HP 4062C/PC Semiconductor Parametric Test System
HP 4062UX Semiconductor Process Control System

# System Information


HP Part No. 04062-90311
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Edition 2
E0295

## Product Warranty

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

Warranty service of this product will be performed at Buyer's facility at no charge within HP service travel areas. Outside HP service travel areas, warranty service will be performed at Buyer's facility only upon HP's prior agreement and Buyer shall pay HP's round trip travel expenses. In all other cases, products must be returned to a service facility designated by HP.

For products returned to HP for warranty service, Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

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

### 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 modifications or misuse, operation outside of the environment specifications for the products, or improper site preparation or maintenance.

No other warranty is expressed or implied. Hewlett-Packard specifically disclaims the implied warranties or 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.

### Certification

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

## Printing History

New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by the customer. The dates on the title page change only when a new edition is published. No information is incorporated into a reprinting unless it appears as a prior update; the edition does not change when an update is incorporated.

The software revision code printed before the date indicates the version level of the software product at the time the manual or update was issued. Many product updates and fixes do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one to one correspondence between product updates and manual updates.

| | |
|---|---|
| Edition 1 | For Rev. C.05.60 and X.05.60, January 1990 |
| Update 1 | For Rev. C.06.00 and X.06.00, May 1991 |
| Update 2 | For Rev. C.06.20, X.06.20, and P.06.20, November 1991 |
| Update 3 | For Emergency Off System, July 1992 |
| Update 4 | For Rev. C.06.30, X.06.30, and P.06.30, January 1993 |
| Update 5 | For Rev. X.07.00, October 1994 |
| Edition 2 | For incorporating all updates, February 1995 |

## 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 may impair the protections provided by the equipment. In addition, it violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for customer's failure to comply with these requirements.

**Note**

HP 4062C/UX complies with INSTALLATION CATEGORY II and POLLUTION DEGREE 2 defined in IEC 1010-1.
HP 4062C/UX is INDOOR USE product.

*GROUND THE INSTRUMENT*

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The power terminal and the power cable must 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*

Operation 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 services and repair to ensure that safety features are maintained.

*DANGEROUS PROCEDURE WARNINGS*

Warnings, such as 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.**

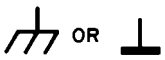
## Safety Symbols

The general definitions of safety symbols used on equipment or in manuals are listed below.

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).

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.




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

Alternating current.

Direct current.



ON (Supply).

OFF (Supply).

STANDBY (Supply).

**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 a procedure, practice, condition or the like, which is essential to highlight.

# Preface

## Purpose

This manual contains the hardware-related information you'll need to maintain your HP 4062 system. Refer to this manual before you begin to operate your HP 4062 system.

## Audience

This manual is intended for system operators and administrators of the HP 4062C/UX/PC.

## Contents

Chapter 1, General Information, covers the HP 4062C/UX/PC's specifications, options, accessories, and system identification.

Chapter 2, Theory of Operation, describes basic system component operating theory.

Chapter 3, Operator Instructions, explains panel features and cleaning procedures.

Chapter 4, Diagnostics, covers system test and verification using the system software's Diagnostics (DIAG) program.

Chapter 5, Technical Information, provides technical HP 4062C/UX/PC application and operator information.

Appendix A, Error Messages, lists all the HP 4062C/UX/PC error messages.

Appendix B, Before Requesting Repair, provides items to check before you request repairs when your HP 4062C/UX/PC is not working properly.

Appendix C, Manual Backdates, describes how to make this manual compatible with previous revisions of the system software.

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# Figures

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# 1

# General Information

## Introduction

This chapter covers HP 4062C/PC Semiconductor Parametric Test System and HP 4062UX Semiconductor Process Control System specifications, identification, options, accessories, and other basic information. Figure 1-1 shows a typical HP 4062C/UX/PC.

If you haven't read the Preface at the beginning of this manual, please do so before continuing. The Preface contains descriptions of the contents of each of this manual's chapters.

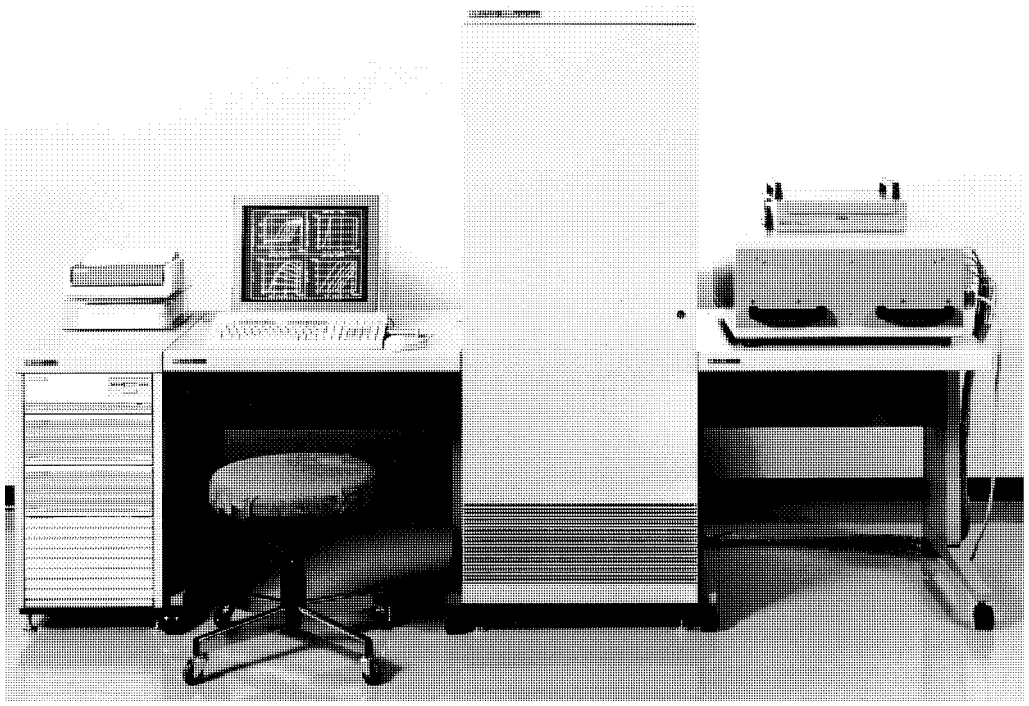

**Figure 1-1. HP 4062C/UX/PC Semiconductor Test System**

**Note** Computer tables are not furnished, but can be ordered separately from HP.

## Configuration

The standard HP 4062C/UX/PC consists of three basic subsystems, totaling four separate instruments (not including the system controller). All subsystems are controlled via the Hewlett-Packard Interface Bus (HP-IB) by a system controller. The system controller is equipped with BASIC for the HP 4062C/PC or BASIC/UX running under the HP-UX operating system for the HP 4062UX.

Throughout the HP 4062C/UX/PC documentation, the following abbreviations are used to identify the HP 4062C/UX/PC's subsystems and instruments.

- SMS: Switching Matrix Subsystem:

  The SMS consists of the following two instruments:

  SWC: HP 4084B Switching Matrix Controller
  SWM: HP 4085B 48-pin or HP 4089B 96-pin Switching Matrix

- DCS: DC Measurement Subsystem: HP 4142B Modular DC Source/Monitor
- CMS: Capacitance Measurement Subsystem:

  The CMS consists of the one of the following instruments:

  CMU: HP 4280A 1 MHz C Meter/C-V Plotter
  CMU84: HP 4284A Precision LCR Meter
  LCR: HP 4274A Multi-Frequency LCR Meter

Figure 1-2 shows the basic configuration for an HP 4062C/UX/PC equipped with a 48-pin SWM, including the system controller. Figure 1-3 shows the basic configuration for an HP 4062C/UX/PC equipped with a 96-pin SWM, including the system controller.

**Note**

In addition, the HP 4062C requires a VFP Timer Board. When the LCR exists in the HP 4062C, it is connected to the HP-IB interface with a select code of 7.

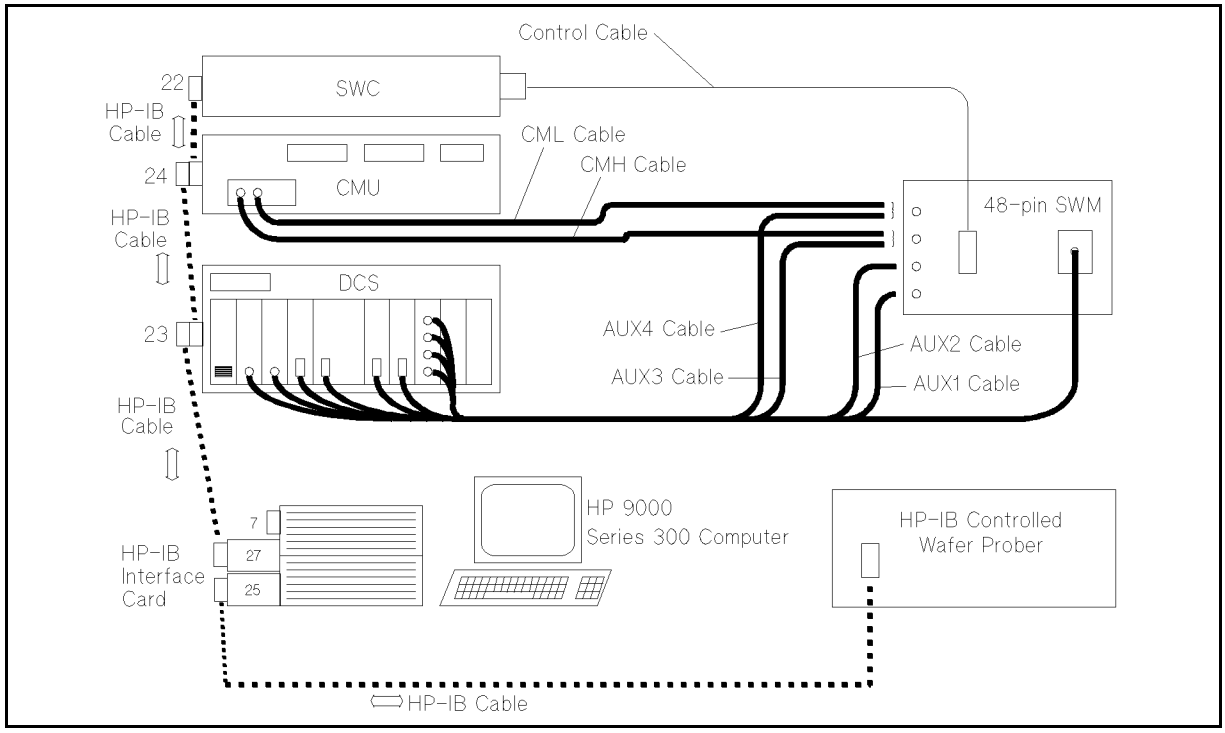


**Figure 1-2. Standard System Configuration (48-pin SWM System)**

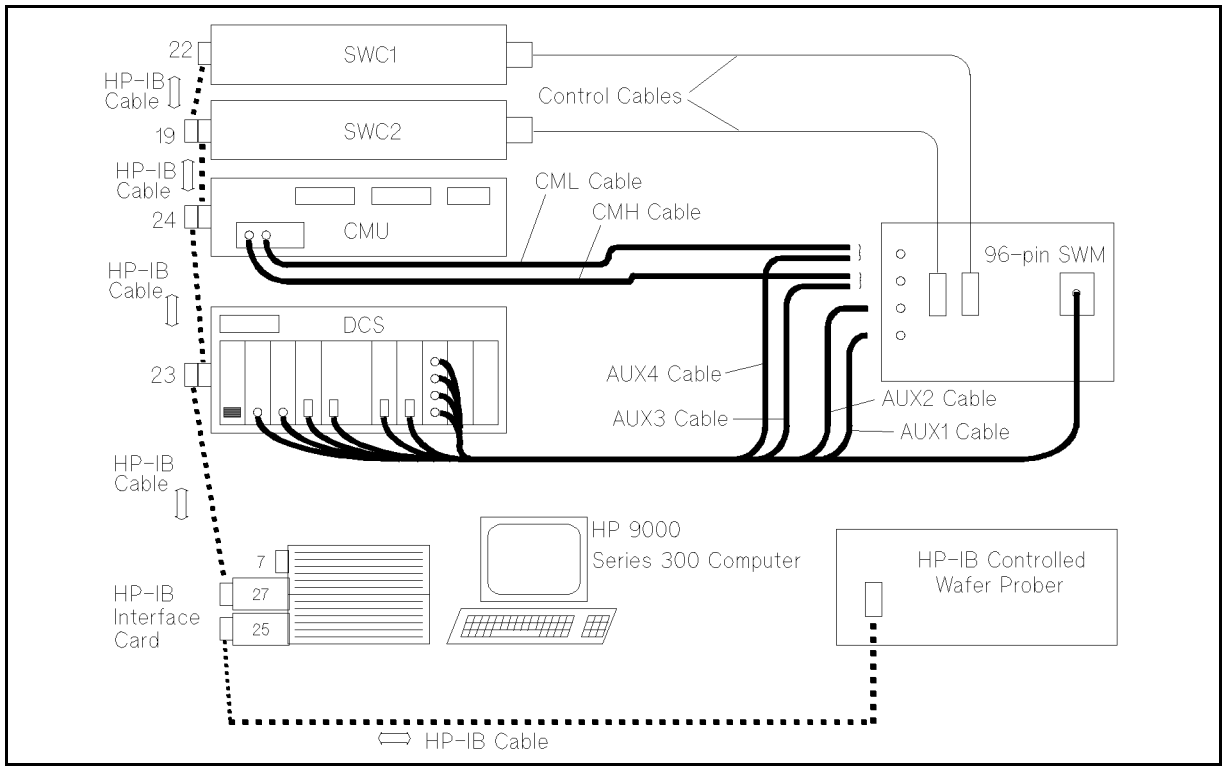


**Figure 1-3. Standard System Configuration (96-pin SWM System)**

## Serial Numbers

Hewlett-Packard uses a two-section, ten-character serial number stamped on a serial number plate or label attached to the back of the system cabinet and rear panels of each instrument. Figure 1-4 shows an example serial number plate. The first four digits and the letter are the serial prefix, and the last five digits are the suffix. The letter in the serial prefix indicates the instrument's country of manufacture.


**Figure 1-4. Serial Number Plate**

Serial number prefixes are the same for identical systems, and they change only when a change is made to the system. The suffix, however, is assigned sequentially and is different for each system.

## Options

Table 1-1 lists the available HP 4062C options; Table 1-2 lists the available HP 4062C/UX options.

**Table 1-1. HP 4062C Options**

| Option | Description |
|---|---|
| 001 | 12-pin Configuration of 48-pin SWM |
| 002 | 24-pin Configuration of 48-pin SWM |
| 003 | 36-pin Configuration of 48-pin SWM |
| 004 | Add Spare Pin Board of 48-pin SWM |
| 012 | 24-pin Configuration of 96-pin SWM |
| 013 | 36-pin Configuration of 96-pin SWM |
| 014 | 48-pin Configuration of 96-pin SWM |
| 015 | 64-pin Configuration of 96-pin SWM |
| 016 | 72-pin Configuration of 96-pin SWM |
| 017 | 84-pin Configuration of 96-pin SWM |
| 018 | 96-pin Configuration of 96-pin SWM |
| 019 | Add Spare Pin Board of 96-pin SWM |
| 020 | Replace an HP 41420A SMU with an HP 41421B SMU |
| 021 | Add Spare HP 41421B SMU |
| 022 | Add Spare HP 41420A SMU |
| 023 | Add Spare HP 41424A VS/VMU |
| 024 | Delete one HP 41421B SMU |
| 025 | Delete one HP 41420A SMU |
| 026 | Delete one HP 41424A VS/VMU |
| 027 | Delete one HP 41425A |
| 050 | 50 Hz Line Frequency |
| 060 | 60 Hz Line Frequency |
| 102 | Delete HP 4280A 1 MHz C Meter/C-V Plotter |
| 110 | Delete Package Device Test Fixtures for 48-pin SWM |
| 115 | Delete Package Device Test Fixtures for 96-pin SWM |
| 130 | Delete System Cabinet |
| 310 | Add HP 4274A Multi-Frequency LCR Meter |
| 311 | Add ±35 V dc Bias for HP 4274A |
| 312 | Add ±100 V dc Bias for HP 4274A |
| 320 | Add HP 4284A 20 Hz – 1 MHz Precision LCR Meter with ±40 V Internal DC Bias Option |
| 340 | Add a Port Expander |
| 341 | Add an SMU Cable (4 m, Triaxial) |
| 405 | System Software Right-to-Copy |
| 450 | Add HP IMA Software License-to-use, Media, and Manuals |
| 451 | Add HP IMA Software License-to-use |
| 503 | HP 16072A Personality Board |

**Table 1-1. HP 4062C Options (continued)**

| Option | Description |
|---|---|
| 540 | Delete HP 16071B Universal Fixture for 48-pin SWM |
| 541 | Delete HP 16072A Personality Board for 48-pin SWM |
| 550 | Delete HP 16376A Universal Fixture for 96-pin SWM |
| 552 | Delete HP 16377A Personality Board for 96-pin SWM |
| 570 | Add HP 16071B Universal Fixture for 48-pin SWM |
| 571 | Add HP 16072A Option 001 Personality Board for 48-pin SWM |
| 572 | Add HP 16072B Personality Board for 48-pin SWM |
| 573 | Add HP 16072B Option 001 Personality Board for 48-pin SWM |
| 580 | Add HP 16376B Universal Fixture for 96-pin SWM |
| 582 | Add HP 16377B Personality Board for 96-pin SWM |
| 701 | Series 300 SPU Rack Mount Kit |
| 702 | Series 300 & Backplane Expander Rack Mount Kit |
| 703 | SPU Rack Mount Kit for Series 300 model 362 and 382 |
| 704 | SPU & Backplane Expander Rack Mount Kit for Series 300 model 362 and 382 |
| 710 | Hard Disk Rack Mount Kit (for HP 9153A/B, or HP 9154A/B) |
| 720 | Hard Disk Rack Mount Kit (for HP 9133H, 7957A/B, 7958A/B, 7959B, HP 7962B, or HP 7963B) |
| 730 | Hard Disk Rack Mount Kit (for HP 7946A) |
| 740 | Cartridge Tape Drive Rack Mount Kit (for HP 9144A or HP 9145A) |
| 910 | Extra System Documentation Library |
| P53 | Add HP IMA/PC Software License-to-use |
| P55 | Add HP IMA/PC Software License-to-use, Media (5.25 inch), and Manuals |
| P57 | Add HP IMA/PC Software License-to-use, Media (3.5 inch), and Manuals |
| PC5 | HP 4062PC Software License-to-use, Media (5.25 inch), and Manuals |
| PC7 | HP 4062PC Software License-to-use, Media (3.5 inch), and Manuals |
| PCL | HP 4062PC Software License-to-use |
| 1BE | Replace System Cabinet with a Small Cabinet (1 m height) |

**Table 1-2. HP 4062UX Options**

| Option | Description |
|---|---|
| 050 | 50 Hz Line Frequency |
| 060 | 60 Hz Line Frequency |
| 022 | HP 4062UX software (1/4 inch tape media), and HP-UX and HP BASIC/UX software (1/4 inch tape media) and manuals |
| 023 | HP 4062UX, HP-UX, and HP BASIC/UX software (DDS[1] formatted DAT[2]) and manuals |
| 024 | HP 4062UX software (DDS formatted DAT) |
| 032 | Software (1/4 inch tape media) and manuals for system software used with C Language |
| 033 | Software (DDS formatted DAT) and manuals for system software used with C Language |
| 1BE | Replace System Cabinet with a Small Cabinet (1 m height) |
| 310 | 12-pin Configuration—HP 4085B (48-pin) SWMs |
| 311 | Add One HP 16320B Pin Board—HP 4085B SWMs |
| 312 | Add Packaged Device Test Fixtures—HP 4085B SWMs |
| 313 | Add HP 16077A Cable Extension Fixture—HP 4085B SWMs |
| 314 | Add HP 16071A Universal Fixture—HP 4085B SWMs |
| 315 | Add HP 16071B Universal Fixture—HP 4085B SWMs |
| 316 | Add HP 16072A Personality Board—HP 4085B SWMs |
| 317 | Add HP 16072A Option 001 Personality Board—HP 4085B SWMs |
| 318 | Add HP 16072B Personality Board—HP 4085B SWMs |
| 319 | Add HP 16072B Option 001 Personality Board—HP 4085B SWMs |
| 330 | 24-pin Configuration—HP 4089B SWMs |
| 331 | Add One HP 16320D Pin Board—HP 4089B SWMs |
| 332 | Add Packaged Device Fixtures—HP 4089B SWMs |
| 333 | Add HP 16378B Cable Extension Fixture |
| 334 | Add HP 16376A Universal Fixture—HP 4089B SWMs |
| 335 | Add HP 16376B Universal Fixture—HP 4089B SWMs |
| 336 | Add HP 16377A Personality Board—HP 4089B SWMs |
| 337 | Add HP 16377B Personality Board—HP 4089B SWMs |
| 340 | Add a Port Expander |
| 341 | Add an SMU Cable (4 m, Triaxial) |

1 DDS stands for Digital Data Storage.

2 DAT stands for Digital Audio Tape.

**Table 1-2. HP 4062UX Options (continued)**

| Option | Description |
|---|---|
| 400 | Add HP 4142B Modular DC Source/Monitor (DCS) |
| 405 | Rack Mount Kit for HP 4142B |
| 410 | Add HP 41420A SMU (200 V/1 A) |
| 411 | Add HP 41421B SMU (100 V/100 mA) |
| 414 | Add HP 41424A VS/VMU |
| 415 | Add HP 41425A AFU |
| 450 | Add HP IMA Software License-to-use, Media (1/4 inch tape), and Manuals |
| 451 | Add HP IMA Software License-to-use |
| 452 | Add HP IMA Software License-to-use, Media (DDS formatted DAT), and Manuals |
| 510 | Add HP 4280A 1 MHz C Meter/C-V Plotter (CMU) |
| 515 | Rack Mount Kit for HP 4280A |
| 520 | Add HP 4274A Multi-Frequency LCR Meter (LCR) |
| 521 | Add ±35 V dc Bias for HP 4274A |
| 522 | Add ±100 V dc Bias for HP 4274A |
| 525 | Rack Mount Kit for HP 4274A |
| 530 | Add HP 4284A 20 Hz – 1 MHz Precision LCR Meter with ±40 V Internal DC Bias Option |
| 535 | Rack Mount Kit for HP 4284A |
| 701 | Series 300 SPU Rack Mount Kit |
| 702 | Series 300 & Backplane Expander Rack Mount Kit |
| 703 | SPU Rack Mount Kit for Series 300 model 362 and 382 |
| 704 | SPU & Backplane Expander Rack Mount Kit for Series 300 model 362 and 382 |
| 710 | Hard Disk Rack Mount Kit (for HP 9153A/B or HP 9154A/B) |
| 720 | Hard Disk Rack Mount Kit (for HP 9133H, 7957A/B, 7958A/B, 7959B, HP 7962B, or HP 7963B) |
| 730 | Hard Disk Rack Mount Kit (for HP 7946A) |
| 740 | Cartridge Tape Drive Rack Mount Kit (for HP 9144A or HP 9145A) |
| 910 | Extra System Documentation Library |

# Accessories

## Furnished Accessories

Table 1-3 lists the accessories furnished with the standard HP 4062C/UX/PC.

**Table 1-3. Furnished Accessories**

| HP Model/PN | Description |
|---|---|
| HP 16066A[1] | Test Fixture Adapter |
| HP 16075A[1] | Relay Test Adapter |
| HP 16076A[1] | System Test Module |
| HP 16355A[2] | Relay Test Adapter |
| HP 16356A[2] | System Test Module |
| HP 16370A[2] | Test Fixture Adapter |
| 04085-69001 | Pin Board Extractor |
| 8710-0900 | Screwdriver |
| 8710-1838[2] | Hexhead Wrench (5 mm) |
| 8710-1839[2] | Hexhead Wrench (6 mm) |

[1] Furnished if your HP 4062C/UX/PC is equipped with a 48-pin SWM.
[2] Furnished if your HP 4062C/UX/PC is equipped with a 96-pin SWM.

In addition to the furnished accessories listed in Table 1-3, the HP 4062C/UX/PC also includes HP 4280A or HP 4284A accessories and your system's manuals.

## Available Accessories

Additional HP 16320B Pin Boards (for HP 4085A/B 48-pin SWMs) and HP 16320D Pin Boards (for HP 4089A/B 96-pin SWMs) can be purchased as replacements or for configuration changes.

## Specifications

This paragraph contains HP 4062C/UX/PC specifications. These specifications are the performance standards or limits against which HP 4062C/UX/PCs are tested. When shipped from the factory, each system meets or exceeds the specifications listed in this paragraph.

For complete DCS specifications, refer to the HP 4142B's *Operation Manual*; for complete CMU specifications, refer to the HP 4280A's *Operation and Service Manual*; for complete CMU84 specifications, refer to the HP 4284A's *Operation Manual*.

### General Description

The HP 4062C/UX/PC measures the dc current, dc voltage, and capacitance of test samples which have up to 96 pins.

- Measurement Functions:

  DC Current, DC Voltage, and Capacitance

  - DC Measurement Mode:

    Spot Measurement, Sweep Measurement, Pulse Measurement, Pulse Sweep Measurement, and Analog Search

- Measurement Pins:

  96 (Maximum)

- SWM Instrument Ports: 9 (optionally 17)

  - High Resolution SMU: 1 port

    Current Measurement Range: ±20 fA to ±1 A

    Voltage Measurement Range: ±40 $\mu$V to ±200 V

  - High Current SMU, Kelvin: 1 port

    Current Measurement Range: ±2 pA to ±1 A

    Voltage Measurement Range: ±40 $\mu$V to ±200 V

  - SMUs, Kelvin: 2 ports

    Current Measurement Range: ±2 pA to ±1 A

    Voltage Measurement Range: ±40 $\mu$V to ±200 V

  - SMUs, Non-Kelvin: 2 ports (optional)

    Current Measurement Range: ±2 pA to ±1 A

    Voltage Measurement Range: ±40 $\mu$V to ±100 V

  - GNDU, Kelvin: 1 port

    Voltage Output Range: 0 V

  - VS/VMU: 4 ports (optionally 10)

    Voltage Output Range: ±1 mV to ±40 V

    Voltage Measurement Range: ±40 $\mu$V[1] to ±40 V

[1] 4 $\mu$V when differential V measurements.

- Capacitance Measurements:
  - CMU

    Test Frequency: 1 MHz

    Capacitance Measurement Range: 1 fF to 1.2 nF

    Conductance Measurement Range: 10 nS to 12 mS

    DC Bias Voltage: ± 100 V
  - CMU84

    Test Frequency: 1 k, 10 k, 100 k, and 1 MHz

    Capacitance Measurement Range: 1 fF to 100 nF

    Conductance Measurement Range: 0.1 nS to 7.5 mS

    DC Bias Voltage: ±40 V

### Switching Matrix Subsystem (SMS)

The HP 4062C/UX/PC's SMS consists of one of the following configurations:

One HP 4085B 48-pin SWM and one HP 4084B SWC.

or

One HP 4089B 96-pin SWM and two HP 4084B SWCs.

- SWM Measurement Pins:

  HP 4085B SWM: 48 (Maximum)

  HP 4089B SWM: 96 (Maximum)

- SWM Instrument Ports:

  The SWM provides 9 instrument ports:

  High Resolution SMU: 1 port

  High Current SMU: 1 port

  Standard SMUs: 2 ports

  GNDU: 1 port

  Auxiliary (AUX): 4 ports (optionally 12 ports)

  Auxiliary ports (AUX1–4) can be used with the DCS's VSs and VMs (up to 4 ports); and the CMS (up to 2 ports—AUX3 and 4) for C, C-V, and C-t measurements.

  If the SWM is equipped with a port expander, up to 12 ports can be used. AUX11–13, AUX21–23, AUX31–32, and AUX41–42 can be used with the DCS's VSs and VMs (up to 10 ports), AUX31 and AUX41 can be used with the CMS for C, C-V, and C-t measurements, and AUX33 and AUX43 can be used with the SMU for general dc measurements.

- Maximum Voltage at Each Port:

  ±200 V: SMU ports

  ±100 V: AUX ports

- Maximum Current through Ports to Pins:

  ±1.6 A: GNDU port

  ±1.0 A: SMU ports

  ±500 mA: AUX1–2 or AUX11–13 and AUX21–23 ports

  ±1.0 A: AUX3–4 or AUX31–33 and AUX41–43 ports

- Maximum Stray Capacitance: ≤6 pF (between C measurement ports)

## DC Measurement Subsystem (DCS)

The HP 4062C/UX/PC's DCS consists of the HP 4142B Modular DC Source/Monitor and your combination of the following plug-in modules:

HP 41421B 100 V/100 mA SMU, 1 slot

HP 41420A 200 V/1 A SMU, 2 slots

HP 41424A VS/VMU, 1 slot

HP 41425A AFU, 1 slot

The DCS provides 8 plug-in module slots.

### High Resolution SMU: 1 port

This port is for low current measurement.

HP 41420A or HP 41421B SMU is used.

**Voltage Source/Monitor Range, Resolution, and Accuracy (@ 48-pin SWM pins)**

| V Range Full Scale | Resolution Force/Measure | Accuracy (Io = Output I) ±(% of reading + % of range + V) |
|---|---|---|
| ±2 V | 100 μV/40 μV | ±(0.05%+0.05%+0.5 Ω×Io+100 μV) |
| ±20 V | 1 mV/400 μV | ±(0.05%+0.05%+0.5 Ω×Io) |
| ±40 V | 2 mV/800 μV | |
| ±100 V | 5 mV/2 mV | |
| ±200 V[1] | 10 mV/4 mV | |

1 HP 41420A SMU only.

**Voltage Source/Monitor Range, Resolution, and Accuracy (@ 96-pin SWM pins)**

| V Range Full Scale | Resolution Force/Measure | Accuracy (Io = Output I) ±(% of reading + % of range + V) |
|---|---|---|
| ±2 V | 100 μV/40 μV | ±(0.05%+0.05%+0.6 Ω×Io+100 μV) |
| ±20 V | 1 mV/400 μV | ±(0.05%+0.05%+0.6 Ω×Io) |
| ±40 V | 2 mV/800 μV | |
| ±100 V | 5 mV/2 mV | |
| ±200 V[1] | 10 mV/4 mV | |

1 HP 41420A SMU only.

**Current Source/Monitor Range, Resolution, and Accuracy**

| I Range Full Scale | Resolution Force/Measure | Accuracy (Vo = Output V) ±(% of reading + of range +A) |
|---|---|---|
| 1 A[1] | 50 μA/20 μA | ±[0.5%+(0.1+0.002×Vo)%] |
| ±100 mA | 5 μA/2 μA | ±[0.2%+(0.1+0.002×Vo)%] |
| ±10 mA | 500 nA/200 nA | |
| ±1 mA | 50 nA/20 nA | |
| ±100 μA | 5 nA/2 nA | |
| ±10 μA | 500 pA/200 pA | |
| ±1 μA | 50 pA/20 pA | ±[0.5%+(0.1+0.002×Vo)%] |
| ±100 nA | 5 pA/2 pA | |
| ±10 nA | 500 fA/200 fA[2] | ±[1%+(0.002×Vo)%+15 pA] |
| ±1 nA | 50 fA/20 fA[2] | ±[1%+(0.002×Vo)%+8 pA] |

1 HP 41420A SMU only.

2 I monitor resolution of 200 fA/20 fA @ 10 nA/1 nA ranges are obtained when the DCS's integration time is set to LONG.

Residual Resistance: ≤0.5 Ω (48-pin SWM); ≤0.6 Ω (96-pin SWM)

Input Resistance: $\geq 10^{12}$ Ω (in I source mode)

Output Terminals: Force and Guard

### High Current SMU: 1 port

This port is for low voltage measurement with high current output.

HP 41420A or HP 41421B SMU is used.

**Voltage Source/Monitor Range, Resolution, and Accuracy**

| V Range Full Scale | Resolution Force/Measure | Accuracy (Io = Output I) ±(% of reading + % of range + V) |
|---|---|---|
| ±2 V | 100 μV/40 μV | ±(0.05%+0.05%+2.5 mΩ×Io+100 μV) |
| ±20 V | 1 mV/400 μV | ±(0.05%+0.05%+2.5 mΩ×Io) |
| ±40 V | 2 mV/800 μV | ±(0.05%+0.05%) |
| ±100 V | 5 mV/2 mV | |
| ±200 V[1] | 10 mV/4 mV | |

1 HP 41420A SMU only.

**Current Source/Monitor Range, Resolution, and Accuracy**

| I Range Full Scale | Resolution Force/Measure | Accuracy (Vo = Output V) ±(% of reading + % of range) |
|---|---|---|
| ±1 A[1] | 50 μA/20 μA | ±[0.5%+(0.1+0.002×Vo)%] |
| ±100 mA | 5 μA/2 μA | ±[0.2%+(0.1+0.002×Vo)%] |
| ±10 mA | 500 nA/200 nA | |
| ±1 mA | 50 nA/20 nA | |
| ±100 μA | 5 nA/2 nA | |
| ±10 μA | 500 pA/200 pA | ±[0.2%+(0.1+0.003×Vo)%] |
| ±1 μA | 50 pA/20 pA | ±[0.5%+(0.01×Vo)%+2 nA] |
| ±100 nA | 5 pA/2 pA | ±[0.5%+(0.1×Vo)%+1 nA] |

1 HP 41420A SMU only.

Note: 10 nA and 1 nA ranges are not specified.

Input Resistance: $\geq 10^{10}$ Ω (in I source mode)

Output Terminals: Force, Sense, and Guard

**SMUs: 2 ports**

HP 41420A or HP 41421B SMU is used.

**Voltage Source/Monitor Range, Resolution, and Accuracy (@ 48-pin SWM pins)**

| V Range Full Scale | Resolution Force/Measure | Accuracy (Io = Output I) ±(% of reading + % of range + V) |
|---|---|---|
| ±2 V | 100 μV/40 μV | ±(0.05%+0.05%+100 μV)(0 A≤Io≤0.1 A)<br>Add 40 mΩ×Io[1] (0.1 A<Io≤0.5 A)<br>Add 200 mΩ×Io[1] (0.5 A<Io≤1 A) |
| ±20 V | 1 mV/400 μV | ±(0.05%+0.05%) (0 A≤Io≤0.1 A)<br>Add 40 mΩ×Io[1] (0.1 A<Io≤0.5 A)<br>Add 200 mΩ×Io[1] (0.5 A<Io≤1 A) |
| ±40 V | 2 mV/800 μV | ±(0.05%+0.05%) |
| ±100 V | 5 mV/2 mV | |
| ±200 V[2] | 10 mV/4 mV | |

1 Reference data only.

2 HP 41420A SMU only.

**Voltage Source/Monitor Range, Resolution, and Accuracy (@ 96-pin SWM pins)**

| V Range Full Scale | Resolution Force/Measure | Accuracy (Io = Output I) ±(% of reading + % of range + V) |
|---|---|---|
| ±2 V | 100 μV/40 μV | ±(0.05%+0.05%+2.5 mΩ×Io+100 μV) |
| ±20 V | 1 mV/400 μV | ±(0.05%+0.05%+2.5 mΩ×Io) |
| ±40 V | 2 mV/800 μV | ±(0.05%+0.05%) |
| ±100 V | 5 mV/2 mV | |
| ±200 V[1] | 10 mV/4 mV | |

1 HP 41420A SMU only.

**Current Source/Monitor Range, Resolution, and Accuracy**

| I Range Full Scale | Resolution Force/Measure | Accuracy (Vo = Output V) ±(% of reading + % of range) |
|---|---|---|
| ±1 A[1] | 50 μA/20 μA | ±[0.5%+(0.1+0.002×Vo)%] |
| ±100 mA | 5 μA/2 μA | ±[0.2%+(0.1+0.002×Vo)%] |
| ±10 mA | 500 nA/200 nA | |
| ±1 mA | 50 nA/20 nA | |
| ±100 μA | 5 nA/2 nA | |
| ±10 μA | 500 pA/200 pA | ±[0.2%+(0.1+0.003×Vo)%] |
| ±1 μA | 50 pA/20 pA | ±[0.5%+(0.01×Vo)%+2 nA] |
| ±100 nA | 5 pA/2 pA | ±[0.5%+(0.1×Vo)%+1 nA] |

1 HP 41420A SMU only.

Note: 10 nA and 1 nA ranges are not specified.

Input Resistance: $\geq 10^{10}$ Ω (I source mode)

Output Terminal: Force, Sense, and Guard

### SMUs on Port Expander: 2 ports

HP 41420A or HP 41421B SMU is used.

**Voltage Source/Monitor Range, Resolution, and Accuracy (@ 96-pin SWM pins)**

| V Range Full Scale | Resolution Force/Measure | Accuracy (Io = Output I) ±(% of reading + % of range + V) |
|---|---|---|
| ±2 V | 100 μV/40 μV | ±(0.05%+0.05%+1.3 Ω×Io+180 μV) |
| ±20 V | 1 mV/400 μV | ±(0.05%+0.05%+1.3 Ω×Io) |
| ±40 V | 2 mV/800 μV | |
| ±100 V | 5 mV/2 mV | |
| ±200 V[1] | 10 mV/4 mV | |

1 HP 41420A SMU only. Note that the maximum voltage is 100 V.

**Current Source/Monitor Range, Resolution, and Accuracy**

| I Range Full Scale | Resolution Force/Measure | Accuracy (Vo = Output V) ±(% of reading + % of range + A) |
|---|---|---|
| ±1 A[1] | 50 μA/20 μA | ±[0.5%+(0.1+0.002×Vo)%] |
| ±100 mA | 5 μA/2 μA | ±[0.2%+(0.1+0.002×Vo)%] |
| ±10 mA | 500 nA/200 nA | |
| ±1 mA | 50 nA/20 nA | |
| ±100 μA | 5 nA/2 nA | |
| ±10 μA | 500 pA/200 pA | ±[0.2%+(0.1+0.003×Vo)%] |
| ±1 μA | 50 pA/20 pA | ±[0.5%+(0.01×Vo)%+2 nA] |
| ±100 nA | 5 pA/2 pA | ±[0.5%+(0.1×Vo)%+1 nA] |

1 HP 41420A SMU only.

Note: 10 nA and 1 nA ranges are not specified.

Input Resistance: $\geq 10^{10}$ Ω (I source mode)

Output Terminal: Force and Guard

### SMU Common Specifications

**Voltage Source/Monitor Ranges and Maximum Currents**

| V Range Full Scale | Maximum Current | |
|---|---|---|
| | HP 41420A | HP 41421B |
| ±2 V | 1.0 A | 100 mA |
| ±20 V | 1.0 A (≤14 V)<br>0.7 A (≤20 V) | 100 mA |
| ±40 V | 350 mA | 50 mA |
| ±100 V | 125 mA | 20 mA |
| ±200 V | 50 mA | — |

**Current Source/Monitor Range and Max. Voltage**

| I Range Full Scale | Maximum Voltage | |
|---|---|---|
| | HP 41420A | HP 41421B |
| ±1 A | 14 V (≤1 A)<br>20 V (≤0.7 A)<br>40 V (≤350 mA)<br>100 V (≤125 mA)<br>200 V (≤50 mA) | — |
| ±100 mA | 100 V (≤100 mA)<br>200 V (≤50 mA) | 20 V (≤100 mA)<br>40 V (≤50 mA)<br>100 V (≤20 mA) |
| ±10 mA<br>±1 mA<br>±100 nA<br>±10 nA<br>±1 nA | 200 V | 100 V |

- Maximum Output Power: 14 W (HP 41420A SMU); 2 W (HP 41421B SMU)
- Current Over-range: 15% of range, 0% of maximum range
- Current/Voltage Compliance:
  - Setting Range:

    1 pA ≤ I Compliance ≤ Maximum I

    V Compliance ≤ Maximum V
  - Setting Accuracy:

    Same as accuracy indicated previously for all SMUs.
  - Opposite Polarity Setting Accuracy:

    +2%: 100 nA to 1 A ranges

    +10%: 1 nA and 10 nA ranges

**Note**

Accuracies are specified at 23° C ±5° C after a minimum 40 minute warm-up period, with less than 3° C temperature change after calibration. Accuracies apply at all measurement pins. Errors double at 5° C–18° C and 28° C–40° C.

### SMU Reference Data

Maximum Capacitance Load: 1000 pF

Maximum Allowable Guard Capacitance: 100 pF

Maximum Slew Rate: 0.2 V/$\mu$s

**Note** Reference data are *not* guaranteed specifications, but are provided as additional operator information.

#### Auxiliary (AUX): 4 ports (optionally 10 ports)

HP 41424A VS/VMU is used.

The VS/VMU provides two V source channels, VS1 and VS2, that can also monitor current; and two V monitor channels, VM1 and VM2, that can also function as a differential voltmeters.

- VS1 and VS2:

**VS Voltage Output Range, Resolution, and Accuracy**

| V Range Full Scale | Resolution | Accuracy | Max. I |
|---|---|---|---|
| ±20 V | 1 mV | ±(0.1% of setting + 10 mV) | 100 mA |
| ±40 V | 2 mV | ±(0.1% of setting + 20 mV) | 20 mA |

**VS Current Measurement Range, Resolution, and Accuracy**

| I Range Full Scale | Resolution | Accuracy | V Range |
|---|---|---|---|
| ±20 mA | 20 μA | ±(3% of reading + 200 μA) | 40 V |
| ±100 mA | 100 μA | ±(3% of reading + 1 mA) | 20 V |

Output Terminal: Force and Guard

**Note** Accuracies are specified at 23° C ±5° C after a minimum 40 minute warm-up period, with less than 3° C temperature change after calibration. Accuracies apply at all measurement pins. Errors double at 5° C–18° C and 28° C–40° C.

- VS Reference Data:

  Output Resistance: ≤2.0 Ω (Typically 1.0 Ω)

  Maximum Capacitance Load: 10 μF

  Maximum Slew Rate: 0.2 V/μs

  Current Limit Accuracy: −0%, +20%

**Note** Reference data are *not* guaranteed specifications, but are provided as additional operator information.

- VM1 and VM2

**VM Input Range, Resolution, and Accuracy (Grounded Measurements)**

| V Range Full Scale | Resolution | Accuracy | AUX Port Number |
|---|---|---|---|
| ±2 V | 40 μV | ±(0.05% of reading + 1.1 mV) | 1–4, 11–13, 21–23 |
| | | ±(0.05% of reading + 1.2 mV) | 31, 32, 41, 42 |
| ±20 V | 400 μV | ±(0.05% of reading + 10 mV) | 1–4, 11–13, 21–23, 31, 32, 41, 42 |
| ±40 V | 800 μV | ±(0.05% of reading + 20 mV) | 1–4, 11–13, 21–23, 31, 32, 41, 42 |

**VM Input Range, Resolution, and Accuracy (Differential Measurements)**

| V Range Full Scale | Resolution | Max. Common Voltage | Accuracy (Vi = VM2 Input V) ±(% of reading + V + common mode error) | AUX Port Number |
|---|---|---|---|---|
| ±0.2 V | 4 μV | 40 V | ±(0.2% + 0.5 mV + 2.5 μV×Vi) | 1–4 |
| | | | ±(0.2% + 0.62 mV + 2.5 μV×Vi) | 11–13, 21–23 |
| | | | ±(0.2% + 0.76 mV + 2.5 μV×Vi) | 31, 32, 41, 42 |
| ±2 V | 40 μV | 40 V | ±(0.1% + 2.1 mV + 25 μV×Vi) | 1–4, 11–13, 21–23, 31, 32, 41, 42 |

**Note**

Accuracies are specified at 23° C ±5° C after a minimum 40 minute warm-up period, with less than 3° C temperature change after calibration. Accuracies apply at all measurement pins. Errors double at 5° C–18° C and 28° C–40° C.

- VM Reference Data:

  Input Resistance: ≥50 MΩ

**Note**

Reference data are *not* guaranteed specifications, but are provided as additional operator information.

### Pulsed Measurements

Pulsed bias and pulsed sweep measurements can be performed using SMUs and VSs.

Measurement Modes:

Pulsed spot, Pulsed linear sweep, and linear sweep with pulsed bias

Pulse Width Setting Range: 1 ms to 50 ms, 0.1 ms resolution

Pulse Period Setting Range: 10 ms to 500 ms, 0.1 ms resolution

Hold Time setting Range: 0 ms to 655.35 s, 0.01 s resolution

Pulsed V Force Range: 2 V to 200 V

Pulsed I Force Range: 10 nA to 1 A

### Ground Unit (GNDU)

The GNDU can be used as measurement ground.

Output V: 0 V

I Range: ±1.6 A

Offset V: ±1 mV

Maximum Capacitance Load: 10 $\mu$F (reference data only)

### Analog Feedback Unit (AFU)

HP 41425A AFU.

By using an analog feedback method, the AFU performs high speed measurements by controlling the output voltage of one SMU (Search SMU) while another SMU (Sense SMU) monitors I or V until a specified target value is reached.

Search SMU Specifications:

Search V Range: 2 V, 20 V, 40 V, 100 V, or 200 V (HP 41420A)

Search V Slew Rate Range: 0.5 mV/ms–100 V/ms

Search Start V Accuracy: 0.5% of setting + 0.5% of V range

Search Stop V Accuracy: 3% of V range

Search V Slew Rate Resolution: 1/100 of slew rate range

Feedback Integration Time Range: 2.5 $\mu$s–500 ms

Sense SMU Specifications:

Setting Range and Resolution: Same as SMU used

Setting Accuracy: SMU's accuracy + 0.1% of setting value + 0.1% of SMU's range

Maximum I Setting Value: 900 mA (HP 41420A); 90 mA (HP 41421B)

Maximum V Setting Value: 180 V (HP 41420A); 90 V (HP 41421B)

### AFU Reference Data

Sense SMU Specifications:

Search V Slew Rate Accuracy: 30% + 10% of slew rate range

Ramp Voltage Stop Delay Time: 5 $\mu$s

Feedback Integration Time accuracy: 30% of Setting

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**Note**

Reference data are *not* guaranteed specifications, but are provided as additional operator information.

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## Capacitance Measurement Subsystem (CMS)

The HP 4062C/UX/PC's CMS consists of the HP 4280A 1MHz C Meter/C-V Plotter, the HP 4284A Precision LCR Meter, or the HP 4274A Multi-Frequency LCR Meter.

### CMU (HP 4280A 1 MHz C Meter/C-V Plotter)

| | |
|---|---|
| Capacitance Measurement Range: | 1 fF to 1.2 nF |
| Conductance Measurement Range: | 0.01 $\mu$S to 12 mS |
| C-t Measurements: | Measurement Time Interval: 60 ms to 32 s |
| | Pulse Width Setting Range: 10 ms to 32 s |
| Test Frequency: | 1 MHz $\pm$0.01% |
| Test Signal Level: | 30 mVrms $\pm$10% and 10 mVrms $\pm$10% for AUX3 and AUX4 ports<br>30 mVrms $\pm$20% and 10 mVrms $\pm$20% for AUX31 and AUX41 ports |
| Display Resolution: | 4-1/2 digits max. |

**C & G Measurement Ranges and Accuracies**

| C & G Range Full Scale | Accuracy[1] $\pm$[% of reading + (% of range)] |
|---|---|
| C:10 pF[2] | $\pm[0.8\%+(0.7+1.5\times G_m/100\ \mu S)]$ |
| G:100 $\mu$S[2] | $\pm[1.5\%+(0.7+0.2\times C_m/10\ pF)]$ |
| C:100 pF | $\pm[0.5\%+(0.1+1.5\times G_m/1000\ \mu S)]$ |
| G:1000 $\mu$S | $\pm[1.5\%+(0.2+0.2\times C_m/100\ pF)]$ |
| C:1000 pF | $\pm[1.5\%+(0.2+3.5\times G_m/10\ mS)]$[3] |
| G:10 mS | $\pm[3.5\%+(0.4+0.5\times C_m/1000\ pF)]$ |

1 $G_m$: conductance measurement value
$C_m$: capacitance measurement value

2 Reference data only—not a guaranteed specification.

3 $\pm[1.7\%+(0.2+3.5\times G_m/10\ mS)]$ for AUX31 and AUX41

**Note**

After the minimum 40 minute warm-up period, accuracy is specified (1) at 23° C $\pm$ 5° C with the test signal level set to 30 mV and MEAS SPEED set to MEDIUM; (2) between any two measurement pins, and (3) with dissipation D $<$ 1. The stray capacitance between two measurement pins is measured first. Then the stray capacitance value is subtracted from the measured data when a DUT is measured.

When using the 10 mV test signal level, add (0.1% + 0.1%) to the C or G error. If the stray capacitance to the guard exceeds 5 pF, add 0.8% of the reading to C or G errors for each 100 pF increment of stray capacitance to the guard. Errors double at 5° C–18° C and 28° C–40° C.

### CMU84 (HP 4284A Precision LCR Meter)

Measurement Range: 1 fF – 1.2 nF and 10 nS – 7.5 mS (1 MHz)
1 fF – 10 nF and 1 nS – 6.3 mS (100 kHz)
1 fF – 100 nF and 0.1 nS – 6.3 mS (10 kHz)
10 fF – 100 nF and 0.1 nS – 0.63 mS (1 kHz)

Measurement Frequency: 1 k, 10 k, 100 k, and 1 MHz

Frequency Accuracy: ±0.01 %

Test Signal Level: 30 mVrms

**Capacitance Measurement Frequencies, Ranges, and Accuracies**

| Frequency (Hz) | C (F) | Accuracy[1] ±[% of reading + (% of range)] |
|---|---|---|
| 1 M | 10 p[2] | ±[0.8%+(1.0+0.6×Gm;/63 μS)] |
| | 100 p | ±[0.8%+(0.3+0.6×Gm/630 μS)] |
| | 1 n[3] | ±[1.9%+(0.2+1.7×Gm/6.3 mS)] |
| 100 k | 10 p[2] | ±[0.4%+(1.0+0.3×Gm/6.3 μS)] |
| | 100 p | ±[0.3%+(0.3+0.3×Gm/63 μS)] |
| | 1 n | ±[0.3%+(0.2+0.4×Gm/630 μS)] |
| | 10 n | ±[0.5%+(0.2+1.0×Gm/6.3 mS)] |
| 10 k | 100 p | ±[0.3%+(0.2+0.3×Gm/6.3 μS)] |
| | 1 n | ±[0.3%+(0.1+0.3×Gm/63 μS)] |
| | 10 n | ±[0.3%+(0.1+0.3×Gm/630 μS)] |
| | 100 n | ±[0.3%+(0.1+1.0×Gm/6.3 mS)] |
| 1 k | 100 p[2] | ±[0.4%+(0.5+0.4×Gm/0.63 μS)] |
| | 1 n | ±[0.3%+(0.1+0.3×Gm/6.3 μS)] |
| | 10 n | ±[0.3%+(0.1+0.3×Gm/63 μS)] |
| | 100 n | ±[0.3%+(0.1+0.3×Gm/630 μS)] |

1 Gm = conductance measurement value

2 Reference data only—not a guaranteed specification.

3 Maximum counts are 12000 (120% full scale).

**Conductance Measurement Frequencies, Ranges, and Accuracies**

| Frequency (Hz) | G (S) | Accuracy[1] ±[% of reading + (% of range)] |
|---|---|---|
| 1 M | 63 $\mu$[2] | ±[0.8%+(1.0+0.6×C$\mu$/10 pF)] |
| | 630 $\mu$ | ±[0.8%+(0.3+0.6×C$\mu$/100 pF)] |
| | 6.3 m[3] | ±[1.3%+(0.2+2.2×C$\mu$/1.0 nF)] |
| 100 k | 6.3 $\mu$[2] | ±[0.4%+(1.0+0.4×C$\mu$/10 pF)] |
| | 63 $\mu$ | ±[0.3%+(0.3+0.3×C$\mu$/100 pF)] |
| | 630 $\mu$ | ±[0.3%+(0.2+0.4×C$\mu$/1 nF)] |
| | 6.3 m | ±[0.7%+(0.2+0.8×C$\mu$/10 nF)] |
| 10 k | 6.3 $\mu$ | ±[0.3%+(0.2+0.3×C$\mu$/100 pF)] |
| | 63 $\mu$ | ±[0.3%+(0.1+0.3×C$\mu$/1 nF)] |
| | 630 $\mu$ | ±[0.3%+(0.1+0.3×C$\mu$/10 nF)] |
| | 6.3 m | ±[0.7%+(0.1+0.7×C$\mu$/100 nF)] |
| 1 k | 0.63 $\mu$[2] | ±[0.4%+(0.5+0.4×C$\mu$/100 pF)] |
| | 6.3 $\mu$ | ±[0.3%+(0.1+0.3×C$\mu$/1 nF)] |
| | 63 $\mu$ | ±[0.3%+(0.1+0.3×C$\mu$/10 nF)] |
| | 630 $\mu$ | ±[0.3%+(0.1+0.3×C$\mu$/100 nF)] |

1 Cm = capacitance measurement value

2 Reference data only—not a guaranteed specification.

**Note**

After the minimum 45 minute warm-up period, accuracy is specified at 23° C ± 5° C with MEAS SPEED set to MEDIUM and with a 30 mVrms test signal level. The stray capacitance between two measurement pins is measured first. Then the stray capacitance value is subtracted from the measured data when a DUT is measured.

### LCR (HP 4274A Multi-Frequency LCR Meter)

Note that HP 4062PC does not support the LCR.

- Measurement Function: Capacitance
- Measurement Frequencies:

  100, 120, 200, 400, 1 k, 2 k, 4 k, 10 k, 20 k, 40 k, 100 kHz ±0.01%

- Measurement Range: 0.001 pF to 1.9 nF
- Accuracy:

  1% of the measurement range as an additional error to the HP 4274A's accuracy.

  This additional error is specified under the following conditions:

  - If capacitance zero offset adjustment is performed.
  - If measurement range is the 100 pF or 1000 pF range.
  - If the dissipation factor of the test device does not exceed 0.1.
  - If the LCR's OSC Level vernier is set to its maximum level on the ×5 and ×1 ranges.

  Internal dc bias options for HP 4274A are not specified for system use.

## System Controller

- Supported Computers:
  - For HP 4062C:

**HP 4062C System Software Revision and Supported Computers**

| System Software Revision | Supported Computer |
|---|---|
| C.05.60<br>C.05.70 | HP 9836A/C (Series 200 Model 236A/C)<br>HP 9000 Series 300 Model 310, 320, 330, 332, 340, 350, 360, 370 |
| C.06.00 | HP 9836A/C (Series 200 Model 236A/C)<br>HP 9000 Series 300 Model 310, 320, 330, 332, 340, 345, 350, 360, 370, 375 |
| C.06.20<br>C.06.30 | HP 9836A/C (Series 200 Model 236A/C)<br>HP 9000 Series 300 Model 310, 320, 330, 332, 340, 345, 350, 360, 362, R/362, 370, 375, 380, 382, R/382 |

  - For HP 4062UX:

**HP 4062UX System Software Revision and Supported Computers**

| System Software Revision | Supported Computer |
|---|---|
| X.05.60<br>X.05.61 | HP 9000 Model 330, 332, 350, 360, 370<br>or HP 9000 Model 318, 319, 340 for diskless cluster configurations |
| X.06.00 | HP 9000 Model 330, 332, 350, 360, 370, 375<br>or HP 9000 Model 318, 319, 340, 345 for diskless cluster configurations |
| X.06.20 | HP 9000 Model 330, 332, 350, 360, 370, 375, 380, 382, R/382<br>or HP 9000 Model 318, 319, 340, 345 for diskless cluster configurations |
| X.06.30 | HP 9000 Model 332, 360, 370, 375, 380, 382, R/382<br>or HP 9000 Model 340, 345 for diskless cluster configurations |
| X.07.00 | HP 9000 Model 360, 370, 375, 380, 382, or R/382;<br>or Model 340, or 345 for diskless cluster configurations.<br>HP 9000 Model 745i, 747i, or 725. |

  - For HP 4062PC (only System Software Revision 6.2 and above):

    HP 82324A High-Performance Measurement Coprocessor and a Vectra PC (IBM PC-AT, IBM PS-2 Model 30/286, or supported AT-compatible computer can be used.). Note that the Vectra PC must be equipped with a VGA display adapter and monitor.

- Operating System:
  - For HP 4062C:

**HP 4062C System Software Revision and Compatible Revision of OS**

| System Software Revision | BASIC Revision |
|---|---|
| C.05.60 | BASIC 5.13 |
| C.05.70<br>C.06.00 | BASIC 6.0 |
| C.06.20<br>C.06.30 | BASIC 6.2[1] or BASIC 6.21[1] |

1 BASIC Plus can be used with BASIC

  - For HP 4062UX:

**HP 4062UX System Software Revision and Compatible Revision of OS**

| System Software Revision | HP-UX Revision | BASIC/UX Revision |
|---|---|---|
| X.05.60<br>X.05.61<br>X.06.00 | HP-UX 7.0 | BASIC/UX 5.52 |
| X.06.20 | HP-UX 8.0 | BASIC/UX 6.2[1] |
| X.06.30 | HP-UX 9.0 | BAISC/UX 6.3[1] |
| X.07.00 | HP-UX 9.05 | BASIC/UX 7.01 |

1 BASIC Plus can be used with BASIC/UX

**HP 4062PC System Software Revision and Compatible Revision of OS**

| System Software Revision | MS-DOS Revision | BASIC/DOS Revision |
|---|---|---|
| P.06.20<br>P.06.30 | 3.1 or later | 6.2[1] |

1 BASIC Plus can be used with BASIC/DOS

- Required Memory:
  - For HP 4062C:

    Greater than 2 MB; greater than 4 MB when using the HP IMA software (add 1 MB when using BASIC Plus)

  - For HP 4062UX:

    For HP series 300 controller, greater than 8 MB (Recommended: Greater than 8 MB); greater than 8 MB when using the HP IMA software (add 1 MB when using BASIC Plus)

    For HP series 700 controller, greater than 32 MB (Recommended: Greater than 64 MB)

  - For HP 4062PC:

    Vectra PC requires greater than 640 KB for MS-DOS.

Measurement coprocessor requires greater than 2 MB; greater than 4 MB when using the HP IMA software (add 1 MB when using BASIC Plus)

- Required Interface/Module:
  - For HP 4062C/UX (Series 300 computer)
    - HP 98624A HP-IB Interface Cards

      For the HP 4062C/UX's hardware
      For the wafer prober
      (Internal HP-IB is for tape drives, printers, and plotters.)

      If your HP 4062UX is configured in a diskless cluster, an HP-IB interface card is not required because the computer's internal HP-IB can be used for the HP 4062UX and wafer prober.
  - For HP 4062UX (Series 700 computer)
    - For instrument control
      - HP E2071B High Performance HP-IB Interface Card
      - Series 745i/747i Internal HP-IB Interface Card
    - For peripheral control
      - HP 25560A EISA HP-IB Interface Card
  - For HP 4062PC
    - HP 82335A/82990A HP-IB Interface Card for the wafer prober

      (Internal HP-IB of the measurement coprocessor is used for the system instruments.)
    - Parallel or serial interface card for MS-DOS (if need)
    - Required peripheral devices for your Vectra PC
- Peripherals
  - Printer

    PPG, MAP, DIAG, PV4062, and BSDM support printers. The following conditions are required for the printers:
    - HP-IB interface printer

      Response to serial polls
      More than 79 characters per line
      More than 24 lines per page
      Sufficient resolution of the printer for graphics dump (if need)
    - RS-232C serial interface printer

      More than 79 characters per line
      More than 24 lines per page
      Sufficient resolution of the printer for graphics dump (if need)
    - Centronics interface printer

      More than 79 characters per line
      More than 24 lines per page
      Sufficient resolution of the printer for graphics dump (if need)

- Plotter

  BSDM supports plotters. The following conditions are required for the plotters:

  - HP-IB interface plotter

    Response to serial polls

## System Software

Standard HP 4062C/UX/PC software provides the following capabilities.

System Initialization

Control of system subsystems

Monitor of system subsystems and measurement data

Parameter measurement utility

Offline debugging (HP 4062UX only)

Probing pattern generation and wafer maps display

BSDM data format generation library

Wafer prober control utility subprograms include Electroglas Model 1034X/2001X and AP-M-3000A/6000A/7000A prober control commands.

Operational Verification Diagnostics

## General Information

- Operating Temperature Range:

  5° C–40° C, 5%–70% RH. Permissible temperature change is less than 3° C after calibration.

- Air Cleanliness: Better than class 100,000

- Power Requirements: 100 V (90–110 V); 120 V (108–132 V); 220 V (198–242 V); 240 V (216–252 V); 48–66 Hz, 1150 VA max.

- Emergency Off Switch (standard cabinet only):

  The standard cabinet (1600 mm height) is furnished with an emergency off switch. Pressing the emergency off switch stops the supply of electric power to the system instruments in an emergency.

- Dimensions:

  System Cabinet (standerd) = 600 mm (W) by 1600 mm (H) by 800 mm (D).

  System Cabinet (small) = 600 mm (W) by 1000 mm (H) by 800 mm (D).

  HP 4085B 48-pin SWM = 470 mm (W) by 230 mm (H) by 440 mm (D).

  HP 4089B 96-pin SWM = 620 mm (W) by 250 mm (H) by 600 mm (D).

  Port Expander = 227 mm (W) by 180 mm (H) by 57 mm (D).

- Weight:

  System Cabinet (standerd) = about 230 kg

System Cabinet (small) = about 210 kg

HP 4085B 48-pin SWM = about 22 kg

HP 4089B 96-pin SWM = about 55 kg

Port Expander = about 1.1 kg

- DCS (HP 4142B) Power Limitation: 32 W

## Typical Performance

- Command Execution Time: (Single user, single task mode for HP 4062UX)
  - Switching Matrix

    Connect: 3.0 ms
  - DC Source/Monitor[1]

    Force (I or V): 2.5 ms

    Measure (I or V): 5 ms

    Analog Search: 25 ms (does not include the switching time; for MOSFET Vth measurement (Id = 1 $\mu$A))

    [1] Integration time set to SHORT: not applicable on 1 nA and 10 nA ranges.
- Typical SWM Performance (at 23 °C, 50%RH)

**Typical SWM Performance (at 23 °C, 50%RH)**

| Parameter | SMU1 | SMU2–4 | AUX1–4 | AUX1*x* & AUX2*x* | AUX31, 32 & AUX41, 42 | AUX33 & AUX43 |
|---|---|---|---|---|---|---|
| Offset Voltage/Pin | 50 $\mu$V | 50 $\mu$V | 50 $\mu$V | 50 $\mu$V | 80 $\mu$V | 80 $\mu$V |
| Offset Current/Pin | 1 pA | 40 pA | 1 nA | 1 nA | 1 nA | 40 pA |
| Isolation Resistance | $8\times10^{13}$ Ω | $5\times10^{11}$ Ω | $4\times10^{8}$ Ω | $4\times10^{8}$ Ω | $4\times10^{8}$ Ω | $5\times10^{11}$ Ω |
| Path to Ground Capacitnce | 30 pF[1] | 60 pF | — | — | — | 60 pF |
| Stray C between CMS ports | — | — | 4 pF[2] | — | 4 pF[3] | — |

1 15 pF for HP 4089A/B SWM.

2 Between AUX3 and AUX4.

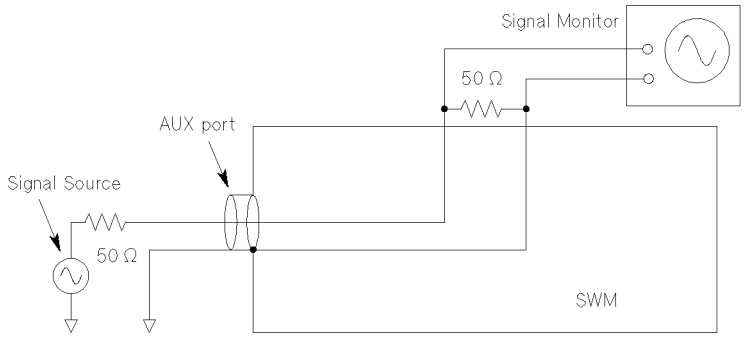
3 Between AUX31 and AUX41.

- Insertion Loss of the AUX Ports

**Insertion Loss of the AUX Ports (dB)**

| SWM and Ports | | Frequency | | | −3 dB Frequency |
|---|---|---|---|---|---|
| | | ≤100 kHz | ≤1 MHz | ≤10 MHz | |
| HP 4085B | AUX1, AUX2 | < 0.5 | < 0.6 | < 5.0 | 7.5 MHz |
| | AUX3, AUX4 | < 0.5 | < 0.6 | < 2.5 | 13.0 MHz |
| HP 4089B | AUX1, AUX2 | < 0.2 | < 0.5 | < 5.5 | 5.5 MHz |
| | AUX3, AUX4 | < 0.3 | < 0.4 | < 2.3 | 11.5 MHz |

The measurement circuit is shown as follows:

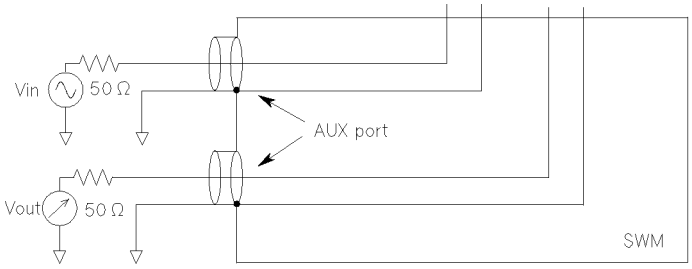


■ Crosstalk of the AUX Ports

**Crosstalk of the AUX Ports (dB)**

| SWM and Ports | | Frequency | | |
|---|---|---|---|---|
| | | <10 kHz | <100 kHz | <1 MHz |
| HP 4085B | AUX1 to AUX2 | <−90 | <−70 | <−50 |
| | AUX3 to AUX4 | | | |
| HP 4089B | AUX1 to AUX2 | <−90 | <−70 | <−50 |
| | AUX3 to AUX4 | <−95 | <−80 | <−60 |

The measurement circuit is shown as follows:

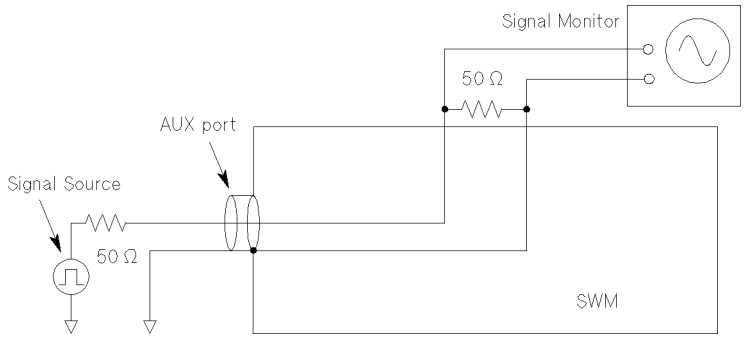



■ Pulse Rising Time and Delay Time

**Pulse Rising Time and Delay Time of the AUX Ports**

| SWM and Ports | | Rising Time | Delay Time |
|---|---|---|---|
| HP 4085B | AUX1, AUX2 | 40 ns | — |
| | AUX3, AUX4 | 30 ns | |
| HP 4089B | AUX1, AUX2 | 60 ns | 25 ns |
| | AUX3, AUX4 | 35 ns | |

The measurement circuit is shown as follows:



# 2

# Theory Of Operation

## Introduction

This chapter covers the fundamental operating theory of the HP 4062C/UX/PC's subsystems and instruments to provide you with a better understanding of the system's hardware and operation.

The information in this chapter will help you understand the system control software described in your HP 4062C/UX/PC's *System Operation* and *Programming Reference* manuals.

## Switching Matrix Subsystem (SMS)

The SMS's configuration depends on your SWM. If your SWM is a 48-pin SWM, the SMS consists of one HP 4085B SWM and one HP 4084B Switching Matrix Controller (SWC). If your SWM is a 96-pin SWM, the SMS consists of one HP 4089A SWM and two HP 4084B SWCs.

### Switching Matrix (SWM)

The SWM's main function is to interconnect the HP 4062C/UX/PC's subsystem components and the SWM's measurement pins (refer to "Measurement Pins") via the SWM's measurement ports (refer to "Ports").

- 48-pin SWM

  Figure 2-1 shows a simplified diagram of a 48-pin SWM interconnected with its SWC, DCS, and CMS.

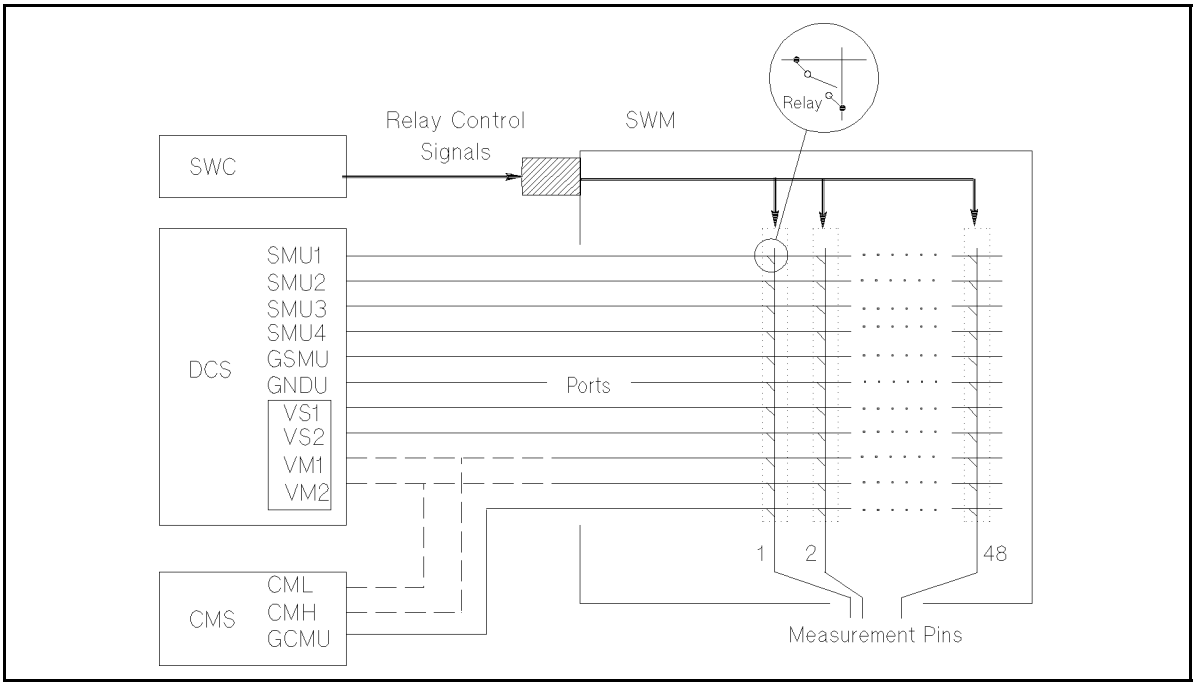



**Figure 2-1. Simplified 48-pin SWM Diagram**

The 48-pin SWM provides 9 measurement ports and 48 measurement pins, thereby constituting a 9 (ports) by 48 (pins) matrix.

Each measurement pin, under software control, can connect to and disconnect from any port, enabling virtually any pin-port connection combination. This lets you control the HP 4062C/UX/PC's subsystem components as if they are built into the SWM.

You can connect the SWM to a wafer prober (using the Personality Board and the prober's probe card) or to one of the furnished test fixtures.

- 96-pin SWM

Figure 2-2 shows a simplified diagram of a 96-pin SWM interconnected with its SWCs, DCS, and CMS.

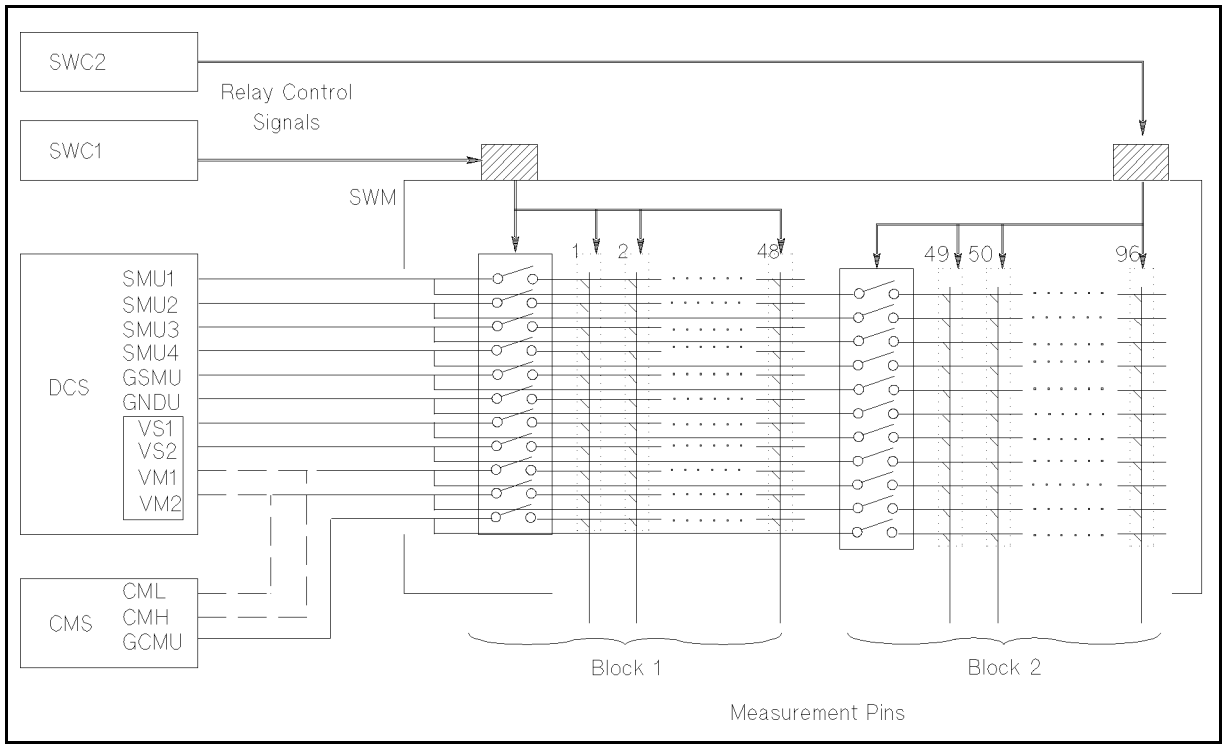



**Figure 2-2. Simplified 96-pin SWM Diagram**

The 96-pin SWM provides 9 measurement ports and 96 measurement pins, thereby constituting a 9 (ports) by 96 (pins) matrix.

Each measurement pin, under software control, can connect to and disconnect from any port, enabling virtually any pin-port connection combination. This lets you control the HP 4062C/UX/PC's subsystem components as if they are built into the SWM.

SWC1 controls measurement pins 1 to 48 (block 1 in Figure 2-2), and SWC2 controls measurement pins 49 to 96 (block 2).

All pin-port interconnections are controlled via the input relays for each block. Input relays are automatically controlled by the Connect or Connect_th TIS subprogram, which connects the specified pin(s) and port(s).

---

**Note**

If you connect a measurement port to measurement pins in both blocks 1 and 2, guard capacitance increases more than usual, resulting in the following:

For capacitance measurements, measurement accuracy is not guaranteed. Capacitance measurement error correction is valid only when the CMS's CML or CMH ports are connected to two measurement pins in either block 1 or block 2.

For SMU measurements, SMU oscillation may occur.

---

You can connect the SWM to a wafer prober (using the Personality Board and the prober's probe card) or to one of the furnished test fixtures.

## Port Expander

You can use a port expander to extend the four AUX ports to twelve ports. Only four ports can be used at a time. Figure 2-3 shows a simplified diagram of the port expander.

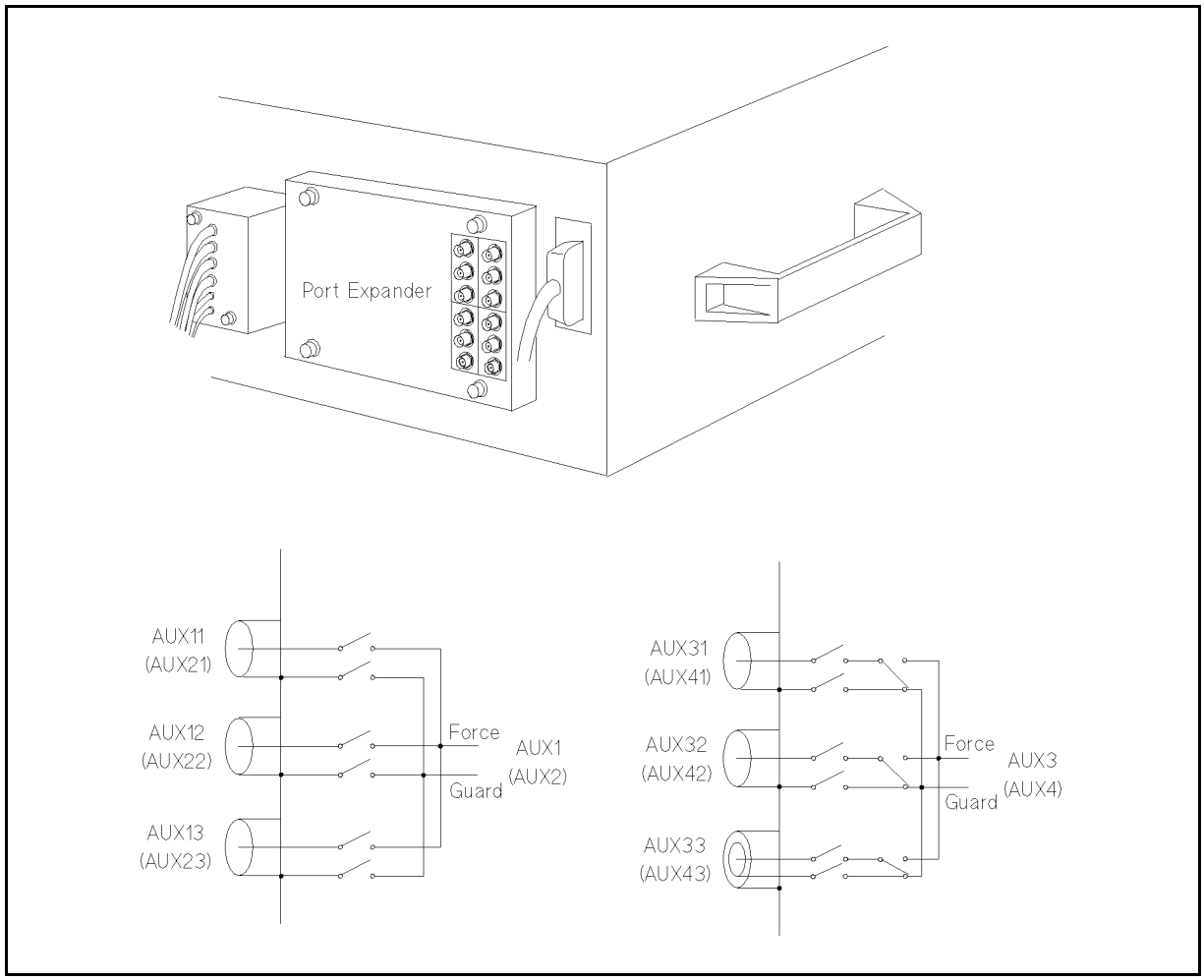



**Figure 2-3. Simplified Port Expander Diagram**

The port expander has four multiplexer (3 to 1) circuits, and the AUX$x$1 – $x$3 terminals on the port expander are connected to the AUX$x$ port in the SWM. The AUX33 and AUX43 terminals are triaxial connectors: the inner conductor is Force, the middle conductor is driving Guard, and the outer conductor is common (ground). The other ten AUX$xx$ terminals are coaxial connectors: the inner conductor is Force and the outer conductor is common (ground).

AUX11–AUX13 and AUX21–AUX23 are designed for a VS or VM unit. AUX31, AUX32, AUX41, and AUX42 are designed for a VS, VM, CMU, or CMU84 unit. AUX33 and AUX43 are designed for an SMU.

## Measurement Pins

Each measurement 'pin,' mounted on a single pin board (refer to "Pin Boards"), is actually a set of three spring-loaded pins—SENSE, FORCE, and GUARD—described as follows:

SENSE: SENSE pins function as the input terminal for Kelvin connections implemented with the SMU2, SMU3, or SMU4 ports. SENSE pins connected to the SMU1, AUX1, AUX2, AUX3 (CMH), or AUX4 (CML) ports are open-terminated, and thus, have no function.

FORCE: FORCE pins function as the output terminals for Kelvin connections implemented with the SMU2, SMU3, or SMU4 ports. FORCE pins function as the input/output terminals for subsystem components connected to the SMU1, AUX1, AUX2, AUX3 (CMH), or AUX4 (CML) ports.

GUARD: GUARD pins function as guard terminals for the SMU, CMH, and CML ports.

Measurement pins are completely isolated from each other to prevent interpin leakage current and to maximize measurement accuracy.

## Ports

The SWM provides 9 measurement ports (ports 1–9) and 2 guard ports (ports 10 and 11). These ports are the SWM's input and output terminals for the HP 4062C/UX/PC's subsystem components.

If the SWM is equipped with a port expander, up to twelve ports can be used. These ports are located between the subsystem components and the SWM's input ports.

Measurement ports connect to the DCS and CMS measurement terminals, and guard ports—SMU1, AUX3 (CMH) or AUX4 (CML) ports—connect to the SMU1 and CMS guard terminals.

Table 2-1 lists SWM port specifics, and Figure 2-4 shows SWM pin-port connections.

You can also connect unsupported instruments to the AUX port on the port expander. For more details, see Chapter 5 in this manual.

**Table 2-1. SWM Port Specifics**

| Port Number | Port Name | Measurement Unit/Terminal | Function |
|---|---|---|---|
| 1 | SMU1 | SMU1 | Low I measurements |
| 2 | SMU2 | SMU2 (S, F, G) | High power dc measurements |
| 3 | SMU3 | SMU3 (S, F, G) | General dc measurements |
| 4 | SMU4 | SMU4 (S, F, G) | General dc measurements |
| 5 | AUX1 | VS or VM | Auxiliary dc V source or dc measurements |
| 6 | AUX2 | VS or VM | Auxiliary dc V source or dc measurements |
| 7 | GNDU | GNDU (S, F) | Circuit common |
| 8 | AUX3 (CMH) | VS, VM, or HIGH CMS terminal | Auxiliary dc V source or dc measurements, or 1 MHz C measurements |
| 9 | AUX4 (CML) | VS, VM, or LOW CMS terminal | Auxiliary dc V source or dc measurements, or 1 MHz C measurements |
| 10 | GSMU | SMU1 Guard terminal | Guarding for low current measurements |
| 11 | GCMU | CMS Guard terminal | Guarding for capacitance measurements |
| 21[1] | AUX11 | VS or VM | Auxiliary dc V source or dc measurements |
| 22[1] | AUX12 | VS or VM | Auxiliary dc V source or dc measurements |
| 23[1] | AUX13 | VS or VM | Auxiliary dc V source or dc measurements |
| 24[1] | AUX21 | VS or VM | Auxiliary dc V source or dc measurements |
| 25[1] | AUX22 | VS or VM | Auxiliary dc V source or dc measurements |
| 26[1] | AUX23 | VS or VM | Auxiliary dc V source or dc measurements |
| 27[1] | AUX31 (CMH) | VS, VM, or HIGH CMS terminal | Auxiliary dc V source or dc measurements, or 1 MHz C measurements |
| 28[1] | AUX32 | VS, VM, or HIGH CMS terminal[2] | Auxiliary dc V source or dc measurements, or 1 MHz C measurements |
| 29[1] | AUX33 (SMU) | SMU (F, G) | General dc measurements |
| 30[1] | AUX41 (CML) | VS, VM, or LOW CMS terminal | Auxiliary dc V source or dc measurements, or 1 MHz C measurements |
| 31[1] | AUX42 | VS, VM, or LOW CMS terminal[2] | Auxiliary dc V source or dc measurements, or 1 MHz C measurements |
| 32[1] | AUX43 (SMU) | SMU (F, G) | General dc measurements |

1 These ports are available if a port expander is equipped with the SWM.

2 You can connect the CMU or CMU84 to the AUX32 and AUX42 ports, but the measured data is not guaranteed.

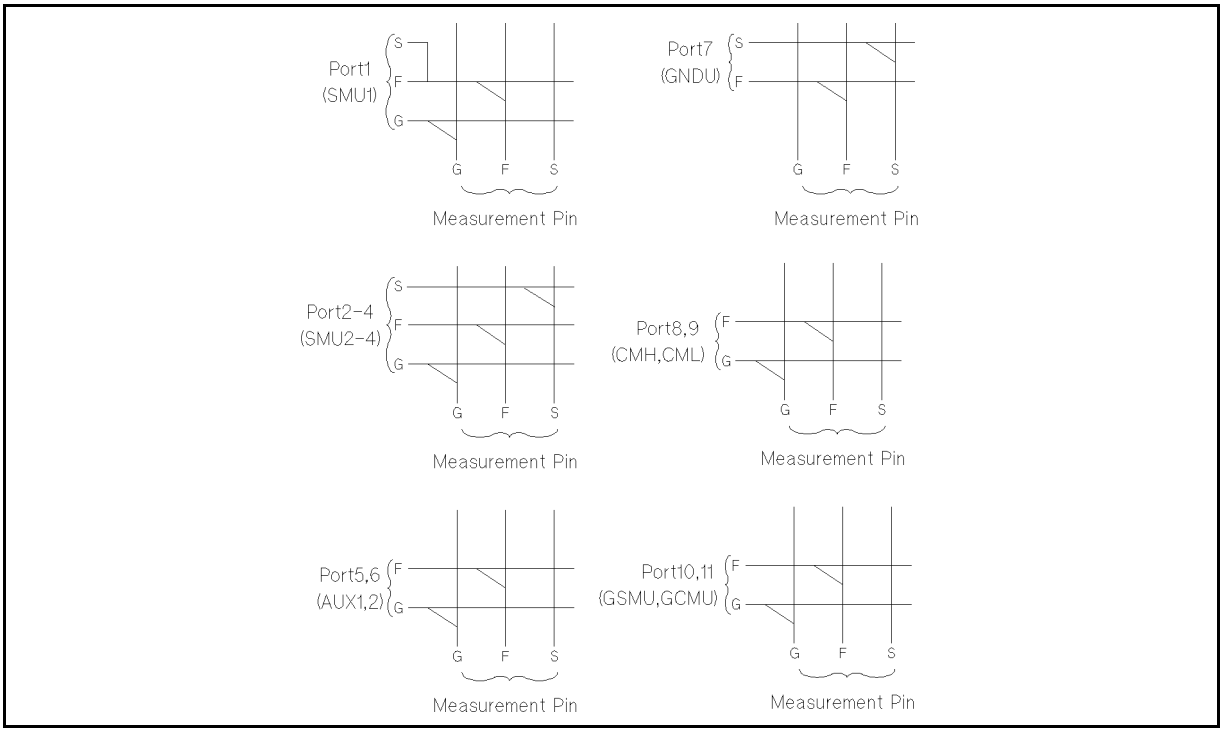



**Figure 2-4. SWM Pin-Port Connections**

## Pin Boards

The SWM's Pin Boards house the measurement pins (as described in "Measurement Pins") and the switching relays for pin-port connections, as shown in Figure 2-1 and Figure 2-2. The 48-pin SWM provides 48 pin board slots, and the 96-pin SWM provides 96 pin boards slots.

All pin boards are identical, and each has 15 switching relays. Each pin board relay is assigned an identifier (for example, K30) to facilitate failure isolation. Relay failures are detected by the diagnostics (DIAG) program.

If the DIAG program detects a relay failure, the failed relay's identifier and pin board number appears on the system controller's display. Refer to Chapter 4 for a complete discussion on the DIAG program.

Figure 2-5 shows the circuit configuration for the pin boards' switching relays with all relays set to Break (off).

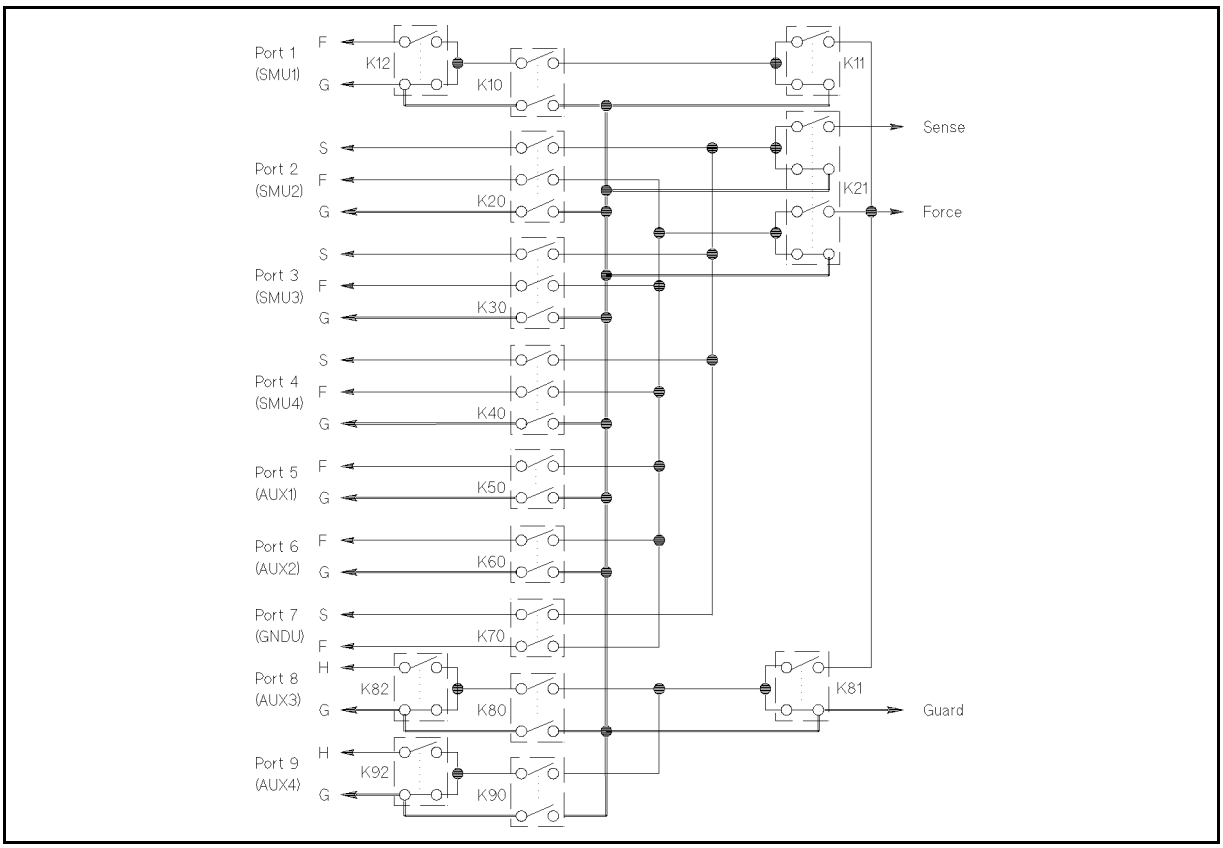



**Figure 2-5. Switching Relay Circuit Configuration**

Figure 2-6, Figure 2-7, and Figure 2-8 show examples of 3 pin-ports connected via their associated pin board relays.

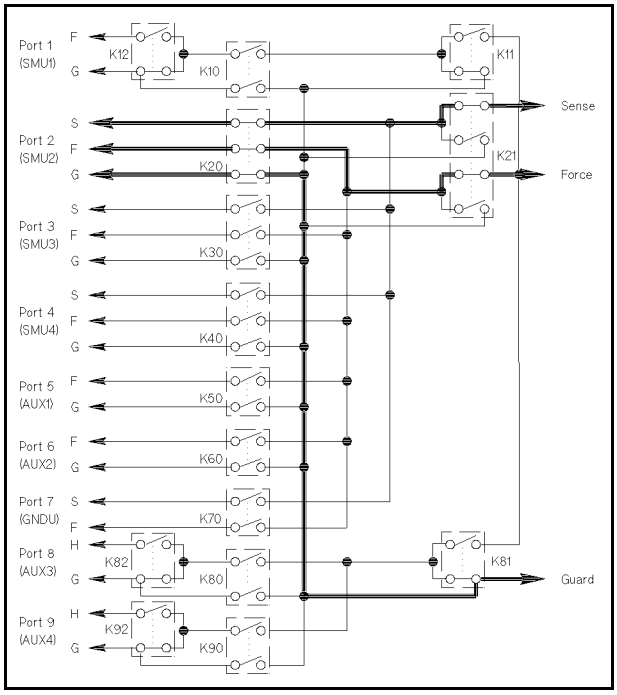



**Figure 2-6.**
**Examples of Pin Board Pin-Port Relay Connections—Port2 (SMU2) Connection**

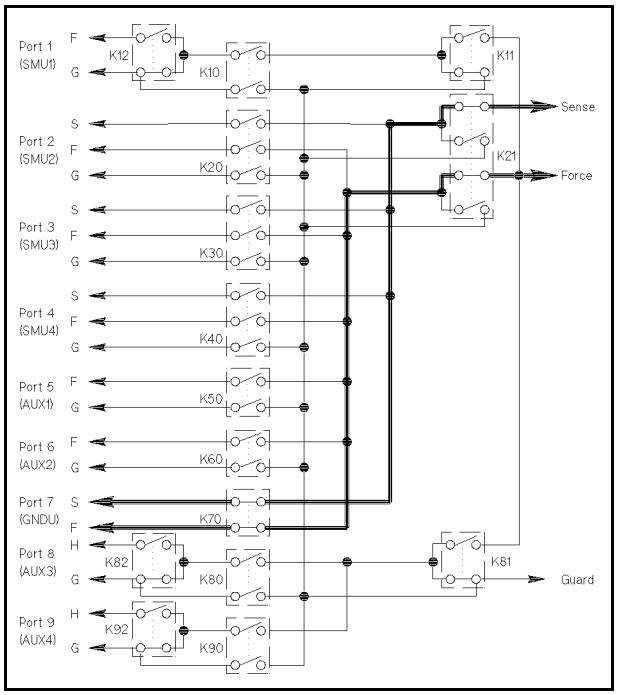



**Figure 2-7.**
**Examples of Pin Board Pin-Port Relay Connections—Port7 (GNDU) Connection**

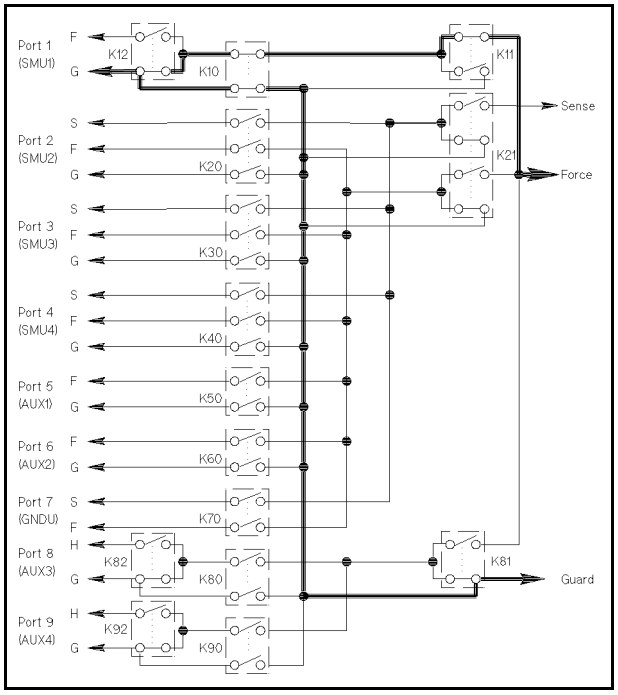



**Figure 2-8.**
**Examples of Pin Board Pin-Port Relay Connections—Port1 (GSMU) Connection**

Table 2-2 lists the Make (on) relays for each SWM port.

**Table 2-2. SWM Ports and Make (on) Relay Relationships**

| Port | Relay |
|---|---|
| 1, SMU1 | K10, K11, K12 |
| 2, SMU2 | K20, K21 |
| 3, SMU3 | K30, K21 |
| 4, SMU4 | K40, K21 |
| 5, AUX1 | K50, K21 |
| 6, AUX2 | K60, K21 |
| 7, GNDU | K70, K21 |
| 8, AUX3 (CMH) | K80, K81, K82 |
| 9, AUX4 (CML) | K90, K81, K92 |
| 10, GSMU | K10, K11 |
| 11, GCMU | K80, K90, K81 |

The Make condition of K11, K12, K21, K81, K82, and K92 is defined as when the force or sense terminal of these relays is set to Make (or on).

The Make or Break status of all pin board relays can be displayed by using the Virtual Front Panel (VFP). Refer to the *System Operation* for complete VFP information.

## Switching Matrix Controller (SWC)

The SWC provides relay switching control signals and dc power for the 48- or 96-pin SWM.

The 48-pin SWM requires one SWC; and the 96-pin SWM requires two SWCs: SWC1 controls pin boards 1 to 48, and SWC2 controls pin boards 49 to 96.

## Safety Features

Because dc voltages up to ±200 V can be present at the SWM's measurement pins, the HP 4062C/UX/PC provides several safety features to protect operating personnel against potential shock hazards.

To perform a measurement, one of two conditions must exist: (1) the SWM must be firmly installed on a wafer prober, or (2) the test fixture adapter must be installed on the SWM with its lid closed.

Condition (1) is detected by the WAFER PROBER SENSE switch, and condition (2) by the FIXTURE CLOSED DETECT switch.

Both these switches are in the SWM and are monitored by the SWC. When both switches are open, the SWC disables SWM output (the SWM's OUTPUT ENABLED lamp goes out). If one of these switches is closed, however, the SWC enables SWM output (the OUTPUT ENABLED lamp lights).

If a closed switch is opened during a measurement, output is disabled immediately. The measurement can continue only after the switch is closed.

## DC Subsystem (DCS)

The DCS's configuration depends on the combination of plug-in modules ordered. Available plug-in modules include two types of Source/Monitor Units (SMUs), a Voltage Source/Voltage Monitor Unit (VS/VMU), an Analog Feedback Unit (AFU), and a Ground Unit (GNDU), as described in "Source/Monitor Units (SMUs)" through "Ground Unit (GNDU)". The DCS's main functions and capabilities are described starting from "Compliance".

For complete information on the DCS, refer to the HP 4142B's *Operation Manual*.

**Warning**

**HP 41423A 1000 V High Voltage Unit (HVU) or HP 41422A 10 A High Current Unit (HCU) are plug-in modules of the HP 4142B DCS and can be installed in the DCS. However, the SWM is not guaranteed for voltage that exceeds ±200 V or current that exceeds ±1 A. If you force high voltage or current to the devices under test (DUTs) through the SWM, the SWM would not only be damaged but you might also get an electrical shock. Do not operate the HP 4062C/UX/PC system if an HVU or HCU is installed in the DCS.**

### Source/Monitor Units (SMUs)

Two types of SMUs are available: the HP 41420A 200 V/1 A SMU, and the HP 41421B 100 V/100 mA SMU.

You can program each SMU to function as either a voltage source/current monitor (V source mode) or as a current source/voltage monitor (I source mode). Figure 2-9 shows a simplified SMU circuit diagram.

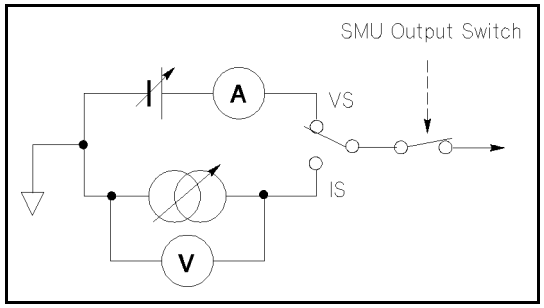



**Figure 2-9. Simplified SMU Circuit Diagram**

Output V and I can be held constant, swept linearly or logarithmically, or pulsed. These functions are described in "Staircase Sweep Measurements" through "Binary and Linear Search Measurements".

Only SMUs 2, 3, and 4 can be used to implement Kelvin connections (not SMU1). Refer to "Kelvin Connections" for more information on Kelvin connections.

## Voltage Source/Voltage Monitor Unit (VS/VMU)

The HP 41424A VS/VMU provides two Voltage Sources (VS1 and VS2) and two Voltage Monitors (VM1 and VM2).

VSs and VMs connect to the SWM's AUX1—4 ports, as listed in Table 2-1, when used with the SWM.

You can also use the VSs and VMs separately from the SWM. For example, you can use a VS to power a wafer prober's lamp.

### VS1 and VS2

Figure 2-10 shows a simplified VS circuit diagram.

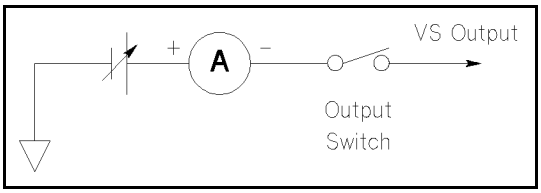



**Figure 2-10. Simplified VS Circuit Diagram**

VS output can be held constant, swept linearly or logarithmically, or pulsed. These functions are described in "Staircase Sweep Measurements" through "Pulsed Sweep Measurements".

Each VS can measure its output current.

### VM1 and VM2

Figure 2-11 shows a simplified VM circuit diagram.

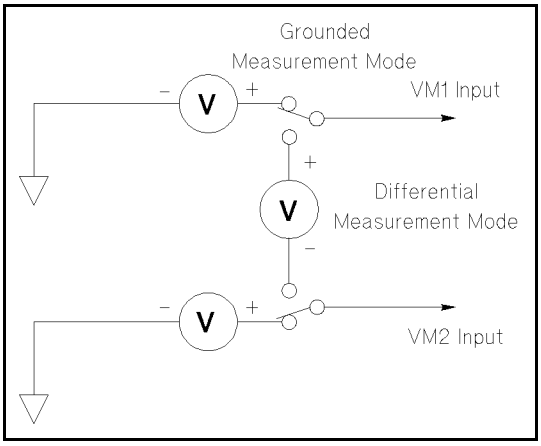



**Figure 2-11. Simplified VM Circuit Diagram**

VMs provide two V measurement modes: Grounded and Differential, as follows:

- Grounded Measurement Mode:

  In the grounded measurement mode, VMs measure the V between ground and the SWM port connected to the VM, up to ±40 V.

- Differential Measurement Mode:

  In the differential measurement mode, VMs measure the voltage between two ports connected to VM1 and VM2, up to ±2 V.

## Analog Feedback Unit (AFU)

The DCS's HP 41425A Analog Feedback Unit (AFU) provides two types of analog searches, feedback and ramp, as determined by the specified *search mode*. Both types of analog search use the AFU and two SMUs: one "search" SMU and one "sense" SMU.

Both feedback and ramp analog searches perform an analog search for a specified *target value*. When this *target value* is "found," the search SMU's output V or I is measured, or both the search and sense SMUs' output V or I is measured, as determined by the specified *measurement mode*.

For more on analog search measurement parameters, see "Analog Search Measurements" and the Set_asearch subprogram's Semantics in the *Programming Reference*.

Figure 2-12 shows a simplified AFU block diagram.

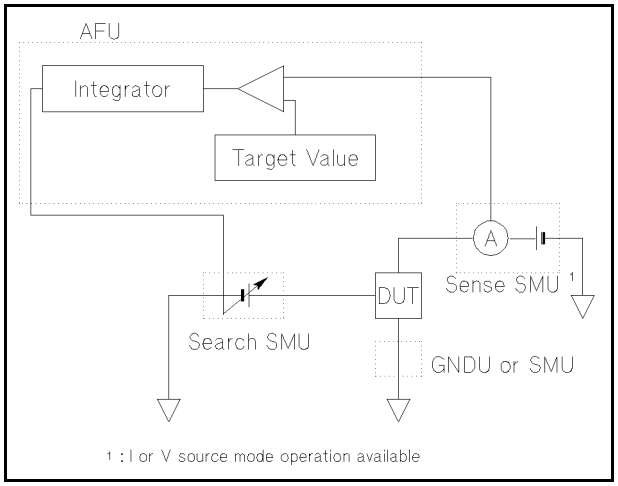



**Figure 2-12. Simplified AFU Block Diagram**

### Feedback Analog Searches

For feedback analog searches, the AFU provides control between the search and sense SMUs via an analog feedback loop until the specified *target value* is found, as follows:

As a feedback analog search begins, the search SMU outputs the *start value* (V) to the test device, and the sense SMU monitors test device output V or I (sense value).

The AFU then compares the sense value to the *target value*, generates a control V proportional to the difference between the sense and *target* values, and outputs this control voltage to the search SMU.

The search SMU, in turn, adjusts its output V to the test device, thereby adjusting test device output (sense value), which is again compared to the *target value* as explained in the previous paragraph.

This feedback process continues until the sense value equals the *target value*. When sense value equals *target value*, the DCS measures the search SMU's output V or I, or both the search and sense SMUs' output V or I, depending on the specified *measurement mode*.

### Ramp Analog Searches

For ramp analog searches, the AFU compares the sense SMU's output V or I (sense value) to the *target value* until the sense value is slightly less than or greater than the *target value*, as follows:

As a ramp analog search begins, the search SMU outputs the *start value* (ramp V) to the test device, the sense SMU monitors test device output V or I (sense value), and the AFU compares the sense value to the *target value*.

The search SMU continues to output a ramp V, and the AFU continuously compares the sense value to the *target value* until the sense value is slightly less than or greater than the *target value*, as determined by the specified *search mode*.

When this sense value to *target value* condition is satisfied, the DCS measures the search SMU's output V or I, or both the search and sense SMUs' output V or I, depending on the specified *measurement mode*.

## Ground Unit (GNDU)

The GNDU provides a measurement ground reference, can output 0 V, and can sink up to ±1.6 A. To cancel the effects of the SWM's residual resistance, you can use the GNDU with SMUs 2, 3, or 4 to implement Kelvin connections.

Refer to "Kelvin Connections" for details on Kelvin connections, and to "Kelvin Connection Applications" in Chapter 5 for additional information.

Figure 2-13 shows a simplified GNDU circuit diagram.


**Figure 2-13. Simplified GNDU Circuit Diagram**

## Compliance

To prevent test device damage, you can specify voltage, current, and power compliance (maximum output) values to limit SMU output. If an SMU reaches compliance, it acts as a constant source, and cannot exceed the specified compliance value. For more on compliance, see "Additional Compliance Information" in Chapter 5.

## Kelvin Connections

To eliminate the effects of test lead and contact residual resistance, you can implement a Kelvin (4-wire) connection by using SMUs 2, 3, or 4 and the GNDU.

**Note**

SMU1 cannot be used for Kelvin connections because its force and sense lines are interconnected inside the SWM.

When compared to 2- or 3- wire connections, Kelvin connections provide a distinct advantage when performing low resistance measurements, for example, forward biased pn junctions. For Kelvin connection application information, see "Kelvin Connection Applications" in Chapter 5.

## Guarding

To virtually eliminate the effects of leakage current and associated measurement errors, each SMU provides a guard terminal that connects to the buffer amplifier's output. The guard terminal's voltage is at the same potential as that of the sense and force leads. Because the guard terminal completely surrounds the sense and force leads with an equipotential, leakage current and its associated errors are negligible.

Complete guarding is also provided for the interconnection cabling between the SWM and the SMUs, and the printed circuits on the SWM's pin boards.

For more on guarding applications, refer to "Additional Guarding Information" in Chapter 5.

## Self-Calibration

To minimize output drift and measurement fluctuations, caused primarily by ambient temperature changes, you can program the DCS to periodically self-calibrate the SMUs and their control circuits (A/D converters).

Self-calibration takes about 40 seconds for a standard DCS configuration.

## Integration Time

To minimize line frequency noise errors, you can select from four DCS digital integration time settings—SHORT, MEDIUM, LONG, and MANUAL

For correct digital integration operation, the FILTER switch on the DCS's rear panel must be set to the line frequency at which your HP 4062C/UX/PC operates. This FILTER switch is set at the factory to the line frequency in your area.

## DCS Output and Measurement Ranges

DCS output and measurement ranges depend on the output V or I you specify, and by the V or I measurement values. For SMUs, ranging also depends on the set compliance value.

The following paragraphs briefly describe the various ranging schemes.

- SMU Voltage Output:

  Fixed range—2, 20, 40, 100, or 200 V (HP 41420A SMU).

- SMU Voltage Measurement:

  Fixed range—depending on the specified voltage compliance.

- SMU Current Output:

  Auto-ranging and Limited Auto-ranging[1]—9 ranges from 1 nA to 100 mA for HP 41421B SMUs; 10 ranges from 1 nA to 1 A for HP 41420A SMUs.

- SMU Current Measurement:

  Auto-ranging and Limited Auto-ranging[1]—Same as above.

- VS Output:

  Fixed range—20 or 40 V.

- VM Measurement:

  Fixed range or Auto-ranging—2, 20, or 40 V; 0.2 or 2 V for differential voltage measurements.

## Staircase Sweep Measurements

SMU and VS output can be swept in a staircase manner, as shown in Figure 2-14, by specifying the following staircase sweep parameters.

| | |
|---|---|
| *Sweep Mode*: | Linear or Log, single or double sweep. |
| *Range*: | Output V or I range. Auto-ranging can be specified. |
| *Start Value*: | V or I value at which sweep begins. |
| *Stop Value*: | V or I value at which sweep ends. |
| *No. of steps*: | Number of sweep steps (up to 1001 points). |
| *Hold Time*: | Wait time before a sweep begins. |
| *Delay Time*: | Wait time before a measurement is made at each sweep step. |
| *Stop Mode*: | Continue or abort sweep setting if an error occurs or if an SMU reaches compliance. |

**Note**

After a measurement sweep, SMU or VS output returns to the specified *start* or *stop value*, as determined by the *stop mode* setting. To protect test devices, reset SMU or VS output to 0 (V or A) after each measurement sweep.

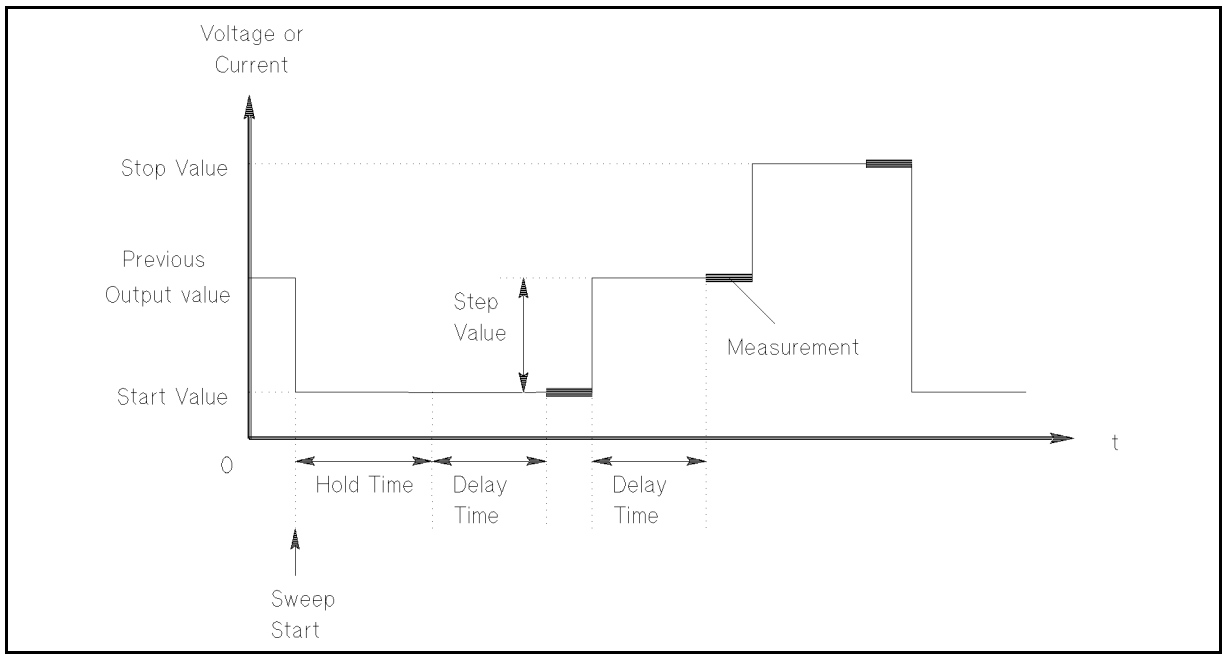



**Figure 2-14. DCS Staircase Sweep Measurement Output**

## Pulsed Bias Spot Measurements

SMU and VS output can be pulsed, as shown in Figure 2-15, by specifying the following pulsed bias spot measurement parameters.

| | |
|---|---|
| *Range*: | Output V or I range. Auto-ranging can be specified. |
| *Pulse Peak*: | Maximum pulse output value. |
| *Pulse Base*: | Output value before a pulse. |
| *Pulse Width*: | Period of time from the beginning of a pulse to the completion of a measurement during that pulse's output. |
| *Hold Time*: | Wait time before pulse output begins. |
| *Pulse Period*: | Period of time from the beginning of one pulse to the beginning of the next pulse. |

**Note**

After a pulsed measurement, SMU or VS output returns to the specified *pulse base* value. To protect test devices, reset SMU or VS output to 0 (V or A) after each pulsed measurement.

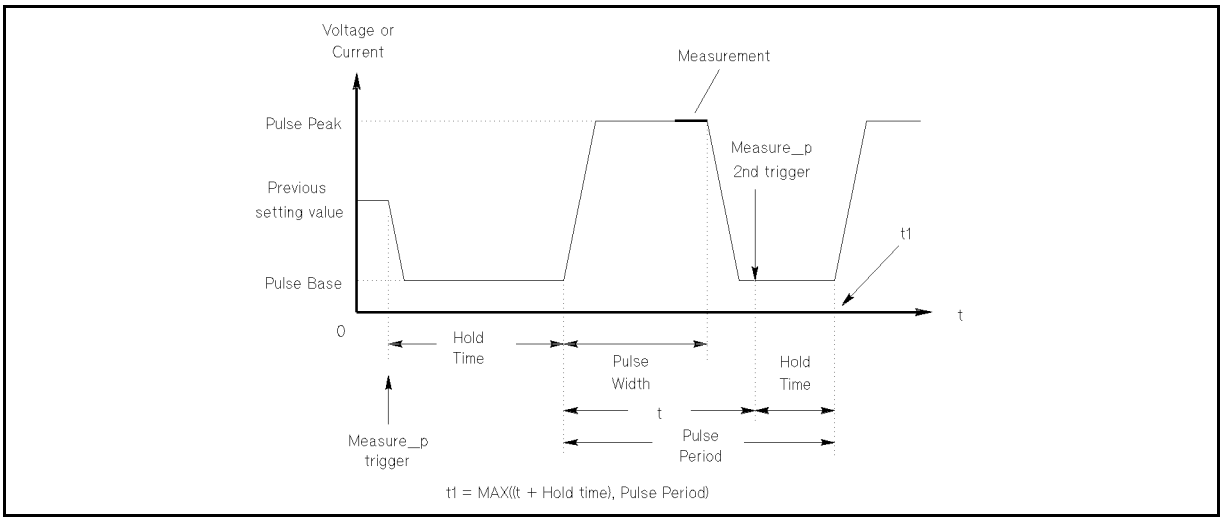



**Figure 2-15. DCS Pulsed Bias Spot Measurement Output**

## Pulsed Bias Sweep Measurements

SMU and VS output can be swept in a staircase manner with pulsed bias, as shown in Figure 2-16, by specifying the following parameters.

| | |
|---|---|
| *Range*: | Output V or I range. Auto-ranging can be specified. |
| *Start Value*: | V or I value at which sweep begins. |
| *Stop Value*: | V or I value at which sweep ends. |
| *No. of steps*: | Number of sweep steps (up to 1001 points). |
| *Pulse Peak*: | Maximum pulse output value. |
| *Pulse Base*: | Output value before a pulse. |
| *Pulse Width*: | Period of time from the beginning of a pulse to the completion of a measurement during that pulse's output. |
| *Hold Time*: | Wait time before sweep and pulse output begins. |
| *Pulse Period*: | Period of time from the beginning of one pulse to the beginning of the next pulse. |

**Note**

After a pulsed bias measurement sweep, SMU or VS output returns to the specified *start value* and *pulse base* value. To protect test devices, reset SMU or VS output to 0 (V or A) after each pulsed bias sweep measurement.

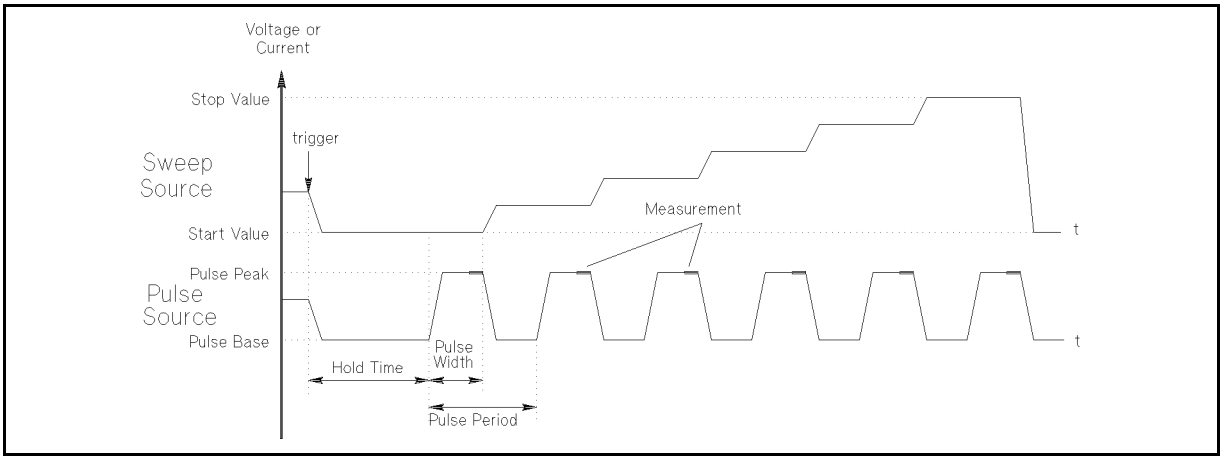



**Figure 2-16. DCS Pulsed Bias Measurement Sweep Output**

## Pulsed Sweep Measurements

SMU or VS sweep output can be pulsed, as shown in Figure 2-17, by specifying the following parameters.

| | |
|---|---|
| *Sweep Mode*: | Single or double sweep. |
| *Range*: | Output V or I range. Auto-ranging can be specified. |
| *Start Value*: | V or I value at which sweep begins. |
| *Stop Value*: | V or I value at which sweep ends. |
| *Hold Time*: | Wait time before a pulsed sweep begins. |
| *No. of steps*: | Number of sweep steps (up to 1001 points). |
| *Pulse Base*: | Output value before a pulse. |
| *Pulse Width*: | Period of time from the beginning of a pulse to the completion of a measurement during that pulse's output. |
| *Pulse Period*: | Period of time from the beginning of one pulse to the beginning of the next pulse. |

**Note**

After a pulsed sweep measurement, SMU or VS output returns to the specified *pulse base* value. To protect test devices, set SMU or VS output to 0 (V or I) after each pulsed sweep measurement.

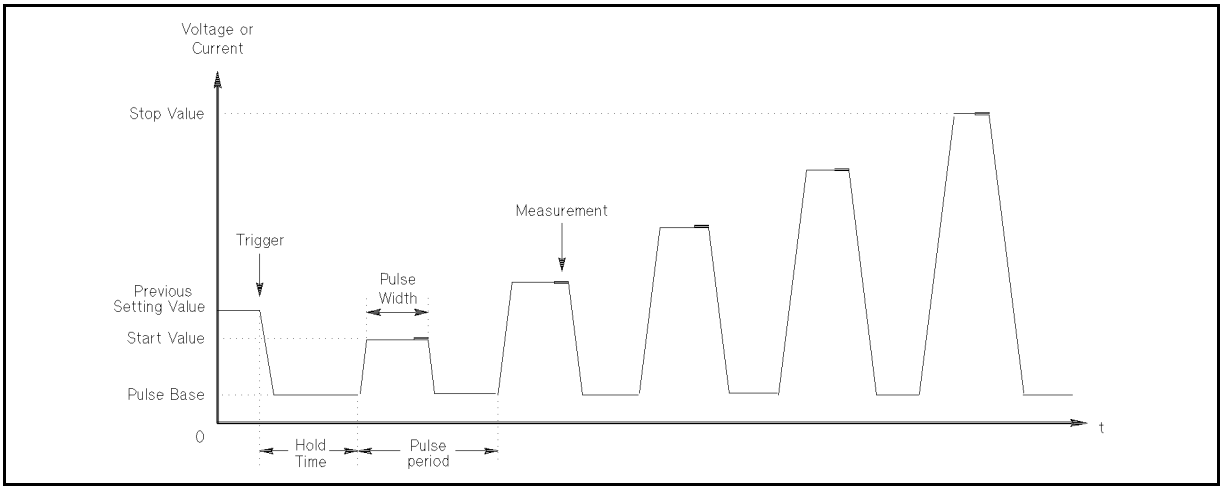



**Figure 2-17. DCS Pulsed Sweep Measurement Output**

## Analog Search Measurements

Analog search measurements are performed by using the DCS's Analog Feedback Unit (AFU), one search SMU, and one sense SMU, as described in "Analog Feedback Unit (AFU)", and by specifying the following parameters.

| | |
|---|---|
| *Search Mode*: | Negative feedback, positive feedback, ramp search—DUT output > target value, and ramp search—DUT output < target value. |
| *Measurement Mode*: | Search SMU or search and sense SMU V or I measurement modes. |
| *Start Value*: | V value at which search begins. |
| *Stop Value*: | V limit value of the swept ramp voltage. |
| *Sense SMU Bias Value*: | Sense SMU V or I bias value. |
| *Target Value*: | V or I value against which sense SMU output is compared. |
| *Ramp Rate*: | Search SMU ramp output V ramp rate. |
| *Hold Time*: | Wait time before an analog search begins. |
| *Feedback Integration Time*: | Analog feedback operation time constant. |
| *Delay Time*: | Wait time required in addition to feedback integration time to ensure that the sense SMU's measurement value is within ±0.1% of the target value. |

Optimum parameter value settings vary depending on test device characteristics and other parameter settings. To help you set optimum parameter values, use the PARA utility subprograms: Para_hfe for $h_{FE}$ measurements, and Para_vth for threshold V measurements.

Figure 2-18 shows analog search measurement waveforms.

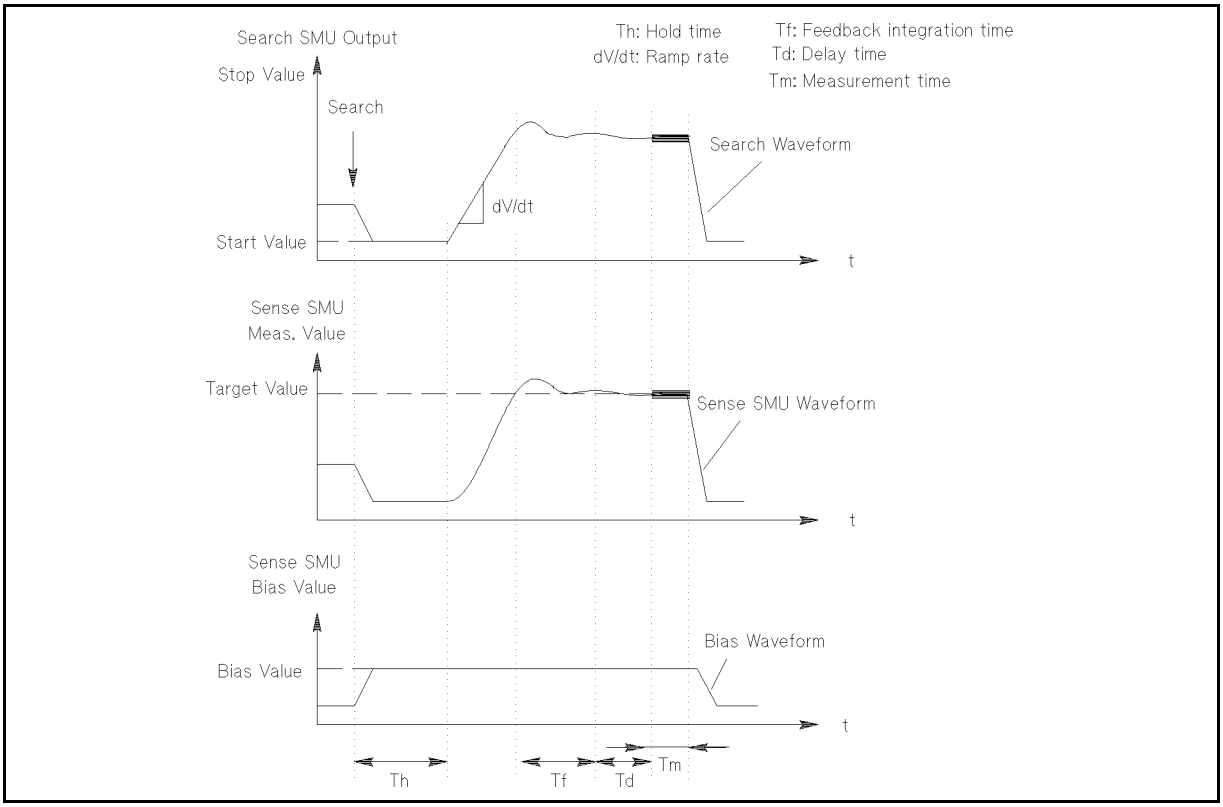



**Figure 2-18. Analog Search Measurement Waveforms**

## Binary and Linear Search Measurements

Binary and linear search measurements are performed by using SMUs, VSs, or VMs; one is a search unit and the other is a sense unit. The search algorithm of these measurements is controlled by software named the Test Instruction Set (TIS).

### Binary Search Measurements

The binary search measurements are performed by the following parameters:

| | |
|---|---|
| *Mode:* | Defines the search unit mode, normal/reset output mode, and convergence mode. |
| *Minimum Search Value:* | Minumum value for the binary search algorithm at the search unit. |
| *Maximum Search Value:* | Maximum value for the binary search algorithm at the search unit. |
| *Target Value:* | Voltage or current value against which the measured value at the sense unit is compared. |
| *Convergence Condition:* | For the accuracy mode, the error range of the target value is specified in percent (%). For the times mode, iteration number of the binary comparison is specified in times. |

Figure 2-19 shows an example wave form of the binary search.

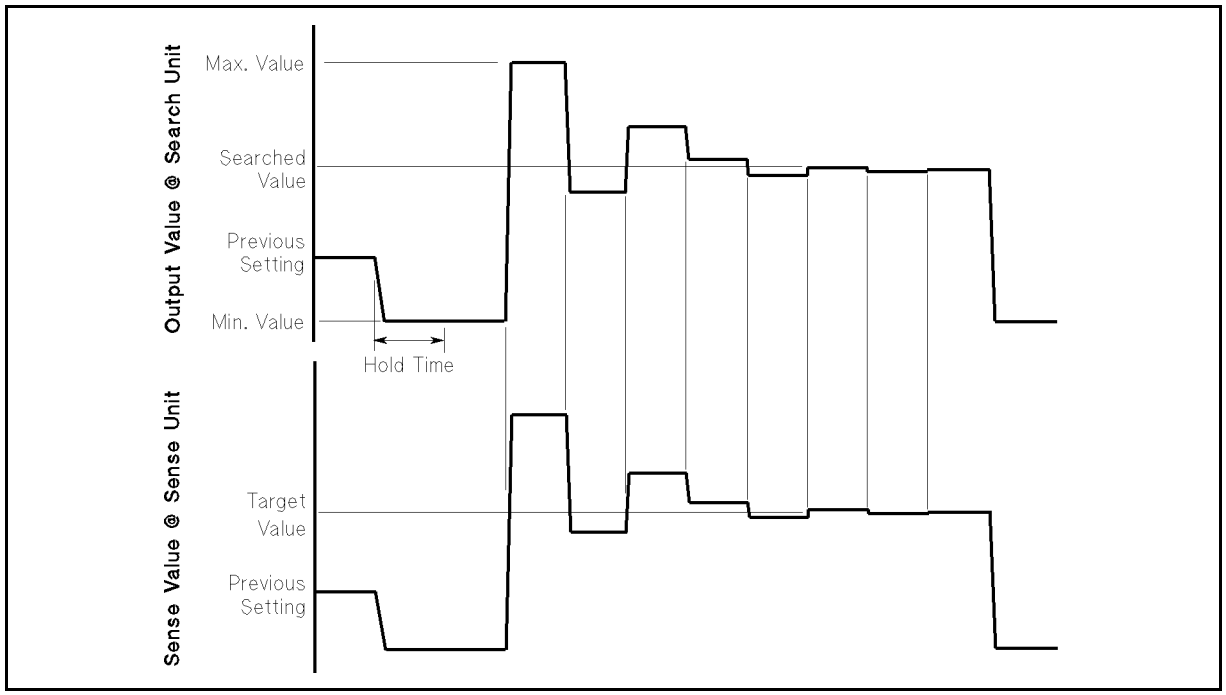



**Figure 2-19. Binary Search Measurement Waveforms**

### Linear Search Measurements

The Linear search measurements are performed by the following parameters:

| | |
|---|---|
| *Mode:* | Defines the search unit mode, normal/reset output mode, stop mode, and sense mode. |
| *Start Value:* | Start value for the linear search algorithm at the search unit. |
| *Stop Value:* | Stop value for the linear search algorithm at the search unit. |
| *Step Value:* | Step value for the search unit output. |
| *Target Value:* | Voltage or current value against which the measured value at the sense unit is compared. |

Figure 2-20 shows an example wave form of the binary search.

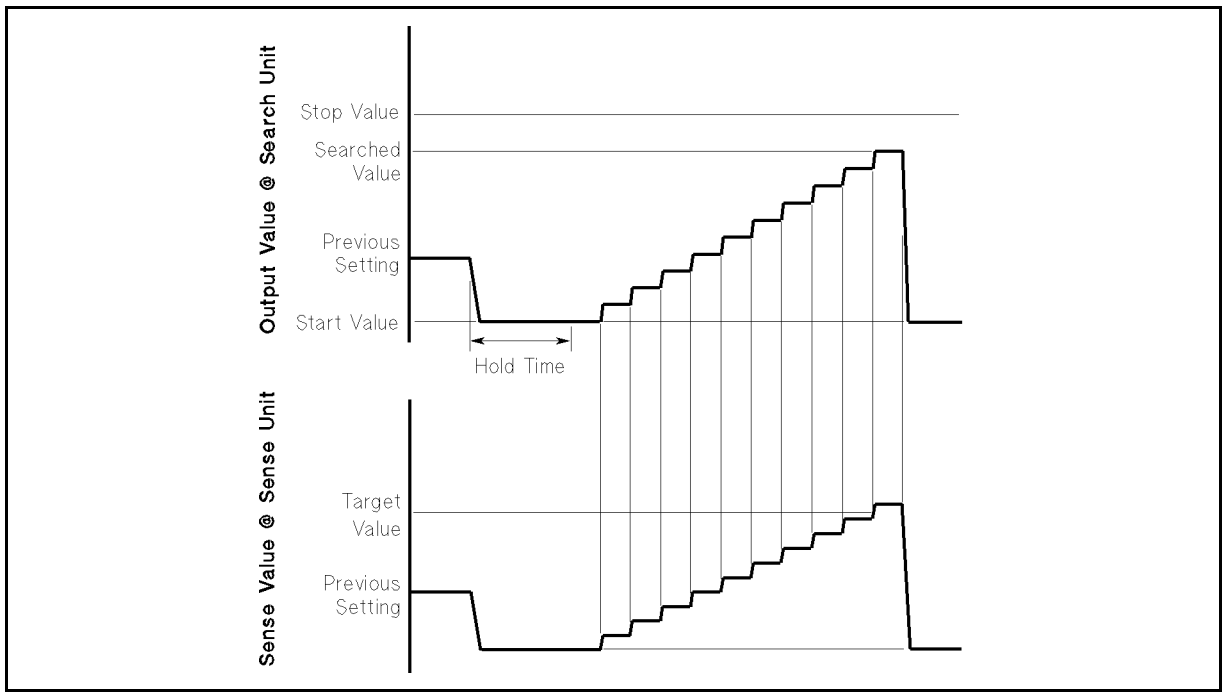



**Figure 2-20. Linear Search Measurement Waveforms**

## DCS Program Memory

You can use the DCS program memory function using the program memory library (PGMLIB). Using the DCS program memory function reduces the time for sending control commands to the DCS, and improves the total throughput for the measurements.

Figure 2-21 shows concepts for using the DCS program memory function.

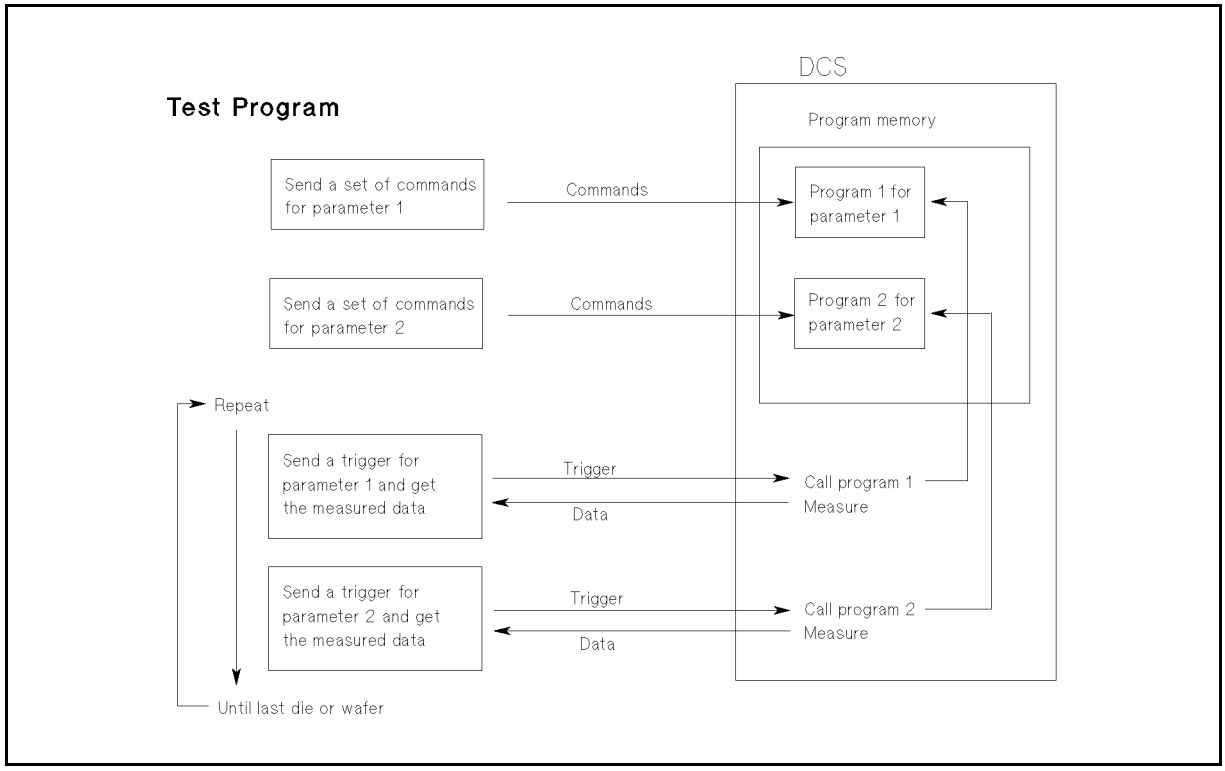



**Figure 2-21. DCS Program Memory Function**

If you measure several devices using the same algorithm and settings, the control command for a measurement is sent once to the DCS and stored in program memory. The DCS executes the stored command when a trigger is sent from the system controller. As a result, the time to transfer the control command for each measurement can be omitted and total throughput of the measurements is improved.

The DCS can store up to 99 programs in the program memory.

## Capacitance Measurement Unit (CMU)

The CMU provides a 1 MHz signal source, a 1 MHz current meter, and a dc bias source. Figure 2-22 shows a simplified CMU circuit diagram.

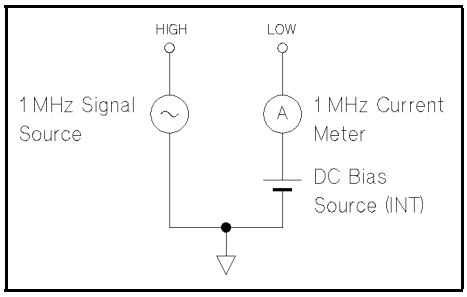



**Figure 2-22. Simplified CMU Circuit Diagram**

The CMU's measurement terminals—UNKNOWN, HIGH, and LOW—and guard terminal connect to the SWM's CMH, CML, and GCMU ports, respectively.

For complete information on the CMU, refer to the HP 4280A's *Operation and Service Manual*.

### Test Signal

The CMU's 1 MHz sinewave test signal provides two output levels: 10 mVrms and 30 mVrms.

### Measurement Modes and Functions

HP 4062C/UX/PC uses only the C-G function.

### Connection Modes

The various CMU connection modes make it possible to reconfigure the CMU's signal source, current meter, and dc bias source internal connections. Note that only CMU internal connection modes CN12, CN15, and CN18 are used for HP 4062C/UX/PC applications.

Figure 2-23 shows the equivalent circuit for each CMU connection mode used with the HP 4062C/UX/PC.

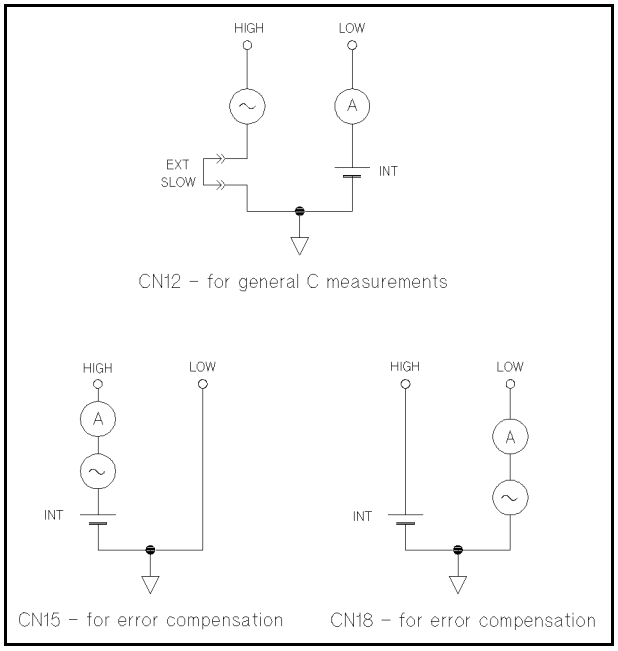



**Figure 2-23. HP 4062C/UX/PC CMU Connection Modes**

For more information on error compensation measurements, see "CMS Error Compensation" in Chapter 5.

## Measurement Ranges

The CMU provides three C-G measurement ranges: 10 pF/100 $\mu$S, 100 pF/1 mS, and 1 nF/10 mS. Note that when the CMU is used for HP 4062C/UX/PC applications, the CMU's C and G range limits are slightly different due to the HP 4062C/UX/PC's built-in error compensation feature. For example, the upper range limits for the 1 nF/10 mS range are about 1.2 nF and 12 mS (not a guaranteed specification).

## Integration Time

The CMU provides 3 integration times you can select from to satisfy the requirements of virtually any measurement.

## Internal DC Bias

The CMU is equipped with a $\pm$100 V dc bias source.

When using the CMU's internal dc bias source for HP 4062C/UX/PC applications, dc bias voltage is referenced to the SWM's CML and GCMU ports.

**Note**

When using the CMU's dc bias source with the HP 4062C/UX/PC, only connection mode CN12 is available. The CMU can be controlled, however, as if set to connection mode CN10. Refer to "Configuration of the CMU Ports" in Chapter 5 for details.

## Internal DC Bias Safety Considerations

The CMU's internal dc bias source can output up to ±100 V. To prevent a potential shock hazard, the CMU is equipped with an INT BIAS limit switch and a REMOTE ON/OFF terminal. During system operation, the furnished BNC shorting cap must be connected to the REMOTE ON/OFF terminal and the INT BIAS limit switch must be set to ±100 V MAX.

**Warning**

**If operating the cmu standalone, remove the bnc shorting cap from the remote on/off terminal: failure to do so may result in hazardous voltages of up to ±100 v at the unknown terminals.**

## C-V Measurements

To facilitate test device C-V characterization, the CMU's internal dc bias source output can be swept in a staircase manner, as shown in Figure 2-24, by specifying the following sweep parameters:

*Start Voltage*: Voltage at which sweep begins.

*Stop Voltage*: Voltage at which sweep ends.

*No. of Steps*: Number of sweep steps.

*Hold Time*: Wait time before sweep begins.

*Delay Time*: Wait time before a measurement is made at each step.

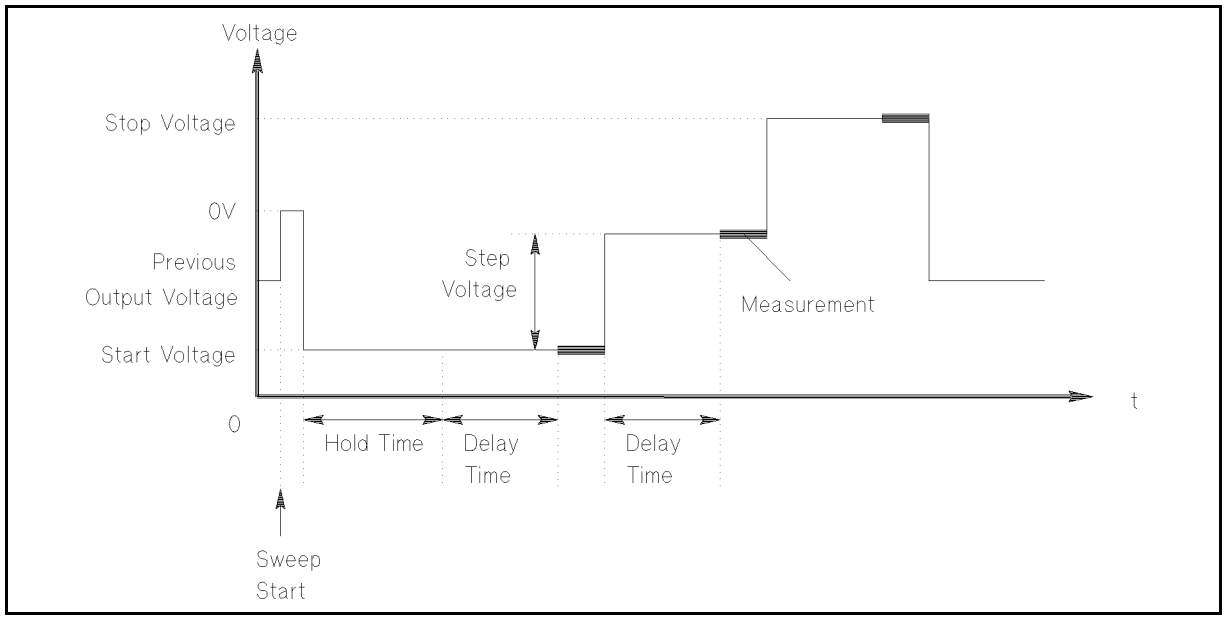



**Figure 2-24. CMU C-V Sweep Measurement Output**

## C-t Measurements

The CMU performs C-t measurements by applying a bias pulse to a device under test, then by measuring capacitance at constant user-specified intervals. Figure 2-25 shows the C-t measurement sequence along with the various measurement parameters. Each parameter is briefly described as follows:

*Pulse Voltage*: Peak bias pulse voltage.

*Meas. Voltage*: Bias voltage at which measurement is made.

*No. of Readings*: Total number of measurements.

*Pulse Width*: Bias pulse width.

*Measurement Interval*: Measurement interval.

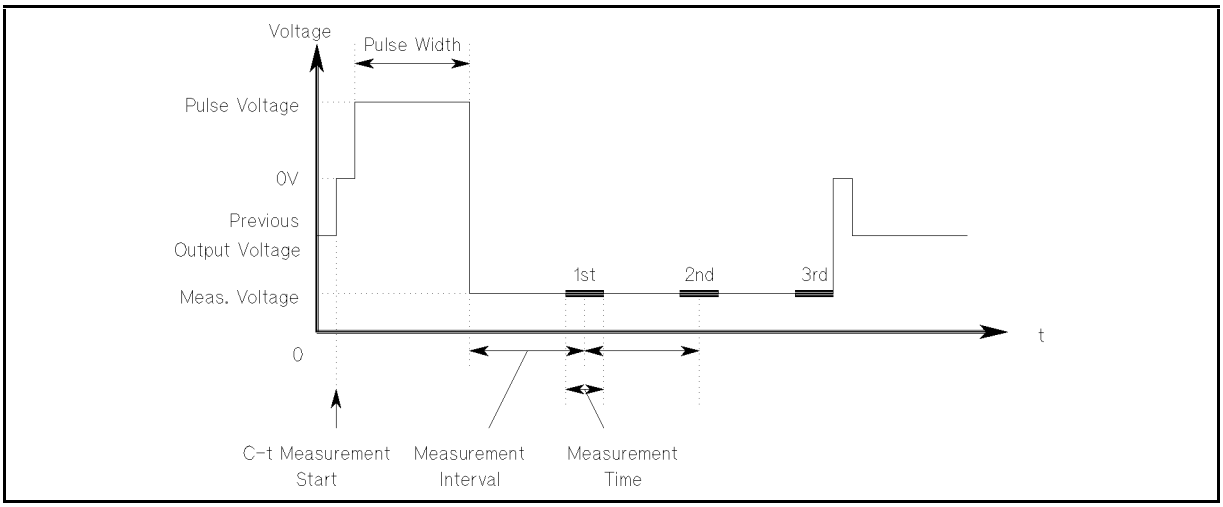
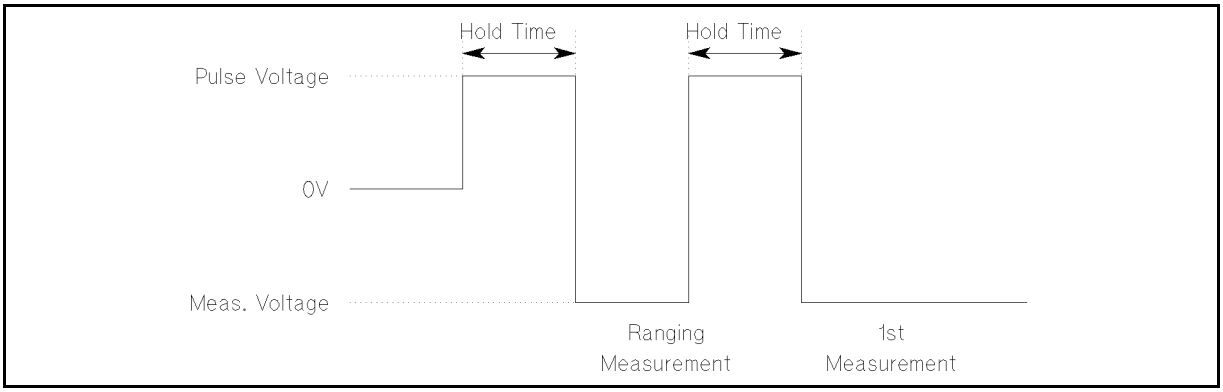



**Figure 2-25. CMU C-t Measurement Sequence**

If range changing occurs before the 1st measurement completes, the bias pulse is applied again, and measurent is performed as follows:




**CMU C-t Measurement Sequence (Continued)**

## Capacitance Measurement Unit 4284 (CMU84)

The CMU84 is an LCR meter with a 20 Hz–1 MHz signal source and a dc bias source. The CMU84's measurement terminals—UNKNOWN Hcur and Hpot, and Lcur and Lpot—connect to the SWM's CMH and CML, respectively.

For complete information on the CMU84, refer to the HP 4284A *Operation Manual*.

**Note**

For HP 4062C/UX/PC application, CMU84 (HP 4284A) must be equipped with Option 001, Power Amplifier/DC Bias, and Option 006, 2 m/4 m Cable Length Operation.

### Test Signal

The CMU84 operates from 20 Hz to 1 MHz with 8610 frequency steps in between. The CMU84's sinewave test signal provides output levels from 5 mVrms to 20 Vrms.

**Note**

The HP 4062C/UX/PC specifies measurement accuracy at 1 kHz, 10 kHz , 100 kHz, and 1 MHz, and 30 mVrms only.

### Measurement Modes and Functions

The HP 4062C/UX/PC uses only the Cp-G function.

### Measurement Ranges

When the CMU84 is used for HP 4062C/UX/PC applications, the CMU84's C and G range limits are about 100 nF and 6.3 mS (depending on the measurement frequency).

### Integration Time

The integration time is the time required to perform an A-D conversion. Generally, a longer conversion time results in more stable and accurate measurement results. SHORT, MEDIUM, or LONG integration times can be selected.

### Internal DC Bias

The CMU84 is equipped with a ±40 V dc bias source. When using the CMU84's internal dc bias source for HP 4062C/UX/PC applications, dc bias voltage is referenced to the SWM's CMH and CML ports.

## C-V Measurements

To facilitate test device C-V characterization, the CMU84's internal dc bias source output can be swept in a staircase manner, as shown in Figure 2-26, by specifying the following sweep parameters:

*Start Voltage*: Voltage at which sweep begins.

*Stop Voltage*: Voltage at which sweep ends.

*No. of Steps*: Number of sweep steps.

*Hold Time*: Wait time before sweep begins.

*Delay Time*: Wait time before a measurement is made at each step.

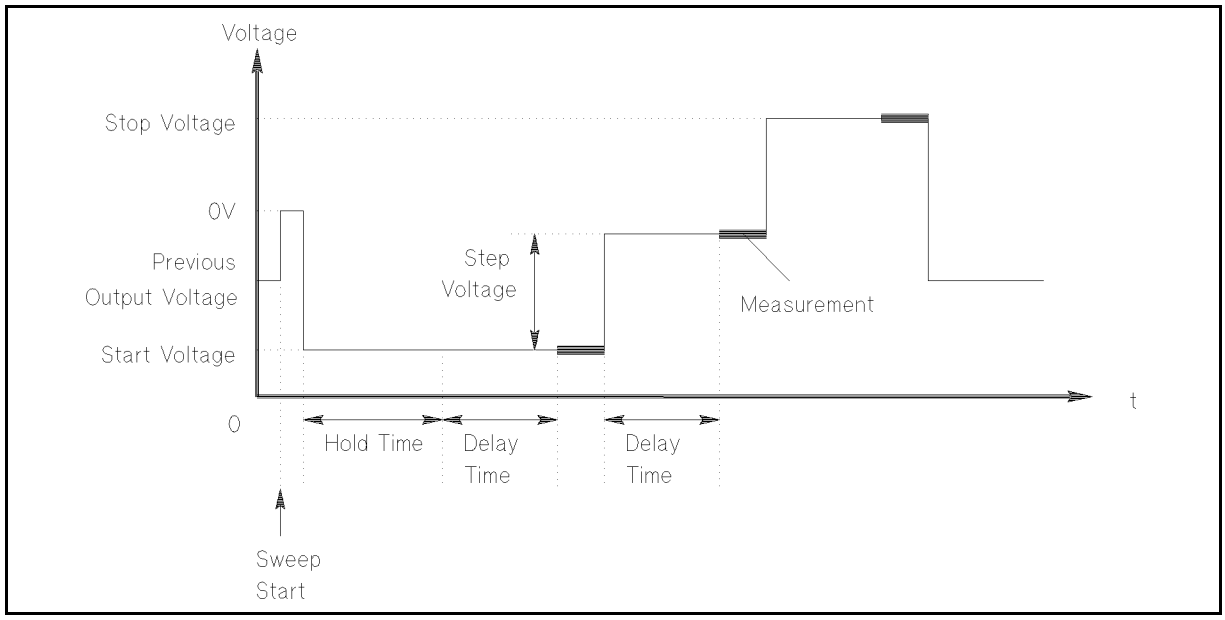



**Figure 2-26. CMU84 C-V Sweep Measurement Output**

# 3

# Operator Instructions

## Introduction

This chapter provides operating information for the HP 4062C/UX/PC, and covers the following topics:

- Front and rear panel keys and indicators for each subsystem component
- Turning your system ON and OFF
- Turning off your system in an emergency (standard cabinet only)
- Subsystem component self-tests
- HP-IB select code settings
- Pin board considerations
- Cleaning contact surfaces and measurement pins

To ensure operator safety and to maintain the integrity and serviceability of your HP 4062C/UX/PC, be sure to observe all notes, warnings, and cautions provided throughout the HP 4062C/UX/PC's documentation.

**Note**

This chapter does not contain programming or measurement-related information. For instructions on how to make measurements under Virtual Front Panel (VFP) control or how to use the Test Instruction Set (TIS), refer to your HP 4062C/UX/PC's *System Operation*.

## Panel Features

Important panel features for the following items are shown in Figure 3-1 to Figure 3-7: front panels of the standard and small system cabinets; front and rear panels of the SWC, DCS, CMU, and CMU84; and panels of the 48-pin and 96-pin SWMs.

Brief descriptions for each subsystem item are keyed to the parenthetically numbered items in each figure.

### System Cabinet

- Standard System Cabinet (1600 mm height)

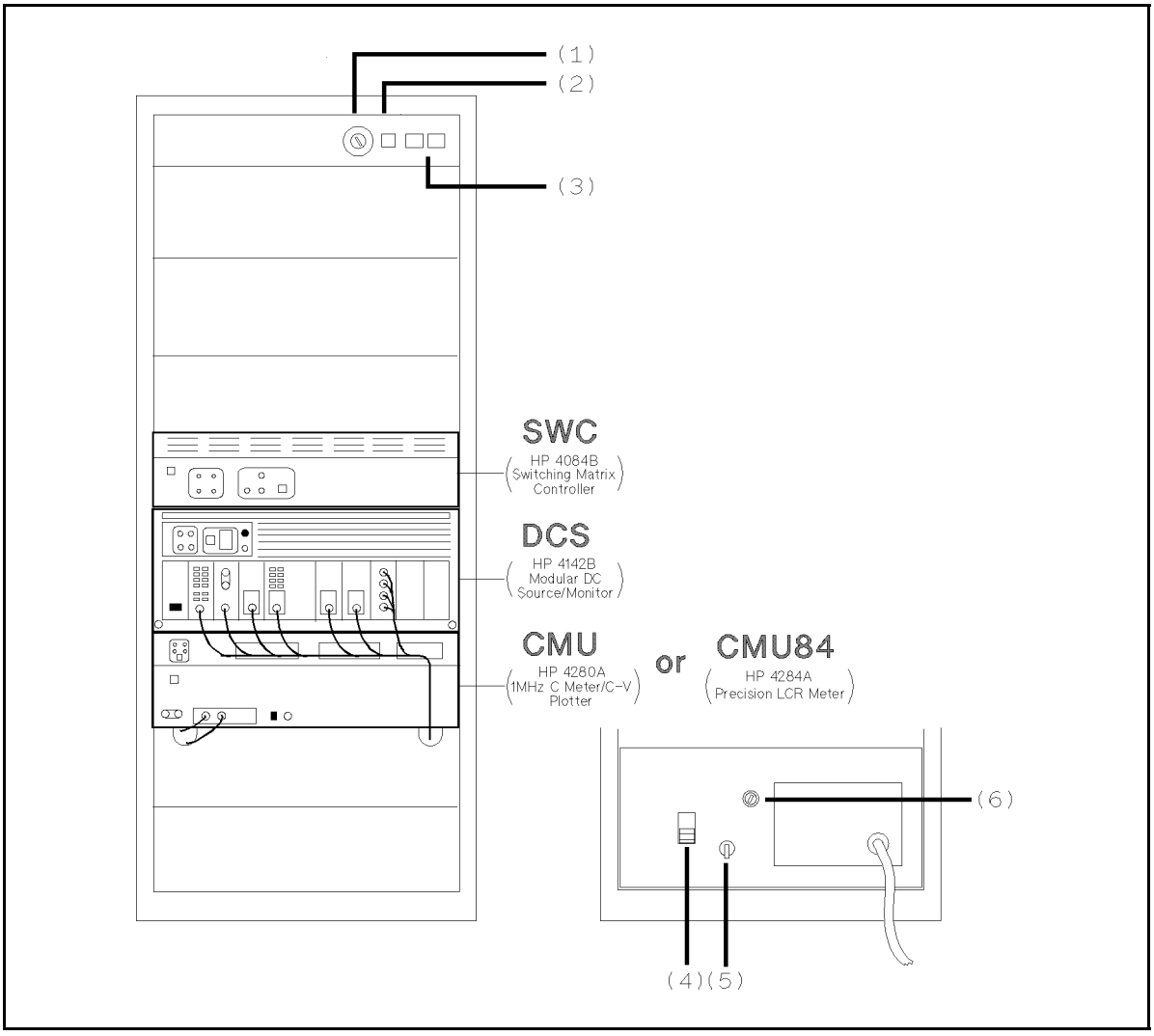



**Figure 3-1. Front and Rear Panels of Standard Cabinet (1600 mm height)**

(1) EMERGENCY OFF Switch:

Pressing the emergency off switch stops the supply of electric power to the system instruments. This switch is a red, circular push-switch, and you must use a mechanical key to reset the locked switch after pressing the emergency off switch.

(2) BREAKER ON Indicator:

The BREAKER ON indicator shows the conditions of circuit breakers in the power distribution unit (PDU). When both the main circuit breaker and the sub-circuit breaker of the emergency off unit are turned on, the BREAKER ON indicator (white) turns on.

(3) LINE Switches:

Main power switch of the system cabinet. Pressing the LINE 1 push-switch supplies the electric power to the system instruments and the green indicator on the LINE 1 switch turns on. Pressing the LINE 0 push-switch stops the supply of electric power to the system instruments and the green indicator turns off.

(4) MAIN BREAKER Switch:

Main breaker switch of the system cabinet. The main breaker for the 100 Vac line voltage option also has a ground-fault circuit interrupter (GFCI) function.

(5) SUB-BREAKER Switch:

Sub-breaker switch for the emergency off unit.

(6) Fuse:

Fuse for the emergency off unit. When replacing the fuse, use the following:

2.5 A, Time Delay (HP part number 2110-0015)

■ Small System Cabinet (1000 mm height)

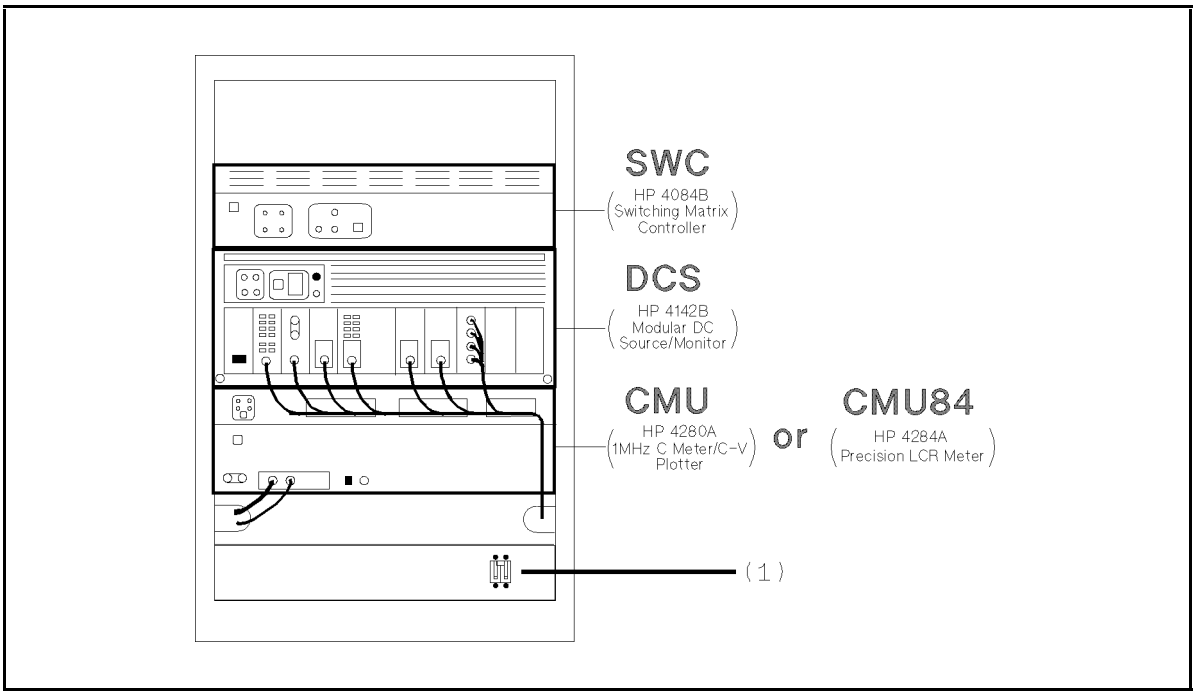



**Figure 3-2. Front and Rear Panels of Small Cabinet (1000 mm height)**

(1) LINE Switch:

System cabinet main power ON/OFF switch. This switch also functions as a circuit breaker.

## Switching Matrix Controller (SWC)

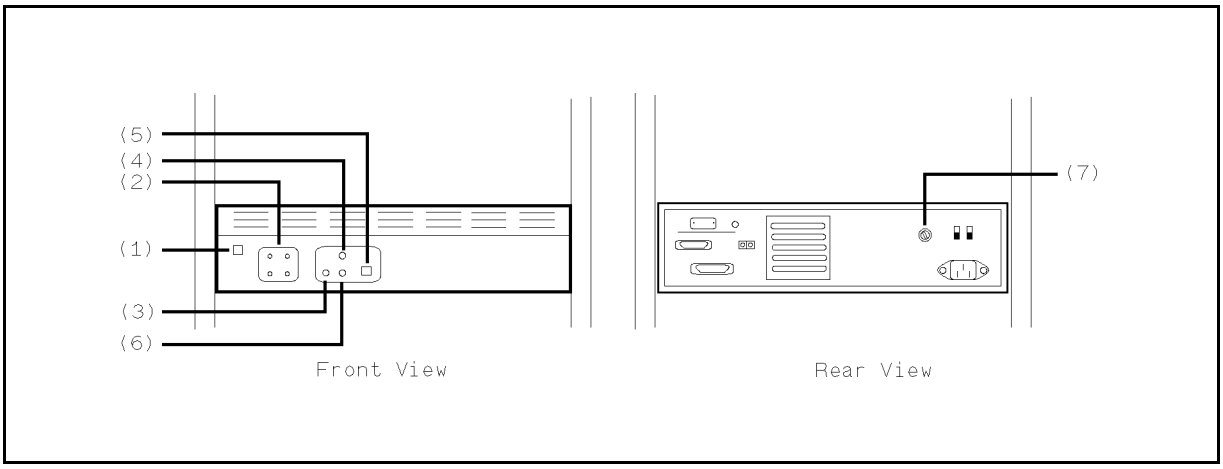



**Figure 3-3. Front and Rear Panels of Switching Matrix Controller (SWC)**

(1) LINE ON/OFF Switch:

Line switch of the SWC.

(2) HP-IB Status Indicators:

LEDs that show the HP-IB status of the SWC.

(3) SWITCHING MATRIX OPEN Indicator:

Lights if the SWM is open. When lit, all SWM measurement pins are disconnected from all measurement ports.

(4) SWITCHING MATRIX CONTROLLER FAIL Indicator:

Lights if the SWC's self-test, which continuously monitors transmissions between the SWC and SWM, detects an error. To prevent illegal operation, the SWC ignores most HP-IB commands when this indicator is lit.

(5) SWITCHING MATRIX LOCAL/TEST Key and Indicator:

Pressing this key while the RMT HP-IB indicator lamp is lit (SWC is under remote control) sets the SWC to local control (RMT lamp goes out). Pressing this key while the SWC is set to local control starts the SWM Relay Test. The indicator lamp at the center of the key lights during the Relay Test. For more on the Relay Test, refer to Chapter 4.

(6) SWITCHING MATRIX FAIL Indicator:

Lights continuously if the SWM fails its self-test; flashes if the SWM fails its Relay Test. If this lamp lights, refer to Chapter 4.

(7) Fuse:

Fuse for the SWC. When replacing the fuse, use the following:

1.5 A, Time Delay (HP part number 2110-0304) for 100 Vac or 120 Vac
750 mA, Time Delay (HP part number 2110-0360) for 220 Vac or 240 Vac

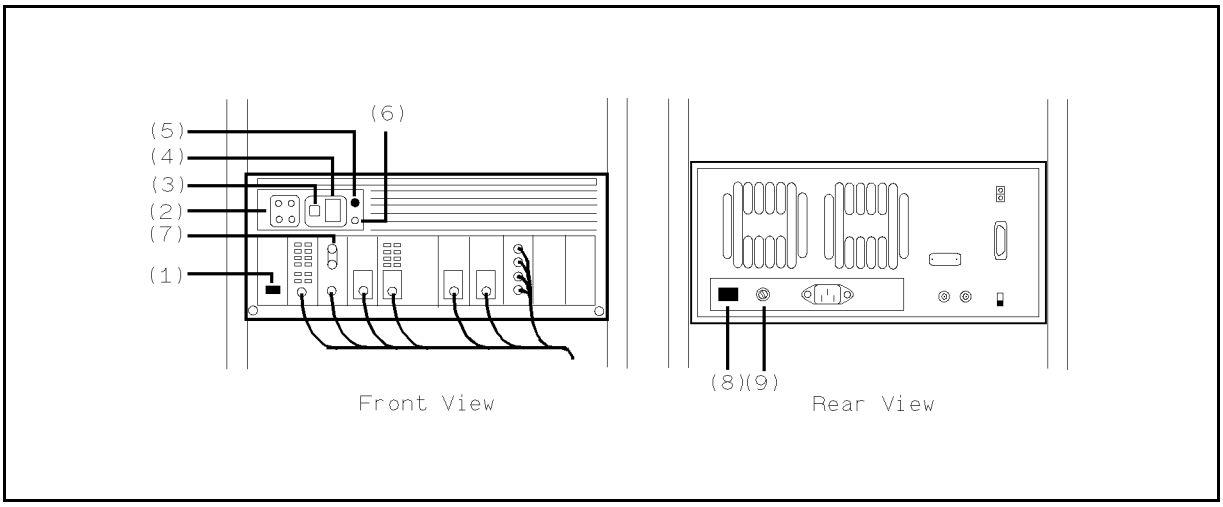



**Figure 3-4. Front and Rear Panels of DC Source/Monitor (DCS)**

(1) POWER Switch:

Main power switch of the DCS. Note that the LINE switch is located on the rear panel of the DCS.

(2) HP-IB Status Indicators:

LEDs that show the HP-IB status of the DCS.

(3) LOCAL/SELF TEST Key:

Pressing this key while the RMT HP-IB indicator lamp is lit (DCS under remote control) sets the DCS to local control (RMT lamp goes out). Pressing this key while the DCS is set to local control starts the DCS self-test/self-calibration. The indicator lamp in the center of this key lights and a "C" is displayed in the ERROR/FAILURE display (4) during self-test/self-calibration.

(4) ERROR/FAILURE Display:

Displays the DCS's status. A "0" indicates normal operation; a "C" appears during self-test/self-calibration. If any other character is displayed, see the HP 4142B's *Operation Manual*.

(5) HIGH VOLTAGE Indicator:

Lights if the DCS output may exceed ±42 V during a measurement, as determined by the specified START and STOP voltages of an SMU operating in the V source mode, or by the V compliance setting of an SMU operating in the I source mode.

(6) MEASURING Indicator:

Lights when the DCS is performing a measurement.

(7) CIRCUIT COMMON (▽)—GND (⊥) Terminals:

For floating and grounded measurements. For system applications, these terminals must be tied together with the attached shorting bar.

(8) LINE ON/OFF Switch:

Line switch of the DCS.

(9) Fuse:

Fuse for the DCS. When replacing the fuse, use the following:

8 A, Non-Time Delay (HP part number 2110-0342) for 100 Vac or 120 Vac
4 A, Non-Time Delay (HP part number 2110-0055) for 220 Vac or 240 Vac

## Capacitance Measurement Unit (CMU)—HP 4280A

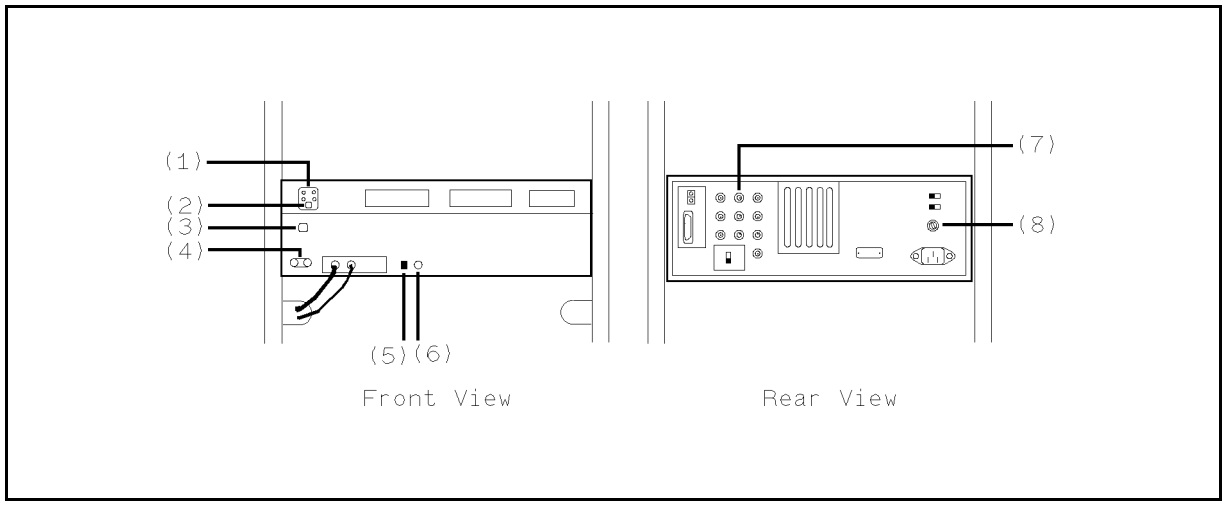



**Figure 3-5. Front and Rear Panels of HP 4280A (CMU)**

(1) HP-IB Status Indicators:

LEDs that show the HP-IB status of the CMU.

(2) LOCAL Key:

Pressing this key sets the CMU to local control (RMT lamp goes out) and enables all front panel keys for manual operation.

(3) LINE ON/OFF Switch:

Line switch of the SWC.

(4) GROUND ($\perp$)—COMMON ($\bigtriangledown$) Terminals:

For floating and grounded measurements. For system applications, these terminals must be tied together with the attached shorting bar.

(5) INT BIAS Limit Switch:

Sets the CMU's internal dc bias source output voltage limit to $\pm$42 V or $\pm$100 V. For system use, this switch must be set to $\pm$100 V and the BNC shorting cap must be connected to the INT BIAS REMOTE ON/OFF connector (6).

(6) INT BIAS REMOTE ON/OFF Connector:

Controls the CMU's internal dc bias source when the INT BIAS limit switch (5) is set to the ±100 V position. When the furnished BNC shorting cap is connected to this connector, the internal dc bias source is enabled; when the shorting cap is removed, the internal dc bias source is disabled.

**Warning** **If using the CMU in a standalone configuration, be sure to remove the BNC shorting cap from the INT BIAS REMOTE ON/OFF connector (6).**

(7) EXT BIAS SLOW Terminal:

For standalone CMU C-t measurements. For system use, the furnished BNC shorting cap must be connected to this terminal.

(8) Fuse:

Fuse for the CMU. When replacing the fuse, use the following:

1.5 A, Time Delay (HP part number 2110-0304) for 100 Vac or 120 Vac
750 mA, Time Delay (HP part number 2110-0360) for 220 Vac or 240 Vac

## Capacitance Measurement Unit (CMU84)—HP 4284A

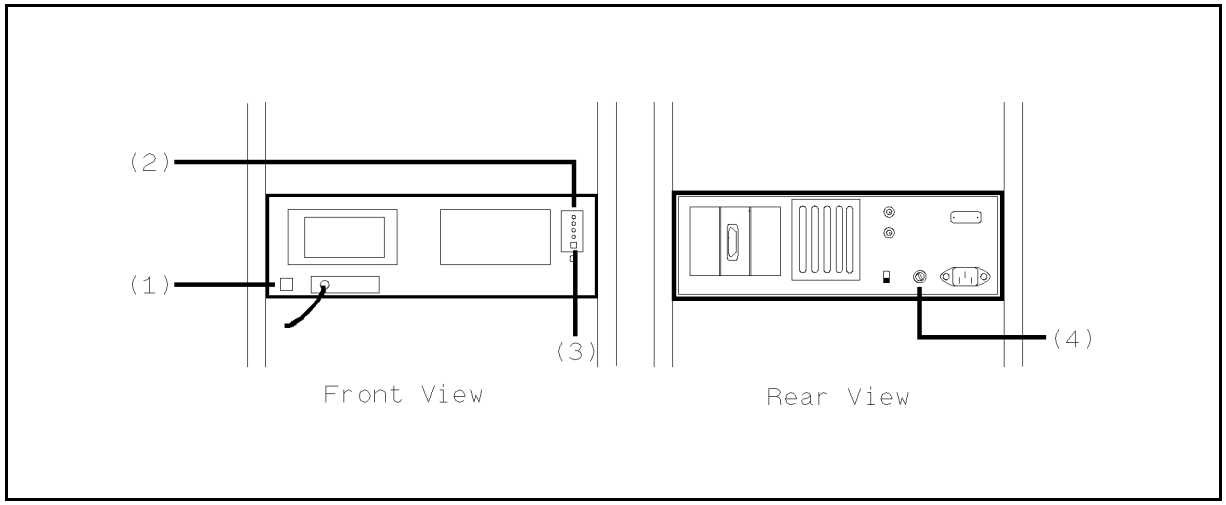



**Figure 3-6. Front and Rear Panels of HP 4284A (CMU84)**

(1) LINE ON/OFF Switch:

Line switch of the CMU84.

(2) HP-IB Status Indicators:

LEDs that show the HP-IB status of the CMU84.

(3) LOCAL Keys:

Pressing these keys sets the CMU84 to local control (RMT lamp goes out) and enables all front panel keys for manual operation.

(4) Fuse:

Fuse for the CMU84. When replacing the fuse, use the following:

3 A, Time Delay (HP part number 2110-0381) for 100 Vac or 120 Vac
2 A, Time Delay (HP part number 2110-0303) for 220 Vac or 240 Vac

## Switching Matrix (SWM)

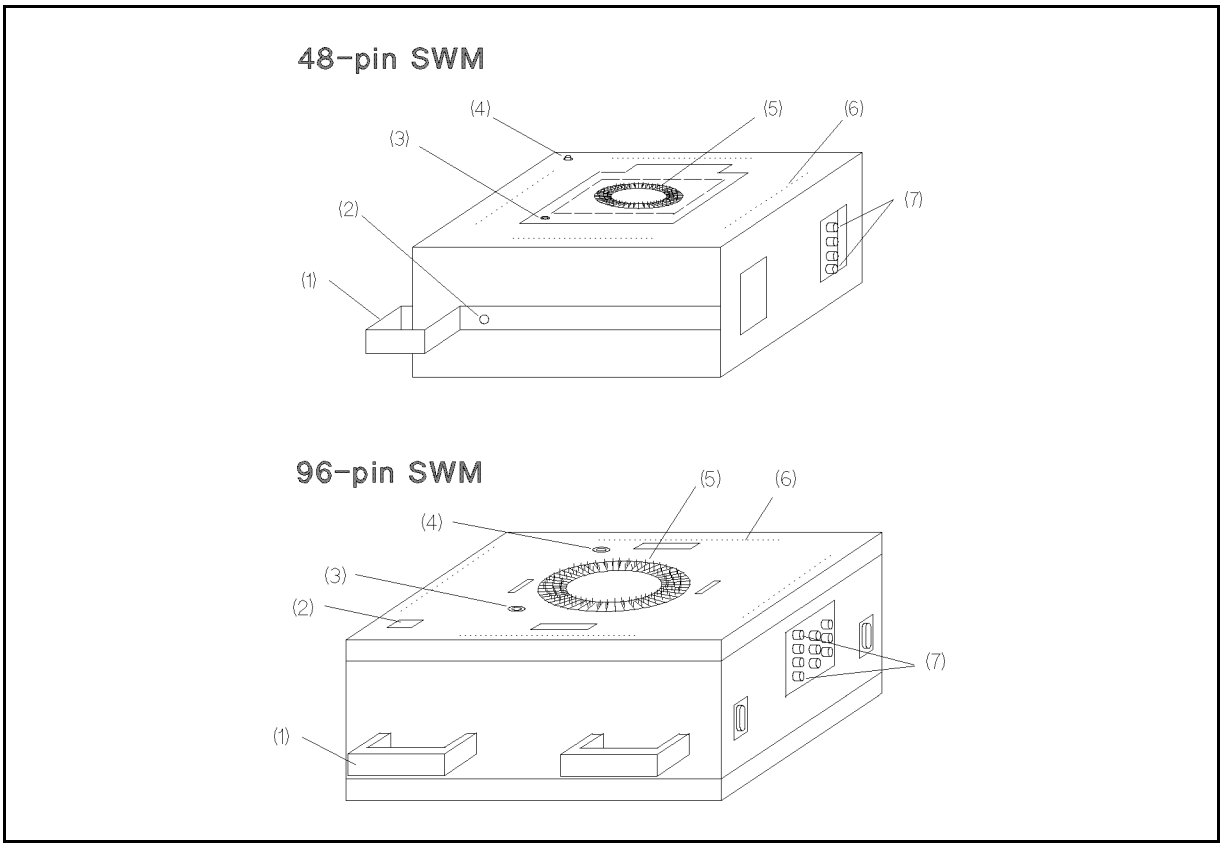



**Figure 3-7. SWM Panel Features**

(1) Handle:

For raising/lowering the SWM when the SWM is attached to a wafer prober.

**Warning** **The SWM is heavy. The 48-pin SWM weighs about 22 kg (44 lb), and the 96-pin SWM weighs about 55 kg (110 lb). Be sure to use the SWM handle(s) when raising and lowering the SWM.**

**Warning** **Keep hands clear of the SWM, hinge, and wafer prober when lowering the SWM into position on your wafer prober.**

(2) OUTPUT ENABLED Indicator:

Lights when the FIXTURE CLOSED DETECT switch (3) or WAFER PROBER SENSE switch (4) is closed. When lit, programmed pin-port connections are made.

⚠

**Warning**

**Potentially hazardous voltages may be present at the measurement pins when the output enabled lamp on the SWM is lit.**

(3) FIXTURE CLOSED DETECT Switch:

Detects whether the test fixture adapter's cover is open or closed.

(4) WAFER PROBER SENSE Switch:

Detects if the SWM is positioned on a wafer prober.

⚠

**Warning**

**If either the FIXTURE CLOSED DETECT switch (3) or WAFER PROBER SENSE switch (4) is closed, dangerous dc voltage exceeding ±42 V may be present at the measurement pins. Severe electric shock will result if the measurement pins are touched.**

**Note**

The FIXTURE CLOSED DETECT and WAFER PROBER SENSE switches are connected in parallel, so if either switch is closed, SWM output is enabled. If both switches are open, SWM output is disabled, thus disconnecting all SWM measurement ports from the measurement pins. Though disabled, you can still control the SWM using VFP or TIS commands. Any changes made while the SWM is disabled are automatically set when one of these switches is closed.

(5) Measurement Pins:

These spring-loaded measurement pins connect (spring pressure contact) to the contacts of a test fixture or wafer prober.

**Caution**

Do not touch the SWM's measurement pins with bare hands. Oil, perspiration, and dirt prevent good electrical contact and degrade measurement accuracy.

(6) Pin Board Fail Indicators:

Light in a sequential pattern during the SWM's Relay Test. If the test detects a defective pin board, the corresponding indicator flashes on and off, as does the FAIL lamp on the SWC.

(7) AUX1, AUX2, AUX3 (CMH), and AUX4 (CML) Ports:

Auxiliary ports (BNC connectors) for connecting the DCS's VSs and VMs, and the CMU's CMH and CML terminals. All AUX ports can connect to the VSs and VMs, but only the AUX3 and AUX4 ports can connect to the CMH and CML terminals, respectively. AUX port connections must be established before you run the START program. Refer to of the *System Operation* for details on the START program.

**Note**

When connecting the SWM's AUX ports to the DCS or CMU, use only the AUX PORT cables furnished with the HP 4062 system. When connecting the SWM's AUX ports to the CMU84, use only the HP 16048E 4 m Test Leads. For more information on how to connect the SWM to the system instruments, see HP 4062C/UX *Installation Manual*.

## Turning your System ON and OFF

LINE switches and circuit breaker switches control the supply of electric power to the system instruments. The LINE switch location of the standard system cabinet (1600 mm height) is different from the small system cabinet (1000 mm height). The switch locations of system instruments and system cabinets are shown in the previous section.

Use the following procedures to turn your system on and of :

- Standard System Cabinet (1600 mm height)
  - Before you turn your system on:
    1. Turn on the main circuit breaker.
    2. Turn on the sub-circuit breaker that controls the supply of electric power to the emergency off unit. When the PDU is ready to supply electric power to the system instruments, the BREAKER ON Indicator (white) turns on.
    3. Press all the LINE switches of the system instruments and set them to ON. Also, press the POWER ON switch on the front panel of the DCS. Note that all the system instruments do not turn on yet.
  - Turn on your system:

    Press the LINE 1 switch on the top right-side of the front door. Then the green indicator on the LINE 1 switch turns on and all the system instruments turn on.
  - Turn off your system:

    Press the LINE 0 switch on the top right-side of the front door. Then the LINE 1 indicator goes out and all the system instruments turn off.

**Note**

Transient current generated by turning the system instruments on or off at the same time may cause noise that affects some instruments other than the HP 4062 system instruments. To reduce the transient current, press the LINE 1 switch and turn on each system instrument.

- Small system cabinet (1000 mm height)
  - Before you turn your system on:

    Press all the LINE switches of system instruments and set them to ON. Also, press the POWER ON switch on the front panel of the DCS. Note that all the system instruments do not turn on yet.
  - Turn on your system:

    Turn on the LINE switch of the system cabinet, which is located at the right-bottom of the front side. All the system instruments turn on.
  - Turn off your system:

    Turn off the LINE switch of the system cabinet, which is located at the right-bottom of the front side. All the system instruments turn off.

**Note**

Transient current generated by turning the system instruments on or off at the same time may cause noise that affects some instruments other than the HP 4062 system instruments. To reduce the transient current, turn on the LINE switch and turn on each system instrument.

## Turning Off your System In an Emergency (Standard Cabinet Only)

The emergency off switch labeled "EMERGENCY OFF" is located at the top-right of the front side. Pressing this switch stops the supply of electric power to the system instruments. The following provides information on how to use the emergency off switch.

If you configure the emergency off system with the HP 4062 system, you must study the emergency off unit before connecting it to other systems. See "Emergency Off System" in Chapter 5.

**Note**

The small system cabinet (1000 mm height) cannot be equipped with an emergency off unit and its power distribution unit (PDU).

### In an Emergency

In an emergency, you only have to press the emergency off switch until it is locked. Then the electric power supplied to the system instruments is stopped.

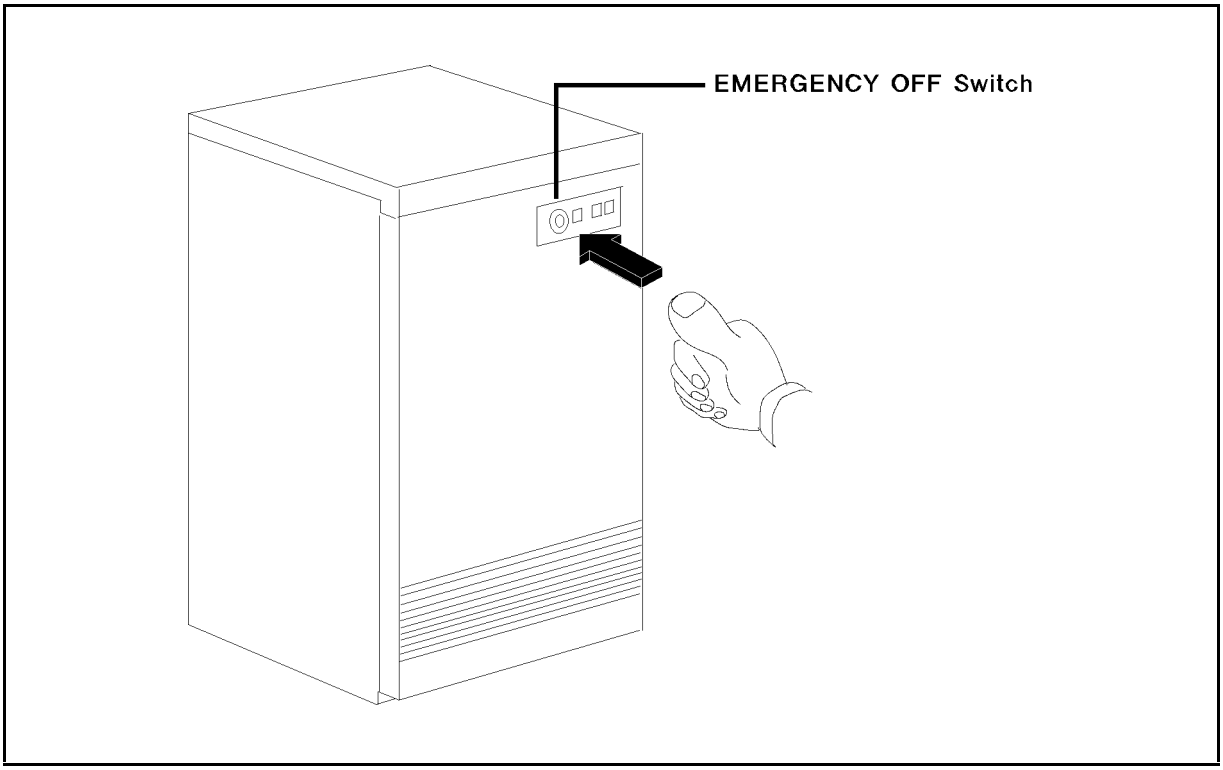



**Figure 3-8. Pressing EMERGENCY OFF Switch**

## Resetting Emergency Off Switch

**Note**

Before resetting the emergency off switch, make sure that all the system instruments have no damage or recover from any damage.

To reset the emergency off switch, you must unlock the locked emergency off switch with a mechanical key. Figure 3-9 shows how to release the locked emergency off switch.

The following describes how to reset the emergency off switch:

1. Insert the key into the keyhole on the emergency off switch.
2. Turn the key counterclockwise and the switch pops up to the default position.
3. If you turn on the system instruments, press the LINE 1 switch on the right-top of the front side.

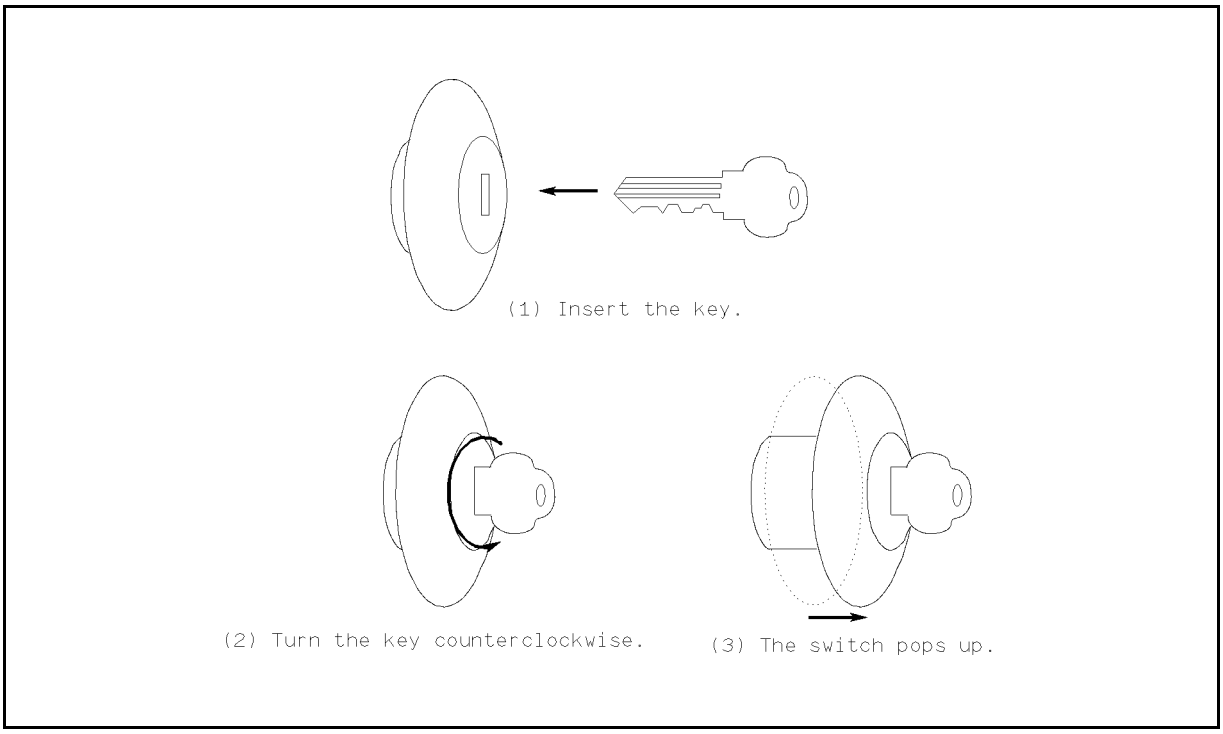



**Figure 3-9. Resetting Locked EMERGENCY OFF Switch**

**Note**

Usually the key should be removed from the emergency off switch and should be kept in a safe place.

The principal operator of your system is responsible for the key. The principal operator authorizes the system restart and resets the emergency off switch.

## Self-tests

Each cabinet mounted HP 4062C/UX/PC subsystem instrument has a self-test function that automatically checks the instrument's basic operation when you turn your system on.

You can also initiate individual instrument self-tests at any time by pressing the following keys:

- The LOCAL/TEST key on the SWC.
- The LOCAL/SELF TEST key on the DCS.
- The SELF TEST key on the CMU.
- The SELF TEST softkey on the CATALOG/SYSTEM MENU of the CMU84.

Or you can execute all the self-tests by executing the diagnostics program (refer to Chapter 4 for details).

In addition, the SWC's self-test function continuously monitors transmissions between the SWC and the SWM during testing.

If an instrument fails self-test, the instrument provides a visual indication, as follows:

- The SWC's FAIL lamp lights.
- The CMU displays an error code in its C display.
- The DCS displays an error code or the slot number of the failed module on its ERROR/FAILURE display.

For more information on CMU, CMU84, and DCS self-test and error codes, refer to the HP 4280A's *Operation and Service Manual*, the HP 4284A's *Operation Manual*, and the HP 4142B's *Operation Manual*, respectively.

**Note**

Before executing the Relay Test, be sure to install the relay test adapter on the SWM. Refer to Chapter 4 on how to install the relay test adapter.

## HP-IB Configuration

Table 3-1 lists the HP 4062C/UX/PC's HP-IB addresses, interface connections, and select codes—all of which are established at system installation.

If you add computer peripherals or other instruments to your HP 4062C/UX, you can connect them to your computer's internal HP-IB, or to an additional interface card installed in your system controller. Be sure to set a unique HP-IB address for each additional system component.

**Table 3-1. HP-IB Configuration**

| Instrument | HP-IB Address | HP 4062C/UX | | HP 4062PC | |
|---|---|---|---|---|---|
| | | HP-IB Interface | SC[1] | HP-IB Interface | SC[1] |
| DCS (HP 4142B) | 23 | HP 98624A HP-IB Interface Card[2] | 27 | Internal HP-IB Interface | 7 |
| CMU (HP 4280A) | 24 | | | | |
| CMU84 (HP 4284A) | 17 | | | | |
| SWC(s) (HP 4084B) | 19[3], 22 | | | | |
| Wafer Prober | *xx*[4] | HP 98624A HP-IB Interface Card[2] | 25 | HP 82335 HP-IB Interface Card | 25 |
| Computer Peripherals | *xx*[5] | Internal HP-IB Interface | 7 | Serial or Parallel Interface | — |
| Other Instruments | *xx*[5] | | | HP 82335 HP-IB Interface Card | 26 |

1 SC stands for Select Code.

2 If your controller is configured in a diskless cluster, internal HP-IB (select code 7) must be used.

3 If your system is equipped with a 96-pin SWM.

4 Depends on your wafer prober

5 Any address permitted by the computer's internal interface. Each device must have a unique address.

**Caution**

Do not connect computer peripherals or additional instruments to the HP 98624A HP-IB Interface Card (select code 27); doing so results in incorrect HP 4062C/UX operation.

## Pin Board Considerations

Occasionally, it is necessary to open the SWM for tasks such as repositioning pin boards (to accommodate reconfiguration requirements for SWMs equipped with less than a full complement of pin boards), cleaning, and so on. Use the following paragraphs to open the SWM.

### Accessing Pin Boards

To access SWM pin boards, refer to Figure 3-10 and perform the following procedure:

1. Turn the HP 4062C/UX/PC off.
2. Remove the SWM's bottom panel as follows:
   - For 48-pin SWMs:

     Using the furnished screw driver, remove all the screws from the bottom panel and remove the SWM's bottom panel.
   - For 96-pin SWMs:

     Using the furnished hexhead wrench, loosen the hexhead screw at each corner of the bottom panel and remove the SWM's bottom panel.
3. Remove the necessary board strut(s) and control bus cable(s)

**Caution**

When removing a control bus cable, disconnect each cable connector from each pin board separately. Do NOT remove the cable by disconnecting one end, then "peeling off" the cable all at once.

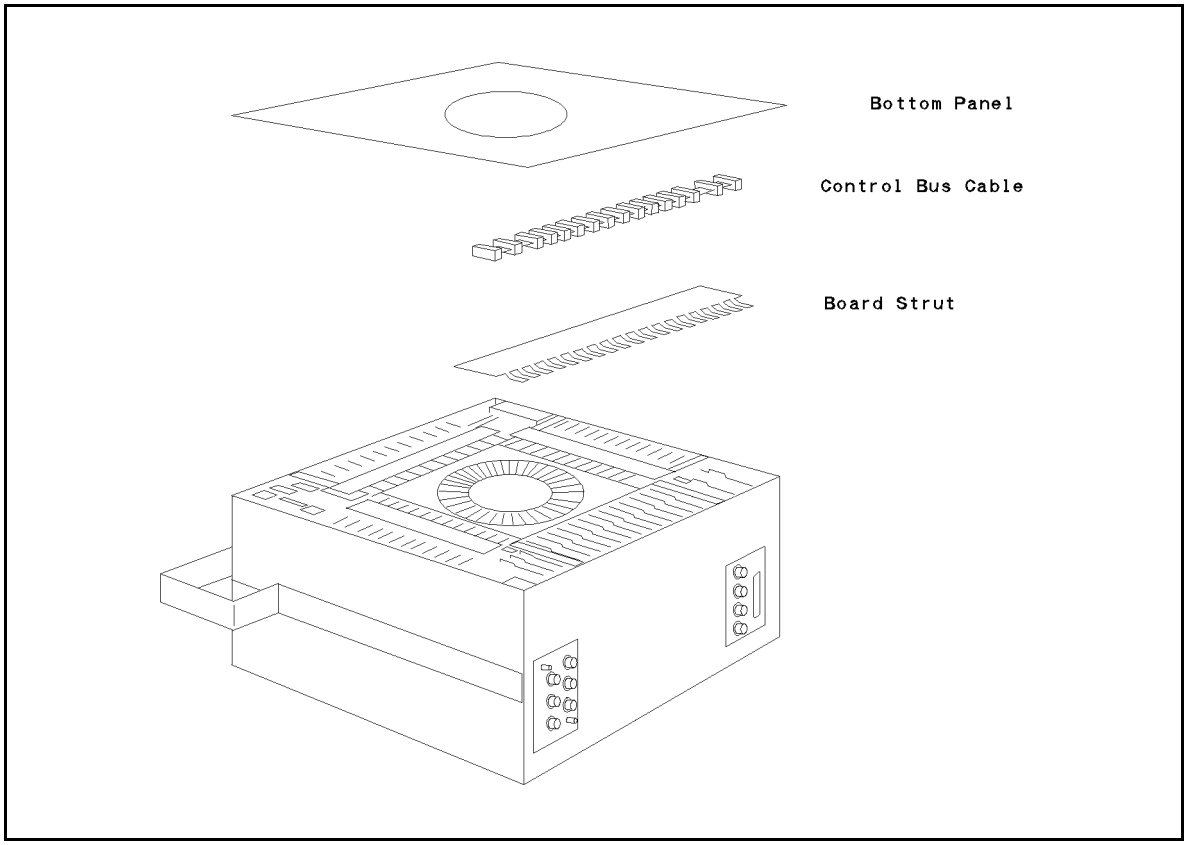



**Figure 3-10. Accessing SWM Pin Boards**

4. Access the desired pin board(s).

   ■ To remove a pin board:

   Use the furnished pin board extractor as shown in Figure 3-11, and gently, but firmly, lift the pin board from its slot.

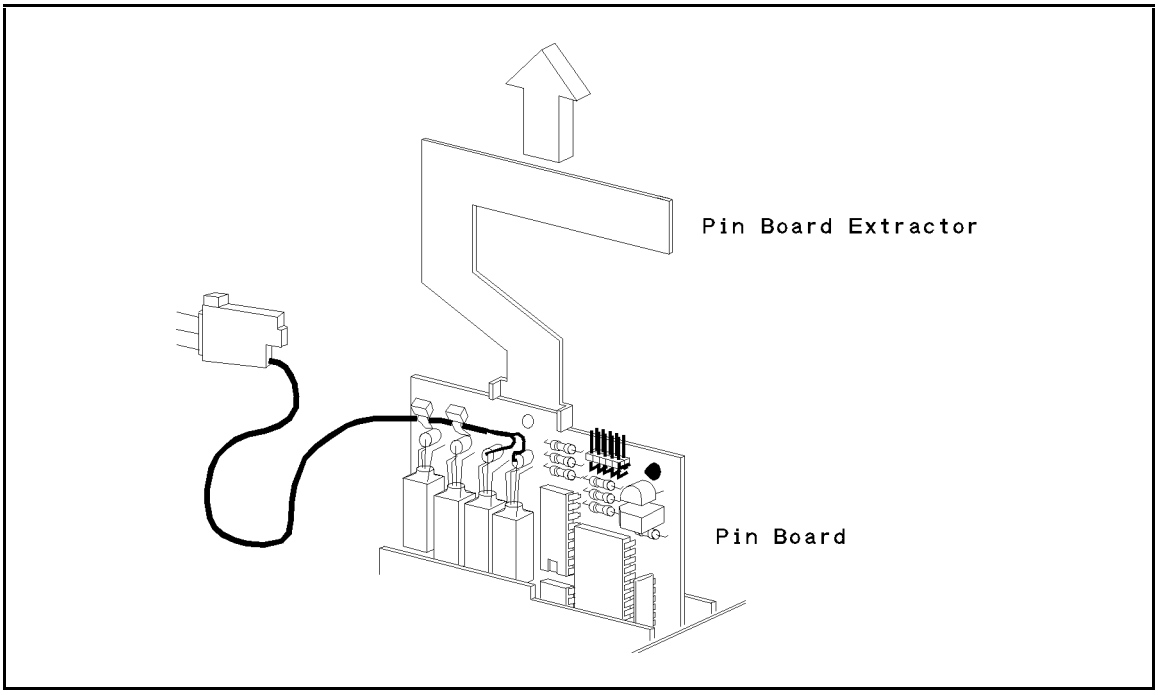



**Figure 3-11. Removing Pin Boards**

- To install a pin board:

  Insert the pin board into the desired slot and exert firm downward pressure to seat the pin board into its mother board connector.

  Position the pin board's cable assembly over the measurement pin mounting ring's guide pins that correspond to the pin board's slot number, and slide the cable assembly down onto the guide pins.

**Caution**

Do not touch pin board edge connectors, soldered surfaces, or pins with bare hands. Handle the pin board by its edges, as shown in Figure 3-12. If any part of the board becomes contaminated, clean it thoroughly, as described in "Cleaning".

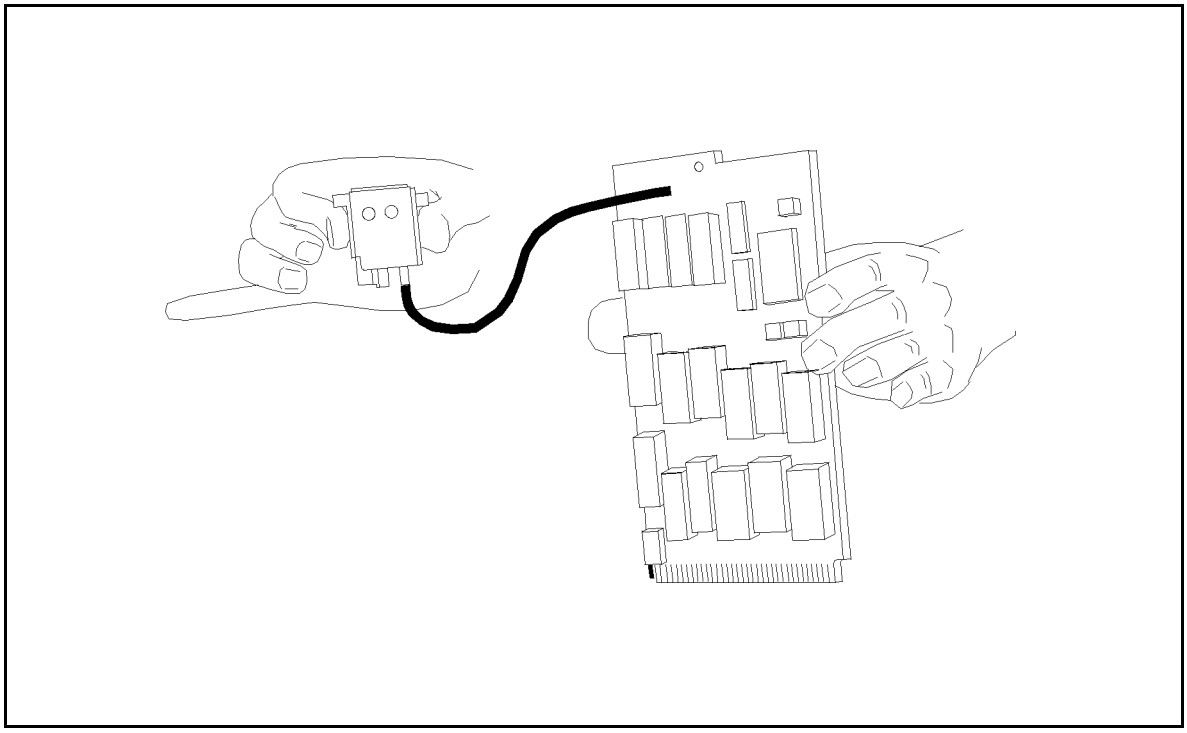


**Figure 3-12. Handling Pin Boards**

5. Reconnect the control cable(s), reinstall the board strut(s), and reinstall the bottom panel.

## Repositioning Pin Boards

Because pin boards are identical and because it is the pin board location, not the pin board, that is addressed by the system, you can reposition any pin board to any pin board slot if necessary.

Examples of when it might be necessary or desirable to reposition one or more pin boards are (1) when the probe card on the wafer prober has been moved, reconfigured, or altered in some way, and (2) when a test fixture has been changed.

## Cleaning

To maintain your HP 4062C's low current measurement capability, pin boards, measurement pins, test fixtures, and exposed signal lines must be kept extremely clean.

When cleaning is necessary, use an air gun or an air shower on the item you're cleaning. Clean the measurement pins by scrubbing them with lint-free paper that's been dipped in alcohol.

If the above procedures do not clean the item thoroughly, apply a generous amount of alcohol on the item you're cleaning, and lightly scrub the item with a soft brush. Rinse with clean alcohol, and let the alcohol that remains evaporate. Do *not* dry the item with a cloth.

When cleaning pin board measurement pins, be sure to remove the board(s) from the SWM first, as described in "Accessing Pin Boards". Do *not* allow alcohol to splash into the SWM.

**Note**

When you clean the measurement pins, be careful not to accidently bend them.

## When You Encounter Power Line Problems

When you encounter power line problems, you must take proper measures to prevent the problem from getting worse.

The measures for dealing with the following problems are described:

- When your circuit breaker opens from an overload of current, and the electric power stops being supplied to the system instruments.
- When your ground-fault circuit interrupter (GFCI) trips from excessive earth leakage current, and the electric power stops being supplied to the system instruments.

In these cases, some primary failures exist in the system cabinet, that is, instruments, power lines, and so on. After the circuit breaker or GFCI activates, the failures must be removed.

### ⚠ When GFCI Activates (100 Vac Power Line Only)

When the earth leakage current exceeds the threshold value, the GFCI trips, the main breaker opens, and the electric power stops being supplied to the system instruments. The GFCI tripping sets the switch to the position between ON and OFF and the GFCI indicator, which is a white button, extends out.

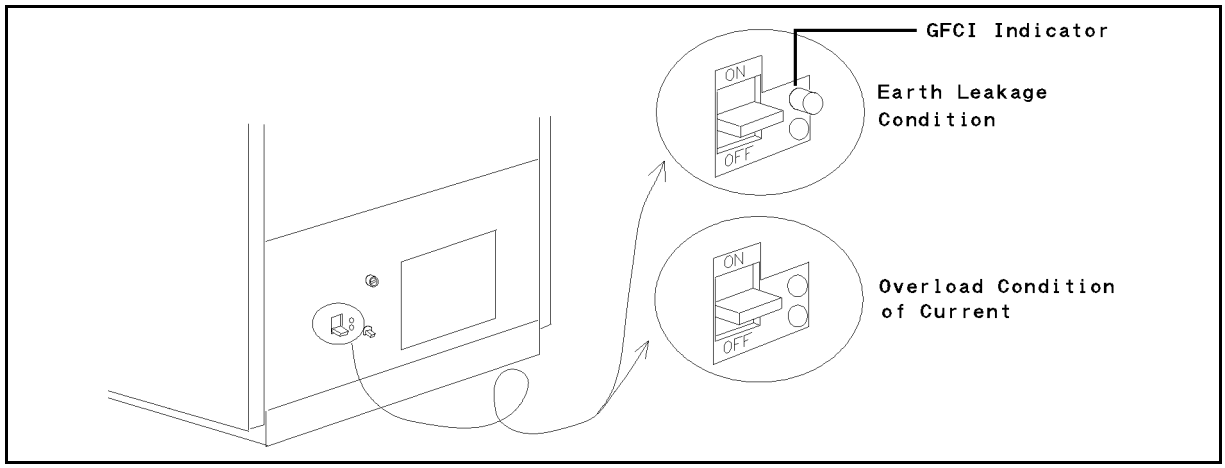



**Figure 3-13. GFCI Condition**

After removing the failures, use the following procedure to reset the GFCI:

1. Set the switch to the OFF position. The GFCI indicator retracts.
2. Set the switch to the ON position.

### When Circuit Breaker Activates

When the ac current exceeds the maximum current of the circuit breaker causing an overload of current, the circuit breaker opens and the electric power stops being supplied to the system instruments. The overload condition of current automatically sets the switch to the OFF position. If your circuit breaker also has a GFCI function, the breaker switch sets to the position between ON and OFF.

After removing the failures, set the switch to the ON position to recover from the open-circuit condition. If your circuit breaker also has a GFCI function, set the switch to the OFF position and then set it to the ON position.

# 4

# Diagnostics

## Introduction

The HP 4062C/UX/PC's Diagnostics (DIAG) program checks the system's basic measurement capabilities by testing each system component.

This chapter provides complete DIAG program information, and covers the following topics:

- Descriptions of the individual DIAG program tests.
- Instructions on when and how to run DIAG.
- What to do if DIAG detects a system failure.
- How to display or print DIAG test results.

## Description

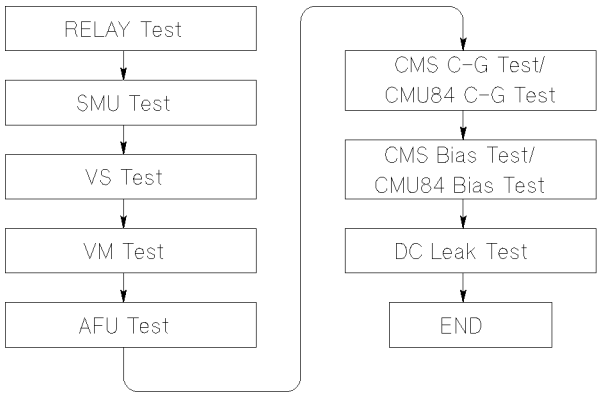
The DIAG program consists of the DIAG Test and the 4274A (LCR) Test, and includes the View Result function for displaying or printing test results, as briefly described in this section.

DIAG tests are independent. Any test can be run by selecting the corresponding softkey when you execute the DIAG program.

- DIAG Test

  The DIAG Test is for verifying correct system operation and to help you troubleshoot your HP 4062C/UX/PC system should a failure occur.

  DIAG test is composed of 10 individual tests, as follows.




  You can execute each test individually, or you can execute all tests in the sequence shown. For best results, execute tests sequentially.

  Note that if you intend to execute tests individually, all tests depend on Relay Test results (except for the Relay Test itself) and most tests depend on SMU Test results, so these two tests must be executed first.

  Individual test execution lets you (1) repeatedly execute a test, (2) execute tests in a desired order, or (3) skip unnecessary tests.

  To ensure HP 4062C/UX/PC measurement reliability, include DIAG in your system's daily startup routine. For a standard HP 4062C/UX/PC configuration, the DIAG program takes about 10 minutes to execute.

  Table 4-1 lists DIAG tests in the proper execution order, briefly describes each test, tells you which accessory you'll need to execute the test, and gives approximate test execution times. For more complete test descriptions, refer to the paragraph for each test.

**Table 4-1. Diagnostics Program Tests**

| Test Name | Description |
|---|---|
| Relay Test | Checks SWM pin board relays for normal Make (on) or Break (off) operation and proper conductance levels. Requires the Relay Test Adapter, and takes about 1 to minute to execute. |
| SMU Test[1] | Performs the DCS's self-test and checks each SMU for correct source/monitor operation. Requires the System Test Module, and takes about 65 seconds to execute. |
| VS Test[2] | Checks the DCS's Voltage Sources (VSs) for correct voltage output. Requires the System Test Module, and takes about 5 seconds to execute. |
| VM Test[2] | Checks the DCS's Voltage Monitors (VMs) for correct voltage measurement accuracy. Requires the System Test Module, and takes about 5 seconds to execute. |
| AFU Test[2] | Checks the DCS's Analog Feedback Unit (AFU) for correct measurement operation. Requires the System Test Module and takes about 15 seconds to execute. |
| CMS C-G Test[1,3] | Performs the CMU's self-test and checks the C-G measurement function for correct operation. Requires the System Test Module, and takes about 20 seconds to execute. |
| CMS Bias Test[2,3] | Checks the CMU's internal dc bias source for correct voltage output. Requires the System Test Module and takes about 6 seconds to execute. |
| CMU84 C-G Test[4] | Performs the OPEN and SHORT correction of the CMU84, checks the C-G measurement accuracy, and measures residual capacitance of the measurement pins. Requires the System Test Module and takes about 25 seconds to execute. |
| CMU84 Bias Test[2,4] | Checks the internal dc bias source accuracy of the CMU84. Requires the System Test Module and takes about 5 seconds to execute. |
| DC Leak Test[2] | Checks SWM leakage current levels. Requires the Test Fixture Adapter and takes about 30 seconds. |

1 Requires the Relay Test prior to execution.
2 Requires the Relay and SMU Tests prior to execution.
3 Performed when CMU exists and is connected to AUX3 (CMH) and AUX4 (CML) ports of the SWM.
4 Performed when CMU84 exists and is connected to AUX3 (CMH) and AUX4 (CML) ports of the SWM.

**Note**

The execution times given in Table 4-1 are for standard HP 4062C/UX/PC configurations. These execution times do not include the time required to change cable connections, and are applicable only when *no* errors are detected.

The DIAG Test checks only the SMUs, VSs, VMs, CMU, and CMU84 connected to an SWM port.

If your DCS is equipped with extra SMUs or VS/VMUs (*not* connected to an SWM port when you run DIAG), you must connect these units via the

interconnection cable, run START, and perform the required test again to check these units.

---

- 4274A Test

  The 4274A Test consists of the following tests:

  LCR Capacitance-Conductance Accuracy (LCR C-G) Test

  LCR DC Bias (LCR Bias) Test

  The LCR C-G Test performs the HP 4274A's self-test, measures stray capacitance in the SWM, and checks the accuracy of capacitance measurements.

  The LCR Bias Test checks the accuracy of the HP 4274A's internal dc bias source output voltage. This test is required only if the HP 4062C/UX/PC is equipped with an internal dc bias option.

  For instructions on how to run the 4274A Test, refer to the HP 4062C/UX/PC *Manual Supplement*.

- View Result

  View Result is for displaying test results on the CRT or for printing test results on a printer. With the DIAG Test, you can store test results into a file, and then display or print the contents of the file with View Result.

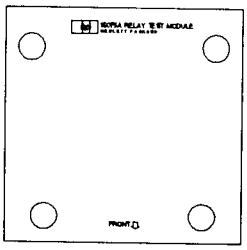
## Pre-Execution Considerations

Before you execute the DIAG program, you need several software and hardware items on hand, and you need to establish certain system conditions. These pre-execution preparation items are covered in the following paragraphs.

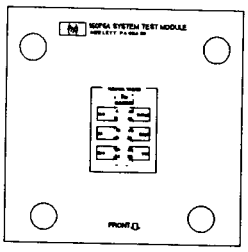
### Hardware Requirements

Figure 4-1 shows the hardware required to run DIAG.

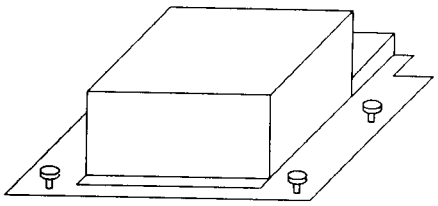
For HP 4085B 48-pin SWM systems:



HP 16075A
Relay Test Adapter

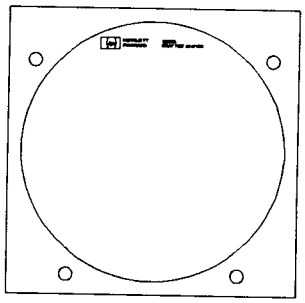


HP 16076A
System Test Module

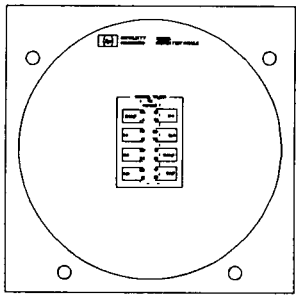


HP 16066A
Test Fixture Adapter

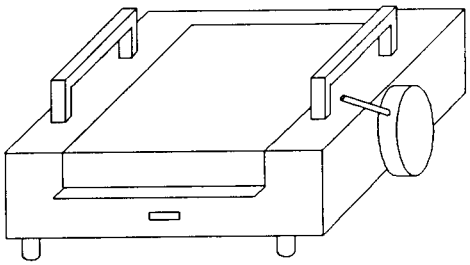
For HP 4089A 96-pin SWM systems:



HP 16355A
Relay Test Adapter



HP 16356A
System Test Module



HP 16370A
Test Fixture Adapter

**Figure 4-1. Required DIAG Test Equipment**

The procedures for mounting test equipment differs depending on which SWM is equipped with your HP 4062C/UX/PC. The procedures are described in the following paragraphs.

**Caution**

Do not touch the SWM's measurement pins or the test equipments' contact pads with bare hands. Oil, perspiration, and dirt prevent good contact and may cause the system to fail the tests.

■ Mounting Test Equipment on 48-pin SWMs

The procedure for mounting the HP 16066A Test Fixture Adapter, HP 16075A Relay Test Adapter, and HP 16346A/B System Calibration Module onto the 48-pin SWM is as follows:

1. Position the required test equipment on the SWM.
2. Tighten the four thumb screws, two at a time, diagonally. That is, tighten the upper right and lower left thumb screws at the same time, for example, then tighten the remaining pair.

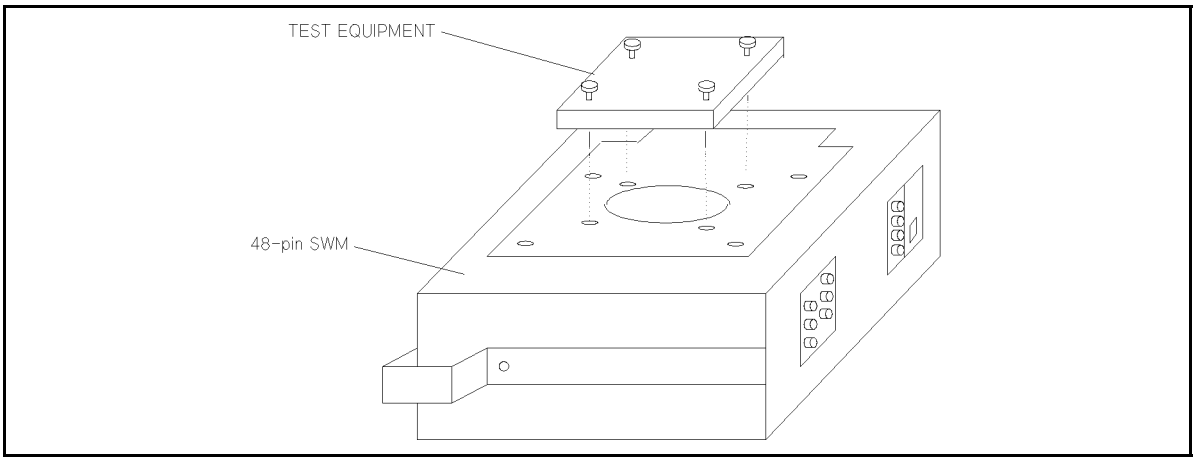



**Figure 4-2. Mounting Test Equipment (48-pin SWMs)**

■ Mounting Test Equipment on 96-pin SWMs

The procedure for mounting the HP 16370A Test Fixture Adapter, HP 16355A Relay Test Adapter, and HP 16366A System Calibration Module onto the 96-pin SWM is as follows: (To mount only the test fixture adapter, start from step 4.)

1. Turn the test fixture adapter and the required test equipment upside down.
2. Position the test equipment in the test fixture adapter and push the test equipment's black push-to-lock fasteners to lock the test equipment into the test fixture adapter.
3. Turn the test fixture adapter over again (topside up).
4. Position the test fixture adapter on the SWM.
5. Push the test fixture adapter's right and left side levers down to secure the test fixture adapter on the SWM.

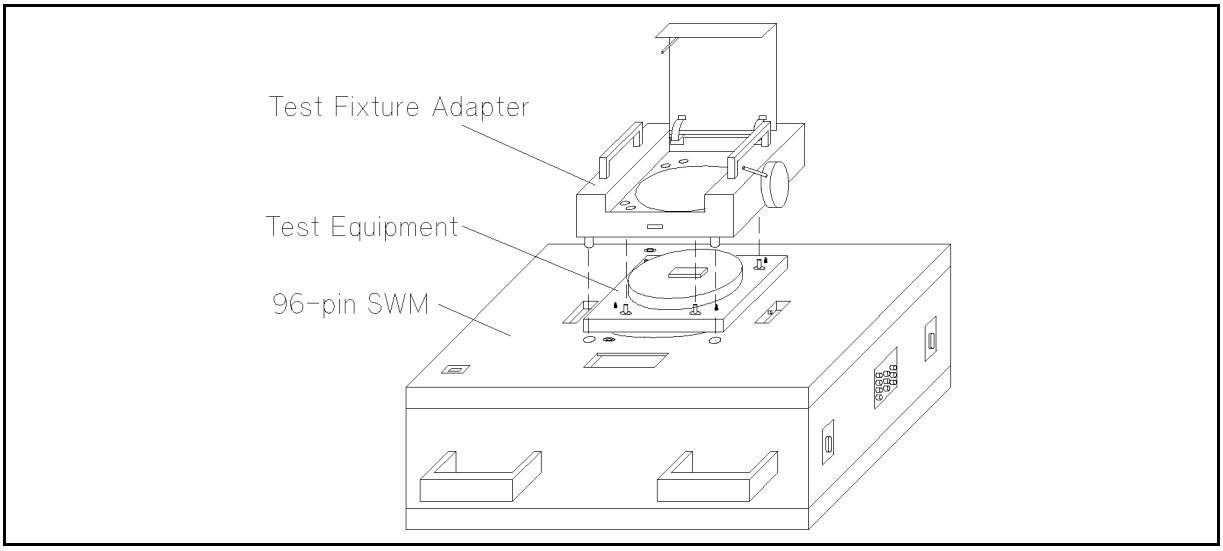



**Figure 4-3. Mounting Test Equipment (96-pin SWMs)**

## System Requirements

If your system is equipped with a 48-pin SWM, at least 12 pin boards must be installed in the SWM at every fourth position, starting with position 4, to perform all the DIAG program tests. Note, however, that only 5 pin boards are required for the Relay Test.

If your system is equipped with a 96-pin SWM, at least 16 pin boards must be installed in the SWM at positions 4, 12, 16, 20, 24, 28, 32, 36, 40, 68, 72, 76, 80, 84, 88, and 96 to perform all the DIAG program tests. Note, however, that only 5 pin boards for each block are required for the Relay Test.

Your HP 4062C/UX/PC is shipped from the factory with pin boards installed in the appropriate positions.

### System Setup Conditions

The following conditions must be satisfied before you run the DIAG program:

- The ID Module must be installed in the system controller.
- The system component interconnection cables must be connected correctly. Refer to the *Installation Manual* for cabling instructions.
- The CMU's front panel INT BIAS switch must be set to the ±100 V MAX position.
- The CMU's front panel REMOTE ON/OFF terminal must be terminated with a BNC shorting cap.
- The CMU's rear panel EXT BIAS SLOW terminal must be terminated with a BNC shorting cap.
- The DCS's rear panel FILTER switch must be set to the correct line frequency.

Be sure there are *no* test samples connected to the SWM before you turn your system on. Next, perform the procedure for turning on your HP 4062C/UX/PC, as described in *System Operation*, and let your system warm up for at least 40 minutes.

When you turn your HP 4062C/UX/PC on, the DCS may exhibit one of the following failure symptoms:

- A character other than "0" is displayed after "C" on the DCS's front panel ERROR/FAILURE display.
- Except for normal fan operation, the DCS is dead: all LEDs are off.

If either symptom occurs, ignore it for the present and let the system fully warm up. After your HP 4062C/UX/PC is warmed up, turn the DCS off, then on again. In most cases this clears the failure symptom.

The SWC may also exhibit a failure symptom when you turn your HP 4062C/UX/PC on. Specifically, the SWC's front panel LEDs may fail to light. If this occurs, turn the SWC off for at least 5 seconds, then turn it back on.

Do not turn the SWC off and on too quickly. Doing so can cause the instrument to *hang up*. This condition is characterized by the lighting of all front panel LEDs and the SWC's refusal to respond to any key operations or HP-IB commands. To recover from this state, turn the SWC off, wait at least 5 seconds, then turn the SWC back on.

## Executing the Diagnostics Program

When your HP 4062C/UX/PC is fully warmed up and you're ready to execute the DIAG program, perform the following procedure:

1. Load BASIC (for HP 4062C),BASIC/UX (for HP 4062UX), or BASIC/DOS (for HP 4062PC).
2. Specify the current mass storage device as follows:
   - For HP 4062UX:

     `MSI "/usr/pcs/diag"` (Return)

   - For HP 4062C/PC with the recommended directory structure:

     `MSI "/PCS/DIAG"` (Return) *for HP 4062C/PC*
     `MSI "\PCS\DIAG"` (Return) *for HP 4062PC*

   - For HP 4062C/PC with the flexible disks:

     Insert SYSTEM SOFTWARE (1) disk into the current system mass storage.
3. Load DIAG as follows:

   `LOAD "DIAG"` (Return)
4. Enable the SWM by installing the test fixture adapter on the SWM (closes the FIXTURE CLOSED DETECT switch). If the test fixture adapter is not available, enable the SWM by pressing and holding the SWM's WAFER PROBER SENSE switch.
5. Select the **RUN** softkey. The DIAG program main menu page appears. Figure 4-4 shows the HP 4062UX DIAG program main menu page. The HP 4062C/PC DIAG program main menu page is similar to the HP 4062UX page.

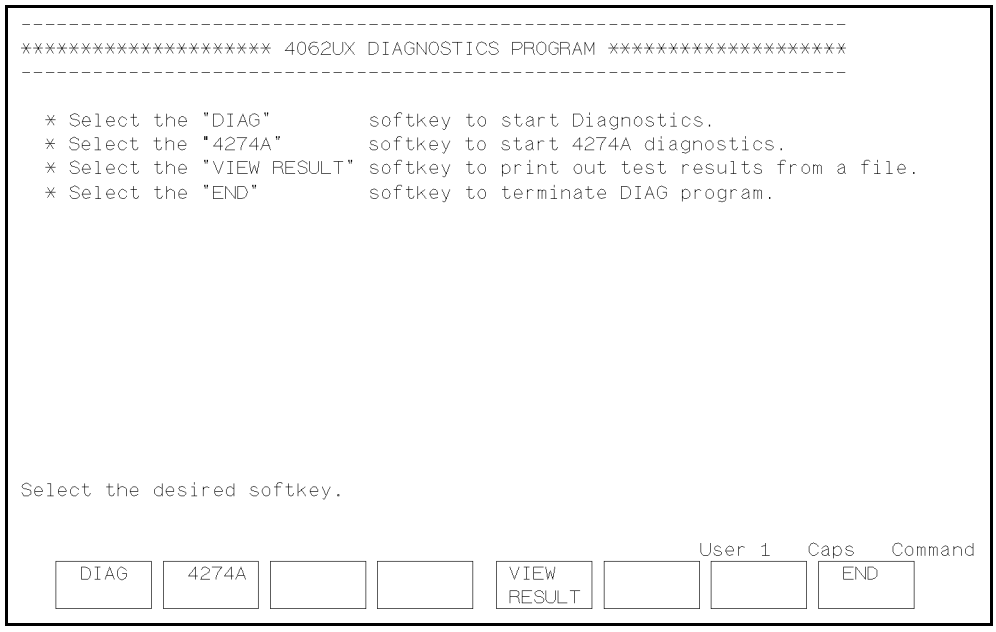



**Figure 4-4. DIAG Program Main Menu Page**

## DIAG Test

The procedure for executing the DIAG Test is as follows:

1. Select the DIAG softkey from the DIAG program main menu page. The system controller automatically executes the system START program, which builds the required COM blocks, initializes the system components, and checks the system configuration.

   During START, the START program page appears on the screen, similar to that shown in Figure 4-5.

```
***************** SYSTEM CONFIGURATION *****************|**** AVAILABLE PINS *****
4084B/4089A SWITCHING MATRIX:              Present       | 01 02 03 04 05 06 07 08
4142B DC SOURCE/MONITOR (Rev. 3.00)        Present       | 09 10 11 12 13 14 15 16
4280A 1MHz C METER/C-V PLOTTER:            Present       | 17 18 19 20 21 22 23 24
4284A 20Hz-1MHz LCR METER (Opt. 001/006): Not present    | 25 26 27 28 29 30 31 32
ELECTROGLAS 2001X WAFER PROBER:            Present       | 33 34 35 36 37 38 39 40
****************** DCS CONFIGURATION ******************* | 41 42 43 44 45 46 47 48
SLOT1: 41421B (SMU1)        SLOT5: 41421B (SMU4)         |
SLOT2:                      SLOT6: 41424A (AUX1/2)       | 49 50 51 52 53 54 55 56
SLOT3: 41420A (SMU2)        SLOT7:                       | 57 58 59 60 61 62 63 64
SLOT4: 41421B (SMU3)        SLOT8: 41425A                | 65 66 67 68 69 70 71 72
************ AUXILIARY PORT CONFIGURATION ************* | 73 74 75 76 77 78 79 80
AUX1: VS1                   AUX3: CMH                    | 81 82 83 84 85 86 87 88
AUX2: VS2                   AUX4: CML                    | 89 90 91 92 93 94 95 96

        Session ID: pcs_125
    Execution mode: ON LINE

System date & time: 1 Nov 1988  00:00:00
```

**Figure 4-5. START Program Page**

   If the displayed configuration is incorrect, or if an error message is displayed, check your setup and system cabling. Refer to Appendix A for the meaning of any error message.

   After the START program, DIAG's title page appears, as shown in Figure 4-6.

```
********************************************************************************


                - - - - - - - - - - - - - - - - - -
                 HP 4062UX Diagnostics Program
                - - - - - - - - - - - - - - - - - -



      * Select the "Start" softkey to begin Diagnostics.
      * Select the "Help" softkey to display the program operating guide.




Mount the 16066A atop the SWM and then select Start.

                                                          User 1   Caps   Command
   [ Start ] [ Help ] [      ] [      ] [      ] [ HP4284A Corr. ] [      ] [ EXIT ]
```

**Figure 4-6. DIAG Program Title Page**

2. Selecting the `Start` softkey displays the DIAG MENU page, similar to that shown in Figure 4-7. On this page, 10 softkeys are available as User 1 and User 2 mode softkeys to let you execute the desired test(s).

   Selecting the `Help` softkey displays a brief DIAG program description and operating guide. You can scroll Help text up or down by using the cursor control keys.

   When your system is equipped with the CMU84 (HP 4284A) as the CMS, the `HP4284A Corr.` softkey is also displayed. Selecting the `HP4284A Corr.` softkey lets you compensate for test leads residuals. If you want to compensate, follow the instructions displayed on the screen.

**Note**

You don't have to compensate for test leads residuals during the DIAG Test, because CMU84 memorizes the results of the compensation once test leads residuals are compensated. The compensation is required only when the system is calibrated (normally once a year).

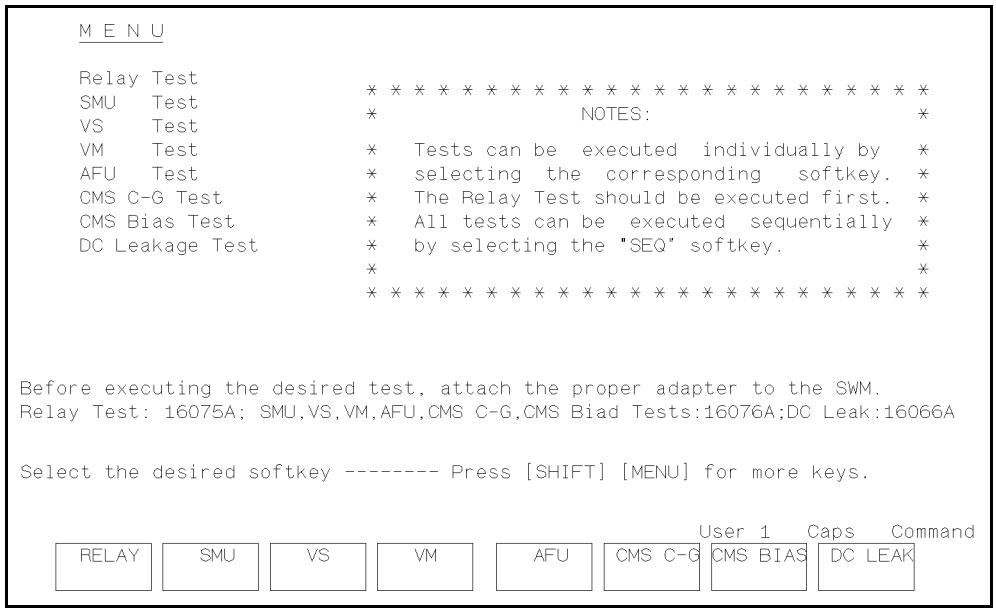



**Figure 4-7. DIAG Menu Page**

**Note**

When a CMU84 is connected to the AUX3 (CMH) and AUX4 (CML) ports of the SWM, the `CMU84 C-G` and `CMU84 BIAS` softkeys replace the `CMS C-G` and `CMS BIAS` softkeys.

From the DIAG Menu page in Figure 4-7, you can execute DIAG tests individually by selecting the softkey for the desired test, or you can execute all tests sequentially, in the order shown on the menu page, by pressing (Shift) (Menu), then by selecting the `SEQ` softkey.

**Note**

If you decide to execute tests individually, perform the Relay Test first, followed by the SMU Test, to ensure the results of the remaining tests.

### Executing Tests Sequentially

Selecting `SEQ` is the easiest way to execute DIAG, as this method takes you step-by-step through the tests, providing helpful prompts along the way. The procedure for performing tests sequentially is as follows:

**Note**

If your HP 4062C/UX is not equipped with a VS/VMU, an AFU, a CMU, or a CMU84, the corresponding tests (VS, VM, AFU, CMS C-G, CMS BIAS, CMU84 C-G, CMU84 BIAS) are automatically skipped. If this is the case and you are performing tests individually, select the `SKIP` softkey to skip tests that are not required.

1. Select the `SEQ` softkey. The following message is displayed:

   ```
   Do you want to keep result in a file ?
   ```

   To keep test results in a file, select the `Yes` softkey and proceed to the next step. If a test results file is not required, select the `No` softkey and proceed to the Relay Test.

2. Enter the desired file name (Return).

**Note**

A typical test results file size is about 200 records (51 kilobytes—if you don't retry the tests).

   You can specify an existing file name, in which case data are appended to the end of the existing file. When printing a test results file of this type, only the most recently entered data are printed.

3. If you specified an existing file name in the previous step, proceed to the Relay Test.

   If you specified a new file name in the previous step, a test results file data entry page, similar to that shown in Figure 4-8, is displayed to let you enter information relevant to the file. Follow the displayed instructions.

```
Model 4062UX
Semiconductor Process Control System          Tested by ________________
Serial Number_____________________            Date ____________________
Temperature_______________________            Humidity ________________

4085B SWITCHING MATRIX                 PRESENT Serial Number ____________
4084B SWITCHING MATRIX CONTROLLER      PRESENT Serial Number ____________
4142B DC SOURCE/MONITOR                PRESENT Serial Number ____________
4280A C METER/C-V PLOTTER              PRESENT Serial Number ____________
4284A 20Hz-1MHz PRECISION LCR METER             Serial Number ____________

Slot 1 _______ ___________________             Serial Number ____________
Slot 2 _______ ___________________             Serial Number ____________
Slot 3 _______ ___________________             Serial Number ____________
Slot 4 _______ ___________________             Serial Number ____________
Slot 5 _______ ___________________             Serial Number ____________
Slot 6 _______ ___________________             Serial Number ____________
Slot 7 _______ ___________________             Serial Number ____________
Slot 8 _______ ___________________             Serial Number ____________
```

**Figure 4-8. Test Results File Data Entry Page**

When finished entering data, the following message is displayed:

```
Are you sure ?
```

If the data is correct, select the `Yes` softkey and proceed to the Relay Test. If you need to make further changes to the data, select the `No` softkey and re-enter data as required.

**Note**

If an error occurs when recording test results, the program aborts and cannot be continued. Possible errors and their probable causes are listed below: where "XXXXX" is the file name (specified in step 2) and "YYYYY" is the temporary file name.

If an error occurs (program aborts), catalog the files on the data disk and delete temporary files (TEMP001, TEMP002, etc.).

`Can't create XXXXX.`

An incorrect mass storage, or a write-protected device is specified. This error may also occur when reading a previously recorded file, or if mass storage is full.

`Can't output data to YYYYY.`

Error when writing data to a temporary file. Disk rejected.

`Can't copy YYYYY to XXXXX.`

Error when copying a temporary file to a user specified file.

`Can't purge YYYYY.`

Error when purging temporary files.

`Can't assign XXXXX (YYYYY).`

The ASSIGN statement failed.

`Error in copying data from YYYYY to XXXXX.`

Error when reading from or writing to a file.

### Relay Test

The Relay Test checks all SWM pin board relays for correct Make (on) or Break (off) operation and proper conductance levels by applying a dc voltage to the relay test adapter, then by measuring the voltage obtained when a specified relay is set to Make.

**Note**

For 48-pin SWMs, at least 5 pin boards, installed in any configuration, must be installed in the SWM to perform the Relay Test.

For 96-pin SWMs, at least 5 pin boards, installed in any configuration, must be installed in each SWM pin board block (blocks 1 and 2) to perform the Relay Test.

The Relay Test can also be considered a relay 'cleaning' operation because all relays are 'wet switched' (set to Make while a voltage is applied) during the test, thereby helping to clean relay contacts.

To execute the Relay Test, perform the following procedure:

1. Install the relay test adapter (for your SWM) on the SWM.

   Be sure the relay test adapter's contacts are clean, and be sure to mount the relay test adapter securely. If the relay test adapter is loose, or if its contacts are dirty, poor contact with the SWM measurement pins will result, and the system may fail the test.

2. Select the RELAY softkey: The Relay Test begins immediately, and the RELAY TEST page shown in Figure 4-9 is displayed.

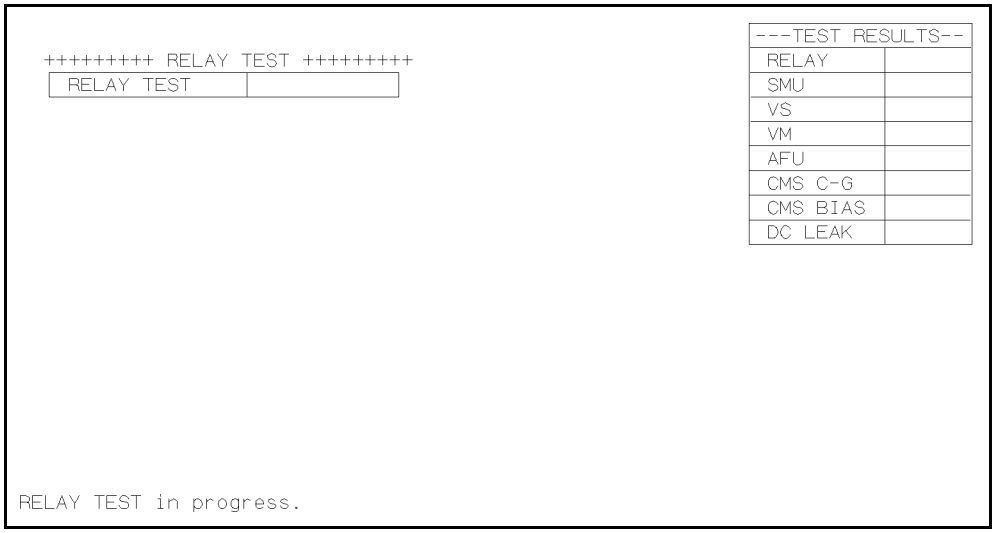



**Figure 4-9. Relay Test Page**

If no errors are detected, all relays are operating correctly, OK is displayed next to RELAY on the TEST RESULT table, and the User 1 mode softkeys are displayed (MENU page softkeys). An asterisk (*) displayed in a softkey label indicates a completed test. If a faulty relay is detected, an error code and message, the failed relay and pin board numbers, a relay failure code, a brief fault description, and the softkeys shown in Figure 4-10 are displayed; and the Relay Test stops.

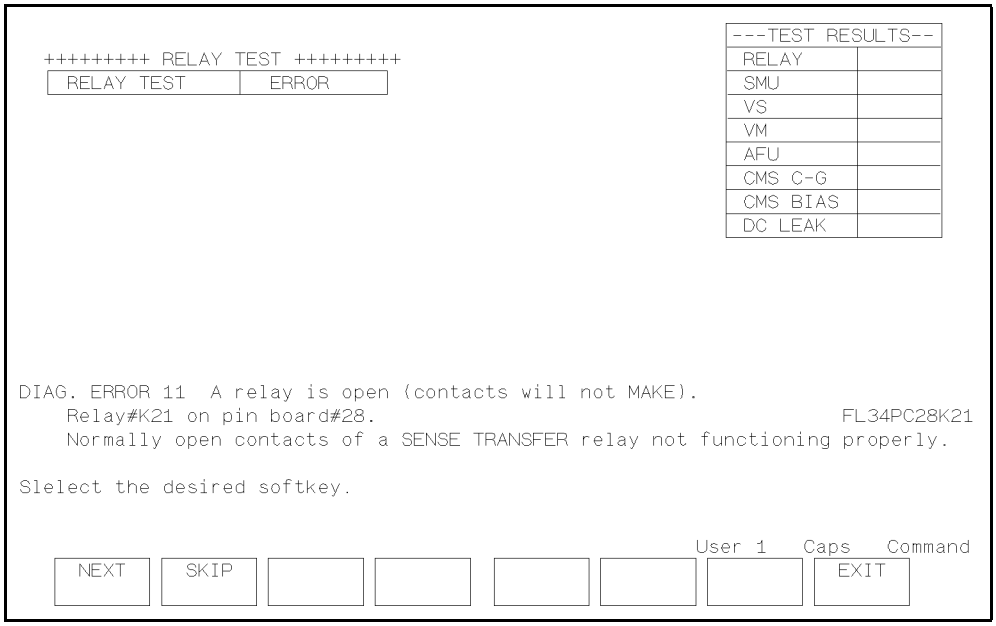



**Figure 4-10. Example Relay Test Error**

**Note**

If the Relay Test detects a faulty relay, it stops, and cannot continue. Therefore, additional faulty relays may exist. After you repair the indicated faulty relay (as described in "Recovering Stuck Relays" and "Replacing SWM Pin Boards"), be sure to execute the Relay Test again to check for additional faulty relays.

3. If an error is detected, select the next operation from the displayed softkeys (shown in Figure 4-10).
4. If your system is equipped with a 96-pin SWM, the Relay Test also checks all input board relays. To perform this test, install the (empty) test fixture adapter on the SWM and select the `NEXT` softkey. To skip this test, select the `SKIP` softkey.

   Input relays for ports that are not connected are not tested. In this case, the RELAY TEST results display for these ports remains blank and OK (*) is displayed next to RELAY on the TEST RESULTS table.
5. If your system is equipped with a port expander, the Port Expander Relay Test also checks all port expander relays. Disconnect all unsupported instruments, and place BNC shorting caps on the connectors in place of the unsupported instruments and also on the unused coaxial connector.

   The test results for the Port Expander Relay Test are displayed as follows:

```
++++++++++++++++++ RELAY TEST ++++++++++++++++++
|              | BLOCK 1 (1-48) | BLOCK 2 (49-96)|
|PIN BOARDS    |OK              |OK              |
|INPUT BOARDS  |OK              |OK              |
|PORT EXPANDER|OK                                 |
```

### SMU Test

The SMU Test performs the DCS's self-test and an operational check of each SMU connected to the SWM for correct source/monitor operation. The SMU Test's operational check includes a Repeat Test and a Spot Test, as follows.

- Repeat Test:

  Performs swept measurements in both V and I source modes using the system test module's 1 MΩ resistor.

- Spot Test:

  Performs spot measurements in both V and I source modes using the system test module's 10 Ω, 1 kΩ, and 1 GΩ resistors.

To execute the SMU Test, perform the following procedure:

---

**Note** Execute the Relay Test first.

---

1. Install the system test module (for your SWM) on the SWM.
2. Select the SMU softkey: The SMU Test begins immediately, and the SMU TEST page shown in Figure 4-11 is displayed.

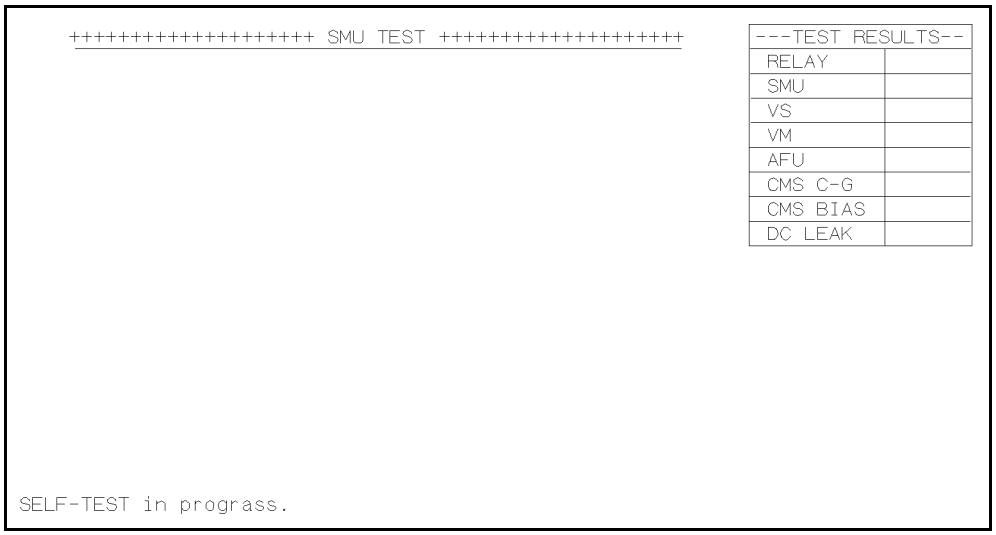



**Figure 4-11. SMU Test Page**

If no errors are detected, all SMUs are functioning properly, OK is displayed next to SMU on the TEST RESULTS table, and the User 1 mode softkeys are displayed (MENU page softkeys). An asterisk ( * ) displayed in a softkey label indicates a completed test. If an SMU fails, an error code, a brief error description, and the softkeys shown in Figure 4-12 are displayed; and the SMU Test stops.

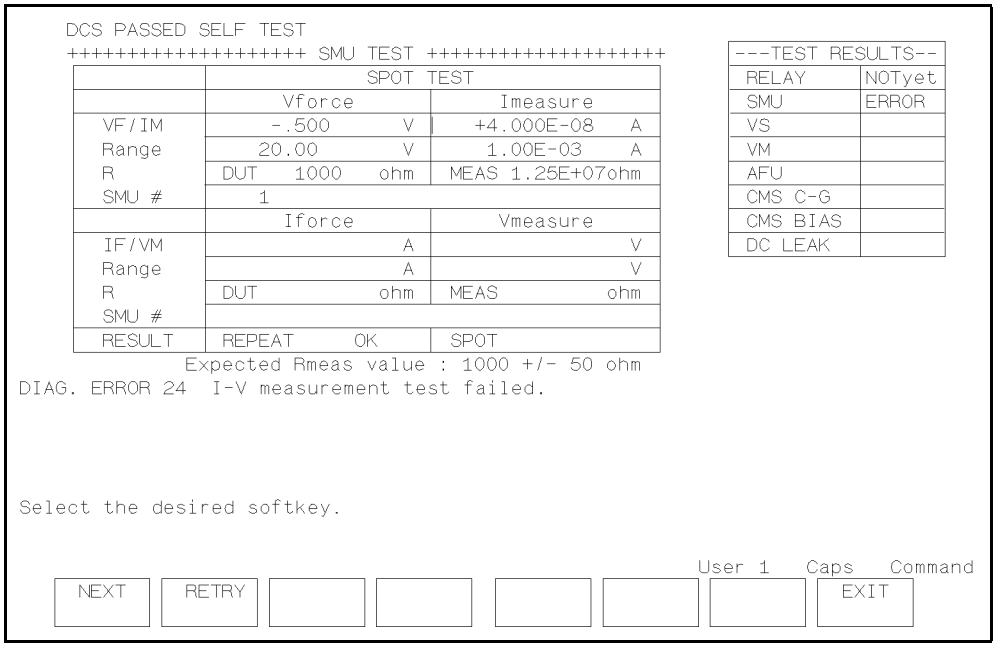



**Figure 4-12. Example SMU Test Error**

3. If an SMU fails, select the next operation from the displayed softkeys (shown in Figure 4-12). `NEXT` (1) continues the SMU test—if there are more SMUs to test—or (2) displays the MENU page softkeys—if all SMUs have been tested.

**Note**

To test SMUs *not* previously connected to the SWM—after you've already executed the SMU Test (for example, if your DCS is equipped with more than 4 SMUs)—connect the SMUs to the SMU ports via the interconnection cable, exit DIAG, run DIAG again, and execute the SMU Test again.

### VS Test

The VS Test checks the voltage sources (VS1 and 2) of the DCS's VS/VMU for correct voltage output and correct current measurement. The voltage output test applies a dc voltage from each VS to the System Test Module's 10 Ω resistor, measuring the resultant voltage drop, and comparing the measurement results against the established limits. The current measurement test applies a dc current from an SMU to a VS forcing 0.0 V through the System Test Module's 10 Ω resistor, measuring current values at both VS and SMU, and comparing their current values.

To execute the VS Test, perform the following procedure:

---

**Note** Execute the Relay and SMU Tests first.

---

1. Install the system test module on the SWM; make sure the DCS's VS1 and VS2 interconnection cables are connected to the SWM's AUX1 and AUX2 ports, respectively.
2. Select the VS softkey: An interconnection cable check is made and the VS Test begins immediately.

   If your DCS is equipped with more than one VS/VMU, follow the displayed instructions.

   If no errors are detected, the VSs are functioning properly.

   If a VS fails, an error code and message is displayed. Figure 4-13 shows an example VS test error display.
3. If a VS fails, select the desired operation from the displayed softkeys (shown in Figure 4-13).

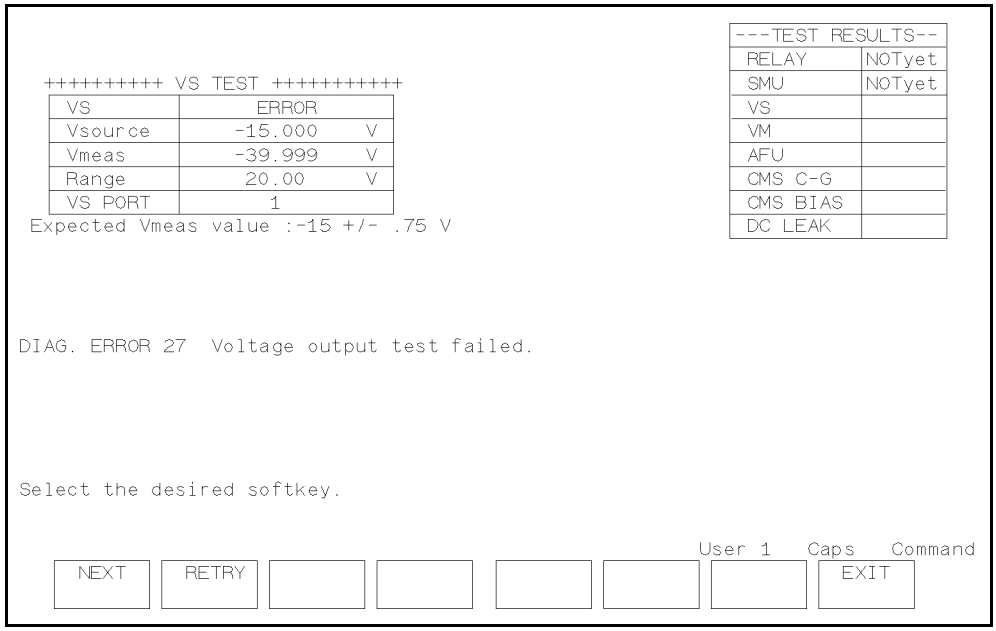



**Figure 4-13. Example VS Test Error**

### VM Test

The VM Test checks the voltage monitors (VM1 and 2) of the DCS's VS/VMU for measurement accuracy. For grounded measurement mode, the VM Test applies a dc voltage from an SMU to the System Test Module's 10 Ω resistor, measuring the resultant voltage drop with each VM, and by comparing the measurement results against the established limits. For differential measurement mode, the VM Test connects a VM1 of the VS/VMU to a SMU throught the SWM, connects a VM2 of the VS/VMU to the GNDU throught the SWM, applies a voltage from an SMU to the VM1, measures the voltage values at both VM1 and SMU, and compares these measured values.

To execute the VM Test, perform the following procedure:

---

**Note** Execute the Relay and SMU Tests first

---

1. Install the system test module on the SWM; make sure the DCS's VM1 and VM2 interconnection cables are connected to the SWM's AUX1 and AUX2 ports, respectively.
2. Select the VM softkey: An interconnection cable check is made and the VS Test begins immediately.

   If your DCS is equipped with more than one VS/VMU, follow the displayed instructions.

   If no errors are detected, the VMs are functioning properly.

   If a VM fails, an error code and message is displayed. Figure 4-14 shows an example VM test error display.
3. If a VM fails, select the desired operation from the displayed softkeys (shown in Figure 4-14).

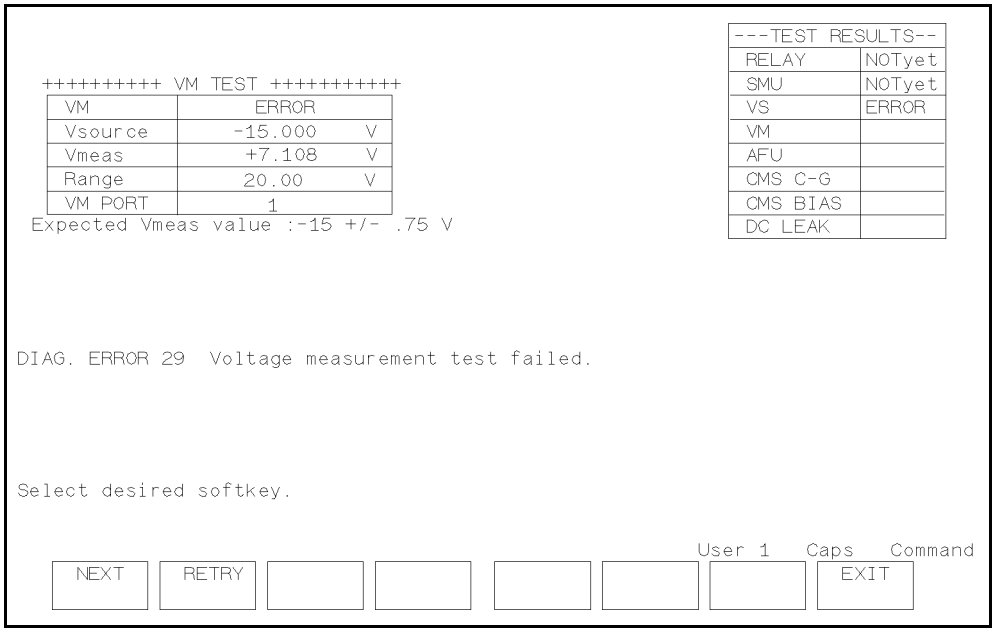



**Figure 4-14. Example VM Test Error**

### AFU Test

The AFU Test checks the DCS's AFU for correct measurement operation by performing an analog search measurement using the system test module's 1 kΩ resistor. Refer to "Analog Feedback Unit (AFU)" in Chapter 2 for an AFU measurement description.

To execute the AFU Test, perform the following procedure:

---

**Note** Execute the Relay and SMU Tests first.

---

1. Install the system test module on the SWM.
2. Select the AFU softkey: The AFU Test begins immediately.

   If no errors are detected, the AFU is functioning properly.

   If the AFU fails, an error code and message is displayed, and the AFU Test stops. Figure 4-15 shows an example AFU Test error display.
3. If the AFU fails, select the desired operation from the displayed softkeys (shown in Figure 4-15).

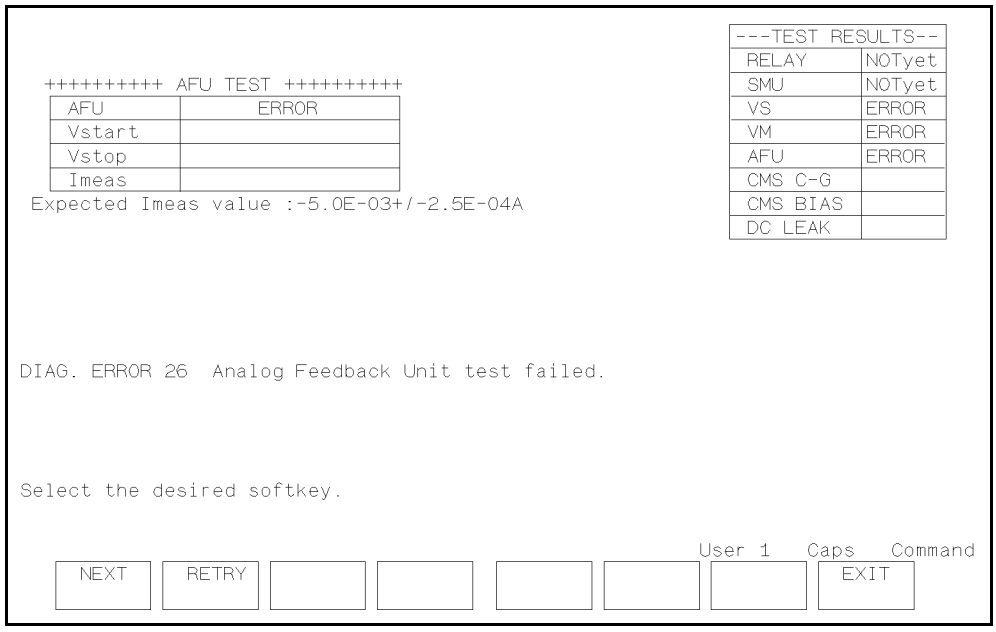



**Figure 4-15. Example AFU Test Error**

### CMS C-G Test

The CMS C-G Test checks the CMU's capacitance C and conductance G measurement functions using the system test module. C and G measurements are performed on the system test module's 100 pF and 1000 pF capacitors, a G measurement is made using the System Test Module's 1 kΩ resistor, and the stray capacitance between SWM measurement pins 8 and 12 is measured.

To execute the CMS C-G Test, perform the following procedure:

---

**Note** Execute the Relay Test first.

---

1. Install the system test module on the SWM; make sure the CMU's CMH and CML interconnection cables are connected to the SWM's AUX3 and AUX4 ports, respectively.
2. Select the `CMS C-G` softkey: The CMS C-G Test begins immediately.

   If no errors are detected, the CMU is functioning properly.

   If the CMU fails, an error code and message is displayed, and the CMS C-G Test stops. Figure 4-16 shows an example CMS C-G Test error display.
3. If the CMU fails, select the desired operation from the displayed softkeys (shown in Figure 4-16).

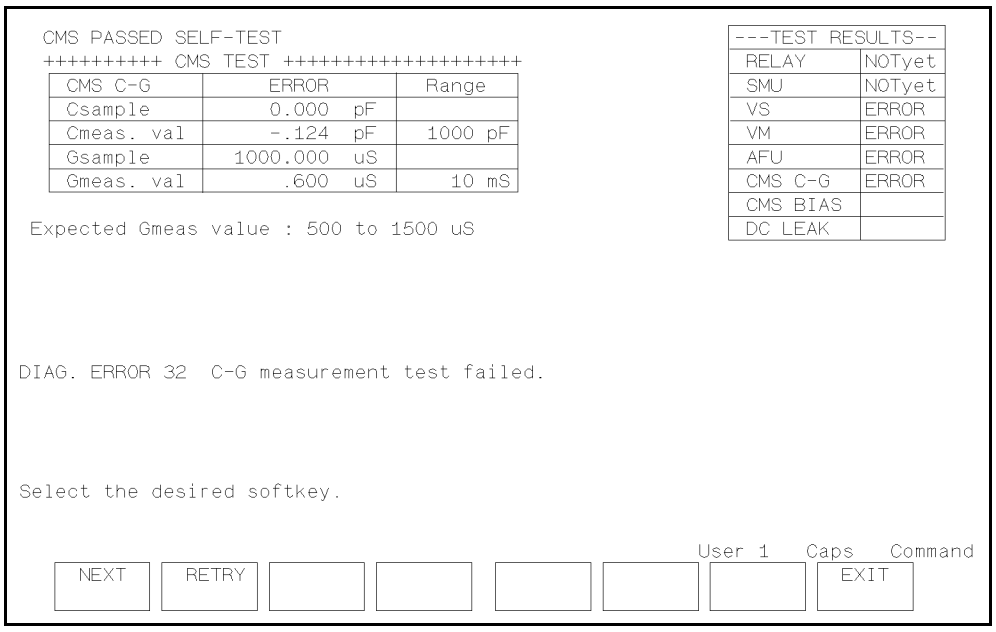



**Figure 4-16. Example CMS C-G Test Error**

### CMS Bias Test

The CMS Bias Test checks the CMU's internal dc bias source by applying a dc bias voltage to the system test module's 10 Ω resistor, measuring the voltage obtained, and comparing measurement results against test limits.

To execute the CMS Bias Test, perform the following procedure:

---

**Note** Execute the Relay and SMU Tests first.

---

1. Install the system test module on the SWM; make sure the CMU's CMH and CML interconnection cables are connected to the SWM's AUX3 and AUX4 ports, respectively.
2. Select the `CMS BIAS` softkey: The CMS Bias Test begins immediately.

   If no errors are detected, the internal dc bias source is functioning properly.

   If the CMU fails, an error code and message is displayed, and the CMS Bias Test stops. Figure 4-17 shows an example CMS Bias Test error display.
3. If the CMU fails, select the desired operation from the displayed softkeys (shown in Figure 4-17).

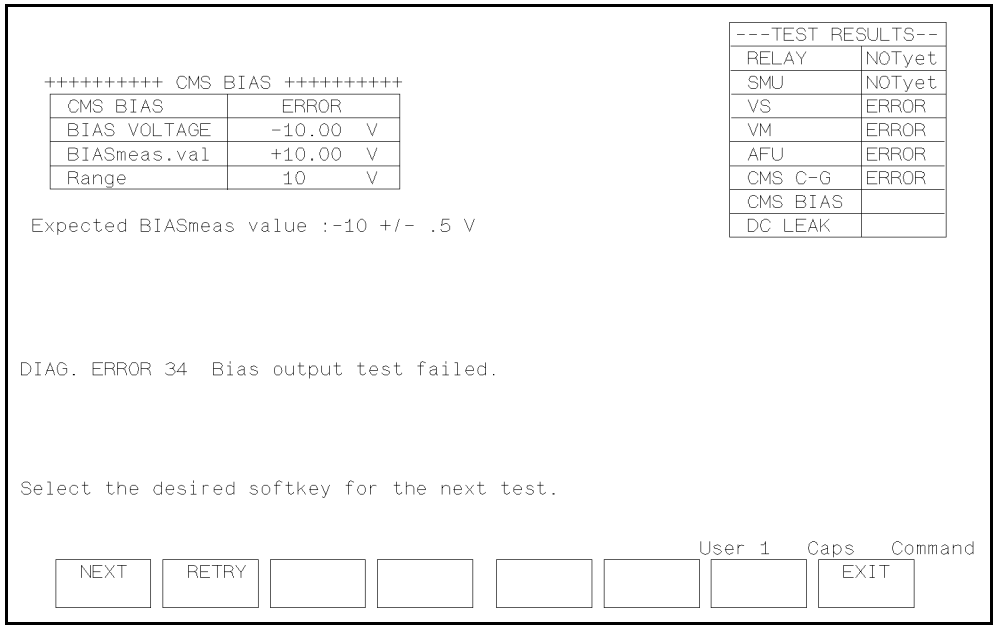



**Figure 4-17. Example CMS Bias Test Error**

### CMU84 C-G Test

The CMU84 C-G Test checks the CMU84's capacitance C and conductance G measurement functions using the system test module. C and G measurements are performed on the system test module's 100 pF and 1000 pF capacitors, a G measurement is made using the System Test Module's 1 kΩ resistor, and the stray capacitance between SWM measurement pins 8 and 12 is measured.

To execute the CMU84 C-G Test, perform the following procedure:

---

**Note** Execute the Relay Test first.

---

1. Install the system test module on the SWM.
2. Select the `CMU84 C-G` softkey: The CMU84 C-G Test begins immediately.

   If no errors are detected, the CMU84 is functioning properly.

   If the CMU84 fails, an error code and message is displayed, and the CMU84 C-G Test stops. Figure 4-18 shows an example CMU84 C-G Test error display.
3. If the CMU84 fails, select the desired operation from the displayed softkeys (shown in Figure 4-18).

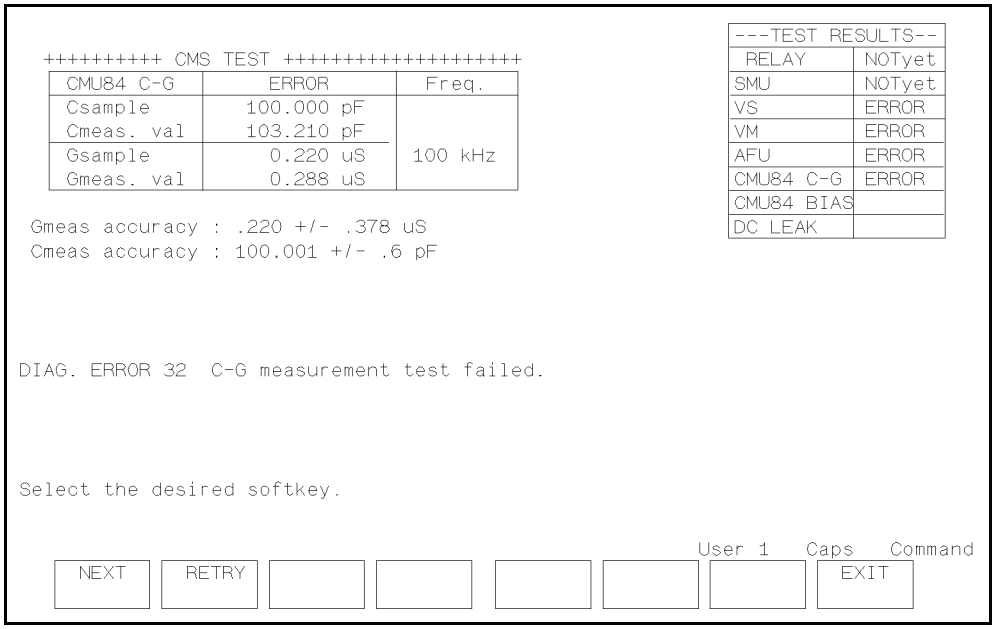



**Figure 4-18. Example CMU84 C-G Test Error**

### CMU84 Bias Test

The CMU84 Bias Test checks the CMU84's internal dc bias source by applying a dc bias voltage to the system test module's 10 Ω resistor, measuring the voltage obtained, and comparing measurement results against test limits.

To execute the CMU84 Bias Test, perform the following procedure:

---

**Note** Execute the Relay and SMU Tests first.

---

1. Install the system test module on the SWM; make sure the CMU84's Test Leads are connected to the SWM's AUX3 and AUX4 ports.
2. Select the `CMU84 BIAS` softkey: The CMU84 Bias Test begins immediately.

   If no errors are detected, the internal dc bias source is functioning properly.

   If the CMU84 fails, an error code and message is displayed, and the CMU84 Bias Test stops. Figure 4-19 shows an example CMU84 Bias Test error display.
3. If the CMU84 fails, select the desired operation from the displayed softkeys (shown in Figure 4-19).

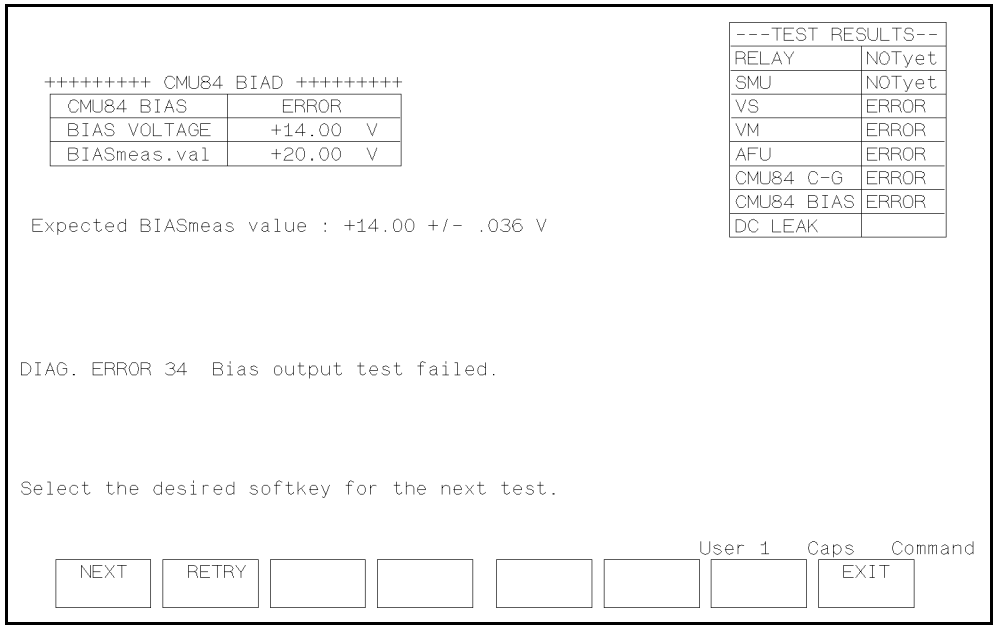



**Figure 4-19. Example CMU84 Bias Test Error**

### DC Leak Test

The DC Leak Test checks the SWM's measurement ports and pin boards for excessive leakage current.

This test includes (1) an Open Test, which uses an SMU to measure the level of SWM leakage current when all pin board relays are set to Break, and (2) a Short Test, which checks SWM current levels by performing a current measurement using an SMU connected to all SWM measurement pins.

To execute the DC Leak Test, perform the following procedure:

---

**Note** Execute the Relay and SMU Tests first.

---

1. Install only the test fixture adapter (no test fixture installed) on the SWM. Close the test fixture adapter's lid.

   Make sure the interconnect cable assembly is properly connected to the SWM's AUX3 and AUX4 ports.

2. Select the `DC LEAK` softkey. The DC Leak Test begins immediately.

   If no errors are detected, the SWM is functioning properly.

   If the SWM fails, an error code and message, and the number of the defective port or measurement pin is displayed. Figure 4-20 shows an example DC Leak Test error display.

3. If the SWM fails, select the desired operation from the displayed softkeys (shown in Figure 4-20).

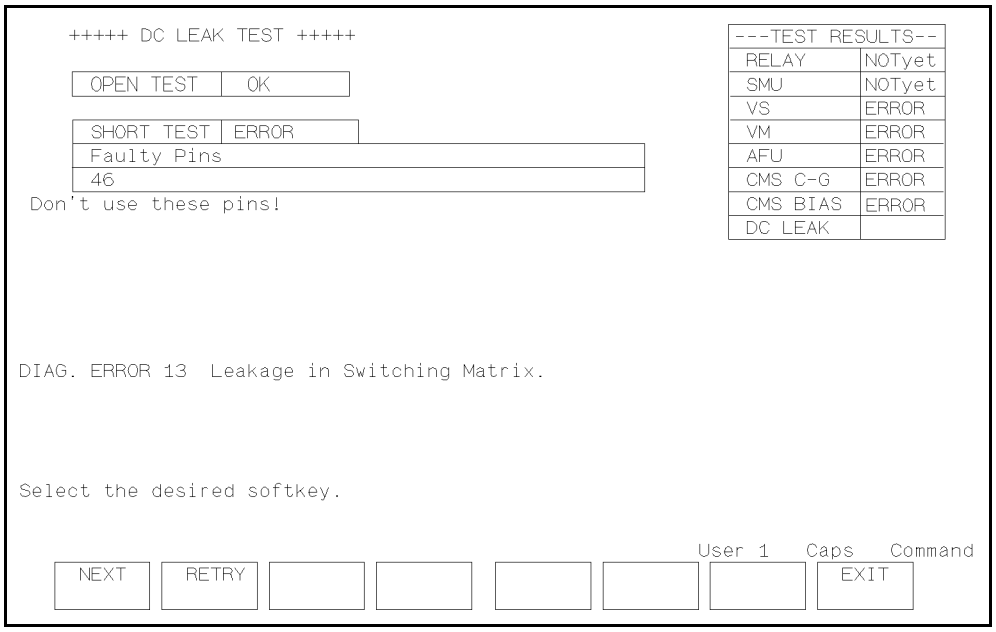



**Figure 4-20. Example DC Leak Test Error**

## View Result

The View Result function lets you display or print DIAG test results. The following procedure explains how to use View Result:

1. Select the `VIEW RESULT` softkey from DIAG's main menu, then select the `READ FILE` softkey from the View Result Menu.
2. Enter the name of the file want to read (Return).
3. To print test results to the display, select the `CRT` softkey. A View Result display page similar to that shown in Figure 4-21 is displayed. To display remaining test results, select the `MORE` softkey.

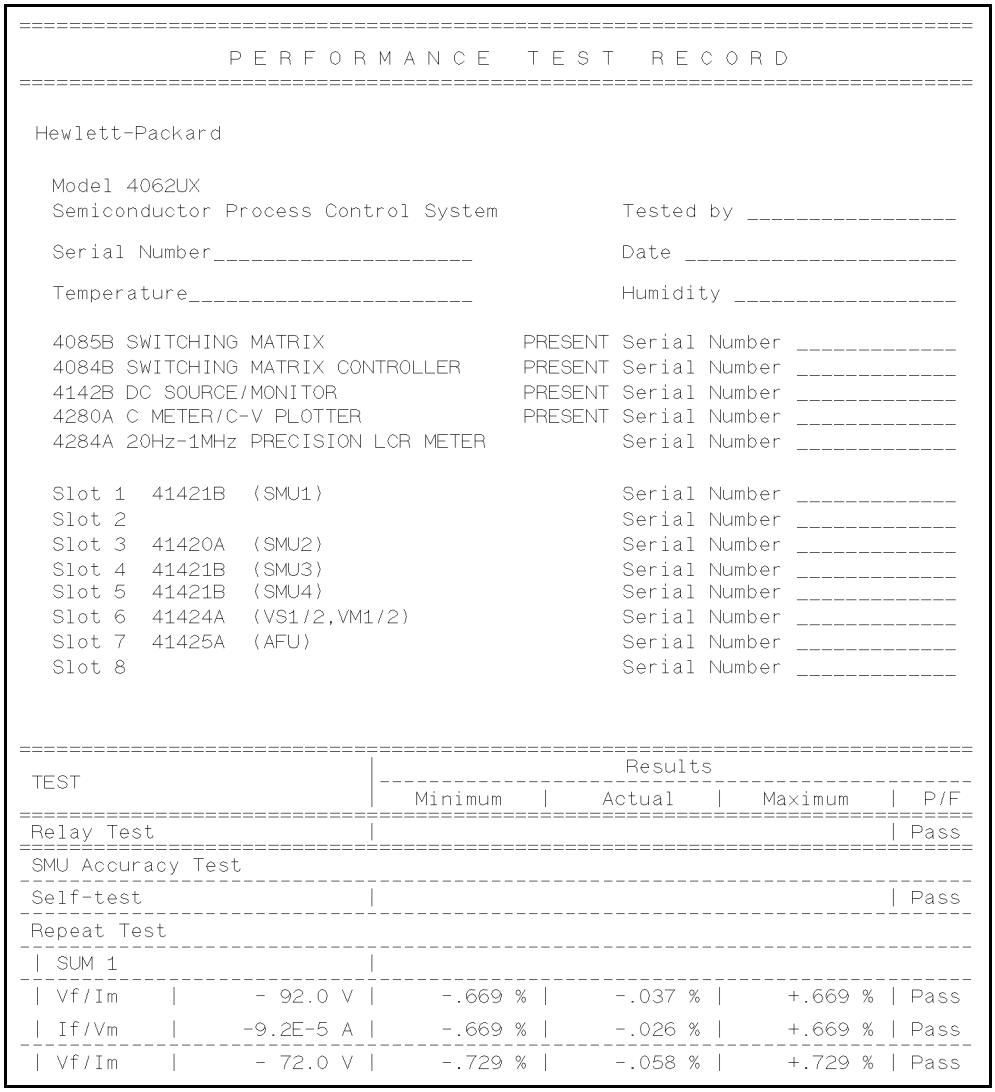
```
================================================================================
                    P E R F O R M A N C E   T E S T   R E C O R D
================================================================================

 Hewlett-Packard


  Model 4062UX
  Semiconductor Process Control System          Tested by ___________________
  Serial Number_____________________            Date _______________________
  Temperature_______________________            Humidity ___________________

  4085B SWITCHING MATRIX                 PRESENT Serial Number ______________
  4084B SWITCHING MATRIX CONTROLLER      PRESENT Serial Number ______________
  4142B DC SOURCE/MONITOR                PRESENT Serial Number ______________
  4280A C METER/C-V PLOTTER              PRESENT Serial Number ______________
  4284A 20Hz-1MHz PRECISION LCR METER    PRESENT Serial Number ______________
```

**Figure 4-21. View Result (CRT) Page**

To print test results on a printer, select the `PRINTER` softkey. Test results similar to those shown in Figure 4-22 are printed. To abort printing, select the `CANCEL` softkey.

**Note**

Confirm that the printer's HP-IB address is 1 and that the printer is connected to the system controller's internal HP-IB interface (select code 7).



```
================================================================================
                    P E R F O R M A N C E   T E S T   R E C O R D
================================================================================

 Hewlett-Packard

   Model 4062UX
   Semiconductor Process Control System          Tested by _________________

   Serial Number_____________________            Date ______________________

   Temperature_______________________            Humidity __________________

   4085B SWITCHING MATRIX                PRESENT Serial Number _____________
   4084B SWITCHING MATRIX CONTROLLER     PRESENT Serial Number _____________
   4142B DC SOURCE/MONITOR               PRESENT Serial Number _____________
   4280A C METER/C-V PLOTTER             PRESENT Serial Number _____________
   4284A 20Hz-1MHz PRECISION LCR METER           Serial Number _____________

   Slot 1  41421B  (SMU1)                        Serial Number _____________
   Slot 2                                        Serial Number _____________
   Slot 3  41420A  (SMU2)                        Serial Number _____________
   Slot 4  41421B  (SMU3)                        Serial Number _____________
   Slot 5  41421B  (SMU4)                        Serial Number _____________
   Slot 6  41424A  (VS1/2,VM1/2)                 Serial Number _____________
   Slot 7  41425A  (AFU)                         Serial Number _____________
   Slot 8                                        Serial Number _____________


================================================================================
 TEST                          |                  Results
                               |   Minimum   |    Actual    |   Maximum   | P/F
================================================================================
 Relay Test                    |                                           | Pass
================================================================================
 SMU Accuracy Test
--------------------------------------------------------------------------------
 Self-test                     |                                           | Pass
--------------------------------------------------------------------------------
 Repeat Test
--------------------------------------------------------------------------------
 | SUM 1                       |
--------------------------------------------------------------------------------
 | Vf/Im    |      - 92.0 V |     -.669 % |     -.037 % |     +.669 % | Pass
 | If/Vm    |     -9.2E-5 A |     -.669 % |     -.026 % |     +.669 % | Pass
--------------------------------------------------------------------------------
 | Vf/Im    |      - 72.0 V |     -.729 % |     -.058 % |     +.729 % | Pass
```

**Figure 4-22. View Result Print Example**

## Error Information

This section briefly describes error messages, what to if an error occurs, and how to recover stuck relays.

### Error Messages

If DIAG detects a failure or if you perform an illegal operation while DIAG is executing, an error code and message is displayed. An example is shown and described as follows:

```
DIAG. ERROR 22   I-V measurement test fails.
```

When an error message is displayed, DIAG. (above) indicates the DIAG program, ERROR 22 is the error code, and the message briefly explains the cause of the error.

Refer to Appendix A for a complete error message listing.

### If An Error Occurs

If an error occurs, if the DIAG program stops, or if your HP 4062C/UX exhibits any anomalies during program execution, check for the following possible causes and execute the DIAG program again:

- Did you install the required test adapter/module securely on the SWM?
- Are the contacts of the test adapter/module clean?
- Is your HP 4062C/UX fully warmed up? Minimum warm-up time is 40 minutes.
- Are all system instruments turned on?
- Are all system instruments interconnected properly? Refer to the *Installation Manual* for interconnection information.
- Are any devices other than the CMU, DCS, and SWC connected to the select code 27 bus?

If you check the above items and the same error occurs after you execute DIAG again, contact the nearest Hewlett-Packard Service Office for assistance. Describe the failure symptom(s) and include any displayed error codes and messages. Refer to "Error Messages" for a brief DIAG error message description.

**Note**

Certain failures can be remedied by replacing a faulty pin board or plug-in module. Refer to "Replacing System Components".

### Recovering Stuck Relays

If the error message shown below is displayed when you execute the Relay Test, the indicated relay on the indicated pin board is stuck. That is, the relay's contacts remain in the Make position, even after you execute a BREAK command.

```
DIAG. ERROR 11   A relay is stuck (contacts will not BREAK).
```

If a relay is stuck, you can usually fix it by performing the following procedure:

1. Note the pin board and relay numbers indicated in the error message.

2. Remove the indicated pin board. Refer to "Accessing Pin Boards" in Chapter 3 for information on accessing pin boards. Figure 4-23 shows SWM pin board locations.

**Caution** Do not touch pin boards with bare hands.

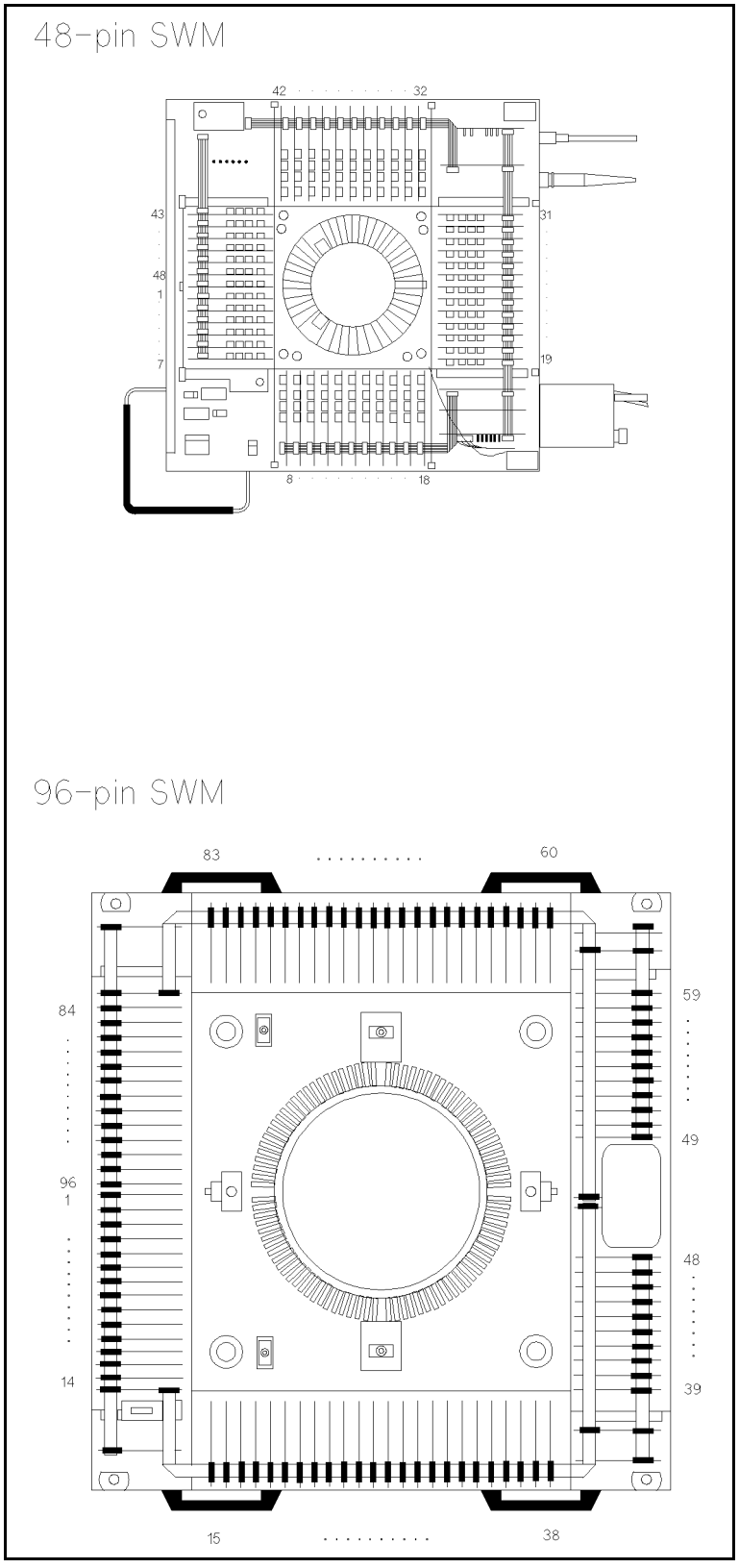



**Figure 4-23. SWM Pin Board Locations**

3. Lightly tap the indicated relay with your finger two or three times. Figure 4-24 shows pin board relay locations, and Figure 4-25 shows SMU input relay board and AUX input relay board relay locations for 96-pin SWMs.

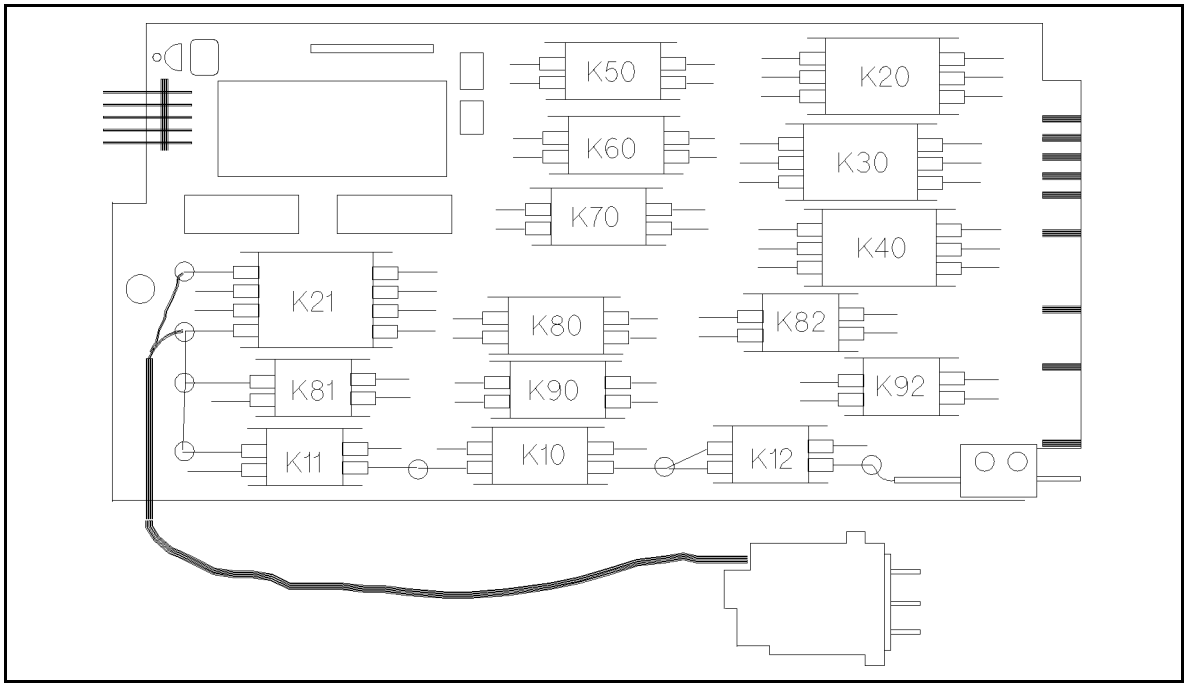



**Figure 4-24. Pin Board Relay Locations**

4. Mark the stuck relay with a ball-point pen to indicate its failure history. If the same relay sticks or fails more than twice, you should replace it. Refer to "Replacing SWM Pin Boards" in this chapter for instructions on replacing pin boards.
5. Reinstall the pin board and execute the DIAG Relay Test again. Remember, the Relay Test stops when a failure is detected, so additional relay failures may occur.

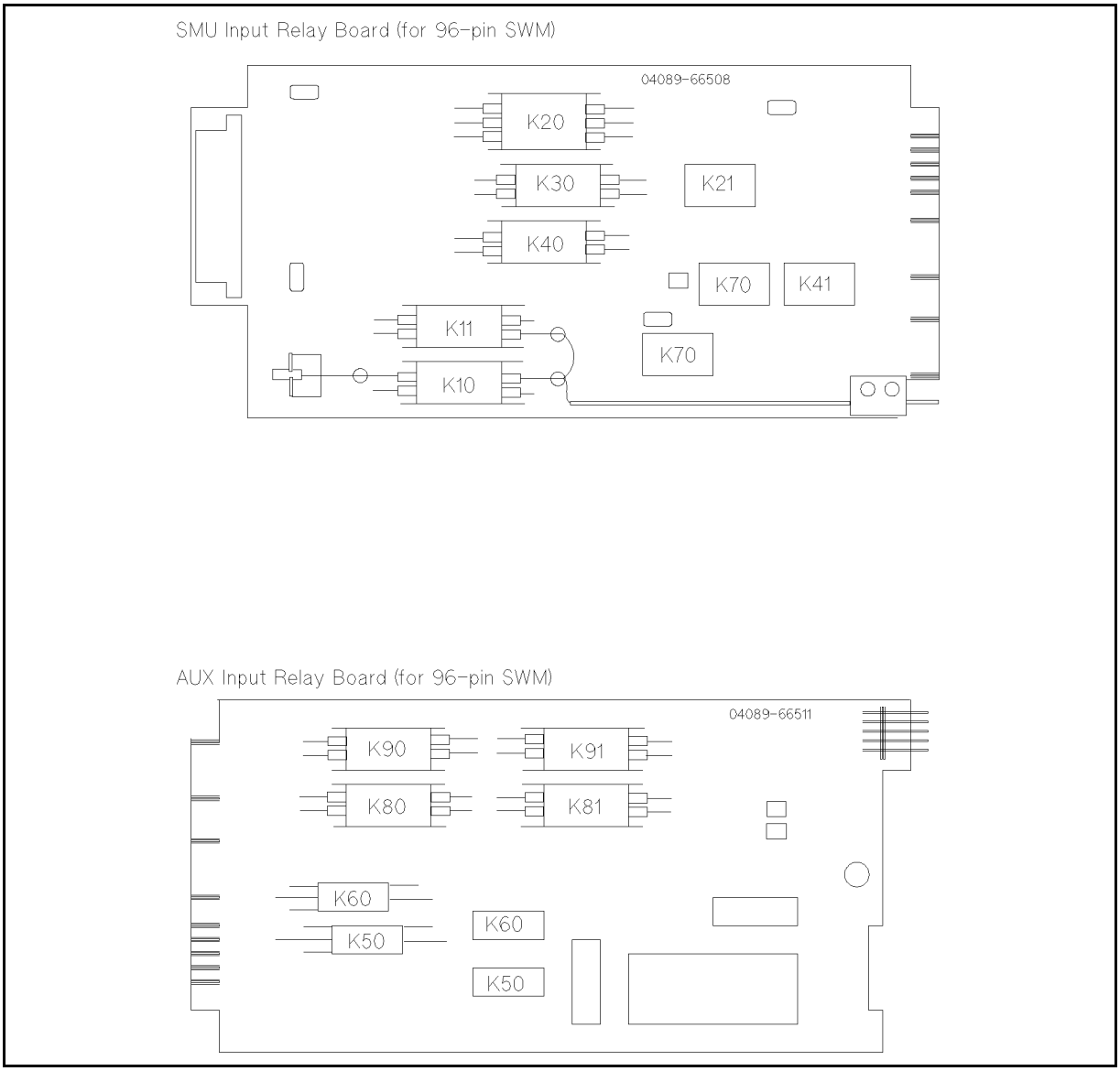



**Figure 4-25. Input Board Relay Locations (96-pin SWMs)**

## Replacing System Components

This section describes how to replace pin boards and DCS plug-in modules.

### Replacing SWM Pin Boards

If a pin board or relay error occurs (DIAG. ERROR 11), you can repair your HP 4062C/UX by replacing the pin board. Refer to "Accessing Pin Boards" in Chapter 3 for instructions on accessing pin boards.

You can replace faulty pin boards in one of two ways, as follows:

1. Replacement with a spare pin board or a new pin board.
2. Replacement with a pin board from another slot. Install another pin board, one not frequently used, into the faulty pin board's slot.

Contact the nearest HP Sales and Service Office to order new pin boards and to have faulty pin boards repaired.

### Replacing DCS Plug-in Modules

If a DCS error message, such as the example message shown below, is displayed, you can repair your HP 4062C/UX by replacing the faulty plug-in module.

```
START ERROR 14 DCS calibration error. SRQ asserted: Error 420 in slot 1
```

In this example, the SMU installed in slot 1 is faulty.

If the error shown in Figure 4-12 occurs during the DIAG program's SMU Test, select the `NEXT` softkey to continue the test. If no other SMU errors occur, repair your HP 4062C/UX by replacing the SMU in slot 1.

To replace a plug-in module, perform the following procedure:

**Warning**

**BEFORE YOU REPLACE ANY DCS PLUG-IN MODULES, BE SURE TO TURN THE DCS OFF BY TURNING OFF THE HP 4062C/UX'S MAIN POWER SWITCH. REFER ALL SUCH REPAIRS TO EXPERIENCED SERVICE PERSONNEL.**

1. Turn off your HP 4062C/UX's main power switch.
2. Remove the interconnection cables from the DCS's front panel.
3. Remove the DCS's front panel by fully loosening the screws that secure the front panel; disconnect the flat cable that interconnects the front panel and the DCS from the DCS's connector.
4. Loosen the faulty plug-in module's two thumb screws.
5. Grasp the thumb screws firmly, and gently pull the faulty plug-in module from its slot.
6. Replace with another plug-in module.

To order new plug-in modules, contact your nearest HP Sales and Service Office.

# 5

# Technical Information

## Introduction

This chapter provides a collection of technical information related to HP 4062 operation and application, and covers the following topics:

- System initial control settings
- DCS and CMS Zero Output status
- Additional compliance information
- Kelvin connection applications
- Additional guarding information
- SMU oscillation
- DCS swept measurements
- CMS Error correction
- CMU port configurations
- Using unsupported instruments
- Using Printer with Serial Interface
- Emergency Off System

## Initial Control Settings

When you turn your HP 4062C/UX/PC on, the initial control settings of each system instrument are slightly different from the control settings established during system initialization. When you execute the system software, each instrument must be initialized to satisfy system requirements.

If you use the CMU for standalone (set to LOCAL) measurements, it's especially important to initialize the CMU to the system before performing system application CMU measurements.

Table 5-1 lists the HP 4062C/UX/PC's initial control settings.

In the HP BASIC or BASIC/UX environment, to initialize the system, execute the START program or the TIS Init_system statement. To use Init_system, link TIS and type in:

```
CALL Init_system  Return
```

This statement initializes the system, but does not change any wafer prober settings.

In the HP-UX environment for the HP 4062UX system, the PCSSTART command can be used to initialize the system. To initialize the system, type:

```
$ pcsstart  Return
```

The PCSSTART command does not affect any wafer prober connected to the HP 4062UX system.

**Warning**

**Do not operate the CMU in a standalone configuration (local mode) without first removing the BNC shorting cap from the front panel REMOTE ON/OFF connector. Failure to remove this BNC shorting cap may expose operating personnel to dc voltages of up to ±100 V.**

**Table 5-1. Initial HP 4062C/UX/PC Control Settings**

| Instrument | Control Settings | |
|---|---|---|
| SWC | All relays in the SWM are set to Break (off). | |
| DCS | SMUs | V Source Mode, 20 V Range, 0 V Output, 100 $\mu$A I Compliance, |
| | VS | 20 V Range, 0 V Output |
| | VM | 20 V Range, Grounded Measurement Mode |
| | Output Switch | OFF |
| | INTEG TIME | SHORT |
| | Self-Test | OFF |
| | Data Output | Binary |
| | Data Buffer | Cleared |
| | Auto Calibration | ON |
| CMU | C-G RANGE | AUTO |
| | SIG LEVEL | 30 mVrms |
| | INTERNAL BIAS | Internal dc Bias ⎓, V Output Lamp ON, 10 V Range, 0 V Output |
| | MEAS SPEED | MEDIUM |
| | TRIGGER | HOLD/MAN |
| | Connection Mode | 12 (CN12) |
| | SELF TEST | OFF |
| | C-HIGH RESOLUTION | OFF |
| | CORRECTION ENABLE | OFF |
| | CABLE LENGTH | 0 m |
| | DIGIT SHIFT C | OFF |
| | DIGIT SHIFT G | OFF |
| | MATH | OFF |
| | C-V Parameters | START V: 0 V |
| | | STOP V: 0 V |
| | | STEP V: 0 V |
| | | HOLD TIME: 3 ms |
| | | STEP DELAY TIME: 3 ms |
| | C-t Parameters | PULSE V: 0 V |
| | | MEAS V: 0 V |
| | | NO OF READINGS: 100 |
| | | th: 10 ms |
| | | td: 250 ms |
| CMU84 | Function | $C_p$-G |
| | Frequency | 1 MHz |
| | Test Signal Level | 30 mVrms |
| | Measurement Range | Auto |
| | Internal Bias | 0 V, DC Bias indicator ON |
| | Trigger | BUS |
| | Measurement Range | AUTO |

## Zero Output

The SMUs and the VSs of the DCS, and internal dc biases of CMU and CMU84 are set to Zero Output when the TIS Disable_port and Disable_port84 statements are executed. Zero Output is defined as follows.

- SMU Zero Output

| | |
|---|---|
| Mode | V Source |
| Output Voltage Range | Not affected (previous setting kept) |
| Output Voltage | 0 V |
| Current Compliance | $\leq$100 $\mu$A |
| Output Switch | ON |

- VS Zero Output

| | |
|---|---|
| Output Voltage Range | Not affected (previous setting kept) |
| Output Voltage | 0 V |
| Current Limiter | 100 mA @ 20 V Range; 20 mA @ 40 V Range |
| Output Switch | ON |

- CMU Zero Output

| | |
|---|---|
| Internal dc Bias | ⎓ |
| V OUTPUT Lamp | ON |
| Internal dc Bias Range | Not affected (previous setting kept) |
| Output Voltage | 0 V |

- CMU84 Zero Output

| | |
|---|---|
| Output Voltage | 0 V |

## Additional Compliance Information

To prevent over-voltage or over-current damage to test devices, you can specify compliance for each SMU. If an SMU reaches compliance, its output remains constant for the remainder of the measurement. For more details, see "Compliance" in Chapter 2.

You can monitor compliance by using the TIS Port_status statement. Refer to the *Programming Reference* for details on Port_status usage.

Figure 5-1 shows an example bipolar transistor measurement setup and Figure 5-2 shows the I-V curve obtained when compliance is reached. When compliance is reached, output I and V become constant for the measurement's duration.

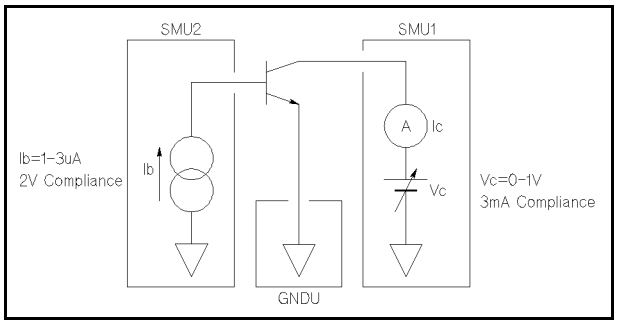



**Figure 5-1. Example Setup Showing Output @ Compliance**

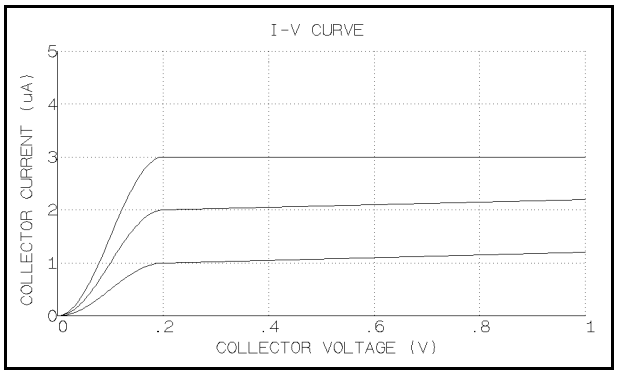



**Figure 5-2. Example Setup Showing Output @ Compliance (Continued)**

When setting compliance, observe the following precautions:

- Do not set V compliance too high.

  When using two SMUs, one set to V source (current monitor) mode and the other to I source (voltage monitor) mode, voltage output may reach compliance if current range changing occurs.

- Do not set I compliance too low.

  An undesired current, in series with an SMU's output, may be generated as a result of dirty contacts—caused by an electrochemical reaction or a temperature difference between contacts.

  This undesired current may exceed an SMU's I compliance setting, causing a voltage greater than the specified output V to be applied to the test device.

- Voltage measurement range is determined by the specified V compliance value.

This means that voltage measurement resolution—100 $\mu$V, 1 mV, 2 mV, 5 mV, or 10 mV—is determined by the compliance setting.

## Kelvin Connection Applications

When you use SMUs 2, 3, and 4 (connected to SWM ports 2, 3, and 4), you can, and should, connect them in conjunction with the DCS's Ground Unit (GNDU) to implement Kelvin connections. For more details, see "Kelvin Connections" in Chapter 2.

You can also implement Kelvin connections when using the universal low leakage fixture and the extension cable fixture.

To implement a Kelvin connection when you use test fixtures, connect the force and sense leads as shown in Figure 5-3 and Figure 5-4. To cancel the effects of residual resistance, test leads should be connected as close as possible to the test device. Note that cable length should not exceed 50 cm.

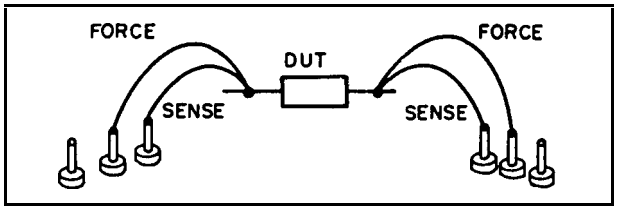



**Figure 5-3. Kelvin connection using the universal low leakage fixture**

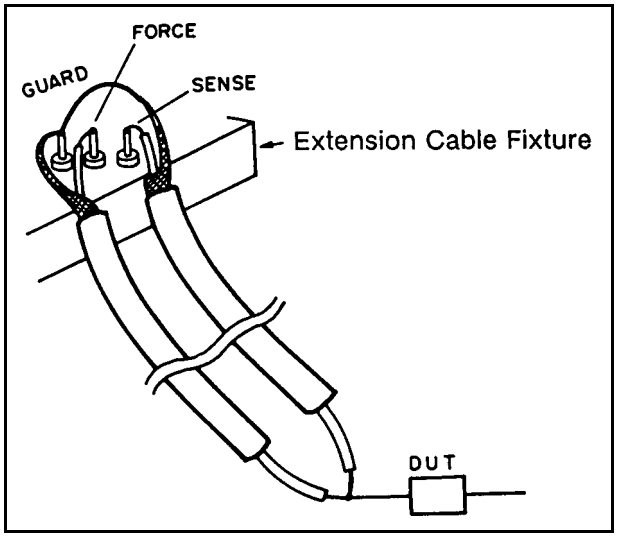



**Figure 5-4. Kelvin connection using the extension cable fixture**

## Additional Guarding Information

Each of the DCS's SMUs provides a guard terminal for minimizing the effects of leakage current and associated measurement errors when performing low current measurements. Refer to "Guarding" in Chapter 2 for the basic theory of guarding.

In the SWM, all dc measurement signal lines are fully guarded.

SMU1's guard terminal is provided as a GSMU for guarding test devices, as shown in Figure 5-5.

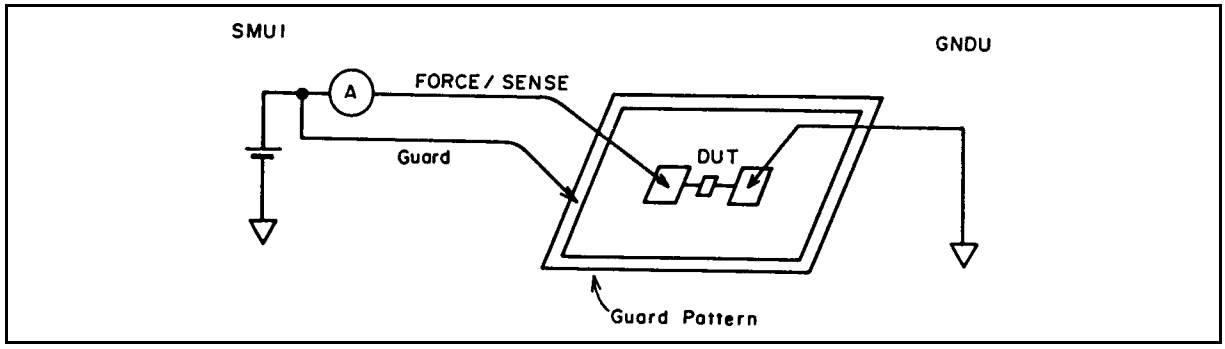



**Figure 5-5. Example of GSMU Use**

The CMU's guard terminal is provided as a GCMU port, which you can connect to test devices through the SWM.

As Figure 5-6 shows, you can effectively eliminate stray capacitance ($C_H$ and $C_L$) by connecting the GCMU to the substrate of the device under test (C).

**Note**

For more effective guarding, extend the guard to your test device directly from the guard terminal instead of using the GSMU or GCMU port.

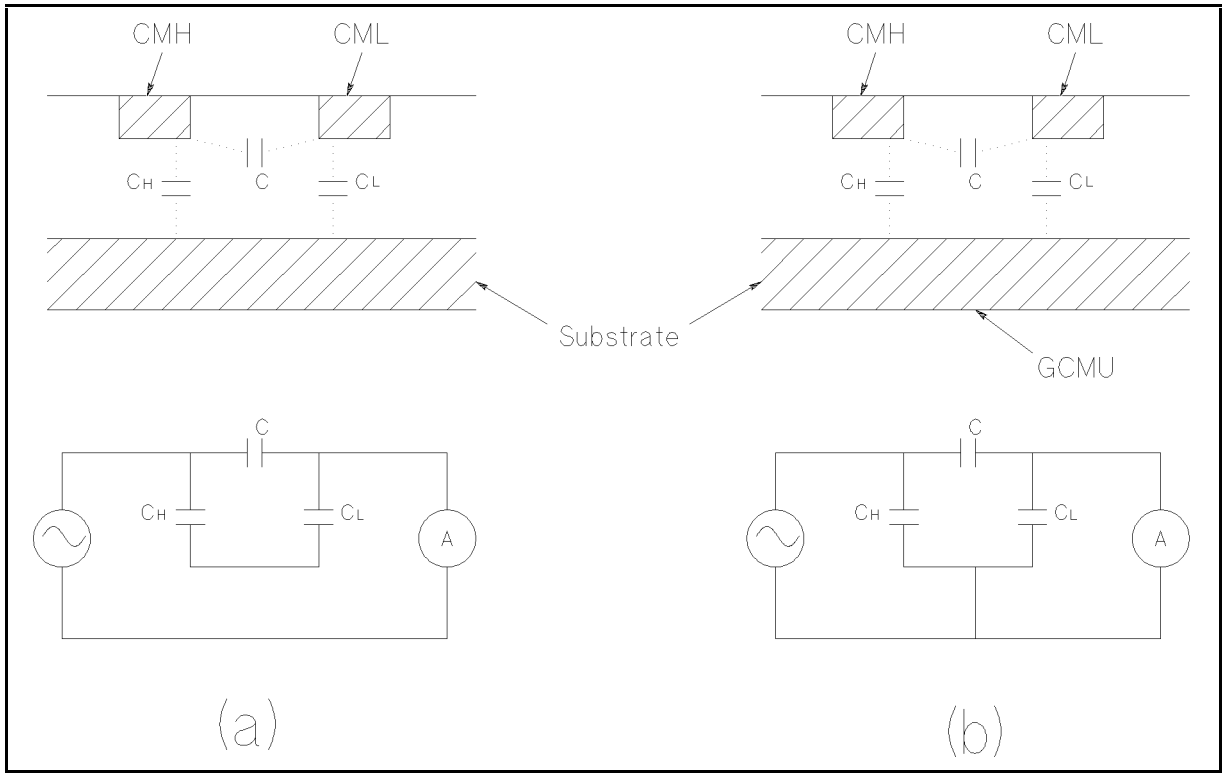



**Figure 5-6. Example of GCMU Use**

(a) When the GCMU is not connected, $C_H$ and $C_L$ affect the C measurement.

(b) With the GCMU connected to the substrate, $C_H$ and $C_L$ is minimized.

## SMU Oscillation

Because the SMUs of the DCS are high speed, highly sensitive amplifiers, SMU oscillation may occur, depending on the load (test device).

If this occurs, oscillation is detected and you can determine the oscillating SMU by using the TIS Port_status statement. Refer to the *Programming Reference* manual for details on Port_status usage.

Bipolar transistors, which have a high $h_{FE}$ and a wide frequency range, are especially likely to oscillate, and produce measurement results similar to those shown in Figure 5-7.

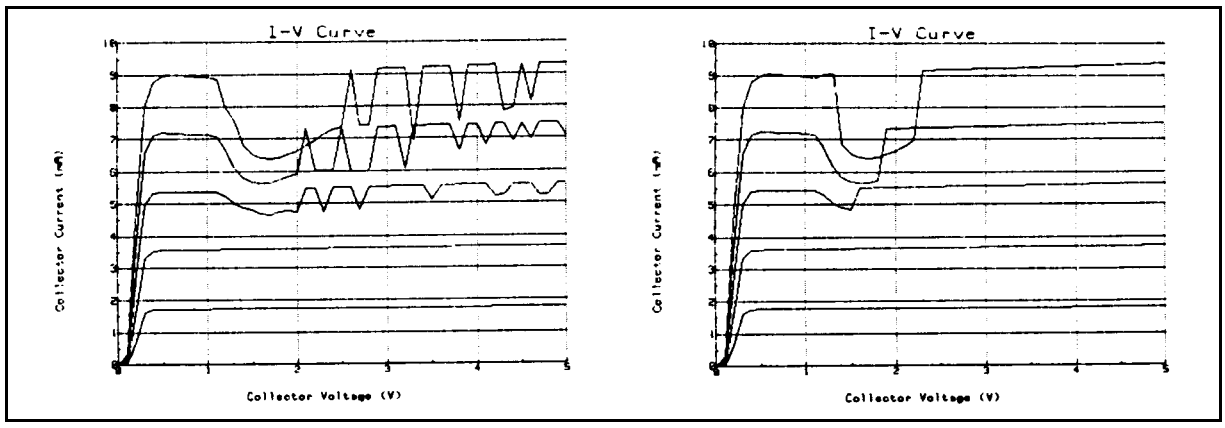



**Figure 5-7. Example Oscillating Test Device Output I-V Curves**

Test device oscillation, however, cannot be detected by the SMU's detection circuits. To prevent test device oscillation, connect a ferrite bead (HP part number 9170-0029) to test device leads as shown in Figure 5-8.

Connect the ferrite bead as close as possible to your test device. You may need to install more than one bead or change to a bead with a different diameter to prevent oscillation. Note that the use of ferrite beads may cause leakage current when performing low current measurements.

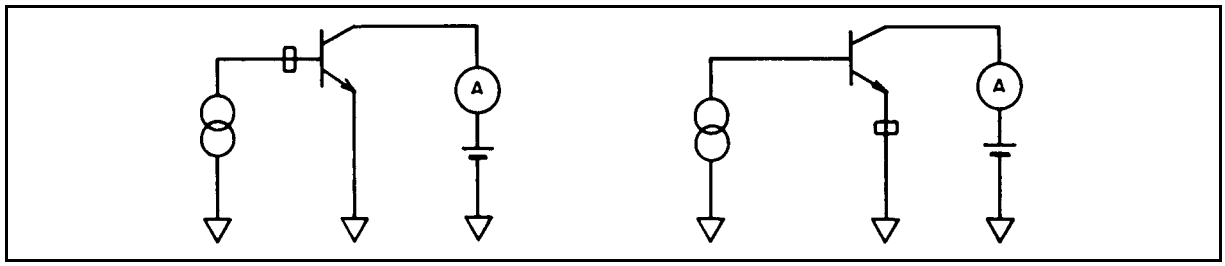



**Figure 5-8. Preventing Test Device Oscillation**

Oscillation may also occur at your test device because of residuals in the SWM and its test fixtures.

If you perform measurements on devices that exhibit negative resistance characteristics, such as tunnel diodes and unijunction transistors, SMUs are especially susceptible to oscillation.

- Voltage controlled negative resistance devices

Connect G in parallel with your test device to cancel negative resistance. To obtain an output I–V curve, use the following equation:

$I_Y = I - G \times V$

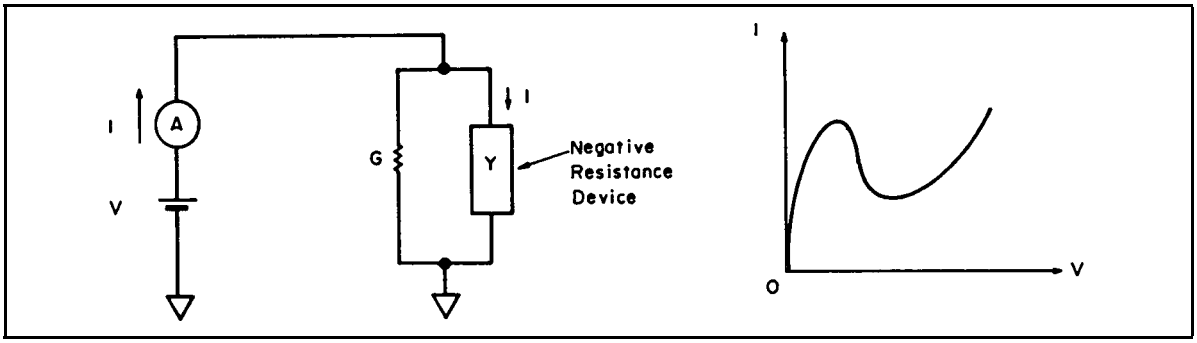



**Figure 5-9. Voltage controlled negative resistance devices**

- Current controlled negative resistance devices

  Connect R in series with your test device to cancel negative resistance. To obtain an output I–V curve, use the following equation:

  $V_Z = V - R \times I$

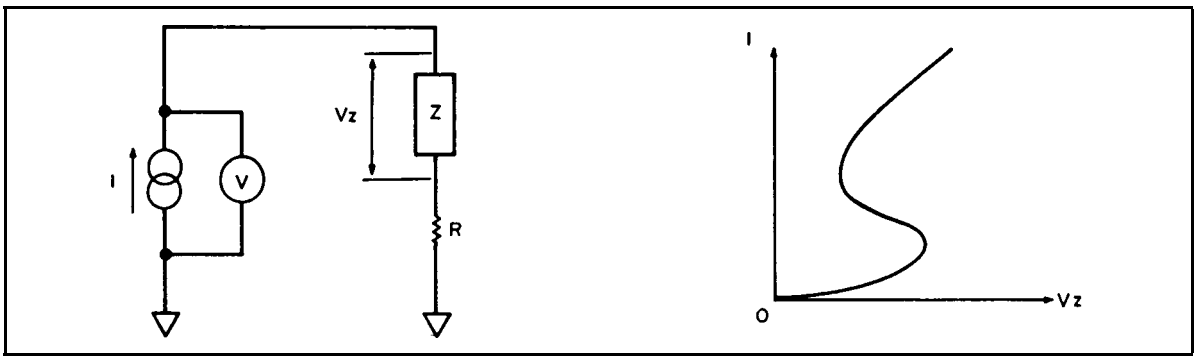



**Figure 5-10. Current controlled negative resistance devices**

## DCS Swept Measurements

You can sweep SMU and VS outputs with TIS statements.

At the completion of a sweep, output voltage or current returns to the specified *start* value. You can set the output levels to their Zero Output values when a sweep ends with the Disable_port statement. See Figure 5-11

Refer to the *Programming Reference* manual for details on Disable_port usage.

**Note**

Upon completion of a swept measurement, the CMU's output voltage returns to the voltage specified by the previous Force_v statement.

1) Output voltage returns to −100 V after the sweep ends.

```
140  !
150  !
160  !
170  Vstart=-100
180  Vstop=0
190  !
200  Set_iv(FNSmu(1),1,0,Vstop,Point)
210  Sweep_iv(FNSmu(1),2,0,Ids(*))
220  !
230  !
240  !
250  !
```

2) Output voltage returns to 0 V with the Disable_port statement.

```
140  !
150  !
160  !
170  Vstart=-100
180  Vstop=0
190  !
200  Set_iv(FNSmu(1),1,0,Vstop,Point)
210  Sweep_iv(FNSmu(1),2,0,Ids(*))
220  Disable_port
230  !
240  !
250  !
260  !
```

**Figure 5-11. Partial DCS Swept Measurement Control Program Examples**

## CMS Error Compensation

The CMU or CMU84 measures impedance, including the following error factors, except the capacitance and conductance of the DUT:

- Stray capacitance and residual resistance of the SWM
- Stray capacitance and residual resistance of the cables between the CMS and SWM

To compensate the measured data, the error factors above must be removed. The TISs for capacitance measurements remove these error factors automatically by matrix operation.

The following covers the error compensation concepts for the CMS.

### CMU Error Compensation

When using the CMU to perform capacitance measurements, stray capacitances and residual resistances inherent in the SWM and in the CMH and CML cables can affect measurement results. Refer to Figure 5-12.

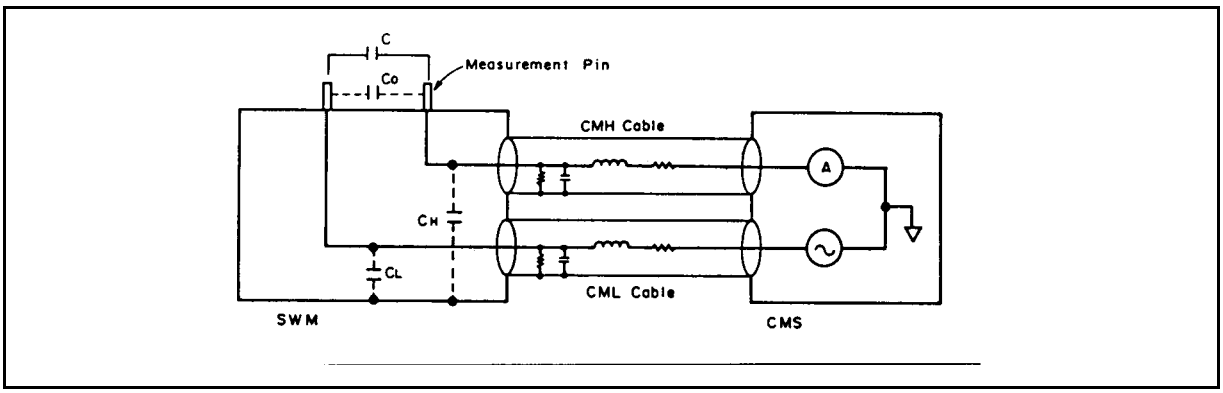



**Figure 5-12. SWM and CMU Cable Strays and Residuals**

Your HP 4062C/UX/PC compensates for error producing elements by automatically subtracting the error values from the measurement results. SWM error values are constant, and the error producing elements of the CML and CMH cables are measured during system START.

When monitoring measurements using the VFP, capacitance results obtained using the Measure_cmu statement are automatically error compensated.

**Note**

Because of the HP 4062C/UX/PC's automatic error correction feature, the system's error compensated measurement results are different from the uncompensated measurement results displayed on the CMU.

## CMU84 Error Compensation

When using the CMU84 to perform capacitance measurements, stray capacitances and residual resistances inherent in the SWM can affect measurement results. The CMU84 automatically compensates the 4 m test leads by itself. Refer to Figure 5-13.

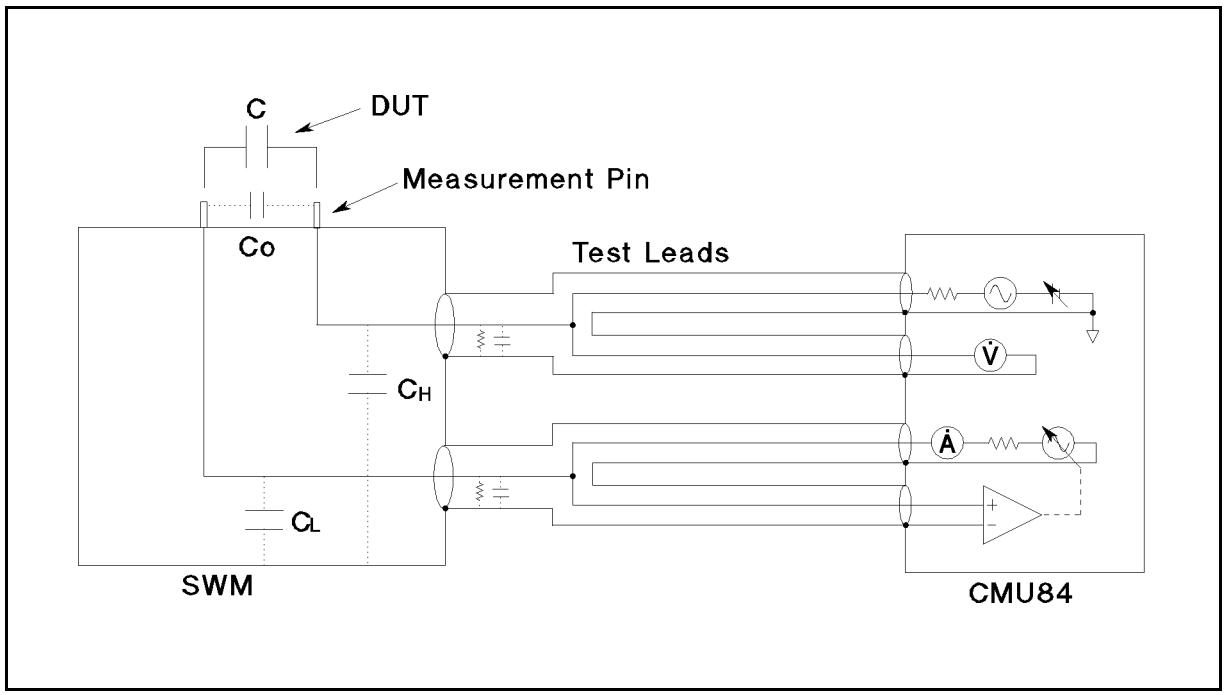



**Figure 5-13. SWM and Test leads Strays and Residuals**

The HP 4062C/UX/PC compensates for error producing elements by automatically subtracting the error values from the measurement results. SWM error values are constant.

**Note**

Because of the HP 4062C/UX/PC's automatic error correction feature, the system's error compensated measurement results are different from the uncompensated measurement results displayed on the CMU84.

## Subtracting Stray Capacitance

Error correction is performed up to the measurement pins only. To obtain accurate capacitance measurement results when using a test fixture or probe card, compensate for the stray capacitance from the test fixture or probe card.

Subtract this stray capacitance Co, shown as Co in Figure 5-12 (capacitance zero-offset value), from your capacitance measurement results as follows:

1. With nothing connected to your test fixture or probe card, perform a capacitance measurement. If you're using a wafer prober, be sure to lower the prober stage (chuck).
2. Note the measurement results (capacitance zero-offset value Co).
3. Connect a test sample and perform a measurement. The measured value Cm includes the stray capacitance Co.
4. Subtract Co from the capacitance measurement results Cm obtained in step 3. This result is the compensated capacitance value C (Cm − Co).

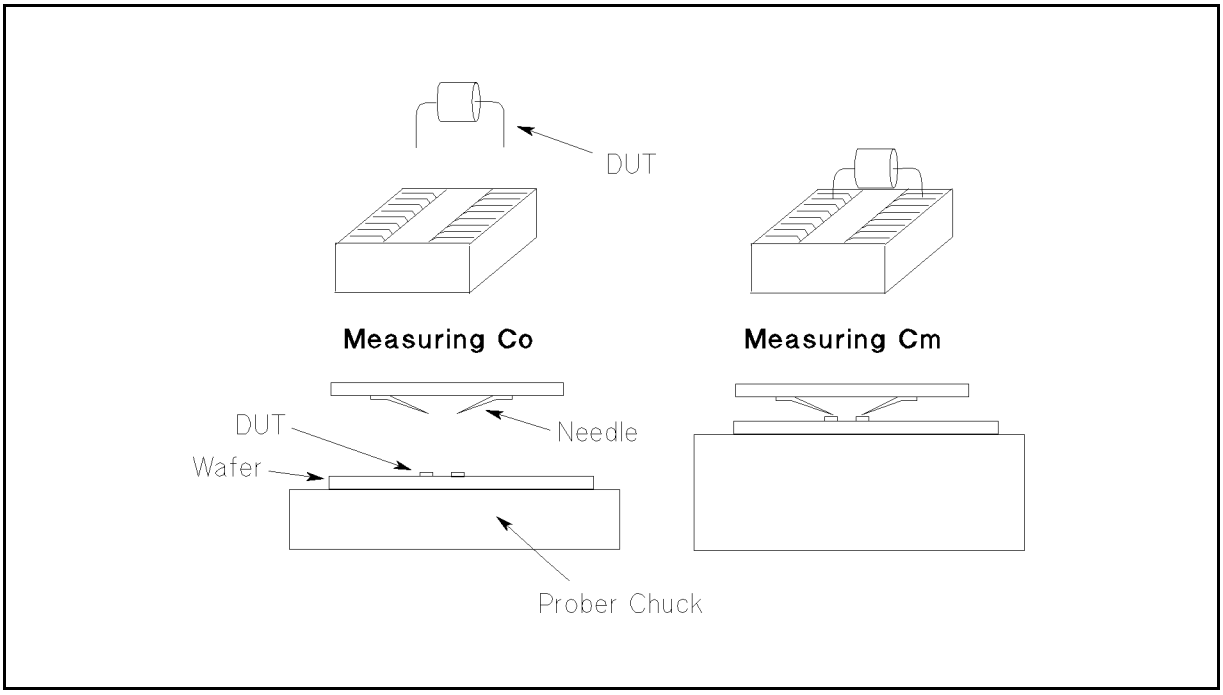



**Figure 5-14. Subtracting Stray Capacitance**

## Configuration of the CMU Ports

The CMU's HIGH and LOW terminals connect to the SWM's AUX3 (CMH) and AUX4 (CML) ports, respectively; and CMU connection mode 12 (CN12) is used. Refer to Figure 5-15.

This cabling configuration provides the following advantages:

- The HIGH terminal has a higher noise-rejection ratio than the LOW terminal and provides better noise rejection when connected to a wafer prober's chuck.
- A wafer's substrate (wafer prober chuck) should not have a voltage potential applied to it, so the CMH and CML ports are reversed inside the test lead assembly.

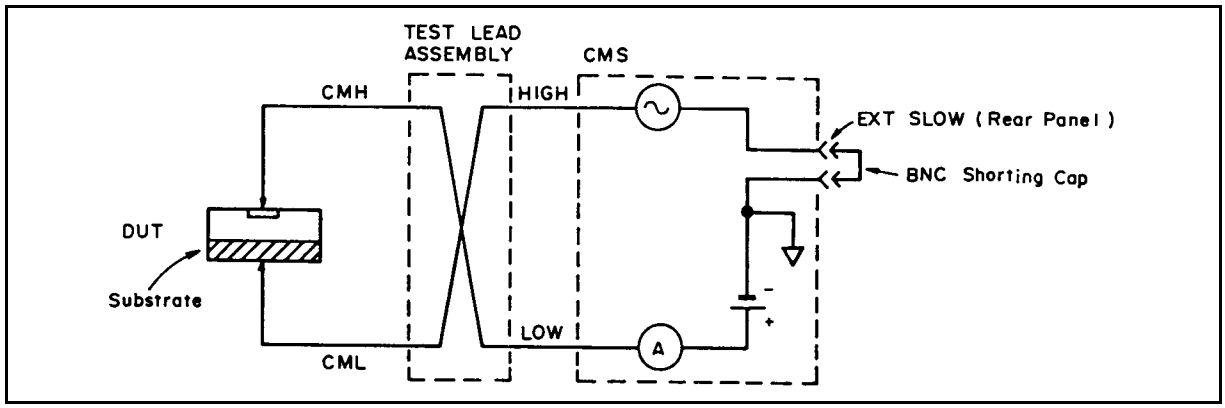



**Figure 5-15. CMU Cable Configuration**

## Using Unsupported Instruments

This section covers the information on how to use unsupported instruments with the HP 4062 system. It is assumed that the unsupported instruments are equipped with an HP-IB or GP-IB interface.

You can use unsupported instruments connected to the SWM. The functions, settings, and so forth, of the instruments are controlled via the HP-IB, and the signal path between the device under test (DUT) and the instruments can be switched by using the SWM.

The auxiliary (AUX) ports of the SWM have coaxial (BNC) connectors, which are used commonly between several instruments. Some instruments can be connected to the AUX ports. You can use up to four AUX ports to connect the instruments. If your SWM is equipped with a port expander, you can use up to 10 AUX ports (BNC connectors) to connect the instruments. For details on the port expander, see "Port Expander" in Chapter 2.

**Note**

When switching the pin-port connections, you must dry switch the relays in the SWM. If a voltage or current is forced from the instruments, making or breaking relays results in poor contact of the relays and you will not get reliable measured data.

### Installing Unsupported Instruments

The unsupported instruments are connected to the HP-IB interface of the system controller with the HP-IB cables. You can connect the instruments to the internal HP-IB (select code 7) of the system controller. Hewlet-Packard, however, recommends that you prepare a new HP-IB interface card not connected to any system instruments or wafer prober. The new HP-IB interface is occupied by the unsupported instruments.

When you install a new HP-IB interface card in the system controller, the select code must be set to an unused number ranging from 8 to 30. For details on the HP-IB interface card, see its *Installation Note*.

## Application Example

The following example measures a voltage using the HP 3478A Digital Multimeter.

The HP 3478A is set to 5 for the primary address, and connected to an HP-IB interface in which the select code is 8. The BNC connector from the HP 3478A is connected to the AUX2. Note that the outer conductor of the AUX ports is connected to the system common, which is set to the same voltage as the GNDU.

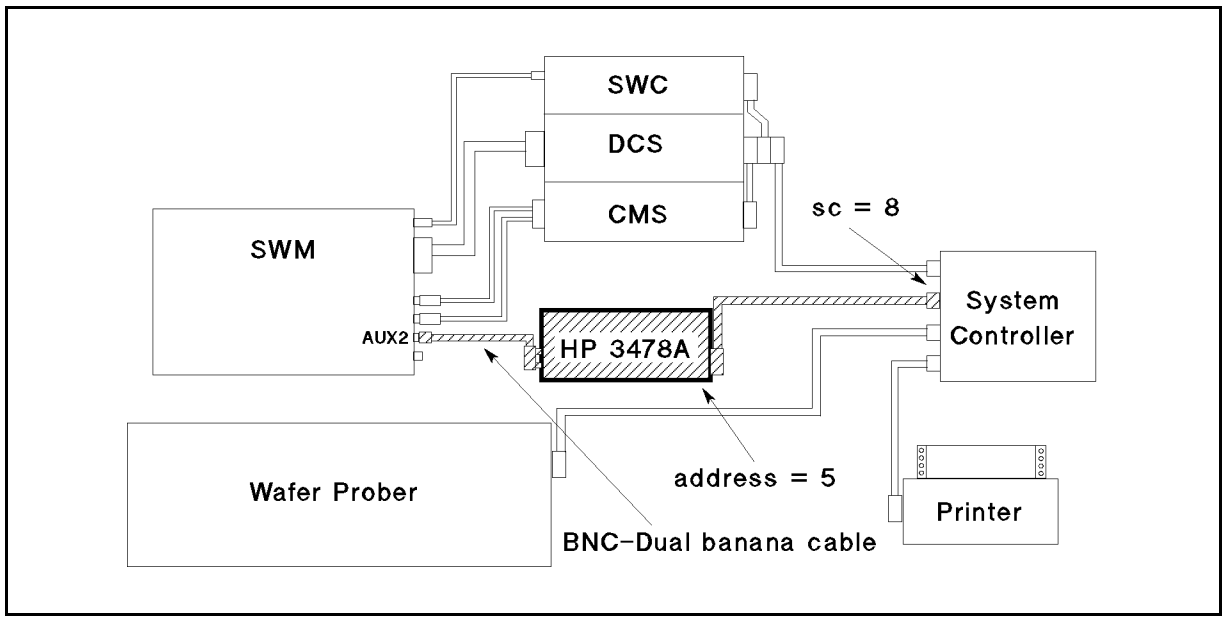



**Figure 5-16. Connecting HP 3478A Digital Multimeter**

The controller sets the HP 3478A to dc voltage function and auto-ranging mode.

- Programming in HP BASIC:

```
10    ! Sample: Using HP 3478A
20    ! Link: TIS
30    !
40    REAL Volts
50    ! HP 3478A Settings
60    OUTPUT 805;"F1"            dc voltage function
70    OUTPUT 805;"RA"            auto-ranging mode
80    !
90    Init_system
100   Connect(FNGnd,8)
110   Connect(FNAux(2),16)
120   OUTPUT 805;"T3"            single trigger
130   ENTER 805;Volts            reading measured data
140   Connect
150   PRINT "Volts = ";Volts
160   !
170   END
```

■ Programming in C

```
/*********************************/
/* Sample: Using HP 3478A        */
/* Source file: vmeas.c          */
/* Compile:                      */
/*    $ cc vmeas.c -lhp4062 -ldvio */
/* Execution:                    */
/*    $ a.out                    */
/*********************************/
#include <stdio.h>
#include <pcs/tis>

main()
{
    int fd, eid8;
    char buffer[81];

    if ((fd = open_tis_hpib_fd()) == -1) error_rep();
    set_tis_hpib_fd(fd);

    if ((eid8 = pcs_hpib_open(8)) == -1) error_rep();
    if (pcs_hpib_output(eid8, 5, "F1", 0) == -1) error_rep();      dc voltage function
    if (pcs_hpib_output(eid8, 5, "RA", 0) == -1) error_rep();      auto-ranging mode
    if (init_system() == -1) error_rep();
    if (connect_pin(fngnd(), 8) == -1) error_rep();
    if (connect_pin(fnaux(2), 16) == -1) error_rep();
    if (pcs_hpib_output(eid8, 5, "T3", 0) == -1) error_rep();      single trigger
    if (pcs_hpib_enter(eid8, 5, buffer, 80) == -1) error_rep();    reading measured data
    if (disconnect_all() == -1) error_rep();

    printf("Measured data = %s\n", buffer);
}
```

## Using Printer with Serial Interface

When using a printer with serial interface, you must set the parameters for asynchronous data communication: baud rate, parity option, character length, and so on. The system programs such as PPG and MAP can print the results on your printer, but cannot control the parameter settings for the interface. You must set the parameters of the serial interface before running the system programs.

### For HP 4062C System

The CONTROL statement sets the parameters for asynchronous data communication. For more details, see *HP BASIC Interfacing Techniques, Volume 2: Specific Interfaces*.

For example, to select a baud rate of 2400 for the built-in serial (RS-232C) interface (select code 9), use the following CONTROL statement:

```
CONTROL 9,3;2400
```

For example, to configure a character format of eight bits per character, two stop bits, and EVEN parity to the built-in serial (RS-232C) interface (select code 9), use the following CONTROL statement:

```
CONTROL 9,4;IVAL("11111",2)
```

### For HP 4062UX System

The CONTROL statement cannot read any hardware bit settings on the serial interface. Therefore, HP recommends the following method to set the parameters for asynchronous data communication:

- The `stty` command sets the parameters of data communication from the HP-UX environment.

For example, to configure a character format of eight bits per character, two stop bits, and EVEN parity to the built-in serial (RS-232C) interface (select code 9), use the following `stty` command from the HP-UX environment:

```
/bin/stty 9600 cs8 parenb -parodd cstopb < /dev/rmb/serialxx
```

Note that the device special file `/dev/rmb/serial`*xx* must be created using the `mknod` command beforehand.

For more details, see the STTY reference page and *HP BASIC Interfacing Techniques, Volume 2: Specific Interfaces*.

### For HP 4062PC

To set the parameters for asynchronous data communication with the COM1 or COM2 port of MS-DOS, use the CONF.EXE utility program from the MS-DOS environment. The CONF.EXE utility program sets the port connection, baud rate, parity, character length, stop bit, and modem settings. For more details, see "Changing the HP BASIC Configuration File" in *Installing and Using HP BASIC in the MS-DOS Environment*.

## Emergency Off System

The emergency off system can automatically or manually stop the supply of electric power to the system instruments under emergency conditions. For example, if an earthquake occurs and the emergency off switch is pressed, electric power supplied to the system instruments stops and a potential fire caused by an electric short circuit can be prevented.

A variety of emergency off systems can be designed depending on the customer's needs. Hewlett-Packard, however, only provides the function to turn off the system instruments of the HP 4062 system. Customers are responsible for designing the emergency off system including the HP 4062 system according to the customer's needs.

The HP 4062 system with the standard system cabinet (1600 mm height) has an *emergency off unit* at the top of the cabinet as shown in Figure 5-17. The emergency off unit has a red, circular push-switch named "EMERGENCY OFF." Pushing the emergency off switch stops the supply of electric power to the system instruments. Once the emergency off switch is pushed, the switch is locked to the pushed condition. To release the locked emergency off switch, you must use a *mechanical key*.

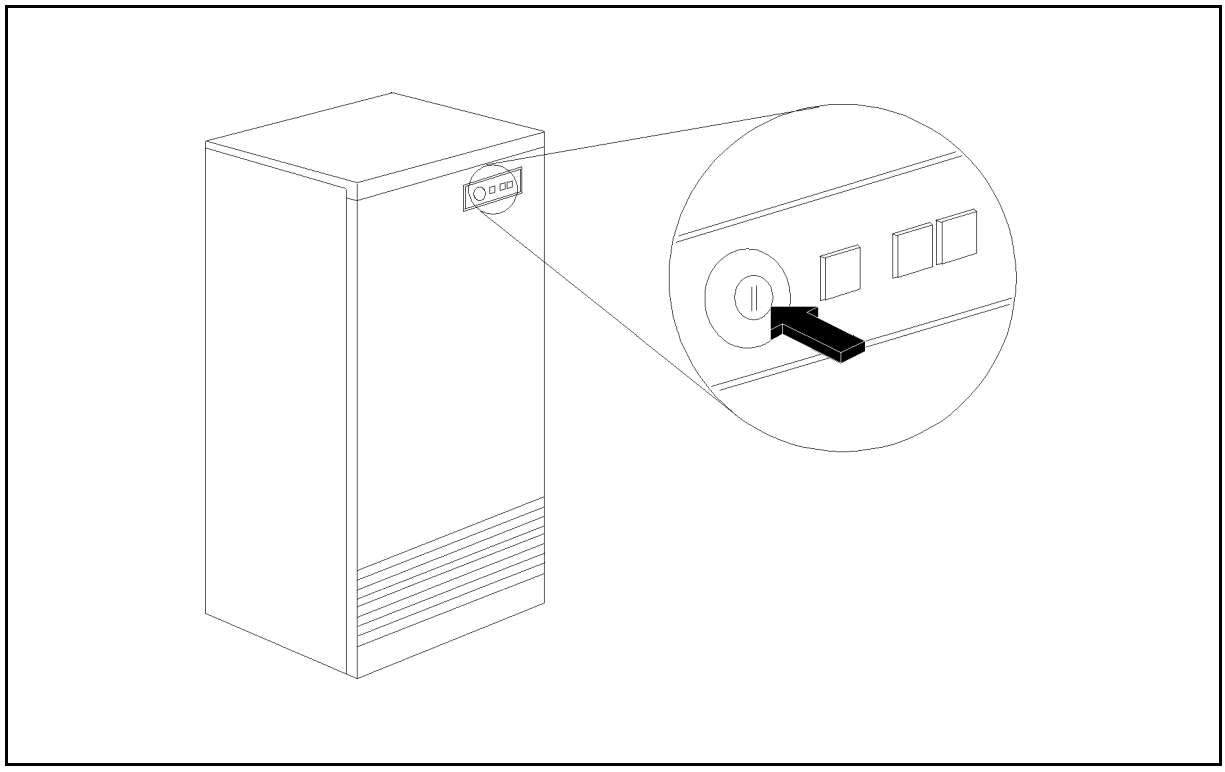


**Figure 5-17. Emergency Off Unit in Standard System Cabinet**

Note that small system cabinet (1000 mm height) has no emergency off unit.

This section provides information on the emergency off unit and power distribution unit for designing the emergency system according to the customer's needs. Included are:

- Circuit diagram and its operation for the emergency off unit and power distribution unit.
- I/O interface (external in/out terminals) specifications of the emergency off unit.
- Example design for an emergency lamp.

## Block Diagram and Operation of the Emergency Off Circuit

Figure 5-18 shows the block diagram of the emergency off circuit. If your system has the 100 Vac power line option, the main circuit breaker also has a ground-fault circuit interrupter (GFCI) function, which senses the earth leakage current. Note that the relay in the figure shows the function that forcing alternating current as well as direct current closes or opens the contacts in the relay.

The Ext In terminals are shorted using a conductor at the factory.

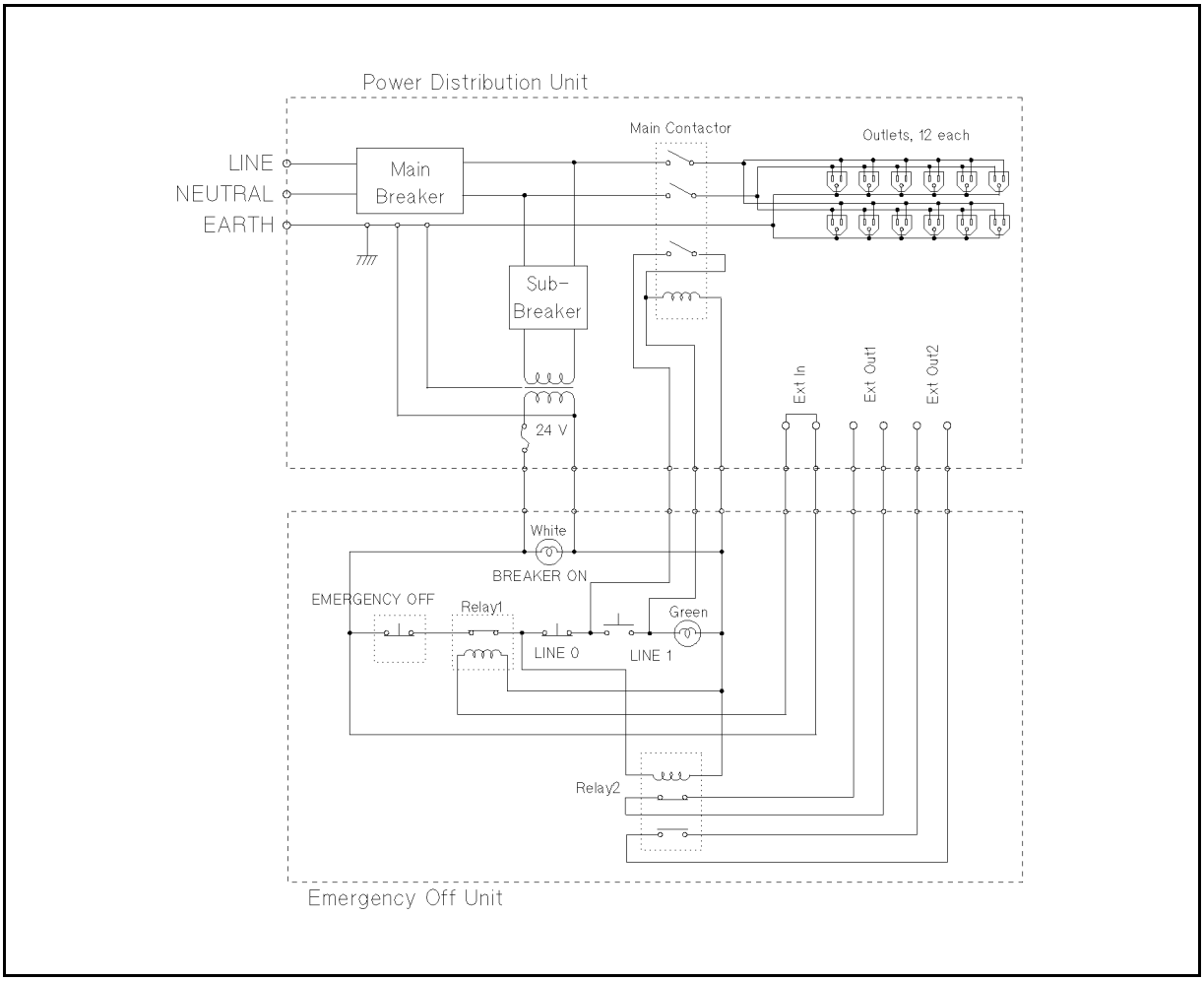



**Figure 5-18. Block Diagram of Emergency Off Circuit**

Switching on the main circuit breaker and sub-circuit breaker turns on the BREAKER ON indicator (white), but the main contactor switch does not close. The figure shows this condition. When the LINE 1 switch closes, the coil of the main contactor is activated and the main contactor switch closes. The LINE 1 indicator (green) also turns on. Under these conditions, the electric power is supplied to the system instruments.

Pressing the LINE 0 switch stops the current through the coil of the main contactor, and the main contactor opens. This stops the electric power to the system instruments.

When the EMERGENCY OFF switch is pressed and its contacts open, the current through the coil of the main contactor stops and the main contactor opens. This stops the electric power to the system instruments.

At the same time, the current through the coil of Relay2 stops. So the Ext Out1 contact opens, and the Ext Out2 contact closes.

Instead of pressing the EMERGENCY OFF switch, opening the Ext In terminals stops the current through the coil of Relay2, and one contact opens and the other closes. Then the current through the coil of the main contactor stops, the main contactor opens, and the electric power to the system instruments stops.

Table 5-2 shows the conditions for the normal operation.

**Table 5-2. Conditions for Normal Operation**

| Operation | Results | | |
|---|---|---|---|
| | **Power for System Instruments** | **Ext Out 1 (NC[1])** | **Ext Out 2 (NO[2])** |
| Pressing LINE 1 | Supply | Close | Open |
| Pressing LINE 0 | Stop | | |
| Pressing EMERGENCY OFF | | Open | Close |
| Opening External In | | | |

1 NC stands for normally closed.

2 NO stands for normally open.

**Note**

Do not accidently turn off the main or sub-breaker, or remove the plug of the main power cable from the outlet. If you do, the current through the coil of Relay2 stops, so the Ext Out1 contact opens and the Ext Out2 contact closes, which is the same result as pressing the EMERGENCY OFF switch.

## ⚠ I/O Specifications

There are four points of I/O interface in the power distribution unit (PDU) that you must note. The followings shows the I/O specification:

| | |
|---|---|
| Outlets for instruments | Maximum current: 30 A for 100 Vac, 24 A for 120 Vac, and 15 A for 220 and 240 Vac. Maximum 6 A for each outlet. |
| Ext In | Steady current: 56±11.2 mA (50 Hz); 50±10 mA (60 Hz) at 24 Vac<br>Transient current: 2 – 3 times that of the steady current |
| Ext Out 1 and Out 2 | Maximum current: 3 A at 250 Vac |

## Example Design for an Emergency Lamp

The following describes a simple example for designing the emergency off system. The operation is as follows:

> After pressing the EMERGENCY OFF switch, the electric power stops being supplied to the system instruments and the emergency lamp turns on.

To accomplish this condition, obtain an emergency lamp that operates on 120 Vac of electric power. The Ext Out 2 terminals (normally open) turn the emergency lamp on or off. The NEUTRAL side of the 120 Vac outlet is connected to a terminal of the emergency lamp, the LINE side of the outlet is connected to one terminal of the Ext Out 2, and the other terminal of the Ext Out 2 is connected to the other terminal of the emergency lamp. Figure 5-19 illustrates the connections. Note that the electric power *must not* be supplied from an outlet of the power distribution unit of the system cabinet, because the electric power of the system instruments through the PDU stops after the emergency off system is activated to shut off power.

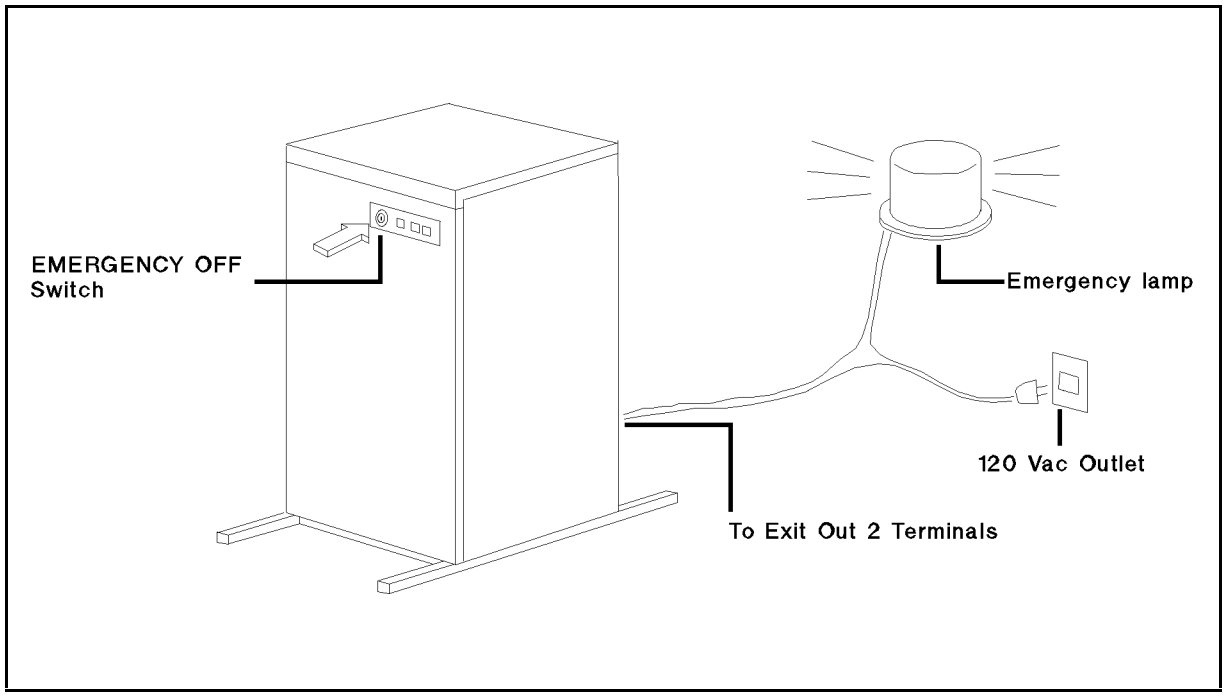



**Figure 5-19. An Example of Emergency Off System**

# A

# Error Messages

## Introduction

If your HP 4062C/UX/PC detects a hardware failure or an illegal operation, an error message or error code, often both, appears on the system controller's display. Errors are divided into two basic categories: system controller-related and HP 4062C/UX/PC-related, as explained here.

- System Controller Errors

  If a system controller error occurs, a BASIC or BASIC/UX language system error code is displayed, as in the following example:

  ```
  Error 7 in 1250  Undefined function or sub
  ```

  If a system controller hardware failure occurs, a SYSTEM ERROR message is displayed. Refer to the *BASIC* or *BASIC/UX Language Reference Manual* for details on system errors.

- HP 4062C/UX/PC Errors

  If an HP 4062C/UX/PC error occurs, an error message is displayed, as in the following example:

  ```
  TIS ERROR 20 Device not present.
  ERROR 449 IN 10
  ```

  Error message prefixes give the name of the program or subprogram in which the error occurred. In the example above, the error occurred in TIS. In some cases, only an error code is displayed.

This appendix lists all the HP 4062C/UX/PC error messages and includes a partial listing of system controller error codes. For details on system controller error codes, refer to the *BASIC* or *BASIC/UX Language Reference Manual*.

## Error Messages Listings

This appendix lists the following HP 4062C/UX/PC system software file error messages:

START, TIS, PGMLIB, VFP, PPG, DIAG, and DVR4284.

**Note**

If an error occurs when using files other than those listed above, an error code is displayed. If an error occurs when using PARA, however, a TIS error message is displayed.

## START Errors

This section lists errors related to your HP 4062C/UX/PC's START program.

- `START ERROR 0 Not authorized to use the software.`
- `START ERROR 0 Not authorized to use the software (some HP-HIL devices locked).`
- `START ERROR 0 Not authorized to use the software. No CODEWORD file found.`

  The ID Module is not connected—or not connected properly—to your system controller, the CODEWORD file does not exist, or the codeword in the CODEWORD file is incorrect.

- `START ERROR 1 SWM/SWC failed power-on test.`
- `START ERROR 2 No pin boards installed in SWM.`
- `START ERROR 3 SWM down. SRQ asserted.`

  A hardware failure occurred during the SWC/SWM power-on self test. Check for one of the following possible causes:

  - A momentary power loss may have occurred.
  - The control cable interconnecting the SWM and SWC is disconnected, making poor contact, or defective.
  - The SWM control bus cable is disconnected, making poor contact, or defective.

  After checking the above, rerun the START program. If the same error code is displayed, contact your system administrator or nearest HP Service Office.

- `START ERROR 4 SWM syntax error. SRQ asserted.`

  The SWC received an illegal program code. Rerun the START program.

- `START ERROR 5 SWM pin board malfunction. SRQ asserted.`

  Pin board failure occurred during the SWC/SWM power-on self test.

- `START ERROR 6 Switching matrix is open.`

  Enable the SWM by installing the Test Fixture Adapter on the SWM (closes the FIXTURE CLOSED DETECT switch) or by pressing and holding the SWM's WAFER PROBER SENSE switch, and rerun the START program.

- `START ERROR 7 This version of switching matrix controller not supported: HP 4084A REV.` *xx.xx*

  HP 4062C/UX/PC supports only the HP 4084B (Rev. 2.0 or later) SWC.

- `START ERROR 10 DCS failed power-on test.`

  A hardware failure occurred during DCS self-test.

- `START ERROR 11 DCS syntax error. SRQ asserted. : Error` *xxx*

  The DCS received an illegal program code. Rerun the START program. The *xxx* above is the DCS's error code. Refer to the HP 4142B's *Operation Manual*, for details on DCS error codes.

- `START ERROR 12 DCS not interlocked. SRQ asserted.`

The interconnect cable assembly is disconnected, making poor contact, or defective. Check these possible causes and rerun the START program.

- `START ERROR 13 DCS shutdown. SRQ asserted.`

  DCS output is disabled because of a momentary power loss or because voltage or current in excess of an SMU's maximum current, voltage, or power was applied to an SMU. Rerun the START program.

- `START ERROR 14 DCS calibration error. SRQ asserted. : Error` *xxx* `in slot` *y*

  A hardware failure occurred during DCS calibration. The *xxx* above is the DCS's error code and *y* is the slot number of the failed module. For example, if the module in slot 1 is not functioning properly, the following error message is displayed.

  ```
  START ERROR 14 DCS calibration error.  SRQ asserted.  : Error 420 in slot 1
  ```

  If this error occurs, contact your system administrator or nearest HP Service Office. For emergency repair, replace or remove the module in the slot indicated and rerun the START program.

- `START ERROR 15 CMS syntax error. SRQ asserted.`
- `START ERROR 16 CMS illegally programmed. SRQ asserted.`
- `START ERROR 17 CMS triggered too fast. SRQ asserted.`

  Check your cabling configuration and BNC shorting cap connections, and rerun the START program.

- `START ERROR 18 CMS sweep/bias error. SRQ asserted.`

  The BNC shorting cap is not connected to the CMS's front panel REMOTE ON/OFF connector. Connect the BNC shorting cap and rerun the START program.

- `START ERROR 19 CMH terminal improperly connected.`
- `START ERROR 19 CMH84 terminal improperly connected.`
- `START ERROR 20 CMH cable connected to CML(AUX4) port on SWM.`
- `START ERROR 20 CMH84 terminal connected to CML (AUX`*xx*`) port on SWM.`
- `START ERROR 20 CMH terminal connected to AUX`*xx*` port on SWM.`
- `START ERROR 20 CMH84 terminal connected to AUX`*xx*` port on SWM.`
- `START ERROR 21 CML terminal improperly connected.`
- `START ERROR 21 CML84 terminal improperly connected.`
- `START ERROR 22 CML cable connected to CMH(AUX3) port on SWM.`
- `START ERROR 22 CML84 terminal connected to CMH (AUX`*xx*`) port on SWM.`
- `START ERROR 22 CML terminal connected to AUX`*xx*` port on SWM.`
- `START ERROR 22 CML84 terminal connected to AUX`*xx*` port on SWM.`

  The CML or CMH cable is connected to the wrong terminal. Check for proper connection between the CMS and SWM, and rerun the START program.

- `START ERROR 23 CMS INT BIAS switch improperly set.`

The CMS's INT BIAS switch is set to the ±42 V MAX position. Set the switch to ±100 V MAX and rerun the START program.

- `START ERROR 24 CMS cable impedance incorrect.`

  CMH or CML cable impedance is either too high or too low. Use the cables furnished with the system and rerun the START program.

- `START ERROR 25 CMU84 SRQ. Error code` *xxx*`. Check the cabling configuration and rerun the pcsstart program. * START ERROR 26 Relays for AUX`*yy*`of port expander cannot be controlled.`

  The Port Expander relays can not be controlled because one of the Port Expander relay control boards is either missing or incorrectly installed. The *yy* above refers to the AUX relays controlled. Check the installation and rerun the START program.

- `START ERROR 51 HVU/HCU NOT supported (remove HVU/HCU).`

  This error is reported with a full screen warning message whenever you attempt to install either an HVU or an HCU into the HP 4062UX system. Shared memory space, which is essential to TIS operation, is intentionally destroyed to avoid HVU/HCU operation during TIS programming.

- `START ERROR 90 SYSCONFIG file not found; on-line mode is not available.`

  Since SYSCONFIG does not exist in "/usr/pcs/etc" directory, you can perform only the off-line mode operation.

- `START ERROR 91 The instruments are being used in another session.`

  Another session already locks the instruments. You can perform only the off-line mode operation until the session is stopped or changed to off-line mode.

- `START ERROR 92 HP-IB timeout is detected at address` *xxx*.

  An expected interrupt did not occur within the specified limits. Check for one of the following possible causes:

  - The HP-IB cables interconnecting the system controller and instruments were *not* connected, making poor contact, or defective, when the START program executed.
  - Instruments were *not* On when the START program executed.
  - HP-IB Interface was *not* functioning properly.

  After checking the above, rerun the START program. If the same error code is displayed, exit from BASIC/UX and HP-UX, then reload HP-UX and BASIC/UX and rerun the START program.

- `START ERROR 100 DUMCONFIG file (`*xxx*`) not found.`
- `START ERROR 101 Non ASCII character '`*xxx*`' in DUMCONFIG file.`
- `START ERROR 102 Error in DUMCONFIG: File incompletely terminated.`
- `START ERROR 110 Error in DUMCONFIG: Invalid pin description:`
- `START ERROR 120 Error in DUMCONFIG: Invalid DCS configuration description:`
- `START ERROR 121 Error in DUMCONFIG: Invalid slot number:`
- `START ERROR 122 Error in DUMCONFIG: HP 41420A can not be installed in DCS slot 1.`

- START ERROR 123 Error in DUMCONFIG: HP 41420A requires slot X to be empty.
- START ERROR 124 Error in DUMCONFIG: Slot X is already occupied by an HP 41420A."
- START ERROR 125 Error in DUMCONFIG: Two or more units assigned in slot X.
- START ERROR 126 Error in DUMCONFIG: Unrecognized module *xxxx*.
- START ERROR 130 Error in DUMCONFIG: Invalid cabling description:
- START ERROR 131 Error in DUMCONFIG: Only Cmu(1) is attachable to CMH port:
- START ERROR 132 Error in DUMCONFIG: Only Cmu(2) is attachable to CML port.
- START ERROR 133 Error in DUMCONFIG: Invalid DCS/CMS unit address:
- START ERROR 134 Error in DUMCONFIG: Invalid SWM port address:
- START ERROR 135 Error in DUMCONFIG: Corresponding unit not installed:
- START ERROR 136 Error in DUMCONFIG: Multiple units are attached to SWM port X.
- START ERROR 137 Error in DUMCONFIG: SMU *xxx* has multiple cabling to SWM ports.
- START ERROR 138 Error in DUMCONFIG: VS *xxx* has multiple cabling to SWM ports.
- START ERROR 139 Error in DUMCONFIG: VM *xxx* has multiple cabling to SWM ports.
- START ERROR 140 Error in DUMCONFIG: Invalid CMS port connection:

  The description of DUMCONFIG is not proper. Rerun the START program. If the same error code is displayed, contact your system administrator or nearest HP Service Office.
- START ERROR 141 Error in DUMCONFIG: Invalid CMU84 port connection: *xxx*.
- START ERROR 142 Error in DUMCONFIG: CMU(*xxx*) has multiple cabling to SWM ports.
- START ERROR 143 Error in DUMCONFIG: CMU84(*xxx*) has multiple cabling to SWM ports.

  The description of DUMCONFIG is not proper. The *xxx* above refers to the unit number. The X refers to a slot or port number. Rerun the pcsstart program. If the same error code is displayed, contact your system administrator or nearest HP Service Office.
- START ERROR 201 Illegal command parameter --- *xxx*.

  Rerun the START program. If the same error code is displayed, contact your system administrator or nearest HP Service Office.
- START ERROR 202 Session *xxx*: Permission denied.

  The session that is specified by environment variable PCS_SESSION_ID does not allow accessing. Rerun the START program. If the same error code is displayed, contact your system administrator or nearest HP Service Office.
- START ERROR 203 Session *xxx* busy.

  Another process is making measurements using TIS statements or locks the instruments.
- START ERROR 300 PCS_SESSION_ID not defined.
- START ERROR 301 Session ID *xxxx* too long.
- START ERROR 310 Group 'pcs' not registered.
- START ERROR 320 Non ASCII character '*xxx*' in SYSCONFIG file.

- START ERROR 321 Invalid SYSCONFIG entry.
- START ERROR 322 SYSCONFIG file contains no effective description.
- START ERROR 323 Error in SYSCONFIG: HP-IB select code must be identical.
- START ERROR 324 Error in SYSCONFIG: HP-IB address XXX not identical among components.
- START ERROR 325 Error in SYSCONFIG: Invalid HP-IB address *xxx*.
- START ERROR 326 Error in SYSCONFIG: Invalid select code *xxx*.
- START ERROR 327 Error in SYSCONFIG: *xxx* is not supported as SWM.
- START ERROR 327 Error in SYSCONFIG: *xxx* is not supported as SWC.
- START ERROR 327 Error in SYSCONFIG: *xxx* is not supported as DCS.
- START ERROR 327 Error in SYSCONFIG: *xxx* is not supported as CMS.
- START ERROR 330 Device file /dev/rmb/hpib*xx* not found.
- START ERROR 331 HP-IB interface card not on select code *xxx*.
- START ERROR 332 /dev/rmb/hpib*xx* is not an HP-IB device file.
- START ERROR 333 HP-IB device file /dev/rmb/hpib*xx* is not for select code *xx*.
- START ERROR 334 /dev/rmb/hpib*xx* is not a raw HP-IB device file.
- START ERROR 340 Test session is in bad state; No control terminal.
- START ERROR 341 Can not create session key file; directory /usr/pcs/sessions not found.
- START ERROR 350 Error on pcsstart invocation; *xxx*

  Check for one of the following possible causes:

  - The system software is not installed properly.
  - System files are destroyed.
  - Cluster node is not added properly.

  Contact your system administrator or nearest HP Service Office.
- START ERROR 400 Test session pcs_*xxx* is in bad state.
- START ERROR 401 Test session is in bad state; No shared memory.
- START ERROR 402 Test session is in bad state; No semaphore.
- START ERROR 404 Invalid shared memory segment.
- START ERROR 405 Invalid shared memory segment.
- START ERROR 406 Invalid semaphore entity.
- START ERROR 407 Semaphore ID mismatched.
- START ERROR 408 Session ID inconsistent between key file and shared memory.
- START ERROR 409 Daemon process ID mismatched.
- START ERROR 410 Pcsstart co-exists; Shared memory found.

- `START ERROR 411 Pcsstart co-exists; Semaphore found.`
- `START ERROR 412 Semaphore removed.`
- `START ERROR 413 The online_lock file seems to be snatched by other session.`
- `START ERROR 450 Fatal error in pcsstart command.`

  Quit the BASIC/UX, log out, log in again, and restart the BASIC/UX. Then execute the START program. If the same error is detected, contact your system administrator or nearest HP Service office.

## TIS Errors

This section lists errors related to your system's TIS software.

`ERROR 392`

An illegal value is specified in a TIS subprogram. For example, if you specify "200" in the "Disable_port" subprogram, this is illegal and must be changed. This error also occurs if the COM blocks established during START are lost and you execute a TIS Init_system subprogram. Rerun the START program.

`ERROR 449`

This error code is preceded by one of the following TIS errors:

- `TIS ERROR 1 Not authorized to use the software.`

  The ID Module is not connected—or not connected properly—to your system controller. Correct the connection and rerun the START program.

- `TIS ERROR 10 HP-IB time out error.`

  An expected interrupt did not occur within the specified limits or a system fatal error occurred. For example, an ON TIMEOUT statement is used abnormally in a measurement program. Initialize the system by executing the Init_system subprogram. If the same error code is displayed, contact your system administrator or nearest HP Service Office.

- `TIS ERROR 11 HP-IB SRQ time out error.`

  An expected interrupt did not occur within the specified limits. The system's control settings were changed or your HP 4062C/UX/PC is trying to execute an illegal program operation. For example, a Connect statement is executed with the SWM open. Initialize the system by executing the Init_system subprogram.

- `TIS ERROR 20 Device not present.`

  An instrument that was not present during START (displayed as Not Present) is specified, or the COM blocks are lost. Check the connection between the instruments and rerun the START program.

- `TIS ERROR 21 Invalid port or pin assigned.`

  A port or pin board is illegally specified. For example, a VS is specified in a Force_i statement; or an illegal pin, such as -5, is specified in a Force_v statement.

- `TIS ERROR 22 Improper number of pass parameters specified.`

  In the Sweep_miv subprogram's calling context, the number of measurement ports in the measurement port list is different than the number of measurement data arrays.

- `TIS ERROR 23 Improper size of pass parameters specified.`

  In the Sweep_miv subprogram's calling context, the size of the measurement data arrays is different than the number of sweep points.

- `TIS ERROR 24 Improper pass parameters' value specified.`

  Improper pass parameter value in a feedback measurement subprogram.

- `TIS ERROR 25 Between PREPARE ... EXECUTE, a port is measure-assigned twice.`

One port is assigned to perform two or more functions within one Prepare ... Execute construct. Rewrite the measurement commands and assign only one function to a port within each Prepare ... Execute construct. Initialize your system using the Init_system subprogram.

- `TIS ERROR 26 Do not execute TIS while using DCS program memory library.`

  After invoking a DCS program memory segment with the Run_dcs_program function, you called a regular TIS function. Only an Init_system, Long_cal, Short_cal, or Disable_port function is allowed to be executed after the execution of the DCS program memory segment.

- `TIS ERROR 30 SWM down. SRQ asserted.`

  The SWC or SWM is not functioning properly. Check your cabling configuration and rerun the START program.

- `TIS ERROR 31 SWM syntax error. SRQ asserted.`

  The SWC received an illegal program code. Initialize your system using the Init_system subprogram.

- `TIS ERROR 32 SWM open. SRQ asserted.`

  SWM output is disabled. This may occur if you're using a wafer prober and your SWM is not mounted properly on the prober; if the Test Fixture Adapter is mounted on SWM but its cover is not closed; or if there is nothing mounted on the SWM.

- `TIS ERROR 33 Specified pin board not present. SRQ asserted.`

  A pin board registered during START (pin number displayed) is specified, but cannot be accessed. Check for proper pin board configuration and installation. If you rearranged pin boards, make sure they are properly installed and that the control bus cable is connected.

- `TIS ERROR 34 Pin board not present.`

  A specified pin board is not installed in the SWM. Check for proper pin board configuration and rerun the START program.

- `TIS ERROR 35 (first pin number) >= (last pin number)`

  In the Connect_th subprogram's calling context, the first specified pin number is larger than the last specified pin number.

- `TIS ERROR 40 DCS reports the error code. Error code is` *xxxx*.

  The DCS received an illegal program code. Initialize your HP 4062C/UX/PC using the Init_system subprogram. The *xxxx* is the DCS's error code.

- `TIS ERROR 41 DCS not interlocked. SRQ asserted.`

  The interconnect cable assembly is disconnected and an attempt was made to output voltage in excess of ±42 V. Connect the cable assembly.

- `TIS ERROR 44 VS output voltage incompatible with set voltage range.`

  A VS's specified output voltage exceeds the selected voltage range. Decrease the output voltage or increase the voltage range setting.

- `TIS ERROR 45 Improper SMU current source, range, or compliance specified.`

The specified compliance value of an SMU is too large for the selected range or specified output value. Decrease the current compliance or the output value, or increase the voltage range setting.

- `TIS ERROR 46 Illegal sweep power-compliance specified.`

  In the Set_iv subprogram's calling context, the specified power compliance is larger than the SMU's maximum output power. Decrease the power compliance setting.

- `TIS ERROR 47 Start and stop value are not same polarity.`

  In the Set_iv subprogram's calling context, the start value and stop value for a current sweep measurement must be the same polarity.

- `TIS ERROR 49 Illegal SMU measurement function assigned.`

  During a sweep or pulsed measurement, an SMU is set to the wrong mode for the specified measurement. SMUs must be set to VS mode for current measurements, and IS mode for voltage measurements.

- `TIS ERROR 50 Target value incompatible with compliance value.`

  In the Set_asearch, Set_bsearch, or Set_lsearch subprograms' calling context in the measurement mode, the target value is larger than the sense unit's compliance value.

- `TIS ERROR 51 This port must be the same V/I mode as the control variable.`

  In the Set_sync subprogram's calling context, the search port's and synchronous search port's output modes (VS or IS) must be the same.

- `TIS ERROR 52 Improper search offset value specified.`

  MAX(|minimum control value| or |start value|) and MAX(|maximum control value| or |stop value|) + |offset| must be within the search unit's range.

- `TIS ERROR 53 Sense port must be different from search port.`

  In the Set_asearch subprogram's calling context, the search and sense ports are both specified (illegally) as the same port (unit).

- `TIS ERROR 54 Target value out of range.`

  The specified target value exceeds the sense unit's measurement range.

- `TIS ERROR 55 Illegal search v_range, time, and speed combination specified.`

  In the Set_asearch subprogram's calling context, the start value, stop value, ramp rate, and feedback integration time settings are incompatible.

- `TIS ERROR 56 SMU output voltage incompatible with set voltage range.`

  An SMU's specified output voltage exceeds the selected voltage range. Decrease the output voltage or increase the voltage range setting.

- `TIS ERROR 57 Analog Feedback Unit (AFU) not present.`

  The AFU is specified for use in a measurement, but is not registered during START, or the COM blocks are lost. Make sure your AFU is installed in the DCS and rerun the START program.

- `TIS ERROR 58 Pulse period incompatible with pulse width.`

The specified pulse width is greater than 50% of the specified pulse period. Decrease the pulse width or increase the pulse period.

- `TIS ERROR 59 Improper DCS sweep, search, and pulse settings.`

  In a sweep, search, or pulsed measurement, the measurement execution subprogram executed before you established the measurement conditions. For example, a Sweep_iv subprogram executed before its corresponding Set_iv subprogram executed.

- `TIS ERROR 60 Improper search values (start_value and stop_value) specified.`

  In the Set_asearch subprogram's calling context, start and stop values must satisfy the following conditions:

  $|\text{start value}| \leq 2$ and $|\text{stop value}| \leq 2$, then $|\text{start} - \text{stop value}| \leq 2$
  $|\text{start value}| \leq 20$ and $|\text{stop value}| \leq 20$, then $|\text{start} - \text{stop value}| \leq 20$

- `TIS ERROR 61 Base_value and peak_value are not same polarity.`

  In a pulsed current measurement, the specified pulse base and peak values must be of the same polarity.

- `TIS ERROR 62 Specified VM is still set to Differential Voltage Measurement mode.`

  In a pulsed measurement, a VM's differential voltage measurement mode cannot be used.

- `TIS ERROR 63 Sync range adjustment error.`

  The synchronous search port's range must be the same as the search port's range. Also, the synchronous search port cannot be set to a range equal to MAX(|maximum search value| or |stop value|) and MAX(|minimum search value| or |start value|) + |offset|.

- `TIS ERROR 64 Cannot specify zero (0) specified for sweep or bias&sweep.`

  In a pulsed sweep or sweep with pulsed bias measurement, you cannot set the pulse period to 0.

- `TIS ERROR 65 Improper pulse measurement pass parameter specified for Set_iv.`

  In the Set_iv subprogram's calling context, the specified compliance value is invalid or the logarithmic sweep mode is specified.

- `TIS ERROR 66 Improper pulse measurement range specified.`

  In a pulsed current measurement, the specified current range is too low for the voltage range set. If the voltage range is larger than 2 V, the current range must be $\geq$ 1E-4 A.

- `TIS ERROR 68 Set_sync and Set_iv cannot specify the same port.`

  The Set_sync and Set_iv subprograms cannot specify the same port.

- `TIS ERROR 69 Set_sync cannot be used with Set_piv or Set_pbias.`

  The secondary sweep parameter cannot be used with pulsed or pulsed bias sweep measurements.

- `TIS ERROR 70 Start or Stop value is out of minimum resolution.`

  Unsuitable start or stop values are set in the Set_iv subprogram, or unsuitable offset or ratio is set in the Set_sync subprogram.

- `TIS ERROR 71 VS cannot be used if the primary SMU is current source mode.`

When using a VS as a secondary sweep source, the VS and SMU must be the same source mode.

- `TIS ERROR 72 Set_sync cannot be used before primary search or sweep setup.`

  The primary sweep port must be set before the secondary sweep port is set.

- `TIS ERROR 73 The secondary sweep port is not set.`

  The secondary sweep port must be set before the secondary sweep array name is specified.

- `TIS ERROR 74 In high voltage state, output relay can't be disconnected.`

- `TIS ERROR 75 In high voltage state, output relay can't be connected.`

  DCS cannot disconnect or connect the output relay when the output voltage is more than 42 V.

- `TIS ERROR 76 Source SMU or VS unit is masked.`

  The specified DCS's module is masked by Ch_sw_off statement. Unmask the module by running the START program or executing the Init_system, Long_cal, or Short_cal subprograms.

- `TIS ERROR 77 TIS cannot be used with this revision.`

  Quasi-pulsed measurements are available for HP 4142B Rev. 4.0 or later.

- `TIS ERROR 80 CMS syntax error. SRQ asserted.`

- `TIS ERROR 81 CMS illegally programmed. SRQ asserted.`

  The CMS received an illegal programming code. Initialize your HP 4062C/UX/PC using the Init_system subprogram.

- `TIS ERROR 82 CMS triggered too fast. SRQ asserted.`

  The CMS received a trigger signal while outputting measurement data from the previous measurement. Make sure that nothing is connected to the CMS's rear panel EXT TRIGGER terminal.

- `TIS ERROR 83 CMS sweep/bias error. SRQ asserted.`

  The BNC shorting cap was removed from the CMS's front panel REMOTE ON/OFF connector. Connect the BNC shorting cap and initialize your HP 4062C/UX/PC using the Init_system subprogram.

- `TIS ERROR 84 CMS output voltage incompatible with set voltage range.`

  The CMS's specified output voltage exceeds the selected voltage range. Decrease the output voltage or increase the voltage range setting.

- `TIS ERROR 85 CMU84 reports an SRQ. Error code is` *xxxx*.

  The CMU84 caused a service request. The *xxxx* is the error code of the CMU84. For the error code, see the *HP 4284A Operation Manual*.

- `TIS ERROR 86 CMU84 Option 001 is not present.`

  In order to force arbitrary voltage by the HP 4284A (CMU84), the HP 4284A must be furnished with Option 001.

- `TIS ERROR 94 Voltage difference between start and stop is less than 10 V.`

The conditions for Set_bdv or Set_ileak are not being met.

For the Set_bdv function, the start and stop values must satisfy the following conditions:

□ Stop $\geq$ start + 10

For the Set_ileak function, the start and stop values must satisfy the following conditions:

□ Start $\leq$ voltage − 10

- `TIS ERROR 95 Measure_bdv can not be used before Set_bdv.`

  You called the Measure_bdv function before setting up the measurement conditions with the Set_bdv function.

- `TIS ERROR 96 Measure_ileak can not be used before Set_ileak.`

  You called the Measure_ileak function before setting up the measurement conditions with the Set_ileak function.

- `TIS ERROR 100 This TIS subprogram is not supported by off-line mode.`

  A TIS subprogram that is not supported by off-line mode is used.

- `TIS ERROR 101 Specified file cannot be opened.`

  The file specified by the Off_line_data subprogram cannot be opened. One of the following may be the cause:

  □ The file does not exist.
  □ The directory pathname is incorrect.

- `TIS ERROR 102 Specified file cannot be opened.`

  The file specified by the Data_creation subprogram cannot be created. One of the following may be the cause:

  □ A file with the same name already exists and is protected.
  □ The directory pathname is incorrect.

- `TIS ERROR 103 Invalid file data is found.`

  While reading the data from the file, invalid data are found. Check for one of the following possible causes:

  □ TIS subprogram name is not proper: The TIS subprogram that is executed in the program is different from the TIS subprogram that is declared in the file, a name that is not TIS subprogram name is detected, or not allowable characters are used.
  □ Measurement data are not proper: data that are not number are detected or not allowable separators are used.
  □ Data that is specified in option parameter does not exist in the file.
  □ During reading the data, the end of file has come.

- `TIS ERROR 200 No test session; TIS is used before START program.`

  TIS subprograms are called before the START program is executed.

- `TIS ERROR 201 Permission denied to access this session.`

  The session that is specified by environment variable PCS_SESSION_ID does not allow accessing. Rerun the START program. If the same error code is displayed, contact your system administrator or nearest HP Service Office.

- `TIS ERROR 202 Session locked.`

  Another process in the same session locks the instruments.

- `TIS ERROR 203 Test session not ready; TIS in used after START failed.`

  TIS subprograms are called after the START program is failed.

- `TIS ERROR 204 Number of session processes exceeds the system limit.`

  More than 11 processes in one session call the TIS subprograms.

- `TIS ERROR 205 No valid HP-IB address; TIS is used after START failed.`

  TIS subprograms are called after the START program is failed.

- `TIS ERROR 220 PCS_SESSION_ID not defined.`
- `TIS ERROR 221 Session identifier too long.`
- `TIS ERROR 222 Failed to attach shared memory.`

  System software is not installed or customized properly. Contact your system administrator or nearest HP Service Office.

- `TIS ERROR 240 Fatal error ( errno =` *xxx* )
- `TIS ERROR 241 Fatal error ( errno =` *xxx* )
- `TIS ERROR 242 Fatal error ( errno =` *xxx* )
- `TIS ERROR 243 Fatal error ( errno =` *xxx* )
- `TIS ERROR 244 Fatal error ( errno =` *xxx* )
- `TIS ERROR 245 Fatal error ( errno =` *xxx* )
- `TIS ERROR 246 Fatal error ( errno =` *xxx* )
- `TIS ERROR 247 Fatal error ( errno =` *xxx* )
- `TIS ERROR 248 Fatal error ( errno =` *xxx* )
- `TIS ERROR 249 Fatal error ( errno =` *xxx* )
- `TIS ERROR 250 Fatal error ( errno =` *xxx* )
- `TIS ERROR 251 Fatal error ( errno =` *xxx* )
- `TIS ERROR 252 Fatal error ( errno =` *xxx* )
- `TIS ERROR 253 Fatal error ( errno =` *xxx* )
- `TIS ERROR 254 Fatal error ( errno =` *xxx* )
- `TIS ERROR 255 Fatal error ( errno =` *xxx* )
- `TIS ERROR 246 Fatal error ( errno =` *xxx* )
- `TIS ERROR 247 Fatal error ( errno =` *xxx* )
- `TIS ERROR 248 Fatal error ( errno =` *xxx* )
- `TIS ERROR 249 Fatal error ( errno =` *xxx* )
- `TIS ERROR 250 Fatal error ( errno =` *xxx* )
- `TIS ERROR 251 Fatal error ( errno =` *xxx* )

- TIS ERROR 252 Fatal error ( errno = *xxx* )
- TIS ERROR 253 Fatal error ( errno = *xxx* )
- TIS ERROR 254 Fatal error ( errno = *xxx* )
- TIS ERROR 255 Fatal error ( errno = *xxx* )
- TIS ERROR 256 Fatal error ( errno = *xxx* )
- TIS ERROR 257 Fatal error ( errno = *xxx* )
- TIS ERROR 258 Fatal error ( errno = *xxx* )
- TIS ERROR 259 Fatal error ( errno = *xxx* )
- TIS ERROR 260 Fatal error ( errno = *xxx* )
- TIS ERROR 261 Fatal error ( errno = *xxx* )
- TIS ERROR 262 Fatal error ( errno = *xxx* )
- TIS ERROR 263 Fatal error ( errno = *xxx* )
- TIS ERROR 264 Fatal error ( errno = *xxx* )
- TIS ERROR 265 Fatal error ( errno = *xxx* )
- TIS ERROR 266 Fatal error ( errno = *xxx* )
- TIS ERROR 267 Fatal error ( errno = *xxx* )
- TIS ERROR 268 Fatal error ( errno = *xxx* )
- TIS ERROR 269 Fatal error ( errno = *xxx* )

A fatal system error occurred. The *xxx* above is the system call's error code. Contact your system administrator or nearest HP Service Office.

## PGMLIB Errors

This section lists errors related to the DCS Program Memory Library (PGMLIB). You need to use the error handling facilities of the C Library and the HP 4062UX to see the PGMLIB error numbers and messages.

- `PGMLIB ERROR 1 Pgm_start is not declared.`

  DCS Program Library functions, such Pgm_force_v, are used before the Pgm_start function.

- `PGMLIB ERROR 2 Pgm_start is nested.`

  Pgm_start is called twice before the first Pgm_start is ended by a Pgm_end function.

- `PGMLIB ERROR 20 Device not present.`

  The DCS is not on line; that is, it is not recognized by the START program.

- `PGMLIB ERROR 21 Invalid port assigned.`

  An invalid port address or a unit address is specified to the function. Note that a SWM pin number is not accepted as the unit specifier for the PGMLIB functions.

- `PGMLIB ERROR 24 Improper pass parameter specified.`

  The parameter value passed is incompatible with the corresponding range restrictions.

- `PGMLIB ERROR 100 Error in Pcs_hpib_open.`
- `PGMLIB ERROR 101 Error in Pcs_hpib_output.`
- `PGMLIB ERROR 102 Error in Pcs_hpib_enter.`
- `PGMLIB ERROR 103 Error in Pcs_hpib_clear.`
- `PGMLIB ERROR 104 Error in Pcs_hpib_spoll.`

  The PGMLIB functions failed to operate on the HP-IB. Check the connection of the HP-IB.

## VFP Errors

This section lists errors related to your HP 4062C/UX/PC's VFP function.

- `WARNING 1 SWM open`

  SWM output is disabled. This may occur if you're using a wafer prober and your SWM is not mounted properly on the prober; if the Test Fixture Adapter is mounted on SWM but its cover is not closed; or if there is nothing mounted on the SWM.

- `WARNING 2 DCS shutdown`

  DCS output is disabled because of a momentary power loss or because voltage or current in excess of an SMU's maximum current or voltage is applied to an SMU. Initialize your HP 4062C/UX/PC using the Init_system subprogram.

- `WARNING 3 DCS not interlocked`

  The interconnect cable assembly is disconnected and an attempt was made to output voltage in excess of ±42 V. Connect the cable assembly.

- `VFP ERROR 1 Improper cursor position`

  The cursor is not positioned correctly for the parameter being set, or you pressed the wrong key when changing a parameter. This error occurs under the following circumstances:

  - If you select the `[ ]` softkey when the cursor is *not* positioned in a `[ ]` field.
  - If you press a numeric key or the space bar when the cursor is positioned in a `[ ]` field.
  - If you select the `[ ]`, `EXECUTE ON / OFF`, or `MEAS / NOT MEAS` softkey when the cursor is positioned in the PIN CONNECTION area.
  - If you rotate the keyboard's rotary knob when output is enabled (EXEC mode) and the cursor is *not* positioned in an output value field.

  Note that you *cannot* change the cursor's position when the EXEC mode is enabled.

- `VFP ERROR 2 Illegal value`

  A value exceeding a parameter's specified limits was entered.

- `VFP ERROR 3 Not allowed while OFF status`

  While in the EXEC mode, an attempt was made to sweep the output of a source device (an SMU, a VS, or the CMS's internal dc bias source) that was set to Off. Set the source device to On by exiting from the EXEC mode and selecting the `EXECUTE ON / OFF` softkey.

- `VFP ERROR 4 Not allowed while ON status`

  An attempt was made to change the voltage range or compliance setting of a source device (an SMU or the CMS's internal dc bias source) that was set to On. Set the source device to Off by selecting the `EXECUTE ON / OFF` softkey before changing parameters.

- `VFP ERROR 5 Not allowed in EXEC mode`

  While in the EXEC mode, an attempt was made to change a control setting, or you pressed a key or selected a softkey other than the `EXECUTE ON / OFF` softkey.

- `VFP ERROR 6 Return (or Enter) key was not pressed`

A parameter is set or a control setting is changed, but not entered, because you did not press Return or Enter.

- `VFP ERROR 7 DCS output voltage incompatible with set voltage range`

  An SMU's specified output voltage exceeds the selected voltage range. Decrease the output voltage or increase the voltage range setting.

- `VFP ERROR 8 SMU voltage compliance incompatible with set current value`

  The product of an SMU's compliance setting multiplied by the SMU's specified output value exceeds the SMU's maximum power. Decrease either the compliance setting or the specified output value.

- `VFP ERROR 9 SMU current compliance incompatible with set voltage value`

  An SMU's specified current compliance setting is too high for the selected voltage range. Decrease the current compliance setting or increase the voltage range setting.

- `VFP ERROR 10 CMS output voltage incompatible with set voltage range`

  The CMS's specified output voltage exceeds the selected dc bias range. Decrease the output voltage or increase the voltage range setting.

- `VFP ERROR 11 Illegal key`

  A key other than a VFP control key was pressed.

- `VFP ERROR 12 DCS not present`

  The DCS was not registered during START (displayed as Not Present) and an attempt was made to operate the DCS. Make sure the DCS is turned on and the HP-IB cable is connected. Rerun the START program.

- `VFP ERROR 13 CMS not present`

  The CMS was not registered during START (displayed as Not Present) and an attempt was made to operate the CMS. Make sure the CMS is turned on and the HP-IB cable is connected. Rerun the START program.

- `VFP ERROR 14 SWM not present`

  The SWM was not registered during START (displayed as Not Present) and an attempt was made to operate the SWM. Make sure the SWC is turned on and the HP-IB cable is connected. Rerun the START program.

- `VFP ERROR 15 Pin board not present`

  A pin board not registered during START (pin number not displayed) is specified. Check for proper pin board configuration and installation. If you rearranged pin boards, make sure they are properly installed and that the control bus cable is connected. Rerun the START program.

- `VFP ERROR 16 System is already locked, not allowed to enter Control mode.`

  The `Lock & Control` softkey is selected while another process locks the instruments.

## PPG Errors

This section lists errors related to your HP 4062C/UX/PC's PPG.

- `PPG ERROR 1 Printer timeout.`

  A printer is not connected, or the HP-IB address of the printer is not set to 1. Make sure a printer is connected and that its HP-IB address is 1.

- `PPG ERROR 6 File name is not specified.`

  The file name is not specified when you save the probing pattern data.

- `PPG ERROR 7 Duplicate file name. Overwrite or Abort ("O", "o": others) ?`

  The specified file name already exists in the directory when you save the probing pattern data.

- `PPG ERROR 8 Max. module number is too large.`

  The maximum module number exceeds the allowable limits because the specified module size is too small. Re-enter the appropriate module size.

- `PPG ERROR 11 Chip size > Wafer size`

  The specified chip size is too large for the specified wafer size. Re-enter the appropriate chip size.

- `PPG ERROR 12 Number of chips is too large ( MAX X=255 Y=255 )`

  The calculated number of chips exceeds the allowable limits (max. 255 for the X-coordinate; 255 for the Y-coordinate) because the specified chip size is too small. Re-enter the appropriate chip size.

- `PPG ERROR 13 Module size * Module number > Chip size`

  The module size multiplied by the module number exceeds the specified chip size. The specified module size is too large or the chip size is too small. Re-enter the appropriate module or chip size.

- `PPG ERROR 14 Module size > Chip size`

  The module size exceeds the specified chip size. The specified module size is too large or the chip size is too small. Re-enter the appropriate module or chip size.

- `PPG ERROR 15 Probing sequence number must be 1 to 6`

  The probing sequence number exceeds the allowable limits. The probing sequence number must be 1 through 6. Re-enter the appropriate probing sequence number.

- `PPG ERROR 16 Wafer size must be 0.1 to 99.99999 inches`

  The wafer size exceeds the allowable limits. The wafer size must be 0.1 through 99.99999 inches. Re-enter the appropriate wafer size.

- `PPG ERROR 17 Chip X-Y size must be 1 to 99999 microns.`

  The X- or Y- chip size exceeds the allowable limits. The X- and Y- chip size must be 1 through 99999 microns. Re-enter the appropriate chip size.

- `PPG ERROR 18 Module X-Y size must be 1 to 99999 microns.`

The X- or Y- module size exceeds the allowable limits. The X- and Y- module size must be 1 to 99999 microns. Re-enter the appropriate module size.

- `PPG ERROR 19 Number of X-Y modules must be 1 to 6.`

  The X- or Y- module number exceeds the allowable limits. The X- and Y- module number must be 1 through 6. Re-enter the appropriate module number.

- `PPG ERROR 21 Illegal input`

  An attempt was made to enter a value that exceeds the specified limits.

- `PPG ERROR 22 No modules have been selected`

  No modules are selected. You must select at least one module. To select modules individually, place the cursor at the desired module and select the `SELECT` softkey. To select all modules, select the `SELECT ALL` softkey.

- `PPG ERROR 26 Number of selected chips is too large. (MAX 32760)`

  The calculated number of chips exceeds the allowable limits (max. 32760) because the specified chip size is too small. Re-enter the appropriate chip size.

- `PPG ERROR 27 No chips have been selected`

  No chips are selected. You must select at least one chip. To select chips individually, place the cursor at the desired chip and select the `SELECT` softkey. To select all chips, select the `SELECT ALL` softkey.

- `PPG ERROR 28 X or Y (No.` *xxx*`) not set. Enter missing value, or delete (no.` *xxx*`).`

  The X- or Y- coordinate is not entered. The *xxx* above is the module number. Enter the appropriate coordinate or delete it.

- `PPG ERROR 31 Wget is not declared`

  The Wget subprogram is not included in your measurement program, or is placed out of sequence. The Wget subprogram must precede the Wstart_number or Wstart_xy subprogram.

- `PPG ERROR 32 Improper number of pass parameters specified`

  Only one coordinate (X- or Y-) is specified in the Wstart_xy subprogram. You must specify both X- and Y-coordinates.

- `PPG ERROR 33 Wstart_xy or Wstart_number is not declared`

  The Wstart_number or Wstart_xy subprogram is not included in your measurement program, or did not precede a Wmove_next, Wmove_number, or Wmove_xy subprogram.

- `PPG ERROR 34 Illegal chip coordinate`

  The X- and Y-chip coordinates specified in the Wmove_xy subprogram designate a non-existent chip.

- `PPG ERROR 35 CHIP not registered`

  A chip not registered during the WAFER configuration stage is specified in a Wmove_number or Wmove_xy subprogram. Execute PPG and register the chip, or delete all references to the chip in your Wmove_number or Wmove_xy subprogram.

- `PPG ERROR 36 MODULE not registered`

A module not registered during the CHIP configuration stage is specified in a Wmove_number or Wmove_xy subprogram. Execute PPG and register the chip, or delete all references to the chip in your Wmove_number or Wmove_xy subprogram.

- `PPG ERROR 41 Illegal VAR NAME ( no VAR NAME in DATA file )`

  A VAR NAME not listed in the data file is specified.

- `PPG ERROR 42 Illegal LIMIT value`

  One or all of the wafer map LIMIT values is specified out of sequence. For example, the uppermost LIMIT value must be $\geq$ the second LIMIT value; the second LIMIT value must be $\geq$ the third LIMIT value, and so on.

- `PPG ERROR 43 Illegal COORDINATE value`

  The X- or Y-axis of the wafer map is improperly scaled. For example, the X-axis minimum value is greater than the X-axis maximum value.

- `PPG ERROR 44 Illegal input ( MAX COLUMN=xx  ROW=yy )`

  The value specified for the X- or Y-axis of the wafer map exceeds the allowable limit (max. xx for the X- [COLUMN] axis, yy for the Y- [ROW] axis).

- `PPG ERROR 71 Illegal DATA file ( MIN Nv=3 )`

  The minimum number of variables (Nv) required for generation of a wafer map is not specified in the data file. At least three (3) variables must be specified (COLUMN, ROW, and measurement data).

- `PPG ERROR 72 Illegal DATA file ( Vn$(1)="COLUMN"  Vn$(2)="ROW" )`

  Illegal string variable is specified. VN$(1) must be "COLUMN" and VN$(2) must be "ROW."

- `PPG ERROR 73 Illegal DATA NAME in SUB Wput_data or SUB Wput_array`

  Null data (" ") is specified as the string variable (DATA NAME) in a SUB Wput_array or SUB Wput_data subprogram.

- `PPG ERROR 74 DATA NAME overflow`

  The number of characters specified in the data file name exceeds the allowable limit (max. 50 characters).

- `PPG ERROR 75 DATA number overflow`

  The number of data file variables multiplied by the number of chips exceeds the allowable limit (max. 1500).

---

**Note**

BASIC/UX Language System errors occurring in PPG are displayed between two graphics arrows, as in the following example:

```
====> ERROR 53 IN 1950 Improper file name <====
```

For details on BASIC/UX errors, refer to the *BASIC* or *BASIC/UX Language Reference Manual*.

---

## Diagnostics (DIAG) Errors

This section lists errors related to the HP 4062C/UX/PC's DIAG software.

- `DIAG. ERROR 10 Switching Matrix not ready.`

  The SWC is not turned on, or the HP-IB cable is not connected (SWC displayed as Not Present during START). Stop the program, check the power and the HP-IB cable, and select the `RUN` softkey.

- `DIAG. ERROR 11` (Switching Matrix error)

  A relay failure is detected in the SWM. The displayed error message indicates the failure location. Make sure the Relay Test Adapter is installed securely on the SWM, and select the `RETRY` softkey.

  If the same error occurs at the same location, contact your nearest HP Service Office. If emergency repair is necessary, replace the defective pin board. See the *System Information* manual for details on replacing pin boards.

  If a DIAG. ERROR 11 followed by the message `A relay is stuck ...` is displayed, you may be able to repair the relay itself. See the *System Information* manual for details.

  Whenever a relay failure occurs, repair or remove the faulty pin board and rerun the relay test to check for additional failures.

- `DIAG. ERROR 12 Leakage in Switching Matrix.`

  Excessive leakage current is detected in the SWM, or in the cabling to the SWM. Contact your nearest HP Service Office.

- `DIAG. ERROR 13 Leakage in Switching Matrix.`

  Excessive leakage current is detected on a pin board. If a test fixture is mounted in the Test Fixture Adapter, remove the fixture and select the `RETRY` softkey. If the same error occurs, contact your nearest HP Service Office.

- `DIAG. ERROR 14 Some pin boards are not installed.`

  Pin boards required for DIAG program are not installed.

- `DIAG. ERROR 19 Block` *x* `Input Relay K`*yz* `test failed.`

  An Input Relay failure is detected in the SWM. The displayed error message indicates the failure location. Make sure the Relay Test Adapter is installed securely on the SWM, and select the `RETRY` softkey. If the same error occurs at the same location, contact your nearest HP Service Office.

- `DIAG. ERROR 20 DC Source/Monitor not ready.`

  The DCS is not turned on, its HP-IB cable is not connected (DCS displayed as Not Present during START), or a plug-in module required for a test's execution is not present or is not connected to the SWM. Stop the program, check these items, and select the `RUN` softkey.

- `DIAG. ERROR 21 DC Source/Monitor failed SELF TEST.`

  An SMU failure is detected during the DCS's self-test. Contact your nearest HP Service Office.

- `DIAG. ERROR 22 I-V measurement test failed.`

- DIAG. ERROR 23 I-V measurement test failed.
- DIAG. ERROR 24 I-V measurement test failed.
- DIAG. ERROR 25 I-V measurement test failed.

  An SMU failure is detected. If the relay test has not yet been performed, run the relay test, then retry the SMU test. If the same error occurs, contact your nearest HP Service Office. If emergency repair is necessary, replace the defective SMU plug-in module. See the *System Information* for details.

- DIAG. ERROR 26 VS$x$ and VS$y$ are not connected.
- DIAG. ERROR 26 VS$x$ is not connected.

  Where $x$ and $y$ are integers from 1 to 16, and $x$ is a lower integer than $y$. If the first error occurs, connect VS$x$ to the AUX1 port, VS$y$ to the AUX2 port, and perform the VS Test again. If the second error occurs, connect VS$x$ to the AUX1 port, and perform the VS Test again.

- DIAG. ERROR 27 Voltage output test failed.

  A VS failure is detected. Contact your nearest HP Service Office.

- DIAG. ERROR 28 VM$x$ and VM$y$ are not connected.
- DIAG. ERROR 28 VM$x$ is not connected.

  Where $x$ and $y$ are integers from 1 to 16, and $x$ is a lower integer than $y$. If the first error occurs, connect VM$x$ to the AUX1 port, VM$y$ to the AUX2 port, and perform the VM Test again. If the second error occurs, connect VM$x$ to the AUX1 port, and perform the VM Test again.

- DIAG. ERROR 29 Voltage measurement test failed.

  A VM failure is detected. Contact your nearest HP Service Office.

- DIAG. ERROR 30 C Meter/C-V Plotter not ready.

  The CMU is not turned on, its HP-IB cable is not connected (CMU displayed as Not Present during START), or it is not connected to the SWM. Stop the program, check the CMU's power, HP-IB cable, and SWM interconnection cables, and select the RUN softkey.

- DIAG. ERROR 31 C Meter/C-V Plotter failed SELF TEST.

  The CMU failed its self-test. Contact your nearest HP Service Office.

- DIAG. ERROR 32 C-G measurement test failed.

  A CMU or CMU84 measurement circuit failure is detected. Contact your nearest HP Service Office.

- DIAG. ERROR 33 Stray capacitance too high.

  Stray capacitance in the SWM or the CMH or CML cable exceeds 10 pF. Contact your nearest HP Service Office.

- DIAG. ERROR 34 Bias output test failed.

  A CMU and CMU84 internal dc bias source failure is detected. Contact your nearest HP Service Office.

- DIAG. ERROR 35 Rear panel short-cap disconnected.

A BNC shorting cap is not connected to the CMU's rear panel EXT. BIAS-SLOW connector.

- `DIAG. ERROR 36 Analog Feedback Unit test failed.`

  A failure is detected in the AFU of the DCS. If this error occurs when all SMUs are functioning normally, contact your nearest HP Service Office.

- `DIAG. ERROR 40` (CMU84 not ready)

  The CMU84 is not turned on, its HP-IB cable is not connected (CMU84 displayed as `Not present` during START), or it is not connected to the SWM. Stop the program, check the CMU84's power, HP-IB cable, and SWM interconnection cables, and select the `RUN` softkey.

- `DIAG. ERROR 45 Port Expander Relay K`*xx* *yyy* `side test failed.`

  DIAG program detected an malfunctioning Port Expander relay K*xx* (where *xx* is one of the relay number). The *yyy* in the above message should be replaced by either `force` or `guard`.

## DVR4284 Errors (Rev. 5.6 or 5.7 only)

This section lists errors related to your system's DVR4284 subprograms.

- `DVR4284 ERROR 1 HP 4284A driver is not initialized yet.`

  The START program has not been run or the COM blocks are lost. Run the START program.

- `DVR4284 ERROR 2 HP 4284A caused an SRQ. Error code is` *zzzzz*.

  A hardware failure occurred. The *zzzzz* above is the CMU84's error code. Refer to the HP 4284A's *Operation Manual*.

- `DVR4284 ERROR 3 Improper Switching Matrix Model.`

  An unexpected error occurred. Contact your system administrator or nearest HP Service Office.

- `DVR4284 ERROR 4 HP 4284A is not present.`

  The CMU84 was not present during START (displayed as Not present) or the COM blocks are lost. Check the connection between the CMU84 and rerun the START program.

- `DVR4284 ERROR 5 Improper Switching Matrix connection.`

  Check your cabling configuration and rerun the START program.

- `DVR4284 ERROR 6 Option #001 is missing.`

  CMU84 is not installed Option 001 Power Amplifier/DC Bias. In this case,

  You can not use Set_cv84 and Sweep_cv84 subprograms.

  The test signal level is limited to 5 mV to 2 V.

  The internal dc bias is fixed to 0 V, 1.5 V, or 2 V.

- `DVR4284 ERROR 7 Improper Integration Time parameter.`

  In the Set_cmu84, the specified measurement integration time value is invalid.

- `DVR4284 ERROR 8 Improper Averaging Time parameter.`

- `DVR4284 ERROR 9 Improper Mode parameter.`

  An unexpected error occurred. Contact your system administrator or nearest HP Service Office.

- `DVR4284 ERROR 10 Improper Signal Level parameter.`

  In Set_cmu84, the specified test signal level value is invalid.

- `DVR4284 ERROR 11 Improper DC Bias parameter.`

  In Force_v84, the specified internal dc bias source value is invalid.

- `DVR4284 ERROR 12 Improper Measurement Function parameter.`

  An unexpected error occurred. Contact your system administrator or nearest HP Service Office.

- `DVR4284 ERROR 13 Improper Frequency parameter.`

  In Frequency84, the specified measurement frequency value is invalid.

- `DVR4284 ERROR 14 Improper Hold/Delay Time parameter.`

  In Set_cv84, the specified hold time or delay time value for the C·G-v sweep measurements is invalid.

- `DVR4284 ERROR 15 Improper Sweep Step parameter.`

  In Set_cv84, the specified number of steps value for the C·G-V sweep measurement is invalid.

- `DVR4284 ERROR 16 Improper Sweep Bias parameter.`

  In Set_cv84, the specified start voltage or stop voltage value is invalid.

## BASIC or BASIC/UX Language System Errors

This section lists several of the more common errors related to the BASIC or BASIC/UX language system. For more details, refer to the *BASIC* or *BASIC/UX Language Reference Manual*.

- `ERROR 5`

  Improper context terminator. You forgot to put an END statement in the program. Also applies to SUBEND and FNEND.

- `ERROR 7`

  Undefined function or subprogram. An attempt was made to call a SUB or user-defined function that is not in memory. Look out for program lines that assume an optional CALL.

- `ERROR 8`

  Improper parameter matching. A type mismatch between a pass parameter and a formal parameter of a subprogram. See *Programming Reference* for parameter types.

- `ERROR 9`

  Improper number of parameters. Passing either too few or too many parameters to a subprogram. Applies only to non-optional parameters. See *Programming Reference* for details on the number of parameters.

- `ERROR 53`

  Improper file name. File names are limited to 10 characters. Foreign characters are allowed, but punctuation is not.

- `ERROR 56`

  File name is undefined. The specified file name does not exist in the directory. Check your disk's contents using the CAT command.

- `ERROR 145`

  May not build COM at this time. An attempt was made to add or change COM while a program was running. For example, a program does a LOADSUB, and the COM in the new subprogram does not match the existing COM. Rerun the START program.

- `ERROR 392`

- `ERROR 499`

  See TIS Errors.

- `ERROR 902`

  Must delete entire context. An attempt was made to delete a SUB or DEF FN statement without deleting its entire context. Easiest way to delete is with DELSUB.

# B

# Before Requesting Repair

If your HP 4062C/UX is not working properly, check the items covered in this appendix before you request repairs.

If, after checking these items, your HP 4062UX is still not working properly, contact the nearest HP service office and provide the following information about your system:

- Model Number and Name
- Serial Number
- Trouble Conditions (in detail)

## General

- The system does not turn on.

  Check all power cables, circuit breakers, and fuses.
- The system controller's display is blank, or displays nothing.

  Check the display's intensity control.

  Check the display's interconnection cables.

  Check for correct voltage switch settings.

## Switching Matrix Subsystem Troubles

- All LEDs on the SWC's front panel light several times after turning the system on.

  Check for correct voltage switch settings.
- All LEDs on the SWC's front panel light while using the system.

  Initialize the SWC by turning it off, waiting at least 1 second, and turning it back on again.
- The SWITCHING MATRIX FAIL indicator lights after turning the system on.

  Check the interconnection cable between the SWC and the SWM.
- The SWITCHING MATRIX CONTROLLER FAIL indicator lights after turning the system on.

  Check the HP-IB address switch setting to make sure it is not set to over 30.

## DC Subsystem Troubles

- All LEDs on the DCS's front panel light several times after turning the system on.

  Check for correct voltage switch settings.

- Measurement values are uneven, even though the INTEG TIME is set to LONG.

  Check to make sure the DCS's rear panel filter switch setting matches the line frequency.

  Check for noise generated by peripheral instruments.

## Capacitance Measurement Unit Troubles

- Err 41, 51, or 71 are displayed when performing the CMU's self-test.

  Disconnect the interconnect cable from the CMU's UNKNOWN terminals.

- DC bias voltage is not applied.

  Check to make sure a BNC shorting cap is connected to the CMU's EXT SLOW BIAS terminal.

- The measurement value displayed on the CMU's front panel and the measurement value obtained by VFP or TIS differ.

  This is because the value obtained by VFP or TIS is error-compensated for by the software. This is not an error.

# C

# Manual Backdates

HP 4062C/UX/PCs may vary slightly, depending on the revision of the system software. The information in this manual applies directly to HP 4062C/UX/PC system software revision 6.2 and above. This appendix contains information for customizing this manual, so that all the information pertains to the HP 4062C/UX/PC that you are using.

**Table C-1. Manual Backdating by Software Revision**

| Software Revision | Make Manual Backdates |
|---|---|
| Rev. C.06.00 and X.06.00 | 1 |
| Rev. C.05.60 and X.05.60 | 1, 2 |

- BACKDATE 1
  - All pages
    1. Delete all descriptions about HP 4062PC.
    2. Delete all descriptions about the emergency off switch.

■ BACKDATE 2

□ All pages

1. Change HP 4089B 96-pin Switching Matrix to HP 4089A 96-pin Switching Matrix.
2. Delete all descriptions about the port expander.

□ "Configuration" in Chapter 1

Change the note as follows:

**Note**

In addition, the HP 4062C requires a VFP Timer Board. When the CMU84 or LCR exists in the HP 4062C, it is connected to the HP-IB interface with a select code of 7.

□ "Specifications" in Chapter 1

1. Delete the "SMUs on Port Expander: 2 ports" in Chapter 1.
2. Change the specification tables for VM1 and VM2 in "Auxiliary (AUX): 4 ports (optionally 10 ports)" in Chapter 1 as follows:

**VM Input Range, Resolution, and Accuracy (Grounded Measurements)**

| V Range Full Scale | Resolution | Accuracy |
|---|---|---|
| ±2 V | 40 μV | ±(0.05% of reading + 1.1 mV) |
| ±20 V | 400 μV | ±(0.05% of reading + 10 mV) |
| ±40 V | 800 μV | ±(0.05% of reading + 20 mV) |

**VM Input Range, Resolution, and Accuracy (Differential Measurements)**

| V Range Full Scale | Resolution | Accuracy (Vi = VM2 Input V) | Max. Common Voltage |
|---|---|---|---|
| ±0.2 V | 4 μV | ±(0.2% of reading + 0.5 mV + 2.5 μV×Vi) | 40 V |
| ±2 V | 40 μV | ±(0.1% of reading + 2.1 mV + 25 μV×Vi) | 40 V |

□ "DCS Program Memory" in Chapter 2

Delete this section.