HEWLETT PACKARD

PCInstruments

Owner's Guide

HP 61011A Relay Multiplexer

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Printing History

New editions of this manual will incorporate all material since the previous edition. Update packages, which may be issued between editions, contain replacement and additional pages to be merged into the manual by the user.

The manual printing date and part number indicate its current edition. The printing date changes when a new edition is printed. (Minor corrections and updates which are incorporated at reprint do not cause the date to change.)

The instrument prefix number alongside the date refers to the first part of the serial number on the bottom of the instrument. This number indicates the version of the instrument that was available at the time that this manual was issued. However, note that, many instrument updates 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 instrument changes and manual updates.

Edition 1.... April 1985....Instrument Prefix 2507A

Safety Summary

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

Ground the Instrument

To avoid potentially hazardous electrical shock, establish a safety ground before connecting user's circuits. Connect the output cable from the Power Pack to the Relay Multiplexer, and then connect the line cord from the Power Pack to the ac line. Detailed instructions are in the HP PC Instruments System Owner's Manual.

Do Not Exceed Input Ratings

Excessive input voltage and current will damage this instrument. Do not exceed 250 V dc, 250 V ac rms, or 350 V ac pk between inputs or from any terminal to ground. Do not exceed 1 A per input. If your equipment is capable of delivering more than 1 A, an external 1 A fuse should be used to prevent accidental damage to the instrument.

Prevent Shorted Inputs

To prevent shorted inputs, do not strip wires back more than 0.2 in.(5 mm). Insert wires fully into connectors. Only use wire gauge between AWG 14 to AWG 28 (1.5 to 0.5 mm^2). Only use the form and type of connector originally supplied with this equipment.

Ensure Equipment Status

This instrument is used under user's program control. Equipment failure, power failure, or program error may result in a hazardous situation. Any application requiring a failsafe method of ensuring equipment status must be provided by the installer. This includes devices such as

interlocks, thermostats, limit switches, or overpressure or overspeed sensors.

Safety Symbols

Instruction manual symbol: the product will be marked with this symbol when it is necessary for you to refer to the manual (see What's in this Manual?)

Indicates measuring earth (ground) terminal.

WARNING

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

CAUTION

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

What's in this Manual?

This manual is a supplement to the HP PC Instruments System Owner's Manual. It contains specific information about your HP PC Instruments Relay Multiplexer, Model 61011A. **You must read the System Owner's Manual before you read this manual.** Warranty and service information is included in the Support Guide in front of your System Owner's Manual.

The System Owner's Manual discusses information that is common to all HP PC Instruments. It also contains specific information about your computer and HP PC Instruments System. If you are a first time user, refer to Table 3 in your System Owner's Manual for the proper reading sequence of your computer and PC Instruments manuals. If you are an experienced user and already have an installed system, you need only read this manual to learn how to operate and program your Relay Multiplexer.

Please insert this manual in the same hardcover binder as your System Owner's Manual. Here is a brief description of the contents of each Chapter in this manual:

Chapter 1 - Product Description
Briefly describes the Relay Multiplexer, gives it's specifications, and lists the items that you receive with it.

Chapter 2 - Trying Out Your Instrument
Gives simple step-by-step instructions that let you quickly perform some operations with nothing connected to the front panel.

Chapter 3 - Manual Instrument Control
Gives detailed operating information not covered in the simplified instructions of Chapter 2.

Chapter 4 - Front Panel Connections
Explains how to connect the Relay Multiplexer to your application.

Chapter 5 - Programming With BASIC
Describes how to control the Relay Multiplexer with a program. All programming statements for the Relay Multiplexer are explained. A simple programming example is included along with a procedure for thermocouple temperature measurements.

Appendix A - Programming Statmeent Summary
Lists all programmings statements that apply to the Relay Multiplexer.

Appendix B - Verification Procedures
Describes verification procedures that you can use to verify the proper operation of the Relay Multiplexer if your suspect an instrument malfunction.

Appendix C - Error Message
Lists all error messages that apply to the Relay Multiplexer.

Appnedix D - Thermocouple Conversion Coefficients
Lists the conversion coefficients for several types of themocouples.

1 Product Description

Introducing the HP PC Instruments Relay Multiplexer

The HP PC Instruments Relay Multiplexer consists of an eight-input multiplexer with a temperature reference for thermocouple applications. Because the inputs on the front of your Relay Multiplexer are bi-directional, the instrument can also be used as a demultiplexer. The Relay Multiplexer is controlled by a computer equipped with HP PC Instruments software and an interface card. The System Owner's Manual tells you all you need to know about the required software and interface card for your computer. Chapters 2 and 3 of this manual explain how to operate the Relay Multiplexer "manually" using the Soft Front Panel (computer display) while Chapter 5 describes programming statements you can use to control it from BASIC.

Multiplexing is generally used when several sources must be switched to a single destination one at a time. The inputs are selected by the Relay Multiplexer and switched to the common output either sequentially or randomly. An example of multiplexing might be when measuring eight different voltage sources. Each voltage source would be connected to an associated input, and the common output would be connected to a digital voltmeter. When used as a demultiplexer, a source such as a dc voltage can be connected to the common output, to subsequently be switched to one of eight different loads. In this case, the inputs are connected to the loads.

The Relay Multiplexer has eight inputs consisting of a set of two relay contacts (double pole-single throw) each. Figure 1-1 shows the details of one of these eight inputs. Multiple relay closures cannot occur; only one input can be switched to the common output at a time. The instrument must also be enabled before any relay closures can occur.

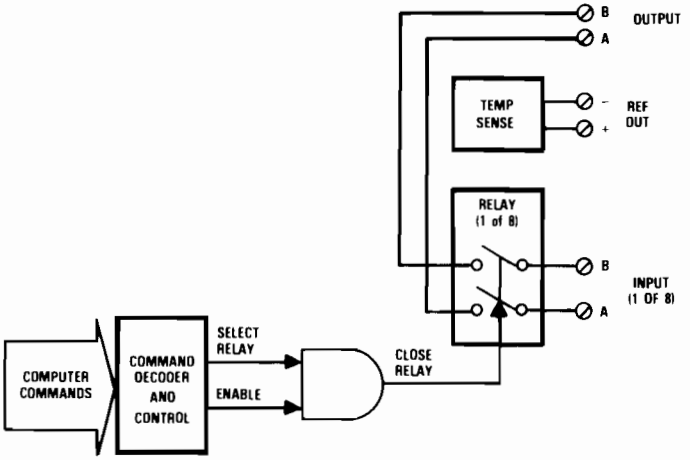

Figure 1-1. Relay Multiplexer Block Diagram

Your Relay Multiplexer can be used with a digital multimeter for compensated thermocouple temperature measurements. An internal sensor on the Relay Multiplexer monitors and converts the temperature at the terminal block, which is where the thermocouple wires are connected, to a reference voltage that appears at the REF OUT terminals on the front of the instrument. This reference voltage is always present on the REF OUT terminals whenever the Relay Multiplexer is plugged in. The REF OUT characteristics are given in Table 1-1.

By connecting a digital multimeter to the REF OUT terminals, you can determine the temperature of the terminal block. Once you know the temperature of the terminal block, you can calculate a thermocouple reference voltage. This thermocouple reference voltage must be added to the voltage that you measure from the thermocouple itself. Only by adding these two voltages together, will you obtain the actual voltage at the sensing junction of the thermocouple. Converting this resultant voltage to a temperature in Celsius will result in an

accurate thermocouple temperature measurement. Chapter 4 in this manual explains how to connect the thermocouple wires and an external digital multimeter to the front of your instrument. Chapter 5 gives the procedure for making accurate temperature measurements from thermocouples.

Items Supplied

In addition to this manual, check that you have received the following items with your Relay Multiplexer:

Power Pack - an ac power transformer with an attached one metre cable. The transformer type was determined by country of destination. Chapter 2 of the System Owner's Manual lists the different types and their part numbers.

Power Cord - connects the Power Pack to an ac source. Plug type was determined by the country of destination. Chapter 2 of the System Owner's Manual lists types and part numbers.

Instrument Interconnect Cable ( ) - connects your instruments to the interface. Refer to Chapter 2 of the System Owner's Manual.

Plug-In Terminal Block ( ) - used to make your application connections to the Relay Multiplexer.

Banana Plug Adapter (2) ( ) - used to connect an instrument with banana plug leads, such as a digital multimeter, to the output screw terminals.

Update Pages - if applicable, update pages are included. Replace the obsolete pages with the new ones before you use this manual.

Table 1-1. Specifications

User Connections:
8 double-ended inputs
1 reference voltage output
1 double-ended output

Input Select Time:
<65 ms (using an OUTPUT statement; includes break-before-make):

Switching Characteristics:
Max. voltage = 250 V dc; 250 V ac rms; 350 V ac pk
Max. current = 1 A dc; 1 A ac rms
(per input or instrument)
Max. power = 50 W dc; 250 VA ac
(per input or instrument)

Resistance:
<1 ohm typical (input to output)

Thermal Offset:
<6μV max. (input to output)

Isolation Voltage Rating:
250 V dc; 250 V ac rms; 350 V ac pk
(between inputs or inputs to ⊥)

DC Isolation Resistance:
$2x10^8$ ohms @ 40°C, 80% rh
(input to input or input to ⊥)

AC Characteristics (50 ohm termination):

	100 kHz	1 MHz	10 MHz
Crosstalk (input to input)	< −73 dB	< −53 dB	< −33 dB
Feedthrough (input to output)	< −73 dB	< −53 dB	< −33 dB
Insertion loss (input to output)	< 0.2 dB	< 0.3 dB	< 0.5 dB

Table 1-1. Specifications (continued)

Capacitance
Open input; input to input <5pF
Closed input < 25pF
Input to ⊥ < 50pF

Operating Temperature Range:
0°C to 40°C

Storage Temperature Range:
−40°C to +80°C

Reference Output Characteristics:
Compensation accuracy = ±2°C (from 2°C to 40°C with 1 hour stabilization period)

REF OUT coefficient = +10 mV/°C (25°C = 0.25 V)

Dimensions:
Length = 295 mm (11.62 in.)
Width = 212 mm (8.35 in.)
Height = 64.5 mm (2.54 in.)

Weight:
0.95 kg (2.09 lbs.)

Factory Defaults:
Label = RELAY.MUX.01 (RELAY.MUX.02 for the second instrument)
Inputs = no input selected
Output = disabled

2 Trying Out Your Instrument

Introduction

The following step-by-step procedure allows you to perform some simple instrument operations. This procedure is especially suitable for first time users who want to quickly become familiar with the basic operation of the Relay Multiplexer. Chapter 3 contains additional operating information that you can use once you have learned the basics in this Chapter.

The Procedure

Trying out your instrument consists of pointing to and selecting various interactive fields on the Soft Front Panel. Before you try out your Relay Multiplexer, you should have: connected it to the interface, applied power, loaded the operating system, renamed (or erased) HPSTATE.HPC to return the instrument to its factory default settings, and run PANELS as explained in Chapters 2 and 3 of your System Owner's Manual.

NOTE

If your instrument is connected to an application, be aware that following these instructions will close the relay contacts of input 3. You may want to disconnect your application connections.

Step 1 - If your Relay Multiplexer is not already in the Interactive Instrument Window, point to and select RELAY.MUX.01 from the label(s) listed in the System View Window (see Figure 2-1). If you have many instruments connected to the interface, use the **ROLL UP** **SYS VIEW** softkey to view them all. When you select an

instrument from the list, the ACTIVE indicator (located on the front of the instrument) lights up.

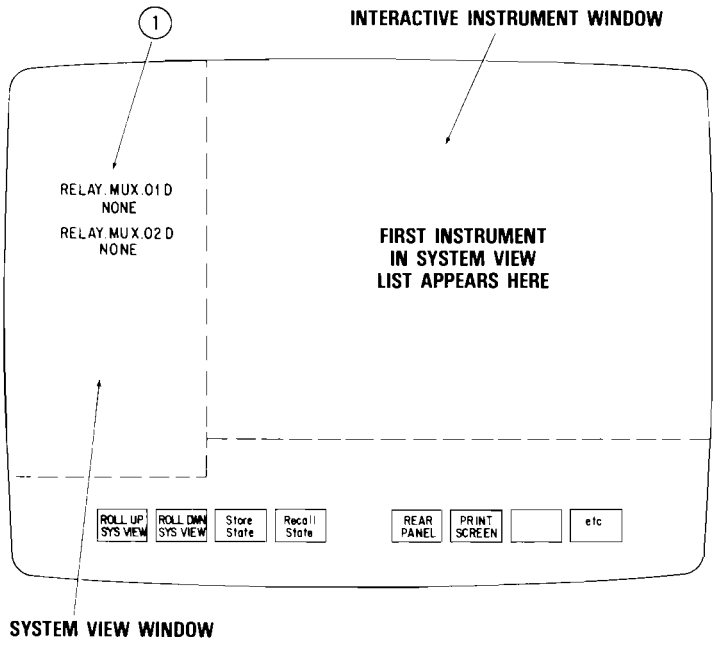

Figure 2-1. Select the Instrument

RELAY.MUX.01 is the factory default label for the Relay Multiplexer. The letter D after the label indicates that the output is disabled at this time (If the D is absent, it means the output is enabled.) The line directly below the label indicates which one of the eight inputs are currently selected on your instrument. NONE means that no inputs are selected at this time. If you have more than one Relay Multiplexer, each additional instrument is assigned a sequentially numbered default label (RELAY.MUX.02, RELAY.MUX.03, etc.).

Step 2 - Once you select RELAY.MUX.01, the RELAY.MUX.01 information in the System View Window disappears, and the RELAY.MUX.01 front panel appears in the Interactive Instrument Window (see Figure 2-2). Notice that NONE is the default selection. To operate RELAY.MUX.01, first point to and select the input 3 field.

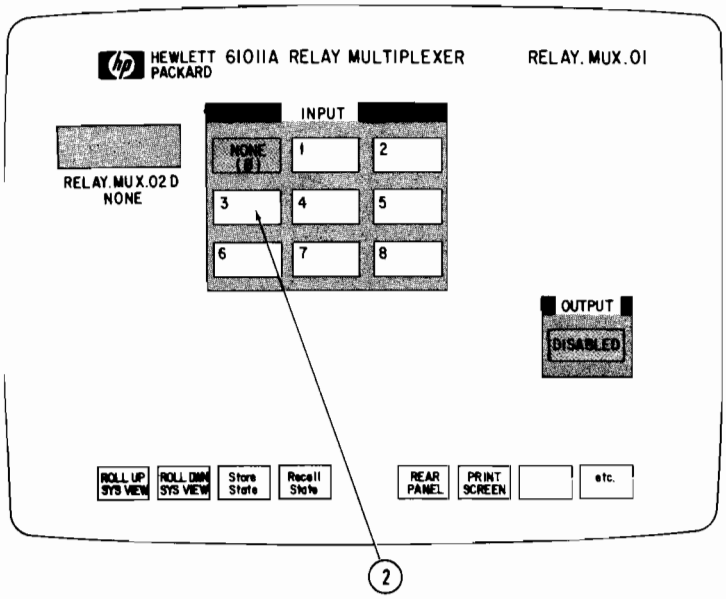

Figure 2-2. Select an Input

Step 3 · When you point to and select the input 3 field, its background turns bright, and the background of NONE turns dark (see Figure 2-3). Because the output field indicates DISABLED, the selection process did not close any relay contacts on your instrument. The output must be enabled before the relay contacts of input 3 can close. Point to and select DISABLED to enable the output. (The output field toggles between ENABLED and DISABLED.)

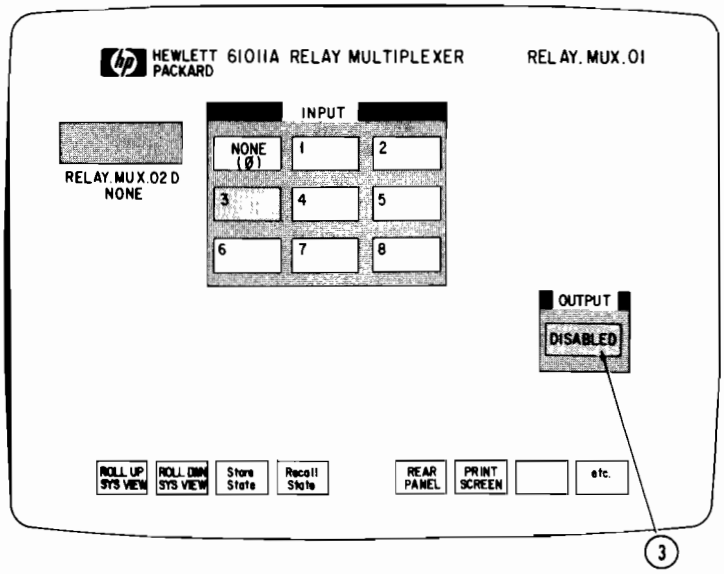

Figure 2-3. Enable the Output

The Result - With the output ENABLED, the relay contacts of input 3 are now closed and input 3 is connected to the output (see Figure 2-4). To try out a different instrument at this time, go to Chapter 2 of its manual; otherwise, press the **etc.** softkey and then the **EXIT** softkey.

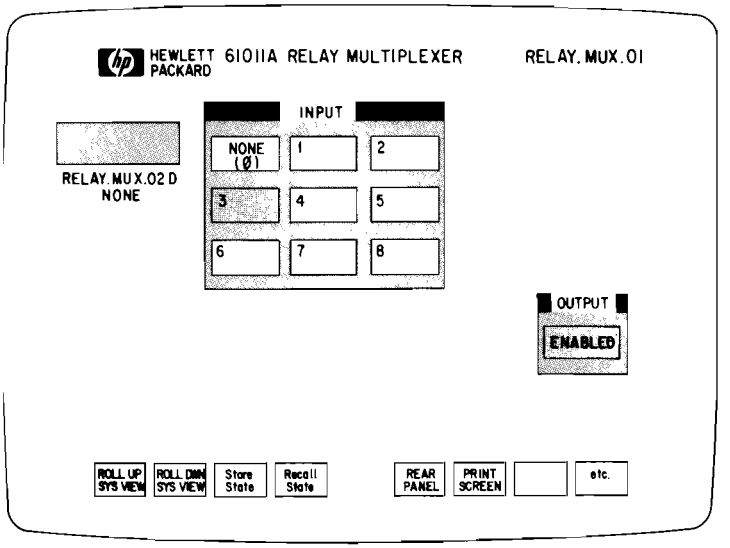

Figure 2-4. Input 3 Activated

What to do Next

Now that you have finished trying out your instrument, the next thing you do depends upon the type of user you are. If you are an experienced PC Instruments user and are already familiar with the System Owner's Manual, read the remaining Chapters in this manual. If you are a first time PC Instruments user, read Chapter 4 in the System Owner's Manual and Chapter 3 in this manual to learn all about manual instrument control. Table 3 in the System Owner's Manual gives the reading sequence of these manuals for first time users.

3 Manual Instrument Control

Introduction

The basics of selecting your instrument and closing a relay have already been discussed in Chapter 2 of this manual. This Chapter covers additional details about operating your instrument. Chapter 4 of the System Owner's Manual describes the Soft Front Panel features (including softkeys) that are common to all instruments.

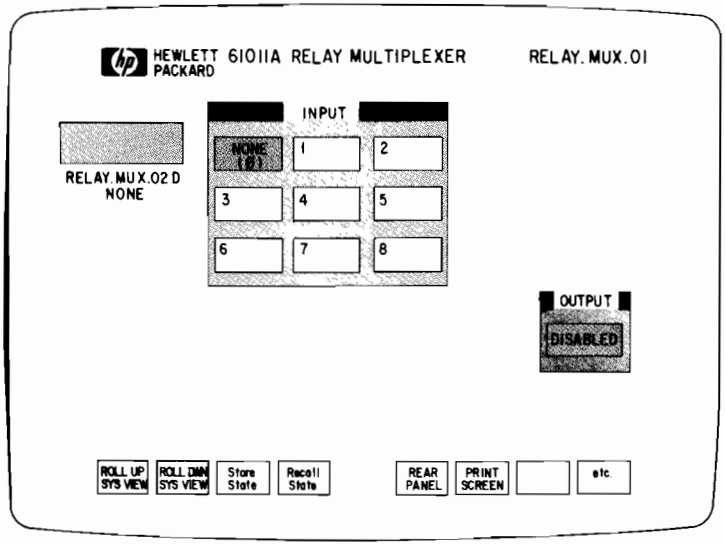

Figure 3-1. Relay Multiplexer Default Settings

Figure 3-1 shows the factory default screen graphics that appear when the first Relay Multiplexer in your PC Instruments System is selected. These defaults are: no input selected, output disabled. The default label (RELAY.MUX.01) appears in the upper right corner of the Interactive Instrument Window. The Interactive Instrument Window can display either the front panel or the rear

panel of your instrument. Use the FRONT PANEL softkey to display the front panel. This is the panel that lets you operate your instrument. If the front panel that appears on your computer's display does not look like Figure 3-1, it means that a previous user has changed the default settings.

Closing a Relay

Closing a relay on the Relay Multiplexer consists of selecting an input and enabling the output. Pointing to and selecting an input in the computer's display turns the background of the input field bright. Only one input can be selected at a time. If one of the other inputs had previously been bright, its background turns dark when the new input is selected. If NONE is selected, any previous input selections are cancelled.

The output must be ENABLED for the selection process to also close the relay contacts of the selected input. When input selections are made with the output enabled, the relay contacts of a deactivated input will always open before the relay contacts of an activated input close. This is referred to as break-before-make. If NONE is selected and the output is enabled, no relay contacts will close. This is a useful feature if you are tying the outputs of several Relay Multiplexers together in a scanning application, and only want a single input switched to the common output when your system is enabled. Simply select NONE on the Relay Multiplexers that you do not want switched to the output.

CAUTION

When connecting several Relay Multiplexers in parallel (see Figure 4-5), the user is rquired to provide the break-before-make operation when switching between inputs on different multiplexers. This is done to avoid shorting the inputs together.

Disabling the output opens any closed relay contacts. When the output is disabled, the selection process has no effect on any relay contacts. The **ENABLE OUTPUTS** and **DISABLE OUTPUTS** softkeys affect your instrument in the same way as output ENABLED/DISABLED.

4 Front Panel Connections

Introduction

The following paragraphs describe how to make connections to the front panel of your Relay Multiplexer. You should become familiar with operating your instrument manually as explained in Chapters 2 and 3 of this manual before you make any front panel connections to your instrument. You may also want to read about programming your instrument in Chapter 5 before you make application connections.

WARNING

To avoid potentially hazardous electrical shock, establish a safety ground before making any front panel connections. Connect the output cable from the Power Pack to the Relay Multiplexer, and then connect the line cord from the Power Pack to the ac line (refer to Chapter 2 of the System Owner's Manual).

This instrument is under user's program control. Equipment failure, power failure, or program error may cause a hazardous situation to occur. Applications requiring a failsafe method of ensuring equipment status must be provided by the installer. When ac power is applied or removed, the relay contacts open.

Application Connections

As shown in Figure 4-1, application (field-wire) connections are made on the plug-in terminal block that mates with the socket on the front of your instrument. Remove the terminal block to facilitate these wire connections.

CAUTION

Excessive input voltage and current will damage this instrument. Do not exceed 250 V dc, 250 V ac rms, or 350 V ac pk between inputs or from any terminal to ground. Do not exceed 1 A per input. If your equipment is capable of delivering more than 1 A, an external 1 A fuse should be used to prevent accidental damage to the instrument.

To prevent shorted inputs, do not strip wires back more than 0.2 in (5 mm). Insert wires fully into connectors.

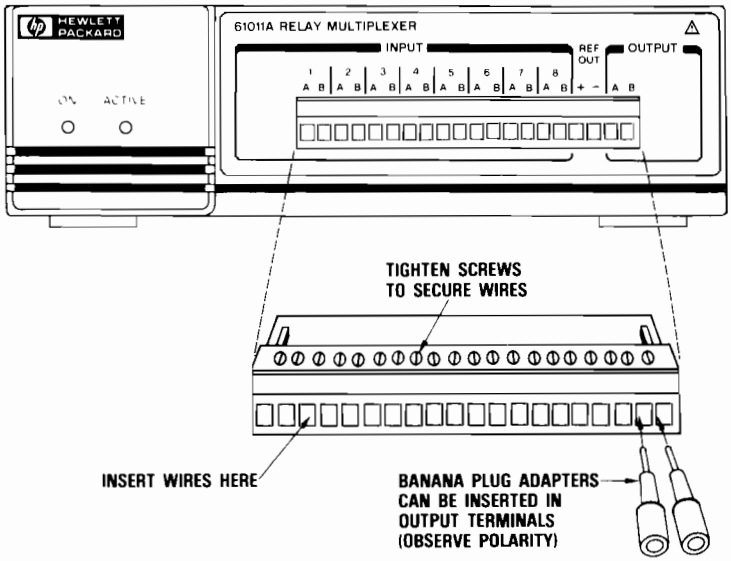

Figure 4-1. Application Connections

Loosen the screws on top of the terminal block. Strip your wires back approximately 0.2 in.(5 mm) and insert them in the square holes on the front of the terminal block. The screw terminals can accommodate wire sizes from AWG 14 to AWG 28 (Metric 1.5-0.5 mm^2). As shown in Figure 4-2, all "A" input terminals are switched to the "A" output terminal and all "B" input terminals are switched to the "B" output terminal. Refer to the label on the front of your instrument as well as Figure 4-2 to make sure that you are inserting your wires into the correct opening.

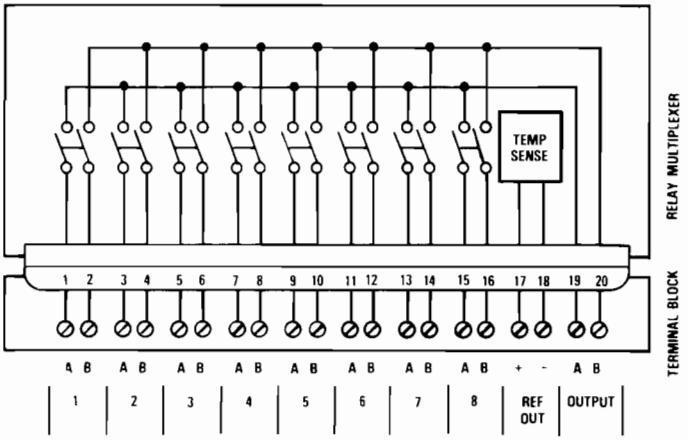

Figure 4-2. Internal Relay Connections

Install the banana plug adapters in the output screw terminals if you will be connecting banana plug leads (from an instrument such as a digital multimeter) to the output. Install the red adapter in the output terminal that is switched to the HI side of the inputs, and the black adapter in the output terminal that is switched to the LO side of the inputs. After you have inserted all your wires and tightened the screws, plug the terminal block into the socket on front of your instrument. When it snaps into place, it is inserted correctly.

Thermocouple Measurement Connections

When you connect your thermocouple wires to the Relay Multiplexer, reserve one of the inputs for monitoring the temperature of the terminal block. Use input 8 because it is adjacent to the REF OUT terminals (See Figure 4-3). Keep the jumper wires for these connectionns as short as possible.

CAUTION

Do not use your Relay Multiplexer as a demultiplexer if the REF OUT terminals are connected to one of the eight inputs.

Connect the positive thermocouple wires and the positive reference output to the "A" input terminals. For the thermocouple measurement procedure (in Chapter 5) to work, all positive inputs must be switched to the same output terminal. The "HI" input of your digital multimeter must be connected to this same output terminal. Remember to use the banana plug adapters in conjunction with your banana plug meter leads at the output terminals (See Figure 4-1). Figure 4-3 shows the "A" terminals being used for all positive (+) connections. With this configuration you have seven inputs available for connecting thermocouples.

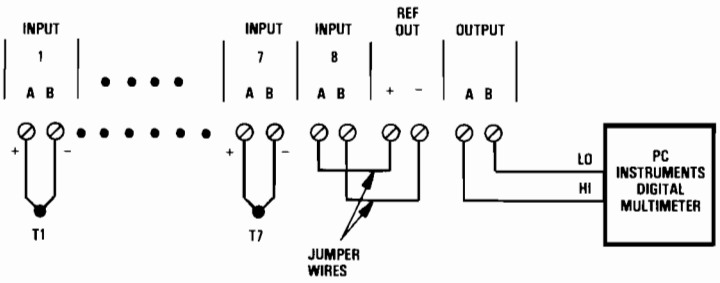

Figure 4-3. Seven Thermocouple Connections

If you need to connect eight thermocouples to your Relay Multiplexer, you can connect a second digital multimeter directly to the REF OUT terminals as shown in Figure 4-4. This allows you to connect an additional thermocouple to input 8.

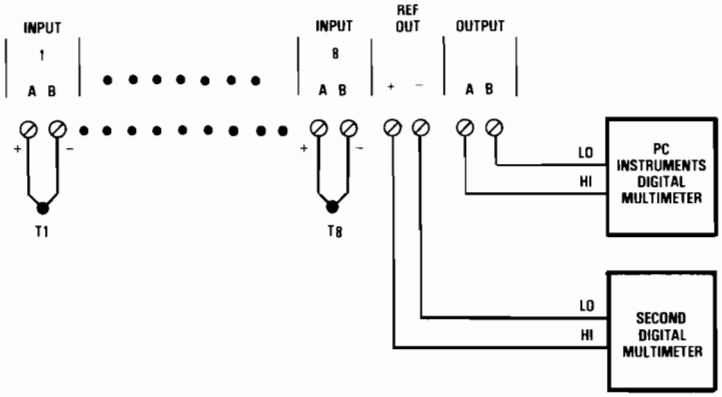

Figure 4-4. Eight Thermocouple Connections

For applications that have more than eight thermocouples, it is best to connect the outputs of several multiplexers together as shown in Figure 4-5. This configuration has the advantage of again using a single multimeter for monitoring the reference outputs as well as measuring the thermocouple voltages. You must supply stacking banana plug patch cords to connect the outputs of your Relay Multiplexers together. Connect your multimeter leads to the patch cords.

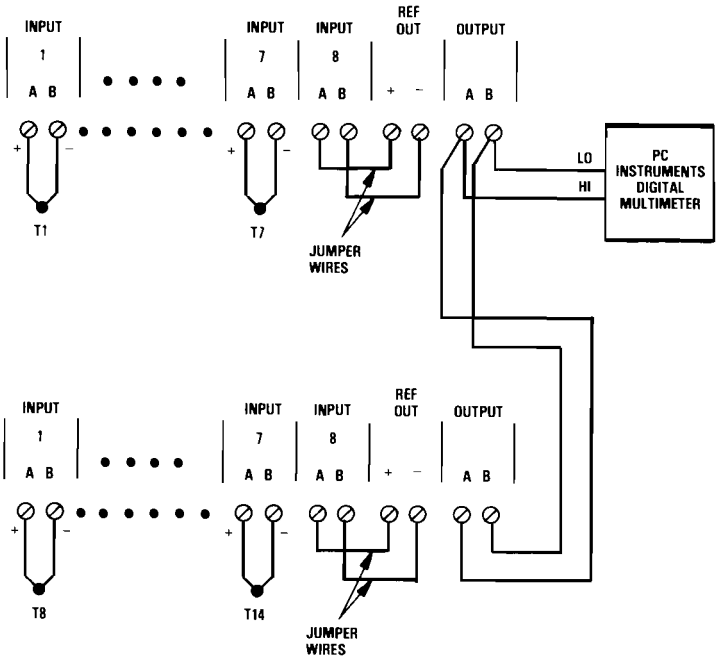

Figure 4-5. Fourteen Thermocouple Connections

5 Programming With BASIC

Introduction

You can write a BASIC program to control the relays on your Relay Multiplexer. Before you attempt this, you should familiarize yourself with controlling the instrument manually (refer to Chapters 2 and 3). Also, you must already know how to write programs in BASIC before you can write your own application program. Chapter 5 of the System Owner's Manual contains information about how to develop and run your program. Before writing your program, you must first use the Soft Front Panel to create a Program Shell as explained in Chapter 4 of the System Owner's Manual. You can also use the Soft Front Panel to assign a label to the Relay Multiplexer and create one or more State files.

This Chapter describes the statements that you can use in your program to control the Relay Multiplexer. These statements fall into two categories: system and instrument. System statements affect other instruments in your system. Instrument statements affect only the specified (labeled) Relay Multiplexer.

NOTE

If the programming statements in this chapter fail to execute, you may have a program error. Refer to Chapter 5 in the System Owner's Manual which discusses error handling methods. Appendix C of this manual lists the error messages that apply to the Relay Multiplexer.

How Statements Control the Relay Multiplexer

Figure 5-1 shows how the programming statements discussed in this Chapter control the Relay Multiplexer. From the diagram you can see that the OUTPUT statement loads the data that selects a specific input into the relay select register. Only one input can be selected at a time. Whether the relay contacts that are associated with the selected input will close depends on whether the ENABLE or the DISABLE statement has also been programmed. If the ENABLE statement is programmed, the selected relay contacts will close. If the DISABLE statement is programmed, the OUTPUT statement cannot close any relay contacts. The INITIALIZE statement simultaneously selects an input and enables or disables the relays.

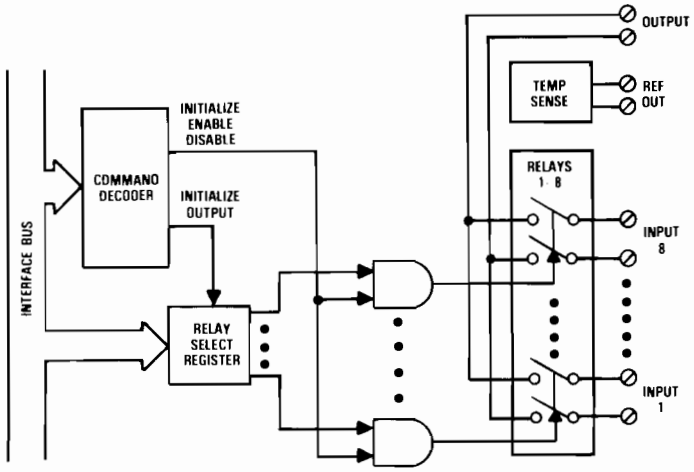

Figure 5-1. How Statements Control the Relay Multiplexer

System Programming Statements

All of the system statements are discussed in Chapter 5 of the System Owner's Manual. Only three of them apply to the Relay Multiplexer:

INITIALIZE.SYSTEM*(statefile)* - where *statefile* is the string variable that is equal to a State filename that you assigned when operating from the Soft Front Panel. This statement sets all Relay Multiplexers in your system to the settings contained in a previously created State file. All other instruments in your system are also initialized. Whenever it is used in your program, the INITIALIZE.SYSTEM statement will override the results of any previously issued instrument statements. If this statement is not used in your program, the Relay Multiplexer will be initialized with the factory default settings (see Table 1-1).

NOTE

The Rear Panel information contained in the State file must agree with your present hardware set-up. Rear Panel mode is described in Chapter 4 of the System Owner's Manual.

ENABLE.SYSTEM - closes the relay contacts of the selected input on all Relay Multiplexers in your system. This statement allows you to select an input before actually closing the relay contacts of that input. The relay contacts of the selected input will only close after the ENABLE.SYSTEM statement is programmed. This statement also enables any other output instruments in your system.

DISABLE.SYSTEM - opens any closed relay contacts on all Relay Multiplexers in your system. This statement also disables any other output instruments in your system.

Instrument Programming Statements

Instrument programming statements only program the instrument that is specified by the *label* parameter. This parameter is either the factory default label (RELAY.MUX.01 for the first Relay Multiplexer in your system) or the user defined label that is assigned to the Relay Multiplexer when the instrument is labeled in Rear Panel mode. The four instrument statements that program the Relay Multiplexer are described as follows.

INITIALIZE*(label,statefile)* - same as INITIALIZE.SYSTEM but sets only the specified Relay Multiplexer to a previously assigned state. Although the State file contains information about the other instruments in your system, only the information that applies to the Relay Multiplexer will be retrieved.

```
Example: 1010 FILE$="YOURFILE"
         1020 CALL INITIALIZE(RELAY.MUX.01,FILE$)
```

This example sets RELAY.MUX.01 to the settings contained in the file YOURFILE. YOURFILE can be any State file that you created and named when operating from the Soft Front Panel. Depending upon the information in this file, your Relay Multiplexer can be initialized with the output enabled or disabled.

OUTPUT*(label,value)* - where *value* is single-precision real variable that must only be set to a number from 0 to 8. This statement selects a specific input on the Relay Multiplexer. The numbers 1 to 8 select the corresponding input; the number 0 selects no input. If an ENABLE statement is in effect, or if the instrument was initialized with the output enabled, the relay contacts of the selected input will be closed. Program execution will wait until the relay closes before continuing. The relay contacts of a previously selected input will always open before the relay contacts of the newly selected input close (break-before-make).

Programming a 0 is useful if you are tying the outputs of

several Relay Multiplexers together in a scanning application (as shown in Figure 4-5). This lets you switch a single input to your common output when using an ENABLE.SYSTEM statement to start your application. Simply program the Relay Multiplexers that you do not want switched to your output to 0.

CAUTION

When connecting several Relay Multiplexers in parallel, the user is required to provide the break-before-make operation when switching between inputs on different multiplexers. This is done to avoid shorting the inputs together.

```
Example: 1010 SWITCH.3=3
         1020 CALL OUTPUT(RELAY.MUX.01,SWITCH.3)
```

This example selects input 3 on RELAY.MUX.01. Line 1010 assigns the value 3 to the variable SWITCH.3. Line 1020 causes input 3 to be selected. Notice that the variable name SWITCH.3 is an example of using a variable name that can be meaningful within the context of a specific application.

ENABLE.OUTPUT*(label)* - same as ENABLE.SYSTEM except that it closes the relay contacts of the selected input only on the specified Relay Multiplexer.

Example: 1010 CALL ENABLE.OUTPUT(RELAY.MUX.01)

This example closes the relay contacts of any selected input on RELAY.MUX.01.

DISABLE.OUTPUT*(label)* - same as DISABLE.SYSTEM except that it opens any closed relay contacts only on the specified Relay Multiplexer.

Example: 1010 CALL DISABLE.OUTPUT(RELAY.MUX.01)

This example opens any closed relay contacts on RELAY.MUX.01.

Relay Closure Example

The following example uses instrument programming statements to first select an input and then close its relay contacts. Before you can try out this example, you have to use the Soft Front Panel to generate a Program Shell. Then exit the Soft Front Panel and run BASIC. Load the Program Shell and type in the lines shown in the example after line 1000. Then run the program to close the relay contacts of input 3.

Normally you would also use the Soft Front Panel to save a State file for all of the instruments in your PC Instruments System. Then you could use an INITIALIZE statement in your program to set the Relay Multiplexer to the settings that you previously saved in the State file. Because the INITIALIZE statement is not used in the example here, your Relay Multiplexer will be set to the factory default settings. This means you must program each function of your instrument separately. When writing your program, remember to use the same labels in your instrument statements that you assigned to the Relay Multiplexer when using the Soft Front Panel. The following example uses the default label RELAY.MUX.01 in the instrument statements.

```
Program Shell
    .
    .
    .
1000 ' User program starts at this line
1010 SOURCE.A=3
1020 CALL OUTPUT(RELAY.MUX.01,SOURCE.A)
```

These statements select input 3. SOURCE.A is a variable that contains the number which specifies input 3.

```
1030 CALL ENABLE.OUTPUT (RELAY.MUX.01)
```

This statement closes the relay contacts of input 3.

```
1040 END
```

Thermocouple Measurement Procedure

The general procedure for using the Relay Multiplexer to make accurate temperature measurements from thermocouples is given in the five steps listed below. Since this is a general procedure, it can be used with any number of thermocouples and any digital multimeter that can measure microvolts. Chapter 4 of this manual explains where to connect your thermocouples and digital multimeter to the Relay Multiplexer in order to use this procedure. Appendix D lists the reference and temperature coefficients for six common types of thermocouples that you can use.

1. Measure the reference voltage (at the REF OUT terminals) from the Relay Multiplexer and convert to a temperature in Celsius. The equation used is:

$$TR = 100*V$$

where: TR = reference temperature in Celsius
V = reference voltage in volts

2. Convert the reference temperature to a thermocouple reference voltage (icepoint equivalent). This is necessary because the National Bureau of Standards uses the icepoint as the fundamental reference for their thermocouple tables (used in Step 5). The equation used is:

$$ER = [a_0 + (a_1*TR) + (a_2*TR^2) + (a_3TR^3)]*10^{-6}$$

where: ER = thermocouple reference voltage in volts
a_0, a_1, a_2, a_3 = reference constants from Table D-1
TR = reference temperature in Celsius

3. Measure the voltage produced by the thermocouple.

ET = voltage produced by the thermocouple

4. Add the reference voltage computed in Step 2 to the voltage measured in Step 3. The equation used is:

$$E = ER + ET$$

where: E = icepoint equivalent thermocouple voltage
ER = thermocouple reference voltage in volts
ET = voltage produced by the thermocouple

5. Convert the sum of Step 4 to a temperature in Celsius. The equation used is:

$$T = b_0 + (b_1 * E) + (b_2 * E^2) + \ldots + (b_9 * E^9)$$

where: T = compensated thermocouple temperature
b_0 through b_9 = temperature constants from Table D-2
E = icepoint equivalent thermocouple voltage

Thermocouple Measurement Example

All of the steps listed in the previous procedure must be carried out for each measurement taken on each thermocouple that is connected to your Relay Multiplexer. You can see that the procedure becomes rather cumbersome if you were to try to do it manually. However, these steps are actually very easy to perform under computer control. The following example shows you how to use the procedure in a Program Shell to automate your thermocouple measurement technique.

This example is written with the assumption that: seven T type thermocouples are connected to inputs 1 through 7, the reference output is connected to input 8, and a PC Instruments Digital Multimeter is used as the measuring device. This configuration is shown in Figure 4-3. The example also uses the default labels RELAY.MUX.01 and DMM.01 in the instrument statements.

Program Shell

```
.
.

1000 ' User program starts at this line
1010 A1=38.709457
1020 A2=0.037085566
1030 A3=0.000056495520
```

These reference coefficients are listed in Table D-1 for type T thermocouples.

```
1040 B0=0.10086091
1050 B1=25727.94369
1060 B2=-767345.8295
1070 B3=78025595.81
1080 B4=-9247486589
1090 B5=6.97688E+11
1100 B6=-2.66192E+13
1110 B7=3.94078E+14
1120 B8=0
1130 B9=0
```

These thermocouple conversion coefficients are listed in Table D-2 for type T thermocouples.

```
1140 REF.OUT=8
1150 CALL OUTPUT(RELAY.MUX.01,REF.OUT)
1160 CALL ENABLE.OUTPUT(RELAY.MUX.01)
```

These statements select and close the relay contacts of input 8 on RELAY.MUX.01. This input is where the REF OUT terminals are connected.

```
1170 CALL SET.FUNCTION(DMM.01,DCVOLTS)
1180 CALL SET.RANGE(DMM.01,R2)
1190 CALL DISABLE.INT.TRIGGER(DMM.01)
```

These statements set up DMM.01 to read dc voltages in the 2 V range. The internal trigger is disabled, which allows the MEASURE statement to trigger the start of a voltage measurement.

```
1200 CALL MEASURE(DMM.01,V)
1210 TR=100*V
```

These statements measure the reference voltage and convert it to a reference temperature in Celsius. Corresponds to step 1 of the procedure.

```
1220 ER=(TR*(A1+TR*(A2+TR*A3)))*10^-6
```

This statement converts the reference temperature to a reference voltage using the coefficients from lines 1010/1030. Corresponds to step 2. The reference voltage is expressed in volts.

```
1230 CALL SET.RANGE(DMM.01,R200MILLI)
1240 FOR TC=1 TO 7
1250 CALL OUTPUT(RELAY.MUX.01,TC)
1260 CALL MEASURE(DMM.01,ET)
```

These statements set the DMM to the 200 millivolt range and start a FOR/NEXT loop to sequentially scan and measure the thermocouples connected to inputs 1 through 7. Corresponds to step 3.

```
1270 E=ER+ET
```

This statement adds the thermocouple reference voltage and the thermocouple voltage. Corresponds to step 4.

```
1280 Z=B5+E*(B6+E*(B7+E*(B8+E*B9)))
1290 T=B0+E*(B1+E*(B2+E*(B3+E*(B4+E*Z))))
```

These statements convert the sum voltage to its corresponding temperature using the coefficients from lines 1040/1130. Corresponds to step 5. The equation must be broke up to avoid memory overflow.

```
1300 PRINT ''TEMP OF TC # '';TC;'' = '';T;'' deg C''
1310 NEXT TC
```

These statements print the temperature of the thermocouple that is connected to the input and repeat the loop for the next input.

```
1320 END
```

A Programming Statement Summary

The following is a summary of the programming statements that can be used to control the Relay Multiplexer. You can use this summary as a reference guide for spelling and syntax of the available statements.

System programming statements:

DISABLE.SYSTEM
ENABLE.SYSTEM
INITIALIZE.SYSTEM(*statefile*)

Instrument programming statements:

DISABLE.OUTPUT(*label*)
ENABLE.OUTPUT(*label*)
INITIALIZE(*label,statefile*)
OUTPUT(*label,value*)

B Verification Procedures

Introduction

Verification procedures for your Relay Mutliplexer are included with your HP PC Instruments software. Instructions on how to load and run these procedures are given in Appendix B of your System Owner's Manual. Step-by-step instructions to guide you through each part of the procedures will appear on your computer's display when you run the Relay Multiplexer verification program. A HELP screen is also provided in the program. This appendix lists the equipment required to verify the Relay Multiplexer and briefly describes the actual tests performed on the Relay Multiplexer.

Equipment Required

You must have an installed PC Instruments Interface Card and a Relay Multiplexer. In addition, an ohmmeter is needed to measure the resistance of the relay contacts, and a voltmeter is needed to measure the reference output voltage. If you have a PC Instruments Digital Multimeter in your system, you can use it to test your Relay Multiplexer. The multimeter must be connected to the same interface card as the Relay Multiplexer that is under test. This makes the procedure faster and more convenient than when you use a non-PC Instruments multimeter. Remember that no verification is performed on the PC Instruments Digital Multimeter in this test and it is assumed that it is functioning correctly.

If you want to use your own multimeter to test the Relay Multiplexer, it must satisfy the following measurement specifications:

	Resolution	**Accuracy**
Resistance	50 milliohms	+0.35%
DC voltage	100 microvolts	+0.05%

Besides the multimeter, you will need the banana plug adapters that are shipped with your Relay Multiplexer, a short jumper wire, a pair of banana plug leads, and a thermometer to determine room temperature in Celsius. The following steps describe how to install your equipment in preparation to running the test. This test configuration is illustrated on the HELP screen in your program.

1. Insert the banana plug adapters in terminals A and B of input 1.
2. Connect the jumper wire from terminal A to terminal B of the output.
3. Connect the banana plug leads from the banana plug adapters to the inputs of your multimeter.

NOTE

It is not necessary to observe polarity when testing the relays. When testing the reference output, however, connect the HI lead of your multimeter to the + reference output terminal, and the LO lead of your multimeter to the – reference output terminal.

What the Test Does

When you first run the verification program, it does a system level verification that partially tests all instruments in your system. This part of the test checks that the interface and instruments respond to commands issued by the computer. It is described in Appendix B of your System Owner's Manual.

After your Relay Multiplexer passes the system level verification, it will appear in a menu along with the other instruments in your system. This menu is the starting point for the instrument-specific verification tests for all of

your instruments. To continue testing your Relay Multiplexer, select it from this list. (When you select an instrument from the list, the ACTIVE indicator on the front of the instrument lights up.) Specifically, the Relay Multiplexer verification checks that:

1. The relay contacts open and close completely by measuring the resistance of the input/output path for each relay in your instrument.

2. The temperature reference voltage is accurate.

If you are using the PC Instruments Digital Multimeter to test your Relay Multiplexer, the verification test will automatically determine whether the individual relay contacts pass or fail the test. A message to that effect will appear on your screen. If you are using your own multimeter to test the relays, the program will print the expected results of each test on the screen. Based on the reading of your multimeter, you must then determine if your Relay Multiplexer has passed or failed. When testing the reference output, the program will also tell you what the expected results should be. You must then determine whether the reference output is accurate, based on the voltage readings of either the PC Instruments Digital Multimeter or your own multimeter.

In Case of Trouble

It is important that you complete all verification tests on both the system and instrument level. If your Relay Multiplexer does not pass these tests, consult your Support Guide for information on the PC Instruments exchange program.

C Error Messages

When operating your instrument from a BASIC program, error messages are only returned when you use the error handling routine that is described in Chapter 5 of the System Owner's Manual. The following error message applies to the Relay Mutliplexer:

204 - Invalid Output Value

D Thermocouple Conversion Coefficients

Table D-1. Constants for Converting from °C to a Thermocouple Reference Voltage.

To calculate an approximate thermocouple reference voltage as a function of temperature in the range of 0°C to 50°C for a given thermocouple, use the equation ER = $[a_0 + (a_1*TR) + (a_2*TR^2) + (A_3*TR^3)]*10^{-6}$ where ER is in volts and TR is in degrees Celsius. The constants that are assigned to the coefficients in this equation are:

	Type E	Type J	Type K	Type R	Type S	Type T
	Nickel-10% Chromium(+) Versus Constantan(−)	Iron(+) Versus Constant(−)	Nickel-10% Chromium(+) Versus Nickel-5%(−) (Aluminum Silicon)	Platinum-13% Rhodium(+) Versus Platinum(−)	Platinum-10% Rhodium(+) Versus Platinum(−)	Copper(+) Versus Constantan(−)
	0°C to 50°C ±0.24	0°C to 50°C ±0.06	0°C to 50°C ±0.14	0°C to 50°C ±0.01	0°C to 50°C ±0.01	0°C to 50°C ±0.08
a_0	0	0	0	0	0	0
a_1	58.637565	50.373743	39.448872	5.2891411	5.3994446	38.709457
a_2	0.046720025	0.030167011	0.024548362	0.013844426	0.012467754	0.037085566
a_3	−0.000014438022	−0.000074293513	−0.000090918433	−0.000020889531	−0.000019934168	0.000056495520

Table D-2. Constants for Converting from a Compensated Thermocouple Voltage to °C.

To calculate an approximate thermocouple temperature as a function of voltage in the selected temperature range for a given thermocouple, use the equation $T = b_0 + (b_1*E) + (b_2*E^2) + \ldots + (b_9*E^9)$ where E is in volts and T is in degrees Celsius. Select a thermocouple that allows you to take temperature measurements in the range that you are interested in. The constants that are assigned to the coefficients in this equation are:

	Type E	Type J	Type K	Type R	Type S	Type T
	Nickel-10% Chromium(+) Versus Constantan(−)	Iron(+) Versus Constant(−)	Nickel-10% Chromium(+) Versus Nickel-5%(−) (Aluminum Silicon)	Platinum-13% Rhodium(+) Versus Platinum(−)	Platinum-10% Rhodium(+) Versus Platinum(−)	Copper(+) Versus Constantan(−)
	−100°C to 1000°C ±0.5°C	0°C to 760°C ±0.1°C	0°C to 1370°C ±0.7°C	0°C to 1000°C ±0.5°C	0°C to 1750°C ±1°C	−160°C to 400°C ±0.5°C
b_0	0.104967248	−0.048868252	0.226584602	0.263632917	0.927763167	0.100860910
b_1	17189.45282	19873.14503	24152.10900	179075.491	169526.5150	25727.94369
b_2	− 282639.0850	−218614.5353	67233.4248	−48840341.37	−31568363.94	−767345.8295
b_3	12695339.5	11569199.78	2210340.682	1.90002E + 10	8990730663	78025595.81
b_4	−448703084.6	−264917531.4	−860963914.9	−4.82704E + 12	−1.63565E + 12	−9247486589
b_5	1.10866E + 10	2018441314	4.83506E + 10	7.62091E + 14	1.88027E + 14	6.97688E + 11
b_6	−1.76807E + 11	0	−1.18452E + 12	−7.20026E + 16	−1.37241E + 16	−2.66192E +13
b_7	1.71842E + 12	0	1.38690E + 13	3.71496E + 18	6.17501E + 17	3.94078E + 14
b_8	−9.19278E + 12	0	−6.33708E + 13	−8.03014E + 19	−1.56105E + 19	0
b_9	2.06132E + 13	0	0	0	1.69535E + 20	0