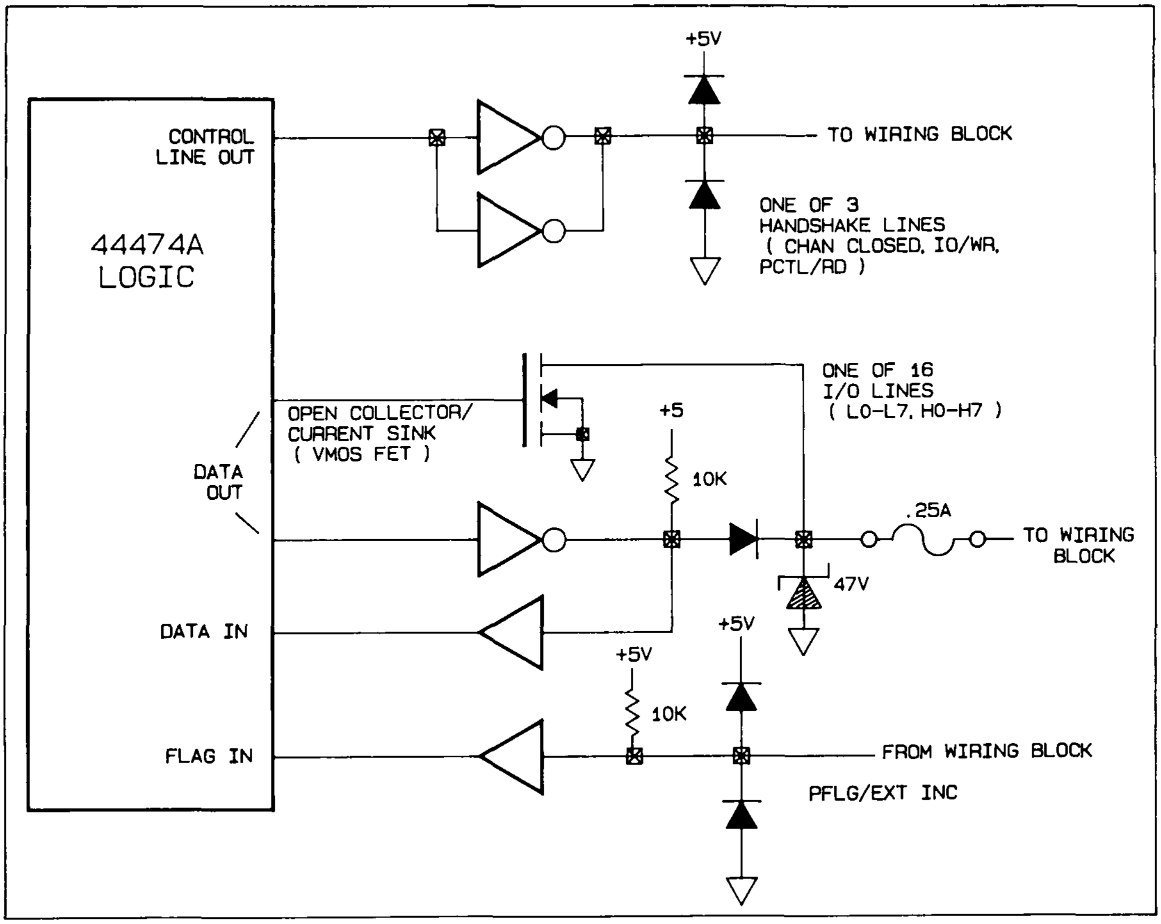



**Figure 12-1 44474A Simplified Schematic**

1. Remove the shields from the plug-in card.

2. Use a stiff bristled camel hair brush (do not use a wire brush) soaked in isopropyl alcohol to wash the pc board.

**CAUTION**

*DO NOT immerse the printed circuit board in any type of fluid.*

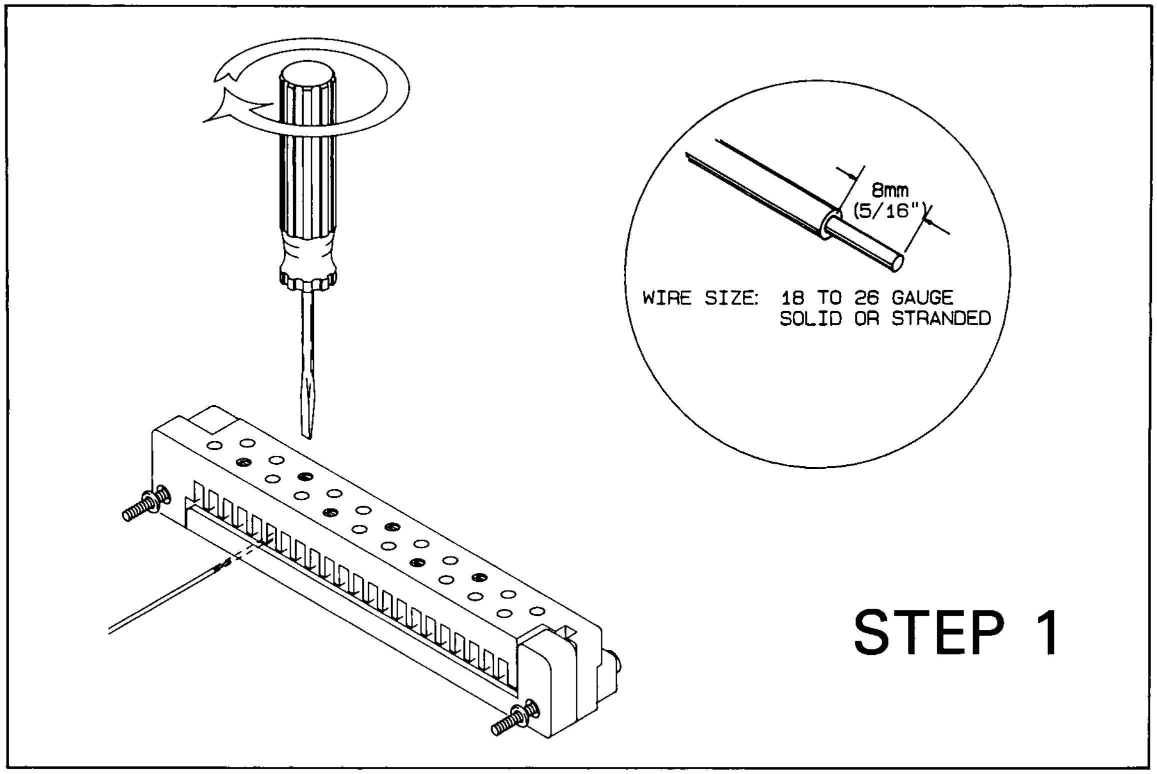
3. Use the stiff bristled brush soaked in deionized or distilled water, to remove any residue left by the alcohol.

4. Allow the printed circuit board to dry thoroughly.

5. Replace the shields.

⚠ **CAUTION**

*The maximum allowable data line-to-chassis voltage limit for the 44474A is +30Vdc. The maximum control line-to-chassis voltage limit is +5Vdc. Damage will occur to the 44474A and possibly the 3488A if any of the above limits are exceeded.*



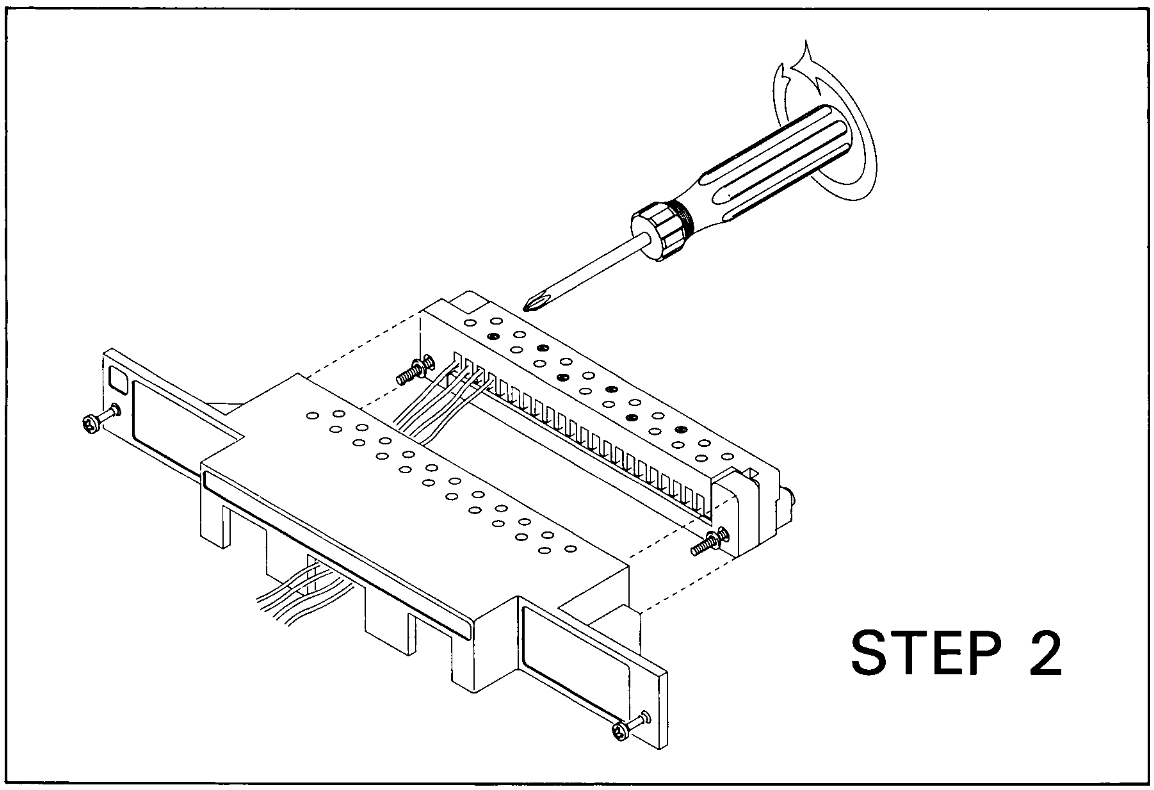




**Figure 12-2 Plug-In Card Wiring**

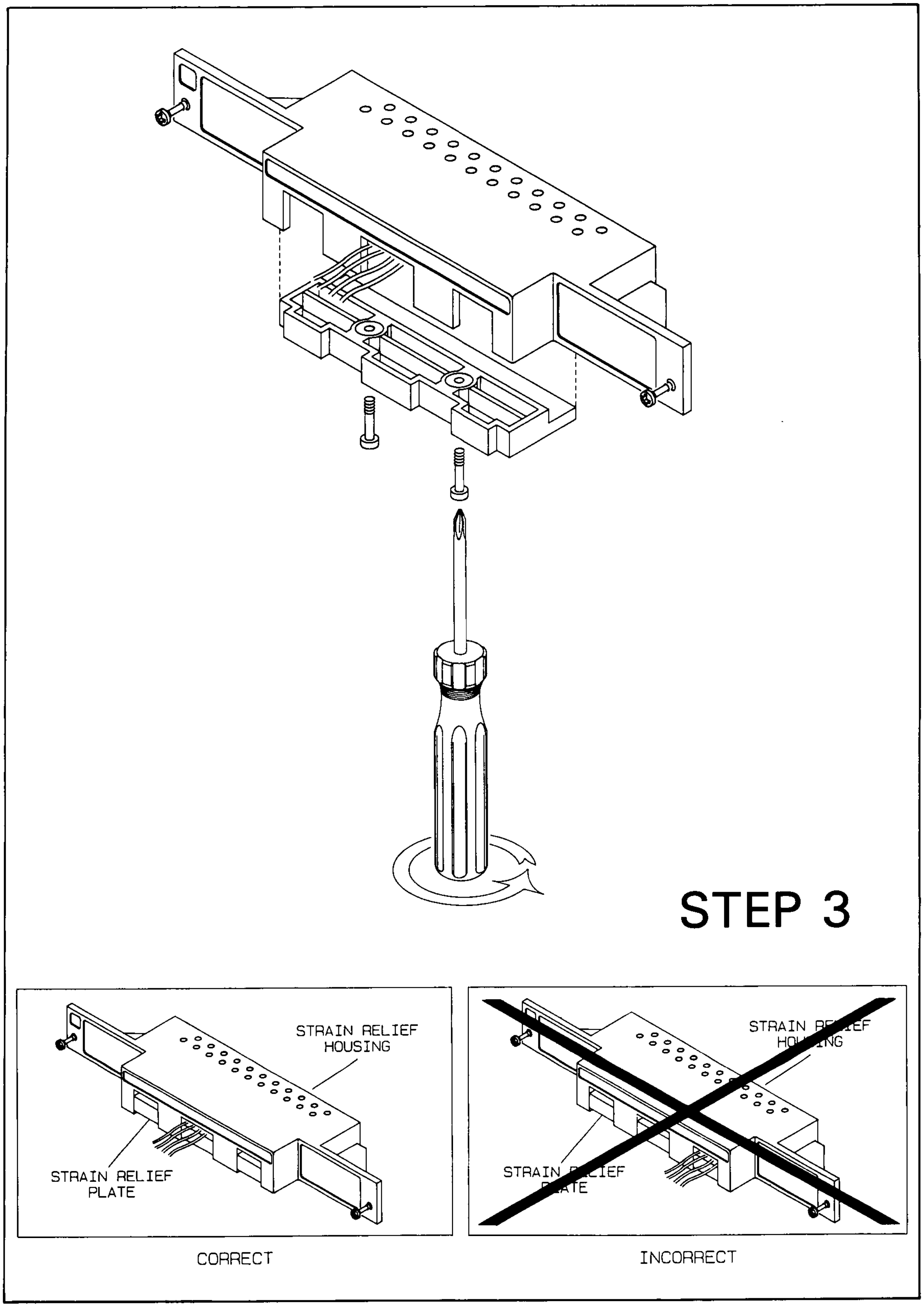
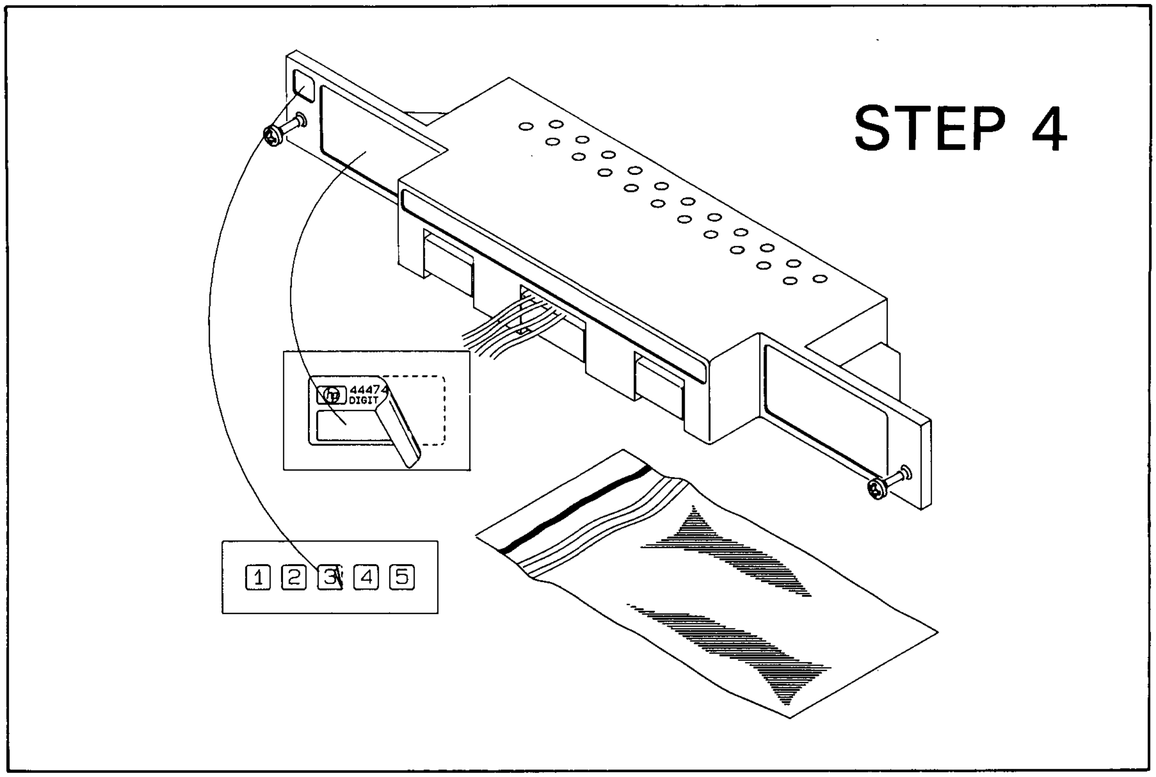



**Figure 12-2. Plug-In Card Wiring (Cont'd)**



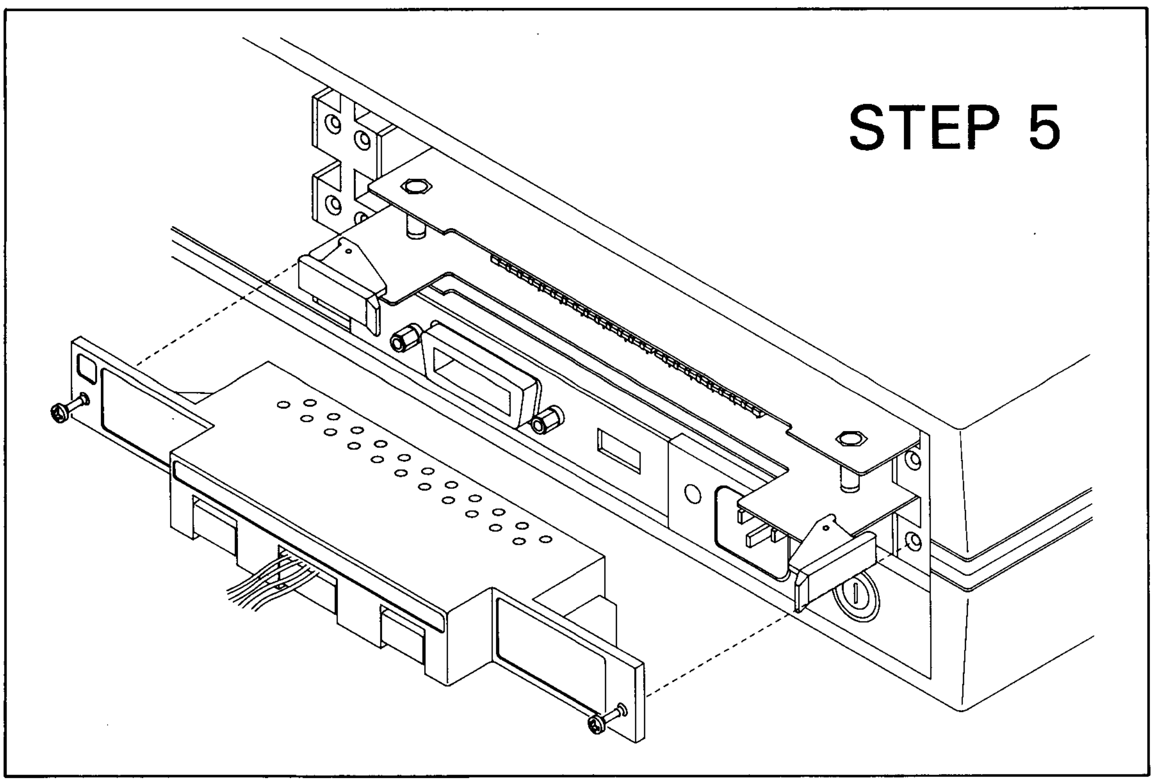




**Figure 12-2. Plug-In Card Wiring (Cont'd)**

## 12-4 TEST FIXTURE

A test fixture is required in order to perform the Operation Verification Tests (Chapter 4 of this manual) and troubleshooting procedures for the 44474A. The test fixture can be either of the following two types:

a. A test fixture is available from Hewlett-Packard (HP part number 03488-66501). The advantages of this fixture are (1) it requires no assembly and (2) it can be used to test the 44470A, the 44471A, the 44473A and the 44474A plug-in cards without modification.

b. A test fixture can be constructed by configuring an HP 44484A removable wiring block as shown in Figure 12-3. This particular test fixture can only be used to test the 44474A.

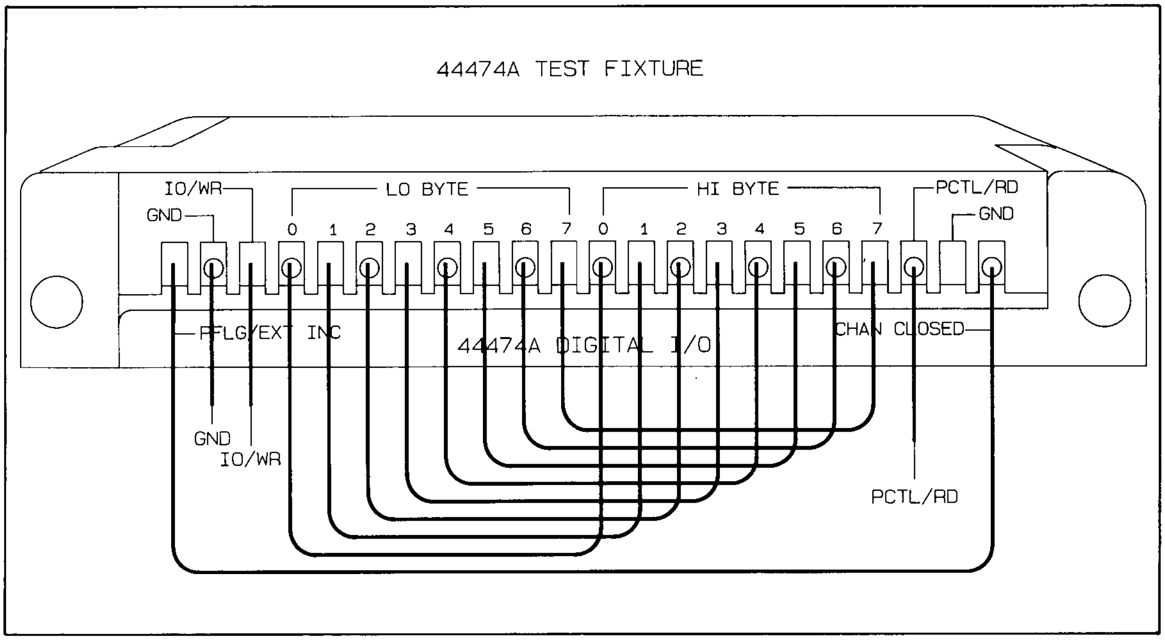



**Figure 12-3 44474A Test Fixture**

The Operational Verification Test (Chapter 4) for this card consists of (1) a data line input/output test, (2) a Channel Closed/External Increment test, and (3) an IO/WR and PCTL/RD line test. The first test uses the test fixture to connect the eight LO BYTE data lines to the eight HI BYTE data lines. Thus, by writing to one set of data lines and reading the data from the other set, the operation of the data lines and the continuity of the fuses and connectors can be verified. The second test uses the test fixture to connect the CHAN CLOSED line to the PFLG/EXT INC line. This test relys on the self-triggering action of these lines to continuously advance through a scan list — thereby testing the lines. The third test checks the operation of the IO/WR and PCTL/RD control lines by individually connecting each line to a dc voltmeter, using the 3488A front panel keys to change the state of the line, and verifying the state change on the voltmeter.

## 12-5 PERFORMANCE TESTS

The following Performance Tests check the 44474A's current sinking and output drive specifications. The results of these tests will verify whether or not the 44474A is operating within its critical specifications.

**WARNING**

*If the 44474A is currently installed into a system, it must be disconnected from the system in order to execute the Performance Tests. This presents two potential safety hazards:*

*a. It is possible for the user to come in contact with high voltage (if high voltage exists in the system).*

*b. Equipment damage may occur should the wrong lines become accidentally connected or disconnected. The user must take the necessary precautions to prevent the above from happening before disconnecting the 44474A.*

### 12-6 Required Test Equipment

DC Power Supply — HP 6216B or equivalent

Digital Multimeter — HP 3478A or equivalent

Oscilloscope — HP 1740A or equivalent

6k ohm resistor

2.5k ohm resistor

300 ohm resistor

100 ohm 3 watt (or greater) resistor

## 12-7 Current Sink And Output Drive Test

1. DATA LINE HIGH OUTPUT TEST: Set the multimeter to measure dc voltage. Use the 3488A's front panel keys to set all data lines to the high state as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44474A.

b. Press the EXECUTE key.

c. Press the WRITE key followed by X02, −1 (where X is the slot occupied by the 44474A).

d. Press the EXECUTE key.

2. Connect the multimeter, and the 300 ohm resistor to the LO BYTE 0 line as shown in Figure 12-4. The dc voltage should be ≥ 2.4Vdc.

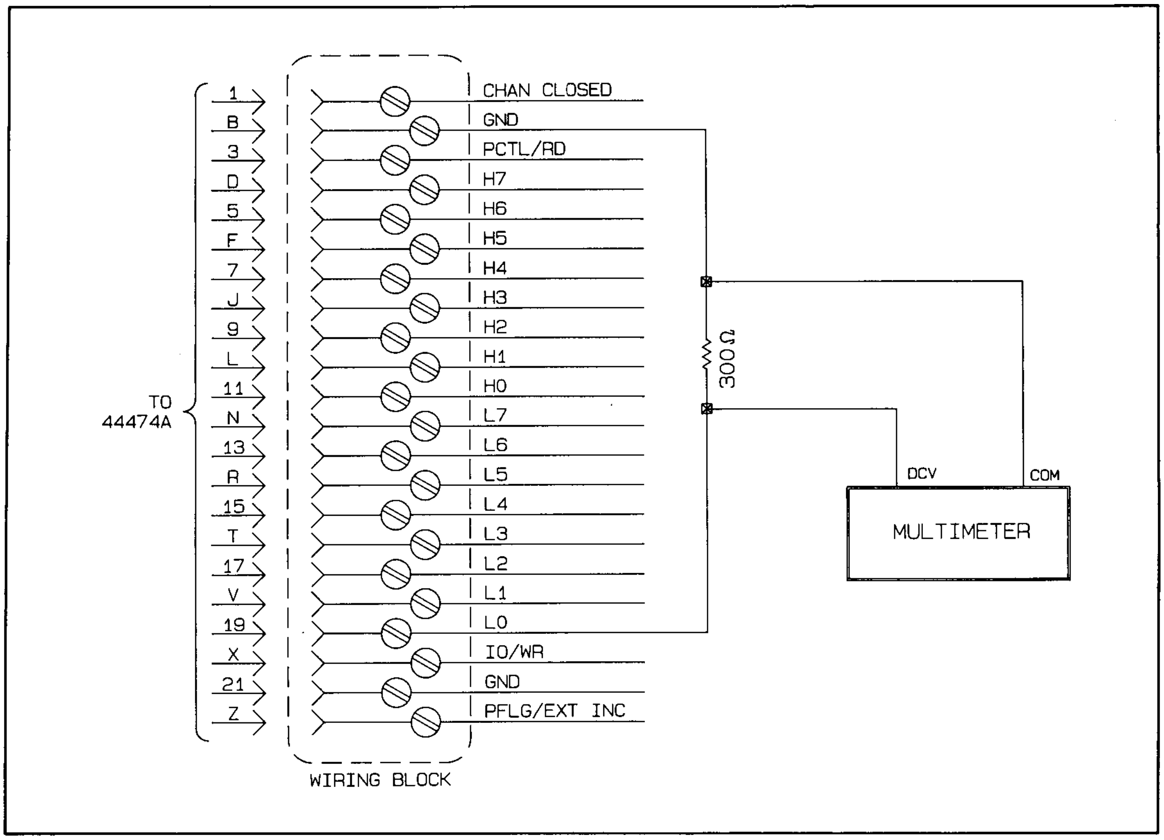



**Figure 12-4 Data Line High Output Test**

3. Repeat step 2 for LO BYTE lines 1 through 7 and HI BYTE lines 0 through 7.

4. DATA LINE LOW OUTPUT TEST: Set all data lines to the low state as follows:

   a. Press the WRITE key followed by X02,0 (where X is the slot occupied by the 44474A).

   b. Press the EXECUTE key.

5. Set the dc power supply to deliver 0Vdc. Connect the dc power supply, the multimeter, and the 100 ohm resistor to line 0 of the LO BYTE as shown in Figure 12-5.

6. Increase the power supply's dc voltage output until 4Vdc is measured on the multimeter.

7. Measure the dc voltage between the 44474A'S LO BYTE 0 and GND lines. The dc voltage should be $\leq$ 0.4Vdc.

8. Repeat steps 5 through 7 for LO BYTE lines 1 through 7 and HI BYTE lines 0 through 7.

9. Set the dc power supply to deliver 0Vdc. Connect the dc power supply, the multimeter, and the 100 ohm resistor to line 0 of the LO BYTE as was done in step 5 (see Figure 12-5).

10. Increase the power supply's dc voltage output until 12.5Vdc is measured on the multimeter.

11. Measure the dc voltage between the 44474A's LO BYTE 0 and GND lines. The dc voltage should be less than 1.25Vdc.

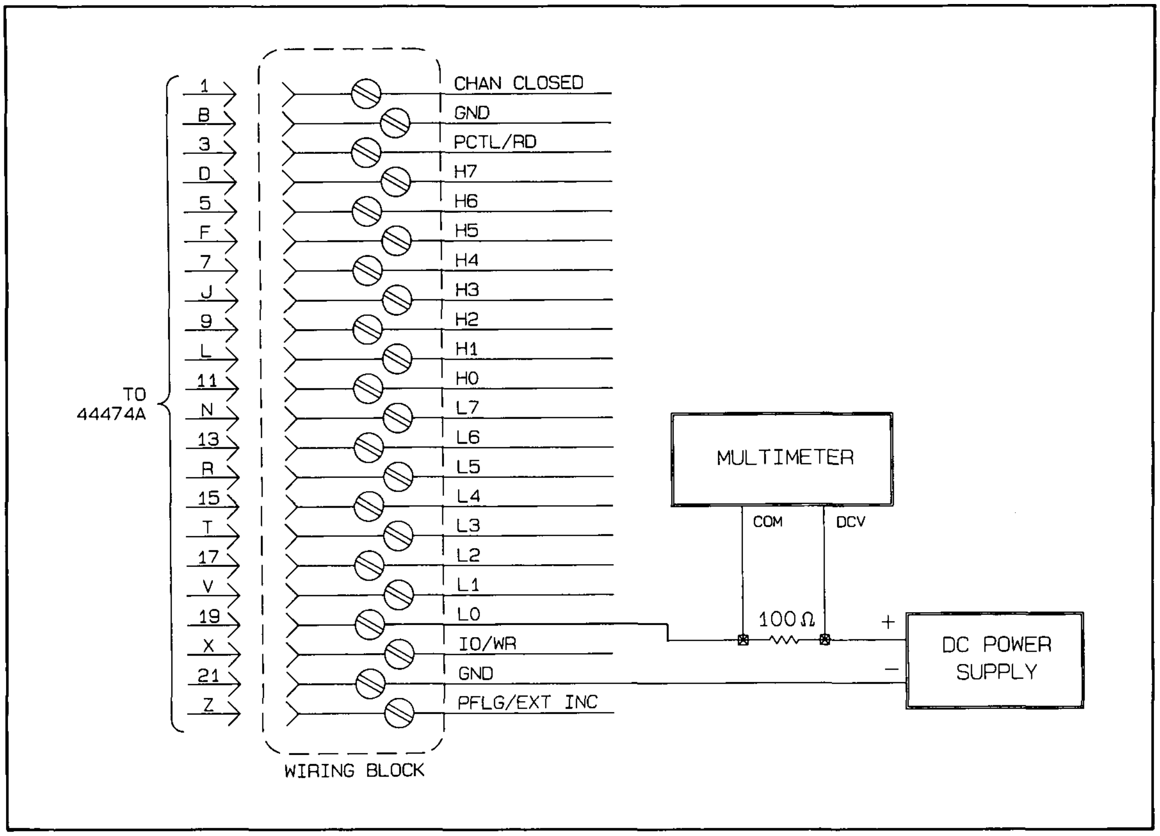



**Figure 12-5 Data Line Low Output Test**

12. Repeat steps 9 through 11 for LO BYTE lines 1 through 7 and HI BYTE lines 0 through 7.

13. CONTROL LINE HIGH OUTPUT TEST: Set the control lines to the high state as follows:

a. Press the CARD RESET key followed by the numeral key corresponding to the slot occupied by the 44474A.

b. Press the EXECUTE key.

14. Connect the multimeter and the 6k ohm resistor to the PCTL/RD line as shown in Figure 12-6. The dc voltage should be ≥ 2.4Vdc.

15. Repeat step 14 for the CHAN CLOSED and IO/WR lines.

16. CONTROL LINES LOW OUTPUT TEST: set the PCTL/RD and the IO/WR control lines to the low state as follows:

a. Press the MODE key followed by X,1,20,1 (where X is the slot occupied by the 44474A).

b. Press the EXECUTE key.

17. Set the dc power supply to deliver 0Vdc. Connect the dc power supply, the multimeter, and the 2.5k ohm resistor to the PCTL/RD line as shown in Figure 12-7.

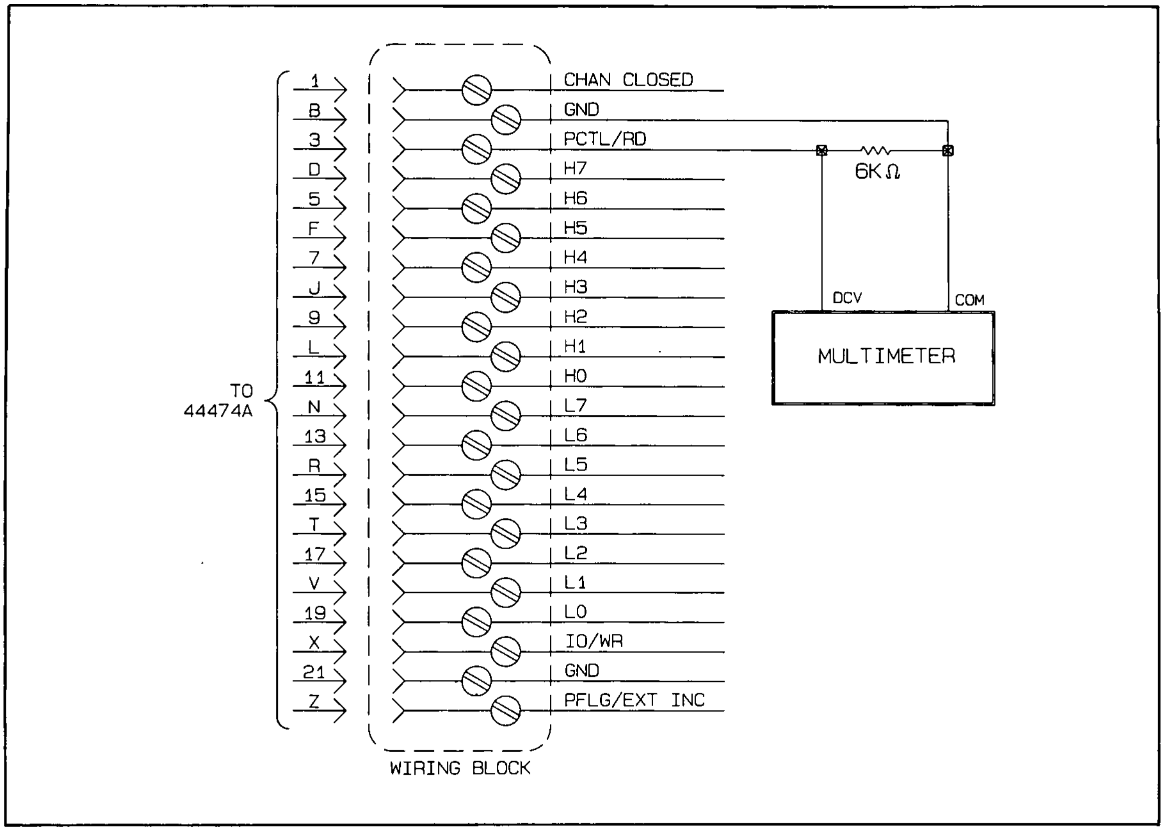



**Figure 12-6 Control Line High Output Test**

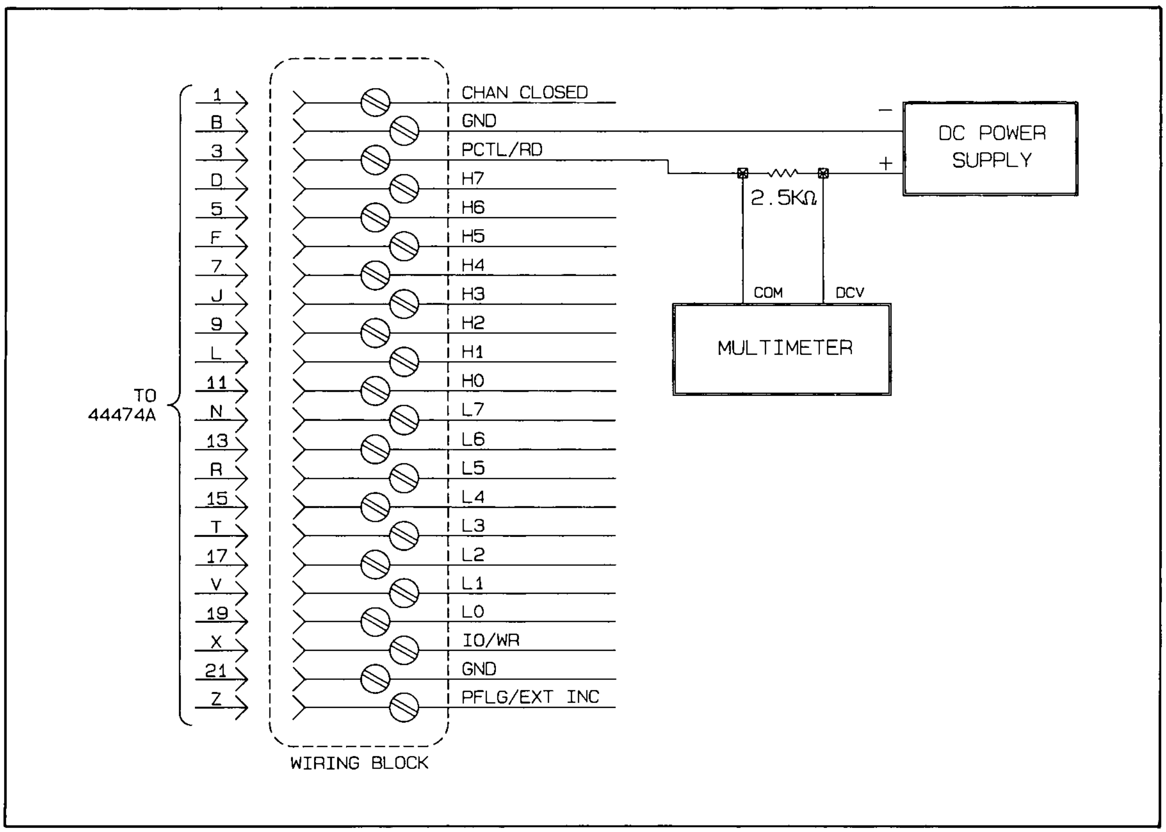



**Figure 12-7 Control Line Low Output Test**

18. Increase the power supply's dc voltage output until 5Vdc is measured on the multimeter.

19. Measure the dc voltage between the 44474A's PCTL/RD and GND lines. The dc voltage should be ≤ 0.5Vdc.

20. Repeat steps 17 through 19 for the IO/WR line.

21. Establish a scan list as follows:

a. Press the SCAN LIST key followed by X00-X05 (where X is the slot occupied by the 44474A).

b. Press the EXECUTE key.

22. Set the dc power supply to deliver 0Vdc. Connect the dc power supply, the multimeter and the 2.5k ohm resistor to the CHAN CLOSED line as shown in Figure 12-8.

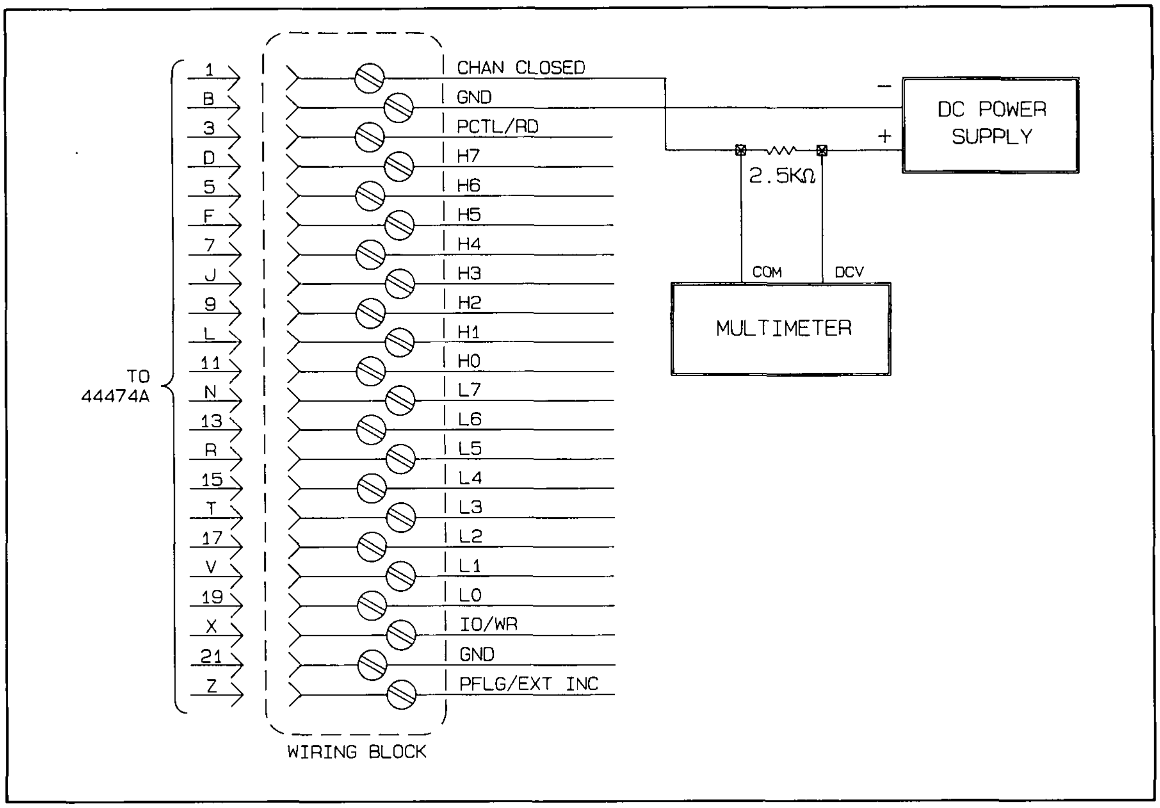



**Figure 12-8 CHAN CLOSED Line Test**

23. Increase the power supply's dc voltage output until 5Vdc is measured on the multimeter.

24. Connect the oscilloscope between the 44474A's CHAN CLOSED and GND lines. Successively press the 3488A's STEP key while monitoring the CHAN CLOSED pulse on the oscilloscope. The low level voltage should be ≤0.5Vdc, the width of each pulse should be ≥ 10$\mu$ seconds.

### 12-8 Corrective Action

If any of the current sink or output drive tests fail, troubleshoot the 44474A. Troubleshooting procedures begin in section 12-22.

## 12-9 REPLACEABLE PARTS

Table 12-1 lists the mechanical and electrical replaceable parts available for the 44474A. The mechanical parts are keyed to Figure 12-9. This figure also provides assembly and disassembly information. The electrical parts are keyed to the schematic and component locator in Figure 12-15. Table 5-2, in Chapter 5, lists the manufacturers code numbers as they apply to the parts list in Table 12-1.

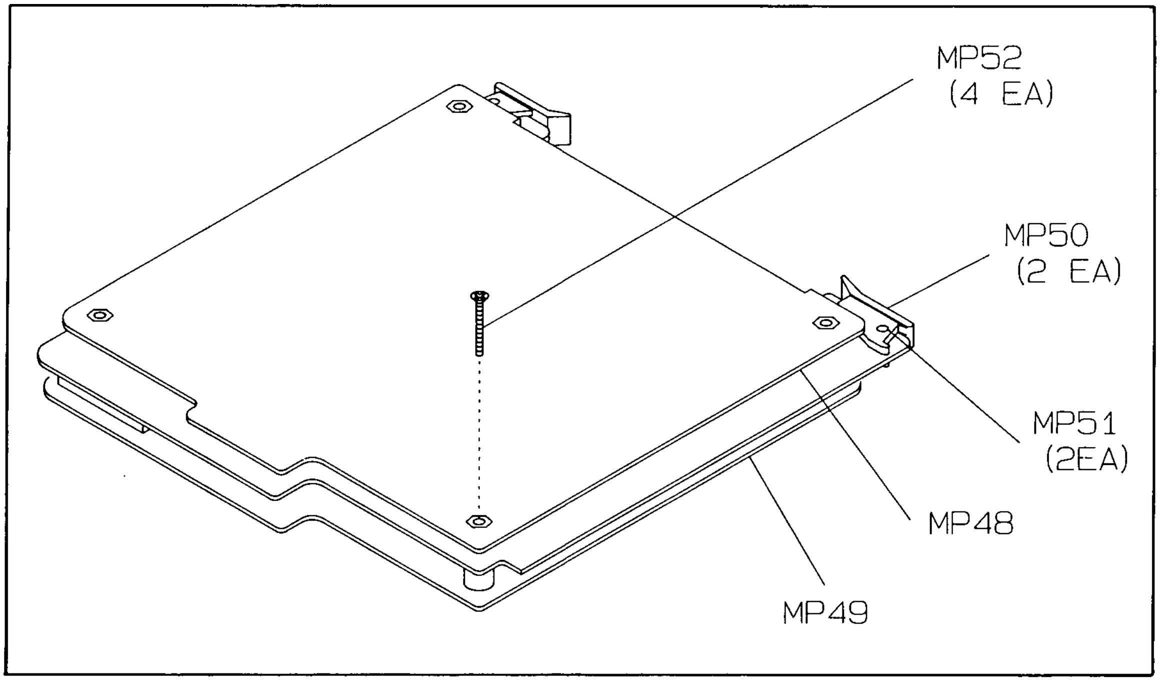



Figure 12-9 44474A Disassembly

## 12-10 44474A THEORY OF OPERATION

The 44474A is made up of 16 bi-directional data lines, three output only handshake lines, one input only PFLG/External Increment line, an address decoder and a card-type buffer. Refer to the 44474A schematic (Figure 12-15) in the following discussions.

## 12-11 Bi-directional Data Lines

Figure 12-10 is a simplified schematic diagram depicting one of the 16 data lines. As shown in the simplified schematic, each data line contains a input buffer and latch, a VMOS FET, a high output driver, protection circuitry, a comparator, and an output latch and buffer.

## 12-12 Input Buffer And Latch

The input buffer provides isolation between the 44474A and the 3488A's data bus. An input buffer is present on each type of option card and prevents excessive loading of the data bus by the option cards.

The input latch holds the output of the input buffer.

## Table 12-1 Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1 | 44474-66501 | 4 | 1 | DIGITAL I/O CARD ERC: 2609 | 28480 | 44474-66501 |
| A1C901 | 0160-0127 | 2 | 1 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| A1C902 | 0160-3847 | 9 | 8 | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C903 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C904 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C905 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C906 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C907 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C908 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C909 | 0160-3847 | 9 | | CAPACITOR-FXD .01UF +100-0% 50VDC CER | 28480 | 0160-3847 |
| A1C910 | 0160-4808 | 4 | 1 | CAPACITOR-FXD 470PF +-5% 100VDC CER | 28480 | 0160-4808 |
| A1CR901 | 1901-0050 | 3 | 24 | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR902 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR903 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR904 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR905 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR906 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR907 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR908 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR909 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR910 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR911 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR912 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR913 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR914 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR915 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR916 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR917 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR918 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR919 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR920 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR921 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR922 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR923 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR924 | 1901-0050 | 3 | | DIODE-SWITCHING 80V 200MA 2NS DO-35 | 28480 | 1901-0050 |
| A1CR925 | 1902-0176 | 6 | 16 | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR926 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR927 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR928 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR929 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR930 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR931 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR932 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR933 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR934 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR935 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR936 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR937 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR938 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR939 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1CR940 | 1902-0176 | 6 | | DIODE-ZNR 47V 5% PD=1W IR=5UA | 28480 | 1902-0176 |
| A1F901 | 2110-0669 | 4 | 16 | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F902 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F903 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F904 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F905 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F906 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F907 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F908 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F909 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F910 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F911 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F912 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F913 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F914 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F915 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1F916 | 2110-0669 | 4 | | FUSE .25A 125V NTD .28X.096 | 28480 | 2110-0669 |
| A1J901 | 5180-6639 | 3 | 1 | CONN-2X11 RT ANG | 28480 | 44474-62102 |
| A1P901 | 5180-6697 | 9 | 1 | CONN-RT ANG 2X15 | 28480 | 1251-8645 |

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

# Table 12-1 Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1Q901 | 1855-0564 | 5 | 16 | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q902 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q903 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q904 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q905 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q906 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q907 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q908 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q909 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q910 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q911 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q912 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q913 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q914 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q915 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1Q916 | 1855-0564 | 5 | | TRANSISTOR MOSFET N-CHAN E-MODE | 17856 | VN10KM |
| A1R901 | 0683-5105 | 4 | 2 | RESISTOR 51 5% .25W FC TC=-400/+500 | 01121 | CB5105 |
| A1R902 | 0683-5105 | 4 | | RESISTOR 51 5% .25W FC TC=-400/+500 | 01121 | CB5105 |
| A1R903 | 0683-4725 | 2 | 16 | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R904 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R905 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R906 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R907 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R908 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R909 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R910 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R911 | 0698-3154 | 0 | 1 | RESISTOR 4.22K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-4221-F |
| A1R912 | 0698-4445 | 4 | 1 | RESISTOR 5.76K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-5761-F |
| A1R913 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R914 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R915 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R916 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R917 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R918 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R919 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R920 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1R921 | 0811-1063 | 8 | 4 | RESISTOR 47 10% 1W PW TC=0+-150 | 28480 | 0811-1063 |
| A1R922 | 0683-2045 | 5 | 16 | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R923 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R924 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R925 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R926 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R927 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R928 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R929 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R930 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R931 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R932 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R933 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R934 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R935 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R936 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R937 | 0683-2045 | 5 | | RESISTOR 200K 5% .25W FC TC=-800/+900 | 01121 | CB2045 |
| A1R938 | 0811-1063 | 8 | | RESISTOR 47 10% 1W PW TC=0+-150 | 28480 | 0811-1063 |
| A1R939 | 0811-1063 | 8 | | RESISTOR 47 10% 1W PW TC=0+-150 | 28480 | 0811-1063 |
| A1R940 | 0811-1063 | 8 | | RESISTOR 47 10% 1W PW TC=0+-150 | 28480 | 0811-1063 |
| A1RP901 | 1810-0269 | 3 | 7 | NETWORK-RES 9-SIP10.0K OHM X 8 | 28480 | 1810-0269 |
| A1RP902 | 1810-0269 | 3 | | NETWORK-RES 9-SIP10.0K OHM X 8 | 28480 | 1810-0269 |
| A1RP903 | 1810-0269 | 3 | | NETWORK-RES 9-SIP10.0K OHM X 8 | 28480 | 1810-0269 |
| A1RP904 | 1810-0269 | 3 | | NETWORK-RES 9-SIP10.0K OHM X 8 | 28480 | 1810-0269 |
| A1RP905 | 1810-0269 | 3 | | NETWORK-RES 9-SIP10.0K OHM X 8 | 28480 | 1810-0269 |
| A1RP906 | 1810-0269 | 3 | | NETWORK-RES 9-SIP10.0K OHM X 8 | 28480 | 1810-0269 |
| A1RP907 | 1810-0269 | 3 | | NETWORK-RES 9-SIP10.0K OHM X 8 | 28480 | 1810-0269 |
| A1U901 | 1820-3297 | 4 | 2 | IC DRVR CMOS/74HC BUS OCTL | 28480 | 1820-3297 |
| A1U902 | 1820-2216 | 5 | 3 | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U903 | 1820-2216 | 5 | | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U904 | 1820-2216 | 5 | | IC FF CMOS D-TYPE POS-EDGE-TRIG OCTL | 27014 | MM74C374N |
| A1U905 | 1820-3297 | 4 | | IC DRVR CMOS/74HC BUS OCTL | 28480 | 1820-3297 |
| A1U906 | 1820-1199 | 1 | 1 | IC INV TTL LS HEX 1-INP | 01295 | SN74LS04N |
| A1U907 | 1820-2538 | 4 | 2 | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C240N |
| A1U908 | 1820-2538 | 4 | | IC DRVR CMOS LINE DRVR OCTL | 27014 | MM74C240N |
| A1U909 | 1820-3082 | 5 | 2 | IC-MC74HC374N | 28480 | 1820-3082 |
| A1U910 | 1826-0138 | 8 | 4 | IC COMPARATOR GP QUAD 14-DIP-P PKG | 01295 | LM339N |

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

## Table 12-1 Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|---|---|---|---|---|---|---|
| A1U911 | 1826-0138 | 8 | | IC COMPARATOR GP QUAD 14-DIP-P PKG | 01295 | LM339N |
| A1U912 | 1820-3082 | 5 | | IC-MC74HC374N | 28480 | 1820-3082 |
| A1U913 | 1826-0138 | 8 | | IC COMPARATOR GP QUAD 14-DIP-P PKG | 01295 | LM339N |
| A1U914 | 1826-0138 | 8 | | IC COMPARATOR GP QUAD 14-DIP-P PKG | 01295 | LM339N |
| A1U915 | 1820-3456 | 7 | 1 | IC-74HCT244 | 28480 | 1820-3456 |
| A1U916 | 1820-1212 | 9 | 1 | IC FF TTL LS J-K NEG-EDGE-TRIG | 01295 | SN74LS112AN |
| A1U917 | 1820-1216 | 3 | 1 | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| A1U918 | 1820-1198 | 0 | 1 | IC GATE TTL LS NAND QUAD 2-INP | 01295 | SN74LS03N |
| MP48 | 03488-00602 | 8 | 1 | CARD SHIELD - CKT | 28480 | 03488-00602 |
| MP49 | 03488-00603 | 9 | 1 | CARD SHIELD - COMP | 28480 | 03488-00603 |
| MP50 | 0403-0464 | 6 | 2 | PC EXTRACTER WHT | 28480 | 0403-0464 |
| MP51 | 1480-0625 | 4 | 2 | PIN GRV 3/32 X 1/4 | 28480 | 1480-0625 |
| MP52 | 0515-0843 | 2 | 4 | SCREW M2.5 X 20 LK | 28480 | 0515-0843 |
| | 5040-5193 | 3 | 1 | STRAIN RELIEF HOUSING | 28480 | 5040-5193 |
| | 5040-5194 | 4 | 1 | STRAIN RELIEF PLATE | 28480 | 5040-5194 |
| | | | | NOTE: HP PRODUCT NUMBER 44484A INCLUDES CONNECTOR TERMINAL BLOCK AND STRAIN RELIEF ASSEMBLY. | | |

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

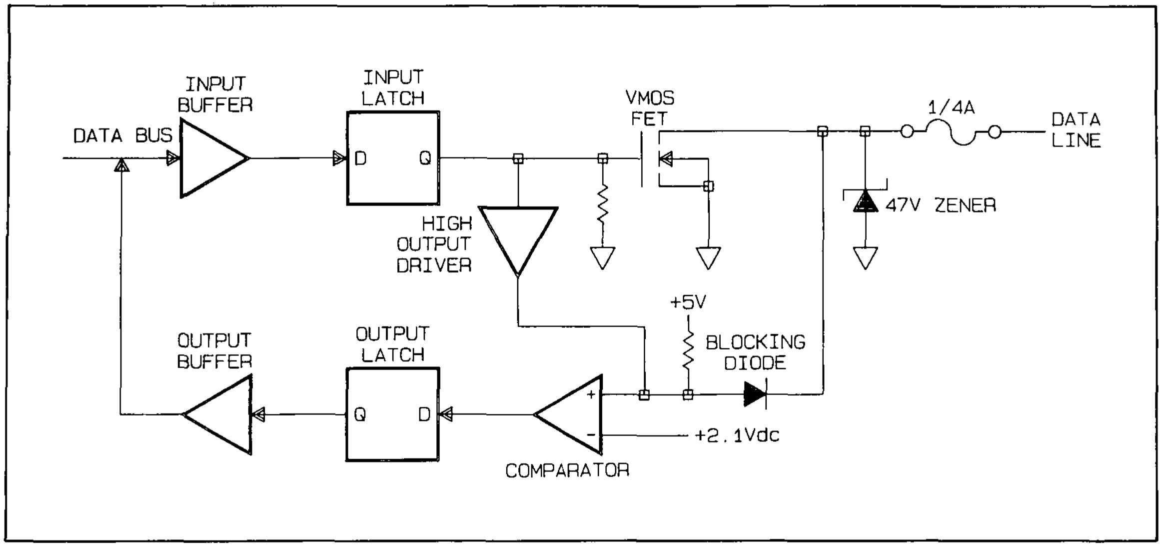



**Figure 12-10 One Data Line**

## 12-13 VMOS FET

When a logic high level is applied to the gate of the FET it conducts heavily, creating a low resistance path from the data line to ground. This is the data line low state. When in this state the FET is capable of sinking an externally supplied current of up to 125 mA.

When a logic low level is applied to the gate of the FET the FET presents a high resistance between the data line and ground. This is the passive high state which occurs at instrument turn-on, following a reset, and whenever the data lines are being read.

Notice the resistor connected between the FET's gate and ground. This resistor holds the gate near ground potential when the 3488A is initially turned-on to ensure that the FET is in the passive high state.

## 12-14 High Output Driver

When a command is issued to set a data line high the FET is in the passive high state (as described in Section 12-13) and the high output driver is enabled. The high output driver provides the output current necessary to maintain a TTL high output level (≥ 2.4 Vdc) under load.

## 12-15 Protection Circuitry

As shown in Figure 12-10, the protection circuitry consists of a 1/4 amp fuse, a 47 V zener diode, and a blocking diode.

The 1/4 amp fuse protects the 44474A from excessive externally applied current.

The zener diode conducts at any voltage of 47 Vdc or greater which limits the applied voltage to a maximum of 47 Vdc. The zener diode provides protection from external overvoltage situations including static electricity.

The blocking diode reverse biases when the applied voltage exceeds +4.3 Vdc preventing externally supplied current from being injected into the 44474A's and the 3488A's +5 Vdc supply line.

## 12-16 Comparator

The comparator maintains correct TTL high and low levels by shifting the voltages from the input to compensate for the forward voltage drop of the blocking diode. A reference voltage of +2.1 Vdc is applied to the inverting input of the comparator. When the input voltage is in the range of 0 Vdc to +4.3 Vdc the blocking diode is forward biased and its forward voltage drop is added to the applied voltage. For example, when 0 Vdc is applied to the data line, +0.7 Vdc is present on the non-inverting input of the comparator. Thus, when the input signal level is > +1.4 Vdc, a voltage > +2.1 Vdc is applied to the non-inverting input of the comparator causing its output to go high. When the applied voltage is < 1.4 Vdc, a voltage < 2.1 Vdc is applied to the comparator's non-inverting input causing its output to go low. In other words, an input voltage < 1.4 Vdc is interpreted as a TTL low level and an input > 1.4 Vdc is interpreted as a TTL high level.

The pull-up resistor (connected to the comparator's non-inverting input in Figure 12-10) allows external ground connections and open circuits to be detected. When the data line is grounded, the blocking diode is forward biased applying a +0.7 Vdc level to the comparator—a TTL low. When the data line is allowed to float (ground connection removed) the non-inverting input of the comparator floats to +5 Vdc — a TTL high. This feature can be used, among other things, to check the continuity of wires. With one end of the wire connected to ground and the other to the data line, a TTL low indicates continuity while a TTL high indicates an open circuit.

## 12-17 Output Latch And Buffer

The output latch holds the output of the comparator.

The output buffer provides isolation between the 44474A and the 3488A's data bus. The output buffer also provides the current necessary to drive the 3488A's data bus.

## 12-18 Handshake Lines

Figure 12-11 is a simplified schematic diagram depicting one of the three output-only handshake lines. As shown in the simplified schematic, each handshake line contains an input buffer and latch, and a driver. The operation of the input buffer and latch is identical to that discussed in Section 12-12. The handshake driver consists of two inverters wired in parallel. By wiring these inverters in parallel, twice the output current of a single inverter is available.

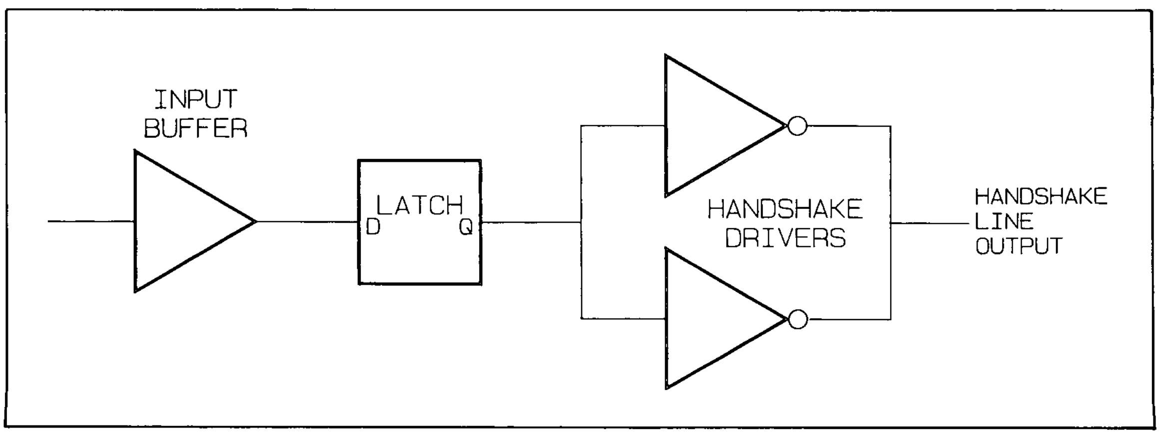



**Figure 12-11 One Handshake Line**

## 12-19 PFLG/External Increment Line

The PFLG/External Increment line performs two different functions depending upon the mode specified.

When handshake mode #5 is specified (see DMODE command in Chapter 3) this line becomes a peripheral flag (PFLG) line and is used by the peripheral device to indicate that it is ready to receive data. In this mode, the PFLG line is applied to the data bus through the card-type buffer.

When the external increment/channel closed mode is specified (see DMODE in Chapter 3), this line in conjunction with the external trigger circuitry, interrupts the 3488A controller whenever an external trigger occurs. In addition, the external trigger circuitry signals the controller to display an error message (ERR 4: TRIG) whenever the external trigger signal exceeds the allowable frequency limit.

A simplified schematic and timing diagram of the external trigger circuitry is shown in Figure 12-12. As indicated by the timing diagram, the triggering process starts when the 3488A controller sets the $\overline{\text{PR}}$ line to the logic low level. This causes each of the J-K flip-flops to have a high level on its Q output and a low level on its $\overline{\text{Q}}$ output. A trigger occurs whenever the external signal on the PFLG/External Increment line goes from a high to a low level. This trigger is applied to the clock input of each J-K flip-flop. When the trigger signal occurs after the preset signal, the B flip-flop has a high level on its J input and a low level on its K input. This causes the Q output of the B flip-flop to remain at the high level. The A flip-flop, however, has a low level on its J input and a high level on its K input. The trigger signal causes the A flip-flop Q output to go from a high to a low level and its $\overline{\text{Q}}$ output to go from a low to a high level. The inverter input goes from a low to a high level and its output goes from a high level to a low level. When the inverter's output (the $\overline{\text{INT}}$ line) goes from a high to a low level, the 3488A controller is interrupted.

In normal triggering situations, as described above, every external trigger pulse will be preceded by an internal preset pulse. It is possible, however, for a second trigger pulse to occur before the second preset pulse has occurred. In other words the external trigger pulse is occurring too fast. When the second trigger occurs too soon, the A flip-flop has a low level on its J input and a high level on its K input. The A flip-flop's output remains the same causing no high to low transition of the $\overline{\text{INT}}$ line and no controller interrupt. At the same time, the B flip-flop has a low level on its J input and a high level on its K input (as a result of the first trigger). The second trigger pulse is applied to the clock input of the B flip-flop causing its Q output to go from a high to a low level. This transition signals the controller, via the card-type buffer, that the trigger is occurring too fast. The controller then displays ERR 4: TRIG.

## 12-20 Address Decoder

The address decoder (U917 in Figure 12-15) is enabled when the $\overline{\text{CS}}$ signal from the 3488A goes low. Once enabled, the address decoder is responsible for enabling the various IC's on the board in response to the instructions it receives via the R/$\overline{\text{W}}$, A0 and A1 signals from the 3488A. Figures 12-13 and 12-14 show the timing relationships between these control lines for both read and write operations.

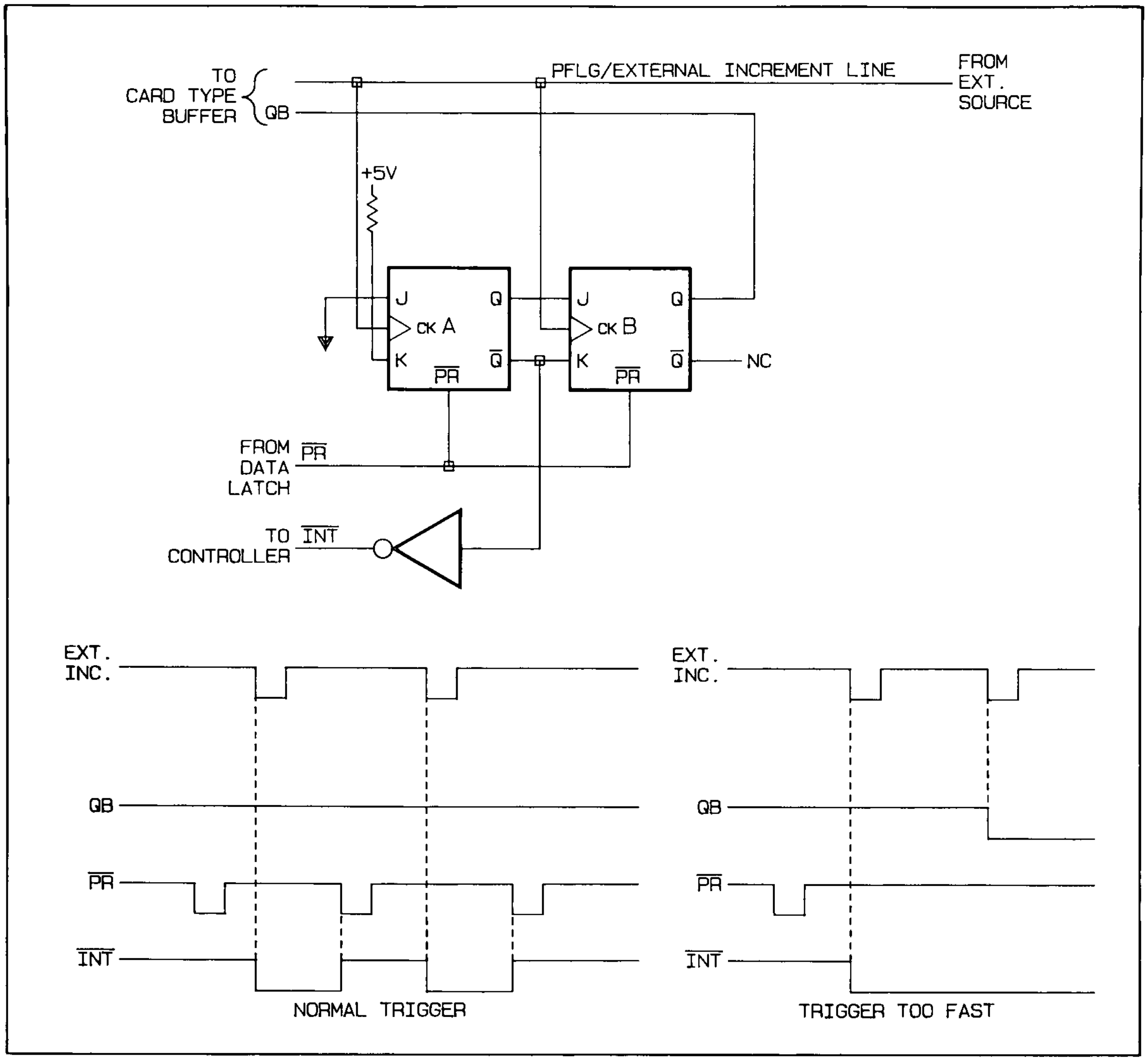



**Figure 12-12 External Trigger Circuit And Timing Diagram**

## 12-21 Card-Type Buffer

The primary purpose of the card-type buffer (U915 in Figure 12-15) is to indicate to the 3488A that a Digital I/O Card is in the particular card slot queried. The card type is determined by the wiring configuration of four of the input lines to the card-type buffer. By connecting one of the inputs to +5 Vdc and three inputs to ground, a 4-bit code (0100) is generated that is recognized by the 3488A as the unique identifier for the Digital I/O Card.

A secondary purpose of the card-type buffer is to buffer the PFLG line and the outputs of the external trigger circuitry.

# 12-22 44474A TROUBLESHOOTING

## 12-23 Introduction

The 16 input/output lines of the 44474A are divided into two groups of 8 lines each. These two groups are referred to as high byte and low byte. All sixteen input/output lines are individually fused. If only a single line appears to be failing, the fuse would be the most likely suspect. The 44474A shields must be removed to check the fuses. The fuses are soldered into the board and can be checked with an ohmmeter.

If all the outputs in either the high byte or low byte are failing, the data latches (U904 hi byte or U903 low byte) or output drivers (U908 for the hi byte or U907 for the low byte) should be suspected. If all outputs are failing, the input buffers (U901 and U905) should be suspected.

Failures only in the handshake lines are limited to U906, U902 and U917 and associated circuitry. The handshake lines are not fused.

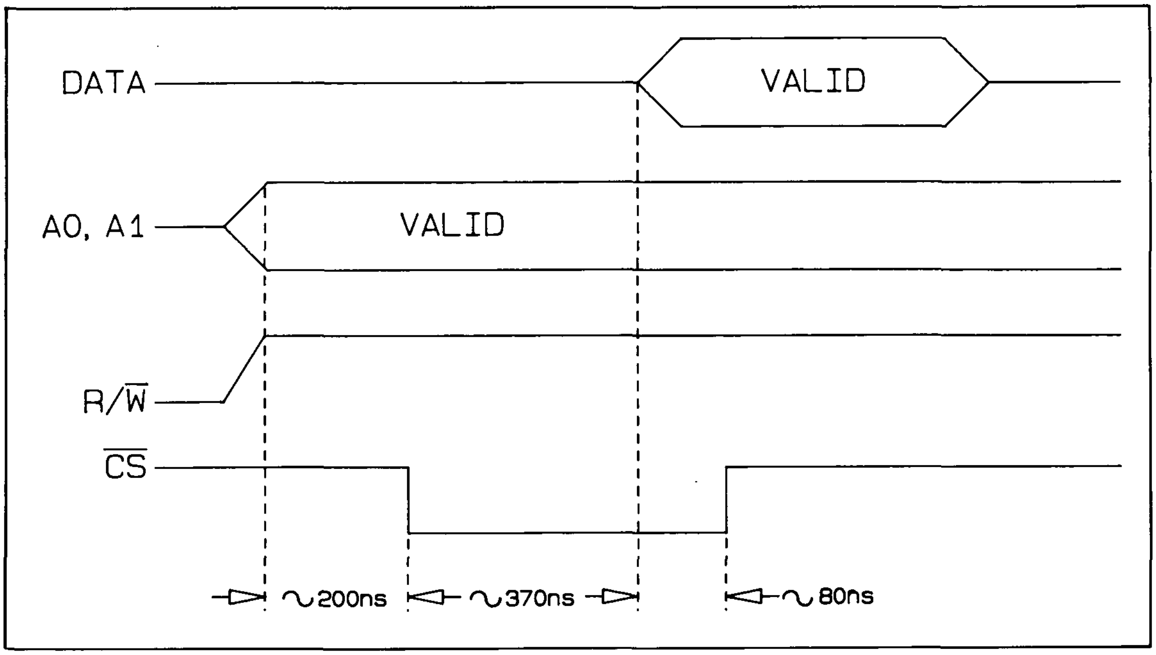



**Figure 12-13 Control Line Timing (Read)**

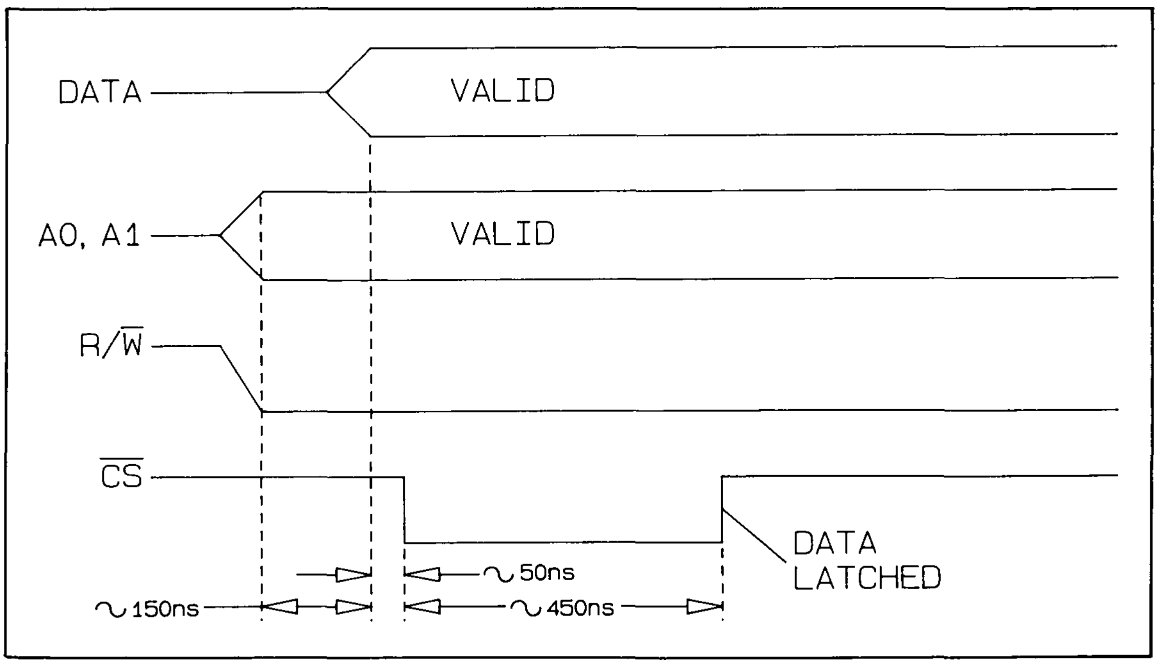



**Figure 12-14 Control Line Timing (Write)**

If the controller beeps and displays ERR 4: HARDWARE TRIGGER TOO FAST, check the input to the PFLG/EXT INCREMENT line. If the input is correct, the problem is isolated to U916, U918 and U915 and associated circuitry. Note that the output of the external trigger circuitry ($\overline{\text{INT}}$) is a direct line to the controller. If, when a digital I/O card is installed, the controller seems to be lost, check the status of the $\overline{\text{INT}}$ line. This line can only be controlled by a 44474A card. For normal controller operation this line must be high. For a discussion of the $\overline{\text{INT}}$ line and the external trigger circuitry refer to Section 12-19.

Troubleshooting the 44474A can be accomplished with a signature analysis procedure. This procedure begins in Section 12-25.

### 12-24 Equipment Required

| | |
|---|---|
| HP 5005A | Signature Multimeter |
| 03488-66501 | Test Fixture |

## 12-25 44474A Signature Analysis

The following pages describe the signature analysis procedures. Each page contains the set-up procedure, the area of the 44474A being checked, the appropriate signatures and general notes about the test.

The procedure has been designed to be in a step-by-step fashion, or, if the symptoms indicate a particular area of the 44474A, specific signatures can be observed. In each case, the set-up procedure must be followed exactly to assure compatible signatures. If the procedure is used in a step-by-step fashion, the changes in the set-up between each step are highlighted.

Each step of the procedure gives the output signatures (and some control signatures) of a particular section of the 44474A. In the NOTES section of each signature analysis procedures step, a note directs the user to a separate sheet, where the input signatures can be found. Between the output signatures and the input signatures, a failing device can be isolated. In some cases the input signatures are given on a sheet labeled FAILED.

The signature analysis procedures require that the top cover of the mainframe and the controller shield be removed. Procedures to remove the cover and shield are located in Chapter 5.

A special controller firmware routine is used to test the 44474A. The 44474A MUST be installed in slot 1. The special routine is accessed by grounding A40SA6. The signature analyzer timing pod connections are made on the controller (A40) board.

The test fixture (03488-66501) must be installed for the signature analysis tests. This fixture is described in Section 12-4. This fixture connects the high byte data lines to the low byte data lines. Additionally, the fixture connects the CHANNEL CLOSED output to the PFLG/Ext Increment line. This loop must be in place for the signature analysis firmware routine to operate.

Once A40SA6 is grounded and power applied, the special routine is accessed by pressing the front panel TEST key. Instead of performing the internal self-test the display will prompt for a number. The 44474A test is selected by pressing the number 4 and EXECUTE. The display will show "DIG CARD S.A." while this test is running.

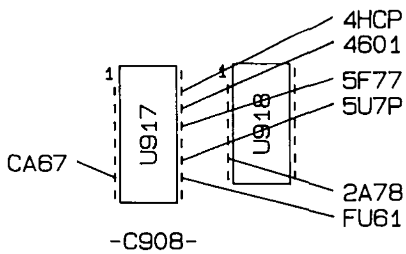
In the following procedures, signatures are taken with the data probe threshold set to normal TTL levels. Two steps, 6 and 7, require that the data probe low threshold be set 1.5 V. This is due to the voltage drop across the blocking diode (see Section 12-16). It is important to return the data probe threshold level to TTL levels before proceeding to Step 8. If the signature analyzer used does not allow the data thresholds to be changed, Steps 6 and 7 must be skipped.

| STEP 1 | CHECKING: 44474A<br>**ADDRESS DECODING (U917, U918)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)
1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START _/‾ STOP ‾_
   CLOCK ‾_
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC

+5 Vdc: 4094




**NOTES**

1. If signatures are correct, proceed to Step 2.
2. If signatures are incorrect, troubleshoot U917 and 918. Additional troubleshooting information is given in FAILED ADDRESS DECODING.

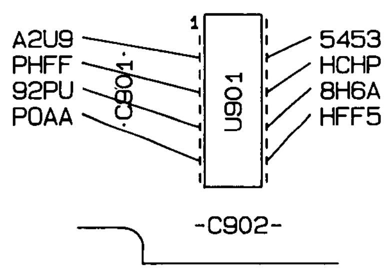
| STEP 2 | CHECKING: 44474A<br>**BACKPLANE BUFFER (U901)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START _/‾ STOP ‾_
   CLOCK ‾_
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




## NOTES

1. If signatures are correct, proceed to Step 3.
2. If signatures are incorrect, troubleshoot U901. Additional troubleshooting information is given in FAILED BACKPLANE BUFFER.

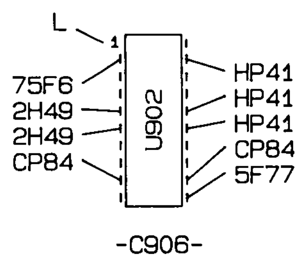
| STEP 3 | CHECKING: 44474A<br>**HANDSHAKE LATCH (U902)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START ⎍ STOP ⎍ CLOCK ⎍
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




**NOTES**

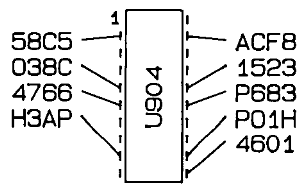
1. If signatures are correct, proceed to Step 4.
2. If signatures are incorrect, troubleshoot U902. Input signatures to U902 are the same as the output signatures of U901 given in Step 2.
3. ''L'' indicates node is low.

| STEP 4 | CHECKING: 44474A<br>**HI BYTE INPUT LATCH (U904)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)
1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START _/‾ STOP ‾_
   CLOCK ‾_
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




-C909-

## NOTES

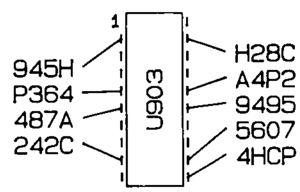
1. If signatures are correct, proceed to Step 5.
2. If signatures are incorrect, troubleshoot U904. Input signatures to U904 are the same as the output signatures of U901 given in Step 2.

| STEP 5 | CHECKING: 44474A<br>**LOW BYTE INPUT LATCH (U903)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)
1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START _/‾ STOP ‾_ CLOCK ‾_
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




**NOTES**

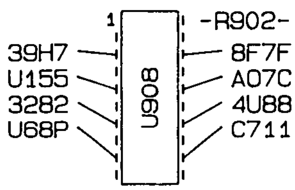
1. If signatures are correct, proceed to Step 6.
2. If signatures are incorrect, troubleshoot U903. Input signatures to U903 are the same as the output signatures of U901 given in Step 2.

| STEP 6 | CHECKING: 44474A<br>**HI BYTE OUTPUT DRIVER (U908)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)
1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START STOP
   CLOCK
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND
13. FOR STEPS 6 AND 7 ONLY, SET DATA PROBE LOW THRESHOLD TO 1.5 V.

+5 Vdc: 4094




**NOTES**

1. If signatures are correct, proceed to Step 7.
2. If signatures are incorrect, troubleshoot U908. Input signatures to U908 are the same as the output signatures of U904 given in Step 4.

# STEP 7

**CHECKING: 44474A**

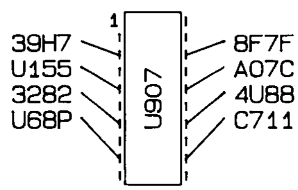
## LOW BYTE OUTPUT DRIVER (U907)

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START STOP
   CLOCK
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND
13. FOR STEPS 6 AND 7 ONLY, SET DATA PROBE LOW THRESHOLD TO 1.5 V.

+5 Vdc: 4094




-R901-

### NOTES

1. If signatures are correct, proceed to Step 8.
2. If signatures are incorrect, troubleshoot U907. Input signatures to U907 are the same as the output signatures of U903 given in Step 5.

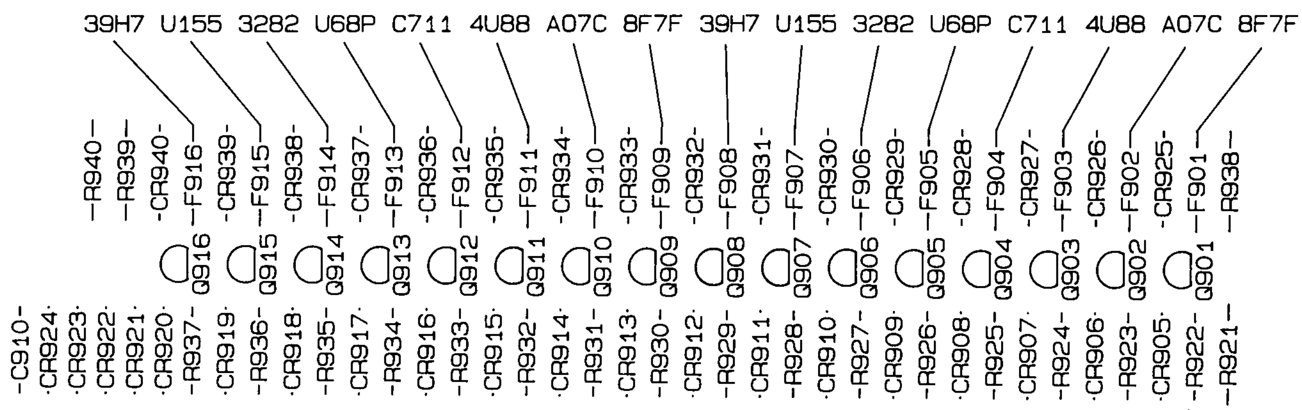
# STEP 8

**CHECKING: 44474A**
## DATA LINE SIGNATURES

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)
1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START STOP
CLOCK
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




**NOTES**

1. Signatures are checked at the fuses.
2. Input signatures to the MOS FETS (Q901...Q916) are the same as the output signatures given in Steps 4 and 5.
3. If signatures are correct, proceed to Step 9.
4. If signatures are incorrect, troubleshoot the output circuitry. Note that the Hi-byte and Low-byte are connected together. An incorrect signature on a given line may be caused by either the Hi-byte or Low-byte output circuitry.

# STEP 9

**CHECKING: 44474A**

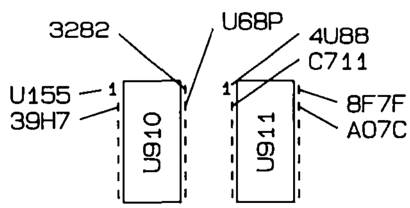
## HI BYTE COMPARATORS (U910, U911)

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START ⎽/⎺ STOP ⎺\⎽
   CLOCK ⎺\⎽
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




**NOTES**

1. If signatures are correct, proceed to Step 10.
2. If signatures are incorrect, troubleshoot U910 and U911. Input signatures to U910 and U911 are the same as the output signatures given in Steps 6 and 7. Note that input signatures require a data probe low level of 1.5 V.

# STEP 10

**CHECKING: 44474A**

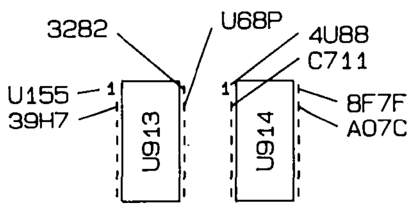
## LO BYTE COMPARATORS (U913, U914)

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START _/‾ STOP ‾_
   CLOCK ‾_
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




**NOTES**

1. If signatures are correct, proceed to Step 11.

2. If signatures are incorrect, troubleshoot U913 and U914. Input signatures to U913 and U914 are the same as the output signatures given in Steps 6 and 7. Note that input signatures require a data probe low level of 1.5 V.

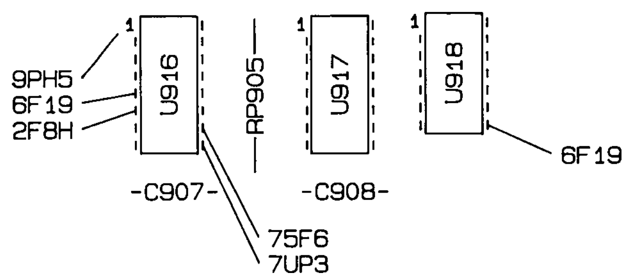
| STEP 11 | CHECKING: 44474A<br>**EXT TRG & PFLG (U916, U918)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START _/‾ STOP ‾_
   CLOCK ‾_
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




## NOTES

1. Signature at pin 1 of U916 is an input from PFLG (U906). If signature is incorrect, troubleshoot U906. U906 signatures are given in Step 12.
2. Signature on pin 6 of U916 is an input to U918.
3. Signature at pin 10 of U916 is an input. If signature is incorrect, troubleshoot U902. U902 signatures are given in Step 3.
4. If signatures are correct, perform Step 12.
5. If signatures are incorrect, troubleshoot U916 and U918.

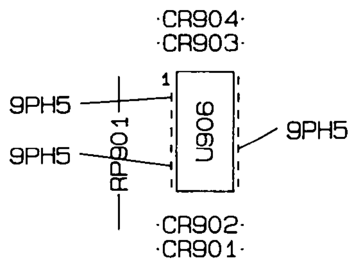
| STEP 12 | CHECKING: 44474A<br>**HANDSHAKE DRIVERS (U906)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START _/‾ STOP ‾_
   CLOCK ‾_
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094




**NOTES**

1. If signatures are correct, proceed to Step 13.
2. If signatures are incorrect, troubleshoot U906. Input signatures to U906 are the same as the output signatures of U902 pins 15, 16 and 19 given in Step 3.

# STEP 13

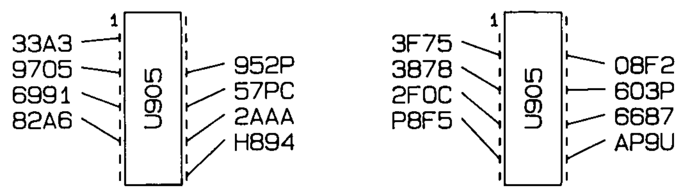
**CHECKING: 44474A**
## BACKPLANE OUTPUT BUFFER (U905)

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)
1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START STOP
   CLOCK
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. REMOVE JUMPER U918 PIN 4 TO GROUND

+5 Vdc: 4094

INPUT SIGNATURES OUTPUT SIGNATURES




**NOTES**

1. Removing jumper from U918 pin 4 enables U905.
2. If output signatures are incorrect, troubleshoot U905. If input signatures are incorrect troubleshoot U905, U909, U912, U915.

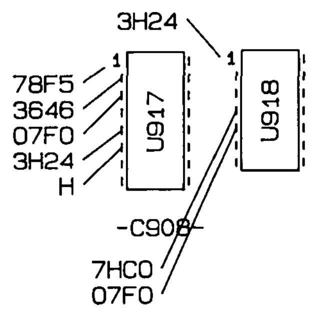
| FAILED ADDRESS DECODING | CHECKING: 44474A<br>**ADDRESS DECODING (U917, U918)** |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START ⎽╱⎺ STOP ⎺╲⎽
   CLOCK ⎺╲⎽
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC

+5 Vdc: 4094




**NOTES**

1. Signatures are inputs to U917 and U918. Output signatures are given in Step 1.
2. 'H' indicates node is tied high.

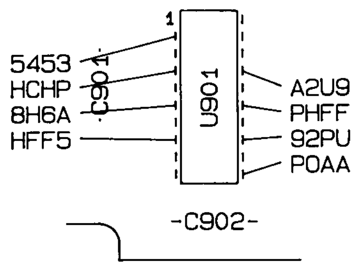
| FAILED BACKPLANE BUFFER | CHECKING: 44474A BACKPLANE BUFFER (U901) |
|---|---|

44474-66501 ERC: 2429

SET-UP
ON CONTROLLER (A40)

1. RP409 INSTALLED
2. ALL SWITCHES ON SP401 OPEN
3. JUMPER SA6 (SERV FUNC) TO GND
4. START/ST/SP TO SA2
5. STOP/QUAL TO SA2
6. CLOCK TO SA5
7. GROUND TO SA4
8. POLARITY: START _/‾ STOP ‾_
   CLOCK ‾_
9. INSTALL 44474A IN SLOT 1
10. INSTALL TEST FIXTURE ON 44474A
11. APPLY POWER, PRESS
    TEST 4 EXEC
12. Jumper U918 PIN 4 TO GROUND

+5 Vdc: 4094




**NOTES**

1. Signatures are inputs to U901. Output signatures are given in Step 2.

HP44474A Relay Card Schematic

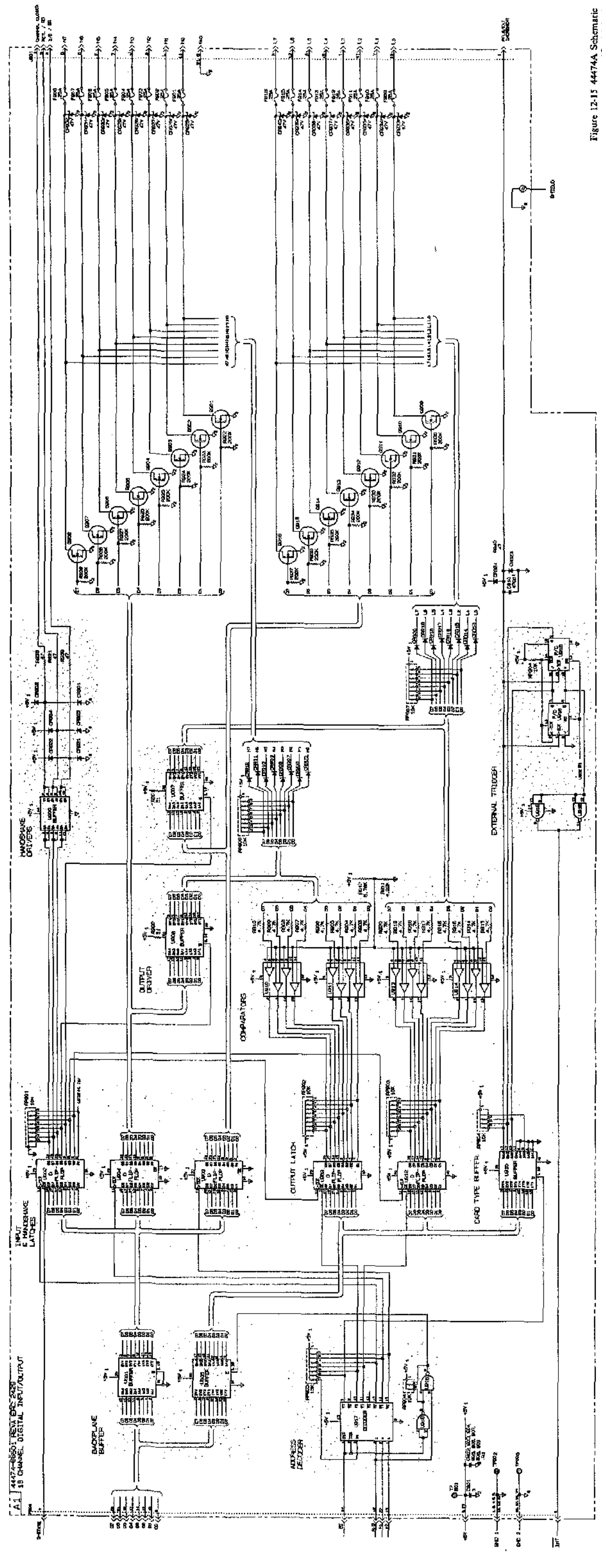
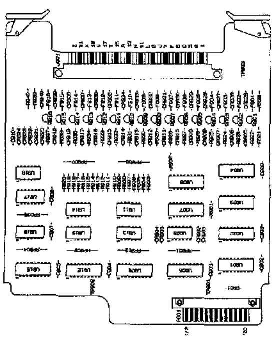
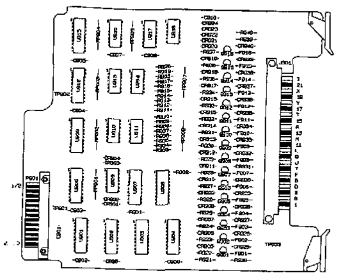


Figure 12-35 44474A Schematic
12-39/12-40



HP44474B Relay Card



Prior to ERC 2609, pins 1 of U903 and U904 were connected to ground.

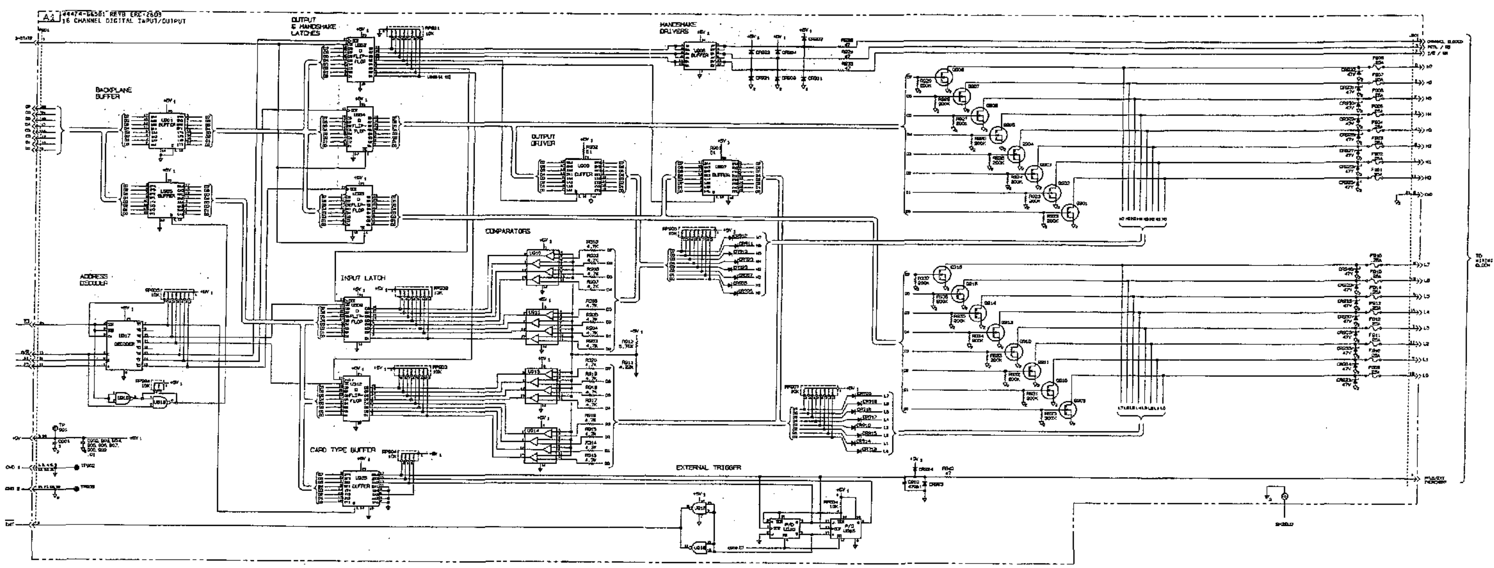


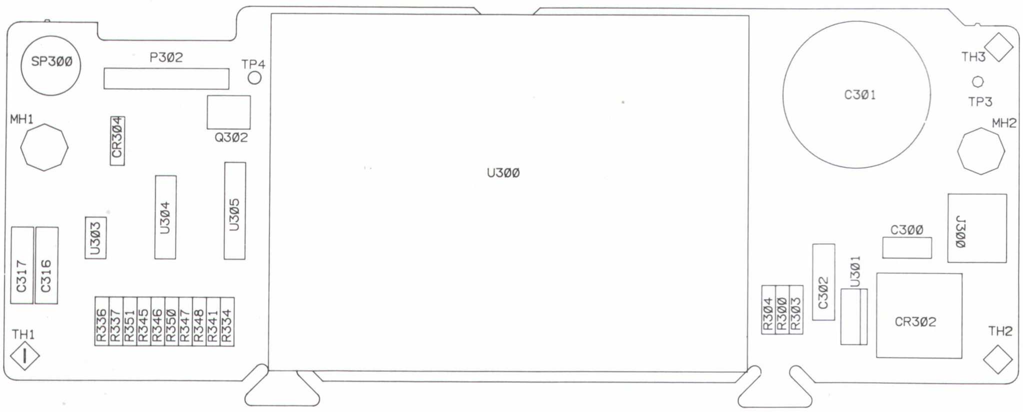

Figure 12-16 44474B Schematic

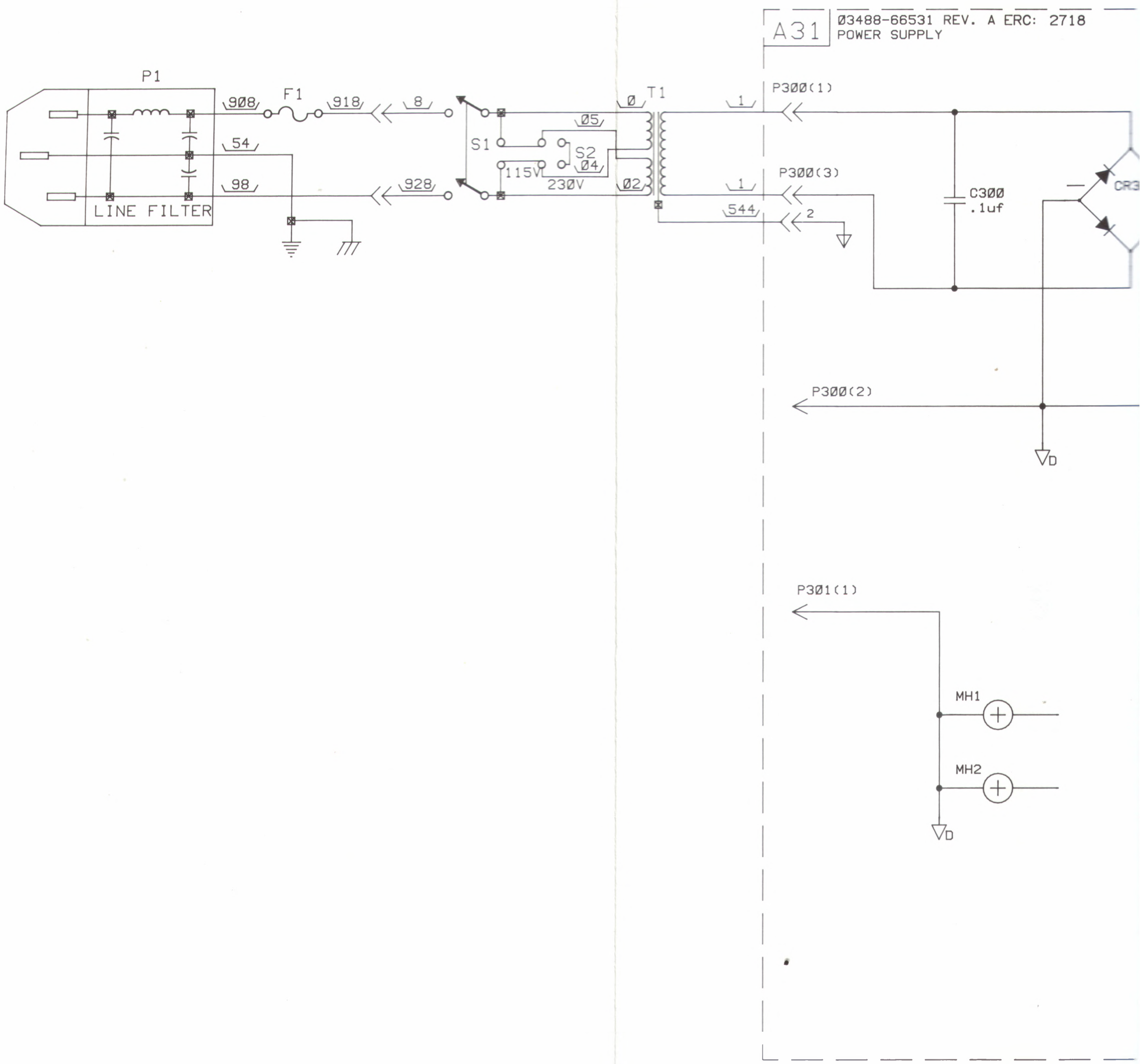
HEWLETT
PACKARD

9282-1078
Binder Only Part No.

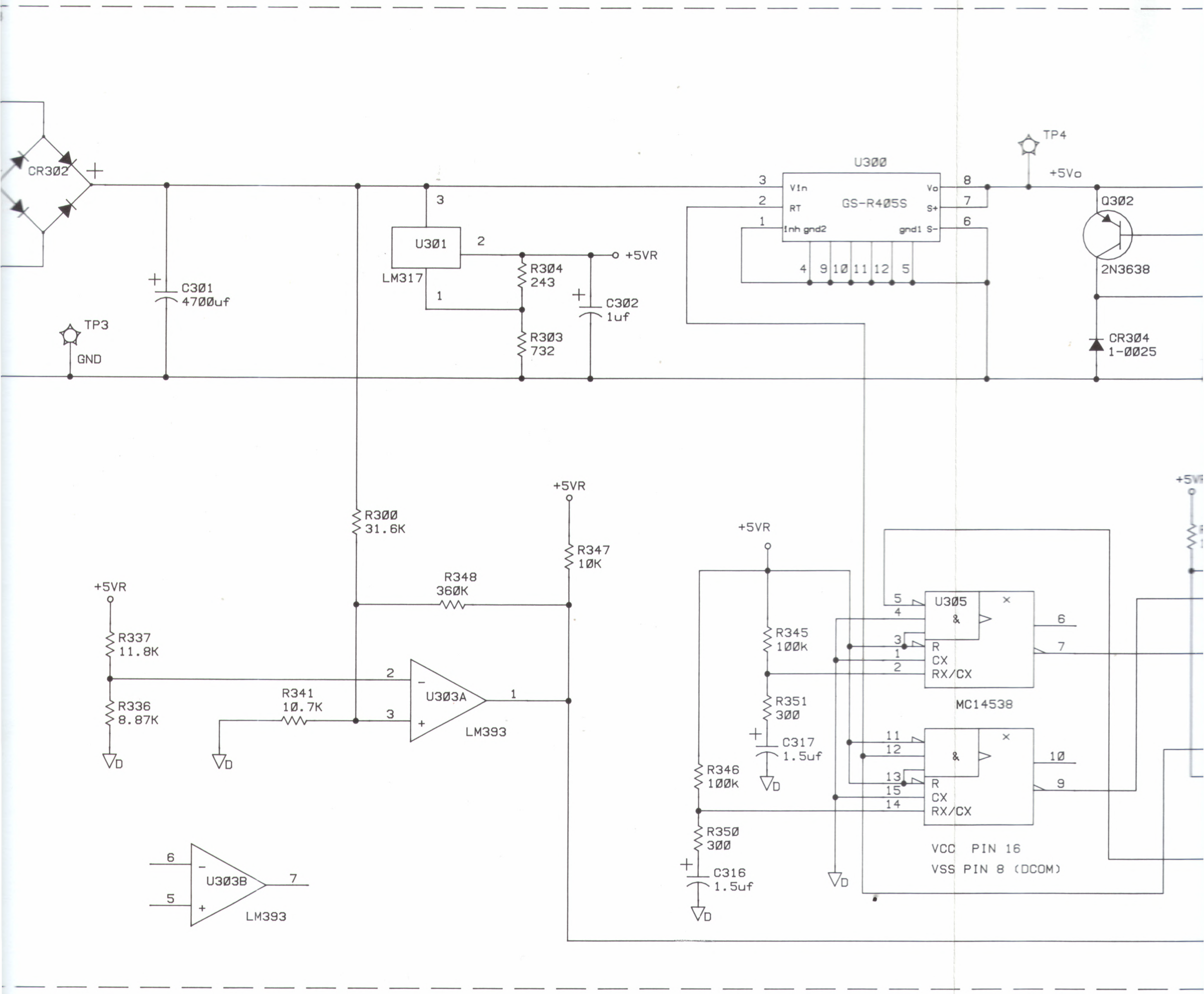
Made in Singapore

Power Supply
Stuffing Diagram




A31
03488-66531 REV. A ERC: 2718
POWER SUPPLY
P1
LINE FILTER
F1
908
918
54
98
8
928
S1
S2
05
04
115V
230V
0
02
T1
1
544
2
P300(1)
P300(3)
P300(2)
C300
.1uf
CR3
P301(1)
MH1
MH2
D

Power Supply



Power Supply

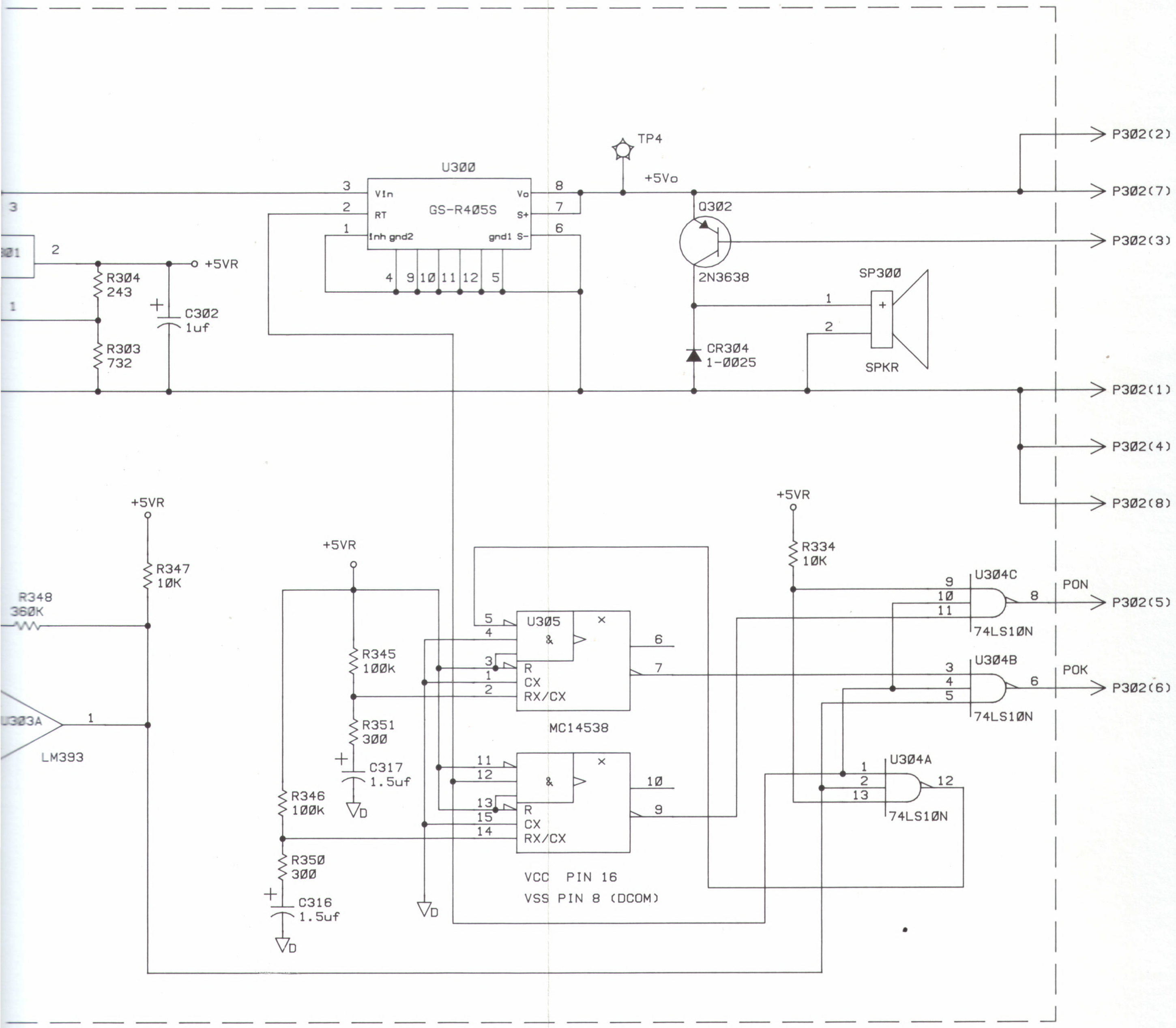
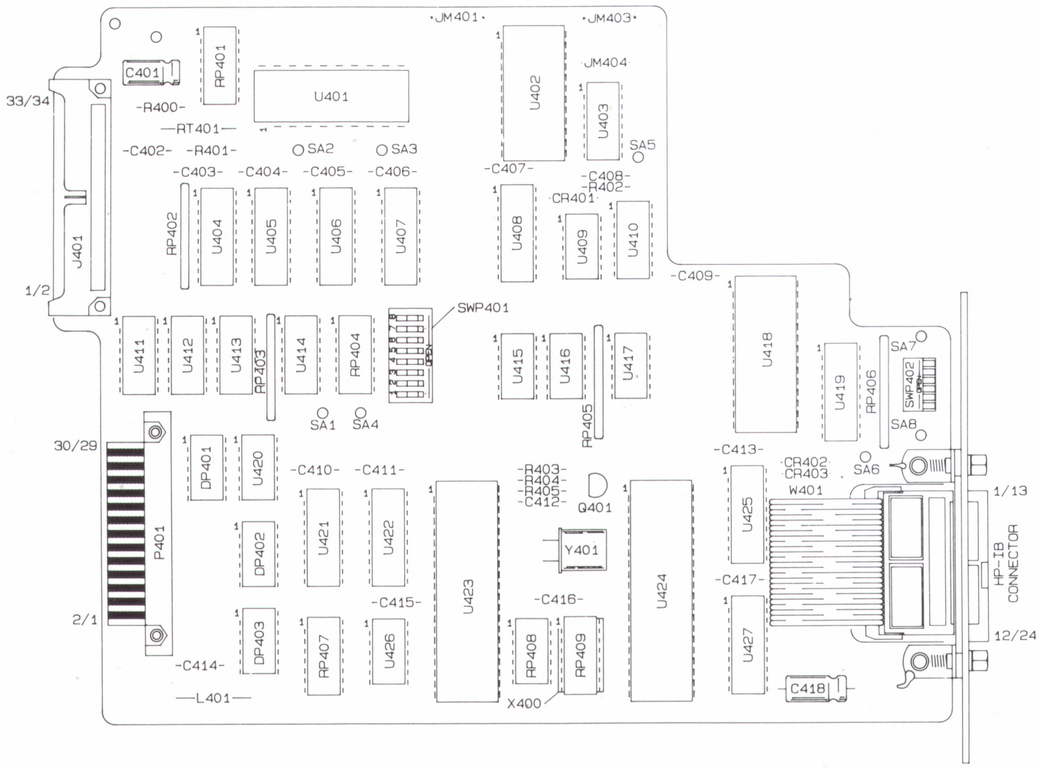
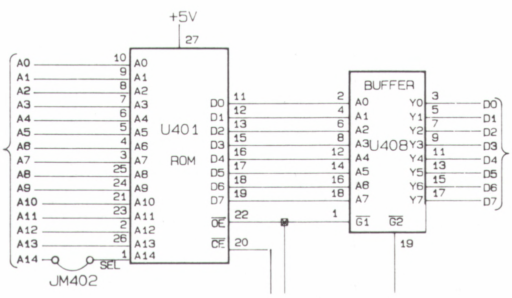


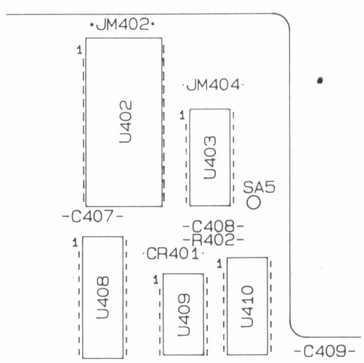

Figure 6-10 Power Supply Schematic

## Controller Stuffing Diagram

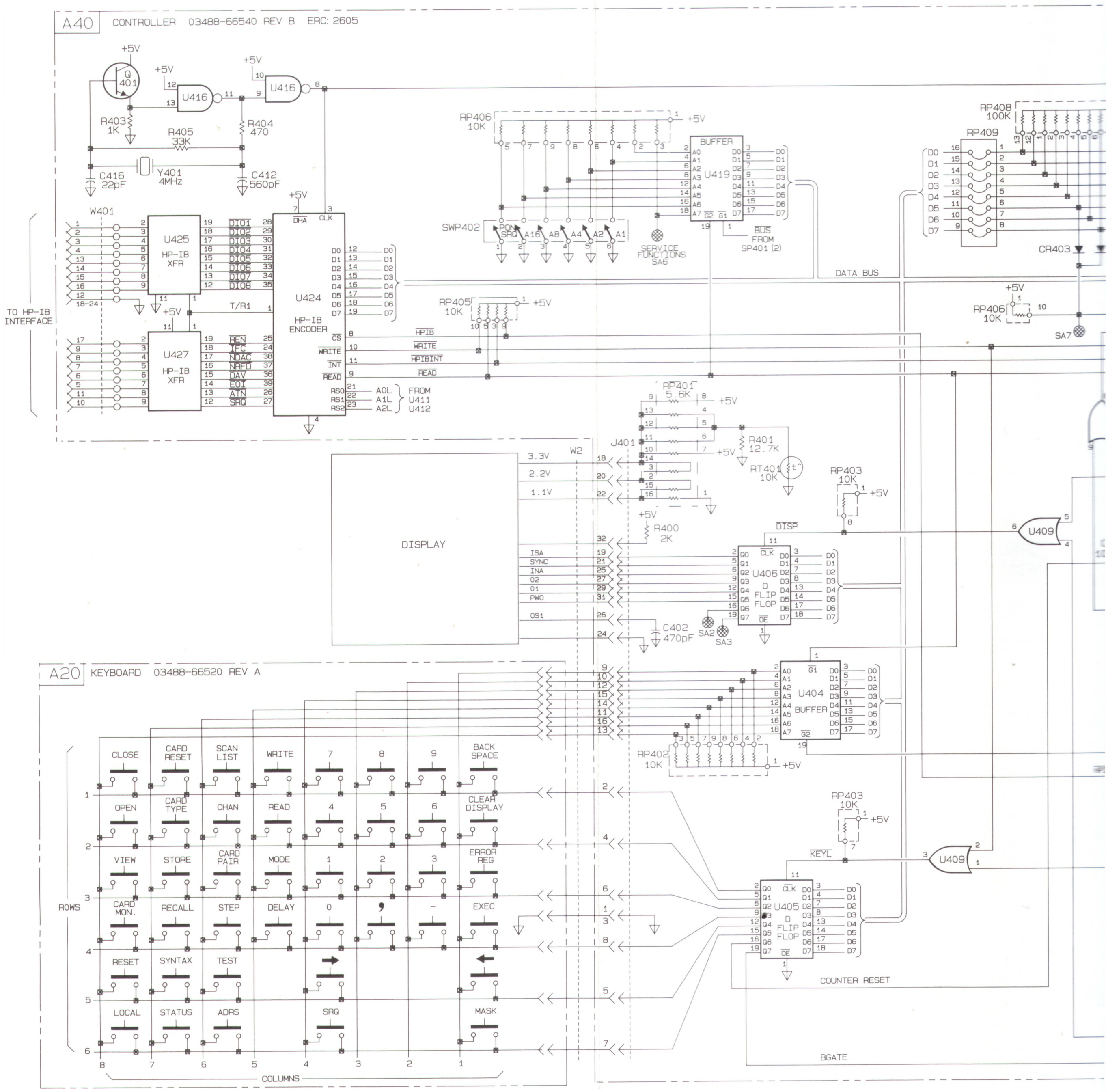


For 03488-66540 Rev. B ERC 2341 the following component locator and schematic change to U401 apply:



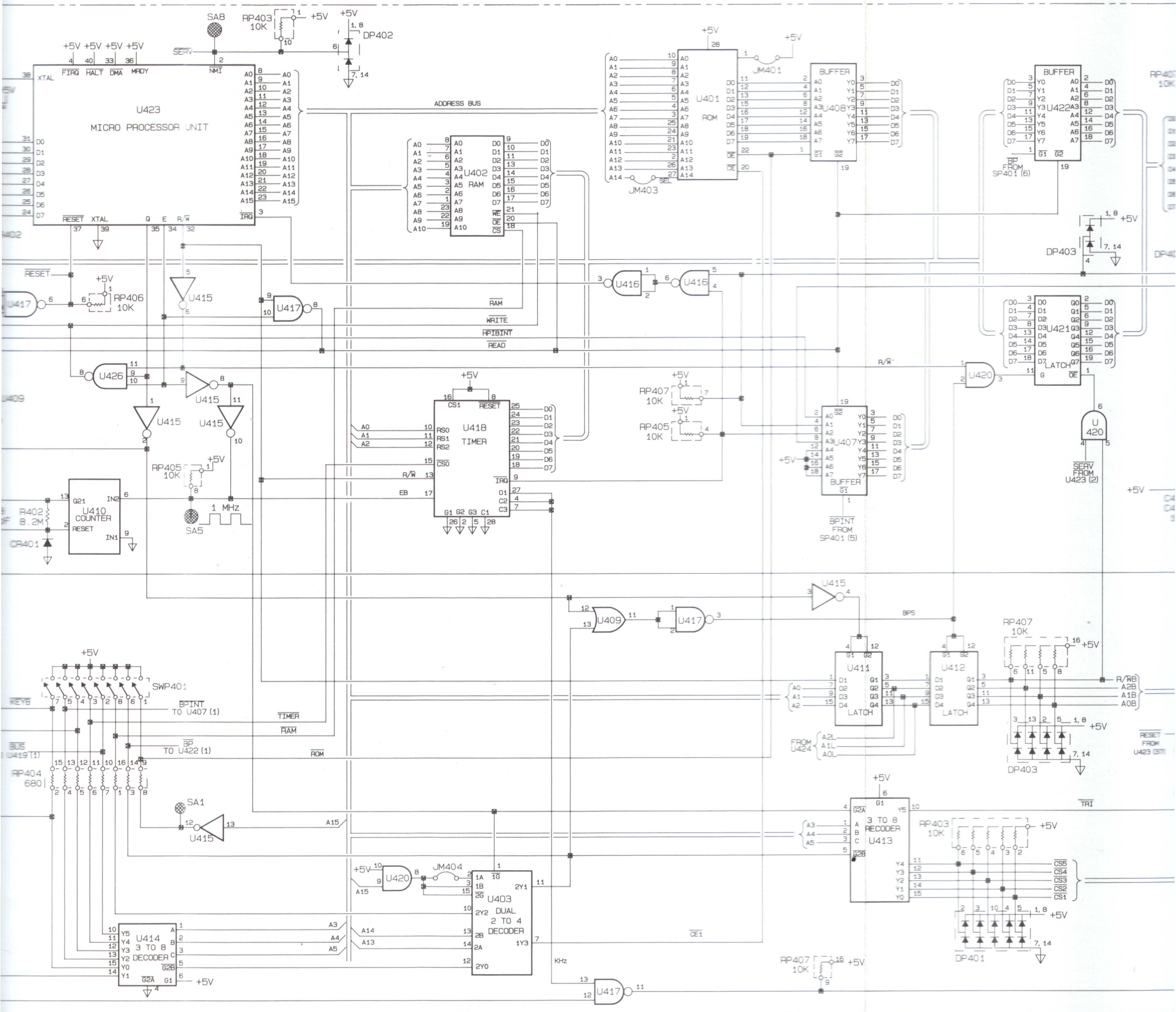


# Controller



A40 CONTROLLER 03488-66540 REV B ERC: 2605
A20 KEYBOARD 03488-66520 REV A
DISPLAY
TO HP-IB INTERFACE
U424 HP-IB ENCODER
U425 HP-IB XFR
U427 HP-IB XFR
U419 BUFFER
U404 BUFFER
U406 D FLIP FLOP
U405 D FLIP FLOP
DATA BUS
SERVICE FUNCTIONS SA6
COUNTER RESET
BGATE
CLOSE
CARD RESET
SCAN LIST
WRITE
BACK SPACE
OPEN
CARD TYPE
CHAN
READ
CLEAR DISPLAY
VIEW
STORE
CARD PAIR
MODE
ERROR REG
CARD MON.
RECALL
STEP
DELAY
EXEC
RESET
SYNTAX
TEST
LOCAL
STATUS
ADRS
SRQ
MASK
ROWS
COLUMNS

Controller




Figur

Controller

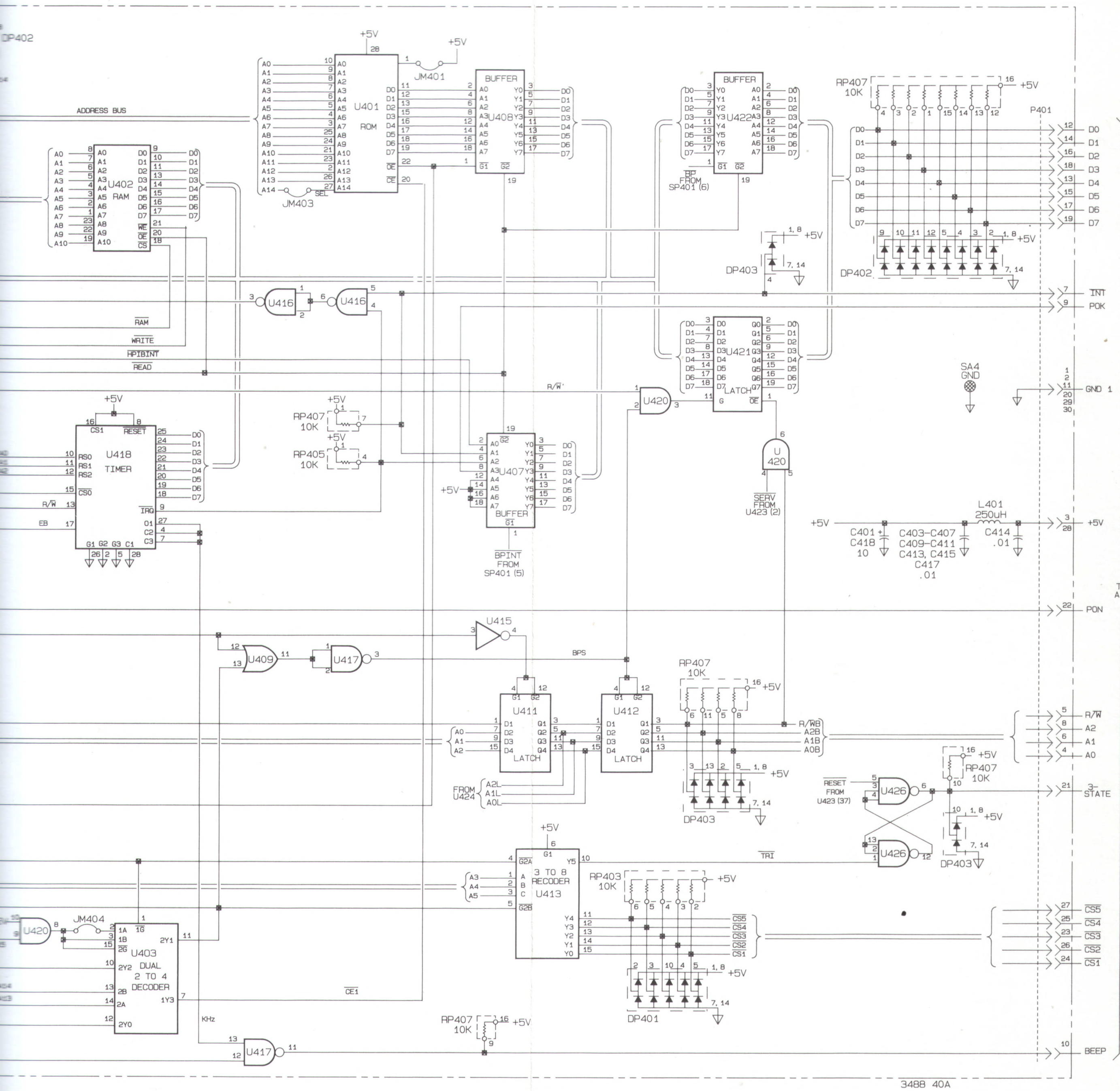



Figure 6-11 Controller Schematic