

# OPERATOR'S MANUAL

## BIT 4886 DIGITAL INTERFACE CARD

KEPCO INC.  
An ISO 9001 Company.

MODEL

**BIT 4886**  
**INTERFACE CARD**

ORDER NO.

REV. NO.

**NOTE: The online version of this manual includes only installation and operation instructions. for the complete manual, contact KEPCO.**

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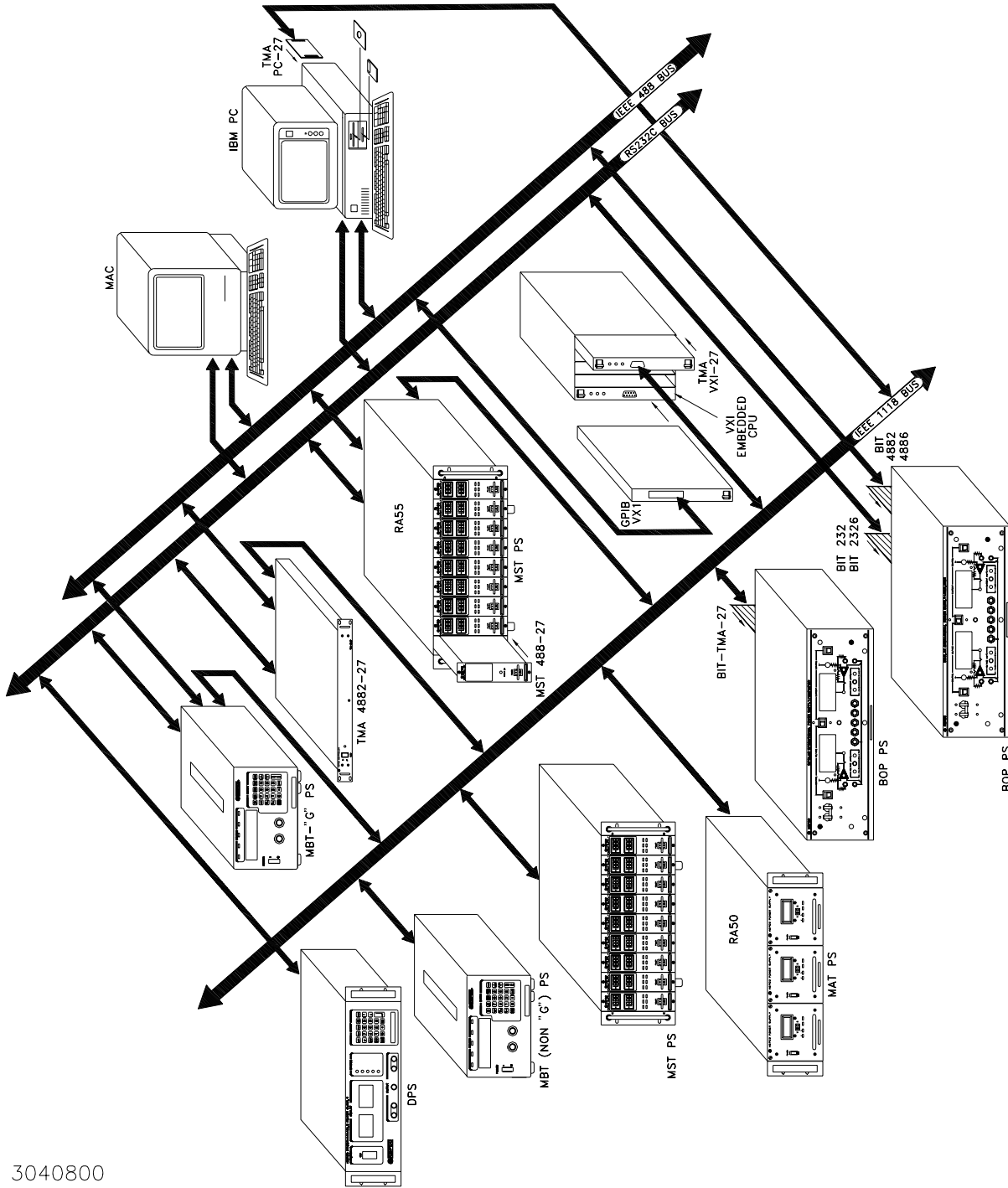


FIGURE 1-1. REMOTELY CONTROLLED POWER SUPPLY CONFIGURATIONS USING KEPKO PRODUCTS

## SECTION 1 - INTRODUCTION

### 1.1 SCOPE OF MANUAL

This manual contains instructions for the installation, operation and maintenance of the BIT 4886 Interface Card manufactured by Kepco, Inc, Flushing, NY, U.S.A.

### 1.2 GENERAL DESCRIPTION

The Kepco BIT Card Series were designed as an accessory for the Kepco BOP series bipolar power supplies. The BIT 4886 card makes it possible to control the BOP output by means of digital input signals via the IEEE 488.2 bus using SCPI commands (see Figure 1-1). The BIT 4886 card acts as an interface between the digital data bus and the BOP, accepting the digital input data and converting it to an analog signal, which in turn, controls the BOP output. The BIT 4886 provides full talk/listen capability and is fully compliant with the SCPI programming language.

At power-up the BIT 4886 is set to local mode, allowing front panel control of the BOP power Supply. Upon power up the BIT 4886 performs a reset, establishing the voltage and current output levels to be 0 volts and the output state to be off.

The BIT 4886 is a 16-bit interface card which allows either plus or minus voltage or current output at 15 bits of resolution.

Table 1-1 shows which specific revisions of BOP models are compatible with BIT 4886 cards.

**TABLE 1-1. APPLICABILITY OF BIT 4886 CARDS TO SPECIFIC BOP MODELS**

MODEL	REVISION NO.	MODEL	REVISION NO.
BOP 20-5M	2 AND LATER	BOP 50-8M	10 AND LATER
BOP 20-10M	17 AND LATER	BOP 72 3M	10 AND LATER
BOP 20-20M	15 AND LATER	BOP 72-6M	14 AND LATER
BOP 36-6M	19 AND LATER	BOP 100-1M	24 AND LATER
BOP 36-12M	13 AND LATER	BOP 100-2M	15 AND LATER
BOP 50-2M	21 AND LATER	BOP 100-4M	14 AND LATER
BOP 50-4M	13 AND LATER	BOP 200-1M	7 AND LATER

NOTE: For modification (to accept the BIT 4886 card) of BOP Models with revision numbers that do not appear in this table, contact Kepco for assistance.

#### 1.2.1 MEASUREMENTS

The readback information for BIT 4886 cards is the average of the last 16 measurements. The measurement average is valid after a time delay which allows the readings to stabilize, plus 320 milliseconds. Issuing a MEAS:VOLT? query before the end of this time delay will retrieve the instantaneous measured voltage from the analog-to-digital converter. After the delay, the measurement returned is the average of the last 16 measurements of the analog-to-digital converters.

## 1.2.2 ENHANCED OPERATION

The BIT 4886 card includes the following enhanced operation features: a) advanced control over the way the unit responds to errors (PAR. 5.2.1), b) advanced limit channel control for applications such as battery, photocell, and large inductor applications (see PAR. 5.2.2) and c) ability to save system settings (PAR. 5.2.3).

## 1.3 SPECIFICATIONS

For voltage and current accuracy specifications of BOP Models with a BIT 4886 card installed, refer to Tables 1-2 and 1-3, respectively. Table 1-5 lists the specifications for the BIT 4886 card.

**TABLE 1-2. BOP VOLTAGE SPECIFICATIONS WITH BIT 4886 INSTALLED**

VOLTAGE SPECIFICATION	BOP 200-1	BOP 100-1M BOP 100-2M BOP 100-4M	BOP 72-3M BOP 72-6M	BOP 50-2M BOP50-4M BOP 50-8M	BOP 36-6M BOP 36-12	BOP 20-5M BOP20-10M BOP20-20M
High range accuracy	24mV	12mV	8mV	6mV	4mV	2.4mV
Low Range Accuracy	6mV	3mV	2mV	1.5mV	1mV	0.6mV
Positive Limit Accuracy	300mV	150mV	100mV	90mV	75mV	36mV
Measurement Accuracy	120mV	60mV	45mV	30mV	24mV	12mV

NOTE: Low range is defined as less than 1/4 of the rated value .

**TABLE 1-3. BOP CURRENT SPECIFICATIONS WITH BIT 4886 INSTALLED**

CURRENT SPECIFICATION	BOP MODEL (ARRANGED BY CURRENT CAPABILITY)									
	20-20M	36-12M	20-10M	50-8M	36-6M 72-6M	20-5M	50-4M 100-4M	72-3M	50-2M 100-2M	100-1M 200-1M
High range accuracy	20mA	6mA	5mA	4mA	1.2mA	1mA	0.5mA	0.36mA	0.25mA	0.12mA
Low Range Accuracy	0.75	0.5mA	0.3mA	0.25mA	0.2mA	0.15mA	0.12mA	0.08mA	0.06mA	0.03mA
Positive Limit Accuracy	40mA	28mA	24mA	20mA	6mA	5mA	8mA	3mA	2mA	1mA
Measurement Accuracy	20mA	14mA	12mA	5mA	3mA	2.5mA	2mA	1.5mA	1mA	0.5mA

NOTES: 1. Low range is defined as less than 1/4 of the rated value  
2. Accuracy specifications apply only after 1 minute warm-up.

### 1.3.1 BIT 4882 COMPATIBILITY

The BIT 4886 card complies with the SCPI 1997 standard as a member of the power supply instrument class. The Bit 4882 product complies with the 1990 version of the SCPI standard. During the years of 1990 to 1997, the SCPI consortium refined the standard, providing direction for the \*RST command and indicating the differences between \*RST and the single byte GPIB command of DCL and SDC. The BIT 4886 card when shipped by KEPCO, is not compatible with user software developed for the BIT 4882. The user can make it more compatible by using the SYST:SET command to reconfigure the operation of DCL, \*RST and the sending of data to the host computer. Appendix B, Figure B-6, illustrates the use of the SYST:SET command to change the BIT 4886 to operate like the BIT 4882, except for some minor differences that will remain for some 4882 command sequences (see Table 1-4).

**TABLE 1-4. COMMAND DIFFERENCES FOR BIT 4886 CARD CONFIGURED AS BIT 4882**

<b>Command</b>	<b>BIT Card Behavior</b>	
	<b>BIT 4882</b>	<b>BIT 4886 configured as BIT 4882</b>
VOLT?MAX	Returns 100	No action - error 113
VOLT? MIN	Returns 0	Returns -Eomax (e.g.for BOP 100-1 returns -100)
VOLT10	Set output = 10V	No action - error 113
OUTP OFF;VOLT 10;OUTP ON	Set output = 0	Set output = 10 volts

**TABLE 1-5. SPECIFICATIONS, BIT 4886**

SPECIFICATION		DESCRIPTION	
OUTPUT VOLTAGE (MAIN CHANNEL)	High Range	Programs BOP to rated value	
	Low Range	Programs BOP to 1/4 rated value	
	Rise and Fall times (VOLT:MIN to VOLT:MAX)	<100 microseconds	
LIMIT CHANNEL ACCURACY		0.5%	
TEMPERATURE COEFFICIENT		Full scale: ± 35 ppm/°C max Zero: High Range ±10 ppm/°C max Low Range ±30 ppm/°C max Voltage Readback: High Range ± 20µV/°C max Low Range ± 10µV/°C max Current Readback: ±10 ppm/°C max	
OPTICAL ISOLATION		Digital and Analog grounds can be separated by a maximum of 500 Volts.	
DIGITAL INPUT FORMAT		Byte-Serial/IEEE	
POWER REQUIREMENT		Supplied by host power supply	
RESOLUTION	PROGRAMMING	15 bits	
	READBACK	15 bits	
LINEARITY	PROGRAMMING	± 1 LSB	
	READBACK	± 2 LSBs	
PROGRAMMING		ACCURACY (% OF MAX. OUTPUT)	CAPABILITY
	VOLTAGE HIGH RANGE	0.01% of $E_{oMAX}$	15 Bits
	VOLTAGE LOW RANGE	0.01% of 1/4 $E_{oMAX}$	15 Bits
	CURRENT HIGH RANGE	0.015% of $I_{oMAX}$ (See Note 1.)	15 Bits
	CURRENT LOW RANGE	0.01% of $I_{oMAX}$	15 Bits
	LIMIT CHANNEL	0.5% (See Note 2.)	12 Bits
DATA READBACK ACCURACY	VOLTAGE	0.05%	% of Max. Voltage or Current
	CURRENT		
LIST TRANSIENT	STEP/TRANSIENT RANGE	500 microseconds to 10 seconds	
	STEP/TRANSIENT ACCURACY	-5 TO + 20 microseconds	
	NUMBER OF STEPS	1002	
	RISE/FALL TIME	>100 microseconds	
ENVIRONMENTAL SPECIFICATIONS	OPERATING TEMP.	0 to 50° C	
	STORAGE TEMP.	-20 to +85° C	
NOTES: 1. The current control specification (stability) of BOP power supplies is not altered or improved by the addition of a BIT 4886 card. The current stability of the BIT 4886 card with most BOPs will be 0.015%. However, Some BOP models have better control specifications, e.g., the BOP 20-5 (0.006% stability), and others have lower stability such as the BOP 100-4 (0.02%), BOP 50-4 (0.05%) and BOP 20-20 (0.1%). All stability measurements are after warm-up time of 5 minutes. 2. For all BOP models (except 200-1) with BIT 4886 card installed typical voltage mode ripple/noise = 4mV rms, max noise = 6mV rms and 60mV p-p. For all BOP 200-1 models typical voltage mode ripple/noise = 4mV rms, maximum voltage mode ripple/noise = 8mV rms and 80mV p-p.			

## SECTION 2 - INSTALLATION

### 2.1 UNPACKING AND INSPECTION

The Interface Card has been thoroughly inspected and tested prior to packing and is ready for operation following installation. Unpack, saving original packing material. If any indication of damage is found, file a claim immediately with the responsible transport service. See Table 2-1 for items supplied.

**TABLE 2-1. ITEMS SUPPLIED**

ITEM	KEPCO PART NUMBER	QUANTITY
PCB Assembly	236-1836	1
Cables #1	241-0889	1
Cables #2	241-0899	1
Knurled Nut (6-32 x 3/4 DIA. BR., THUMB)	102-0023	3
Washers (#6 EXT. LOCK, STEEL)	103-0046	3
Label, Address	188-1726	1
Label, Control Identification	188-1826	1
Bracket	128-1810	1

### 2.2 SET START-UP DEFAULTS (SEE FIGURE 2-1)

The start-up default, consisting of the Device Address (GPIB address) is initially set by means of DIP switches as described in PAR. 2.2.1. The default power supply identification is described in PAR. 2.2.2.

### 2.2.1 SET (GPIB) DEVICE ADDRESS (SEE FIGURE 2-1)

The Device Address for the interface card is set by means of DIP switch S1, positions 1 through 5 (Figure 2-1). The Device Address is the permanent Listener or Talker address of the interface card on the GPIB. It is factory preset to address 6. If a different Device Address is required in your system, proceed as follows. There are 31 (1-31) possible choices (See Table 2-2).

1. Position the Interface Card as depicted in Figure 2-1.
2. The Device Address DIP switches are positions 1 through 5 (from right to left, Figure 2-1). These switches are preset by Kepco to address 6. For other device addresses set them according to Table 2-2.

### 2.2.2 POWER SUPPLY IDENTIFICATION

The BIT 4886 controller is factory set to report power supply voltage as 200 Volts and current as 20 Amperes. The controller card has nonvolatile random access memory which is used to store these values. A special GPIB command of DIAG:PST is used to set the voltage and current of the power supply which has the BIT 4886 card installed. Other commands can be used to establish other operating characteristics such as the language and DCL operation. See Appendix B and PAR. 4.2 for detailed procedures and instructions.

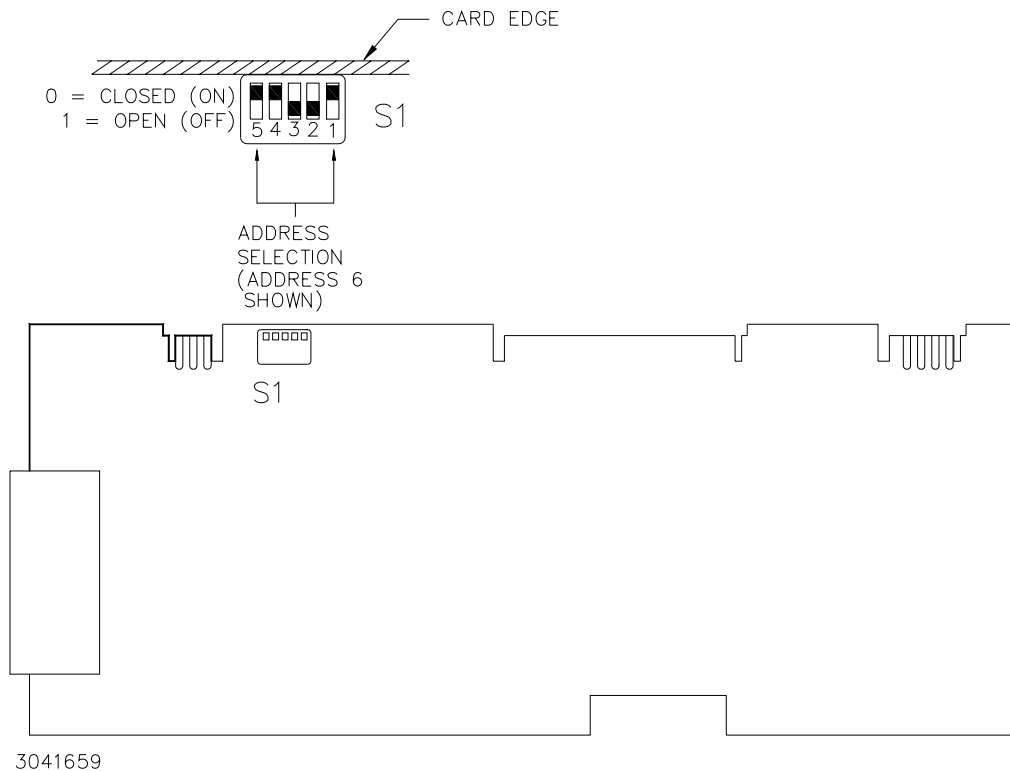


FIGURE 2-1. BIT 4886 SWITCH LOCATIONS



**TABLE 2-2. DEVICE ADDRESS SELECTION**

DECIMAL ADDRESS	SELECTOR SWITCH S1 SECTION (SIGNAL LINE)				
	A5	A4	A3	A2	A1
1	0	0	0	0	1
2	0	0	0	1	0
3	0	0	0	1	1
4	0	0	1	0	0
5	0	0	1	0	1
6	0	0	1	1	0
7	0	0	1	1	1
8	0	1	0	0	0
9	0	1	0	0	1
10	0	1	0	1	0
11	0	1	0	1	1
12	0	1	1	0	0
13	0	1	1	0	1
14	0	1	1	1	0
15	0	1	1	1	1
16	1	0	0	0	0
17	1	0	0	0	1
18	1	0	0	1	0
19	1	0	0	1	1
20	1	0	1	0	0
21	1	0	1	0	1
22	1	0	1	1	0
23	1	0	1	1	1
24	1	1	0	0	0
25	1	1	0	0	1
26	1	1	0	1	0
27	1	1	0	1	1
28	1	1	1	0	0
29	1	1	1	0	1
30	1	1	1	1	0
31	1	1	1	1	1

NOTE: 0 = CLOSED (ON) (Towards printed circuit board)  
1 = OPEN (OFF) (Away from printed circuit board)

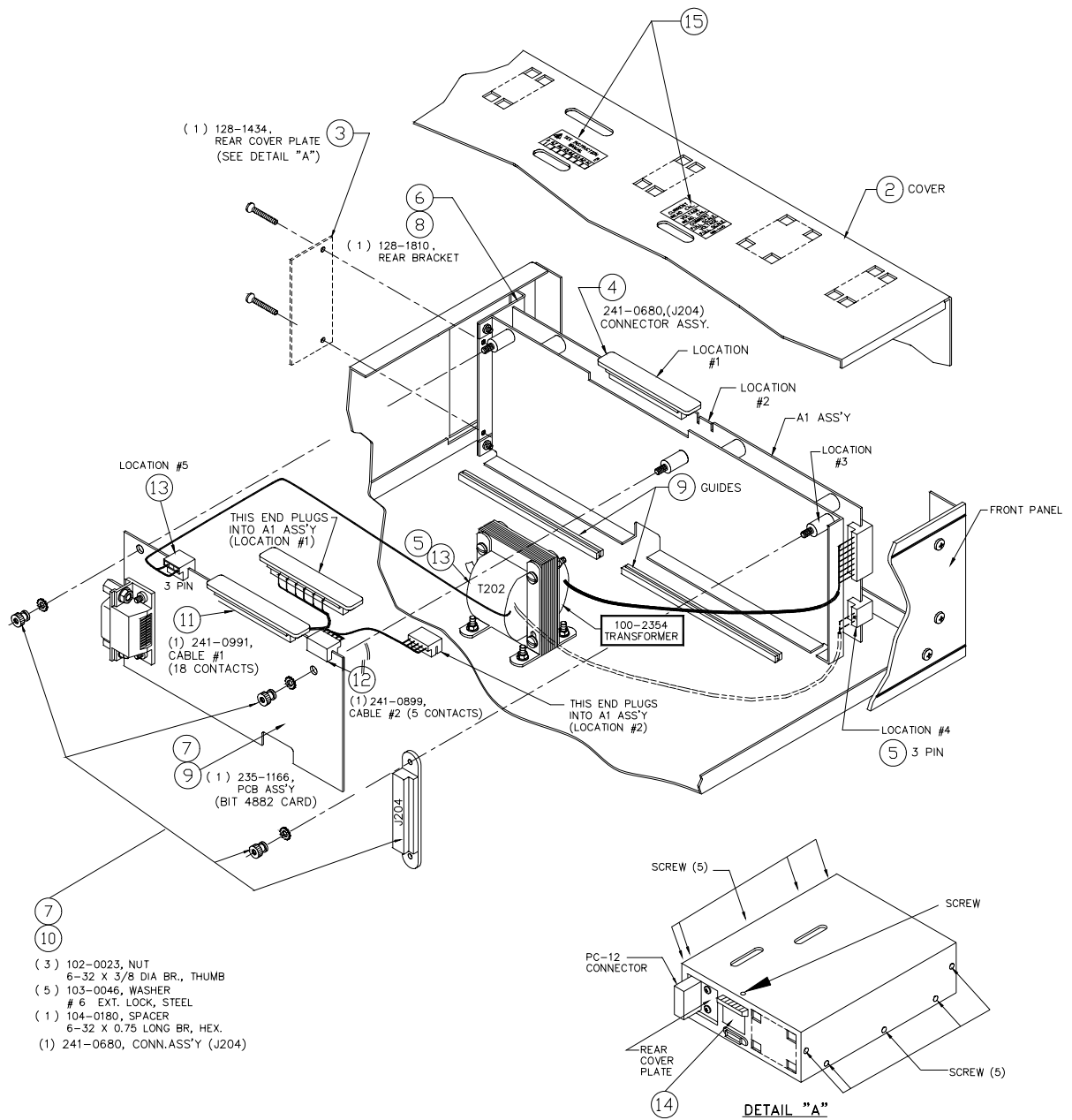
## 2.3 INSTALLATION OF INTERFACE CARD INTO THE BOP

Refer to Figure 2-2 to install the BIT 4886 interface card.

**CAUTION: The BIT 4886 card contains ESD sensitive components. Follow all procedures in effect at your facility for handling ESD sensitive components.**

NOTE: Step numbers coincide with encircled numbers on Figure 2-2.

- Step 1. Remove a-c power to BOP by disconnecting line cord.
- Step 2. Remove BOP cover (see Section 5, Figure 5-1 of your BOP Instruction Manual).
- Step 3. Remove and discard Rear Cover Plate (PN 128-1434) and associated hardware.
- Step 4. Remove J204 Connector Assembly (PN 241-0680) from Location #1, save for Step 9.
- Step 5. Locate Transformer T202 and unplug connector from Location #4 only.
- Step 6. Locate Rear Bracket and note part number (stamped on outside left edge):  
if PN 128-1566, remove and discard, replace with Bracket noted in Step 8.
- Step 7. Unpack the BIT 4886 Interface Card Installation Components (PCB Assembly, Cables #1 and #2, Connector Assembly, three (3) Knurled Nuts, five (5) washers, Spacer and Bracket).
- Step 8. Mount Rear Bracket (PN 128-1810) if required, (ref. Step 6, above).
- Step 9. Install PCB Assembly (PN 236-1836) into the guides, slide into position so that mounting holes in PCB Assembly line up with the two mounting posts on the BOP mounting bracket.
- Step 10. Secure the BIT 4886 Interface Card to the Mounting Posts using the Knurled Nuts and Lockwashers. Mount Connector J204 (Ref. Step 4, above) into Location #3 using the Lockwashers, Hex Spacer and knurled nut.
- Step 11. Install Cable #1 (18-position connectors) to the BIT 4886 Interface Card, mate the other end of the cable with Location #1 on BOP A1 Assembly.
- Step 12. Install Cable #2 (5-position connectors) to the BIT 4886 Interface Card, mate the other end of the cable with Location #2 on BOP A1 Assembly.
- Step 13. Plug in 3 pin Connector from Transformer 100-2354 (removed in step 5) into BIT 4886 Card, Location #5.
- Step 14. Mark "-4886" after Model No. on Nameplate (see Detail A).
- Step 15. On BOP cover, peel off "Control Identification" label (PN 188-1107) and "Address Label" (PN 188-1012). Affix revised "Control Identification" label (PN 188-1826) and "Address Label" (PN 188-1726) in vacated positions (with part numbers facing front panel).
- Step 16. Initialize the GPIB per PAR. 4.2, then proceed to step 17.
- Step 17. Perform calibration procedure detailed in Section 3 of this manual.
- Step 18. Reinstall BOP cover.



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FIGURE 2-2. INSTALLATION OF MODEL BIT 4886 INTO BOP

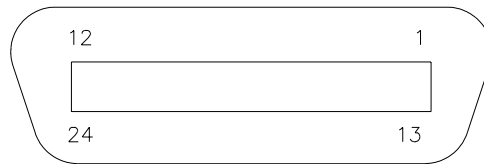
**2.4 INPUT/OUTPUT SIGNALS**

The IEEE 488 port is a 24 pin IEEE 488 connector (Figure 2-3) and conforms mechanically and electrically to the IEEE 488 standard. Refer to Table 2-3 for pin assignments.

**TABLE 2-3. INPUT/OUTPUT PIN ASSIGNMENTS**

PIN	SIGNAL NAME	FUNCTION
1	DI01	I/O Line
2	DI02	I/O Line
3	DI03	I/O Line
4	DI04	I/O Line
5	EOI	End or Identify
6	DAV	Data Valid
7	NRFD	Not Ready for Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Shield
13	DI05	I/O Line
14	DI06	I/O Line
15	DI07	I/O Line
16	DI08	I/O Line
17	REN	Remote Enable
18	GND	Ground (signal common)
19	GND	Ground (signal common)
20	GND	Ground (signal common)
21	GND	Ground (signal common)
22	GND	Ground (signal common)
23	GND	Ground (signal common)
24	LOGIC GND	Logic Ground

IEEE 488 BUS (GPIB) 24 PIN RECEPTACLE



3041133

**FIGURE 2-3. IEEE 488 (GPIB) CONNECTOR**

## 2.5 INITIAL CHECK-OUT PROCEDURE

After the BIT 4886 card has been installed per PAR. 2.3, perform the following procedure to verify that it is functioning properly.

1. Connect the BOP-BIT 4886 power supply to the GPIB and apply power to BOP power supply. The BOP-BIT 4886 will beep for less than 1 second, then will be ready for use.
2. Send the **\*IDN?** query via the GPIB.

Assuming the BIT 4886 card is installed in a BOP 72-6 as an example, verify that the unit responds with **KEPCO,BIT488-6 72-6,A38621 11/10/98,1.81-1.81**.

If the unit responds with **KEPCO,BIT488-6 200-20,A38621 10/01/98,1.81-1.81**, it means that the card was not initialized (see PAR. 4.2).

Note that date **10/01/98** is the initial calibration date performed at the factory and indicates the card has never been calibrated by the user.

3. Send **VOLT?** Verify that unit responds with **0** (indicating voltage is set to 0, the power up condition).
4. Send **FUNC:MODE CURR**. Verify that BOP front panel current led lights.
5. Send **FUNC:MODE VOLT**. Verify that BOP front panel voltage LED will lights.
6. Send **OUTPUT ON;VOLT MAX**. Verify that the BOP power supply provides maximum output voltage (e.g., 72V d-c. for BOP 72-6).



## SECTION 3 - CALIBRATION

NOTE: The calibration procedures below are for the purpose of recalibration and for the case where the BIT card is installed by the user. Unless otherwise noted, syntax is in SCPI.

### 3.1 EQUIPMENT REQUIRED

The following is a listing of equipment required for calibration of the Interface Card installed in a Kepco "BOP" Series Power Supply:

- A. Precision digital voltmeter (DVM), minimum resolution 7 digits (suggested):
- B. An IEEE 488 System Controller, (with appropriate software) connected to BOP Power Supply with an IEEE 488 cable.
- C. Precision four-terminal current shunt (sense resistor) with suitable power rating and tolerance for the currents to be measured.
- D. Heat sink, capable of dissipating 10 times power rating of sense resistor

### 3.2 BOP POWER SUPPLY ADJUSTMENTS

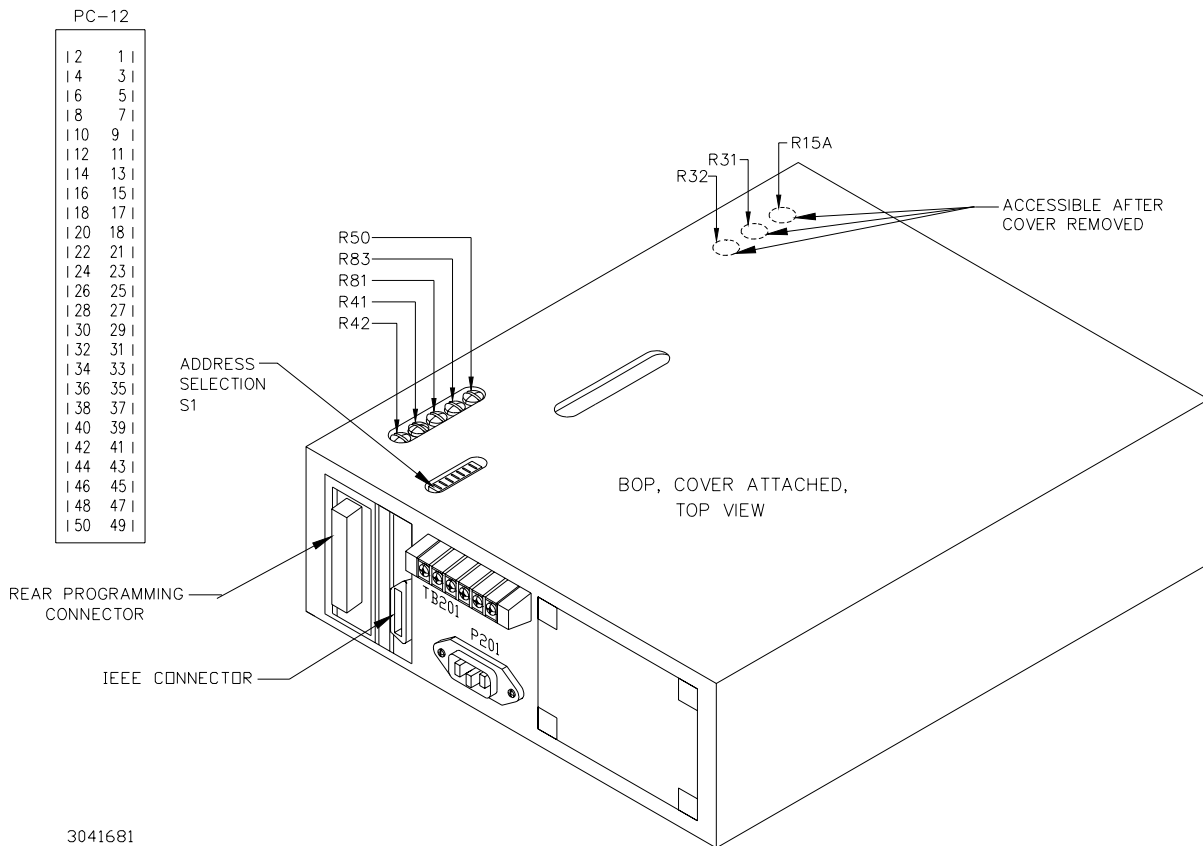
#### 3.2.1 ADJUSTMENT OF THE BOP $\pm 10$ VOLT CALIBRATION CONTROLS (R31, R32)

NOTE: BOP cover removal required for this step.

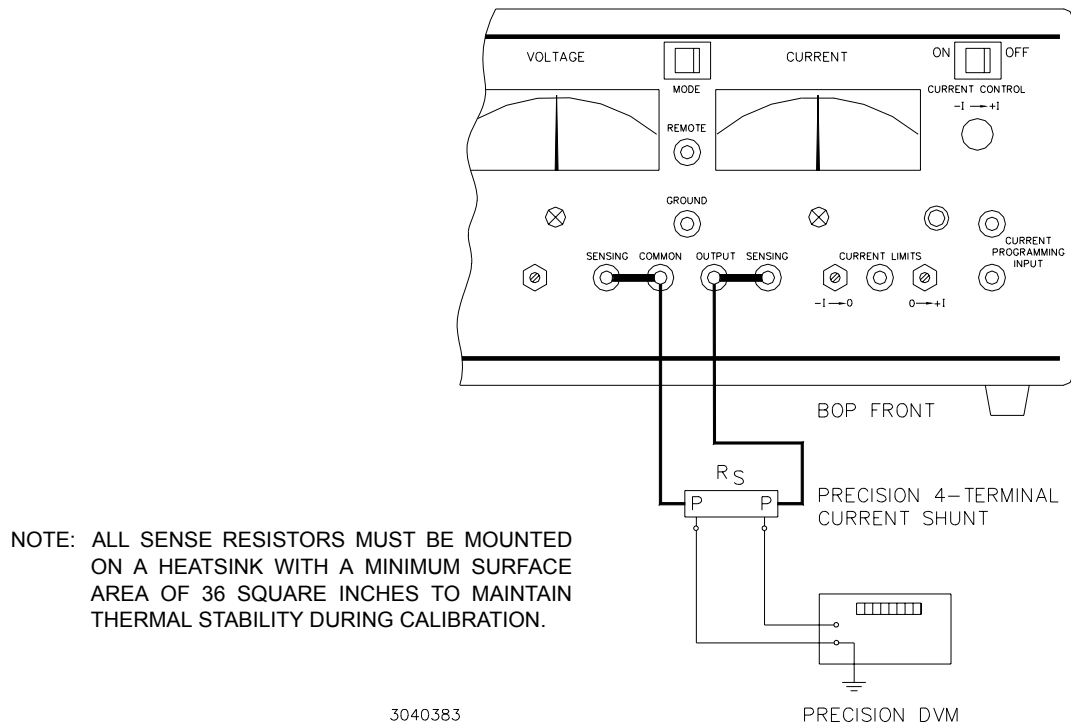
1. Connect the DVM to the REAR PROGRAMMING CONNECTOR (PC-12); between common and pin 28 (+10Vdc REFERENCE).
2. Turn the BOP Power Supply "ON" and locate the calibration controls (see Figure 3-1). Adjust R31 for +10.000  $\pm$ 0.0005Vdc.
3. Turn the BOP Power Supply "OFF" and connect DVM between common and pin 22 (-10Vdc REFERENCE) at the REAR PROGRAMMING CONNECTOR (PC).
4. Turn the BOP Power Supply "ON". Adjust R32 for -10.000  $\pm$ 0.0005Vdc.
5. Turn the BOP Power Supply "OFF".

#### 3.2.2 ADJUSTMENT OF THE AMMETER ZERO (R50)

1. Without a load connected to the BOP output, connect the DVM to the REAR PROGRAMMING CONNECTOR (PC-12); between COMMON and pin 10.
2. Turn the BOP Power Supply "ON" and locate AMMETER ZERO control R50 (see Figure 3-1).
3. Adjust the AMMETER ZERO control R50 for zero,  $\pm$ 100 microvolts.
4. Turn the BOP Power Supply "OFF".



**FIGURE 3-1. BOP POWER SUPPLY, INTERNAL CALIBRATION CONTROL LOCATIONS**



**FIGURE 3-2. CURRENT SHUNT CONNECTIONS**



### 3.3 CALIBRATION OF BIT 4886 INTERFACE CARD

Calibration of the BIT 4886 card is performed using SCPI commands. The Instrument driver available at [www.kepcopower.com/drivers.htm](http://www.kepcopower.com/drivers.htm) provides a graphical interface with informational displays and prompts which lead you through the calibration of the BIT 4886 card. This VISA compliant driver works with many GPIB cards from suppliers like National Instruments and Hewlett-Packard.

Calibration using the graphical interface is described in PAR. 3.3.2; as an alternative to the graphical interface, the BIT 4886 card can also be calibrated using the manual procedure described in PAR. .

NOTE: During calibration various circuits of the BIT 4886 Interface Card are verified. If an error occurs during the verification process, the interface card will beep and an error 240, Hardware, will be placed in the error queue.

The calibration values for different BOP Models are defined in Tables 3-1 and 3-2 for voltage and current, respectively. For each step requiring a measurement during calibration the tolerance of the measurements are included in Tables 3-1 and 3-2 and are not repeated in the individual steps.

Table 3-3 lists suggested sense resistors and includes Kepco and Manufacturer's part numbers. The accuracy of these resistors is 0.1% and will result in a system accuracy of 0.11% if the listed values in Tables 3-1 and 3-2 are used. **For a system accuracy of 0.01%, measure the actual value of the sense resistor accurate to 7 places. Then calculate the expected values per Table 3-2 notes A-E; use with the listed tolerances of Table 3-2 to perform the calibration.**

**TABLE 3-1. CALIBRATION MEASUREMENTS AND TOLERANCES - VOLTAGE**

MODEL	LOW RANGE ZERO	VOLT ZERO	MAX OUTPUT	HIGH RANGE ACCURACY	LOW RANGE ACCURACY	LOW RANGE NOMINAL	VOLTAGE LIMIT ADJUST
	PAR. STEP 2	PAR. STEP 3	PAR. STEPS 4, 5	PAR. STEPS 6, 8	PAR. STEPS 11, 13	PAR. STEP 10	PAR. STEP 15
	PAR. 3.3.2 STEP 4	PAR. 3.3.2 STEP 5	N/A	PAR. 3.3.2 STEPS 6, 7	PAR. 3.3.2 STEPS 8, 9	N/A	PAR. 3.3.2 STEP 3
<b>BOP 20-5M BOP 20-10M BOP 20-20M</b>	0V ±0.0003V	0V ±0.0003V	20V	20.0015V (MAX) -20.0015V (MIN) ±0.0015V	5.0003V (MAX) -5.0003V (MIN) ±0.0003V	5V	+20.0035V ±0.0035V
<b>BOP 36-6M BOP 36-12M</b>	0V ±0.0004V	0V ±0.0004V	36V	36.0027V (MAX) -36.0027V (MIN) ±0.0027	9.0006V (MAX) -9.0006V (MIN) ±0.0006	9V	+36.005V ±0.005V
<b>BOP 50-2M BOP 50-4 BOP 50-8</b>	0V ±0.0005V	0V ±0.0005V	50V	50.0035V (MAX) -50.0035V (MIN) ±0.0035	12.5009V (MAX) -12.5009V (MIN) ±0.0009	12.5V	+50.007V ±0.007V
<b>BOP 72-3M BOP 72-6M</b>	0V ±0.001V	0V ±0.001V	72V	72.005V (MAX) -72.005V (MIN) ±0.005	18.0014V (MAX) -18.0014V (MIN) ±0.0014	18V	+72.0095V ±0.0095V
<b>BOP 100-1M BOP 100-2M BOP 100-4M</b>	0V ±0.001V	0V ±0.001V	100V	100.0075V (MAX) -100.0075V (MIN) ±0.0075	25.002V (MAX) -25.002V (MIN) ±0.002	25V	+100.0125V ±0.0125V
<b>BOP 200-1M</b>	0V ±0.002V	0V ±0.002V	200V	200.01V (MAX) -200.01V (MIN) ±0.01	50.004V (MAX) -50.004V (MIN) ±0.004	50V	+200.025V ±0.025V

**TABLE 3-2. CALIBRATION MEASUREMENTS AND TOLERANCES - CURRENT**

MODEL	SENSE RESISTOR VALUE (SEE NOTE AND TABLE 3-3)	LOW CURRENT ZERO	MAIN CURRENT ZERO	MAIN CURRENT NOMINAL	HIGH CURRENT ACCURACY	LOW CURRENT NOMINAL	LOW CURRENT ACCURACY	CURRENT LIMIT ADJUST
		PAR. STEP 17	PAR. STEP 18	PAR. STEPS 19, 20	PAR. STEPS 21, 23	PAR. STEP 24, 25	PAR. STEPS 26, 28	PAR. STEP 30
		PAR. 3.3.2 STEP 15	PAR. 3.3.2 STEP 18	N/A	PAR. 3.3.2 STEPS 19, 20	N/A	PAR. 3.3.2 STEPS 16, 17	PAR. 3.3.2 STEP 15
<b>BOP 100-1M BOP 200-1M</b>	1 Ohm	0V ±0.000025V	0V ±0.00005V	1V	1.000075V (MAX) -1.000075V (MIN) ±0.000075V	0.25V	0.25005V (MAX) -0.25005V (MIN) ±0.00005V	1.0013V ±0.0013V
<b>BOP 50-2M BOP 100-2M</b>	1 Ohm	0V ±0.00005V	0V ±0.0001V	2V	2.00015V (MAX) -2.00015V (MIN) ±0.00015V	0.5V	0.5001V (MAX) -0.5001V (MIN) ±0.0001V	2.00026V ±0.00026V
<b>BOP 72-3M</b>	1 Ohm	0V ±0.000075V	0V ±0.00015V	3V	3.0003V (MAX) -3.0003V (MIN) ±0.0003V	0.75V	0.75015V (MAX) -0.75015V (MIN) ±0.00015V	3.0039V ±0.0039V
<b>BOP 50-4 BOP 100-4M</b>	1 Ohm	0V ±0.0001V	0V ±0.0002V	4V	4.0004V (MAX) -4.0004V (MIN) ±0.0004V	1V	1.0002V (MAX) -1.0002V (MIN) ±0.0002V	4.0007V ±0.0007V
<b>BOP 20-5M</b>	0.1 Ohm	0V ±0.0000125V	0V ±0.000025V	0.5V	0.5000375V (MAX) -0.5000375V (MIN) ±0.0000375V	0.125V	0.125025V (MAX) -0.125025V (MIN) ±0.000025V	0.50065V ±0.00065V
<b>BOP 36-6M BOP 72-6M</b>	0.1 Ohm	0V ±0.000015V	0V ±0.00003V	0.6V	0.600045V (MAX) -0.600045V (MIN) ±0.0000225V	0.15V	0.15003V (MAX) -0.15003V (MIN) ±0.00003V	0.60075V ±0.00075V
<b>BOP 50-8</b>	0.1 Ohm	0V ±0.00002V	0V ±0.00004V	0.8V	0.80006V (MAX) -0.80006V (MIN) ±0.00006V	0.2V	0.20004V (MAX) -0.20004V (MIN) ±0.00004V	0.80105V ±0.000105V
<b>BOP 20-10M</b>	0.1 Ohm	0V ±0.000025V	0V ±0.00005V	1.0V	1.000075V (MAX) -1.000075V (MIN) ±0.000075V	0.25V	0.25005V (MAX) -0.25005V (MIN) ±0.00005V	1.00013V ±0.00013V
<b>BOP 36-12M</b>	0.01 Ohm	0V ±0.000003V	0V ±0.000006V	0.12V	1.020009V (MAX) -1.020009V (MIN) ±0.000009V	0.03V	0.030006V (MAX) -0.030006V (MIN) ±0.000006V	0.120016V ±0.000016V

**TABLE 3-2. CALIBRATION MEASUREMENTS AND TOLERANCES - CURRENT (CONTINUED)**

MODEL	SENSE RESISTOR VALUE (SEE NOTE AND TABLE 3-3)	LOW CURRENT ZERO	MAIN CURRENT ZERO	MAIN CURRENT NOMINAL	HIGH CURRENT ACCURACY	LOW CURRENT NOMINAL	LOW CURRENT ACCURACY	CURRENT LIMIT ADJUST
		PAR. STEP 17	PAR. STEP 18	PAR. STEPS 19, 20	PAR. STEPS 21, 23	PAR. STEP 24, 25	PAR. STEPS 26, 28	PAR. STEP 30
		PAR. 3.3.2 STEP 15	PAR. 3.3.2 STEP 18	N/A	PAR. 3.3.2 STEPS 19, 20	N/A	PAR. 3.3.2 STEPS 16, 17	PAR. 3.3.2 STEP 15
BOP 20-20M	0.001 Ohm	0V ±0.00000005V	0V ±0.0000001V	0.02V	0.02000015V (MAX) -0.02000015V (MIN) ±0.00000015V	0.005V	0.0050001V (MAX) -0.0050001V (MIN) ±0.0000001V	0.0200025V ±0.0000025V
REFER TO NOTES IF EXACT SENSE RESISTOR VALUE IS KNOWN.	R <sub>SENSE</sub> SEE NOTE.	SEE NOTE A.	SEE NOTE B.	SEE NOTE C.	SEE NOTES C AND D	SEE NOTE E.	SEE NOTES E AND B.	SEE NOTE F.
USE SPACE PROVIDED AT RIGHT FOR CALCULATED VALUES.								

**NOTES:** The following formulas are used to calculate proper calibration values if the exact Sense Resistor value is known.

$R_{SENSE}$  = the measured value of the sense resistor to 6 places (minimum).

$I$  = Rated current output of BOP (e.g., for BOP 50-4M,  $I = 4$ )

A.  $(R_{SENSE}) (I/4) (0.00005)$

B.  $(R_{SENSE}) (I/4) (0.0001)$  [FOR MODELS WHERE  $I = 3$  OR  $4$  USE  $(R_{SENSE}) (I/4) (0.00015)$ ]

C.  $(R_{SENSE}) (I)$

D.  $(R_{SENSE}) (I) (0.00075)$  [FOR MODELS WHERE  $I = 3$  OR  $4$  USE  $(R_{SENSE}) (I) (0.00012)$ ]

E.  $(R_{SENSE}) (I/4)$

F.  $[(R_{SENSE}) (I_{max})]/3800$

**TABLE 3-3. SUGGESTED SENSE RESISTORS**

FOR BOP WITH RATED CURRENT	USE SENSE RESISTOR VALUE	KEPCO PART NO.	MANUFACTURER	MANUFACTURER PART NO.
20A	0.001 OHM, 30W	KT 3126	ISOTEK	RTO-B-R1-1
12A	0.01 OHM, 30W	KT 3130	ISOTEK	RTO-B-R01-1
5A, 6A, 8A, 10A	0.1 OHM, 30W	KT 3131	ISOTEK	RTO-B-R001-1
1A, 2A, 3A, 4A	1 OHM, 30W	KT 3146	ISOTEK	RTO-B-1R00-1.0

NOTE: ALL SENSE RESISTORS MUST BE MOUNTED ON A HEATSINK WITH A MINIMUM SURFACE AREA OF 36 SQUARE INCHES TO MAINTAIN THERMAL STABILITY DURING CALIBRATION (KEPCO P/N 136-0451 RECOMMENDED FOR KT SENSE RESISTORS LISTED).

### 3.3.1 MANUAL CALIBRATION

1. Initiate calibration by sending the SCPI command **SYSTem:PASSword:CENable DEFAULT** and then send **CAL:STATe 1**. The password (DEFAULT) has been set at the factory. If the password has been changed from DEFAULT, substitute the correct password for the unit in the **SYST:PASS:CEN** command. If the password has been forgotten, consult factory.

If voltage calibration is not needed, proceed to step 16 for current calibration.

2. Set the BOP to zero volts output under the 1/4 range by sending **CAL:LVOLT ZERO**. Connect a Digital Voltmeter (DVM) to the BOP output to measure the power supplies output. Send the Command **CAL:DPOT 32** to increase the output voltage until the DVM no longer changes in response to the command. Then send the Command **CAL:DPOT -32** to the unit. Adjust A1R81 on BOP until the DVM reads the voltage specified in Table 3-1 for LOW RANGE ZERO.
3. Set the BOP output voltage to zero by sending **CAL:VOLT ZERO**. Send the command **CAL:DPOT 1** to increase the voltage or **CAL:DPOT -1** to decrease the voltage until the DVM reads the voltage specified in Table 3-1 for VOLT ZERO.
4. Set the BOP to maximum positive output voltage by sending **CAL:VOLT MAX**. Measure the voltage output using a DVM of at least 7 digits in accuracy.
5. Decrease the voltage output by sending **CAL:DPOT -1** commands until the voltmeter reads less than the rated output voltage specified in Table 3-1 for MAX OUTPUT. Then send **CAL:DPOT 1** and verify the voltage is slightly above the rated output voltage specified in Table 3-1 for MAX OUTPUT
6. Referring to Table 3-1 (HIGH RANGE ACCURACY) for value and  $\pm$  tolerance, send the command **CAL:DATA -10** to decrease the voltage until the voltage is less than the rated output. Send the command **CAL:DATA 1** to increase the voltage or the command **CAL:DATA -1** to decrease the voltage until the DVM reads the value specified in Table 3-1 for HIGH RANGE ACCURACY MAX.
7. Set the BOP to maximum negative output by sending **CAL:VOLT MIN**. Continue to measure the output of the supply using the DVM.
8. If the output is less negative than the value specified in Table 3-1 for HIGH RANGE ACCURACY MIN, send **CAL:DATA -100** and verify the output is now more negative. If the value is still not more negative, Send **CAL:DPOT -1** to change the course adjustment and provide a more negative output.

Send the command **CAL:DATA 10** to increase the voltage. Continue to send **CAL:DATA 10** until the voltage is less negative than value specified in Table 3-1 for HIGH RANGE ACCURACY MIN. Send **CAL:DATA -1** until the reading is within the limits specified in Table 3-1 for HIGH RANGE ACCURACY MIN

If the **CAL:DPOT** command was used to adjust the negative output, send **CAL:VOLT MAX** to the unit and repeat step 6 before proceeding to step 9.

9. Set the BOP to 1/4 scale (low) range positive output voltage by sending **CAL:LVOLT MAX**. Output voltage should be as specified in Table 3-1 for LOW RANGE NOMINAL. Measure the voltage output using a Digital Voltmeter of at least 7 digits in accuracy.

10. Decrease the voltage output by sending **CAL:DPOT -1** commands until the voltmeter reads less than the rated output. Then send **CAL:DPOT 1** and verify the voltage is slightly above value specified in Table 3-1 for LOW RANGE NOMINAL.
11. Send the command **CAL:DATA -10** to decrease the voltage until the voltage is less than value specified in Table 3-1 for LOW RANGE ACCURACY MAX. Send the command **CAL:DATA 1** to increase the voltage and if over the voltage use **CAL:DATA -1** to obtain the value specified in Table 3-1 for LOW RANGE ACCURACY MAX.
12. Set the BOP to maximum negative 1/4 scale range output by sending **CAL:LVOLT MIN**. Continue to measure the output of the supply.
13. If the output is less negative than the value specified in Table 3-1 for LOW RANGE ACCURACY MIN, send **CAL:DATA -100** and verify the output is now more negative. If the value is not more negative, Send **CAL:DPOT -1** to change the course adjustment and provide a more negative output.

Send the command **CAL:DATA 10** to increase the voltage. Continue to send **CAL:DATA 10** until the voltage is less negative than the value specified in Table 3-1 for LOW RANGE ACCURACY MIN. Send **CAL:DATA -1** until the reading is within the limits specified in Table 3-1 for LOW RANGE ACCURACY MIN.

If the **CAL:DPOT** command was used to adjust the negative output, send **CAL:LVOLT MAX** to the unit and repeat step 11 before proceeding to step 14.

14. Set the BOP to voltage limit by sending **CAL:VPR MAX**. Continue to measure the output of the BOP.
15. Send the command **CAL:DATA -10** to decrease the voltage until the output voltage measured is within, or close to, the tolerance specified in Table 3-1 for VOLTAGE LIMIT ADJUST. Send the command **CAL:DATA 1** to increase the voltage or **CAL:DATA -1** to decrease the voltage as necessary until the measured value is within the tolerance specified in Table 3-1 for VOLTAGE LIMIT ADJUST.

NOTE: If Current calibration is not required, proceed to step 31.

16. Send **CAL:ZERO** to prepare for current calibration. After sending the command, the BOP output will be set to zero volts. Connect the Kelvin type sense resistor to the BOP output using a heat sink capable of dissipating 10 times rated power of sense resistor. Connect the DVM to the sensing terminals of the Kelvin type sense resistor as shown in Figure. Table 3-2 provides suggested sense resistor values for various BOP current outputs, as well as the formula for calculating expected measured values and tolerances for any sense resistor where the precise resistance is known. Table 3-3 lists possible sources for obtaining the suggested sense resistors
17. Set the BOP to zero volts across the sense resistor (corresponding to zero current) under the low (1/4 Scale) current range by sending **CAL:LCURR ZERO**. Monitor the DVM connected to the sense resistor and send the Command **CAL:DPOT 64** to increase the output voltage and **CAL:DPOT -32** to set the digital pot to the center of its range. Adjust A1R83 on BOP until the DVM reads the voltage specified in Table 3-2 for LOW CURRENT ZERO.
18. Set the BOP current to 0 Amps in current mode by sending **CAL:CURR ZERO**. Use the command **CAL:DPOT 1** to increase the current or **CAL:DPOT -1** to decrease the current until the DVM reads the voltage specified in Table 3-2 for MAIN CURRENT ZERO.

19. Set the BOP to maximum positive output current by sending **CAL:CURR MAX**. Measure the voltage across the sense resistor using a Digital Voltmeter of at least 7 digits in accuracy. Verify the DVM reads the voltage specified in Table 3-2 for MAIN CURRENT NOMINAL. The voltage shown on the DVM should be positive; if not, reverse the leads to the DVM.
20. Decrease the voltage across the sense resistor by sending **CAL:DPOT -1** commands until the voltmeter reads less than the value specified in Table 3-2 for MAIN CURRENT NOMINAL. Then send **CAL:DPOT 1** and verify the voltage is slightly above the specified voltage.
21. Send the command **CAL:DATA -10** to decrease the voltage across the sense resistor until the voltage is less than the value specified in Table 3-2 for HIGH CURRENT ACCURACY MAX. Send the command **CAL:DATA 1** to increase the voltage or **CAL:DATA -1** to decrease the voltage until the DVM reads the voltage specified in Table 3-2 for HIGH CURRENT ACCURACY MAX.
22. Set the BOP to maximum negative output by sending **CAL:CURR MIN**. Continue to measure the voltage across the sense resistor.
23. If the voltage across the sense resistor is less negative than the value specified in Table 3-2 for HIGH CURRENT ACCURACY MIN, send **CAL:DATA -100** and verify the output is now more negative. If the value is not more negative than the value found in Table 3-2 for HIGH CURRENT ACCURACY MIN, send **CAL:DPOT -1** to change the course adjustment and provide a more negative output.

Send the command **CAL:DATA 10** to increase the voltage across the sense resistor. Continue to send **CAL:DATA 10** until the voltage is less than the value specified in Table 3-2 for HIGH CURRENT ACCURACY MIN. Send **CAL:DATA -1** until the DVM reads the voltage specified in Table 3-2 for HIGH CURRENT ACCURACY MIN.

If the **CAL:DPOT** command was used to adjust the negative output, send **CAL:CURR MAX** to the unit and repeat step 21 before proceeding to step 24.

24. Set BOP to the maximum current at low range (1/4 Scale) by sending **CAL:LCURR MAX**. Verify the DVM reads the voltage specified in Table 3-2 for LOW CURRENT NOMINAL.
25. Decrease the voltage across the sense resistor by sending **CAL:DPOT -1** commands until the voltmeter reads less than the value specified in Table 3-2 for LOW CURRENT NOMINAL. Then send **CAL:DPOT 1** and verify the voltage is slightly above this value.
26. Send the command **CAL:DATA -10** to decrease the voltage across the sense resistor until the voltage is less than the value specified in Table 3-2 for LOW RANGE ACCURACY MAX. If necessary, send the command **CAL:DATA 1** to increase the voltage across the sense resistor or **CAL:DATA -1** to decrease the voltage across the sense resistor until the DVM reads the voltage specified in Table 3-2 for LOW RANGE ACCURACY MAX.
27. Set the BOP to maximum negative 1/4 scale range output current by sending **CAL:LCURR MIN**. Continue to measure the voltage across the sense resistor.
28. If the voltage across the sense resistor is less negative than the value specified in Table 3-2 for LOW RANGE ACCURACY MIN, send **CAL:DATA -100** and verify the output is now more negative. If the value is not more negative, Send **CAL:DPOT -1** to change the course adjustment and provide a more negative output.

Send the command **CAL:DATA 10** to increase the voltage across the sense resistor. Continue to send **CAL:DATA 10** until the voltage is less than the value specified in Table 3-2 for LOW RANGE ACCURACY MIN. Send **CAL:DATA -1** until the reading is within the limits specified in Table 3-2 for LOW RANGE ACCURACY MIN.

If the `CAL:DPOT` command was used to adjust the negative output, after adjusting the negative supply output, send `CAL:LCURR MAX` to the unit and repeat step 26 before proceeding to step 29.

- 29. Set the BOP to current limit by sending `CAL:CPR MAX`. Continue to measure the output of the BOP.
- 30. Send the command `CAL:DATA -10` to decrease the voltage across the sense resistor until the output voltage measured is within, or close to, the tolerance specified in Table 3-2 for CURRENT LIMIT ADJUST. Send the command `CAL:DATA 1` to increase the voltage or `CAL:DATA -1` to decrease the voltage as necessary until the measured value is within the tolerance specified in Table 3-1 for CURRENT LIMIT ADJUST.
- 31. Save the calibration levels by sending `CAL:SAVE 2/21/2004`. The 9 characters at the end are optional and are the calibration date of the power supply. The date entered in this manner is reported in the `*idn?` query. This can be prove useful for checking calibration dates when periodic calibration is imposed by system or quality requirements.

**3.3.2 CALIBRATION OF BIT 4886 INTERFACE CARD USING THE VISA DRIVER SOFT PANEL**

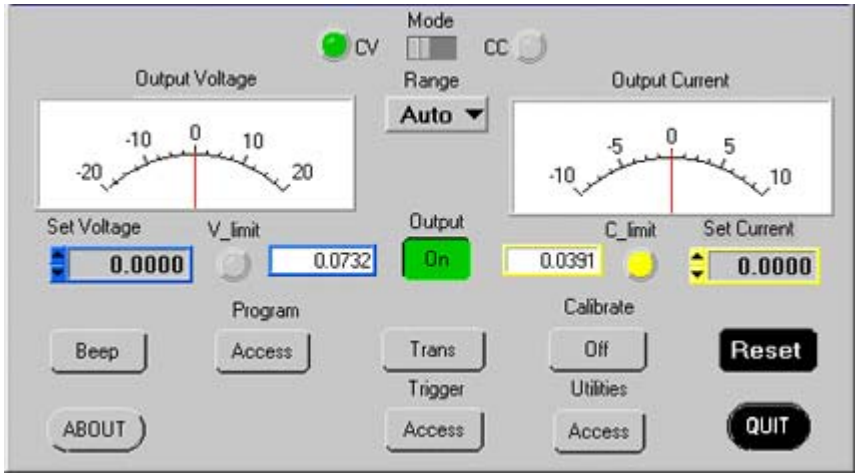
Calibration of the BIT 4886 card installed in the BOP is performed using SCPI commands implemented through the Instrument driver. The driver provides a graphical interface with informational displays and prompts which lead you through the calibration of the BIT 4886 card. This VISA compliant driver works with many GPIB cards from suppliers like National Instruments and Hewlett-Packard.

NOTE: PC-12 connector (See Figure 2-2) must be installed for BOP to function.

The following calibration procedure uses the “soft” front panel which is part of the CVI driver for the BIT 4886 which can be downloaded from the Kepco website at:

[www.kepcopower.com/drivers.htm](http://www.kepcopower.com/drivers.htm)

Unzip the files and doubleclick on setup.exe to install the driver. The bit\_mdac folder will be added to the Start - Programs folder. Doubleclick bit\_mdac.exe to run the program, and refer to the visamdac.pdf in the bit\_mdac folder for details about using the soft front panel.



**FIGURE 3-3. MAIN PANEL**

### 3.3.2.1 CALIBRATION BASICS

**CAUTION:** Before performing calibration, set BOP OUTPUT to OFF and connect short across BOP output, then set OUTPUT to ON and Voltage to 10V. **It is necessary to wait 10 minutes before calibrating the unit to allow for thermal stabilization.** After 10 minutes, set OUTPUT to OFF and remove short from BOP output, then proceed with calibration.

All adjustments are done using the six arrow buttons of the Calibration Panel (see Figure 3-4 and Table 3-4). The double arrow buttons  $\ll$  and  $\gg$  either increase ( $\gg$ ) or decrease ( $\ll$ ) the output five steps at a time; the  $\leftarrow$  and  $\rightarrow$  buttons either increase ( $\rightarrow$ ) or decrease ( $\leftarrow$ ) the output one step at a time. The triple arrow buttons  $\lll$  and  $\ggg$  either increase ( $\ggg$ ) or decrease ( $\lll$ ) the output 80 steps at a time. The  $\ll$ ,  $\gg$ ,  $\leftarrow$ , and  $\rightarrow$  buttons only work within the 80-step window established by  $\lll$  and  $\ggg$ .

For MAX and MIN Calibrations fine adjustment is done using the  $\ll$ ,  $\gg$ ,  $\leftarrow$ , and  $\rightarrow$  buttons. If the value can not be set within the specified tolerance using the fine adjustment, use the coarse adjustment to increase ( $\ggg$ ) or decrease ( $\lll$ ) the output, as needed, then use the fine adjust buttons to set the value within tolerance. Where large adjustment is necessary,  $\lll$  and  $\ggg$  can be used first to bring the output close before using the  $\ll$ ,  $\gg$ ,  $\leftarrow$ , and  $\rightarrow$  buttons.

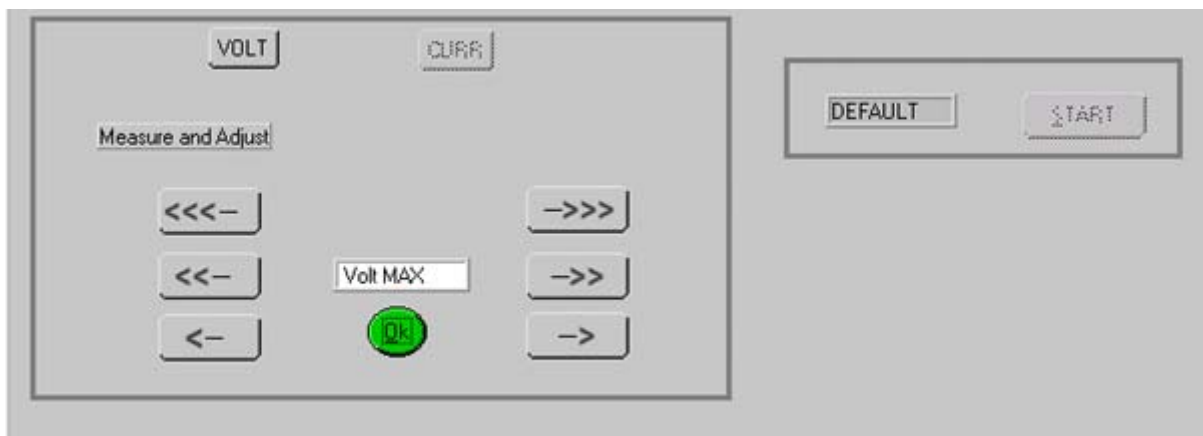


FIGURE 3-4. CALIBRATION PANEL

TABLE 3-4. CALIBRATION PANEL FUNCTIONS

BUTTON OR WINDOW	Function
START button	Initiates calibration
Text box (Adjacent to <b>START</b> button)	Used to enter unit password
VOLT button	Initiates Voltage calibration
CURR button	Initiates Current calibration
Message box (below <b>VOLT</b> buttons)	Provides instructions about the calibration process.
White text window (above <b>OK</b> button)	Displays the parameter currently being calibrated.
Á button	Fine Adjustment - Decreases the output value by one LSB.
Ë button	Fine Adjustment - Increases the output value by one LSB.
$\ll$ button	Adjustment - Decreases the output value by five LSBs.
$\gg$ button	Adjustment - Increases the output value by five LSBs.
$\lll$ button	Coarse Adjustment - Decreases the output value by 80 LSBs.
$\ggg$ button	Coarse Adjustment - Increases the output value by 80 LSBs.
OK button	Enters the value displayed in the white text window



### 3.3.2.2 CALIBRATION PROCEDURE

1. Click on the **Calibration Off** button on the main panel (see Figure 3-4). This will open a calibration panel (see Figure 3-4 and Table 3-4) that allows calibration in either voltage or current mode.
2. The password (DEFAULT) has been set at the factory. If it has not been changed, it will be displayed in the box adjacent to the **Start** button on the right side of the panel. If the password has been changed from DEFAULT, substitute the proper password in the box adjacent to the **Start** button and click the **Start** button. If the password has been forgotten, consult factory. If the password is correct, the **Volt** and **Curr** buttons will become active. Otherwise the message **ERROR! - Wrong Password** is displayed and you must enter the correct password and click **Start** again.
3. For Voltage Calibration, click **Volt** button. The text window reads **volt ZERO** and the message **Adjust for ZERO R81 (Eo Zero) on BOP A1 card.** is displayed.
4. Connect a DVM to the output of the unit and adjust the R81 Potentiometer on A1 board of BOP until the DVM reads the voltage specified in Table 3-1 for Low Range Zero, then click **OK** button.

NOTE: Use external DVM for all measurements.

5. The text window reads **volt ZERO** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust the output until the DVM reads the voltage specified in Table 3-1 for VOLT ZERO, then click **OK** button.
6. The text window reads **volt MAX** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust until DVM reading is as specified in Table 3-1 for High Range Accuracy. Click **OK** when done.
7. The text window reads **volt MIN** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust until DVM reading is as specified in Table 3-1 for High Range Accuracy, then click **OK** button. NOTE: If the **<<<—** or **—>>>** button is depressed, proceed to step 6 after clicking **OK**.
8. The text window reads **lvolt MAX** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust output until DVM reads voltage specified in Table 3-1 for Low Range Accuracy, then click **OK** button.
9. The text window reads **lvolt MIN** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust until DVM reads voltage specified in Table 3-1 for Low Range Accuracy, then click **OK** button. NOTE: If the **<<<—** or **—>>>** button is depressed, proceed to step 8 after clicking **OK**.
10. The text window reads **volt PROTECT** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust until DVM reading is as specified in Table 3-1. Click **OK** when done.
11. Voltage calibration is complete. If desired, the voltage calibration can be repeated by clicking **Volt** at the calibration panel (Figure 3-4). If current calibration is not necessary, proceed to step 23.

12. At the calibration panel (Figure 3-4) click **CURR** to begin current calibration of the unit. **Connect CALIBRATION RESISTOR!** window opens.
13. Connect load (see Table 3-3) across the output of the unit and connect DVM across the load as shown in Figure 3-2. Voltage measurements must be converted to Amperes using Ohm's law,  $E = IR$ . Click **OK** button to close **Connect CALIBRATION RESISTOR** window.
14. The test window reads **LCurr ZERO** and the message **Adjust for ZERO R83 (lo Zero) on BOP A1 card.** will be displayed.
15. Adjust the R83 Potentiometer on A1 board of BOP, until the external DVM reads voltage specified in Table 3-2, then click **OK** button.
16. The text window reads **LCurr MAX** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust output until DVM reads voltage specified in Table 3-2 for Low Current Accuracy, then click **OK** button.
17. The text window reads **LCurr MIN** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust until DVM reads voltage specified in Table 3-2 for Low Current Accuracy, then click **OK** button. NOTE: If the **<<<←** or **→>>>** button is depressed, proceed to step 8 after clicking **OK**.
18. The text window reads **Curr ZERO** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust the output until the DVM reads the voltage specified in Table 3-2 for Main Current Zero, then click **OK** button.
19. The text window reads **Curr MAX** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust output until DVM reads the voltage specified in Table 3-2 for High Current Accuracy, then click **OK** button.
20. The text window reads **Curr MIN** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust until DVM reading is as specified in Table 3-2 for High Current Accuracy. NOTE: If the **<<<←** or **→>>>** button is depressed, proceed to step 19 after clicking **OK**.
21. The text window reads **Curr PROTECT** and the message **Measure and Adjust.** is displayed. Using the **←** and **→** and **◀** and **▶** buttons (see PAR. 3.3.2.1), adjust until DVM reading is as specified in Table 3-2. Click **OK** when done.
22. Current calibration is complete. If desired, the current calibration can be repeated by clicking **Curr** at the calibration panel (Figure 3-4).
23. To exit Calibration, click on the **Calibration On** button on the main panel (Figure 3-3). This will open a panel that allows the calibration to be saved. Click **SAVE** to save the calibration constants (both voltage and current), or **CANCEL** to return to the old calibration.

## SECTION 4 - OPERATION

### 4.1 GENERAL

The Kepco BOP Power Supply, with an installed BIT 4886 Interface Card, may be programmed over the IEEE 488 standard communication bus (General Purpose Interface Bus, GPIB) using SCPI (Standard Commands for Programmable Instruments). SCPI provides a common language used in an automatic test system. (Refer to Table 2-3 for input/output signal allocations.)

NOTE: Upon power up, the BOP output is set to off, VOLTage and CURRent are set to 0. VOLTage and CURRent commands will not change the BOP output until the command OUTPut ON is sent to the BIT 4886.

#### 4.1.1 PROGRAMMING TECHNIQUES TO OPTIMIZE POWER SUPPLY PERFORMANCE

Proper programming techniques can offer significant response time improvement and reduce undesirable transients at the power supply output. The key to performance optimization is to minimize mode changes (voltage mode/current limit to current mode/voltage limit or vice versa). Mode changes should be limited to changes in load conditions (to which the power supply will respond automatically), or by programming the limit parameter when required by the user application.

The proper way to program the power supply is to initially program the operating parameter to zero and the complementary limit parameter to the desired maximum value. Subsequent commands should change only the operating parameter. (The operating parameter is the parameter that controls the output, e.g., voltage controls the output in voltage mode, current in current mode.) The complementary limit parameter should be programmed only when there is a need to change it.

##### 4.1.1.1 EXAMPLE OF PROPER PROGRAMMING

Assume the power supply is intended to operate in a test application that requires a set of specific output voltages. The initial set of commands should program output voltage and current limit. If the same current limit applies to the rest of the test, all subsequent commands should only program output voltage.

### 4.2 INITIALIZATION OF THE BIT 4886 CARD

When a BIT 4886 Card is installed in a BOP it must be initialized prior to use. The initialization of the BOP BIT card is performed via the GPIB bus. The process can be accomplished using the supplied computer program (see PAR. 4.2.1) or by sending SCPI commands over the GPIB (see PAR. 4.2.2).

#### 4.2.1 INITIALIZATION USING CVI DRIVER

The initialization procedure uses the "soft" front panel which is part of the CVI driver for the BIT 4886 which can be downloaded from the Kepco website at: [www.kepcopower.com/drivers.htm](http://www.kepcopower.com/drivers.htm).

1. Unzip the files and doubleclick on setup.exe to install the driver. The bit\_mdac folder will be added to the Start - Programs folder. Doubleclick bit\_mdac.exe to run the program, and refer to the visamdac.pdf in the bit\_mdac folder for details about using the soft front panel.

2. Connect GPIB cable from the rear of the BOP with BIT 4886 Card installed to a Microsoft Windows-based computer with National Instruments VISA software installed and verify that BOP has standard PC-12 connector installed (Figure 2-2).
3. Install the VISA driver per the text file included with the driver. At the Start-up screen (Figure 4-1) set the correct GPIB Address and click **CONNECT**. Upon successful initialization the initialization window closes and the Power Supply Type field of the Start-up window (Figure 4-1) shows BIT 4886. Click **Continue**.
4. Refer to Figure 4-2 and enter the following information:
  - **Select Model:** e.g., BOP 100-2.
  - **Serial Number:** Enter serial number found on the rear nameplate of BOP power supply.
  - **Option Number:** If unit is a special (modified) unit, enter 5-digit suffix found in the Manual Addendum
  - Press the **Initialize Card** button

NOTE: If initialization fails and an error message is displayed, repeat step 3, making sure that the proper information is entered.



FIGURE 4-1. VISA DRIVER START-UP

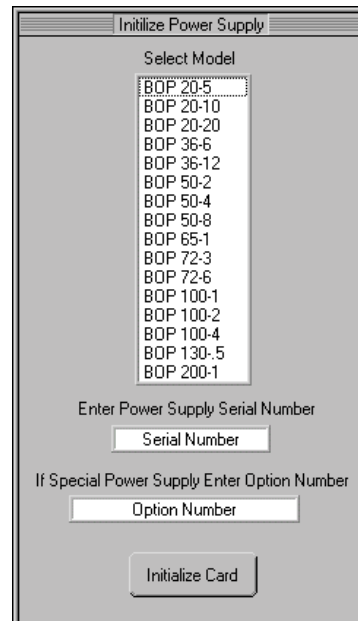


FIGURE 4-2. BIT 4886 CARD INITIALIZATION USING VISA DRIVER

1. After initialization, proceed to PAR. 3.3.2 to calibrate the upgraded unit.

#### 4.2.2 INITIALIZATION USING SCPI COMMANDS

1. Using the GPIB interactive mode, set up the GPIB interface. For a National Instruments card, it is done by the following steps.
  - A. Start the interactive GPIB program.

- B. Type `ibfind DEVx` where x is the hex address of the BOP.
  - C. Type `ibwrt "*idn?"`
  - D. Type `IBREAD 100`. The GPIB will show the identifier string of the BOP as: **KEPCO, BOP 200-20**, with additional characters indicating the revision level of the firmware.
2. Send the password initialization string of: `SYST:PASS:CEN DEFAULT`.
  3. Send the BOP configuration code. The configuration code format is VOLTAGE,CURRENT; for example the 100 Volt, 1 Amp BOP 100-1M is identified as 100,1. The sequence to be sent is: `DIAG:PST 100,1`.
  4. Calibrate the unit per PAR. 3.3. Failure to calibrate the unit will result in the \*TST? query reporting a FLASH memory error.
  5. After the calibration has been completed, the master calibration levels can be established using the following command: `CAL:COPY WORK FACT`.

#### 4.2.3 PASSWORD SETUP.

To change a password send:

`SYST:PASS:CEN DEFAULT`

`SYST:PASS:NEW DEFAULT new_password`

#### 4.2.3.1 FORGOTTEN PASSWORDS

If the password is lost, it is possible to enable the password interface by sending

`SYST:PASS:CEN POWERSUPPLIER`

Once enabled, the password can be set to DEFAULT by sending

`SYST:SEC:OVERRIDE`

#### 4.3 BUILT IN TEST

Refer to Performance Measurements, PAR. 6.4.

#### 4.4 IEEE 488 (GPIB) BUS PROTOCOL

Table 4-1 defines the interface capabilities of the Interface Card (Talker/Listener) relative to the IEEE 488 (GPIB) bus (reference document *ANSI/IEEE Std 488: IEEE Standard Digital Interface for Programmable Instrumentation*) communicating with a Host Computer–Controller (Talker/Listener).

**TABLE 4-1. IEEE 488 (GPIB) BUS INTERFACE FUNCTIONS**

<b>FUNCTION</b>	<b>SUBSET SYMBOL</b>	<b>COMMENTS</b>
Source Handshake	SH1	Complete Capability (Interface can receive multiline messages)
Acceptor Handshake	AH1	Complete Capability (Interface can receive multiline messages)
Talker	T6	Basic talker, serial poll, unaddress if MLA (My Listen Address) (one-byte address)
Listener	L4	Basic listener, unaddress if MTA (My Talk Address) (one-byte address).
Service Request	SR1	Complete Capability. The interface sets the SRQ line true if there is an enabled service request condition.
Remote/Local	RL2	No Local lock-out.
Parallel Poll	PP0	No Capability
Device Clear	DC1	Complete Capability. Controller sends DCL (Device Clear) and SDC (Selected Device Clear) to selected power supply.
Device Trigger	DT1	Complete Capability
Controller	C0	No Capability

Tables 4-2 and 4-3 define the messages sent to the Interface Card, or received by the Interface Card, via the IEEE 488 bus in IEEE 488 command mode and IEEE 488 data mode, respectively. These messages are enabled during the “handshake” cycle, with the Interface Card operating as either a Talker or a Listener.

**TABLE 4-2. IEEE 488 (GPIB) BUS COMMAND MODE MESSAGES**

<b>MNEMONIC</b>	<b>MESSAGE DESCRIPTION</b>	<b>COMMENTS</b>
ATN	Attention	Received
DAC	Data accepted	Received or Sent
DAV	Data Valid	Received or Sent
DCL	Device Clear	Received
GET	Group Executive Trigger	Received
IFC	Interface Clear	Received
MLA	My Listen Address	Received
MTA	My Talk Address	Received
OTA	Other Talk Address	Received
RFD	Ready for Data	Received or Sent
SDC	Selected Device Clear	Received
SPD	Serial Poll Disable	Received
SPE	Serial Poll Enable	Received
SRQ	Service Request	Sent
UNL	Unlisten	Received
UNT	Untalk	Received

**TABLE 4-3. IEEE 488 (GPIB) BUS DATA MODE MESSAGES**

MNEMONIC	MESSAGE DESCRIPTION	COMMENTS
DAB	Data Byte	Received or Sent
END	End	Received or Sent
EOS	End of String	Received or Sent
RQS	Request Service	Sent
STB	Status Byte	Sent

## 4.5 SCPI PROGRAMMING

SCPI (Standard Commands for Programmable Instruments) is a programming language conforming to the protocols and standards established by IEEE 488.2 (reference document *ANSI/IEEE Std 488.2, IEEE Standard Codes, Formats, Protocols, and Common Commands*). SCPI commands are sent to the Interface Card as output strings within the selected programming language (PASCAL, BASIC, etc.) in accordance with the manufacturer's requirements for the particular GPIB interface card used.

Different programming languages (e.g., BASIC, C, PASCAL, etc.) have different ways of representing data that is to be put on the IEEE 488 bus. It is up to the programmer to determine how to output the character sequence required for the programming language used. Address information (GPIB address) must be included before the command sequence. (See PAR. 2.2.1 to establish the Interface Card GPIB address.)

### 4.5.1 SCPI MESSAGES

There are two kinds of SCPI messages: program messages from controller to power supply, and response messages from the power supply to the controller. Program messages consist of one or more properly formatted commands/queries and instruct the power supply to perform an action; the controller may send a program message at any time. Response messages consist of formatted data; the data can contain information regarding operating parameters, power supply state, status, or error conditions.

### 4.5.2 COMMON COMMANDS/QUERIES

Common commands and queries are defined by the IEEE 488.2 standard to perform overall power supply functions (such as identification, status, or synchronization) unrelated to specific power supply operation (such as setting voltage/current). Common commands and queries are preceded by an asterisk (\*) and are defined and explained in Appendix A (see Table 4-4). Refer also to syntax considerations (PARs 4.5.2 through 4.5.5).

### 4.5.3 SCPI SUBSYSTEM COMMAND/QUERY STRUCTURE

Subsystem commands/queries are related to specific power supply functions (such as setting output voltage, current limit, etc.) Figure 4-3 is a tree diagram illustrating the structure of SCPI subsystem commands used in the Interface Card with the "root" at the left side, and specific commands forming the branches. The following paragraphs introduce the subsystems; subsystem commands are defined and explained in Appendix B (see Table 4-4).

#### 4.5.3.1 INITIATE SUBSYSTEM

This subsystem enables the trigger system. When a trigger is enabled, the triggering action will occur upon receipt of a GPIB <GET>, \*TRG or TRIGger command. If a trigger circuit is not enabled, all trigger commands are ignored.

#### 4.5.3.2 MEASURE SUBSYSTEM

This query subsystem returns the voltage and current measured at the power supply's output terminals.

#### 4.5.3.3 [SOURCE:]VOLTAGE AND [SOURCE:]CURRENT SUBSYSTEMS

These subsystems program the output voltage and current of the power supply.

#### 4.5.3.4 OUTPUT SUBSYSTEM

This subsystem controls the power supply's voltage and current outputs

#### 4.5.3.5 LIST SUBSYSTEM

The LIST subsystem can be used to generate transients, waveforms and execute a series of steps repeatedly. Up to 1002 power supply settings can be stored temporarily. Each setting consists of either a voltage or current value (depending on whether the power supply has been set to constant voltage or constant current mode), and a corresponding dwell time, the duration those settings are in effect. These settings may be executed in sequence as they are entered, or executed in a user-determined sequence that also allows individual settings to be repeated more than once. In addition, the entire sequence may be repeated for a specific number of times, or run indefinitely until commanded to stop. The sequence can also be run in reverse order to produce inverted waveforms.

The dwell time for each step is between 0.0005 and 10 seconds.

#### 4.5.3.6 STATUS SUBSYSTEM

This subsystem programs the power supply status register. The power supply has two groups of status registers: Operation and Questionable. Each group consists of three registers: Condition, Enable, and Event.

#### 4.5.3.7 SYSTEM SUBSYSTEM

This subsystem is used to establish system settings

#### 4.5.4 PROGRAM MESSAGE STRUCTURE

SCPI program messages (commands from controller to power supply) consist of one or more *message units* ending in a *message terminator* (required by Kepco power modules). The message terminator is not part of the syntax; it is defined by the way your programming language indicates the end of a line (such as a "newline" or "end-of-line" character). The message unit is a keyword consisting of a single command or query word followed by a message terminator (e.g., CURR?<newline> or TRIG<end-of-line>). The message unit may include a data parameter after the keyword separated by a space; the parameter is usually numeric (e.g., CURR 5<newline>), but may also be a string (e.g., OUTP ON<newline>). Figure 4-4 illustrates the message struc-



ture, showing how message units are combined. The following subparagraphs explain each component of the message structure.

NOTE: An alternative to using the message structure for multiple messages defined in the following paragraphs is to send each command as a separate line. In this case each command must use the full syntax shown in Appendix B.

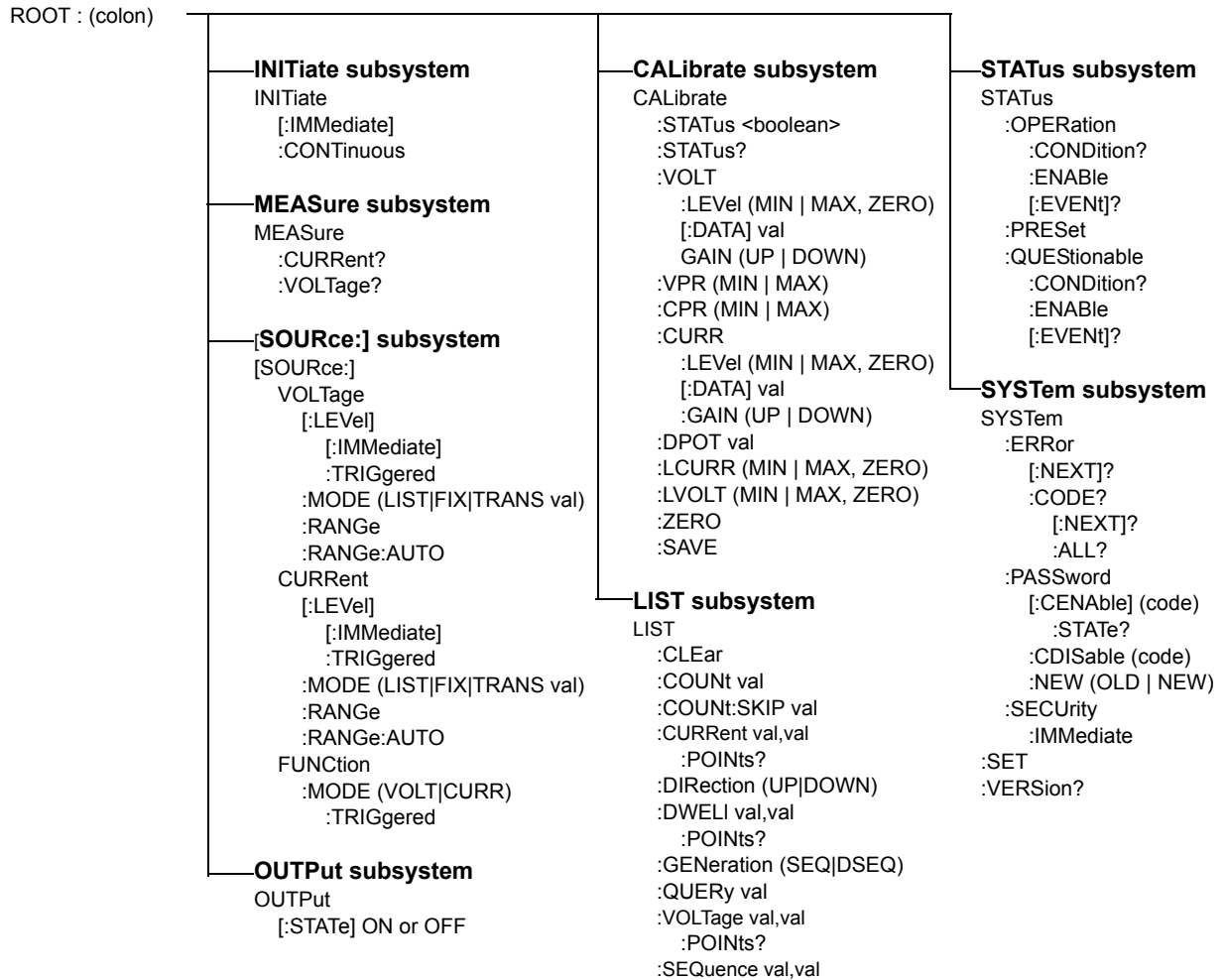


FIGURE 4-3. TREE DIAGRAM OF SCPI COMMANDS USED WITH BIT 4886 INTERFACE CARD

**TABLE 4-4. SCPI COMMAND INDEX**

COMMAND	PARAGRAPH	COMMAND	PARAGRAPH
*CLS	A.2	[SOUR:]LIST:COUN:SKIP, ?	B.29, B.30
*ESE	A.3	[SOUR:]LIST:CURR, ?	B.31, B.32
*ESE?	A.4	[SOUR:]LIST:CURR:POIN?	B.33
*ESR?	A.5	[SOUR:]LIST:DIR, ?	B.34, B.35
*IDN?	A.6	[SOUR:]LIST:DWEL, ?	B.36, B.37
*OPC	A.7	[SOUR:]LIST:DWEL:POIN?	B.38
*OPC?	A.8	[SOUR:]LIST:GEN, ?	B.39, B.40
*OPT?	A.9	[SOUR:]LIST:QUER, ?	B.41, B.42
*RCL	A.10	[SOUR:]LIST:SEQ, ?	B.43, B.44
*RST	A.11	[SOUR:]LIST:VOLT, ?	B.45, B.46
*SAV	A.12	[SOUR:]LIST:VOLT:POIN?	B.47
*SRE	A.13	[SOUR:]CURR, ?	B.48, B.49
*SRE?	A.14	[SOUR:]CURR:MODE, ?	B.50, B.51
*STB?	A.15	[SOUR:]CURR:RANG, ?	B.52, B.53
*TRG	A.16	[SOUR:]CURR:RANG:AUTO	B.54
*TST?	A.17	[SOUR:]CURR:TRIG?	B.55, B.56
*WAI	A.18	[SOUR:]VOLT, ?	B.57, B.58
CAL:CPR	B.4	[SOUR:]VOLT:MODE, ?	B.59, B.60
CAL:[STAT], ?	B.4, B.5	[SOUR:]VOLT:RANG, ?	B.61, B.62
CAL:CURR	B.6	[SOUR:]VOLT:RANG:AUTO	B.63
CAL:DATA	B.7	[SOUR:]VOLT:TRIG	B.64, B.65
CAL:DPOT	B.8	STAT:OPER:COND?	B.66
CAL:LCURR	B.9	STAT:OPER:ENAB, ?	B.67, B.68
CAL:LVOLT	B.10	STAT:OPER:[EVEN]?	B.69
CAL:SAVE	B.11	STAT:PRES	B.70
CAL:VOLT	B.12	STAT:QUES:[EVEN]?	B.71
CAL:VPR	B.13	STAT:QUES:COND?	B.72
CAL:ZERO	B.14	STAT:QUES:ENAB, ?	B.73, B.74
INIT:[IMM]	B.15	SYST:BEEP	B.75
INIT:CONT, ?	B.16, B.17	SYST:ERR?	B.76
MEAS:CURR?	B.18	SYST:ERR:CODE?	B.77, B.78
MEAS:VOLT?	B.19	SYST:PASS CEN, CDIS	B.79, B.80
OUTP:[STAT], ?	B.20, B.21	SYST:PASS:STAT	B.82
[SOUR:]FUNC:MODE, ?	B.22, B.23	SYST:SEC	B.83
[SOUR:]FUNC:MODE:TRIG, ?	B.24, B.25	SYST:SET, ?	B.84, B.85
[SOUR:]LIST:CLE	B.26	SYST:VERS?	B.86
[SOUR:]LIST:COUN, ?	B.27, B.28		

NOTE: Commands listed above that are followed by ", ?" have a related query.

#### 4.5.4.1 KEYWORD

Keywords are instructions recognized by a decoder within the Interface Card, referred to as a “parser.” Each keyword describes a command function; all keywords used by the Interface Card are listed in Figure 4-3.

Each keyword has a long form and a short form. For the long form the word is spelled out completely (e.g. STATUS, OUTPUT, VOLTAGE, and TRIGGER are long form keywords). For the short form only the first three or four letters of the long form are used (e.g., STAT, VOLT, OUTP, and TRIG).

You must use the rules above when using keywords. Using an arbitrary short form such as ENABL for ENAB (ENABLE) or IMME for IMM (IMMEDIATE) will result in an error. Regardless of which form chosen, you must include all the letters required by that form.

To identify the short form and long form in this manual, keywords are written in upper case letters to represent the short form, followed by lower case letters indicating the long form (e.g., IMMEDIATE, EVENT, and OUTPUT). The parser, however, is not sensitive to case (e.g., outp, OutP, OUTPUT, ouTPut, or OUTp are all valid).

#### 4.5.4.2 KEYWORD SEPARATOR

If a command has two or more keywords, adjacent keywords must be separated by a colon (:) which acts as the keyword separator (e.g., CURR:LEV:TRIG). The colon can also act as a root specifier (paragraph 4.5.4.7).

#### 4.5.4.3 QUERY INDICATOR

The question mark (?) following a keyword is a query indicator. This changes the command into a query. If there is more than one keyword in the command, the query indicator follows the last keyword. (e.g., VOLT? and MEAS:CURR?).

#### 4.5.4.4 DATA

Some commands require data to accompany the keyword either in the form of a numeric value or character string. Data always follows the last keyword of a command or query (e.g., VOLT:LEV:TRIG 14 or SOUR:VOLT? MAX

#### 4.5.4.5 DATA SEPARATOR

Data must be separated from the last keyword by a space (e.g., VOLT:LEV:TRIG 14 or SOUR:VOLT? MAX

#### 4.5.4.6 MESSAGE UNIT SEPARATOR

When two or more message units are combined in a program message, they must be separated by a semicolon (;) (e.g., VOLT 15 ;MEAS:VOLT? and CURR 12 ;CURR:TRIG 12.5).

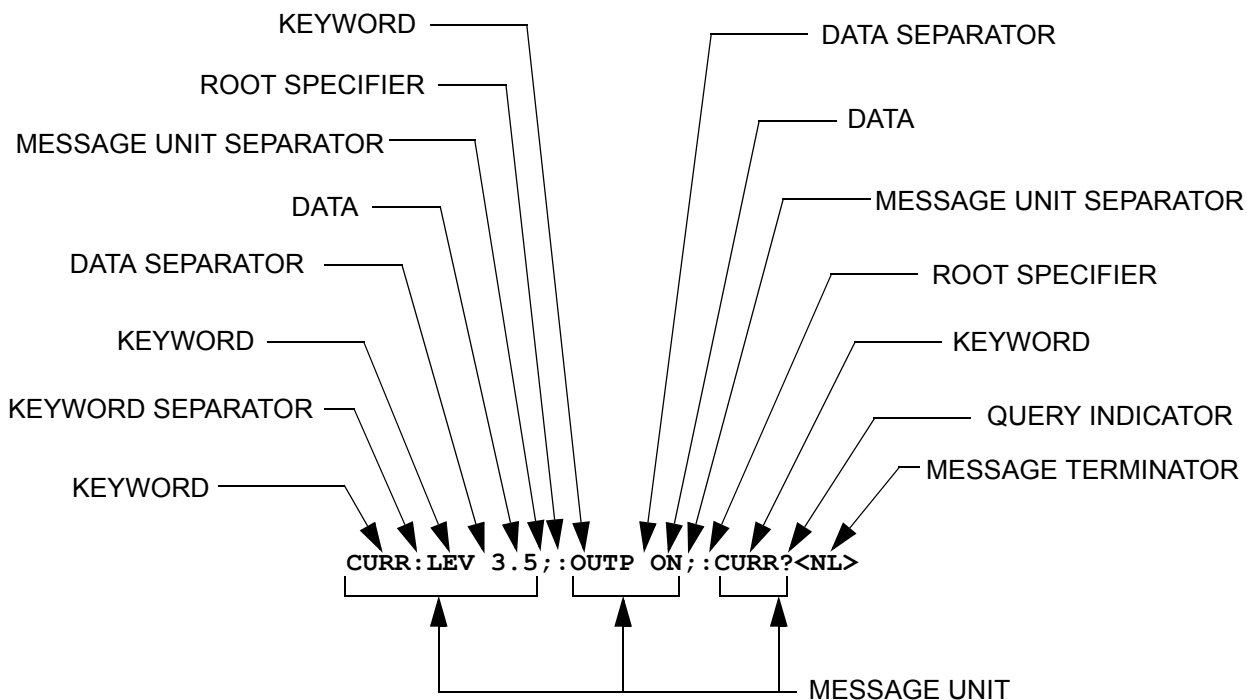


FIGURE 4-4. MESSAGE STRUCTURE

#### 4.5.4.7 ROOT SPECIFIER

The root specifier is a colon (:) that precedes the first keyword of a program message. This places the parser at the root (top left, Figure 4-3) of the command tree. Note the difference between using the colon as a keyword separator and a root specifier in the following examples:

**VOLT:LEV:IMM 16** Both colons are keyword separators.

**:CURR:LEV:IMM 4** The first colon is the root specifier, the other two are keyword separators.

**VOLT:LEV 6;:CURR:LEV 15** The second colon is the root specifier, the first and third are keyword separators

**:INIT ON;:TRIG;:MEAS:CURR?:VOLT?** The first three colons are root specifiers.

#### 4.5.4.8 MESSAGE TERMINATOR

The message terminator defines the end of a message. Three message terminators are permitted:

- new line (<NL>), ASCII 10 (decimal) or 0A (hex)
- (<CR>), ASCII 13 (decimal) or 0D (hex)
- both of the above (<CR> <NL>)

Your GPIB interface card software will automatically send a message terminator. For example, the HP BASIC OUTPUT statement inserts <NL> after the last data byte. When binary data is exchanged, <END> must be used. The combination <NL><END> terminator can be used for all data except binary data.

NOTE: Kepco power modules *require* a message terminator at the end of each program message. The examples shown in this manual assume a message terminator will be added

at the end of each message. Where a message terminator is shown it is represented as `<NL>` regardless of the actual terminator character.

#### 4.5.5 UNDERSTANDING THE COMMAND STRUCTURE

Understanding the command structure requires an understanding of the subsystem command tree illustrated in Figure 4-3. The “root” is located at the top left corner of the diagram. The parser goes to the root if:

- a message terminator is recognized by the parser
- a root specifier is recognized by the parser

*Optional keywords* are enclosed in brackets [ ] for identification; optional keywords can be omitted and the power supply will respond as if they were included in the message. The root level keyword [SOURCE] is an optional keyword. Starting at the root, there are various branches or paths corresponding to the subsystems. The root keywords for the Interface Card are :INITiate, :MEASure, :OUTPut, [:SOURce], :STATus, and :SYSTEM. Because the [SOURCE] keyword is optional, the parser moves the path to the next level, so that VOLTage, CURRent, and FUNCtion commands are at the root level.

Each time the parser encounters a keyword separator, the parser moves to the next indented level of the tree diagram. As an example, the STATus branch is a root level branch that has three sub-branches: OPERation, PRESet, and QUEStionable. The following illustrates how SCPI code is interpreted by the parser:

**STAT:PRES<NL>**

The parser returns to the root due to the message terminator.

**STAT:OPER?;PRES<NL>**

The parser moves one level in from STAT. The next command is expected at the level defined by the colon in front of OPER?. Thus you can combine the following message units STAT:OPER? and STAT:PRES;

**STAT:OPER:COND?;ENAB 16<NL>**

After the OPER:COND? message unit, the parser moves in one level from OPER, allowing the abbreviated notation for STAT:OPER:ENAB.

#### 4.5.6 PROGRAM MESSAGE SYNTAX SUMMARY

- Common commands begin with an asterisk (\*).
- Queries end with a question mark (?).
- Program messages consist of a root keyword and, in some cases, one or more message units separated by a colon (:) followed by a message terminator. Several message units of a program message may be separated by a semicolon (;) without repeating the root keyword.
- If a program message has more than one message unit, then a colon (:) must precede the next keyword in order to set the parser back to the root (otherwise the next keyword will be taken as a subunit of the previous message unit).

e.g., the command `meas:volt?;curr?` will read output voltage and output current since both `volt?` and `curr?` are interpreted as subunits of the `meas` command.

- Several commands may be sent as one message; a line feed terminates the message. Commands sent together are separated by a semicolon (;). The first command in a mes-

sage starts at the root, therefore a colon (:) at the beginning is not mandatory.

e.g., the command `meas:volt?;:curr?` will read output voltage and programmed current since the colon preceding `curr?` indicates that `curr?` is not part of the `meas` command and starts at the root.

- UPPER case letters in mnemonics are mandatory (short form). Lower case letters may either be omitted, or must be specified completely (long form)  
e.g., `INSTrument` (long form) has the same effect as `INST` (short form).
- Commands/queries may be given in upper/lower case (long form)  
e.g., `SoURCe` is allowed.
- Text shown between brackets [] is optional.  
e.g., `:[SOUR]VOLT:[LEV] TRIG` has the same effect as `:VOLT TRIG`

#### 4.5.7 SCPI PROGRAM EXAMPLE

Figure 4-5 is an example of a program using SCPI commands to program a BOP Power Supply. The program illustrated is for a configuration using an IBM PC or compatible with a National Instruments GPIB interface card. (It will be necessary to consult the manufacturer's data to achieve comparable functions with an interface card from a different manufacturer.) This program sets output voltage (Voltage mode) or voltage limit (Current mode) to 5V, and current limit (Voltage mode) or output current (Current mode) to 1A, then reads the measured (actual) voltage and current, then prints the measurements.

```
/* **** */
/* Sample Program For KEPCO power supply, using National Instruments */
/* GPIB interface card and IBM PC or compatible computer */
/* **** */

#include <stdio.h>
#include "decl.h"
char rd_str[80]; // Input buffer
char dat_str[80]; // Output buffer
int bd,adr;
main() {
    adr = ibfind("DEV6"); // Open DEV6 (defined by IBCONF)
    bd = ibfind ("GPIB0"); // Open GPIB card
    ibsic (bd); // Send Interface Clear
    strcpy(dat_str,"OUTPUT ON"); // SCPI default is Output off
    ibwrt(adr,dat_str,strlen(dat_str)); // Power supply is
    // in voltage mode
    // outputing 0 volts
    strcpy(dat_str,"VOLT 5;CURR 1"); // Define a set command
    ibwrt(adr,dat_str,strlen(dat_str)); // Send string to power supply
    strcpy(dat_str,"MEAS:VOLT?;CURR?"); // Define a measure command
    ibwrt(adr,dat_str,strlen(dat_str)); // Send string to power supply
    strset(rd_str,'\0'); // Clear input buffer
    ibrd(adr,rd_str,64); // Read result of measure
    printf("received : %s\n",rd_str); // Print voltage and current
}

/* **** */
```

FIGURE 4-5. TYPICAL EXAMPLE OF INTERFACE CARD PROGRAM USING SCPI COMMANDS

## APPENDIX A - SCPI COMMON COMMAND/QUERY DEFINITIONS

### A.1 INTRODUCTION

This appendix defines the SCPI common commands and queries used with the BIT 4886 Interface Card. Common commands and queries are preceded by an asterisk (\*) and are defined and explained in paragraphs A.2 through A.18, arranged in alphabetical order. Table A-1 provides a quick reference of all SCPI common commands and queries used in the Interface Card.

**TABLE A-1. IEEE 488.2 COMMAND/QUERY INDEX**

COMMAND	PAR.	COMMAND	PAR.
*CLS	A.2	*RST	A.11
*ESE, ?	A.3, A.4	*SAV	A.12
*ESR?	A.5	*SRE, ?	A.13, A.14
*IDN?	A.6	*STB?	A.15
*OPC, ?	A.7, A.8	*TRG	A.16
*OPT?	A.9	*TST?	A.17
*RCL	A.10	*WAI	A.18

### A.2 \*CLS — CLEAR STATUS COMMAND

**\*CLS**

Syntax: \*CLS

Description: **Clears status data.** Clears the error queue of the instrument. Forces power supply to “operation complete idle” and “operation complete query” state. Clears all Event Registers summarized in Status Byte Register without affecting the corresponding Enable Registers: Standard Event Status Register (ESR), Operation Status Event Register, Questionable Status Event Register, and Status Byte Register (STB). Related commands: \*OPC \*OPC?. (See example, Figure A-1.)

### A.3 \*ESE — STANDARD EVENT STATUS ENABLE COMMAND

**\*ESE**

Syntax: \*ESE <integer> where <integer> = positive whole number: 0 to 255 per Table A-2.  
Default Value: 0

Description: **This command programs the standard Event Status Enable register bits.** The contents function as a mask to determine which events of the Event Status Register (ESR) are allowed to set the ESB (Event Summary Bit) of the Status Byte Register. Enables the Standard events to be summarized in the Status Byte register (1 = set = enable function, 0 = reset = disable function). All of the enabled events of the standard Event Status Enable register are logically ORed to cause ESB (bit 5) of the Status Byte Register to be set (1 = set = enable, 0 = reset = disable). (See example, Figure A-1.)

**TABLE A-2. STANDARD EVENT STATUS ENABLE REGISTER AND STANDARD EVENT STATUS REGISTER BITS**

CONDITION	NU	NU	CME	EXE	DDE	QUE	NU	OPC
BIT	7	6	5	4	3	2	1	0
VALUE	128	64	32	16	8	4	2	1

NU (Not Used)  
 CME Command Error  
 EXE Execution Error  
 DDE Device Dependent Error  
 QUE Query Error  
 OPC Operation Complete

## \*ESE?

### A.4 \*ESE? — STANDARD EVENT STATUS ENABLE QUERY

Syntax: \*ESE?                      Return value: Integer> value per Table A-2.

Description: **Returns the mask stored in the Standard Event Status Enable Register.** Contents of Standard Event Status Enable register (\*ESE) determine which bits of Standard Event Status register (\*ESR) are enabled, allowing them to be summarized in the Status Byte register (\*STB). All of the enabled events of the Standard Event Status Enable Register are logically ORed to cause ESB (bit 5) of the Status Byte Register to be set (1 = set = enable function, 0 = reset = disable function). (See example, Figure A-1.)

## \*ESR?

### A.5 \*ESR? — EVENT STATUS REGISTER QUERY

Syntax: \*ESR?  
Return value: <integer> (Value = contents of Event Status register as defined in Table A-2.)

Description: **Causes the power supply to return the contents of the Standard Event Status register. After it has been read, the register is cleared.** The Standard Event Status register bit configuration is defined in Table A-2 (1 = set, 0 = reset). The error bits listed in Table A-2 are also related to error codes produced during parsing of messages and to errors in the power supply (see PAR. B.76)

- Any 1xx type error sets the Command error bit (5) see.
- Any 2xx type error sets the Execution error bit (4).
- Any 3xx type error sets the Device error bit (3). The Device error bit will be set when Current Error or Voltage Error is detected and the corresponding Status Questionable bit is set (see PAR. B.28).
- Any 4xx type error sets the Query error bit (2).

Related Commands: \*CLS, \*ESE, \*OPC. (See example, Figure A-1.)

## \*IDN?

### A.6 \*IDN? — IDENTIFICATION QUERY

Syntax: \*IDN?  
Return value: Character string

Description: **Identifies the instrument.** This query requests identification. The power supply returns a string which contains the manufacturer name, the model, the serial number and the firmware level. The character string contains the following fields: <Manufacturer>, <Model>, <Voltage>, <Current>, <Serial Number>, <Main revision>-<Flash revision> where: <Manufacturer> = KEPCO, <Model> = BIT 4886, <Serial Number> = SSSSSS <date> = (see CAL:SAVE DATE, PAR. B.11) <Main revision>=n.m, e.g, 1.0) ><Firmware revision>=n.m (n.m revision, e.g, 1.0) (See example, Figure A-1.)

## \*OPC

### A.7 \*OPC — OPERATION COMPLETE COMMAND

Syntax: \*OPC

Description: **Causes power supply to set status bit 0 (Operation Complete) when pending operations are complete** This command sets Standard Event Status Register bit 0 (see Table A-2) to “1” when all previous commands have been executed and changes in output level have been completed. This command does not prevent processing of subsequent commands, but bit 0 will not be set until all pending operations are completed. (1 = set = enable function, 0 = reset = disable function). (See example, Figure A-1.) As an example, the controller sends command(s), then sends \*OPC. If controller then sends \*ESR?, the power supply responds with either a “0” (if the power supply is busy executing the programmed commands), or a “1” (if the previously programmed commands are complete). (See example, Figure A-1.)



# \*OPC?

## A.8 \*OPC? — OPERATION COMPLETE QUERY

Syntax: \*OPC?

Return value: <1> (ASCII) placed in output queue when power supply has completed operation.

Description: **Indicates when pending operations have been completed.** When all pending operations are complete (all previous commands have been executed and changes in output level have been completed) a "1" is placed in the Output Queue. Subsequent commands are inhibited until the pending operations are completed. \*OPC? is intended to be used at the end of a command line so that the application program can monitor the bus for data until it receives the "1" from the power supply Output Queue. (See example, Figure A-1.)

*CLS	Power supply clears status data.
*ESE 60	Power supply enables bits 5, 4, 3 and 2, allowing command error, execution error, device dependent error and query error to set the Event Status Summary bit when an STB command is executed.
*ESE?	Returns 60, (value of the mask) verifying that bits 5, 4, 3 and 2 are enabled.
*ES	Unknown command will set command error (Bit 5).
*ESR?	Returns 32 (bit 5 set), indicating Command Error has occurred since the last time the register was read.
*IDN?	Power supply returns: KEPCO, BIT 4886 100-2 123456 1.8-1.8
*OPC	Allows status bit 0 to be set when pending operations complete
VOLT 21;CURR 3	Sets output voltage to 21V, output current to 3A
*ESR	Returns 129 (128 + 1, power on, bit 7 = 1, operation complete, bit 1 = 1)
*ESR	Returns 0 (event status register cleared by prior *ESR?)
VOLT 15;CURR 5;*OPC?	Sets output voltage to 15V, output current to 5A, puts "1" on output bus when command operations are complete.
*RST	Power supply reset to power on default state.
*SRE 40	When ESB or QUES bits are set (Table A-3), the Request for Service bit will be set.
*SRE?	Returns the value of the mask (40).
*STB?	For example, the Power supply responds with 96 (64 + 32) if MSS and the Event Status Byte (Table A-3) summary bit have been set. The power supply
	returns 00 if no bits have been set.
VOLT 25	Power supply voltage commanded to 25V.
VOLT:TRIG 12	Programs power supply voltage to 12V when *TRG received.
INIT	Trigger event is initialized.
*TRG	Power supply reverts to commanded output voltage of 12V. ** LOAD DISCONNECTED
*TST?	Power supply executes self test and responds with 0 if test completed successfully, with 1 if test failed.

FIGURE A-1. GPIB COMMANDS

# \*OPT?

## A.9 \*OPT? — OPTIONS QUERY

Syntax: \*OPT?  
Returns string determined by power supply model.

Description: **Causes the power supply to return an ASCII string which defines the functionality of the power supply.** The functionality is defined as follows:

STRING DATA	MEANING
CAL	Support for CALibrate is present.
RL1	Commands sent over GPIB cause unit to enter remote mode (except for MEASure).
MEM	Indicates the number of memory steps supported.
LST	Indicates the number of LIST steps supported.

# \*RCL

## A.10 \*RCL — RECALL COMMAND

Syntax: \*RCL <integer> (1 to 99)

Description: **Restores power supply to previously defined levels of output voltage, output current and triggers.** This command selects one of the 99 power supply memory locations, each of which stores values for output current, and output voltage and trigger levels. Executing a \*RCL recalls the previously defined trigger settings from memory and places them in the trigger control section of the BIT 4886. Executing a second \*RCL will cause the values in the trigger control section to be moved to the bit 4886 output channel, allowing the power supply to operate with the recalled trigger information. The following parameters are affected by \*RCL: VOLT:TRIG, CURR:TRIG, and FUNC:MODE:TRIG.

# \*RST

## A.11 \*RST — RESET COMMAND

Syntax: \*RST

Description: **Resets power supply to the power on default state.** The power supply output set to off (see DIAG:OUTP, Table 5-1, to establish the “off” state parameters) and the power supply is programmed to the power on values of the following parameters: CURR[:LEV][:IMM] = 0, VOLT[:LEV][:IMM] = 0, MODE = VOLT. If the power supply is in either an overvoltage or overcurrent state, this condition is reset by \*RST. After sending \*RST it is necessary to send OUTPUT on for programmed values to appear at the output. The \*RST command always returns the mode to Voltage and the range to automatic.(See example, Figure A-1.)

# \*SAV

## A.12 \*SAV — SAVE COMMAND

Syntax: \*SAV <integer> (1 to 99)

Description: **Saves the present state of output voltage, output current and trigger values, to the specified memory location.** This command stores the present state of the power supply to one of 99 memory locations in Flash Memory (see PAR. 5.2.4). The following parameters are stored by \*SAV: VOLT:TRIG, CURR:TRIG, and FUNC:MODE:TRIG. The stored values can be restored by the \*RCL command.

# \*SRE

## A.13 \*SRE — SERVICE REQUEST ENABLE COMMAND

Syntax: \*SRE<integer> where <integer> = value from 0 - 255 per Table A-3, except bit 6 cannot be programmed.

Description: **Sets the condition of the Service Request Enable register.** The Service Request Enable register determines which events of the Status Byte Register are summed into the MSS (Master Status Summary) and RQS (Request for Service) bits. RQS is the service request bit that is cleared by a serial poll, while MSS is not cleared when read. A "1" (1 = set = enable, 0 = reset = disable) in any Service Request Enable register bit position enables the corresponding Status Byte bit to set the RQS and MSS bits. All the enabled Service Request Enable register bits then are logically ORed to cause Bit 6 of the Status Byte Register (MSS/RQS) to be set. Related Commands: \*SRE?, \*STB?. (See example, Figure A-1.)

**TABLE A-3. SERVICE REQUEST ENABLE AND STATUS BYTE REGISTER BITS**

CONDITION	OPER	MSS RQS	ESB	MAV	QUES	ERR QUE	NU	NU
BIT	7	6	5	4	3	2	1	0
VALUE	128	64	32	16	8	4	2	1

OPER      Operation Status Summary  
MSS        Master Status Summary  
RQS        Request for Service  
ESB        Event Status Byte summary  
MAV        Message available  
QUES      QUEStionable Status Summary  
ERR QUE   1 or more errors occurred (see  
              PAR. B.76)  
NU         (Not Used)

**A.14 \*SRE? — SERVICE REQUEST ENABLE QUERY**

**\*SRE?**

Syntax:    \*SRE?                      Response: <integer> = value from 0 - 255 per Table A-3.

Description: **Reads the Service Enable Register.** Used to determine which events of the Status Byte Register are programmed to cause the power supply to generate a service request (1 = set = function enabled, 0 = reset = function disabled). Related Commands: \*SRE, \*STB? (See example, Figure A-1.)

**A.15 \*STB? — STATUS BYTE REGISTER QUERY**

**\*STB?**

Syntax:    \*STB?                      Response: <integer> value from 0 to 255 per Table A-3.

Description: **Reads Status Byte Register without clearing it.** This Query reads the Status Byte Register (bit 6 = MSS) without clearing it (1 = set = function enabled, 0 = reset = function disabled). The register is cleared only when subsequent action clears all set bits. MSS is set when the power supply has one or more reasons for requesting service. (A serial poll also reads the Status Byte Register, except that bit 6 = RQS, not MSS; and RQS will be reset.) Related Commands: \*SRE, \*SRE?. (See example, Figure A-1.)

**A.16 \*TRG — TRIGGER COMMAND**

**\*TRG**

Syntax:    \*TRG

Description: **Triggers the power supply to be commanded to preprogrammed values of output current and voltage.** When the trigger is armed (checked by examining WTG bit in Status Operational Condition register) \*TRG generates a trigger signal. The trigger will change the output of the power supply to the output voltage and current levels specified by VOLT:TRIG and CURR:TRIG commands and clear the WTG bit in the Status Operation Condition register. If INIT:CONT has been issued, the trigger subsystem is immediately rearmed for subsequent triggers, and the WTG bit is again set to 1. \*TRG or GET are both addressed commands (only devices selected as listeners will execute the command). Related Commands: ABOR, INIT, TRIG, CURR:TRIG, VOLT:TRIG. (See example, Figure A-1.)

**A.17 \*TST? — SELF TEST QUERY**

**\*TST?**

Syntax:    \*TST?                      Returned value: 0 or non-zero (0 = pass test, non-zero = fail test)

Description: **Power Supply test.** This query causes the power supply to do a self test and provide the controller with pass/fail results. A 0 is returned if the unit passes the test. If the unit fails, a number is returned to indicate the cause of the error. The test executes each of the subtests even when any one fails. If any test fails an error code bit is set which is returned to the user. The error codes returned are listed in Table 6-3.

**A.18 \*WAI — WAIT-TO-CONTINUE COMMAND**

**\*WAI**

Syntax:    \*WAI                      Response:

Description: **Causes the power supply to wait until all previously issued commands and queries are complete before executing subsequent commands or queries.** This command can be used to guarantee sequential execution of commands and queries. When all pending operations are complete (all previous commands have been executed, changes in output level have been completed), the WAI command is completed and execution of subsequent commands can continue.



## APPENDIX B - SCPI COMMAND/QUERY DEFINITIONS

### B.1 INTRODUCTION

This appendix defines the SCPI subsystem commands and queries used with the BIT 4886 Interface Card. Subsystem commands are defined in PAR. B.4 through B.86, arranged in groups as they appear in the tree diagram, Figure 4-3. Table B-1 provides a quick reference of all SCPI subsystem commands and queries used in the Interface Card.

**TABLE B-1. SCPI SUBSYSTEM COMMAND/QUERY INDEX**

COMMAND	PAR.	COMMAND	PAR.
CAL:CPR	B.3	[SOUR:]LIST:SEQ, ?	B.43, B.44
CAL:STAT, ?	B.4, B.5	[SOUR:]LIST:VOLT, ?	B.45, B.46
CAL:CURR	B.6	[SOUR:]LIST:VOLT:POIN?	B.47
CAL:DATA	B.7	[SOUR]:CURR, ?	B.48, B.49
CAL:DPOT	B.8	[SOUR]:CURR:MODE, ?	B.50, B.51
CAL:LCURR	B.9	[SOUR]:CURR:RANG, ?	B.52, B.53
CAL:LVOLT	B.10	[SOUR]:CURR:RANG:AUTO	B.54
CAL:SAVE	B.11	[SOUR]:CURR:TRIG?	B.55, B.56
CAL:VOLT	B.12	[SOUR]:VOLT	B.57, B.58
CAL:VPR	B.13	[SOUR]:VOLT:MODE, ?	B.59, B.60
CAL:ZERO	B.14	[SOUR]:VOLT:RANG, ?	B.61, B.62
INIT[:IMM]	B.15	[SOUR]:VOLT:RANG:AUTO	B.63
INIT:CONT, ?	B.16, B.17	[SOUR]:VOLT:TRIG	B.64, B.65
MEAS:CURR?	B.18	STAT:OPER:COND?	B.66
MEAS:VOLT?	B.19	STAT:OPER:ENAB, ?	B.67, B.68
OUTP[:STAT], ?	B.20, B.21	STAT:OPER[:EVEN]?	B.69
[SOUR:]FUNC:MODE, ?	B.22, B.23	STAT:PRES	B.70
[SOUR:]FUNC:MODE:TRIG, ?	B.24, B.25	STAT:QUES[:EVEN]?	B.71
[SOUR:]LIST:CLE	B.26	STAT:QUES:COND?	B.72
[SOUR:]LIST:COUN, ?	B.27, B.28	STAT:QUES:ENAB, ?	B.73, B.74
[SOUR:]LIST:COUN:SKIP, ?	B.29, B.30	SYST:BEEP	B.75
[SOUR:]LIST:CURR, ?	B.31, B.32	SYST:ERR?	B.76
[SOUR:]LIST:POIN?	B.33	SYST:ERR:CODE?	B.77, B.78
[SOUR:]LIST:DIR, ?	B.34, B.35	SYST:PASS GEN, CDIS	B.79, B.80
[SOUR:]LIST:DWEL, ?	B.36, B.37	SYST:PASS:STAT	B.82
[SOUR:]LIST:DWEL:POIN?	B.38	SYST:SEC	B.83
[SOUR:]LIST:GEN, ?	B.39, B.40	SYST:SET, ?	B.84, B.85
[SOUR:]LIST:QUER, ?	B.41, B.42	SYST:VERS?	B.86
NOTE: Commands listed above that are followed by “, ?” have a related query.			

## B.2 NUMERICAL VALUES

The SCPI data parser on the BIT 4886 supports a maximum of 8 digits after the decimal point and a maximum integer of  $4 \times 10^8$ . Any values greater than these are not processed by the device and no error is generated. The largest string that can be received or transmitted by the BIT 4886 is 253 characters.

All numerical data is returned in scientific notation, digits with decimal point and Exponent, e.g., 2.71E1 for 27.1 after calibration constants have been applied. Thus, for example, VOLT 14;VOLT? may return 1.39997E1 which indicates that the unit has been calibrated to provide 13.9997V for a programmed value of 14V, within the calculation accuracy of the BIT 4886. Error “-120” results from syntactical errors, e.g., the exponent exceeds 8, a letter is identified, etc. Error “-222” is produced if the value exceeds the range of acceptable values for the parameter.

## B.3 CALibrate:CPRotect COMMAND

# CAL:CPR

Syntax: Short Form: CAL:CPR {MIN | MAX}  
Long Form: CALibrate:CPRotect {MIN | MAX}

Description: **Selects Current Protection limit calibration, only effective with power supply in Calibrate status.** CAL:CPR MAX selects maximum positive current protection limit calibration. CAL:CPR MIN selects maximum negative current protection limit calibration. **Related Commands:** CAL:STAT, CAL:ZERO, CAL:DATA, CAL:SAVE.

## B.4 CALibrate:STATus COMMAND

# CAL:STAT

Syntax: Short Form: CAL:STAT <boolean>  
Long Form: CALibrate:STATus <boolean>  
where boolean = 0 or OFF, 1 or ON

Description: **Sets the power supply to Calibrate status.** <boolean> 1 or ON causes power supply to enter Calibrate status. <boolean> 0 or OFF causes power supply to exit Calibrate status. If the wrong password was not enabled, error message -224 is posted to the queue. **Related Commands:** CAL:STAT, CAL:VOLT, CAL:CURR, CAL:ZERO, CAL:DATA, CAL:DPOT, CAL:SAVE. (See example, Figure B-1.)

## B.5 CALibrate[:STATus]? QUERY

# CAL[:STAT]?

Syntax: Short Form: CAL:STAT? Long Form: CALibrate:STATus?

**Return Value:** <DATA>

where DATA = ZERO-ZERO, VOLT-ZERO, VOLT-MAX, VOLT-MIN, CURR-ZERO, CURR-MAX, CURR-MIN, or OFF.

Description: **Identifies whether the power supply is in Calibrate status and indicates which calibration step is active.** OFF indicates power supply is not in Calibrate status. ZERO-ZERO indicates power supply is at 0V, 0A, waiting for connection of load resistor. VOLT-ZERO indicates zero offset voltage adjustment is active. VOLT-MAX indicates maximum voltage adjustment is active. VOLT-MIN indicates minimum (negative) voltage adjustment is active. CURR-ZERO indicates zero offset current adjustment is active. CURR-MAX indicates maximum current adjustment is active. CURR-MIN indicates minimum (negative) current adjustment is active. **Related Commands:** CAL:STAT, CAL:VOLT, CAL:CURR, CAL:ZERO, CAL:DATA, CAL:DPOT, CAL:SAVE. (See example, Figure B-1.)

SYST:PASS:CEN 1234	If password set to 1234, enables commands requiring password.
CAL:STAT 1	Power supply enters Calibrate status.
CAL:STAT?	Returns ZERO-ZERO indicating power supply in Calibrate status.
CAL:VOLT ZERO	Voltage Zero Calibration selected.
CAL:VOLT MAX	Voltage positive Calibration selected.
CAL:DPOT 1	Output voltage increased by 10 LSB.
CAL:VOLT MIN	Voltage negative Calibration selected.
CAL:DATA -2	Output voltage decreased by 2 LSBs.
CAL:ZERO	Output voltage and current set to zero.
---	* User connects shunt and connects DVM to output.
CAL:CURR ZERO	Current Zero Calibration selected.
CAL:DPOT -1	Output current decreased by 10 LSB.
CAL:CURR MIN	Current negative Calibration selected.
CAL:DPOT 1	Output current increased by 10 LSB.
CAL:CURR MAX	Current positive Calibration selected.
CAL:DATA -1	Output current decreased by 1 LSB.
CAL:SAVE	Calibration values saved.
CAL:STAT 0	Power supply exits Calibrate mode.
CAL:STAT?	Returns 0 indicating power supply not in Calibrate status
---	* User disconnects shunt and DVM.

FIGURE B-1. USING CALIBRATION COMMANDS AND QUERIES

## B.6 CALibrate:CURRENT COMMAND

## CAL:CURR

Syntax: Short Form: CAL:CURR {MIN | MAX | ZERO}  
 Long Form: CALibrate:CURR {MIN | MAX | ZERO}

Description: **Selects Current calibration, only effective with power supply in Calibrate status.** CAL:CURR ZERO selects Current Zero Calibration. CAL:CURR MIN selects Current Full Scale Negative Calibration. CAL:CURR MAX selects Current Full Scale Positive Calibration. Normally Current Zero is done first, then Current Full Scale Positive Calibration. **Related Commands:** CAL:STAT, CAL:VOLT, CAL:CURR, CAL:ZERO, CAL:DATA, CAL:DPOT, CAL:SAVE. (See example, Figure B-1.)

## B.7 CALibrate:DATA COMMAND

## CAL:DATA

Syntax: Short Form: CAL:DATA {N} Long Form: CALibrate:DATA {N}

Description: **Provides fine adjustment of output during calibration only; increases or decreases output by N LSB's.** CAL:CURR -N decreases output by N LSBs. CAL:CURR N increases output by N LSBs. This command is used during calibration to adjust the output for zero calibration as well as full scale calibration. This command is only effective if Calibration status is active. **Related Commands:** CAL:STAT, CAL:VOLT, CAL:LVOLT, CAL:LCURR, CAL:CURR, CAL:DPOT, CAL:ZERO, CAL:SAVE. (See example, Figure B-1.)

## B.8 CALibrate:DPOT COMMAND

## CAL:DPOT

Syntax: Short Form: CAL:DPOT {N} Long Form: CALibrate:DPOT {N}

Description: **Provides coarse adjustment of the output during calibration to within 5% of maximum and 2% of nominal; increases or decreases output by 50 LSB increments.** Acceptable values of N are within  $\pm 32$ , corresponding to  $\pm 1600$  ( $50 \times 32$ ) LSB's. CAL:DPOT -N decreases output voltage by N LSBs. CAL:VOLT N increases output voltage by N LSBs. This command is used during calibration to adjust the output for Zero calibration as well as Full Scale Positive calibration. Output voltage is monitored on a calibrated digital multimeter and increased or decreased as required using this command. Output current is monitored on a calibrated digital multimeter (reading voltage at the sense terminals of the shunt resistor) and increased or decreased as required using this command. This command is only effective if Calibration status and either Voltage Zero, Voltage Maximum, Current Zero or Current Maximum calibration are active. CAL:STAT, CAL:VOLT, CAL:LVOL, CAL:VOLT, CAL:CURR, CAL:DATA, CAL:ZERO, CAL:SAVE. (See example, Figure B-1.)

## B.9 CALibrate:LCURR COMMAND

# CAL:LCURR

Syntax: Short Form: CAL:LCURR {MIN | MAX | ZERO}  
Long Form: CALibrate:LCURR {MIN | MAX | ZERO}

Description: **Selects low current range (1/4 scale) Current calibration, only effective with power supply in Calibrate status.** CAL:LCURR ZERO selects Low Current Range Zero Calibration. CAL:LCURR MIN selects Low Current Range Full Scale Negative Calibration. CAL:LCURR MAX selects Low Current Range Full Scale Positive Calibration. Normally Low Current Range Zero is done first, then Low Current Range Full Scale Positive Calibration. **Related Commands:** CAL:STAT, CAL:VOLT, CAL:CURR, CAL:ZERO, CAL:DATA, CAL:DPOT, CAL:SAVE. (See example, Figure B-1.)

## B.10 CALibrate:LVOLT COMMAND

# CAL:LVOLT

Syntax: Short Form: CAL:LVOLT {MIN | MAX | ZERO}  
Long Form: CALibrate:LVOLT {MIN | MAX | ZERO}

Description: **Selects low voltage range (1/4 scale) Voltage calibration, only effective with power supply in Calibrate status.** CAL:LVOLT ZERO selects Low Voltage Range Zero Calibration. CAL:LVOLT MIN selects Low Voltage Range Full Scale Negative Calibration. CAL:LVOLT MAX selects Low Voltage Range Full Scale Positive Calibration. Normally Low Voltage Range Zero is done first, then Low Voltage Range Full Scale Positive Calibration. **Related Commands:** CAL:STAT, CAL:VOLT, CAL:CURR, CAL:ZERO, CAL:DATA, CAL:DPOT, CAL:SAVE. (See example, Figure B-1.)

## B.11 CALibrate:SAVE COMMAND

# CAL:SAVE

Syntax: Short Form: CAL:SAVE Long Form: CALibrate:SAVE  
Short Form: CAL:SAVE DATE <string> Long Form: CALibrate:SAVE DATE <string>  
where DATE is optional allowing <string> of up to 12 contiguous characters identifying calibrations date to be saved. Active DATE <string > is returned by \*IDN? query.

Description: **Saves computed calibration values in non-volatile memory.** This command saves only the calibration values computed after entering Calibration status. If, for example, only Voltage calibration was performed, these are the only values saved. These values are stored in Flash Memory (see PAR. 5.2.4). Previous values are not lost, and can be restored (see PAR. 5.2.4.1). This command should be the last command before exiting Calibrate status. CAL:STAT, CAL:DATA, CAL:DPOT, CAL:VOLT, CAL:CURR, CAL:ZERO. (See example, Figure B-1.)

## B.12 CALibrate:VOLTage COMMAND

# CAL:VOLT

Syntax: Short Form: CAL:VOLT {MIN | MAX | ZERO}  
Long Form: CALibrate:VOLT {MIN | MAX | ZERO}

Description: **Selects Voltage calibration, only effective with power supply in Calibrate status.** CAL:VOLT ZERO selects Voltage Zero Calibration. CAL:VOLT MIN selects Voltage Full Scale Negative Calibration. CAL:VOLT MAX selects Voltage Full Scale Positive Calibration. Normally Voltage Zero is done first, then Voltage Full Scale Positive Calibration. **Related Commands:** CAL:STAT, CAL:VOLT, CAL:CURR, CAL:ZERO, CAL:DATA, CAL:DPOT, CAL:SAVE. (See example, Figure B-1.)

## B.13 CALibrate:VPRotect COMMAND

# CAL:VPR

Syntax: Short Form: CAL:VPR {MIN | MAX}  
Long Form: CALibrate:VPRotect {MIN | MAX}

Description: **Selects Voltage Protection limit calibration, only effective with power supply in Calibrate status.** CAL:VPR MAX selects maximum positive voltage protection limit calibration. CAL:VPR MIN selects maximum negative voltage protection limit calibration. **Related Commands:** CAL:STAT, CAL:ZERO, CAL:DATA, CAL:SAVE.

## B.14 CALibrate:ZERO COMMAND

# CAL:ZERO

Syntax: Short Form: CAL:ZERO Long Form: CALibrate:ZERO

Description: **Sets output to zero while calibration equipment connections are changed.** This command is used when changing from Voltage to Current calibration or vice-versa. CAL:ZERO sets output voltage and current to zero. The user then connects or disconnects the shunt resistor or the digital voltmeter from the output terminals of the power supply as required for the subsequent Voltage or Current calibration. The next command should select the new parameter to be calibrated. **Related Commands:** CAL:STAT, CAL:VOLT, CAL:CURR, CAL:SAVE. (See example, Figure B-1.)



### B.15 INITiate[:IMMEDIATE] COMMAND

## INIT[:IMM]

Syntax: Short Form: INIT[:IMM] Long Form: INITiate[:IMMEDIATE]

Description: **Enables a single trigger.** This command enables a single trigger. A \*TRG command completes the sequence. Upon receipt of the \*TRG command, the power supply will return to the commanded values of voltage and current established by the VOLT:TRIG and CURR:TRIG commands. After a \*TRG command has been received, subsequent \*TRG commands have no effect unless preceded by INIT or INIT:CONT ON. Related Commands: \*TRG, TRIG. (See example, Figure B-3.)

### B.16 INITiate:CONTinuous COMMAND

## INIT:CONT

Syntax: Short Form: INIT:CONT {ON | OFF} or {1 | 0} (1 = on, 0 = off)  
Long Form: INITiate:CONTinuous {ON | OFF} or {1 | 0} (1 = on, 0 = off)

Description: **INIT:CONT ON enables continuous triggers.; INIT:CONT OFF disables continuous triggers.** If INIT:CONT is OFF, then INIT[:IMM] arms the trigger system for a single trigger. If INIT:CONT is ON, then the trigger system is continuously armed and INIT[:IMM] is redundant. Executing \*RST command sets INIT:CONT to ON. (See example, Figure B-3.)

### B.17 INITiate:CONTinuous QUERY

## INIT:CONT?

Syntax: Short Form: INIT:CONT? Long Form: INITiate:CONTinuous?  
Return Value: 1 or 0

Description: **Determines whether continuous triggers are enabled or disabled.** Power supply returns value of INIT:CONT flag: "1" = continuous triggers are enabled (INIT:CONT ON); "0" = continuous triggers disabled (INIT:CONT OFF). (See example, Figure B-3.)

### B.18 MEASure[:SCALar]:CURRent[:DC]? QUERY

## MEAS:CURR?

Syntax: Short Form: MEAS[:SCAL]:CURR[:DC]?  
Long Form: MEASure[:SCALar]:CURRent[:DC]?  
Return Value: <num\_value> (digits with decimal point and Exponent)

Description: **Measures actual current.** This query returns the actual value of output current (measured at the output terminals) as determined by the programmed value of voltage and current and load conditions. (See example, Figure B-3.)

### B.19 MEASure[:VOLTage][:SCALar][:DC]? QUERY

## MEAS:VOLT?

Syntax: Short Form: MEAS[:SCAL]:VOLT[:DC]?  
Long Form: MEASure[:SCALar]:VOLTage[:DC]?  
Return Value: <num\_value> (digits with decimal point and Exponent)

Description: **Measures actual voltage.** This query returns the actual value of output voltage (measured at the output terminals) as determined by the programmed value of voltage and current and load conditions. (See example, Figure B-3.)

### B.20 OUTPut[:STATe] COMMAND

## OUTP

Syntax: Short Form: OUTP[:STAT] <boolean> Long Form: OUTPut[:STATe] <boolean>  
<boolean>=(0 or OFF, 1 or ON)

Description: **Enables or disables the power supply output.** Upon power up the power supply is in Local mode: the output is always on and the front panel controls affect the unit's operation. Upon entering Remote mode, the default state is OUTP OFF; OUTP ON must be executed to enable the output. When OUTP OFF is executed, the programmed values of voltage and current are saved, then voltage and current are programmed to 0. When OUTP ON is executed, the power supply output is restored to the previously saved programmed values. The saved values of voltage and current can be viewed by VOLT? and CURR? queries. Related Commands: OUTP?.

### B.21 OUTPut[:STATe] QUERY

## OUTP?

Syntax: Short Form: OUTP[:STAT]? Long Form: OUTPut[:STATe]?  
Return Value: <int\_value> (0 or 1)

Description: **Indicates whether power supply output is enabled or disabled.** Returns 0 if output disabled, returns 1 if output enabled. Related Commands: OUTP.

## B.22 [SOURCE:]FUNCTION:MODE COMMAND

# FUNC:MODE

Syntax: Short Form: FUNC:MODE {VOLT | CURR} Long Form: [SOURCE:]FUNCTION:MODE {VOLT | CURR}

Description: **Establishes the operating mode of the power supply.** VOLT = Constant Voltage mode (CV). CURR = Constant Current mode (CC). FUNC:MODE VOLT commands power supply to Voltage mode, FUNC:MODE CURR commands power supply to Current mode. Commanded mode establishes parameters (voltage or current) monitored for error conditions. Actual mode depends upon load conditions. When commanded to Voltage mode, if load conditions cause the power supply to try to exceed the current limit, the unit will flag an error condition. When commanded to Current mode, if load conditions cause the power supply to try to exceed the voltage limit, the unit will flag an error condition. If VOLT:MODE or CURR:MODE is set to TRANS, FUNC:MODE command automatically changes the mode to FIXEd. (See example, Figure B-3.)

## B.23 [SOURCE:]FUNCTION:MODE? QUERY

# FUNC:MODE?

Syntax: Short Form: FUNC:MODE? Long Form: [SOURCE:]FUNCTION:MODE?

**Return value:** 0 (voltage mode) or 1 (current mode)

Description: **Returns the operating mode of the power supply.** 0 = Constant Voltage mode (CV). 1 = Constant Current mode (CC).

## B.24 [SOURCE:]FUNCTION:MODE:TRIGger

# FUNC:MODE:TRIG

Syntax: Short Form: FUNC:MODE:TRIG {VOLT | CURR}  
Long Form: [SOURCE:]FUNCTION:MODE:TRIGger {VOLT | CURR}

Description: **Establishes the operating mode of the power supply when a TRIGger command is sent.** VOLT = Constant Voltage mode (CV). CURR = Constant Current mode (CC). This command establishes the operating mode for triggers which is be saved or recalled using \*SAV or \*RCL command. FUNC:MODE:TRIG VOLT commands power supply to Voltage mode when a TRIGger command is sent, FUNC:MODE:TRIG CURR commands power supply to Current mode when a TRIGger command is sent. If VOLT:MODE or CURR:MODE is set to TRANS, FUNC:MODE:TRIG command automatically changes the mode to FIXEd. (See example, Figure B-4.)

## B.25 [SOURCE:]FUNCTION:MODE:TRIGger? QUERY

# FUNC:MODE:TRIG?

Syntax: Short Form: FUNC:MODE:TRIG? Long Form: [SOURCE:]FUNCTION:MODE:TRIGger?

**Return value:** 0 = voltage mode or 1 = current mode

Description: **Returns the operating mode which the power supply will enter when a trigger command is .** VOLT = Constant Voltage mode (CV). CURR = Constant Current mode (CC). (See example, Figure B-4.)

## B.26 [SOURCE:]LIST:CLEar COMMAND

# LIST:CLE

Syntax: Short Form: LIST:CLE Long Form: LIST:CLEar>

Description: **Clears all list entries by setting all pointers to 0.** Also sets LIST:DIR to UP, LIST:GEN to DSEQ, Related Commands: All LIST commands (See example, Figure B-2.)

## B.27 [SOURCE:]LIST:COUNT COMMAND

# LIST:COUN

Syntax: Short Form: LIST:COUN<int\_value 0 to 255> Long Form: LIST:COUNt> <int\_value 0 to 255>

Description: **Establishes how many times the list is executed.** Allows user to establish how many times the list (established by LIST:GEN DSEQ or LIST:GEN SEQ and LIST:SEQ) is executed. The order (beginning to end or end to beginning) is determined by LIST:DIR. For LIST:COUN 0, the unit will execute the sequence indefinitely until either a VOLT:MODE FIXED, or PROG:STOP command is received. Commands: LIST:GEN, LIST:SEQ, LIST:DIR. (See example, Figure B-2.)

## B.28 [SOURCE:]LIST:COUNT? QUERY

# LIST:COUN?

Syntax: Short Form: LIST:COUNT? Long Form: LIST:COUNT?

**Return Value:** <int\_value>

Description: **Identifies how many times the list will be executed.** Returns value set by LIST:COUN command. (See example, Figure B-2.)

# LIST:COUN:SKIP

## B.29 [SOURCE:]LIST:COUN:SKIP COMMAND

Syntax: Short Form: LIST:COUN:SKIP nn Long Form: LIST:COUN:SKIP nn  
 nn = <int\_value 0 to 255>

Description: **Allows beginning steps of list-generated waveform to be run once, then ignored.**

When a list is to be repeated using LIST:COUNT, this command allows the user to skip the first nn steps once the full set has been executed. After the first iteration (which executes all steps), the first nn steps are skipped. The LIST:COUN:SKIP command allows the user to precondition a list-generated waveform by setting unique conditions at the beginning that are not repeated for the rest of the repetitions. LIST:CLEAR sets nn to 0. Only works in LIST:DIR UP mode, if LIST:DIR DOWN is issued, this command has no effect. Related Commands: LIST:COUN, LIST:COUN:SKIP?, LIST:SEQ, LIST:DIR, LIST:CLEAR. (See example, Figure B-2.)

# LIST:COUN:SKIP?

## B.30 [SOURCE:]LIST:COUN:SKIP? QUERY

Syntax: Short Form: LIST:COUN:SKIP? Long Form: LIST:COUN:SKIP?  
 Return Value: <int\_value>

Description: **Identifies how many steps will be skipped the first time the list is executed.** Returns value set by LIST:COUN:SKIP command. (See example, Figure B-2.)

# LIST:CURREN

## B.31 [SOURCE:]LIST:CURREN COMMAND

Syntax: Short Form: LIST:CURREN <exp\_value>, <exp\_value>, . . . (to max of 1002 data points)  
 Long Form: LIST:CURREN <exp\_value>, <exp\_value>, . . . (to max of 1002 data points)  
 <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Adds the current value (in Amps) to list.** This command sequentially adds LIST:CURREN values to the main channel List Data Table locations illustrated in Table B-2. Starting location is indicated by LIST:CURREN:POIN? These locations correspond to the default sequence (LIST:GEN DESQ). The maximum number of entries is 1002. Since the input buffer of the BIT 4886 has a limit of 253 characters, multiple commands are necessary to complete the full 1002 entries of the list. If LIST:VOLT has any entries, an error message: -221,"Settings conflict" is posted in the error queue. Related Commands: LIST:CURREN:POIN?. (See example, Figure B-2.)

TABLE B-2. List Data Table

Location (DSEQ)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	.....	1001
Main Channel (commanded mode) LIST:CURREN or LIST:VOLTage																			.....	
LIST:DWELI																			.....	

NOTE: FUNC:MODE determines whether main channel is for voltage or current. FUNC:MODE CURREN must precede LIST:CURREN commands, FUNC:MODE VOLT must precede LIST:VOLT commands

# LIST:CURREN?

## B.32 [SOURCE:]LIST:CURREN? QUERY

Syntax: Short Form: LIST:CURREN? Long Form: LIST:CURREN?  
 Return Value: <value1>, <value2>, . . . to <value16>

Description: **Identifies the parameters (main channel) entered for the list.** Starting at location established by LIST:QUERY, returns comma-separated list of up to 16 values indicating the main channel parameters entered. i.e., the contents of main channel locations of Table B-2. Related Commands: LIST: CURREN, LIST:QUERY. If LIST:VOLT has any entries, an error message: -221,"Settings conflict" is posted in the error queue. (See example, Figure B-2.)

# LIST:CURREN:POIN?

## B.33 [SOURCE:]LIST:CURREN:POIN? QUERY

Syntax: Short Form: LIST:CURREN:POIN? Long Form: LIST:CURREN:POIN?  
 Return Value: <value> (0 to 1001)

Description: **Identifies the total number of points in a list and the next location to be filled by LIST:CURREN command.** The LIST:CURREN pointer is initially at 0 via LIST:CLEAR. For each data point entered by a LIST:CURREN command the list pointer is incremented. If LIST:CURREN:POIN? returns 5, the LIST:CURREN pointer is at 5 indicating there are 6 data points comprising the list. If LIST:VOLT has any entries, an error message: -221,"Settings conflict" is posted in the error queue. Related Commands: LIST:CURREN. (See example, Figure B-2.)

## LIST:DIR

### B.34 [SOURCE:]LIST:DIRrection COMMAND

Syntax: Short Form: LIST:DIR (UP|DOWN) Long Form: LIST:DIRrection (UP|DOWN)  
Description: **Allows the list to be executed from beginning to end (UP) or from end to the beginning (DOWN).** \*RST or LIST:CLEAR sets the list to the UP direction (beginning to end). Works with both LIST:GEN DSEQ and LIST:GEN SEQ commands. Related Commands: LIST:GEN. LIST:SEQ, LIST:DWEL?. (See example, Figure B-2.)

## LIST:DIR?

### B.35 [SOURCE:]LIST:DIRrection? QUERY

Syntax: Short Form: LIST:DIR? Long Form: LIST:DIRrection?  
Return Value: <value> (UP or DOWN)

Description: **Identifies the for executing the list established by LIST:DIR.** Related Commands: LIST: DIR. (See example, Figure B-2.)

## LIST:DWEL

### B.36 [SOURCE:]LIST:DWELI COMMAND

Syntax: Short Form: LIST:DWEL <value> (0.0005 to 10),<value>,<value>, . . . to maximum of 1002 values  
Long Form: LIST:DWELI <value> (0.0005 to 10),<value>,<value>, . . . to maximum of 1002 values  
Description: **Determines how long the main channel parameters will be active.** Sets time value (from 0.0005 to 10) in seconds for List:Dwell locations illustrated in Table B-2. These locations are associated with the corresponding main channel locations illustrated in Table B-2. The main channel is determined by FUNC:MODE, either current (FUNC:MODE CURR) or voltage (FUNC:MODE VOLT) If LIST:DWEL is entered for only location 0, that time duration will apply to all steps when either VOLT:MODE LIST or CURR:MODE LIST is executed. Related Commands: VOLT:MODE, FUNC:MODE, LIST:CURR, LIST:VOLT, LIST:DWEL?, LIST:SEQ. (See example, Figure B-2.)

## LIST:DWEL?

### B.37 [SOURCE:]LIST:DWELI? QUERY

Syntax: Short Form: LIST:DWEL? Long Form: LIST:DWELI?  
Return Value: <value>

Description: **Identifies the dwell times entered for the list.** Starting at location established by LIST:QUERY, returns comma-separated list of up to 16 values indicating the dwell time parameters entered. i.e., the contents of LIST:DWEL locations of Table B-2. Related Commands: LIST: DWEL, LIST:QUERY. (See example, Figure B-2.)

### B.38 [SOURCE:]LIST:DWELI:POINts? QUERY

## LIST:DWEL:POIN?

Syntax: Short Form: LIST:DWEL:POIN? Long Form: LIST:DWELI:POINts?  
Return Value: <value> (0 to 1001)

Description: **Identifies the number of locations for which time values have been entered and the next location to be filled by a LIST:DWEL command.** If LIST:DWEL:POIN? returns 6, dwell times have been entered for locations 0 through 5 and location 6 is the next to be filled by a LIST:DWEL command. LIST:DWEL, LIST:DWEL:POIN. (See example, Figure B-2.)

NOTES:	Examples below are intended only to illustrate command functions. Refer to PAR. 4.1.1 for programming techniques to optimize performance.
FUNC:MODE VOLT	Initializes the power supply mode to be voltage.
LIST:CLEAR	Initializes the list processor to add entries, clears main channel (LIST:CURREN or LIST:VOLT) and LIST:DWEL data tables (Table B-2) and List Sequence table (Table B-3).
LIST:dwel .010	Sets the time duration for location 0 to be 0.010 second (Since dwell times for the rest of the locations in the list are not entered before running the list, the dwell time will be 0.010 second for all locations).
LIST:VOLT -20,-18,-16,-14,-12,-10,-8,-6,-4,-2,0	Starting at location 0 (-20), up to location 10 (0), fills the list with 11 data points.
LIST:VOLT:POIN?	Returns 11. Indicates that 11 data points have been entered, and location 11 is the next location to be filled (for the 12th data point).
NOTE: See PAR. B.2 for format and accuracy of all numerical data returned.	
LIST:QUERY?	Returns 0 (pointer cleared by LIST:CLE).
LIST:VOLT?	Returns -20,-18,-16,-14,-12,-10,-8,-6,-4,-2,0 (the contents of locations 0 through 10). (See PAR. B.2 for format and accuracy of numerical data.)
list:volt 2,4,6,8,10,12,14,16,18,20	Adds 10 points to the list (location 11 through 20). List now has 21 points.
LIST:VOLT:POIN?	Returns 21 (the next location to be filled by LIST:VOLT).
LIST:VOLT?	Returns -20,-18,-16,-14,-12,-10,-8,-6,-4,-2,0,2,4,6,8 (the contents of locations 0 through 15).
LIST:GEN SEQUENCE	Enables the execution of a user-determined sequence list
LIST:seq 0, 0, 0, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	Establishes the user-determined sequence.
LIST:seq 19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1,0	Continues the user-determined list sequence. The SEQ values entered mean that if LIST:GEN SEQ is issued, the list will execute location 0 four times (-20V for 40 milliseconds) location 1 through 20 and 19 through 0 (10 milliseconds each) for a total of 44 data points when VOLT:MODE LIST is issued.
LIST:SEQ?	Returns 0,0,0,0,1,2,3,4,5,6,7,8,9,10,11,12 (LIST:SEQ locations 0 through 15).
LIST:QUERY 16	Start LIST queries from location 16.
LIST:SEQ?	Returns 13,14,15,16,17,18,19,20,19,18,17,16,15,14,13,12 (LIST:SEQ locations 16 through 31).
LIST:QUERY 32	Start LIST queries from location 32.
LIST:SEQ?	Returns 11,10,9,8,7,6,5,4,3,2,1,0 (LIST:SEQ locations 32 through 43).
LIST:COUNT 100	Specifies that when VOLT:MODE LIST is issued, the user-determined sequence will be executed 100 times. (44 steps in the list will be executed 100 times)
LIST:COUN:SKIP 4	Specifies that the first 4 steps of the sequence will only be executed the first time through the list. For the subsequent 99 iterations established by LIST:COUNT 100, location 0 (-20V) will last 10 milliseconds.
CURR 1;VOLT -20	initializes the BOP output
OUTPUT ON	Turns the output on (BOP now provides -20 volts)
VOLT:MODE LIST	Executes the list. For 40 milliseconds the BOP outputs -20V, then output a staircase triangle wave from -20V to +20V and back down to -20V. This staircase will have a uniform spacing between voltage changes of 10 milliseconds and will repeat 100 times.
VOLT?	Returns -20 (the last step in the list set the unit to -20V).
LIST:GEN?	Returns SEQ to indicate the list will be executed in the user-determined order entered by LIST:SEQ (Table B-3).

**FIGURE B-2. USING LIST COMMANDS AND QUERIES (SHEET 1 OF 2)**

LIST:GEN DSEQ	Changes the list to execute sequentially from locations 0 through 20).
LIST:COUN:SKIP?	Returns 4. Skip first 4 steps after the first time through count.
LIST:COUN:SKIP 0	Specifies no steps to be skipped after the first time through the count.
LIST:COUNT?	Returns 100.
LIST:COUNT 10	Determines that the list will be repeated 10 times when executed.
LIST:COUNT?	Returns 10.
VOLT:MODE LIST	Initiates execution of the list. The unit outputs a sawtooth waveform that increases from -20V to +20V and repeats 10 times. There is an abrupt change from +20V to -20V each time the list transitions from location 20 to location 0.
VOLT?	Returns 20, (the last step in the list set the unit to 20V.
LIST:VOLT:POIN?	Returns 21 (the next location to be filled by LIST:VOLT).
LIST:VOLT 10,0,-10	Add 3 points to the list (location 21 through 23).
LIST:COUN?	Returns 10 indicating that the list will be repeated 10 times when executed.
LIST:DIR?	Returns UP (the default.)
LIST:DIR DOWN	Reverses the sequence order.
VOLT:MODE LIST	The list (24 steps) is executed. The output starts at -10V, goes to 0V, to 10V to 20V then decreases to -20V in 2V steps and repeats 10 times. The sawtooth is similar to the previous sawtooth, except the waveform is inverted and the abrupt change from -20 to +20 is executed in three steps of 10 volts.
LIST:GEN?	Returns DSEQ (default sequence))
LIST:GENERATION:SEQ	Changes sequence to user determined sequence.
VOLT:MODE:LIST	The original list of 4400 points will be executed (without the three new steps.)
LIST:QUERY 0	Sets query pointer to zero.
LIST:DWEL:POIN?	Returns 1 indicating the next dwell time will be entered in location 1.
LIST:DWELL .01,.01,.01,.01,.01,.01,.01,.01,.01	Enters dwell time of 0.01 seconds in locations 1 through 9.
LIST:DWELL 1	Enters dwell time of 1 second in location 10.
VOLT:MODE LIST	the list is not executed, the unit returns error -221,Settings Error indicating the lists are not balanced.
LIST:DWELL:POINTS?	Returns 11 to indicate the dwell list has 11 entries
LIST:VOLT:POINTS?	Returns 24 to indicate the voltage list has 24 entries.
LIST:DWELL .01,.01,.01,.01,.01,.01,.01,.01,.01,.1,.1,-1	Dwell times are entered in locations 11 through 23.
DWELL:POINTS?	Returns 24 indicating there are now 24 step dwell times on the list.
LIST:QUER?	Returns 0 indicating list queries will start from location 0
LIST:QUER 18	Causes list queries to start at location 18
LIST:DWEL?	Returns 01,.01,.1,.1,.1 (the dwell times for locations 18 through 23.
LIST:VOLT?	Returns 16,18,20,10,0,-10
LIST COUNT 0	List will repeat indefinitely.
VOLT:MODE LIST	The list is executed. Stair case wave now consists of 24 steps of .01 seconds except for the 0V step (location 10) which outputs 0V for 1 second. The end of the staircase has three steps of 0.1 second.
LIST:GEN?	Returns error -221,Settings Error because a LIST command cannot be executed while the LIST is still being executed.
VOLT:MODE FIX	Stops execution of the list
VOLT?	VOLT?Returns -20 (the last step in the list set the unit to -20V.
VOLT: -4	Programs output to -4V
VOLT:MODE TRAN .05	Prepares for a voltage transient lasting 0.05 seconds.
VOLT:RANG 4	Sets unit to 1/4 scale (e.g., for BOB 20-20M, maximum voltage now 5V
VOLT: 3	Output goes to +3V for 0.05 second, then returns to -4V.

**FIGURE B-2. USING LIST COMMANDS AND QUERIES (SHEET 2 OF 2)**

# LIST:GEN

## B.39 [SOURCE:]LIST:GENeration COMMAND

Syntax: Short Form: LIST:GEN (SEQ | DSEQ)  
 Long Form: LIST:GENeration (SEQUence | DSEQUence)

Description: **Establishes the order for executing the list.** Selects either default sequence (DSEQ) or a user-determined sequence (SEQ).

DSEQ is the default sequence shown in Table B-2 and Table B-3, 0 through 1001. When LIST:GEN DSEQ is issued, the data points are executed in order either from beginning (location 0) to end (the last location with data, up to location 1001), or from end to beginning (location 0). The order is established by LIST:DIR command.

SEQ allows the list to be executed by an arbitrary sequence (up to 512 steps) determined by LIST:SEQ and LIST:DIR. Related Commands: LIST:SEQ, LIST:DIR. (See example, Figure B-2.)

**TABLE B-3. List Sequence Table**

LOCATION	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	.....	511	512		1001	
DSEQ	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	.....					1001
SEQ																			.....			NOT AVAILABLE		

## B.40 [SOURCE:]LIST:GENeration? QUERY

# LIST:GEN?

Syntax: Short Form: LIST:GEN? Long Form: LIST:GENeration?  
 Return Value: <value> (SEQ or DSEQ)

Description: **Identifies the sequence for executing the list.** Returns DSEQ for the default sequence, SEQ for user-determined sequence. Related Commands: LIST:GEN. (See example, Figure B-2.)

## B.41 [SOURCE:]LIST:QUERy COMMAND

# LIST:QUER

Syntax: Short Form: LIST:QUER <int\_value>  
 Long Form: LIST:QUERy <int\_value>  
 int\_value = 0 to 1001

Description: **Determines first location to be queried by LIST:SEQ? query.** Related Commands: LIST:SEQ?, LIST:QUER?. (See example, Figure B-2.)

## B.42 [SOURCE:]LIST:QUERy? QUERY

# LIST:QUER?

Syntax: Short Form: LIST:SEQ? Long Form: LIST:SEQUence?  
 Return Value: <int\_value>

Description: **Identifies first location to be queried by LIST:SEQ?, LIST:VOLT?, LIST:CURR?, LIST:DWEL? queries.** Related Commands: LIST:QUER, LIST:SEQ. (See example, Figure B-2.)

## B.43 [SOURCE:]LIST:SEQUence COMMAND

# LIST:SEQ

Syntax: Short Form: LIST:SEQ <int\_value>, <int\_value>, etc. to max. of 512 locations  
 Long Form: LIST:SEQUence <int\_value>, <int\_value>, etc. to max. of 512 locations  
 int\_value = 0 to 511

Description: **Determines the order to execute data points of the list when LIST:GEN SEQ is issued.** Integer values fill the SEQ cells of the List Sequence Table (see Table B-3) in order, starting at location 0. For example, for a list with five points, if LIST:SEQ 4,2,1,3,0 is followed by LIST:GEN SEQ, the list will start from data point 4 (see Table B-2), then execute points 2, 1, 3, 0. (On the other hand, if LIST:GEN DSEQ is issued, data points are executed sequentially starting at 0, then 1, 2, 3, 4.) SEQ steps can be arranged to repeat steps in any order; for example a 17-step sequence for a list having five data points may be as follows: LIST SEQ 0,1,2,3,4,5,4,3,2,1,0,5,5,5,1,1,1 Related Commands: LIST:GEN, LIST:DIR, LIST:COUN, LIST:COUN:SKIP. (See example, Figure B-2.)

## B.44 [SOURCE:]LIST:SEQUence? QUERY

# LIST:SEQ?

Syntax: Short Form: LIST:SEQ? Long Form: LIST:SEQUence?  
 Return Value: <value1>, <value2>, . . . to <value16>

Description: **Identifies the user-determined sequence for executing the list.** Starting at location established by LIST:QUERy, returns comma-separated list of up to 16 values indicating the user-determined sequence for executing the list, i.e., the contents of the SEQ locations of Table B-3. Related Commands: LIST:SEQ, LIST:QUERy. (See example, Figure B-2.)

#### B.45 [SOURce:]LIST:VOLTage COMMAND

## LIST:VOLT

Short Form: LIST:VOLT[:LEV] <exp\_value>, <exp\_value>, . . . (to max of 1002 data points)  
Long Form: LIST:VOLTage[:LEVel] <exp\_value>, <exp\_value>, . . . (to max of 1002 data points)  
<exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Adds the voltage value (in Amps) to list.** This command sequentially adds LIST:VOLTage values to the main channel List Data Table locations illustrated in Table B-2. LIST:CLE sets starting location to 0. Next location indicated by LIST:VOLT:POIN? These locations correspond to the default sequence (LIST:GEN DESQ) The maximum number of entries is 1002. Since the input buffer of the BIT 4886 has a limit of 253 characters, multiple commands are necessary to complete the full 1002 entries of the list. If LIST:CURR has any entries, an error message: -221,"Settings conflict" is posted in the error queue. Related Commands: LIST:VOLT:POIN?, FUNC:MODE, LIST:CLE, \*RST. (See example, Figure B-2.)

#### B.46 [SOURce:]LIST:VOLTage? QUERY

## LIST:VOLT?

Syntax: Short Form: LIST:VOLT? Long Form: LIST:VOLTage?  
Return Value: <value1>, <value2>, . . . to <value16>

Description: **Identifies the parameters (main channel) entered for the list.** Starting at location established by LIST:QUERY, returns comma-separated list of up to 16 values indicating the main channel parameters entered. i.e., the contents of the main channel locations of Table B-2. Related Commands: LIST:VOLT, LIST:QUERY. If LIST:CURR has any entries, an error message: -221,"Settings conflict" is posted in the error queue. (See example, Figure B-2.)

#### B.47 [SOURce:]LIST:VOLTage:POINts? QUERY

## LIST:VOLT:POIN?

Syntax: Short Form: LIST:VOLT:POIN? Long Form: LIST:VOLTage:POINts?  
Return Value: <value> (0 to 1001)

Description: **Identifies the total number of points in a list and the next location to be filled by LIST:VOLT command.** The LIST:VOLT pointer is initially at 0 via \*RST or LIST:CLE. For each data point entered by a LIST:VOLT command the list pointer is incremented. If LIST:VOLT:POIN? returns 5, the LIST:VOLT pointer is at 5 indicating there are 5 data points comprising the list (locations 0 through 4) and location 5 is the next to be filled. If LIST:CURR has any entries, an error message: -221,"Settings conflict" is posted in the error queue. Related Commands: LIST:VOLT. (See example, Figure B-2.)

#### B.48 [SOURce:]CURRent[:LEVel][:IMMEDIATE][:AMPLitude] COMMAND

## CURR

Syntax: Short Form: [SOUR:]CURR[:LEV][:IMM][:AMP] <exp\_value>  
Long Form: [SOURce:]CURRent[:LEVel][:IMMEDIATE][:AMPLitude] <exp\_value>  
<exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Sets programmed current level at power supply output.** This command programs output current to a specific value; actual output current will depend on load conditions. If CURR:RANG is set to 4, any data that exceeds 1/4 of  $I_{MAX}$  causes error message -222 "data out range" to be posted to the error queue (See example, Figure B-3.)

#### B.49 [SOURce:]CURRent[:LEVel][:IMMEDIATE][:AMPLitude] QUERY

## CURR?

Syntax: Short Form: [SOUR:]CURR[:LEV][:IMM][:AMP]? MIN, MAX  
Long Form: [SOURce:]CURRent[:LEVel][:IMMEDIATE][:AMPLitude]? MIN, MAX  
Return Value: <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Returns either the programmed value, maximum value, or minimum value of current.** The CURR? query returns the programmed value of current. Actual output current will depend on load conditions. The CURR?MAX query returns the maximum current allowed for a particular model. CURR? Returns programmed current value. CURR? MAX returns maximum current allowed for power supply. CURR? MIN returns minimum current allowed for power supply (always negative). **Related Commands:** CURR. (See example, Figure B-3.)



- NOTES: 1. The power supply is assumed to be operating in constant voltage mode.  
 2. Examples below are intended only to illustrate command functions. Refer to PAR. 4.1.1 for programming techniques to optimize performance.

OUTP ON	Turns the output on.
VOLT 21; CURR 1.5	Power supply output programmed to go to 21V, current limit 1.5A
INIT:CONT ON	Continuous triggers enabled.
INIT:CONT?	Power supply returns "1."
VOLT:TRIG 15;CURR:TRIG 3	Power supply output programmed to return to 15V, current limit 3A upon receipt of trigger.
*TRG	Power supply output returns to 15V,current limit 3A.
VOLT 21; CURR 5E-2	Power supply output programmed to go to 21V, current limit 0.05A
MEAS:VOLT?	If actual value of output voltage is 20.9V, power supply returns 2.09E1.
MEAS:CURR?	If actual value of output current is 0.0483A, power supply returns 4.83E-2.
FUNC:MODE CURR	Establishes constant current mode as power supply operating mode.
VOLT 21; CURR 1.1	Power supply programmed to voltage limit 21V, 1.1A.
CURR?	Returns 1.1.
FUNC:MODE VOLT	Establishes constant voltage mode as power supply operating mode.
CURR:TRIG?	Returns 3 (current value established by CURR:TRIG).
VOLT:TRIG?	Returns 15 (voltage value established by VOLT:TRIG).
TRIG	Power supply output returns to 15V, current limit 3A.
INIT:CONT 0	Triggers disabled.
INIT:CONT?	Power supply returns "0."
VOLT 0	Power supply output programmed to go to 0V.
MEAS:VOLT?	Returns 0. (measured output voltage).
VOLT?	Returns 0.(programmed output voltage).
CURR?	Returns 1.5 (programmed current).
MEAS:CURR?	Returns 0. (measured output current).
CURR:RANG 4	Set the current range to 1/4 of full scale. The maximum current for a 55-1 BOP is now 0.25ampere.
CURR .3	Selecting a range greater than 0.25 results in no change of output current.
CURR .2	Sets power supply to deliver 0.2 ampere at 0.024% accuracy.
CURR AUTO	The power supply remains in 1/4 scale.
CURR .5	Sets the output to be 1/2 ampere in the high range.
CURR:RANG?	Unit returns a 1 indicating unit range.is full scale.

FIGURE B-3. PROGRAMMING THE OUTPUT

**B.50 [SOURce:]CURRENT:MOD COMMAND**

**CURR:MOD**

Syntax: Short Form: [SOUR:]CURR:MOD (FIX | LIST | TRAN) nn  
 Long Form: [SOURce:]CURRent:MODE (FIXed | LIST | TRANsient) nn  
 nn = <value> = time in seconds for transient

Description: **Allows the user to execute or stop a list, or to execute a transient.** The default mode is FIXed: the power supply executes commands normally, and LIST commands can be issued to establish the parameters and sequence of a list.

When CURR:MODE LIST is issued, a list is executed (See LIST commands and Figure B-2). While the list is being executed, LIST commands are not accepted and will produce a command error. Issuing CURR:MODE FIX while the list is running will stop the execution of the list and return power supply to settings in effect prior to running the list. If the list runs to completion, the settings of the last step of the list will be in effect.

CURR:MODE TRANS nn causes the next CURR: command to produce a transient pulse of nn seconds duration, after which the current reverts back to the previous setting (Similar to VOLT:MODE TRANS (see PAR. B.59 for examples).If the time nn exceeds 10 seconds, error message -222 "data out range" is posted to the error queue. **Related Commands:** LIST commands. (See example, Figure B-2.)

### B.51 [SOURce:]CURRent:MODE? QUERY

Syntax: Short Form: [SOUR:]CURR[:LEV]:MOD?  
Long Form: [SOURce:]CURRent[:LEVe]:MODE?

**Return value:** FIXED or LIST or TRANS

Description: **Identifies active current mode.** Returns LIST while list is being executed. Returns TRANSIENT after CURR:MODE:TRAN command has been issued, but before CURR: or \*TRG command executes the transient. Returns FIXED while in fixed (default) mode of operation. **Related Commands:** LIST commands. (Similar to VOLT:MODE?, see Figure B-2.)

## CURR:MOD?

### B.52 [SOURce:]CURRent[:LEVe]RANGe COMMAND

Syntax: Short Form: [SOUR:]CURR[:LEV]:RANG <value>  
Long Form: [SOURce:]CURRent[:LEVe]:RANGe <value>  
<value> = 1 (full scale) or 4 (1/4 scale)

Description: **Allows the user to specify the operating range for control of output current.** Range = 1 allows control of output current from 0 to full scale. Range = 4 allows the full range of the 16 bit D to A converter to control 1/4 of the full scale output current. This command will generate a command warning error if the unit is not in current mode. It will be remembered until a func:mode command is processed. (See example, Figure B-3.)

## CURR:RANG

### B.53 [SOURce:]CURRent[:LEVe]RANGe? QUERY

Syntax: Short Form: [SOUR:]CURR[:LEV]:RANG?  
Long Form: [SOURce:]CURRent[:LEVe]:RANGe?

Description: **Identifies programmed current range.** Returns 1 (full scale) or 4 (1/4 scale) (See example, Figure B-3.)

## CURR:RANG?

## CURR:RANG:AUTO

### B.54 [SOURce:]CURRent[:LEVe]RANGe:AUTO COMMAND

Syntax: Short Form: [SOUR:]CURR[:LEV]:RANG:AUTO <boolean>  
Long Form: [SOURce:]CURRent[:LEVe]:RANGe:AUTO <boolean>  
<boolean> = 1 (on) or 0 (off)

Description: **Allows the user to specify automatic range for control of output voltage or current.** Upon power up or upon receiving \*RST, automatic ranging is selected. Automatic ranging can be turned off by VOLT:RANG:AUTO 0, CURR:RANG:AUTO 0, VOLT:RANG 1 or 4, or CURR:RANG 1 or 4. When automatic ranging is set, the correct range is automatically selected based on the programmed parameter. If the programmed parameter is more than 1/4 of nominal full scale, full scale is selected; if equal to or less than 1/4 of full scale, the 1/4 scale range is selected. For example, if auto ranging is set for a unit with 100V nominal output operating in voltage mode, a programmed voltage of up to 25.0V automatically selects range to 1/4 scale, while programming anything above 25.0V selects full scale. Function is identical to VOLT:RANG:AUTO.

### B.55 [SOURce:]CURRent[:LEVe]TRIGgered[:AMPlitude] COMMAND

Syntax: Short Form: [SOUR:]CURR[:LEV]:TRIG[:AMP] <exp\_value>  
Long Form: [SOURce:]CURRent[:LEVe]:TRIGgered[:AMPlitude] <exp\_value>  
<exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Programs current value to be transferred to output by \*TRG or TRIG commands.** This command can be used to reset many power supplies to preselected parameters by issuing a single \*TRG or TRIG command. Actual output current will depend on load conditions. If the value exceeds the maximum for the model being programmed, error message -222, "Data out of range" is posted in output queue. **Related Commands:** CURR, \*TRG, TRIG (See example, Figure B-4.)

## CURR:TRIG

### B.56 [SOURce:]CURRent[:LEVe]TRIGgered[:AMPlitude]? QUERY

Syntax: Short Form: [SOUR:]CURR[:LEV]:TRIG[:AMP]?  
Long Form: [SOURce:]CURRent[:LEVe]:TRIGgered[:AMPlitude]?

**Return Value:** <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Returns the current value established by CURR:TRIG command.** (See example, Figure B-4.)

## CURR:TRIG?

NOTES: 1. The power supply is assumed to be operating in constant voltage (CV) mode.  
 2. Examples below are intended only to illustrate command functions. Refer to PAR. 4.1.1 for programming techniques to optimize performance.

*RST	BOP goes to 0 volts, 0 amperes, Voltage mode
VOLT 10;CURR 1	The voltage is placed in memory of the BOP. No Output Changes
OUTP ON	Turns on Output, 10 Volts up to 1 ampere will be delivered.
VOLT:TRIG 1;CURR:TRIG 2	Trigger is placed in RAM
*SAV 6	Volt 1, Current 2 and Volt mode stored in Memory location 6
*TRG	No action - Trigger control not send
VOLT:TRIG 3;FUNC:MODE:TRIG CURR	No action -trigger placed in RAM
*SAV 7	volt 3, curr 2, current mode saved in location 7
*RCL 6;VOLT:TRIG?	BOP returns 1 (= 1V) (saved value of memory 6)
FUNC:MODE:TRIG?	BOP returns 0 (= trigger will command voltage mode)
*RCL 6;VOLT?	BOP returns 1 (output voltage now set to 1V.).
*RCL 7;:INIT;:VOLT:TRIG?	Enables the trigger capability, unit returns 3 (= 3V)
*TRG	The voltage is set to 3, and the unit mode changes to Current
FUNC:MODE:TRIG?;:FUNC MODE VOLT	Unit switches to voltage mode. Returns 1 (= trigger will command current mode.
FUNC:MODE:TRIG?	Unit returns 0 indicating Voltage mode trigger in effect.

FIGURE B-4. USING RECALL AND TRIGGER FUNCTIONS

**B.57 .[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPlitude] COMMAND**

**VOLT**

Syntax: Short Form: [SOUR:]VOLT[:LEV][:IMM][:AMP] <exp\_value>  
 Long Form: [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPlitude] <exp\_value>  
 <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Sets programmed voltage level at power supply output.** This command programs output voltage to a specific value; actual output voltage will depend on load conditions. If the value exceeds the maximum for the model being programmed, error message -222, "Data out of range" is posted in output queue. (See example, Figure B-3.)

**B.58 [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPlitude]? QUERY**

**VOLT?**

Syntax: Short Form: [SOUR:]VOLT[:LEV][:IMM][:AMP]? {MIN | MAX}  
 Long Form: [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPlitude]? {MIN | MAX}

Description: **Identifies programmed voltage, maximum allowable voltage, or minimum voltage (always 0).** The VOLT? query returns the programmed value of voltage. Actual output voltage will depend on load conditions. The VOLT?MAX query returns the maximum voltage allowed for a particular model. VOLT? MIN returns minimum voltage allowed for power supply (always negative). **Related Commands:** VOLT. (See example, Figure B-3.)

**B.59 [SOURce:]VOLTage:MODE COMMAND**

**VOLT:MOD**

Syntax: Short Form: [SOUR:]VOLT:MOD (FIX | LIST | TRAN) nn  
 Long Form: [SOURce:]VOLTage:MODE (FIXed | LIST | TRANsient) nn  
 nn = <value> = time in seconds for transient

Description: **Allows the user to execute or stop a list, or to execute a transient.** The default mode is FIXed: the power supply executes commands normally, and LIST commands can be issued to establish the parameters and sequence of a list.

When VOLT:MODE LIST is issued, a list is executed (See LIST commands and Figure B-2). While the list is being executed, LIST commands are not accepted and will produce a command error. Issuing VOLT:MODE FIX while the list is running will stop the execution of the list and return power supply to settings in effect prior to running the list. If the list runs to completion, the settings of the last step of the list will be in effect.

VOLT:MODE TRANs nn causes the next VOLT: command to produce a transient pulse of nn seconds duration, after which the voltage reverts back to the previous setting. E.g., VOLT:25 sets the out-

put to 25 volts, and VOLT:MODE TRAN .02 primes the unit for a transient of 0.02 seconds. When VOLT:10 is issued, the power supply output goes to 10V for 0.02 seconds, then reverts to 25V. Similarly, sending VOLT:TRIG 14, VOLT:MODE TRAN .05 and \*TRG causes the output to go to 14V for 0.05 seconds, then revert to 25V. **Related Commands:** LIST commands. (See example, Figure B-2.)

### B.60 [SOURce:]VOLTage:MODE? QUERY

## VOLT:MOD?

Syntax: Short Form: [SOUR:]VOLT[:LEV]:MOD?  
 Long Form: [SOURce:]VOLTage[:LEVel]:MODE?  
**Return value:** FIXED or LIST or TRANS

Description: **Identifies active voltage mode.** Returns LIST while list is being executed. Returns TRANSIENT after VOLT:MODE TRAN nn command has been issued, but before VOLT: or \*TRG command executes the transient. Returns FIXED while in fixed (default) mode of operation. **Related Commands:** LIST commands. (See example, Figure B-2.)

### B.61 [SOURce:]VOLTage[:LEVel]RANGe COMMAND

## VOLT:RANG

Syntax: Short Form: [SOUR:]VOLT[:LEV]:RANG <value>  
 Long Form: [SOURce:]VOLTage[:LEVel]:RANGe <value>  
 <value> = 1 (full scale) or 4 (1/4 scale)

Description: **Allows the user to specify the operating range for the active mode (either voltage or current).** When in voltage mode this command establishes the voltage range, in current mode it establishes the current range. Range = 1 allows control of output voltage or current from 0 to full scale. Range = 4 allows the full range of the 16 bit D to A converter to control 1/4 of the full scale output voltage or current to provide greater accuracy. This command overrides VOLT:RANG:AUTO and turns auto ranging off. (Similar to CURR:RANG shown in Figure B-3.)

### B.62 [SOURce:]VOLTage[:LEVel]RANGe? QUERY

## VOLT:RANG?

Syntax: Short Form: [SOUR:]VOLT[:LEV]:RANG?  
 Long Form: [SOURce:]VOLTage[:LEVel]:RANGe?  
**Return value:** 1 (full scale) or 4 (1/4 scale)

Description: **Identifies active range.** Returns 1 (full scale) or 4 (1/4 scale) (Similar to CURR:RANG? shown in Figure B-3.)

## VOLT:RANG:AUTO

### B.63 [SOURce:]VOLTage[:LEVel]RANGe:AUTO COMMAND

Syntax: Short Form: [SOUR:]VOLT[:LEV]:RANG:AUTO <boolean>  
 Long Form: [SOURce:]VOLTage[:LEVel]:RANGe:AUTO <boolean>  
 <boolean> = 1 (on) or 0 (off)

Description: **Allows the user to specify automatic range for control of output voltage or current.** Upon power up or upon receiving \*RST, automatic ranging is selected. Automatic ranging can be turned off by VOLT:RANG:AUTO 0, CURR:RANG:AUTO 0, VOLT:RANG 1 or 4, or CURR:RANG 1 or 4. When automatic ranging is set, the correct range is automatically selected based on the programmed parameter. If the programmed parameter is more than 1/4 of nominal full scale, full scale is selected; if equal to or less than 1/4 of full scale, the 1/4 scale range is selected. For example, if auto ranging is set for a unit with 100V nominal output operating in voltage mode, a programmed voltage of up to 25.0V automatically selects range to 1/4 scale, while programming anything above 25.0V selects full scale. Function is identical to CURR:RANG:AUTO.

### B.64 [SOURce:]VOLTage[:LEVel]TRIGgered[:AMPlitude] COMMAND ?

## VOLT:TRIG

Syntax: Short Form: [SOUR:]VOLT[:LEV]:TRIG[:AMP] <exp\_value>  
 Long Form: [SOURce:]VOLTage[:LEVel]:TRIGgered[:AMPlitude] <exp\_value>  
 <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Programs voltage value to be transferred to output by \*TRG or TRIG commands.** Actual output voltage will depend on load conditions. If the value exceeds the maximum for the model being programmed, error message -222,"Data out of range" is posted in output queue. If value exceeds VOLT:LIM:HIGH value, a value corresponding to the voltage limit will be programmed. (See example, Figure B-4.)

**B.65 [SOURce:]VOLTage[:LEVel]TRIGgered[:AMPLitude]? QUERY****VOLT:TRIG?**

Syntax: Short Form: [SOUR:]VOLT[:LEV]:TRIG[:AMP]?  
 Long Form: [SOURce:]VOLTage[:LEVel]:TRIGgered[:AMPLitude]?

**Return Value:** <exp\_value> = digits with decimal point and Exponent, e.g., 2.71E1 for 27.1

Description: **Returns value representing voltage value to be programmed by \*TRG or TRIG command established by VOLT:TRIG command.** (See example, Figure B-4.)

**B.66 STATus:OPERation:CONDition QUERY****STAT:OPER:COND?**

Syntax: Short Form: STAT:OPER:COND? Long Form: STATus:OPERation:CONDition?

**Return Value:** <int\_value> 0 to 1313 (1 + 32 + 256 + 1024).

Description: **Returns the value of the Operation Condition Register (see Table B-4).** The Operation Condition Register contains unlatched real-time information about the operating conditions of the power supply. Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). (See example, Figure B-5.)

**TABLE B-4. OPERATION CONDITION REGISTER, OPERATION ENABLE REGISTER, AND OPERATION EVENT REGISTER BITS**

CONDITION	NU	CC	NU	CV	NU	NU	NU	NU
BIT	15-11	10	9	8	7 - 6	5	4 - 1	0
VALUE	32,768 - 2048	1024	512	256	128 - 64	32	16 - 2	1

CC - POWER SUPPLY IN CONSTANT CURRENT MODE  
 CV - POWER SUPPLY IN CONSTANT VOLTAGE MODE  
 NU - NOT USED

**B.67 STATus:OPERation:ENABLE COMMAND****STAT:OPER:ENAB**

Syntax: Short Form: STAT:OPER:ENAB <int\_value> 0 to 1313 (1 + 32 + 256 + 1024)  
 Long Form: STATus:OPERation:ENABLE <int\_value> 0 to 1313 (1 + 32 + 256 + 1024)

Description: **Sets Operation Enable Register.** The Operation Enable Register is a mask for enabling specific bits in the Operation Event Register which will cause the operation summary bit (bit 7) of the Status Byte register to be set Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). The operation summary bit is the logical OR of all the enabled bits in the Operation Event register. (See example, Figure B-5.)

**B.68 STATus:OPERation:ENABLE? QUERY****STAT:OPER:ENAB?**

Syntax: Short Form: STAT:OPER:ENAB? Long Form: STATus:OPERation:ENABLE?

**Return Value:** <int\_value> 0 to 1313 (1 + 32 + 256 + 1024).

Description: **Reads Operation Enable Register (see Table B-4).** Returns value of Operation Enable Register bits. Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). (See example, Figure B-5.)

**B.69 STATus:OPERation[:EVENT] QUERY****STAT:OPER?**

Syntax: Short Form: STAT:OPER[:EVENT]? Long Form: STATus:OPERation[:EVENT]?

**Return Value:** <int\_value> 0 to 1313 (1 + 32 + 256 + 1024).

Description: **Indicates changes in conditions monitored by Operational Event Register (see Table B-4).** Returns the value of the Operation Event register. The Operation Event register is a read-only register which holds (latches) all events that occur. Reading the Operation Event register clears it. (See example, Figure B-5.)

**B.70 STATus:PRESet COMMAND****STAT:PRES**

Syntax: Short Form: STAT:PRES Long Form: STATus:PRESet

Description: **Disables reporting of all status events.** This command sets all bits of the Operation Condition (Table B-4) and Questionable Condition Registers to 0, preventing all status events from being reported. (See example, Figure B-5.)

NOTES: 1. The power supply is assumed to be operating in constant voltage (CV) mode.  
 2. Examples below are intended only to illustrate command functions. Refer to PAR. 4.1.1 for programming techniques to optimize performance.

```

STAT:PRES                Operation Condition and Questionable Condition registers are
                          reset.
STAT:QUES:ENAB 12228     Allows latching of CE and VE bits
STAT:OPER:ENAB 1280      Mask enabled for CC and CV bits.
STAT:OPER:ENAB?          Returns 1280 (256 + 1024) (CC and CV bits set).
INIT:CONT ON             Continuous triggers enabled.
STAT:OPER:COND?          Power supply returns 256 to indicate that power
                          supply is in constant voltage mode.
STAT:OPER?               Returns 256, indicating that since the last reading
                          of the Operation Event Register the power supply has entered
                          Constant Voltage mode.
STAT:OPER?               Returns 0 indicating no changes since previous reading of the
                          Operation Event register.
STAT:QUES?               Returns 0 (no questionable conditions occurred since previous
                          reading
                          --- OVERCURRENT CONDITION OCCURS
SYST:ERR?                Power supply returns 0, "No error" message.
*RST::VOLT 5;CURR 1;OUTP ON The BOP is in Voltage mode and delivering 5 Volts
*ESR?                    Bop returns a 0 - all functions are normal
FUNC:MODE CURR           BOP is in Current mode but Limit Light is on
*ESR?;STAT:QUES:COND?   BOP returns 8;4097 - Current error.
*ESR?;STAT:QUES?        BOP returns 0;4096 - no new errors, Current Error
*ESR?;STAT:QUES?        BOP returns 0;0 - no new errors
MEAS:CURR?;VOLT?        BOP returns 1.0E-4;5.00003E0 - Voltage is 5 volts
STAT:QUES:COND?         BOP returns 4097 - error still in effect
                          Short is applied to the BOP
*ESR?;STAT:QUES:COND?   BOP returns 0;1 - Current mode is selected
MEAS:VOLT?;CURR?        BOP returns.1E-4;1.00003E0 - Current is 1 amperes
FUNC:MODE VOLT;*ESR?    BOP switches mode, returns 3 - settling
*ESR?;STAT:QUES?        BOP returns 8;8194
                          Short is removed from the BOP output
STAT:QUES:COND?         BOP returns 2, voltage mode operation OK.
  
```

FIGURE B-5. USING STATUS COMMANDS AND QUERIES

B.71 STATus:QUESTIONable[:EVENT]? QUERY

# STAT:QUES?

Syntax: Short Form: STAT:QUES[EVENT]? Long Form: STATus:QUESTIONable[EVENT]?

Return Value: <int\_value> actual register value

Description: **Indicates the latched condition of the Questionable Event register.** Returns the value of the Questionable Event register (see Table B-5). The Questionable Event register is a read-only register which holds (latches) all events. Only bits 13 and 12 are latched in the Status Questionable Event register. Bits 0 and 1 of the Status Questionable Condition Register are not latched in the power supply. Reading the Questionable Event register clears it. (See example, Figure B-5.)

TABLE B-5. QUESTIONABLE EVENT REGISTER, QUESTIONABLE CONDITION REGISTER AND QUESTIONABLE CONDITION ENABLE REGISTER BITS

CONDITION	NU	CE	VE	NU	CM	VM
BIT	15-14	13	12	11 - 2	1	0
VALUE	32,768 -16,359	8192	4096	2048 - 4	2	1

CE CURRENT ERROR  
 VE VOLTAGE ERROR  
 CM CURRENT MODE  
 VM VOLTAGE MODE  
 NU NOT USED

**B.72 STATus:QUESTIONable:CONDition? QUERY****STAT:QUES:COND?**

Syntax: Short Form: STAT:QUES:COND? Long Form: STATus:QUESTIONable:CONDition?  
**Return Value:** <int\_value> actual register value

Description: **Returns the value of the Questionable Condition Register (see Table B-5).** The Questionable Condition Register contains unlatched real-time information about questionable conditions of the power supply. Bit set to 1 = condition (active, true); bit reset to 0 = condition (inactive, false). Bits 1 or 0 may be both be set, indicating the power supply is settling after a voltage change. (See example, Figure B-5.)

**B.73 STATus:QUESTIONable:ENABLE COMMAND****STAT:QUES:ENAB**

Syntax: Short Form: STAT:QUES:ENAB <int\_value> Long Form: STATus:QUESTIONable:ENABLE <int\_value>

Description: **Programs Questionable Condition Enable Register (see Table B-5).** The Questionable Condition Enable Register determines which conditions are allowed to set the Questionable Condition Register; it is a mask for enabling specific bits in the Questionable Event register that can cause the questionable summary bit (bit 3) of the Status Byte register to be set. The questionable summary bit is the logical OR of all the enabled bits in the Questionable Event register. Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). (See example, Figure B-5.)

**B.74 STATus:QUESTIONable:ENABLE? QUERY****STAT:QUES:ENAB?**

Syntax: Short Form: STAT:QUES:ENAB? Long Form: STATus:QUESTIONable:ENABLE?  
**Return Value:** <int\_value> actual register value

Description: **Reads Questionable Condition Enable Register (see Table B-5).** Power supply returns value of Questionable Condition Enable Register, indicating which conditions are being monitored. Bit set to 1 = function enabled (active, true); bit reset to 0 = function disabled (inactive, false). **Related Commands:** STAT:QUES?. (See example, Figure B-5.)

**B.75 SYSTem:BEEP COMMAND****SYST:BEEP**

Syntax: Short Form: SYST:BEEP Long Form: SYSTem:BEEP  
Description: Causes the unit to emit a brief audible tone

**B.76 SYSTem:ERRor? QUERY****SYST:ERR?**

Syntax: Short Form: SYST:ERR? Long Form: SYSTem:ERRor?  
**Return Value:** <int\_value,string>

Description: **Posts error messages to the output queue.** Returns the next error number followed by its corresponding error message string from the instrument error queue. The error queue is a FIFO (first in first out) buffer that stores errors as they occur. As it is read, each error is removed from the queue and the next error message is made available. When all errors have been read, the query returns 0,"No error". If more errors are accumulated than the queue can hold, it will overflow. The oldest errors stay in the queue but the most recent errors are discarded. The last error in the queue will be -350,"Too many errors." Error messages are defined in Table B-6.

**B.77 SYSTem:ERRor:CODE? QUERY****SYST:ERR:CODE?**

Syntax: Short Form: SYST:ERR:CODE? Long Form: SYSTem:ERRor:CODE?

Description: Returns the three character error code without the ASCII definition string. The error codes are defined in table B-6 (See example, Figure B-6.)

**B.78 SYSTem:ERRor:CODE:ALL? QUERY****SYST:ERR:CODE:ALL?**

Syntax: Short Form: SYST:ERR:CODE:ALL? Long Form: SYSTem:ERRor:CODE:ALL?  
Return Value:

Description: Returns a comma-separated list of all error codes. A maximum of 15 codes will be returned; if the queue is empty, the power supply returns 0.

**B.79 SYSTem:PASSword:CENable COMMAND****SYST:PASS:CEN**

Syntax: Short Form: SYST:PASS:CEN <val>  
Long Form: SYSTem:PASSword:CENable <val>

Description: Sets the password enable state if the value matches the current password. This command allows other commands such as DIAG:SAV and CALibrate to operate.

**TABLE B-6. ERROR MESSAGES**

ERROR MESSAGE	ESR ERROR BIT SET (SEE PAR. A.5)	EXPLANATION
0, "No error"	None	No error
-100, "Command error"	Command Error bit 5	Command and data understood, but more information included which is not recognized.
-120, "Numeric data error"	Command Error bit 5	Expected number but other characters were detected
-203, "Command Protected"	Execution error bit 4	Password must be CENabled
-221, "Settings Conflict"	Execution error bit 4	Calibration state not enabled but CALibrate command received
-222, "Current, Voltage or Data out of range"	Execution error bit 4	Value (current or voltage) exceeds power supply rating or (data) exceeds acceptable command parameters
-223, "Too Much Data"	Execution error bit 4	During a LIST command, the list became full, preventing all the data from being added to the list
-226, "Lists not same length"	Execution error bit 4	During a LIST command, number of DWEL list entries was not equal to 1 and did not match number of LIST:VOLT or LIST:CURR entries.
-240, "Hardware error"	Execution error bit 4	Power supply did not respond to command
-301, "Voltage Error"	Device Error bit 3 (1)	Voltage output not within error window; unit set to output off -- only valid for DIAG:ERR 1, 2 or 3 mode (see PAR. 5.2 and Table 5-1).
-302, "Current Error"	Device Error bit 3 (1)	Current output not within error window; unit set to output off -- only valid for DIAG:ERR 1, 2 or 3 mode (see PAR. 5.2 and Table 5-1).
-311, "Memory Error"	Device Error bit 3 (1)	*SAV (save), *RCL (recall), or CALibrate:STORe error
-350, "Queue Overflow"	Device Error bit 3 (1)	Error queue was full, error events have been lost.
-400, "Query Error"	Query Error bit 2	Data requested was lost due to 253 character limit or BIT 4886 output buffer
-420, "Query Unterminated"	Query Error bit 2	Controller sent query but did not accept data from power supply. See VOLT? (PAR. B.58), CAL:SAVE (PAR. B.58) commands
(1) The Device error bit may be set when the status monitoring functions of the power supply detect an overvoltage/undervoltage condition.		

**B.80 SYSTem:PASSword:CDISable COMMAND**

**SYST:PASS:CDIS**

Syntax: Short Form: SYST:PASS:CDIS <val> Long Form: SYSTem:PASSword:CDISable <val>  
 Description: Clears the password enable state if the value matches the current password.

**B.81 SYSTem:PASSword:NEW COMMAND**

**SYST:PASS:NEW**

Syntax: Short Form: SYST:PASS:NEW <old password>, <new password>  
 Long Form: SYSTem:PASSword:NEW <old password>, <new password>  
 Description: **Establishes new password.** The old (current) password is checked, then the replaced by the new password. (See example, Figure B-6.)

**B.82 SYSTem:PASSword:STATe? QUERY**

**SYST:PASS:STAT?**

Syntax: Short Form: SYST:PASS:STAT? Long Form: SYSTem:PASSword:STATe?  
 Return Value: <int\_value> 0 or 1  
 Description: Returns a 1 if the password state is enabled or a 0 if it is disabled.

**B.83 SYSTem:SECurity:IMMEDIATE COMMAND**

**SYST:SEC:IMM**

Syntax: Short Form: SYST:SEC:IMM Long Form: SYSTem:SECurity:IMMEDIATE  
 Description: **Initializes all NVRAM variable to factory defaults.** Empties all memory locations.



# SYST:SET

## B.84 SYSTem:SET COMMAND

- Syntax: Short Form: SYSTem:SET {CM0 | CM1 | DC0 | DC1 | LF0 | LF1 | RO0 | RO1}  
Long Form: SYSTem:SET {CM0 | CM1 | DC0 | DC1 | LF0 | LF1 | RO0 | RO1}
- Description: **Establishes Device Clear, Line Feed, and Reset functions. Sending SYST:SEC:IMM sets LF1, DC0, and RO0 (as if CM0 was sent)**
- DC0 Device Clear functions per IEEE 488.2 Standard. (No effect on the device (power supply), only clears internal status registers.)
  - DC1 Device Clear functions identical to \*RST (Output set to 0V, voltage mode and output set to OFF except if RO1 (see below) is set.)
  - LF0 Line Feed not provided upon empty buffer condition
  - LF1 Line Feed provided if buffer is empty and a read is performed.
  - RO0 \*RST and power up set output to OFF, 0V, 0A, voltage mode.
  - RO1 \*RST sets output to ON, 0V, 0A, voltage mode. Subsequent VOLT and CURR commands are immediately present at the output without sending OUTP ON (OUTP OFF and OUTP ON function normally to turn the output off or on.)
  - CM0 Establishes DC0, LF0, RO0 conditions described above. (SCPI 1997 Standard compliance)
  - CM1 Establishes DC1, LF1, RO1 conditions described above. (Compatible with software versions 1.2 and earlier) (See example, Figure B-6.)

# SYST:SET?

## B.85 SYSTem:SET? QUERY

- Syntax: Short Form: SYST:SET? Long Form: SYSTem:SET?  
Return Value: DC<n>,LF<n>,RO<n> where n = 0 or 1
- Description: **Identifies functions established by SYST:SET command.** (See example, Figure B-6.)

# SYST:VERS?

## B.86 SYSTem:VERSion? QUERY

- Syntax: Short Form: SYST:VERS? Long Form: SYSTem:VERSion?  
Return Value: <int\_value>.<int\_value> (YYYY.V)
- Description: **Identifies SCPI Version implemented.** Returns SCPI Version number:  
YYYY = year, V = Revision number for specified year. (See example, Figure B-6.)

SYST:VERS?	Unit returns 1997
SYST:SET?	Unit returns DC0,LF0,RL0
SYST:PASS:NEW DEFAULT,OKAY	Unit changes password to be OKAY
SYST:SET LF1,RL1,DC1	Configures BIT 4886 card as BIT 4882 (see PAR. 1.3.1).
DIAG:SAV;:SYST:ERR:CODE?	BOP returns -231 indicating command is protected
SYST:PASS:CEN OKAY	Password enabled commands are accepted
DIAG:SAV	Unit saves the LF1 state for next power on cycle.

FIGURE B-6. USING SYSTEM COMMANDS AND QUERIES

