

OPERATOR MANUAL

BIT 4882 BIT 4882F DIGITAL INTERFACE CARD

KEPCO INC.
An ISO 9001 Company.

MODEL BIT 4882, BIT 4882F INTERFACE CARD

ORDER NO.

REV. NO.

IMPORTANT NOTES:

- 1) This manual is valid for the following Model and associated serial numbers:

| MODEL | SERIAL NO. | REV. NO. |
|-------|------------|----------|
|-------|------------|----------|

- 2) A Change Page may be included at the end of the manual. All applicable changes and revision number changes are documented with reference to the equipment serial numbers. Before using this Instruction Manual, check your equipment serial number to identify your model. If in doubt, contact your nearest Kepco Representative, or the Kepco Documentation Office in New York, (718) 461-7000, requesting the correct revision for your particular model and serial number.
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INSTRUCTION MANUAL CORRECTION

KEPCO MODEL BIT 4882

SECTION 4, OPERATION, add the following:

NOTE:

The VISA query function (included in the latest versions of the VISA libraries) is not supported by the BIT 4882. In newer XP and Vista computers a delay is needed to insure the BIT 4882 has time to return the response to the query. The VISA query has no provisions to add a delay, nor can it issue a series of read strobes between sending the request and receiving data from the device. Instead of the VISA query, use one of the two methods described below. Method 2 is recommended.

1. Use a VISA Write followed by VISA Read with a small delay between the functions. The delay is determined by computer speed. A 2 millisecond delay between the Write and Read functions will be sufficient to insure that there is enough time to receive a response for all valid queries.
2. Follow the VISA Write with a series of VISA Read strobes while waiting for the data available bit to be true, followed by the VISA Read function when data is available. This method provides the highest throughput.

TABLE OF CONTENTS

| SECTION | PAGE |
|---------------------------------|--|
| SECTION 1 - INTRODUCTION | |
| 1.1 | Scope of Manual 1-1 |
| 1.2 | General Description..... 1-1 |
| 1.3 | Specifications, BIT 4882, BIT 4882-F and BIT 4886 1-2 |
| SECTION 2 - INSTALLATION | |
| 2.1 | Unpacking and Inspection 2-1 |
| 2.2 | Set Start-up Defaults 2-1 |
| 2.2.1 | Set (GPIB) Device Address 2-1 |
| 2.2.2 | Start-up Language Default..... 2-1 |
| 2.2.3 | IEEE Cable Shield Ground Selection 2-1 |
| 2.2.4 | Set Power Supply Identification Switch 2-1 |
| 2.3 | Installation of Interface Card into the BOP 2-3 |
| 2.4 | Input/OUtput Signals 2-8 |
| SECTION 3 - CALIBRATION | |
| 3.1 | Equipment Required..... 3-1 |
| 3.2 | Adjustment of the Bop ± 10 Volt Calibration Controls (R31, R32)..... 3-1 |
| 3.3 | Adjustment of the Ammeter Zero (R50) 3-1 |
| 3.4 | Adjustment Of The Output Voltage Zero (R81) 3-2 |
| 3.5 | Adjustment of the Full Scale Output Voltage (R21)..... 3-2 |
| 3.6 | Voltage Reading Zero Calibration (R35) 3-3 |
| 3.7 | Voltage Reading Calibration (R19)..... 3-4 |
| 3.8 | Adjustment of the Output Current Zero (R83) 3-4 |
| 3.9 | Adjustment of the Full Scale Output Current (R22) 3-5 |
| 3.10 | Current Reading Zero Calibration (R36)..... 3-5 |
| 3.11 | Current Reading Calibration (R20)..... 3-8 |
| SECTION 4 - OPERATION | |
| 4.1 | General..... 4-1 |
| 4.2 | IEEE 488 (GPIB) Bus Protocol 4-1 |
| 4.3 | SCPI Programming 4-2 |
| 4.3.1 | SCPI Messages 4-3 |
| 4.3.2 | Common Commands/Queries 4-3 |
| 4.3.3 | SCPI Subsystem Command/Query Structure..... 4-3 |
| 4.3.4 | Program Message Structure..... 4-4 |
| 4.3.4.1 | Keyword 4-5 |
| 4.3.4.2 | Keyword Separator 4-6 |
| 4.3.4.3 | Query Indicator 4-6 |
| 4.3.4.4 | Data 4-6 |
| 4.3.4.5 | Data Separator..... 4-6 |
| 4.3.4.6 | Message Unit Separator 4-6 |
| 4.3.4.7 | Root Specifier 4-6 |
| 4.3.4.8 | Message Terminator 4-7 |
| 4.3.5 | Understanding The Command Structure 4-7 |
| 4.3.6 | Program Message Syntax Summary 4-8 |
| 4.3.7 | SCPI Program Example..... 4-8 |
| 4.4 | CIIL Programming 4-9 |

TABLE OF CONTENTS

SECTION PAGE

APPENDIX A - SCPI COMMON COMMAND/QUERY DEFINITIONS

| | | |
|------|---|-----|
| A.2 | *CLS — Clear Status Command | A-1 |
| A.3 | *ESE — Standard Event Status Enable Command | A-1 |
| A.4 | *ESE? — Standard Event Status Enable Query | A-2 |
| A.5 | *ESR? — Event Status Register Query | A-2 |
| A.6 | *IDN? — Identification Query | A-2 |
| A.7 | *OPC — Operation Complete Command | A-2 |
| A.8 | *OPC? — Operation Complete Query | A-2 |
| A.9 | *RST — Reset Command | A-2 |
| A.10 | *SRE — Service Request Enable Command | A-3 |
| A.11 | *SRE? — Service Request Enable Query | A-4 |
| A.12 | *STB? — Status Byte Register Query | A-4 |
| A.13 | *TRG — Trigger Command | A-4 |
| A.14 | *TST? — Self Test Query | A-4 |
| A.15 | *WAI — Wait-To-Continue Command | A-4 |

APPENDIX B - SCPI COMMAND/QUERY DEFINITIONS

| | | |
|------|--|-----|
| B.1 | Introduction | B-1 |
| B.2 | INITiate[:IMMediate] Command | B-1 |
| B.3 | INITiate:CONTinuous Command | B-1 |
| B.4 | INITiate:CONTinuous Query | B-1 |
| B.5 | MEASure[:SCALar]:CURRent[:DC]? Query | B-2 |
| B.6 | MEASure:VOLTag[:SCALar][:DC]? Query | B-2 |
| B.7 | [SOURce:]CURRent[:LEVel][:IMMediate][:AMPlitude] Command | B-2 |
| B.8 | [SOURce:]CURRent[:LEVel][:IMMediate][:AMPlitude] Query | B-3 |
| B.9 | [SOURce:]CURRent[:LEVel]TRIGgered[:AMPlitude] Command | B-3 |
| B.10 | [SOURce:]CURRent[:LEVel]TRIGgered[:AMPlitude]? Query | B-3 |
| B.11 | [SOURce:]VOLTag[:LEVel][:IMMediate][:AMPlitude] Command | B-3 |
| B.12 | [SOURce:]VOLTag[:LEVel][:IMMediate][:AMPlitude]? Query | B-3 |
| B.13 | [SOURce:]VOLTag[:LEVel]TRIGgered[:AMPlitude] Command | B-4 |
| B.14 | [SOURce:]VOLTag[:LEVel]TRIGgered[:AMPlitude]? Query | B-4 |
| B.15 | [SOURce:]FUNction:MODE | B-4 |
| B.16 | STATus:OPERation:CONDition Query | B-4 |
| B.17 | STATus:OPERation:ENABle Command | B-4 |
| B.18 | STATus:OPERation:ENABle? Query | B-5 |
| B.19 | STATus:OPERation[:EVENT] Query | B-5 |
| B.20 | STATus:PRESet Command | B-5 |
| B.21 | STATus:QUESTionable[:EVENT]? Query | B-5 |
| B.22 | STATus:QUESTionable:CONDition? Query | B-5 |
| B.23 | STATus:QUESTionable:ENABle Command | B-6 |
| B.24 | STATus:QUESTionable:ENABle? Query | B-6 |
| B.25 | SYSTem:ERRor? Query | B-7 |
| B.26 | SYSTem:LANGUage Command | B-7 |
| B.27 | SYSTem:VERSion Query | B-7 |

APPENDIX C - CIIL COMMAND DEFINITIONS

LIST OF FIGURES

| FIGURE | TITLE | PAGE |
|--------|---|------|
| 1-1 | Remotely Controlled Power Supply Configurations Using Kepco Products..... | vi |
| 2-1 | BIT 4882 and BIT 4882-F Switch and Adjustment Locations | 2-2 |
| 2-2 | Installation of Model BIT 4882-f into BOP | 2-4 |
| 2-3 | Installation of Model BIT 4882 into BOP | 2-6 |
| 2-4 | IEEE 488 (GPIB) Connector | 2-8 |
| 3-1 | BOP Power Supply, Internal Calibration Control Locations | 3-2 |
| 3-2 | Current Shunt Connections..... | 3-7 |
| 4-1 | Tree Diagram of SCPI Commands Used with BIT 4882, BIT 4882-F and BIT 4886 Interface Card..... | 4-3 |
| 4-2 | Message Structure | 4-5 |
| 4-3 | Typical Example of Interface Card Program Using SCPI Commands | 4-9 |
| A-1 | GPIB Commands | A-3 |
| B-1 | Programming the Output..... | B-2 |
| B-2 | Using Status Commands and Queries..... | B-6 |
| B-3 | Using System Commands and Queries | B-7 |
| C-1 | FNC — Function Command..... | C-1 |
| C-2 | INX — Initiate Op Code Command..... | C-2 |
| C-3 | FTH — Fetch Command | C-2 |
| C-4 | SET Command | C-3 |
| C-5 | RST — Reset Command | C-4 |
| C-6 | CNF, IST — Confidence Test, Internal Self Test Commands..... | C-4 |
| C-7 | STA — Status Command..... | C-5 |
| C-8 | GAL — Go to alternate Language Command | C-6 |

LIST OF TABLES

| TABLE | TITLE | PAGE |
|-------|---|------|
| 1-1 | Kepeco BIT 488, BIT 4882, and BIT 4886 Digital Programming Cards | 1-1 |
| 1-2 | Applicability of BIT 4882, 4882-F and BIT 4886 Cards to Specific BOP Models | 1-2 |
| 1-3 | Specifications, BIT 4882, BIT 4882-F AND BIT 4886 | 1-2 |
| 2-1 | Power Supply Identification Switch S2 Setting | 2-2 |
| 2-2 | Device Address Selection | 2-3 |
| 2-3 | Input/Output Pin Assignments | 2-8 |
| 3-1 | BOP Power Supply, Internal Calibration Controls | 3-3 |
| 3-2 | Calibration Measurements and Tolerances - Current | 3-6 |
| 3-3 | Suggested Sense Resistors | 3-7 |
| 4-1 | IEEE 488 (GPIB) Bus Interface Functions | 4-1 |
| 4-2 | IEEE 488 (GPIB) Bus Command Mode Messages | 4-2 |
| 4-3 | IEEE 488 (GPIB) Bus Data Mode Messages | 4-2 |
| 4-4 | SCPI Command Index | 4-4 |
| 4-5 | Rules Governing Shortform Keywords | 4-5 |
| A-1 | IEEE 488.2 Command/query Index | A-1 |
| A-2 | Standard Event Status Enable Register and Standard Event Status Register Bits | A-1 |
| A-3 | Service Request Enable and Status Byte Register Bits | A-3 |
| B-1 | SCPI Subsystem Command/query Index | B-1 |
| B-2 | Operation Condition Register, Operation Enable Register, and Operation Event Register Bits | B-4 |
| B-3 | Questionable Event Register, Questionable Condition Register and Questionable Condition Enable Register Bits | B-5 |
| B-4 | Error Messages | B-7 |
| C-1 | CIIL Subsystem Command/query Index | C-1 |
| C-2 | CIIL Error Messages | C-5 |
| C-3 | CIIL Error Handling Utility Commands | C-6 |

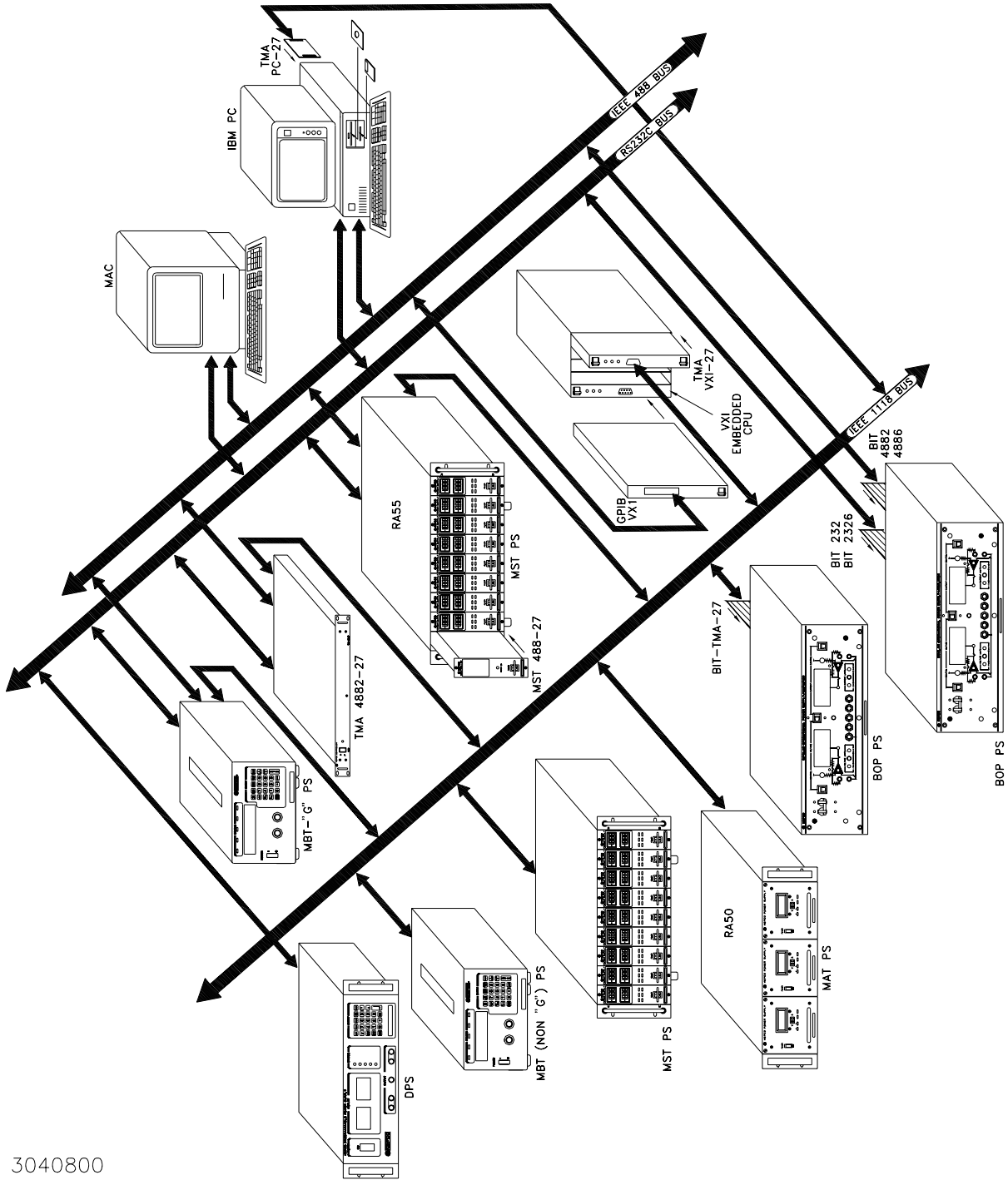


FIGURE 1-1. REMOTELY CONTROLLED POWER SUPPLY CONFIGURATIONS USING KEPKO PRODUCTS

SECTION 1 - INTRODUCTION

1.1 SCOPE OF MANUAL

This manual contains instructions for the installation, operation and maintenance of the BIT 4882, BIT 4882-F, and BIT 4886 Interface Cards manufactured by Kepco, Inc., Flushing, NY, U.S.A. References to "Interface Card" refer to both models.

1.2 GENERAL DESCRIPTION

The Kepco BIT Card Series were designed as an accessory for the Kepco BOP series bipolar power supplies. The BIT cards make it possible to control the BOP output by means of digital input signals (see Figure 1-1). The BIT 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 4882, BIT4882-F and BIT 4886 provide full talk/listen capability. They are fully compliant with SCPI and CIIL high level programming languages.

The BIT 488 design group consists of four models. Field installable interface cards carry the prefix "BIT". BOP bipolar power supplies with an installed BIT interface card carry the suffixes shown in Table 1-1.

TABLE 1-1. KEPKO BIT 488, BIT 4882, AND BIT 4886 DIGITAL PROGRAMMING CARDS

| FIELD INSTALLABLE PROGRAMMING CARD MODEL | FACTORY INSTALLED PROGRAMMING CARD BOP SUFFIX | INPUT CODING | RESOLUTION | | REMARKS |
|--|---|---------------|------------------|------------------|-------------------------------|
| | | | MAIN CHANNEL | LIMIT CHANNEL | |
| BIT 488-B | -488-B | BYTE-SERIAL | 12 BITS (BINARY) | 8 BITS (BINARY) | FOR THE IEEE-488 OR GPIB BUIS |
| BIT 488-D | -488-D | BYTE-SERIAL | 3-DIGIT (BCD) | 2-DIGIT (BCD) | |
| BIT 4882 (See Table 1-2) BIT 4882-F (See Table 1-2) | -4882 | BYTE-SERIAL | 12 BITS (BINARY) | 12 BITS (BINARY) | |
| BIT 4886 | -4886 | BYTE-SERIAL | 16 BITS (BINARY) | 16 BITS (BINARY) | |
| BIT TMA-27 | -TMA | 2-WIRE-SERIAL | 12 BITS (BINARY) | 12 BITS (BINARY) | KEPCO CONTROL BUS |

Except for the installation procedures, the BIT 4882 and 4882-F cards are functionally identical. The BIT 4886 card is functionally identical to the BIT 4882 card are except that the BIT 4886 provides 16 bit resolution vs. 12 bit for the BIT 4882. The BIT 4882 and BIT 4886 cards include a PC board mounted IEEE 488 connector used with the BOP Models indicated in Table 1-2; the BIT 4882-F is an earlier version of the BIT 4882 which is compatible with most BOP models, although it is intended for earlier BOP Models indicated in Table 1-2.

TABLE 1-2. APPLICABILITY OF BIT 4882, 4882-F AND BIT 4886 CARDS TO SPECIFIC BOP MODELS

| BOP TO BE MODIFIED | | APPLICABLE CARD | BOP TO BE MODIFIED | | APPLICABLE CARD |
|--------------------|--------------|-----------------|--------------------|---------------|-----------------|
| MODEL | REVISION NO. | | MODEL | REVISION NO. | |
| 20-5M | 1 | BIT 4882-F | 50-8M | 4 TO 9 | BIT 4882-F |
| | 2 AND LATER | BIT 4882 | | 10 AND LATER | BIT 4882 |
| 20-10M | 12 TO 16 | BIT 4882-F | 72 3M | 5 TO 9 | BIT 4882-F |
| | 17 AND LATER | BIT 4882 | | 10 AND LATER | BIT 4882 |
| 20-20M | 8 TO 14 | BIT 4882-F | 72-6M | 7 TO 13 | BIT 4882-F |
| | 15 AND LATER | BIT 4882 | | 14 AND LATER | BIT 4882 |
| 36-6M | 12 TO 18 | BIT 4882-F | 100-1M | 17 TO 23 | BIT 4882-F |
| | 19 AND LATER | BIT 4882 | | 24 AND LATER | BIT 4882 |
| 36-12M | 7 TO 12 | BIT 4882-F | 100-2M | 10 TO 14 | BIT 4882-F |
| | 13 AND LATER | BIT 4882 | | 15 AND LATER | BIT 4882 |
| 50-2M | 16 TO 20 | BIT 4882-F | 100-4M | 6 TO 13 | BIT 4882-F |
| | 21 AND LATER | BIT 4882 | | 14 AND LATER | BIT 4882 |
| 50-4M | 6 TO 12 | BIT 4882-F | 200-1M | 6 AND EARLIER | BIT 4882-F |
| | 13 AND LATER | BIT 4882 | | 7 AND LATER | BIT 4882 |

NOTE: For modification of BOP Models with revision numbers that do not appear in this table, contact Kepco for assistance.

1.3 SPECIFICATIONS, BIT 4882, BIT 4882-F AND BIT 4886 (SEE TABLE 1-3)

TABLE 1-3. SPECIFICATIONS, BIT 4882, BIT 4882-F AND BIT 4886

| SPECIFICATION | | DESCRIPTION | |
|--------------------------------|---------|--|-----------------------------------|
| OUTPUT VOLTAGE (MAIN CHANNEL) | | 0 ± 10V | |
| OUTPUT VOLTAGE (LIMIT CHANNEL) | | 0 to +10V | |
| OUTPUT CURRENT (EACH CHANNEL) | | 0 to ± 2 mA max. | |
| OUTPUT IMPEDANCE | | <0.05 ohms | |
| TEMPERATURE COEFFICIENT | | Full scale: ± 35 ppm/°C max Zero: ± 20µV/°C max | |
| OPTICAL ISOLATION | | Digital and Analog grounds can be separated by a maximum of 500 Volts. | |
| DIGITAL INPUT FORMAT | | Byte-Serial | |
| POWER REQUIREMENT | | Supplied by BOP | |
| PRGRAMMING RESOLUTION | VOLTAGE | RATING/DESCRIPTION | CONDITION |
| | CURRENT | 0.024% | 12 Bits |
| DATA READBACK ACCURACY | VOLTAGE | BIT 4882, 4882-F: 0.1% | % of Max. Voltage or Max. Current |
| | CURRENT | BIT 4886: 0.2% | |

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.

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

Start-up defaults, consisting of Device Address, Language, IEEE Cable Shield Ground State, and Power Supply Identification are initially set by means of DIP switches as described in the following paragraphs.

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

The Device Address for the interface card is initially 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 (0-30) possible choices (See Table 2-1).

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

2.2.2 START-UP LANGUAGE DEFAULT (SEE FIGURE 2-1)

DIP switch S1 position 6 sets the Start-up Language Default:

- 0 = SCPI (factory default)
- 1 = CIL

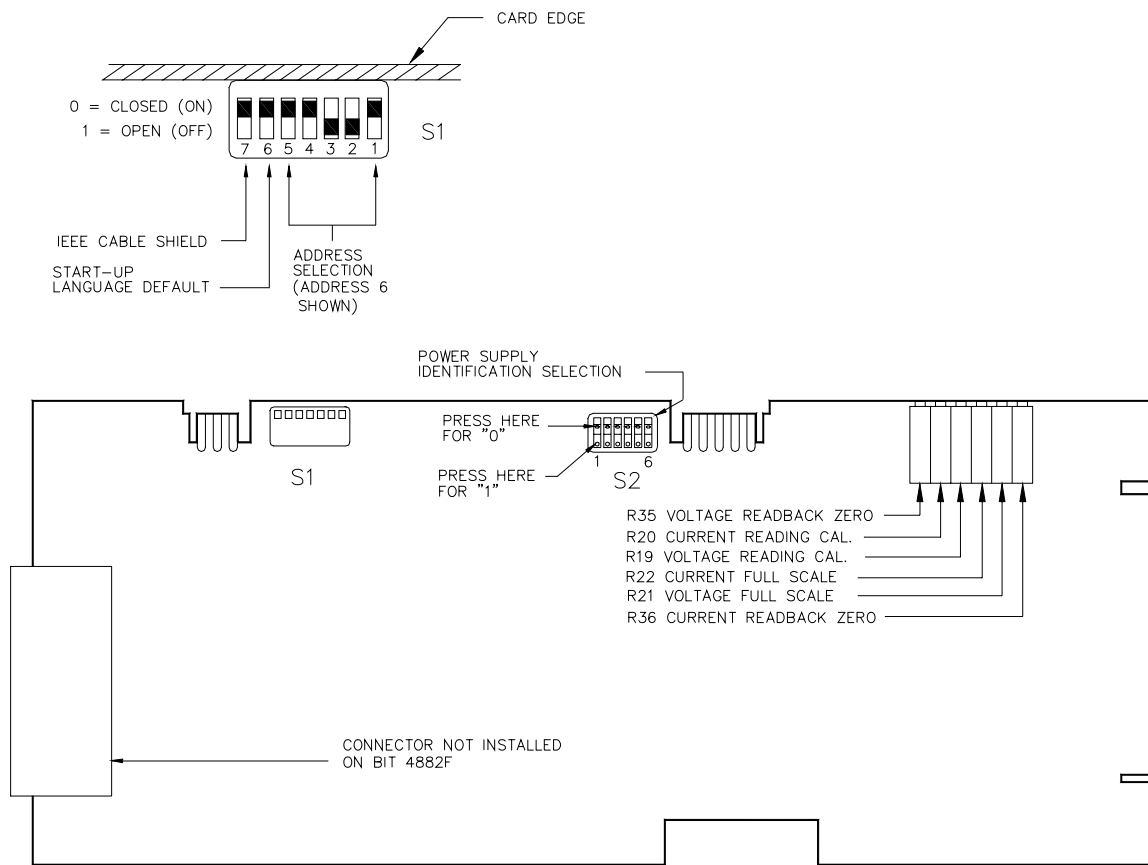
2.2.3 IEEE CABLE SHIELD GROUND SELECTION (SEE FIGURE 2-1)

The interface card is shipped from the factory configured so that the IEEE cable shield will be grounded to the BOP chassis. In some cases, however, it may be desirable to break this connection to eliminate system "ground loops." DIP switch S1 position 7 sets the Shield Ground state:

- 0 = shield grounded (factory default)
- 1 = shield not grounded

2.2.4 SET POWER SUPPLY IDENTIFICATION SWITCH (SEE FIGURE 2-1)

Power Supply Identification switch S2 (Figure 2-1) identifies the BOP model to be controlled by the interface card. Set Switch S2 positions 1 through 6 in accordance with Table 2-2.



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FIGURE 2-1. BIT 4882 AND BIT 4882-F SWITCH AND ADJUSTMENT LOCATIONS

TABLE 2-1. POWER SUPPLY IDENTIFICATION SWITCH S2 SETTING

| MODEL | SELECTOR SWITCH S2 SECTION | | | | | |
|-----------|----------------------------|------|------|------|------|------|
| | SW#1 | SW#2 | SW#3 | SW#4 | SW#5 | SW#6 |
| BOP 50-2M | 0 | 0 | 0 | 0 | 0 | 0 |
| 100-1M | 1 | 0 | 0 | 0 | 0 | 0 |
| 20-10M | 0 | 1 | 0 | 0 | 0 | 0 |
| 36-6M | 1 | 1 | 0 | 0 | 0 | 0 |
| 50-4M | 0 | 0 | 1 | 0 | 0 | 0 |
| 72-3M | 1 | 0 | 1 | 0 | 0 | 0 |
| 100-2M | 0 | 1 | 1 | 0 | 0 | 0 |
| 20-20M | 1 | 1 | 1 | 0 | 0 | 0 |
| 36-12M | 0 | 0 | 0 | 1 | 0 | 0 |
| 50-8M | 1 | 0 | 0 | 1 | 0 | 0 |
| 72-6M | 0 | 1 | 0 | 1 | 0 | 0 |
| 100-4M | 1 | 1 | 0 | 1 | 0 | 0 |
| 200-1M | 1 | 0 | 1 | 1 | 0 | 0 |
| 20-5M | 0 | 1 | 1 | 1 | 0 | 0 |

2.3 INSTALLATION OF INTERFACE CARD INTO THE BOP

- Refer to Figure 2-2 to install the BIT 4882-F interface card.
- Refer to Figure 2-3 to install the BIT 4882 or BIT 4886 interface card.

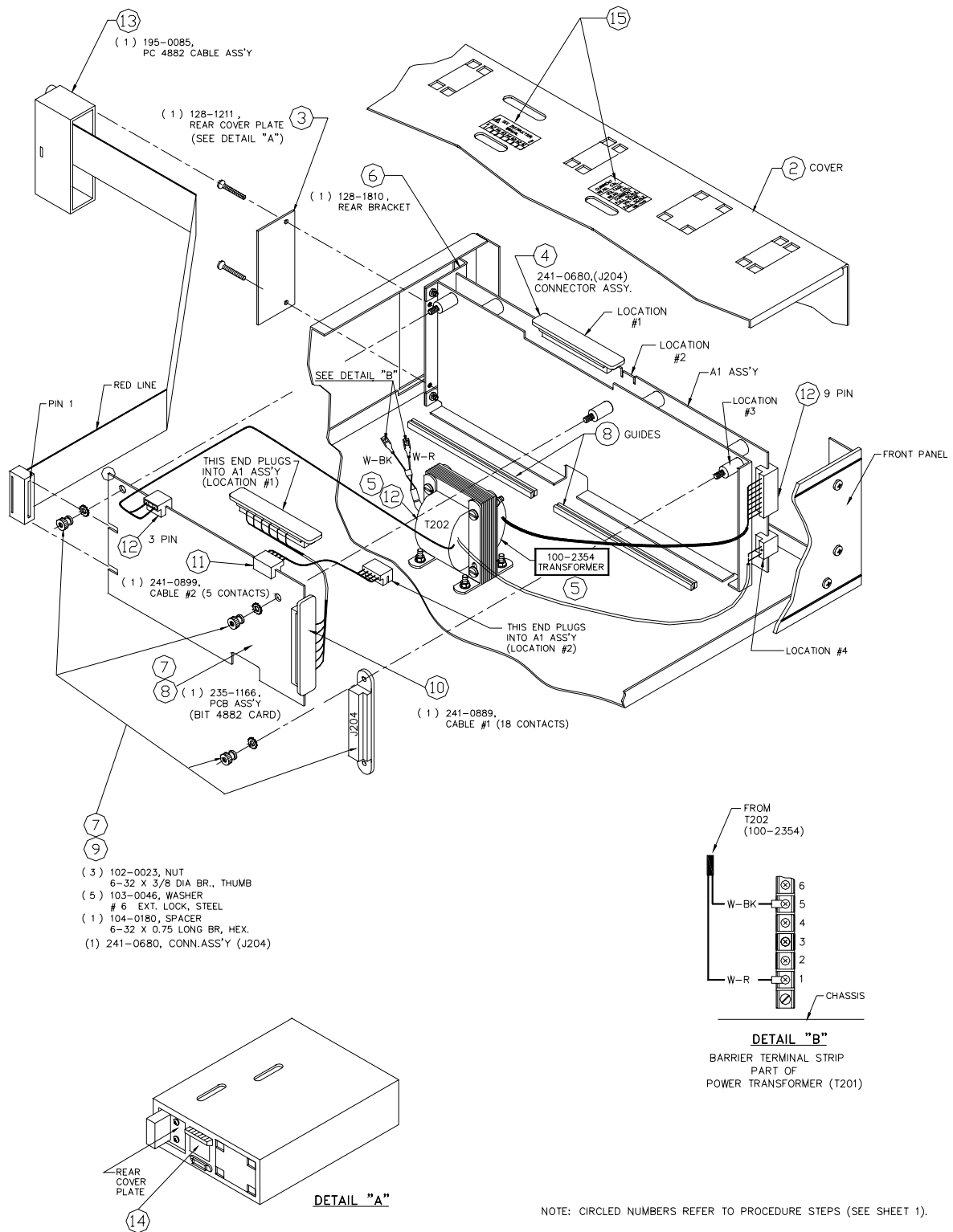
TABLE 2-2. DEVICE ADDRESS SELECTION

| DECIMAL ADDRESS | SELECTOR SWITCH S1 SECTION (SIGNAL LINE) | | | | |
|-----------------|--|----|----|----|----|
| | A5 | A4 | A3 | A2 | A1 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 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 |

NOTE: Step numbers coincide with encircled numbers on Figure 2-2, sheet 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 not PN 128-1810, contact Kepco.
- Step 7. Unpack the BIT 4882-F Interface Card Installation Components (Transformer, PCB Assembly, Cables #1 and #2, Connector Assembly, three (3) Knurled Nuts, five (5) washers, Spacer and Bracket).
- Step 8. Install PCB Assembly (PN 235-1166) into the guides, slide into position so that mounting holes in PCB Assembly line up with the three mounting posts on the BOP mounting bracket.
- Step 9. Secure the BIT 4882-F 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 10. Install Cable #1 (18-position connectors) to the BIT 4882-F Interface Card; mate the other end of the cable with Location #1 on BOP A1 Assembly.
- Step 11. Install Cable #2 (5-position connectors) to the BIT 4882-F Interface Card; mate the other end of the cable with Location #2 on BOP A1 Assembly.
- Step 12. Plug in 3-pin connector (Ref. Step 5, above) from Transformer 100-2354 as shown.
- Step 13. Plug in Ribbon Cable Assembly 195-0085 as shown. Secure ribbon cable connector to chassis using knurled nut.
- Step 14. Mark "-4882" after Model No. on Nameplate (see Detail A).
- Step 15. Remove "Control Identification" label (PN 188-1107) and "Address Label" (PN 188-1012). Affix revised "Control Identification" label (PN 188-1445) and "Address Label" (PN 188-1726) in vacated positions (with part numbers facing front panel).
- Step 16. Reinstall BOP cover.
- Step 17. Perform calibration procedure detailed in Section 3 of this manual.

FIGURE 2-2. INSTALLATION OF MODEL BIT 4882-F INTO BOP (SHEET 1 OF 2)



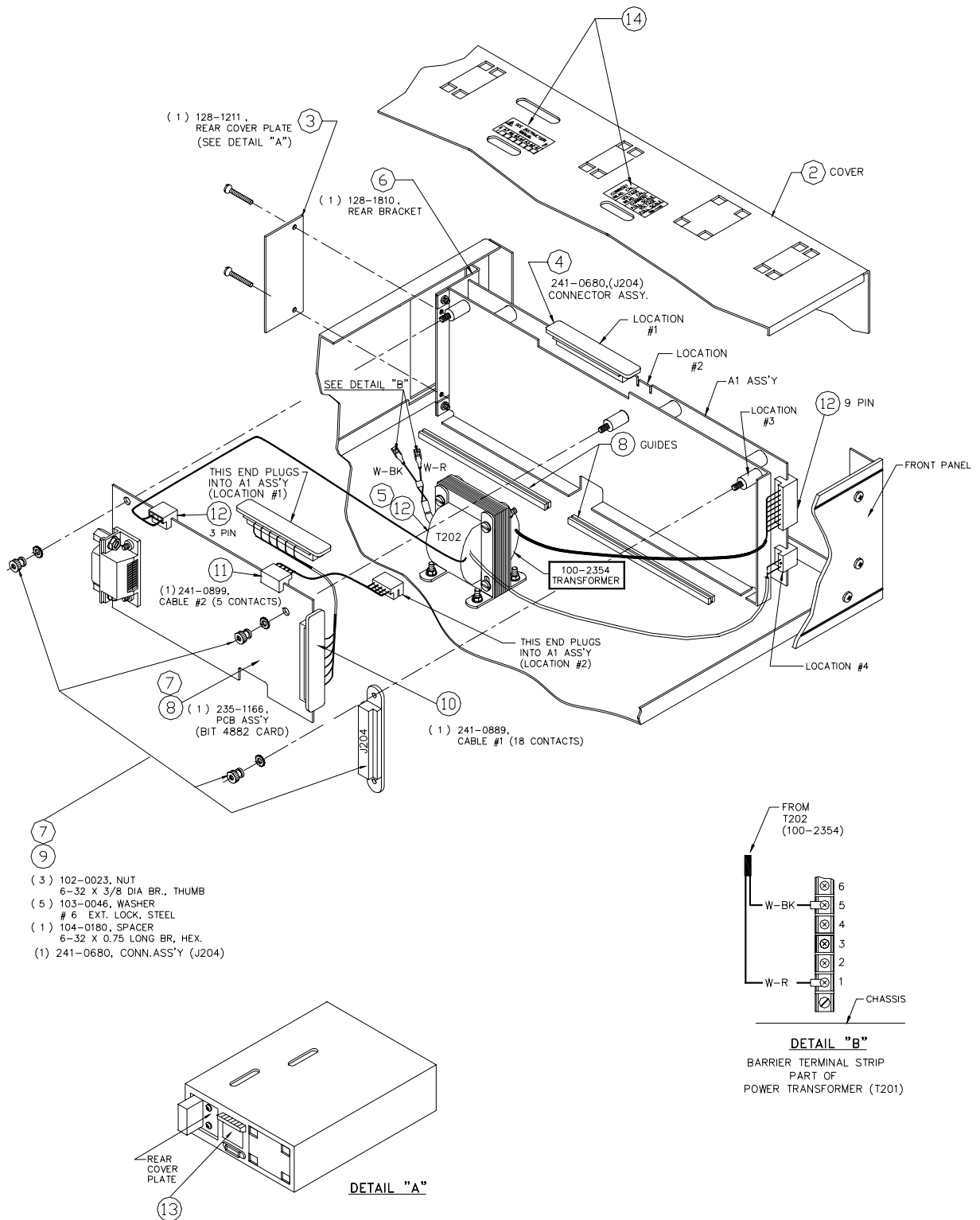
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FIGURE 2-2. INSTALLATION OF MODEL BIT 4882-F INTO BOP (SHEET 2 OF 2).

NOTE: Step numbers coincide with encircled numbers on Figure 2-3, sheet 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 not PN 128-1810, contact Kepco.
- Step 7. Unpack the BIT 4882 Interface Card Installation Components (PCB Assembly, Cables #1 and #2, Connector Assembly, three (3) Knurled Nuts, five (5) washers, Spacer and Bracket).
- Step 8. Install PCB Assembly (PN 235-1166) into the guides, slide into position so that mounting holes in PCB Assembly line up with the three mounting posts on the BOP mounting bracket.
- Step 9. Secure the BIT 4882 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 10. Install Cable #1 (18-position connectors) to the BIT 4882 Interface Card, mate the other end of the cable with Location #1 on BOP A1 Assembly.
- Step 11. Install Cable #2 (5-position connectors) to the BIT 4882 Interface Card, mate the other end of the cable with Location #2 on BOP A1 Assembly.
- Step 12. Plug in 3-pin connector (Ref. Step 5, above) from Transformer 100-2354 as shown.
- Step 13. Mark "-4882" after Model No. on Nameplate (see Detail A).
- Step 14. Remove "Control Identification" label (PN 188-1107) and "Address Label" (PN 188-1012). Affix revised "Control Identification" label (PN 188-1445) and "Address Label" (PN 188-1726) in vacated positions (with part numbers facing front panel).
- Step 15. Reinstall BOP cover.
- Step 16. Perform calibration procedure detailed in Section 3 of this manual.

FIGURE 2-3. INSTALLATION OF MODEL BIT 4882 INTO BOP (SHEET 1 OF 2)



3041073

NOTE: CIRCLED NUMBERS REFER TO PROCEDURE STEPS (SEE SHEET 1).

FIGURE 2-3. INSTALLATION OF MODEL BIT 4882 INTO BOP (SHEET 2 OF 2).

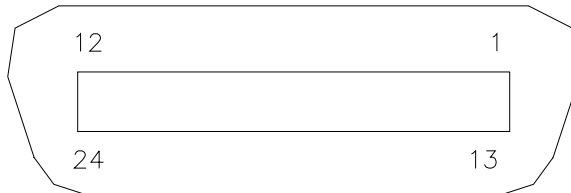
2.4 INPUT/OUTPUT SIGNALS

The IEEE 488 port is a 24 pin IEEE 488 connector (Figure 2-4) 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 2-4. IEEE 488 (GPIB) CONNECTOR

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), 5 digit minimum resolution (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 (with suitable power rating and tolerance for the currents to be measured).

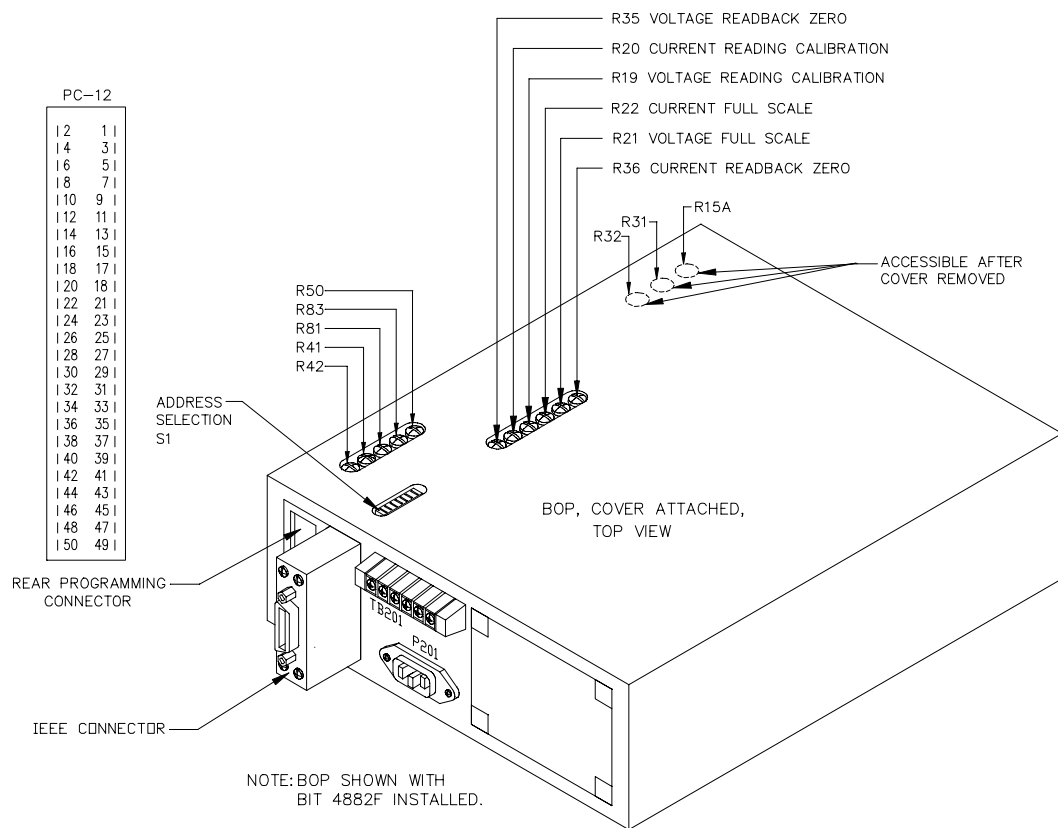
3.2 ADJUSTMENT OF THE BOP ± 10 VOLT CALIBRATION CONTROLS (R31, R32)

NOTE: BOP cover removal required for this step.

1. Connect a 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, refer to Table 3-1). Adjust R31 for +10.000Vdc.
3. Turn the BOP Power Supply "OFF" and connect DVM between common and pin 22 (-10Vdc REFERENCE).
4. Turn the BOP Power Supply "ON". Adjust R32 for -10.000Vdc.
5. Turn the BOP Power Supply "OFF".

3.3 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, refer to Table 3-1).
3. Adjust the control for zero, ± 100 microvolts.
4. Turn the BOP Power Supply "OFF".



3040403

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

3.4 ADJUSTMENT OF THE OUTPUT VOLTAGE ZERO (R81)

1. Without a load connected to the BOP output, connect a DVM between the FRONT PANEL SENSING TERMINALS of the BOP Power Supply.
2. Turn the BOP Power Supply "ON", program the BOP Power Supply to ZERO VOLTAGE AND MAXIMUM CURRENT LIMIT.
 - If using SCPI send `VOLT 0;CURR MAX`
 - If using CIIIL send `FNC DCS:CH1 VOLT 0 with CURL .5`
3. Locate Eo COMP AMP ZERO control R81 (see Figure 3-1, refer to Table 3-1).
4. Adjust control R81 for zero, ± 100 microvolts.

3.5 ADJUSTMENT OF THE FULL SCALE OUTPUT VOLTAGE (R21)

1. Program the BOP Power Supply for PLUS FULL SCALE VOLTAGE.
 - If using SCPI send `VOLT MAX;CURR MAX`
 - If using CIIIL send `FNC DCS:CH1 VOLT xx with CURL .5` where **xx** is the maximum rated output voltage of the BOP.

2. MEASURE the output voltage at the sense terminals at the BOP front panel using the DVM.
3. Locate VOLTAGE FULL SCALE control R21 (see Figures 2-1 and 3-1, refer to Table 3-1).
4. Adjust control R21 as needed until DVM reads FULL SCALE VOLTAGE, ± 1 millivolt.

TABLE 3-1. BOP POWER SUPPLY, INTERNAL CALIBRATION CONTROLS

| REFERENCE DESIGNATION | CONTROL NAME | PURPOSE | ADJUSTMENT PROCEDURE (PAR.) |
|----------------------------|------------------------------|---|-----------------------------|
| R19 * | VOLTAGE READING | 'MEASURE'd voltage reading adjustment | 3.7 |
| R20 * | CURRENT READING | 'MEASURE'd current reading adjustment | 3.11 |
| R21 * | VOLTAGE FULL SCALE | Full scale output voltage adjustment | 3.5 |
| R22 * | CURRENT FULL SCALE | Full scale output current adjustment | 3.9 |
| A1R31, A1R32 | (\pm) 10V CAL. | Reference voltage calibration | 3.2 |
| R35 * | VOLTAGE READBACK ZERO | Zero output voltage readback adjustment | 3.6 |
| R36 * | CURRENT READBACK ZERO | Zero output current readback adjustment | 3.10 |
| R50 * | AMMETER ZERO | Sensing amplifier offset adjustment | 3.3 |
| A1R81 | E _O COMP AMP ZERO | Voltage channel zero adjustment | 3.4 |
| A1R83 | I _O COMP AMP ZERO | Current channel zero adjustment | 3.8 |
| * Located on BIT 4882 card | | | |

3.6 VOLTAGE READING ZERO CALIBRATION (R35)

1. Program the BOP power supply for ZERO VOLTAGE and MAXIMUM CURRENT LIMIT.
 - If using SCPI send `VOLT 0;CURR MAX`
 - If using CIIIL send `FNC DCS:CH1 VOLT 0 with CURL .5`

2. MEASURE the output voltage using programming commands, then check the readback data.

- In SCPI send **MEAS:VOLT?**
- In CIIL: send **FNC DCS:CH1 GAL**
F0
INX VOLT
FTH VOLT

NOTE: For subsequent measurements using CIIL it is only necessary to send **INX VOLT** and **FTH VOLT** commands.

3. Locate VOLTAGE READBACK ZERO control R35 (see Figures 2-1 and 3-1, refer to Table 3-1).
4. Adjust control R35 until the readback value is not 0.0 using MEASURE commands (see step 2) as needed.
5. Adjust control R35 (opposite direction from step 4 above) until the readback value is 0.0 using MEASURE commands (see step 2) as needed. Once a stable value of 0.0 is reached, continue rotating R35 four full (360°) turns in the same direction. Verify readback voltage is 0.0 using MEASURE commands (see step 2) as needed.

3.7 VOLTAGE READING CALIBRATION (R19)

1. Program the BOP power supply for PLUS FULL SCALE VOLTAGE, less one percent, e.g., for a 20V unit, program BOP to 19.8V (verify by reading external DVM).

- If using SCPI send **VOLT yy;CURR MAX**
- If using CIIL send **FNC DCS:CH1 VOLT yy with CURL .5**
where **yy** is the maximum rated output voltage of the BOP less one percent.

2. MEASURE the output voltage using programming commands, then check the readback data.

- In SCPI send **MEAS:VOLT?**
- In CIIL: send **FNC DCS:CH1 GAL**
F0
INX VOLT
FTH VOLT

NOTE: For subsequent measurements using CIIL it is only necessary to send **INX VOLT** and **FTH VOLT** commands.

3. Locate VOLTAGE READ. CAL. control R19 (see Figures 2-1 and 3-1, refer to Table 3-1).
4. Adjust control R19 until the readback value matches the programmed value using MEASURE commands (see step 2) as needed.
5. Turn the BOP Power Supply "OFF".

3.8 ADJUSTMENT OF THE OUTPUT CURRENT ZERO (R83)

1. With the BOP Power Supply "OFF", connect a precision current shunt (R_S) between the FRONT PANEL OUTPUT TERMINALS.

2. Connect the DVM to the other two terminals of the precision shunt as shown in Figure 3-2.

3. Turn the BOP "ON" and program the BOP Power Supply to ZERO CURRENT and MAXIMUM VOLTAGE LIMIT.
 - If using SCPI send **FUNC:MODE CURR;:CURR 0;VOLT MAX**
 - If using CIIL send **FNC DCS:CH1 CURR 0 with VLTL 20**
4. Locate Io COMP AMP ZERO control R83 (see Figure 3-1, refer to Table 3-1).
5. Adjust control R83 for zero, per Table 3-2, OUTPUT CURRENT ZERO.
6. Turn the BOP Power Supply "OFF".

3.9 ADJUSTMENT OF THE FULL SCALE OUTPUT CURRENT (R22)

1. With the BOP Power Supply "OFF", connect the PRECISION 4-TERMINAL SHUNT to the power supply output terminals and connect the DVM to the PRECISION 4-TERMINAL SHUNT (see Figure 3-2)
2. Turn the BOP Power Supply "ON" and program the BOP Power Supply for PLUS FULL SCALE CURRENT and MAXIMUM VOLTAGE LIMIT.
 - If using SCPI send **FUNC:MODE CURR;:CURR MAX;VOLT MAX**
 - If using CIIL send **FNC DCS:CH1 CURR zz with VLTL 20** where **zz** is the maximum rated output current of the BOP.
3. Locate CURRENT FULL SCALE control R22 (see Figures 2-1 and 3-1, refer to Table 3-1).
4. MEASURE the output current using the DVM. Adjust control R22 as needed until DVM reads exactly FULL SCALE CURRENT per Table 3-2, FULL SCALE CURRENT ACCURACY.

3.10 CURRENT READING ZERO CALIBRATION (R36)

NOTE: The Output Current Zero Adjustment (PAR. 3.8) must be done before performing the following procedure, and the PRECISION 4-TERMINAL SHUNT should be still connected to the power supply output terminals.

1. Program the BOP Power Supply for ZERO CURRENT and MAXIMUM VOLTAGE LIMIT.
 - If using SCPI send **FUNC:MODE CURR;:CURR 0;VOLT MAX**
 - If using CIIL send **FNC DCS:CH1 CURR 0 with VLTL 20**
2. MEASURE the output current using programming commands, then check the readback data.
 - In SCPI send **MEAS:CURR?** then check the readback data.
 - In CIIL: send **FNC DCS:CH1 GAL**
F0
INX CURR
FTH CURR

NOTE: For subsequent measurements using CIIL it is only necessary to send **INX CURR** and **FTH CURR** commands.

3. Locate CURRENT READBACK ZERO control R36 (see Figures 2-1 and 3-1, refer to Table 3-1).
4. Adjust control R36 until the readback value is not 0.0 using MEASURE commands (see step 2) as needed.

5. Adjust control R36 (opposite direction from step 4 above) until the readback value is 0.0 using MEASURE commands (see step 2) as needed. Once a stable value of 0.0 is reached, continue rotating R36 four full (360°) turns in the same direction. Verify readback current is 0.0 using MEASURE commands (see step 2) as needed.

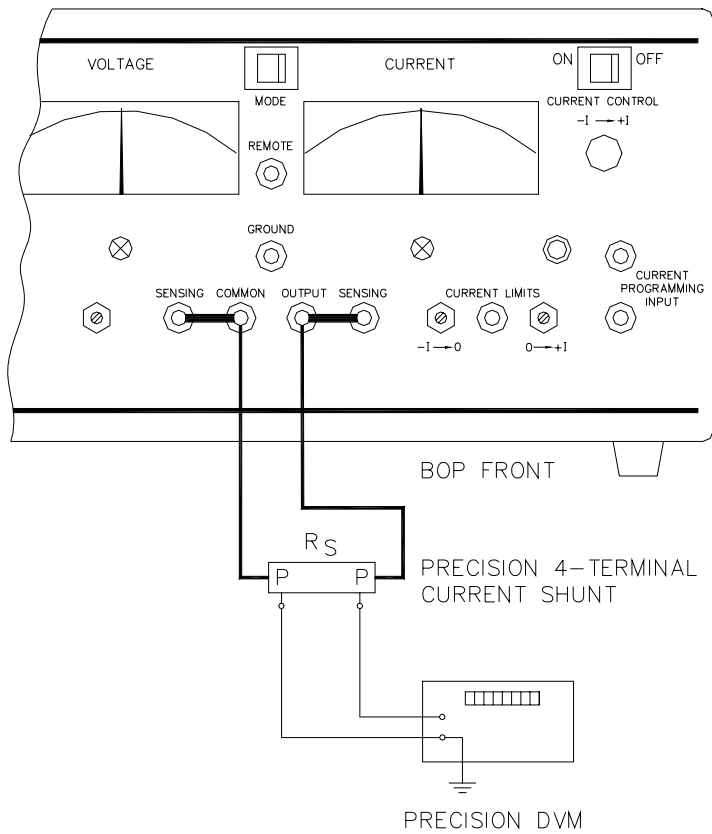
TABLE 3-2. CALIBRATION MEASUREMENTS AND TOLERANCES - CURRENT

| MODEL | SENSE RESISTOR VALUE (SEE NOTES AND TABLE 3-3) | OUTPUT CURRENT ZERO | FULL SCALE CURRENT ACCURACY |
|---|---|---------------------------|--|
| BOP 100-1M BOP 200-1M | 1 Ohm | 0V ±0.000025V | 1V (MAX) -1V (MIN) ±0.000150V |
| BOP 50-2M BOP 100-2M | 1 Ohm | 0V ±0.00005V | 2V (MAX) -2V (MIN) ±0.00030V |
| BOP 72-3M | 1 Ohm | 0V ±0.000075V | 3V (MAX) -3V (MIN) ±0.0006V |
| BOP 50-4 BOP 100-4M | 1 Ohm | 0V ±0.0001V | 4V (MAX) -4V (MIN) ±0.0008V |
| BOP 20-5M | 0.1 Ohm | 0V ±0.0000125V | 0.5V (MAX) -0.5V (MIN) ±0.0000750V |
| BOP 36-6M BOP 72-6M | 0.1 Ohm | 0V ±0.000015V | 0.6V (MAX) -0.6V (MIN) ±0.000090V |
| BOP 50-8 | 0.1 Ohm | 0V ±0.00002V | 0.8V (MAX) -0.8V (MIN) ±0.00012V |
| BOP 20-10M | 0.1 Ohm | 0V ±0.000025V | 1.0V (MAX) -1.0V (MIN) ±0.000150V |
| BOP 36-12M | 0.1 Ohm | 0V ±0.00003V | 1.2V (MAX) -1.2V (MIN) ±0.00018V |
| BOP 20-20M | 0.01 Ohm | 0V ±0.0000005V | 0.2V (MAX) -0.2V (MIN) ±0.0000030V |
| REFER TO NOTES IF EXACT SENSE RESISTOR VALUE IS KNOWN. | R _{SENSE} SEE NOTE. | SEE NOTE A. | SEE NOTES C AND D |
| USE SPACE PROVIDED AT RIGHT FOR CALCULATED VALUES. | | | |
| <p>NOTES: The following formula is used to calculate proper calibration values if the exact Sense Resistor value is known.</p> <p>R_{SENSE} = the measured value of the sense resistor to 6 places (minimum).</p> <p>I = Rated current output of BOP (e.g., for BOP 50-4M, I = 4)</p> <p>(R_{SENSE}) (I) (0.00075) [FOR MODELS WHERE I = 3 OR 4 USE (R_{SENSE}) (I) (0.00012)]</p> | | | |

TABLE 3-3. SUGGESTED SENSE RESISTORS

| VALUE | KEPCO PART NO. | MANUFACTURER | MANUFACTURER PART NO. |
|----------|----------------|--------------|-----------------------|
| 0.01 OHM | 115-2997 | ISOTEK | RUG-Z-R010-0.1 TK10 |
| 0.1 OHM | 115-2995 | ISOTEK | RUG-Z-R100-0.1 TK10 |
| 1 OHM | 115-2996 | ISOTEK | RUG-Z-1R00-0.1 TK10 |

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.



3040383

FIGURE 3-2. CURRENT SHUNT CONNECTIONS

3.11 CURRENT READING CALIBRATION (R20)

NOTE: The Full Scale Output Current Adjustment (PAR. 3.9) must be done before performing the following procedure, and the PRECISION 4-TERMINAL SHUNT should be still connected to the power supply output terminals.

1. Program the BOP Power Supply for PLUS FULL SCALE CURRENT, less one percent (verify by reading external DVM). E.g., for 20V

- If using SCPI send **FUNC:MODE CURR;:CURR zz;VOLT MAX**
- If using CIIL send **FNC DCS:CH1 CURR zz with VLTL 20**
where **zz = aa - (aa/100)** where **aa** is the maximum rated output current of the BOP (e.g., for BOP 20-10M, **zz = 10-(10/100) = 9.9**).

2. MEASURE the output current using programming commands, then check the readback data.

- In SCPI send **MEAS:CURR?** then check the readback data.
- In CIIL: send **FNC DCS:CH1 GAL**
F0
INX CURR
FTH CURR

NOTE: For subsequent measurements using CIIL it is only necessary to send **INX CURR** and **FTH CURR** commands.

3. Locate CURRENT READ. CAL. control R20 (see Figures 2-1 and 3-1, refer to Table 3-1).

4. Adjust control R20, until the measured value matches the programmed value using MEASURE commands (see step 2) as needed.

SECTION 4 - OPERATION

4.1 GENERAL

The Kepco BOP Power Supply, with an installed BIT 4882, BIT 4882-F or BIT 4886 Interface Card, may be programmed over the IEEE 488 standard communication bus (General Purpose Interface Bus, GPIB) using either SCPI (Standard Commands for Programmable Instruments) or CIIL (Control Interface Intermediate Language) commands. SCPI and CIIL provide a common language used in an automatic test system. (Refer to Table 2-3 for input/output signal allocations.)

4.2 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

| FUNCTION | SUBSET SYMBOL | COMMENTS |
|--------------------|---------------|--|
| 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

| MNEMONIC | MESSAGE DESCRIPTION | COMMENTS |
|----------|-------------------------|------------------|
| 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 |

4.3 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.)

4.3.1 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.

4.3.2 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 3.4.3 through 3.4.6).

4.3.3 SCPI SUBSYSTEM COMMAND/QUERY STRUCTURE

Subsystem commands/queries are related to specific power supply functions (such as setting output voltage, current limit, etc.) Figure 4-1 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 subsystem commands are defined and explained in Appendix B (see Table 4-4).

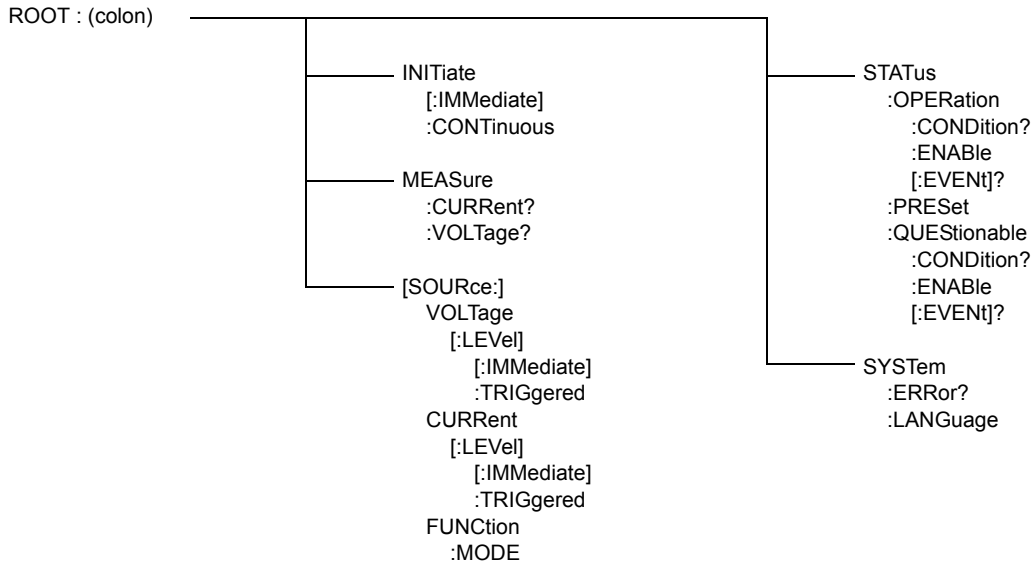


FIGURE 4-1. TREE DIAGRAM OF SCPI COMMANDS USED WITH BIT 4882, BIT 4882-F AND BIT 4886 INTERFACE CARD

4.3.4 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 4-2 illustrates the message structure, 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.

TABLE 4-4. SCPI COMMAND INDEX

| COMMAND | PAGE | COMMAND | PAGE |
|-------------|------|-------------------|------|
| *CLS | A-1 | [SOUR]:CURR? | B-5 |
| *ESE | A-2 | [SOUR]:CURR:TRIG | B-6 |
| *ESE? | A-2 | [SOUR]:CURR:TRIG? | B-6 |
| *ESR? | A-3 | [SOUR]:VOLT | B-7 |
| *IDN? | A-3 | [SOUR]:VOLT? | B-7 |
| *OPC | A-4 | [SOUR]:VOLT:TRIG | B-8 |
| OPC? | A-4 | [SOUR]:VOLT:TRIG? | B-8 |
| *RST | A-5 | [SOUR]:FUNC:MODE | B-9 |
| *SRE | A-6 | STAT:OPER:COND? | B-9 |
| *SRE? | A-6 | STAT:OPER:ENAB | B-10 |
| *STB? | A-7 | STAT:OPER:ENAB? | B-10 |
| *TRG | A-7 | STAT:OPER? | B-11 |
| *TST | A-8 | STAT:PRES | B-11 |
| *WAI | A-8 | STAT:QUES? | B-12 |
| INIT[:IMM] | B-1 | STAT:QUES:COND? | B-12 |
| INIT:CONT | B-1 | STAT:QUES:ENAB | B-13 |
| INIT:CONT? | B-2 | STAT:QUES:ENAB? | B-13 |
| MEAS:CURR? | B-3 | SYST:ERR? | B-14 |
| MEAS:VOLT? | B-3 | SYST:LANG | B-14 |
| [SOUR]:CURR | B-4 | | |

4.3.4.1 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 4-1.

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). The rules governing short form keywords are presented in Table 4-5.

TABLE 4-5. RULES GOVERNING SHORTFORM KEYWORDS

| IF NUMBER OF LETTERS IN LONGFORM KEYWORD IS: | AND FOURTH LETTER IS A VOWEL? | THEN SHORT FORM CONSISTS OF: | EXAMPLES |
|--|-------------------------------|-----------------------------------|-------------------------|
| 4 OR FEWER | (DOES NOT MATTER) | ALL LONG FORM LETTERS | MODE |
| 5 OR MORE | NO | THE FIRST FOUR LONG FORM LETTERS | MEASure, OUTPut, EVENT |
| | YES | THE FIRST THREE LONG FORM LETTERS | LEVel, IMMediate, ERRor |

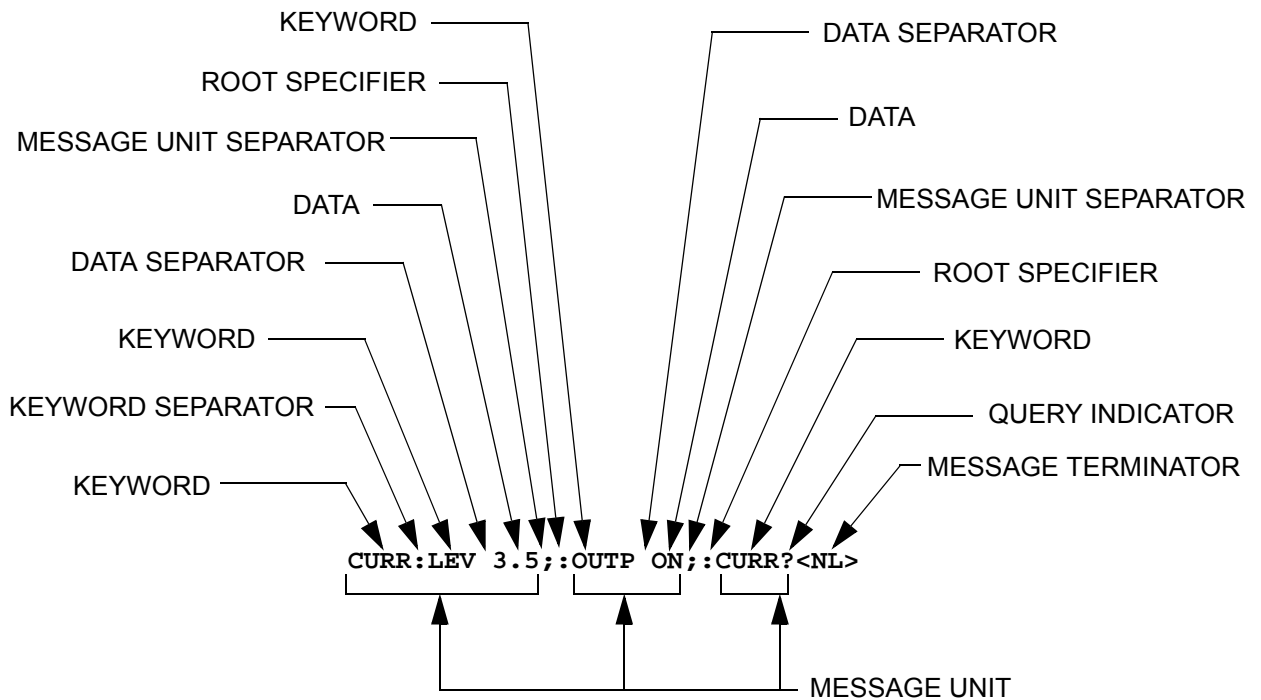


FIGURE 4-2. MESSAGE STRUCTURE

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).

4.3.4.2 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 3.4.4.7).

4.3.4.3 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?).

4.3.4.4 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

4.3.4.5 DATA SEPARATOR

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

4.3.4.6 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).

4.3.4.7 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.

4.3.4.8 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: Kepeco 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.

4.3.5 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.

4.3.6 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 message 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., **INST** (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`

4.3.7 SCPI PROGRAM EXAMPLE

Figure 4-3 is an example of a program using SCPI commands to program an MST 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
    ibsre(bd,1);         // Set remote line true

    strcpy(dat_str,"VOLT 5;CURR 1"); // Define a set command
    strcat(dat_str,"\r\n");          // Append delimiter
    ibwrt(adr,dat_str,strlen(dat_str)); // Send string to power supply

    strcpy(dat_str,"MEAS:VOLT?;CURR?"); // Define a measure command
    strcat(dat_str,"\r\n");          // Append delimiter
    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 4-3. TYPICAL EXAMPLE OF INTERFACE CARD PROGRAM USING SCPI COMMANDS

4.4 CIIL PROGRAMMING

The CIIL command language is used on early models of Kepco power supplies and controllers. The command functions are included here for compatibility with other equipment programmed with CIIL commands. The CIIL command set for the Interface Card is defined and explained in Appendix C.

APPENDIX A - SCPI COMMON COMMAND/QUERY DEFINITIONS

A.1 INTRODUCTION

This appendix defines the SCPI common commands and queries used with the BIT 4882 and BIT 4882-F Interface Cards. Common commands and queries are preceded by an asterisk (*) and are defined and explained in paragraphs A.2 through A.15, 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 | *SRE, ? | A.10, A.11 |
| *ESE, ? | A.3, A.4 | *STB? | A.12 |
| *ESR? | A.5 | *TRG | A.13 |
| *IDN? | A.6 | *TST? | A.14 |
| *OPC, ? | A.7, A.8 | *WAI | A.15 |
| *RST | A.9 | | |

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). 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>, <Serial Number>, <Firmware revision> where: <Manufacturer> = KEPCO, <Model> = BOP BIT 488), <Serial Number> = MM,DD,YY-SSS (MM - month, DD - day, YY - year, SSS - serial number in that day) <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.)

*RST

A.9 *RST — RESET COMMAND

Syntax: *RST

Description: **Resets power supply to the power on default state.** The power supply is programmed to the power on values of the following parameters: CURR[:LEV][:IMM] = 0, VOLT[:LEV][:IMM] = 0, CURR:PROT[:LEV] = max overcurrent value, VOLT:PROT[:LEV] = (maximum overvoltage value,

OUTP[:STAT] = OFF. If the power supply is in either an overvoltage or overcurrent state, this condition is reset by *RST. (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, BOP BIT 488 REV 1. |
| *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

A.10 *SRE — SERVICE REQUEST ENABLE COMMAND

***SRE**

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.25)
NU (Not Used)

A.11 *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.12 *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.13 *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.14 *TST? — SELF TEST QUERY

*TST?

Syntax: *WAI Returned value: 0 or 1 (0 = pass test, 1 = 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 cyclic redundancy check (CRC) is performed on non-volatile RAM. A "1" is returned if there is an error.

CAUTION: TO AVOID DAMAGE TO THE LOAD, DISCONNECT THE LOAD BEFORE ISSUING THIS COMMAND. (DURING THE SELF-TEST, THE BOP IS PROGRAMMED TO FULL SCALE POSITIVE AND FULL SCALE NEGATIVE OUTPUT.)

A.15 *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 4882 and BIT 4882-F Interface Cards. Subsystem commands are de

efined in PAR. B.2 through B.25, arranged in groups as they appear in the tree diagram, Figure 4-1. 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. |
|-------------------|------------|--------------------|------------|
| INIT[:IMM] | B.2 | STAT:OPER:ENAB, ? | B.17, B.18 |
| INIT:CONT, ? | B.3, B.4 | STAT:OPER[:EVENT]? | B.19 |
| MEAS:CURR? | B.5 | STAT:PRES | B.20 |
| MEAS:VOLT? | B.6 | STAT:QUES[:EVENT]? | B.21 |
| [SOUR]:CURR | B.7, B.8 | STAT:QUES:COND? | B.22 |
| [SOUR]:CURR:TRIG? | B.9, B.10 | STAT:QUES:ENAB, ? | B.23, B.24 |
| [SOUR]:VOLT | B.11, B.12 | SYST:ERR? | B.25 |
| [SOUR]:VOLT:TRIG | B.13, B.14 | SYST:LANG | B.26 |
| [SOUR:]FUNC:MODE? | B.15 | SYST:VERS? | B.27 |
| STAT:OPER:COND? | B.16 | | |

B.2 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-1.)

B.3 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 OFF. (See example, Figure B-1.)

B.4 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-1.)

NOTE: Power supply assumed to be operating in constant voltage mode.

| | |
|--------------------------|--|
| 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 2.09E+1. |
| 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). |

FIGURE B-1. PROGRAMMING THE OUTPUT

B.5 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-1.)

B.6 MEASure:VOLTage[:SCALar][:DC]? QUERY

MEAS:VOLT?

Syntax: Short Form: MEAS[:SCAL]:VOLT[:DC]? Long Form: MEASure[:SCALar]:VOLTage[:DC]?

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-1.)

B.7 [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., 2.71E+1 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 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-1.)

B.8 [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., 2.71E+1 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 0). **Related Commands:** CURR. (See example, Figure B-1.)

B.9 [SOURce:]CURRent[:LEVel]TRIGgered[:AMPlitude] COMMAND

CURR:TRIG

Syntax: Short Form: [SOUR:]CURR[:LEV]:TRIG[:AMP] <exp_value>
Long Form: [SOURce:]CURRent[:LEVel]:TRIGgered[:AMPlitude] <exp_value>
<exp_value> = digits with decimal point and Exponent, e.g., 2.71E+1 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-1.)

B.10 [SOURce:]CURRent[:LEVel]TRIGgered[:AMPlitude]? QUERY

CURR:TRIG?

Syntax: Short Form: [SOUR:]CURR[:LEV]:TRIG[:AMP]?
Long Form: [SOURce:]CURRent[:LEVel]:TRIGgered[:AMPlitude]?
Return Value: <exp_value> = digits with decimal point and Exponent, e.g., 2.71E+1 for 27.1

Description: Returns the current value established by CURR:TRIG command. (See example, Figure B-1.)

B.11 [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., 2.71E+1 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-1.)

B.12 [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 0). **Related Commands:** VOLT. (See example, Figure B-1)

B.13 [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., 2.71E+1 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-1.)

B.14 [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., 2.71E+1 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-1.)

B.15 [SOURce:]FUNCtion:MODE

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 automatically switch to Current mode and 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 automatically switch to Voltage mode and flag an error condition. (See example, Figure B-1.)

B.16 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-2). 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-2.)

TABLE B-2. OPERATION CONDITION REGISTER, OPERATION ENABLE REGISTER, AND OPERATION EVENT REGISTER BITS

| CONDITION | NU | CC | RC | 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
 RC - RELAY CLOSED
 NU - NOT USED

B.17 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-2.)

B.18 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-2).** 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-2.)

B.19 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-2).** 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-2.)

B.20 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-2) and Questionable Condition Registers to 0, preventing all status events from being reported. (See example, Figure B-2.)

B.21 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 questionable events that occurred since previous STAT:QUES? query.** Returns the value of the Questionable Event register (see Table B-3). The Questionable Event register is a read-only register which holds (latches) all events. Reading the Questionable Event register clears it. (See example, Figure B-2.)

TABLE B-3. QUESTIONABLE EVENT REGISTER, QUESTIONABLE CONDITION REGISTER AND QUESTIONABLE CONDITION ENABLE REGISTER BITS

| | | | | | | | | | | | | | | |
|-----------|---------------|------|------|-----|-----|-----|----|----|----|----|----|----|----|--------------------|
| CONDITION | NU | PL | OL | RE | NU | NU | NU | NU | NU | OT | NU | CE | VE | PL POWER LOSS |
| BIT | 15-12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | OL OVERLOAD |
| VALUE | 32,768 - 4096 | 2048 | 1024 | 512 | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | RE RELAY ERROR |
| | | | | | | | | | | | | | | OT OVERTEMPERATURE |
| | | | | | | | | | | | | | | CE CURRENT ERROR |
| | | | | | | | | | | | | | | VE VOLTAGE ERROR |
| | | | | | | | | | | | | | | NU NOT USED |

B.22 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-3).** 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). (See example, Figure B-2.)

NOTE: The power supply is assumed to be operating in cV (constant voltage) mode.

STAT:OPER:ENAB 1545Mask enabled for OL, RE, OT and VE bits.
 STAT:OPER:ENAB? Returns 1545 (32 + 1024) (OL, RE, OT and VE bits set).
 STAT:PRES Operation Condition and Questionable Condition registers are reset.
 INIT:CONT ON Continuous triggers enabled.
 STAT:OPER:COND? Power supply returns 768 (256 + 512) to indicate that power supply is constant voltage mode and relays are closed.
 STAT:OPER? Returns 1536, e.g., (1024 + 512) indicating that since the last reading of the Operation Event Register the power supply has entered Constant Current mode, the relays are still closed
 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
 --- OVERTEMPERATURE CONDITION OCCURS
 STAT:QUES? Returns 3 (overcurrent protection tripped since the last STAT:QUES? query).
 STAT:QUES:COND? Returns 3, (Power supply still in overcurrent protection state).
 STAT:QUES? Returns 0, (Register cleared by previous STAT:QUES?).
 STAT:QUES:COND? Returns 3, (Power supply still in overtemperature state).
 --- Overtemperature condition cleared.
 STAT:QUES:COND? Returns 0.
 SYST:ERR? Power supply returns 0, "No error" message.

FIGURE B-2. USING STATUS COMMANDS AND QUERIES

B.23 STATus:QUESTionable:ENABLE Command

STAT:QUES:ENAB

Syntax: Short Form: STAT:QUES:ENAB <int_value> Long Form: STATus:QUESTionable:ENABLE <int_value>

Function: Programs Questionable Condition Enable Register.

Description: Programs Questionable Condition Enable Register (see Table B-3). 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-2.)

B.24 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-3). 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-2.)

SYST:ERR?

B.25 SYSTem:ERRor? QUERY

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-4.

TABLE B-4. ERROR MESSAGES

| ERROR MESSAGE | EXPLANATION |
|--|---|
| 0, "No error" | No error |
| -100, "Command error" | Command and data understood, but more information included which is not recognized. |
| -222, "Data [current or voltage] out of range" | Value exceeds power supply rating |
| -240, "Hardware error" | Power supply did not respond to command |

SYST:LANG

B.26 SYSTem:LANGUage COMMAND

Syntax: Short Form: SYST:LANG Long Form: SYSTem:LANGUage

Description: **Allows CIIL command language (see Appendix C) to be used to program the power supply.** (CIIL is included to provide compatibility with earlier Kepco equipment.) Once CIIL is selected, the CIIL command 'GAL' followed by the command 'SCPI' must be sent for the power supply to respond to SCPI commands (with the exception of this command, SYST:LANG, which is always active).

SYST:VERS?

B.27 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-3.)

| | |
|---------------|--|
| SYST:VERS | Returns 1998.0. |
| SYST:KLOC ON | keypad locked, only remote control possible. |
| SYST:KLOC? | Returns 1 indicating keypad locked. |
| SYST:KLOC OFF | keypad unlocked, pressing LOCAL key allows Local mode operation. |
| SYST:KLOC? | Returns 0 indicating keypad unlocked. |

FIGURE B-3. USING SYSTEM COMMANDS AND QUERIES

APPENDIX C - CIIL COMMAND DEFINITIONS

C.1 INTRODUCTION

This appendix defines the CIIL commands used with the BIT 4882, BIT 4882-F and BIT 4886 Interface Cards. Table C-1 provides a quick reference of all CIIL commands used in the Interface Card.

TABLE C-1. CIIL SUBSYSTEM COMMAND/QUERY INDEX

| COMMAND | PAGE | COMMAND | PAGE |
|---------|------|---------|------|
| CNF | C-4 | RST | C-4 |
| FNC | C-1 | SET | C-3 |
| FTH | C-2 | SRN | C-3 |
| GAL | C-6 | SRX | C-3 |
| INX | C-2 | STA | C-5 |
| IST | C-4 | | |

FNC

- Syntax:** Stimulus mode: FNC DCS :CH1 <SET Command>
 Sensor mode: FNC DCS <VOLT or CURR command> :CH1
- Function:** This operator is used with either the SET command to program a power supply's output (stimulus mode), or with the VOLT and CURR commands to read its output settings (sensor mode).
- Description:** The first operand contains the three (3) letter mnemonic pertaining to the device on the control bus, in this case DCS (Direct Current Source). If a reading is being set up, the modifier VOLT or CURR follows. The next operand is used to select the specific channel of the device being programmed or read from.
- Example:**
- | | |
|---|---|
| FNC DCS :CH1 SET VOLT 15 FNC DCS :CH1 SET CURR 3 FNC DCS VOLT :CH1 FNC DCS CURR :CH1 | Power supply commanded to 15V Power supply commanded to 3A Power supply returns value which represents actual output voltage Power supply returns value which represents actual output current |
|---|---|

NOTE: Actual output voltage and current depends on load conditions

FIGURE C-1. FNC — FUNCTION COMMAND

INX

- Syntax:** INX VOLT (initiate voltage reading)
INX CURR (initiate current reading)
- Function:** Commences a data acquisition process in accordance with the preceding FNC command.
- Description:** The response to the INX command is a dynamic time-out value, unless a catastrophic error condition exists, in which case an error message will be returned. If the time-out value returned is not zero, this indicates the power supply's output voltage or current has not yet settled. A time delay should be observed before proceeding with the FTH command, or the command may be repeated until a zero value is returned, but the preceding FTH command must also be repeated.
- Example:** INX VOLT Power supply initiates voltage reading)
FTH VOLT Power supply sends voltage reading to controller)

FIGURE C-2. INX — INITIATE OP CODE COMMAND

FTH

- Syntax:** FTH VOLT (fetch voltage reading)
FTH CURR (fetch current reading)
- Function:** Commands the previously designated power supply to return the requested data reading.
- Description:** This command must immediately follow an INX command. The value returned is the value of the output voltage or current, whichever was requested, unless a catastrophic error condition exists, in which case an error message will be returned. The value observed will be in scientific notation.
- Example:** INX VOLT Power supply initiates voltage reading)
FTH VOLT Power supply sends voltage reading to controller)

FIGURE C-3. FTH — FETCH COMMAND

SET, SRX, SRN

Syntax: FNC DCS :CH1 SET VOLT <value> CURL <value>
FNC DCS :CH1 SET CURR <value> VLTL <value>
SRX Set Range Maximum
SRN Set Range Minimum

Function: This operator is used in conjunction with FNC (in stimulus mode) to specify the output mode of the power supply being programmed.

Description: The first operand is the noun modifier and the second operand specifies the value. The first operand field of the command contains the four(4) letter mnemonic for the output mode of the power supply. The choices are:

| | |
|------|------------------------|
| VOLT | VOLTAGE MODE OPERATION |
| VLTL | VOLTAGE LIMIT |
| CURR | CURRENT MODE OPERATION |
| CURL | CURRENT LIMIT |

The second operand field of the command contains the value assigned to the chosen output mode. This value may be specified as accurately as the resolution of the power supply allows. It can be directly specified in ASCII integer, decimal, or in scientific notation.

There may be two (2) set commands, separated by a space (ASCII 32), for each power supply being programmed. The following are the only allowable combinations:

VOLT with CURL
CURR with VLTL

The limit parameter (CURL or VLTL) may not be set without the main parameter. A polarity sign may precede the VOLT or CURR value so that the power supply's polarity may be selected.

In the case of Kepco's BOP power supplies, the two related Op Codes, SRX and SRN are functionally identical to the SET command, since there is only one range, 0 - maximum. The commands are included only for compatibility.

Example: FNC DCS :CH1 SET VOLT 5 CURL 3 Power supply commanded to 5V (Voltage mode) with current limit of 3A.
FNC DCS :CH1 SET CURR 2 VLTL 17 Power supply commanded to 2A Current mode) with voltage limit of 17V

FIGURE C-4. SET COMMAND

RST

Syntax: RST DCS :CH1

Function: This operator is used to return a power supply to its power-on state. The output voltage and current are programmed to zero.

Example: RST DCS :CH1 The power supply is reset.

FIGURE C-5. RST — RESET COMMAND

CNF, IST

Syntax: CNF or IST

Function: Causes power supply to execute confidence test.

Description: The CNF operator commands the BOP to execute the confidence test procedure defined for the BOP power supplies (IST is functionally identical to CNF for BOP power supplies). The procedure consists of programming voltage and current to their maximum values, checking for error flags, then programming voltage and current to zero. The results of CNF are obtained through the STA command.

Example: CNF Power supply executes confidence test.
IST Power supply executes self test.

FIGURE C-6. CNF, IST — CONFIDENCE TEST, INTERNAL SELF TEST COMMANDS

STA

Syntax: STA

Function: Causes power supply to return operating status to controller.

Description: This operator commands the power supply to report its present operating status. Status is reported in the form of a message (character string) as defined below. Any catastrophic error conditions (indicated by * in the table below) which exist will be reported, until the error condition is corrected. As required by CIIL, all error messages begin with an ASCII "F" (Fault) followed by a 2 digit code, "07" (Halt). The code that follows (DCSnn) indicates the type of device and the channel number. The next 3 digit code describes the nature of the fault: "DEV" for device related errors or "MOD" for non-device errors, such as syntax.

TABLE C-2. CIIL ERROR MESSAGES

| ERROR MESSAGE | EXPLANATION |
|--|---|
| F07 DCSnn DEV Power Loss | The power supply has lost its input power. * |
| F07 DCSnn DEV Device Turned Off (BOP) | A shutdown occurred due to overvoltage or overcurrent. * |
| F07 DCSnn DEV Over Temperature | A shutdown occurred due to thermal causes. * |
| F07 DCSnn DEV Overload | The voltage or current limit point was exceeded. * |
| F07 DCSnn DEV Voltage Fault | The output voltage is not within limits (voltage mode). * |
| F07 DCSnn DEV Current Fault | The output current is not within limits (current mode). * |
| F07 DCSnn DEV Load Path Fault | Open or miswired load or error sense leads detected. * |
| F07 DCSnn MOD Invalid Command | Improper syntax was used. ** |
| F07 DCSnn DEV Not Ready | The output voltage or current has not settled. ** |
| F07 DCSnn DEV Device Not Present | The specified power supply was not present during power up or during the last DCL. ** |
| F07 DCSnn DEV Device Not Responding | The power supply has failed to communicate to the controller. ** |
| F07 DCSnn DEV Invalid Voltage Range | The programmed voltage is outside the power supply's range. ** |
| F07 DCSnn DEV Invalid Current Range | The programmed current is outside the power supply's range. ** |
| F07 DCSnn DEV Set Modifier Error | An improper SET command was sent. ** |
| F07 DCSnn DEV Invalid Device ID | The selected channel was not between 1-31. ** |
| * Catastrophic error | |
| ** Non-Catastrophic error | |

FIGURE C-7. STA — STATUS COMMAND

GAL

Syntax: GAL

Function: Enables utility commands which change error handling defaults.

Description: This command enables the utility commands listed below. If no GAL command is issued, the default conditions are T0, F1, and P1. Once the GAL command is issued, the appropriate utility command may be sent to change the default condition.

TABLE C-3. CIIL ERROR HANDLING UTILITY COMMANDS

| UTILITY COMMAND | DESCRIPTION |
|-----------------|---|
| T0 | Instructs non-catastrophic error messages to be erased from memory if any command is sent prior to STA command. |
| T1 | Instructs non-catastrophic error messages to be stacked in memory until STA command is sent. |
| F0 | Fetch Mode 0. Ignores error conditions when performing FTH command. |
| F1 | Fetch Mode 1. Reports any error conditions which are present during FTH command. |
| P0 | Power Loss Mode 0. Reports a power loss message only once until power is restored to the power module. |
| P1 | Power Loss Mode 1. Continuously reports a power loss message until power is restored to the power module. |

Note: The defaults are T0, F1 and P1

Example: GAL Enables utility commands.
F0 Causes controller to ignore error conditions during FTH command.

FIGURE C-8. GAL — GO TO ALTERNATE LANGUAGE COMMAND