KEITHLEY

MODEL 224
PROGRAMMABLE CURRENT SOURCE

QUICK REFERENCE GUIDE

INTRODUCTION

This reference and programming guide contains information on front panel operation, IEEE bus operation (commands and codes) and several short programs to get the Model 224 "up and running" using several different controllers. For complete details of these operating parameters consult the Model 224 and Model 2243 Instruction Manuals. The Model 2243 IEEE-488 interface is optional.

The programs in this booklet accept a numeric input from the controller keyboard, program the Model 224/2243 for autoranging and set the instrument output to the values entered. All other parameters remain unchanged, but may also be altered by including another string variable.

CONTENTS

CONDENSED SPECIFICATIONS

Range	Maximum Output	Accuracy (1 Year) ±(%rdg + offset) 18°-28°C	Step Size
100mA	±101.00mA	0.1 % + 50μA	50μA
10mA	±19.995mA	0.05% + 10μA	5μA
1mA	±1.9995mA	0.05% + 1μA	500nA
100 μA	±199.95 μA	0.05% + 100nA	50nA
10 μA	±19.995 μA	0.05% + 10nA	5nA

OUTPUT RESISTANCE: Greater than $10^{12}\Omega$.
OUTPUT CAPACITANCE: Less than 20pF.
VOLTAGE LIMIT: Bipolar, 1 to 105V in 1V programmable steps.
RESPONSE TIME: Less than 3ms to within 0.1% of programmed change.
TRANSIENT RECOVERY TIME: Less than 3ms to rated accuracy following any change in compliance voltage.
GUARD OUTPUT:
Maximum Load Capacitance: 10nF.
Maximum Load Current: Absolute total (Output + Guard) not to exceed 105mA.
Accuracy: ±1mV (excluding output lead voltage drop).
INCREMENT/DECREMENT: Automatic, manual or trigger modes.
Range of Dwell Times: 50ms to 999.9s.
Accuracy of Dwell Times: ±(0.05 + 20μs).
Step Size: Selected digit on a fixed range. Minimum step size 0.1% of range.
Current Limit: Maximum is ±(Full Scale) on range selected.
OUTPUT LOAD: Output load must be non-inductive.

SAFETY SYMBOLS AND TERMS

The symbol  on the instrument denotes that user should refer to the operation section in the Model 224 Instruction Manual.

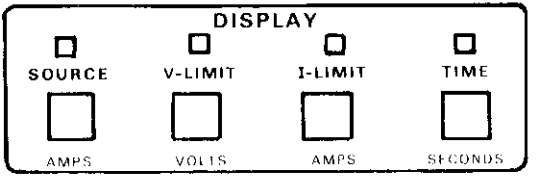
The symbol  on the instrument denotes that high voltage may be present on the output terminals.

The **WARNING** used in this guide explains dangers that could result in personal injury or death.

SAFETY PRECAUTIONS

1. Before operation, ground the instrument through a properly earth grounded power receptacle.
2. Before servicing, disconnect the instrument from the power line, all other equipment and consult the Model 224 Instruction Manual.
3. Do not touch the rear panel terminals while the instrument is turned on or connected to any other test equipment. Common mode voltage and programmed output current may be present.

DISPLAY CONTROLS



SOURCE (Select Source Current)

Description
The SOURCE button selects the source function for display and/or modification. The source current can be modified using the DATA keys or the INCR/DECR function. In order for the source current to be modified, the display mode must be in the source function.

Operation
1. Press the SOURCE button.
2. The present source value appears on the display.

Typical Use
Selecting the source current fo display and/or modification.

I-LIMIT (Current Limit)

Description
I-limit is the programmed limit of the source current. The range of I-limit is +101E-3A to −101E-3A. The I-limit must be programmed before using the auto mode. Both I-limits (HI and LO) must be set on the same range.

Operation
1. Press the I-LIMIT button.
2. Enter the desired HI I-limit on the display using the DATA keys.
3. Press the ENTER button.
4. Press the I-LIMIT button.
5. Enter the desired LO I-limit on the display using the DATA keys.
6. Press the ENTER button.

Typical Use
1. Safety precaution for personal as well as the instrument.
2. Specifying a range of current output when using the auto mode.

V-LIMIT

Description
The V-LIMIT button selects the voltage compliance limit for display and/or modification. The range of compliance is 1V to 105V in 1V steps. The power up default value is 3V. Always select a compliance limit suitable to the application.

Operation
1. Press the V-LIMIT button.
2. Enter the desired voltage compliance limit using the DATA keys.
3. Press the ENTER button.

Typical Use
Limiting voltage compliance to protect external circuitry.

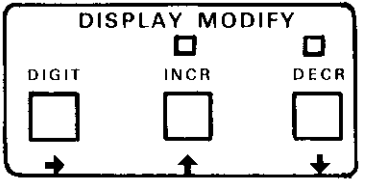
TIME (Dwell Time)

Description
The dwell time is the rate of increment or decrement when using the display modifying mode. The range dwell time is 50msec to 999.9sec. The dwell time must be programmed before using the auto mode.

Operation
1. Press the TIME button.
2. Enter the desired dwell time on the display using the DATA keys.
3. Press the ENTER button.

Typical Use
Selecting a rate of current change for testing semiconductors.

DISPLAY MODIFY GROUP



DIGIT (Digit Selection)

Description
The DIGIT button selects a display for modification in the source mode. The DIGIT button must be enabled (that is, the digit to be modified be selected) in order for AUTO, TRIG, INCR and DECR to operate.

Operation
1. Press the SOURCE button.
2. Press the DIGIT button the correct number of times to select the desired modify digit.

Typical Use
Selecting resolution of increment or decrement of source value.

INC (Increment Digit)

Description
Pressing the INCR button while in the manual mode increments the displayed source value starting at the selected modifying digit by one count. In the auto mode, pressing the INCR button increments the displayed value at the rate of the programmed dwell time (TIME). This action also begins at the selected modifying digit and it continues until it is stopped or the value reaches the HI l-limit.

Operation

1. Press trhe SOURCE button.
2. Press the DIGIT button the correct number of times to select the desired modify digit.
3. Press the INCR button to increment the selected modify digit (source value).

Typical Use

Incrementing the source value in a sweep of precise current steps (auto mode) or manually produce precise current steps (semi-auto mode) to obtain a family of curves for a semiconductor device.

DECR (Decrement Digit)

Description

Pressing the DECR button while in the manual mode decrements the displayed source value starting at the selected modifying digit by one count. In the auto mode, pressing the DECR button decrements the displayed source value at the rate of the programmed dwell time (TIME). This action also begins at the selcted modify digit and it continues until it is stopped or the value reaches the LO l-limit.

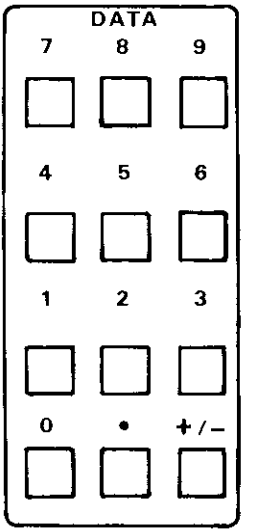
Operation

1. Press the SOURCE button.
2. Press the DIGIT button the number of times to select the desired modify digit.
3. Press the DECR button to decrement the selected modifying digit and therefore the source value.

Typical Use

Decrementing the source value in a sweep of precise current steps (Auto mode) or manually produce precise current steps (Semi-auto mode).

DATA KEYPAD



DATA

Description
The DATA keys allow entry of numeric data for the source, time, I-limit and V-limit modes. Only the present display mode is affected by the data input. The ± button affects the sign of the source, I-limit and V-limit modes. It also affects the sign of the exponent in the time mode.

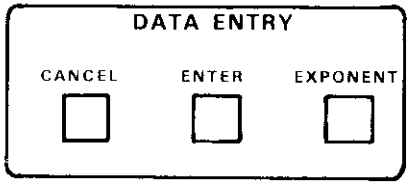
Operation

1. Select a display mode (Source, V-limit, I-limit or Time).
2. Enter the desired vaue using the DATA keys.
3. Press the ENTER button.

Typical Use

Changing the value of the displayed function.

DATA ENTRY CONTROLS



CANCEL (CANCEL Data Entry Operation)

Description
The CANCEL button momentarily blanks the display and terminates the data entry operation. The displayed value reverts to the previous value. This button is useful to clear an error when using the DATA keys.

Operation
1. Select a display mode (Source, V-limit, I-limit or Time).
2. Enter the desired value using the DATA keys. To illustrate the CANCEL button function make a deliberate mistake in the value entered.
3. Press the CANCEL button.
4. At this point, the display reverts to the original value.

Typical Use
Clear an error when using the DATA keys to modify source, I-limit, V-limit, and time data.

ENTER (ENTER Data)

Description
Pressing the ENTER button loads the displayed data into the Model 224. This button works in conjunction with the DATA keys when modifying the source, time, I-limit or V-limit data.

Operation
1. Select a display modify mode (Source, V-limit, I-limit or Time).
2. Enter the desired value using the DATA keys.
3. Press the ENTER button.
4. The new data is now the present value.

Typical Use
Enter new data in the display modify modes.

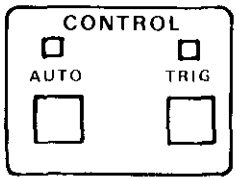
EXPONENT (EXPONENT Data)

Description
The EXPONENT button allows entry of exponent data using the DATA keys. The EXPONENT button is operational in the V-limit mode.

Operation
1. Select a display modify mode (source, I-limit or time).
2. Enter the value desired using the DATA keys.
3. Use the EXPONENT key to move the cursor to the displayed exponent.
4. Use the DATA keys to enter the desired exponent.
5. Press the ENTER button.

Typical Use
Selecting resolution of increment or decrement of source value.

CONTROL GROUP



AUTO (AUTO Increment/Decrement Digits)

Description
In the auto mode, the increment and decrement functions change the source value at the rate of the programmed dwell time and in the specified direction. The HI and LO I-limits must be set before the auto function can be used.

Operation
1. Select I-limits.
2. Select dwell time.
3. Press the SOURCE button.
4. Press the DIGIT button the correct number of times to select the modify digit.
5. Press the AUTO button.
6. Press INCR or DECR to modify the source value. In the operate mode the output tracks the display.

Typical Use
Producing a sweep of precise current steps for obtaining a family of curves of a transistor.

TRIG (Rear Input Trigger)

Description

The TRIG button enables the rear panel external trigger input. Applying the proper trigger pulse (TTL level negative going and greater than 10μsec in duration) modifies the selected digit by one count. Use with the digit, increment and decrement functions. The HI and LO limits must be set before TRIG can be used.

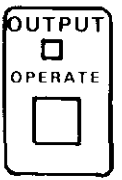
Operation

1. Press the SOURCE button.
2. Press the DIGIT button the correct number of times to select the modify digit.
3. Press the TRIG button.
4. Press the INCR or DECR to specify which direction the source value is to change.
5. Apply the proper trigger pulse to the EXTERNAL TRIGGER INPUT.

Typical Use

Other instruments modify the Model 224 source current (e.g. Keithley Model 195A).

OUTPUT CONTROL



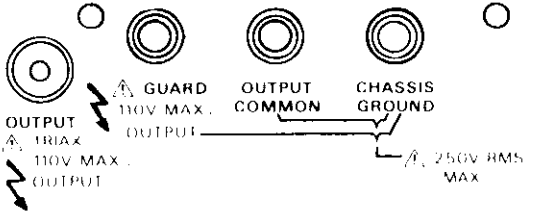
OPERATE

Description
The OPERATE button applies the programed source current to the rear panel output terminal. The output is programmed to 0.000E-6A when the OUTPUT LED is off.

Operation
1. Press the SOURCE button.
2. Enter the desired value using the DATA keys.
3. Press the OPERATE button.
4. At this point the programmed source value is present on the output terminals.

Typical Use
Apply the programmed source value to the rear panel output connector.

REAR PANEL CONNECTORS



OUTPUT

The OUTPUT connector is a Teflon® insulated female triax connector. The maximum output is 101mA at 105V compliance.

WARNING

Lethal potentials may be present on the OUTPUT terminal. Always verify that the instrument is in the standby mode and not floating above earth ground before touching any rear panel terminal.

GUARD

The GUARD terminal provides a low impedance voltage source that is equal to the output compliance voltage. The GUARD terminal is useful in reducing leakage currents for critical applications. The maximum load capacitance is 10nF. The maximum load current (output + guard) is not to exceed 105mA.

WARNING

Lethal potentials may be present on the GUARD terminal. Do not touch when the instrument is turned on or connected to any other equipment.

OUTPUT COMMON

The OUTPUT COMMON terminal provides easy access to the inner shield of the output connector. The inner shield of the output connector is output common. The maximum common mode voltage is 250Vrms DC to 60Hz.

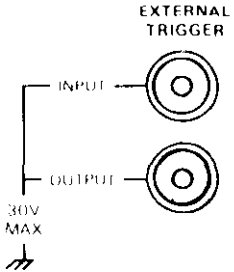
WARNING

Lethal potentials may be present on the OUTPUT COMMON terminal. Do not touch the terminal when the instrument is turned on or connected to any other equipment.

CHASSIS GROUND

The CHASSIS GROUND terminal provides easy access to chassis ground (earth ground).

EXTERNAL TRIGGER CONNECTORS



EXTERNAL TRIGGER INPUT

The external trigger input is a female BNC connector that accepts the proper trigger pulse (TTL level negative going and greater than 10μsec in duration) for modifying the displayed source value. This input is operational only in the trigger (front panel TRIG enabled) mode.

Operation:

1. Press the SOURCE button.
2. Press the DIGIT button the correct number of times to select the modifying digit.
3. Press the TRIG button.
4. Press INCR or DECR to specify which direction the source value is to change.
5. Apply the proper trigger pulse to the EXTERNAL TRIGGER INPUT.

Typical Use

Other instruments modify the Model 224 source current (e.g. Keithley Model 195A).

EXTERNAL TRIGGER OUTPUT

The EXTERNAL TRIGGER OUTPUT connector is a female BNC connector that outputs a TTL level negative going pulse of a minimum duration of 10μsec. The pulse appears at the end of the programmed dwell time. The trigger output is independent of the front panel trigger mode.

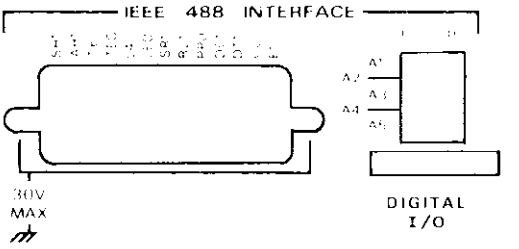
Operation:

1. Set up for auto mode.
2. The pulse appears at the end of each dwell time period.

Typical Use

The pulse triggers another instrument into its primary function (e.g. make a measurement, print out data, etc.).

IEEE INTERFACE CONNECTORS



*IEEE-488 INTERFACE

This connector provides IEEE-488 bus connection to the Model 2243. The connector mates with the Keithley Model 7008-3 or 7008-6 cables. With the Model 2243 IEEE-488 optional interface the Model 224 can be used with programmed control over the IEEE-488 bus.

*DIGITAL I/O

The digital I/O port consists of four input and four output lines as well as IEEE common and +5VDC. The output will drive one TTL load. The instrument can be programmed to generate an SRQ upon any change in the four bit input data.

*ADDRESS

The address switches are used to set the primary address of the Model 2243 IEEE-488 interface. The factory set value is 19 (10011). The primary address is updated only upon power up.

*These connectors are present only when the Model 2243 IEEE-488 interface is installed in the Model 224. For more information concerning these connectors refer to the Model 2243 Instruction Manual.

1. Turn on the Model 224.
2. Select the desired I-limits.
3. Select desired V-limit.
4. Select the desired source current.

There are three ways to select the desired source current:
Manual Selection
Semi-Auto Selection
Auto Selection

Manual Selection: (For use in applying a single current value).
A. Enter the desired source current using the DATA keys.
B. Press ENTER. (The previous output value remains unchanged until ENTER is pressed)

Semi-Auto Selection: (For use in applying precise steps of current).
A. Select modifying digit. (Use DIGIT button).
B. Use INCR or DECR to modify the source current. In the operate mode the output tracks the display.

Auto Selection: (For use in applying a sweep of precise current steps).
A. Select desired increment/decrement rate (TIME).
B. Select modifying digit. (Use DIGIT button).
C. Use INCR or DECR to modify the source current. In the operate mode, the output tracks the display.

NOTE: Auto selection can be used to select a single current value or to generate a sweep of precise current steps. The desired I-limits must be set in order to use the auto mode. Consult the Model 224 Instruction Manual for full details.

5. Connect the appropriate load.
6. Press OPERATE to output the programmed source current.

PROGRAM CODES

DISPLAY:
D0 = Source
D1 = Voltage Limit
D2 = Dwell Time

FUNCTION:
F0 = Standby
1. Set output current to zero on 20μA range.
2. Reduce voltage limit to less than 32V.

F1 = Operate
Set output to value programmed.

PREFIX: (NDCI, V, W)
G0 = Source, Compliance and Time with prefix is transmitted.
NDCI + n.nnnnE + n, V + n.nn00E + n,
W + n.nnnnE + n
G1 = Source, Compliance and Time without prefix is transmitted.
+ n.nnnnE + n, + n.nn00E + n,
+ n.nnnnE + n
NDCI + n.nnnnE + n for current
V + n.nn00E + n for voltage limit
W + n.nnnnE + n for time
"N" is replaced with "O" if an over compliance condition exists.

STATUS WORD:
G0 status word with model number prefix transmitted.
22400000000;
G1 status word without model number prefix transmitted:
00000000;

I/O STATUS:
G0 I/O status with prefix transmitted:
I/Oii,oo
G1 I/O status without prefix transmitted:
ii,oo
where i is the input from 0 to 15;
where o is the output from 0 to 15.

EOI:
K0 = EOI transmitted on last byte out.
K1 = EOI is not transmitted.

SRQ:

Mnn: nn = 0 to 31 base 10 or
00000 to 11111 base 2.
0 = bit disabled
1 = bit enabled
Bits: SRQ mask
MSB7: N/A
6: N/A
5: N/A
4: Input Port Change
3: End of Dwell Time
2: I Limit Reached
1: Over Voltage Limit
0: IDDC, IDDCO or −REN (No Remote)

SRQ BYTE:

BITS:	DATA	ERROR
MSB7	N/A	N/A
6	SRQ	SRQ
5	Data = 0	Error = 1
4	N/A	N/A
3	Input Port Change	N/A
2	End of Dwell Time	−REN (No Remote)
1	I Limit Reached	IDDCO
0	Over Voltage Limit	IDDC

RANGES:

R0 = Auto Range (Force Most Significant Number)
R5 = Full scale: 20 μA 2.0E−5
R6 = Full scale: 200 μA 2.0E−4
R7 = Full scale: 2mA 2.0E−3
R8 = Full scale: 20mA 2.0E−2
R9 = Full scale: 101mA 1.01E−1

IEEE TERMINATOR CHARACTER:

Yc = The (ASCII) byte contains an ASCII character which will be used as the terminator for all data until changed. The power up default is (CR) (LF). [NOTE: ASCII (DEL) indicates no terminator, ASCII (LF) indicates (CR) (LF), and ASCII (CR) indicates (LF) (CR).] Terminators not allowed: All capital letters; all numbers; (blank); + - / , . e

INPUTS:

I(sign)n.nnnE(sign)nn
Current Source Output Value
Limits: 0 to ± 101.00mA

V(sign)n.nnnnE(sign)nn
Voltage Limit
Limits: 1 to 105V

W(sign)n.nnnE(sign)nn
Time
Limits: 50.00msec to 999.9sec (1msec steps)

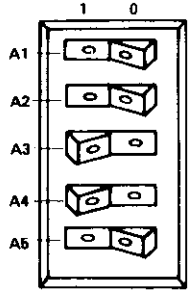
I/O PORT:

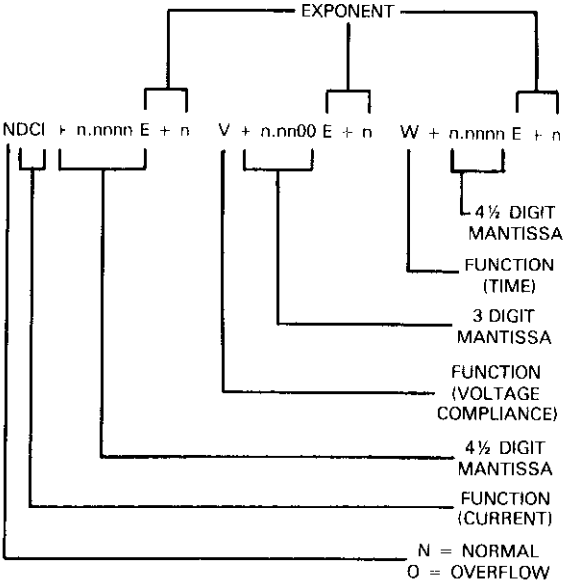
0n.nnnnEnn
Set control bits on "X"
n = 0 to 16 base 10 or
0000 to 1111 base 2
if 0 then bit low
if 1 then bit high

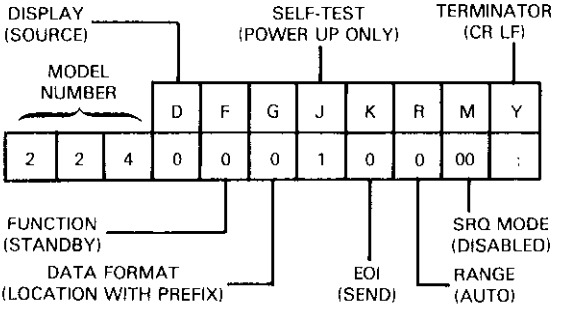
OUTPUT STATUS STRING ON TALK:

U0 = Output status word on next read.
Format: 2 2 4 D F G J K R M Y
Default: 2 2 4 0 0 0 0 0 0 0 0 :
J is cleared to 0 after status word is read.

U1 = Output I/O status on next read.
Read input on X only.
I/Oii,oo = I/O status
where i is the input from 0 to 15.
where o is the output from 0 to 15.




EXPONENT
NDCI ± n.nnnn E ± n
V ± n.nn00 E ± n
W ± n.nnnn E ± n
4½ DIGIT MANTISSA
FUNCTION (TIME)
3 DIGIT MANTISSA
FUNCTION (VOLTAGE COMPLIANCE)
4½ DIGIT MANTISSA
FUNCTION (CURRENT)
N = NORMAL
O = OVERFLOW


DISPLAY (SOURCE)
SELF-TEST (POWER UP ONLY)
TERMINATOR (CR LF)
MODEL NUMBER
D F G J K R M Y
2 2 4 0 0 0 1 0 0 00 :
FUNCTION (STANDBY)
DATA FORMAT (LOCATION WITH PREFIX)
EOI (SEND)
SRQ MODE (DISABLED)
RANGE (AUTO)

PROGRAMS

The following programs are designed to be a simple aid to the user, and are not intended to suit specific needs. Detailed information can be found in the manual.

IBM PC or XT Personal Computer (Keithley Model 8573 Interface)

The following program sends a command string to the Model 224 and displays the instrument data string on the IBM CRT. The equipment required for this program is the IBM PC or XT computer, the Keithley Instruments Model 8573 interface and the DOS 2.0 operating system. The GPIB software and hardware must be configured per the Keithley Instruments Model 8573 instruction manual.

DIRECTIONS

1. Using the rear panel switches, set the Model 2243 to primary address 19 (10011).
2. While the power is off, connect the instrument to the interface.
3. Type the command BASICA on the IBM keyboard to get into the IBM interpretive BASICA language.
4. Type in the command LOAD "DECL" to prepare the system for programming. The LOAD "DECL" command takes up the first five lines of the program (refer to the program).
5. *Type in the following program starting with line 10.*
6. Type in RUN to execute the program.
7. The CRT will display "COMMAND".
8. Enter the desired command string and press return. For example to program a current of 10mA on the Model 224, enter I10E-6X.
9. The entire reading string from the instrument will then appear on the CRT.
10. To exit the program type EXIT and press return.

PROGRAM	COMMENTS
10 CLS	
20 NA$ = "GPIB0":CALL IBFIND (NA$,BRD0%)	Find the board number.
30 NA$ = "DEV0":CALL IBFIND (NA$,M224%)	Find the 224 number.
40 V% = 19:CALL IBPAD (M224%,V%)	Change to primary address 19.
50 V% = 1:CALL IBSRE (BRD0%,V%)	Set REN true.
60 INPUT"COMMAND";CMD$	Prompt for command string.
70 IF CMD$ = "EXIT" THEN 150	See if program is to be halted.
80 IF CMD$ = " " THEN 60	If null command string go back and get another.
90 CALL IBWRT(M224%,CMD$)	Address 224 to listen and send command string.
100 RD$ = SPACE$(50)	Assign reading input buffer.
110 CALL IBRD(M224%,RD$)	Address 224 to listen and input data string.
120 RD$ = LEFT$(RD$,IBCNT%)	Trim string to proper size.
130 PRINT RD$	Display the reading on the CRT.
140 GOTO 60	Repeat.
150 V% = 0:CALL IBONL (BRD0%,V%)	Close the board file.
160 CALL IBONL (M224%,V%)	Close the instrument file.
170 END	

NOTE: If conversion to numeric variable is desired, change lines 120 and 130 as follows:

```
120 RD = VAL(MID$(RD$,5,14))
130 PRINT RD
```

NOTE: Lines 1-6 of this program need not be typed in and are not shown here. When the command LOAD"DECL" is entered, lines 1-6 are loaded from the disc into the computer. An address value must be added in place of the "X"s on lines 1 and 2.

APPLE II (APPLE Interface)

This program sets up the Model 224 output according to the values entered from the APPLE II keyboard.

DIRECTIONS

1. Set switches on the Model 2243 to primary address 19 (10011).
2. Connect the Model 224 to APPLE II and APPLE IEEE interface.
3. *Enter the program below using the RETURN key after each line.*
4. Type in RUN.
5. The display will read "ENTER I".
6. To program the Model 224 to 10μA output, type 10E-6 and depress the RETURN key.
7. The display will read "ENTER V".
8. To program the Model 224 to 20V compliance limit, type 20 and depress the RETURN key.
9. The programmed change can be verified by selecting one of the front panel DISPLAY pushbuttons and reading the display value.

PROGRAM	COMMENTS
10 PRINT "ENTER I"	
20 INPUT I$	Enter desired current. (Example: 10μA = 10E-6)
30 PRINT "ENTER V"	
40 INPUT V$	Enter desired voltage. (Example: 20V = 20).
50 Z$ = CHR$(26)	Define Z$ = CTRL-Z.
60 PR#3	Set to I/O on the IEEE bus.
70 IN# 3	
80 PRINT "RA"	Sent remote enable all.
90 PRINT "WT3,";Z$;"R0F1X"; "I";I$;"V";V$;"X"	Output to IEEE bus, address 19.
100 PRINT "LF1"	Send line feed after carriage return.
110 *PR# 0*	*Set to I/O on the CRT and* keyboard.
120 IN# 0	
130 GO TO 10	Repeat
140 END	End of program.

If conversion to numeric variable is desired, add the following:

```
134 A = VAL(MID$(A$,5,11))
136 PRINT A
```

This program sets up the Model 224 output according to the values entered from the HP-85 keyboard, using the 82937A GPIB interface.

DIRECTIONS

1. Set switches on the Model 2243 to primary address 19 (10011).
2. Connect the Model 224 to the HP 85 and HP 82937A GPIB interface.
3. Enter the program below using the END LINE key after each line.
4. Type RUN and depress the END LINE key.
5. The display will read "ENTER I =".
6. To program the Model 224 to 10μA output, type 10E-6 and depress the END LINE key.
7. The display will read "ENTER V =".
8. To program the Model 224 to 20V compliance limit, type 20 and depress END LINE key.
9. The programmed change can be verified by selecting one of the front panel DISPLAY pushbuttons and reading the display value.

PROGRAM	COMMENTS
10 REMOTE 719	Remote enable instrument at address 19.
20 DISP "ENTER I ="	
30 INPUT I$	Enter desired current. (Example: 10μA = 10E-6)
40 DISP "ENTER V="	
50 INPUT V$	Enter desired voltage. (Example: 20V = 20).
60 OUTPUT 719;"R0F1X", "I",I$,"V",V$"X"	Output to IEEE bus, address 19.
70 GO TO 20	Repeat
80 END	End of program.

This program sets up the Model 224 output according to the values entered from the HP 9825 keyboard, using the 98034A HPIB interface and a 9872AA extended I/O ROM.

DIRECTIONS

1. Set switches on the Model 2243 to primary address 19 (10011).
2. Connect the Model 224 to HP 9825A and 98034A HPIB interface.
3. Enter the program below, using the STORE key after each line. Line numbers are automatically assigned by the 9825A.
4. Depress the RUN key.
5. The display will read "enter i = ?".
6. To program the Model 224 to 10μA output, type 10E-6 and depress the CONTINUE key.
7. The display will read "enter v = ?."
8. To program the Model 224 to 20V compliance limit, type 20 and depress the CONTINUE key.
9. The programmed change can be verified by selecting one of the front panel DISPLAY pushbuttons and reading te display value.

PROGRAM	COMMENTS
0 dim A$[20],I$[20],V$[20]	Dimension string variables.
1 dev "224", 719	Define bus address 19 as 224.
2 ent "enter i – ?",I$	Enter desired current. (Example: 10μA = 10E-6).
3 ent "enter v = ?",V$	Enter desired voltage. (Example: 20V = 20).
4 "224" → A$	Set A$ = "224".
5 wrt A$,"R0F1X", "I", I$,"V",V$,"X"	Output to IEEE bus, address 19.
6 gto 2	Repeat
7 end	End of program.

This program sets up the Model 224 output according to the values entered from the HP 9816 keyboard, using the 82937A GPIB interface and the 98611A Opt 650 BASIC system floppy disc.

DIRECTIONS

1. Set the switches on the Model 2243 to primary address 19 (10011).
2. Connect the Model 224 to the HP 9816 and HP 92937A GPIB interface.
3. Insert the 98611A Opt 650 BASIC system floppy disc into the disk drive.
4. Type EDIT and then press the EXEC key.
5. Enter the following program using the ENTER key after each line.
6. Press the RUN key.
7. The display will read "ENTER I =".
8. To program the Model 224 to output 10μA, type 10E-6F1 and depress the ENTER key.
9. The display will read "ENTER V =".
10. To program the Model 224 to 20V compliance limit, type 20 and depress the ENTER key.
11. The programmed change can be verified by selecting one of the front panel DISPLAY pushbuttons and reading the displayed value.

PROGRAM	COMMENTS
10 REMOTE 719	Remote enable instrument at address 19.
20 INPUT "ENTER I = ",I$	Enter desired current. (Example: 10μA = 10E-6)
30 INPUT "ENTER V = ",V$	Enter desired voltage limit. (Example: 20 = 20V)
40 OUTPUT 719;"R0F1X"; "I",I$,"V",V$,"X"	Output to IEEE bus, address 19.
60 GO TO 20	Repeat
70 END	End of program.

This program sets up the Model 224 output according to the values entered from the HP-9845B keyboard using the 98034A HPIB interface and an I/O ROM.

DIRECTIONS

1. Set switches on the Model 2243 to primary address 19 (10011).
2. Connect Model 224 to HP 9845B and 98034A interface.
3. Enter the program below using the STORE key after each line.
4. Depress the RUN key.
5. The display will read "ENTER I" in the lower left corner.
6. To program the Model 224 to 10μA output, type 10E-6 and depress the STORE key.
7. The display will read "ENTER V" in the lower left hand corner.
8. To program the Model 224 to 20V compliance limit, type 20 and depress the STORE key.
9. The programmed change can be verified by selecting one of the front panel DISPLAY pushbuttons and reading the display value.

PROGRAM	COMMENTS
10 DIM I$(20), V$(20)	Dimension string variables.
20 SRCE = 719	Define bus address 19 as SRCE.
30 INPUT "ENTER I", I$	Enter desired current. (Example: 1μA = 10E-6).
40 INPUT "ENTER V",V$	Enter desired voltage. (Example: 20V = 20).
50 OUTPUT SRCE; "R0F1X"; "I";I$;"V";V$;"X"	Output to IEEE bus, address 19.
60 GO TO 30	Repeat
70 END	

This program sets up the Model 224 output according to the values entered from the TEK 4052 with an 4051 GPIB interface.

DIRECTIONS

1. Set switches on the Model 2243 to primary address 19 (10011).
2. Connect Model 224 to TEK 4051 IEEE interface.
3. Enter the program below using the RETURN key after each line.
4. Type in RUN.
5. The display will read "ENTER I".
6. To program the Model 224 to 10μA output, type 10E-6 and depress the RETURN key.
7. The display will read "ENTER V".
8. To program the Model 224 to 20V compliance limit, type 20 and depress the RETURN key.
9. The programmed change can be verified by selecting one of the front panel DISPLAY pushbuttons and reading the display value.

PROGRAM	**COMMENTS**
10 PRINT @ 37, 0: 10, 255, 13	
20 INPUT "ENTER I"	
30 INPUT I$	Enter desired output. (Example: 10μA = 10E-6)
40 PRINT "ENTER V"	
50 INPUT V$	Enter desired compliance. (Example: 20V = 20.)
60 PRINT @19:"R0F1X","I", I$,"V",V$"X"	Output to IEEE bus, address 19.
70 GO TO 20	Repeat
80 END	End of program.

DEC LSI 11

The following program sets up the Model 224 to output according to the values entered from the DEC LSI 11. The LSI 11 must be configured with 16k words of RAM and an IBV 11 IEEE interface. The software must be configured with IB software as well as the FORTRAN and the RT-11 operating system.

DIRECTIONS

1. Set the switches on the Model 2243 to primary address 19 (10011).
2. Connect the Model 224 to the IBV 11 IEEE cable.
3. Enter the following program using the editor under RT 11 and the name IPHILD.
4. Compile using the FORTRAN compiler as follows: FORTRAN IPHILD.
5. Link with the system and IB libraries as follows: LINK IPHILD,IBLIB
6. Type RUN IPHILD and depress the RETURN key.
7. The display will read "ENTER ADDRESS".
8. Type in 19 and depress the RETURN key.
9. The display will read "ENTER I = ".
10. To program the Model 224 to output 10μA type in 10E-6F1 and depress the RETURN key.
11. The display will read NDCA + 0.0000E-5.

```
PROGRAM                                  COMMENTS
   INTEGER*2PRIADR
   LOGICAL*1 MSG(80), INPUT(80)
   DO 2 I = 1,10
   CALL IBSTER (I,O)                     Turn off IB errors.
 2 CONTINUE
   CALL IBSTER (15,5)                    !Allow 5 error 15's
   CALL IBTIMO (120)                     !Allow 1 second bus
                                         timeout
   CALL IBTERM (''10)                    !Set LF as terminator
   CALL IBREN                            !Turn remote one
 4 TYPE 5
 5 FORMAT (1X,'ENTER ADDRESS',$)         !Input the address 19
   ACCEPT 10, PRIADR
10 FORMAT (214)
12 TYPE 15
15 FORMAT (1X,'ENTER I = ',$)            !Prompt for desired I
   CALL GETSTR (5,MSG,72)                !Get the test setup
   CALL IBSEOI (MSG,-1,PRIADR)           !Program the 224
18 I=IBRECV (INPUT,80,PRIADR)            !Get data from the 224
   INPUT (I + 1)=0
   CALL PUTSTR(7,INPUT,'0')
   CALL IBUNT                            !Untalk the 224
   GO TO 12                              !Repeat
   END
```

This program sets up the Model 224 output according to the values entered from the PET/CBM 2001 keyboard.

DIRECTIONS

1. Set switches on the Model 2243 to primary address 19 (10011).
2. Connect Model 224 to PET/CBM 2001 IEEE interface.
3. Enter the program below using the RETURN key after each line.
4. Type RUN and depress the RETURN key.
5. The display will read "ENTER I".
6. To program the Model 224 to 10μA output, type 10E-6 and depress the RETURN key.
7. The display will read "ENTER V".
8. To program the Model 224 to 20V compliance limit, type 20 and depress the RETURN key.
9. The programmed change can be verified by selecting one of the front panel DISPLAY pushbuttons and reading the display value.

PROGRAM	COMMENTS
10 OPEN 6, 19	Open file 6, primary address 19.
20 INPUT "ENTER I"; I$	Enter desired current. (Example: 10μA = 10E-6)
30 INPUT "ENTER V";V$	Enter desired voltage. (Example: 20V = 20)
40 PRINT#6,"R0F1X","I", I$,"V",V$,"X"	Output to IEEE-488 bus, address 19.
50 GOTO 20	Repeat
60 END	End of program.

The following program sends a data string from the E-H 7000 computer to the Model 224 and then displays the instruments reading on the computer CRT. The E-H 7000 must be configured with MS-DOS, IO-SYS and BASICA as outlined in its instruction manual.

DIRECTIONS

1. Using the rear panel switches, set the Model 224 for primary address 19 (10011).
2. While the power is off connect the Model 224 to PORT 1 of the computer.
3. While in BASICA, type LOAD "EHE488.CMP" to load the GPIB handler software.
4. Add the lines below to the front of the program now in memory; press the return key after each line is typed. The complete program may now be saved in the usual manner.
5. Press the computer F2 key to run the program. The CRT will prompt with "COMMAND?".
6. Type in the desired command. For example, to program a current of 10mA on the Model 224, enter I10E-3X.
7. The entire reading string from the instrument will then appear on the CRT.

```
PROGRAM                          COMMENTS
 10 CLS
 20 GOSUB 65010                  'Initialize Handler Software
 30 CALL PORT1                   'Initialize Port 1
 40 CALL INIT                    'Initialize Interface
 50 DEV$ = "19 "                 'Primary Address = 19
 60 INPUT "COMMAND"; C$          'Prompt for Command
                                  String
 70 IF C$ = "" THEN 60           ' If Null Input Go Back
 80 IN$ = SPACE$(60)             ' Define Reading Buffer
 90 CALL SNDSTR(DEV$,C$)         ' Send Command String to
                                  224
100 CALL RCVSTR(DEV$,            'Get Reading From 224
    IN$)
110 PRINT IN$                    'Display Reading String on
                                  CRT
120 GOTO 60                      'Repeat
```

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