OPERATOR'S MANUAL

BOP -H SERIES
HIGH PERFORMANCE, 400W
BIPOLAR OPERATIONAL POWER SUPPLY

KEPCO INC.

MODEL
BOP -H SERIES
POWER SUPPLY

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.

3)

Data subject to change without notice.

P/N 243-1398

KEPCO®
THE POWER SUPPLIER™

KEPCO, INC. ● 131-38 SANFORD AVENUE ● FLUSHING, NY. 11355 U.S.A. ● TEL (718) 461-7000 ● FAX (718) 767-1102
email: hq@kepcopower.com ● World Wide Web: ww.kepcopower.com

KEPCO®
THE POWER SUPPLIER™

MODIFICATION OF STANDARD

KEPCO MODEL BOP 20-20HD

NOTE:

This manual applies to Kepco Model BOP 20-20HD, the first of a new BOP-H Series. It is equipped with the following options:

- Option D (Display/Front Panel Control)
- Option S (Master/Slave)

Subsequent units that have these options installed will be designated as:

BOP 20-20HD04

in accordance with Table 1-1 of the manual.

KEPCO, INC. ● 131-38 SANFORD AVENUE ● FLUSHING, NY. 11355 U.S.A. ● TEL (718) 461-7000 ● FAX (718) 767-1102
email: hq@kepcopower.com ● World Wide Web: www.kepcopower.com

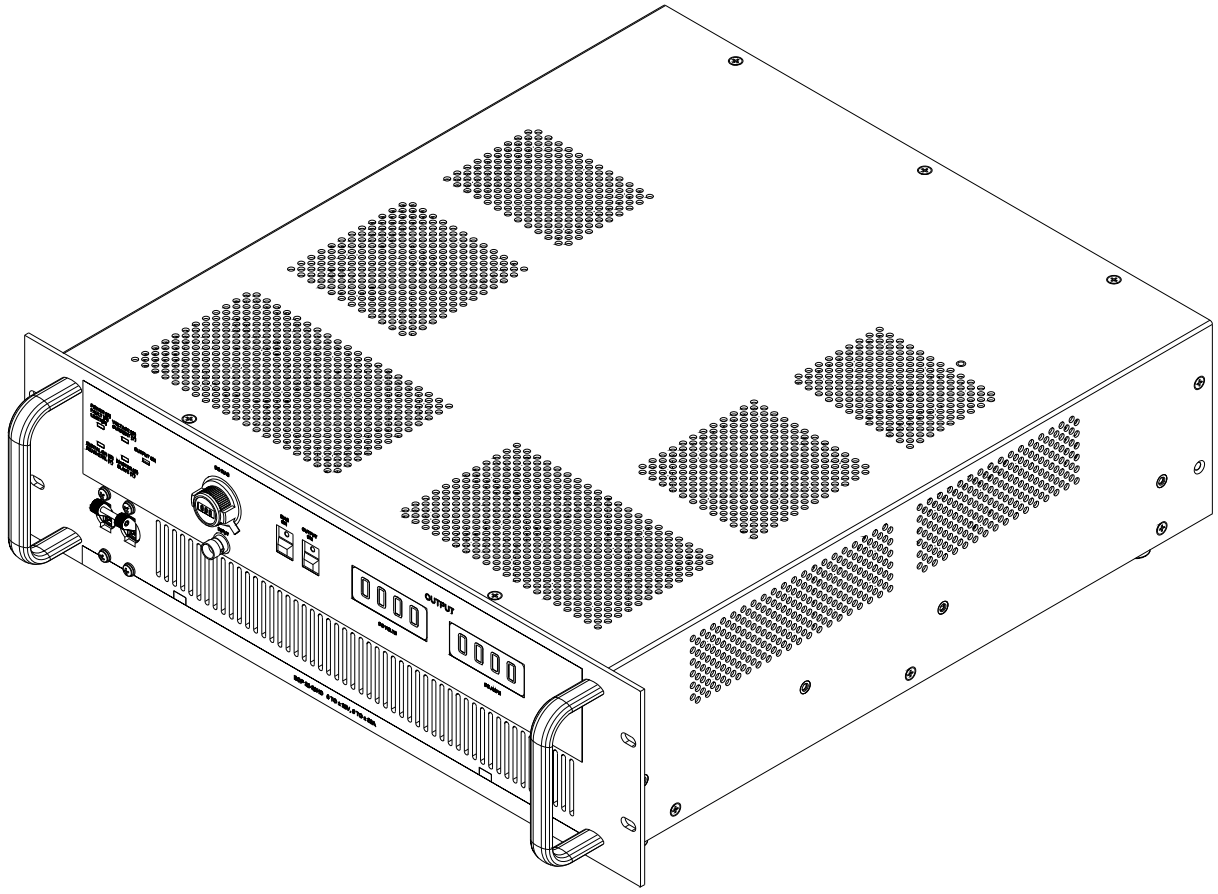
TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES



3044328

FIGURE 1-1. BOP 20-20H 400W POWER SUPPLY, D OPTION (DISPLAY/FRONT PANEL CONTROL) INSTALLED)

SECTION 1 - INTRODUCTION

1.1 SCOPE OF MANUAL

This manual contains instructions for the installation and operation of the BOP-H Series of 400 Watt High Performance bipolar operational power supplies, hereafter referred to as BOP-H or simply BOP, manufactured by Kepco, Inc., Flushing, New York, U.S.A.

1.2 OPTIONS

The BOP-H configuration is defined by options indicated by a suffix following the H of the model comprised of letters which define the primary options installed, and in some cases, numbers which define any secondary options installed.. Primary options are defined by letters D, G and E and are explained in PAR. 1.2.1 below. Secondary options are explained in PAR. 1.2.2. Consult factory for the BOP-H models and options available.

1.2.1 PRIMARY OPTIONS

The primary options define the method of controlling the unit.

There are three primary options indicated by a letter suffix following the H:

- D Option (Front panel display/control)
- G Option (Digital remote control via GPIB and RS 232)
- E Option (Digital remote control via LAN/Ethernet and USB)

More than one primary option can be installed, but only one digital interface can be selected. The following combinations are possible

- H: Rear panel analog control input only, w/o front panel display/control and w/o digital control
- HD: front panel control, no remote digital control
- HG: with GPIB/ RS232 digital control, w/o front panel display/control
- HE: with LAN digital control, w/o front panel display/control
- HDG: with both front panel display/control and GPIB/RS232 digital control
- HDE: with both front panel display/control and LAN digital control

1.2.1.1 DISPLAY/FRONT PANEL CONTROL (D OPTION):

D Option models allow front panel control of the BOP-H. This option includes two digital meters on the front panel used to display output DC voltage and output DC current. Also included are an OUTPUT ON switch that allows output on-off control from the front panel, DC bias pot and BIAS ON switch that allows on-off control of DC bias from the front panel and an INPUT twinax BNC jack for remote control of the main channel.

1.2.1.2 DIGITAL REMOTE CONTROL (G OPTION, E OPTION)

G or E Option models include a factory installed digital interface card that allows digital remote control. Digital remote control for G Option models is via GPIB or RS 232 protocols using SCPI commands. Digital remote control for E Option models is via either an ethernet/LAN interface using a web browser, an RS 232 interface, or via a USB digital interface. Both digital options include a local digital bus (IEEE 1118, Bitbus) used for communication between units connected in series or parallel (see Option S, PAR. 1.2.6).

1.2.2 SECONDARY OPTIONS

There are six secondary options which are defined in the following paragraphs. Table 1-1 lists the combinations of secondary options as defined by a numerical suffix.

TABLE 1-1. ADDITIONAL OPTION(S) INSTALLED

Suffix	Options installed					
	L	C	LC	S	R	Z
01	YES					
02		YES				
03			YES			
04				YES		
05						YES
06	YES			YES		
07	YES				YES	
08	YES					YES
09		YES		YES		
10		YES				YES
11			YES			YES
12			YES	YES		
13	YES			YES	YES	
14	YES			YES		YES
15	YES				YES	YES
16	YES			YES	YES	YES

1.2.3 INDUCTIVE LOAD OPTIMIZATION (L OPTION): L Option models are stable handling heavy inductive loads (factory tests were performed with loads up to 1 Henry). The L Option can be enabled/disabled by a microswitch on the rear panel.

1.2.4 CAPACITIVE LOAD OPTIMIZATION (C OPTION): C Option models are stable handling capacitive loads (factory tests were performed with loads up to 10mF). The C Option can be enabled/disabled by a microswitch on the rear panel.

1.2.5 INDUCTIVE LOAD OPTIMIZATION (LC OPTION): LC Option models include both L Option (see PAR. 1.2.3) and C Option (see PAR. 1.2.4). The L/C Option can be enabled/disabled by a rear panel microswitch. Once enabled, a rear panel microswitch allows selection of either L Option or C Option.

1.2.6 MASTER/SLAVE (S OPTION): S Option models have the ability to be connected in series or parallel with identical BOP models for increased voltage or current, respectively. Multiple units can be connected in a master/slave configuration to provide a single integrated output where control of the master controls the series/parallel system. Universal cable kits can be used for connecting both series and parallel configurations; the only differences between kits are the number of cables included, corresponding to the number of BOP units to be configured.

1.2.7 RELAY - CROWBAR (R OPTION): R Option consists of an internal normally-closed relay or contactor that is in parallel with the BOP output. The relay is open during normal operation, and closes upon a) input power loss, b) internal fault, or c) external shutdown. This option is useful when driving inductive loads by shorting the BOP output, allowing the load's stored energy to

dissipate when one of the conditions mentioned above occurs.. This option is only available when L Option is installed.

1.2.8 DC CURRENT TRANSFORMER (DCCT) (Z OPTION): Z Option models use a DCCT current transformer as an output current transducer. The use of output current feedback and monitoring of the DCCT device permits higher performance accuracy and stability when the unit is operated in current mode when compared to the resistive shunt included in models without the Z Option.

1.3 GENERAL DESCRIPTION.

Kepco Series BOP H Bipolar Power Supplies are linear stabilizers for laboratory and systems applications, able to operate in all four voltage-current quadrants, and able to pass smoothly through the zero point. The BOP is an all solid-state design, featuring IC operational amplifiers in the control circuit section and silicon power transistors mounted on fan-cooled heat sinks in the complementary power stage.

The BOP has two bipolar control channels (voltage or current mode), selectable and individually controllable either a) from the front panel controls and a remote signal applied to the INPUT connector on the front panel if D Option is installed, or b) by remote signals applied to the Analog Port at the rear panel. The BOP output is protected by bipolar limit circuits. The positive and negative current or voltage limit points can be manually set or remotely programmed simultaneously or individually. The BOP features automatic crossover with a rectangular characteristic between each principal control channel and its associated limit channels.

All control and limit channels are connected to the complementary output stage via an EXCLUSIVE OR gate, so that only one channel, main or limit, is in control of the BOP output at any one time. The BOP output can be programmed over its full output range in both voltage mode and current mode by an external ±10 volt signal. This signal can be applied to either a) the front panel INPUT connector (if D option is installed) or b) the rear panel Analog Port. The limit control loops/channels can be controlled locally through the rear panel trimpots and through analog remote signals applied to the rear panel Analog Port.. The lower value (either local or remote) will be active.

If a digital remote card is installed (G or E Option models), and the BOP output is being controlled digitally, it can only control the main channel and its complementary limit channel, with identical values for positive and negative limits. The lower limit value between the remote Analog Port, rear panel trimpots, and the digital setting will be active. The output value programmed digitally for the main channel (voltage in voltage mode, current in current mode) will be summed with either a) the programming signal from the Analog Port or b) the programming signal from the front panel INPUT jack and/or the internal DC Bias if D Option installed.

1.4 ELECTRICAL SPECIFICATIONS, GENERAL

See Table 1-2 for general specifications

TABLE 1-2. GENERAL SPECIFICATIONS

SPECIFICATION		RATING/DESCRIPTION	CONDITION/COMMENT
Input Voltage (Nominal)		115/ 230Vrms	Range: ±9% Rear panel selection
Input Brown-out Voltage		104Vrms	@ 115V/60Hz, Sourcing nominal output power
Input Frequency (Nominal)		50/ 60Hz	Range:± 3Hz
Input Current		9.1Arms	@ 115V/60Hz, Sourcing nominal output power
Input Power (Active)		870W	@ 115V/60Hz, Sourcing nominal output power
Power Factor		0.8	@ 115V/60Hz, Sourcing nominal output power
Efficiency		45%	@ 115V/60Hz, Sourcing nominal output power
Input Leakage Current		50uArms	@ 115V/ 60Hz, Sourcing nominal output power
Insulation Coordination		• Installation Cat. 2 • Over-voltage Cat. 2 • Pollution Degree 2	Maximum 420V DC or Peak between each output terminal and chassis-ground.
Type Of Stabilizer		Voltage-Current, 4-quadrant	
Topology		Linear, Half Bridge	Class AB
Output Voltage	Voltage Mode	0 to $\pm E_O$nom V (DC or peak)	See Table 1-3 for $E_O$nom values.
	Current Mode	0 to ± (1.04)($E_O$nom) V (DC or peak)	
Output Current	Voltage Mode	0 to ± (1.04)($I_O$nom) A (DC or peak)	See Table 1-3 for $I_O$nom values.
	Current Mode	0 to ± $I_O$nom A (DC or peak)	
Output Power (Nominal)	Source Mode	400 Watts (DC or peak)	See Table 1-3 for DC for source mode power values.
	Sink Mode	200 Watts (DC or peak)	Dissipative sink of 400W for short term operation. Limited automatically to 200W after a critical heatsink temp. is reached. See Table 1-3 for DC for sink mode power values.

TABLE 1-2. GENERAL SPECIFICATIONS (CONTINUED)

SPECIFICATION		RATING/DESCRIPTION	CONDITION/COMMENT
Voltage, Analog Programming (Voltage mode)	Gain/DC Transfer Factor	$+E_O$nom/10V/V or $-E_O$nom/10V/V, using a rear panel micro-switch	Default values, for 10V programming signal: Change the gain/transfer factor by attaching resistors at the rear panel Control/Access terminal block using a screwdriver for a range of 0.1 to 10 (with 1.0 the default value) times nominal preamp transfer factor value. See Table 2-3, items 5 through 8 for details. Default Gain is +2A/V or -2A/V for BOP 20-20HD
	Accuracy	0.05% of rated output	
	DC Bias	$(-1.005)E_O$nom to $(+1.005)E_O$nom	D Option only.
Voltage Static Specifications (Voltage mode)	Source effect	0.001% of rated output	Input voltage = nominal ±9%
	Load effect	0.002% of rated output	No load to (1.05 x $E_O$max)/$I_O$max
	Time effect (8h)	0.002% of rated output	After 30 minutes of conditioning
	Temp. coefficient	0.001% of rated output/ °C	Averaged for the operating temperature range.
	Ripple & noise (rms)	0.002% of rated output	
Current, Analog Programming (Current mode)	Gain/DC Transfer Factor	$+I_O$nom/10A/V or $-I_O$nom/10A/V, using a rear panel micro-switch	Default values, for 10V programming signal. Change the gain/transfer factor by attaching resistors on the rear euro-block using a screwdriver for a range of 0.1 to 10 (with 1.0 the default value) times nominal preamp transfer factor value. See Table 2-3, items 5 through 8 for details.+2A/V or -2A/V for BOP 20-20HD
	Accuracy	0.05% of rated output	
	DC Bias	$(-1.005)I_O$nom to $(+1.005)I_O$nom	D Option only.
Current Static Specifications (Current mode)	Source effect	0.001% of rated output	
	Load effect	0.002% of rated output	
	Time effect (8h)	0.005% of rated output	
	Temp. coefficient	0.002% of rated output/ °C	
	Ripple & noise (rms)	0.008% of rated output	

TABLE 1-2. GENERAL SPECIFICATIONS (CONTINUED)

SPECIFICATION	RATING/DESCRIPTION	CONDITION/COMMENT
Analog Programming Input		
Type	Differential	The output can be controlled by the sum of analog and digital controls. See Tables 2-1 and 2-6 for details.
Max Voltage	±10V (differential), ±15V to signal ground/ COM S	
Impedance	50k Ohms (differential), 500k Ohms (to signal ground/COM S	
Location	Twinax BNC on front panel for D Option (Display) or use the Analog Port (rear panel 15pin D-type connector)	
Output ON-OFF (Enable-Disable) Control	Rear panel isolated on/off controlling signal	A rear microswitch establishes which control is active: front- for D Option (Display) only or rear. The DIGITAL ON (G) REM ON-OFF (Y) front panel light shows which control is active. See Tables 2-1, 2-2 and 2-4 for details.
D Option (Display)	In addition to basic unit control, the unit has two switches for DC bias on/off and overall output on/off	
G or E Options (Digital remote control)	On/off using a remote digital command; if digital interface is in control, local and analog control is disabled.	
Voltage Mode/Current Mode Controls	• Using rear panel microswitch. • Using a rear panel remote isolated signal. • Using a digital command (for an optional digital card installed and active). If in control, the digital interface disables the local or analog control.	A rear micro-switch establishes whether local or analog- remote control is enabled. The front panel VOLTAGE (G) CURRENT (Y) indicator lights green or yellow to show the actual mode of operation. See Tables 2-1, 2-2 and 2-4 for details.
Digital Programming	Optional Digital card Installed inside the unit. G Option for either GPIB or RS 232 control, or E Option for either LAN, RS 232 or USB control.	Able to control the mode of operation, output on-off status, the output voltage and current and to monitor DC output voltage and current.
Calibration	Trimpots for analog control (see Section 4 for details.). Digital calibration for G or E option.	
Voltage - Dynamic Specs (Voltage Mode)		
3-dB Bandwidth	50kHz	Sine with full scale input amplitude, Nominal Resistive Load
Rise-fall time (10-90%)	7µs	±full scale input, Nominal Resistive Load
Slew rate (max)	4.5V/µs	±full scale input, Nominal Resistive Load
Current Dynamic Specs (Current mode)		
3-dB Bandwidth	38kHz	Sine with full scale input amplitude, Short-circuit
Rise-fall time (10-90%)	9µs	±full scale input, Short-circuit
Slew rate (max)	3.5A/µs	±full scale input, Short-circuit

TABLE 1-2. GENERAL SPECIFICATIONS (CONTINUED)

SPECIFICATION	RATING/DESCRIPTION	CONDITION/COMMENT
Special Dynamic Configurations		
Preamplifier bandwidth reduction	16kHz bandwidth, using rear panel switch, mode independent (see Table 2-2 for details).	To reduce total unit's bandwidth in voltage mode or current mode, attach external capacitor to corresponding terminals of Control/Access terminal block (see Table 2-3) using a screwdriver.
Main loop bandwidth reduction	Possible for both voltage and current by adding compensation at rear euro-block.	
L, C, LC Options	Rear panel microswitches able to set or disable L, C and L/C Options. With L/C enabled, rear panel microswitch allows selection of either L or C Option.	The unit can be populated for any option combinations (see Table 1-1).
Voltage/Current Limits (Pos & Neg)		
Local/ rear panel adjustment. range	0.2% to 104% of rated output	Lowest of local and remote analog and digital limit value is active. Ten turns trimpot control for each limit $+E_O$lim, $-E_O$lim, $+I_O$lim, $-I_O$lim; Full scale tolerance: 1%
Analog-remote adjustment range	2% to 100.2% of rated output	For 0V to +10V controlling voltage, Accuracy: 0.1% for voltage and 0.2% for current
Digital-remote adjustment range	0.2% to 100.1% of rated output	Accuracy: 0.05% for voltage and 0.1% for current
Analog Readback For Voltage and Current		For 0 to ±Nominal output voltage and current.
Range	0 to ±10V	
Accuracy	0.1% of Full Scale	
Max current	4mA	Available at the Analog Port (see Table 2-6 for details.

TABLE 1-2. GENERAL SPECIFICATIONS (CONTINUED)

SPECIFICATION		RATING/DESCRIPTION	CONDITION/COMMENT
Reference Voltages	Value	+10V, -10V	The reference voltages are available for external usage (for limits for example) at the rear Analog Port (see Table 2-6 for details)
	Tolerance	±5mV	
	Load Current	4mA max.	
	Source Effect	0.0005%	
	Load Effect	0.0005%	
	Time Effect	0.005%	
	Temperature Coefficient	0.005%/°c	
Kelvin Connection (remote error sensing)		Possible, with max 0.25V/ wire	Sensing terminal are available at rear Terminal Block (see Table 2-3 for details)
Local Output Monitoring	Type	D Option (Display) only: Digital Panel Meters for output voltage and current.	Digital Panel Meter w. pos-green backlight. Able to display DC and signals with less than 0.1Hz frequency.
	Accuracy	Digital Panel Meter: ± (0.2% of rating + 1-count) typical	
Front Panel Lights (See Figure 2-1 and Table 2-1 for details)		POWER (G), FAULT (R) or LIMIT (O)	Lit green when power on. Lit red when fault. Lit orange when in current or voltage limit mode.
		V MODE (G) or C MODE (Y)	Lit green when in Voltage Mode. Lit yellow when in Current Mode
		OUTPUT ON	Lit green when output is ON (enabled) and it is not lit when the output is OFF (disabled)
		MASTER (G) or SLAVE (Y)	Lit green for master. Lit yellow for slave
		DIG ON (G) or REM ON-OFF (Y)	Lit green when digital interface is active. Lit yellow when output on-off is via remote signal applied to rear panel EXTL CTRL Port.
Flag Signals		On-off	Isolated signals (see Table 2-5 for details).
		Fault	
		Voltage-Current Mode	
		Limit	
Front panel controls and inputs (see Figure 2-1 for details)	All options	Input Circuit Breaker	Dual pole, magnetic circuit breaker with current trip coil for input overcurrent
	D Option installed	• Digital output voltage (VOLTS) and current (AMPS) LCD meters • DC bias-on switch • DC bias adj. pot with mechanical read-out • Output on-off switch • Input Twinax BNC jack	

TABLE 1-2. GENERAL SPECIFICATIONS (CONTINUED)

SPECIFICATION		RATING/DESCRIPTION	CONDITION/COMMENT
Rear panel controls and inputs	All Options	• AC inlet • AC selector • Output power terminals/busbars • Euro-block with: monitoring, sensing, grounding network, grounding, reducing bandwidth, changing gain/DC transfer factor terminals • Analog I/O port (analog remote input for main channel and 4-limits, output voltage and current monitoring signals, ±10V references • (4) Limit trimpots • Fault reset push-button • Setting microswitches (voltage-current mode, remote-local for mode control, front-rear for on/off, invert-noninvert configuration, regular-reduced (low) preamplifier bandwidth, yes-no for CB tripping at power loss, yes-no for CB tripping at failure • External control port, w. isolated signals (on-off, shut-down, reset, voltage-current mode, inter-lock shut-down if internally set to enable) • External flag port, w. isolated signals (on-off, fault, voltage-current mode, limit)	See Figure 2-2 and Table 2-2 for details.
	L, C, LC Options	Two switches allow selection of • L option installed: Reg (standard) or L • C option installed: Reg (standard) or C • LC option installed: Reg (standard) or L or C	See Figure 2-2 and Table 2-2 for details.
	S Option (Master-Slave)	• Control and Protection port IN • Control and Protection port OUT • Master-slave setting micro-switches (alone-multiple, series-parallel, master-slave) • Slave address microswitches	See Figure 2-2 and Table 2-2 for details.
	G Option	• GPIB port • RS232 port • BitBus port • Trigger port	See Figure 2-2 and Table 2-2 for details.
	E Option	• LAN port • USB port • BitBus port • Trigger port • LAN reset switch • LAN indicators	See Figure 2-2 and Table 2-2 for details.

TABLE 1-2. GENERAL SPECIFICATIONS (CONTINUED)

SPECIFICATION		RATING/DESCRIPTION	CONDITION/COMMENT
Series or Parallel configurations (of identical units)	Type of connection	Master-Slave	
	Implementation	The cable KIT is universal, independent of model or series/parallel configuration, without any changes to the units. The cable KIT is number-of-units dependent.	Each unit, master and all slaves, must have the S-option installed (factory pre-calibrated)
	Max units in series	Max 3 units	
	Max units in parallel	Max 5 units	
Protections		(a) Input over-current (b) Wrong AC input (230V for 115V setting) (c) Heat sink overtemperature (d) Heat sink cooling air overtemperature (e) Fan not running (f) Output sensing error (g) Interlock (h) Multiple units interlock (i) Input power loss (j) Output crowbar contactor (optional)	• (a), (b) trips input circuit breaker. • (c) through (h) faults the unit. A rear panel switch can be set up to either trip or not trip (default) the input circuit breaker. A fault sets the output to OFF, set the limits to zero and activates a temporary output crowbar (for standard and L option only). • (c to f) are indicated by corresponding LEDs on rear panel • (i) A rear panel switch can be set to either trip or not trip the input circuit breaker upon input power loss. The default position is to trip at power loss. • (j) Protects the load and the BOP against an inductive load's overvoltage generated upon BOP power loss or failure.
Temperature	Operating	0 to +50° C	Full power to 40°C, Derate output power 10W per °C above 40°C.
	Storage	-20 to +85° C	
Humidity		0 to 95% RH	
Shock		20g/11ms/50% half sine	Non-operating
Vibration	5-10Hz	10mm, double amplitude	Non-operating
	10-55Hz	2g	
Altitude		Sea level to 10,000ft	For operating temperature range
Cooling	Type	2-DC Fans	Zero clearance between stacked units.
	Air Flow	Front to rear	
	Air Intake	front and sides	
Dimensions		5.25” H x 19” W x 18.75” D (133.4mm H x 482.6.3mm W x 476.25mm D)	
Weight	BOP 100W, 200W **(6)**	60 lbs (27.2 kg)	Unpacked

TABLE 1-2. GENERAL SPECIFICATIONS (CONTINUED)

SPECIFICATION		RATING/DESCRIPTION	CONDITION/COMMENT
Connections	Source power	3-pin IEC connector	
	Load connections, Grounding, GND network	Rear: nickel plated copper busbars; GND and GND NET on the above euro-block terminals	
	Analog control	14-pin euro-block terminals 15-pin D type female connector, Analog I/O port 8-pin phone jack, External control port 6-pin phone jack, External flag port	
		Twinax BNC jack, Input	D Option (Display)
	S Option (Master-Slave)	15-pin D type female connector: Master-Slave control and protect IN 15-pin D type female connector: Master-Slave control and protect OUT	
	G and E Option (Digital Control)	GPIB and RS232 for G option LAN/ Ethernet and USB for E option	

TABLE 1-3. OUTPUT RANGES, TRANSFER FACTOR AND OUTPUT IMPEDANCE

MODEL (1)	DC OR PEAK OUTPUT RANGES		DC OR PEAK OUTPUT POWER		d-c CLOSED LOOP GAIN		OUTPUT RESISTANCE	
	OUTPUT VOLTAGE E_O	OUTPUT CURRENT I_O	SOURCE	SINK	VOLTAGE MODE	CURRENT MODE	VOLTAGE MODE	CURRENT MODE
	V	A	W	W	G_V (V/V)	G_I (A/V)	SERIES R mΩ	SHUNT R kΩ
BOP 5-80H	0 to ±5	0 to ±80	400	200	0.5	8.0	0.002	3.0
BOP 10-40H	0 to ±10	0 to ±40	400	200	1.0	4.0	0.005	13
BOP 20-20H	0 to ±20	0 to ±20	400	200	2.0	2.0	0.02	50
BOP 36-12H	0 to ±36	0 to ±12	432	216	3.6	1.2	0.06	150
BOP 50-8H	0 to ±50	0 to ±8	400	200	5.0	0.8	0.12	300
BOP 72-6H	0 to ±72	0 to ±6	432	216	7.2	0.6	0.24	600
BOP 100-4H	0 to ±100	0 to ±4	400	200	10.0	0.4	0.5	1300

1.5 MISCELLANEOUS FEATURES

1.5.1 OUTPUT RANGE

The BOP can be locally (front panel) adjusted, or remotely programmed, from (–)100% to (+)100% of its rated d-c or a-c peak voltage and current range. The Class AB bipolar output stage permits operation as either a *source* or a *sink*. (See Figure 1-2). Note that the BOP can not operate as a sink (quadrants II and IV, Figure 1-2) for long periods of time at full sink power, because the unit has a dissipative sink. Therefore, either the duty cycle must be reduced as shown in Figure 1-2, or the sink power will be reduced automatically at 50% (with limits to 50%) if the heatsink temperature reaches a critical value while the unit is at full sink power.

NOTE: The BOP is operating as a *source* if the direction of its output voltage is the same as the direction of its output current. The BOP is operating as a *sink* if the direction of its output voltage is opposite that of its output current. An illustrative case is shown in Figure. 1-3, where the BOP is programmed to deliver a sine wave output and where the load produces a phase shift between the output voltage and current.

1.5.2 PROGRAMMING FEATURES

The BOP main channel (either voltage or current) can be programmed by an analog voltage. either through the rear panel Analog Port, or for D Option (Display option) models, through the INPUT connector on the front panel. Main channel programming can also be done digitally. G Option models allow programming via either a GPIB interface or RS 232 interface. E Option models allow programming either via a LAN/Ethernet interface using a web browser, via an RS 232 interface or via a USB interface. See Figures 2-1 and 2-2 and Tables 2-1, 2-2 and 2-4 for details.

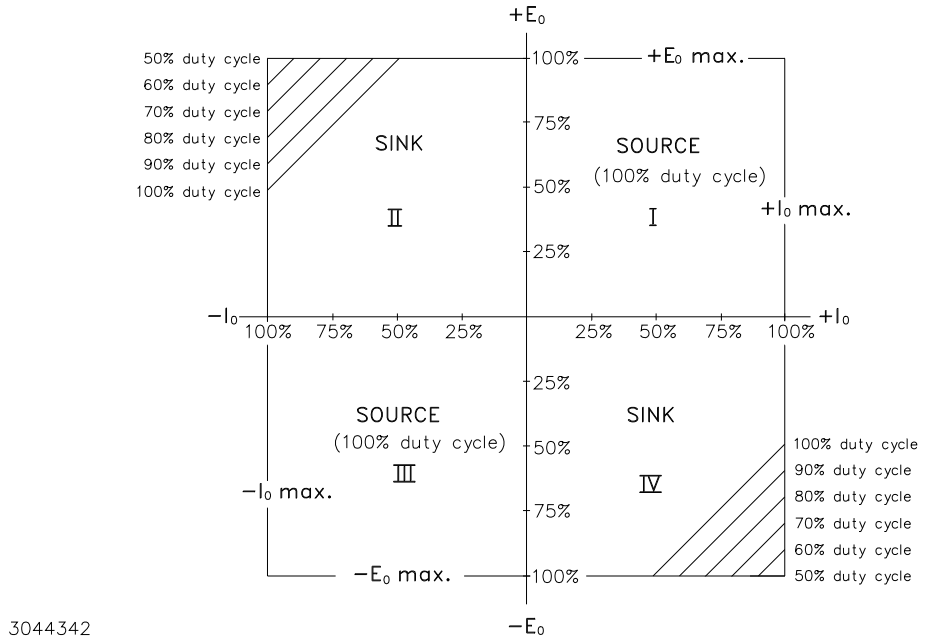


FIGURE 1-2. BOP OUTPUT CHARACTERISTIC

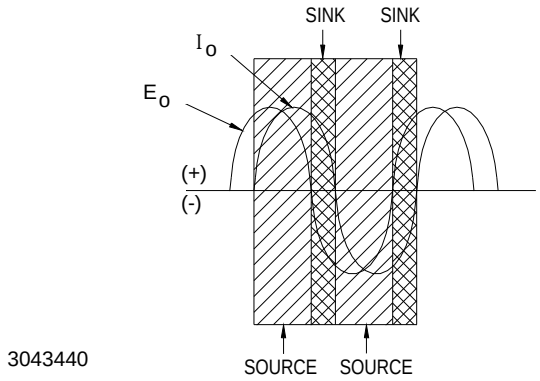


FIGURE 1-3. BOP OUTPUT WAVEFORMS WITH PHASE SHIFT

1.5.3 ON-OFF FEATURE

If the unit does not have a D-option, or if the D-option is installed, but the rear panel FP-RP switch is set to RP position, then the output can be turned ON or OFF by applying a signal at EXT CTRL Port pin 2 referenced to pin 8 (see Tables 2-2 and 2-4 for details). The front panel DIG ON (G) - REM ON-OFF (Y) indicator will light yellow to indicate remote output on-off control. Also, the front panel OUTPUT ON indicator will light green for output ON, with no light for output OFF.

If the D-option is installed and the rear panel FP - RP switch is set to FP (default) position, then the output can be turned ON or OFF by sequentially pressing the front panel OUTPUT ON switch (see Figure 2-1 and Table 2-1 for details). If a digital option (either E-option or G-option) is installed and active, the output ON-OFF control is determined exclusively by the digital command. At Flag Port pin 1 referenced to pin 6, an isolated ON-OFF signal flag is available (see Table 2-5 for details).

1.5.4 LOAD REACTANCE

1.5.4.1 DRIVING AN INDUCTIVE LOAD IN CURRENT MODE

BOP power supplies with L Option are optimized for driving large inductor loads (up to 1H values have been tested), however higher values are possible.

For units without L Option, when driving inductive loads higher than 0.2mH, the system may become unstable. There are two means of eliminating oscillation in the current loop operating with moderate inductive loads and moderate voltage and current:

1. Add capacitance in parallel with the output (inductive load). The value of capacitor can be from 0.1 μF to 1.0 μF depending on the value of the load inductance.

2. Add a series-connected resistor-capacitor network in parallel with the BOP output/inductive load. The value of resistor should be in the range of 100 to 500 Ohms and the value of capacitor should be 0.1 μF to 0.5 μF, depending on the load inductance value.

Both 1 and 2 above are recommended when the BOP is used with a very low frequency output into inductive loads.

CAUTION: When driving heavy inductive loads with high currents, it is possible for the BOP and the load to be damaged by a) an A-C input power loss, b) BOP failure or c) external shutdown which prevents the load's stored energy from being dissipated inside the BOP. To avoid possible damage from the inductance kick-back voltage observe the following:

- **Use BOP with R Option installed.**
- **Set BOP output current and/or voltage to zero and turn off the BOP after the output current actually reaches a zero value.**
- **Use properly rated (voltage and current) bipolar transorbs or a properly rated bipolar crowbar element connected directly at the output of the BOP. These solutions may also be combined.**

For units both with and without L option, if the system becomes unstable at the crossover between voltage mode and current limit mode when driving an inductive load in current mode, the power supply can be further optimized by reducing the current loop bandwidth. This can be accomplished by connecting a ceramic capacitor rated for 50V across ICOR_A and ICOR_B terminals of the Control/Access Terminal Block on the rear panel (see Figure 2-3 and Table 2-3). The value of the capacitor is correlated to the load's inductance. A value in the range of 0.001μF to 1μF is recommended.

1.5.4.2 DRIVING A CAPACITIVE LOAD IN VOLTAGE MODE

BOP power supplies with C Option are optimized for driving large capacitive loads (e.g., solar panels and solar cells) Values up to 10mF have been tested, however higher values are possible.

Units without C Option can become unstable when driving a capacitive load higher than 0.5μF in voltage mode. Install an external ceramic capacitor rated for 50V across pins VCOR_A and VCOR_B of the Control/Access Terminal Block on the rear panel (see Figure 2-3 and Table 2-3).This capacitor will reduce the voltage loop bandwidth. The value of the capacitor is correlated to the load's capacitance. A value in the range of 0.001μF to 1μF is recommended. This method can also be used for C Option models if the system becomes unstable at the crossover between voltage mode and current mode.

1.5.5 REMOTE TURN-OFF

Remote turn-off of the BOP, equivalent to tripping the front panel ON-OFF circuit breaker to OFF, can be accomplished by applying an isolated 15V CMOS signal at EXT CTRL Port pin 3 (active low) referenced to pin 8, or by applying a N.O. relay contact between pin 3 and pin 8 (see Table 2-4 for details). The above will be effective after the rear panel YES - NO (CB@FAIL switch is set from NO (default) position to YES (See Table 2-2 for details).

1.5.6 CIRCUIT BREAKER SHUTDOWN PREVENTION

Tripping of the front panel ON-OFF circuit breaker can be prevented when either input power is lost or the unit faults. However, because some faulting-errors are generated during a power off event, for the circuit breaker not to trip at power loss the rear panel YES - NO (CB@FAIL) switch has to be set to (or remain in) the default NO position.

Setting the NO - YES (CB@P.LOSS) switch on the rear panel to NO prevents the front panel ON - OFF circuit breaker from tripping when input power loss is detected (see Table 2-2, item 38 for details).

Setting the YES - NO (CB@FAIL) switch on the rear panel to NO prevents the front panel ON - OFF circuit breaker from tripping when a fault is detected (see Table 2-2, item 39 for details).

1.5.7 REFERENCES

Two reference/bias sources (±10V) are provided for control and biasing purposes. These reference sources are available at the Analog Port, pins 1 (-10V) and 8 (+10V) both referenced to pin 9 (return) (see Table 1-2 for specifications and Table 2-6 for details).

An unregulated +24V supply voltage through a 3.9kOhm current limiting resistor is available for external controls at EXT CTRL Port pin 1, referenced to pin 8. The 24V supply is isolated versus the unit's output and its return is connected to the unit's chassis-ground.

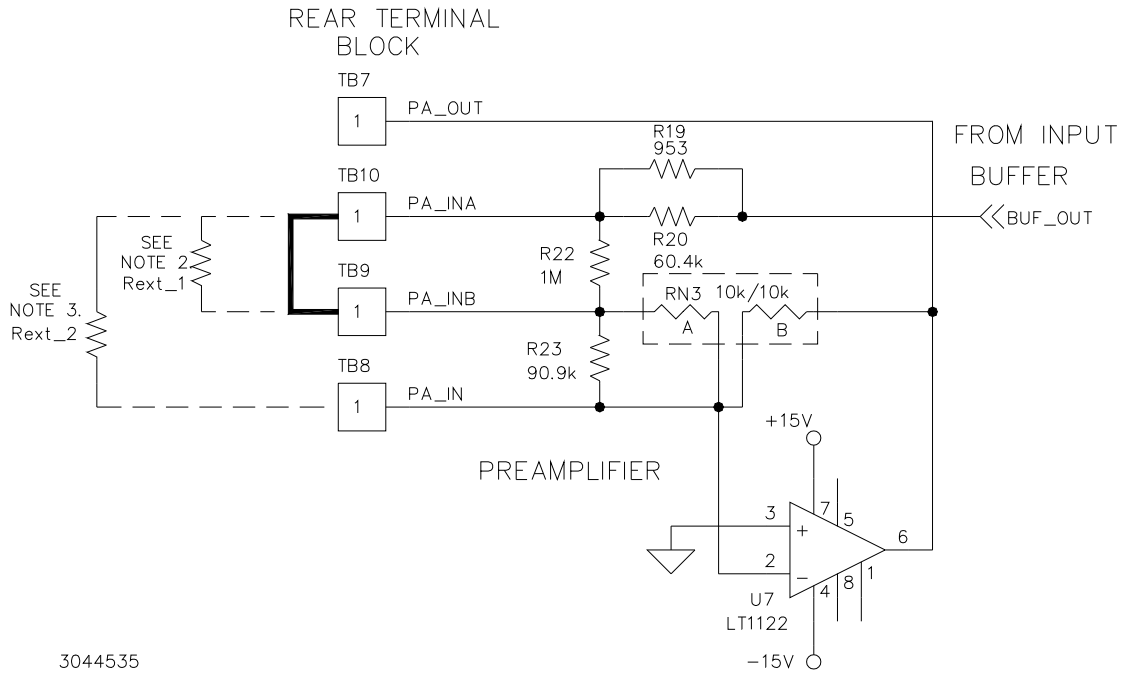
1.5.8 SERIES OR PARALLEL OPERATION

Series or parallel operation requires Option S; see PAR. 5.3 for setup. Refer to PAR. 5.4.5 for operation of series configurations and to PAR. 5.3.5 for operation of parallel configurations.

1.5.9 VOLTAGE CONTROL CHANNEL

The Bipolar Voltage Amplifier, with a fixed gain (See Table 1-2 for gain/DC transfer factor value) allows the BOP output voltage to be controlled, for the default setting of the Pre-amplifier amplification factor, by means of an external ±10 volts source, from (–) 100% (through zero) to (+) 100% of the rated value. Refer to PAR. 3.3.8 for details.

See Figure 2-1 and Table 2-1 for front panel control details (D option only). See Figure 2-2 and Tables 2-2 and Table 2-6 for rear panel control details (all options). See Table 2-3 and Figure 1-4 for details about changing the Preamplifier's gain/amplification factor, and the BOP unit's gain/transfer factor, respectively. The Preamplifier is common to both the voltage channel and current channel; if its gain is changed, it will affect both voltage mode and current mode transfer factors.



NOTES:

1. Jumper wire between TB9 and TB10 (default, shown):
   G_{PREAMP} = 1.005 ±0.02%.
2. If R_{ext_1} replaces jumper wire between TB9 and TB10:
   $G_{PREAMP} = ((10)(R_{ext\_1}) + (10000))/((1009.947)(R_{ext\_1}) + 9947))$
   For R_{ext_1} = 99k Ohms, G_{PREAMP} = 0.1 (minimum allowed)
3. With jumper wire between TB9 and TB10: removed and R_{ext_2} connected between TB8 and TB10 (as shown)
   $G_{PREAMP} = ((10)(R_{ext\_2}) + (10090.09))/((1009.947)(R_{ext\_2}) + 946.45))$
   For R_{ext_2} = 62 Ohms, G_{PREAMP} = 10 (maximum allowed)

FIGURE 1-4. HOW TO CHANGE PREAMPLIFIER GAIN

1.5.10 EXTERNAL VOLTAGE MONITOR

Voltage Monitoring signal VMON at pin 15, referenced to pin 10, of the Analog Port (12, Figure 2-2) is available for external voltage monitoring (see Table 1-2 for specifications and Table 2-6 for details).

1.5.11 EXTERNAL CURRENT MONITOR

Current Monitoring signal CMON at pin 3, referenced to pin 10, of the Analog Port (12, Figure 2-2) is available for external current monitoring (see Table 1-2 for specifications and Table 2-6 for details).

1.5.12 MODE CONTROL

The BOP is equipped with a rear panel-mounted VM - CM switch, active if the LOC - REM switch is set to LOC (local, default) position, which selects bipolar voltage or bipolar current mode operation. See Table 2-2, item 26 for details.

With the rear LOC - REM switch set to REM (remote) position, the mode of operation can be set by a remote signal applied to EXT CTRL Port pin 5 referenced to pin 8 (see Figure 2-2, Table 2-2 and Table 2-4 for details).

If a digital option (E option or G option) is installed and active, the mode of operation is determined exclusively by the digital command. The mode of operation is indicated by the VOLTAGE (G)/CURRENT (Y) front panel indicator (see Figure 2-1 and Table 2-1 for details). An isolated VM-CM signal flag is available at Flag Port pin 3 referenced to pin 6 (see Table 2-5 for details).

1.5.13 CURRENT CONTROL CHANNEL

The Bipolar Current Amplifier, with a fixed gain (See Table 1-2 for gain/DC transfer factor value) allows the BOP output current to be controlled, for the default setting of the Preamplifier amplification factor, by means of an external ±10 volts source, from (–) 100% (through zero) to (+) 100% of the rated value. Refer to PAR. 3.3.9 for details.

See Figure 2-1 and Table 2-1 for front panel control details (D option only). See Figure 2-2 and Tables 2-2 and 2-6 for rear panel control details (all options). See Table 2-3 and Figure 1-4 for details about changing the Preamplifier's gain/amplification factor and the BOP unit's gain/transfer factor, respectively. The Pre-amplifier is common to both voltage channel and current channel; if its gain is changed, it will affect both voltage mode and current mode transfer factors.

1.5.14 BOUNDING

The BOP has four output voltage/current limiting circuits –VLIM, +VLIM, – ILIM and +ILIM for overvoltage/overcurrent protection in either operating mode (refer to All limiting circuits can be screwdriver adjusted by means of rear panel trimpots (see Table 2-2, items 31 through 34). In addition, all four limits can be remotely controlled by means of 0 to 10 volt d-c control voltages applied via the Analog Port, pins 5, 6, 13 and 14 (see Table 2-6. The four limits may be remotely programmed independently, or the (±) voltage and (±) current limits can be controlled in pairs. The lower limit control value, between the rear panel setting and the remote control signal, will be active.

The four boundary quantities, (±) E_o max. Limit and (±) I_o max. Limit as applied to the Limit Channel, are actually about 10% greater than the rated values E_o max. and I_o max. for each BOP model. See Table 1-2 for minimum limit values. To avoid uncertainty related to zero reference for multiple output control loops the minimum limit values are not zero. See Figure 1-5 for a graphic representation of boundaries and limits.

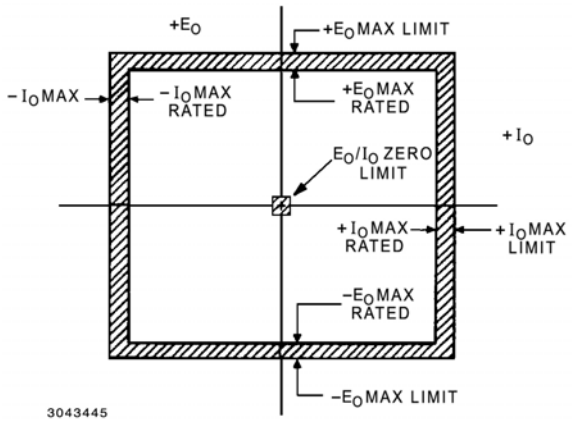


FIGURE 1-5. BOUNDARIES AND LIMITS

1.5.15 FRONT PANEL STATUS INDICATIONS

Refer to Figure 2-1 for the location of front panel terminations and controls and Table 2-1 for function details.

1.5.15.1 POWER (G)/FAULT (R)/LIMIT (O) INDICATOR

The indicator lights green when the unit is operating properly and lights orange if the unit is in voltage or current limit mode. If the unit faults and if the faulting is not set to trip the input circuit breaker, the indicator lights red.

1.5.15.2 OUTPUT ON INDICATOR

Independent of the controlling mode (local, remote analog or remote digital), the indicator lights green if the output is ON and goes out if output is OFF.

1.5.15.3 MASTER (G)/SLAVE (Y) INDICATOR

If the unit is set as Standalone or a Master for a series or parallel configuration, the indicator lights green. The indicator lights yellow for a unit set as Slave.

1.5.15.4 DIG ON/REM ON-OFF INDICATOR

If the unit is under digital control (including output on-off control), the indicator lights green. The indicator lights yellow (if digital control is either not installed or not active) when the output on-off is set to be controlled by a rear analog remote control. The indicator goes out if digital control is either not installed or not active, and the unit is controlled by the D-option (front panel control).

1.5.16 REAR PANEL STATUS INDICATIONS

Four red lights show the following fault causes if the faults are not set to trip the input circuit breaker:

- OT- heatsink cooling air over-temperature, corrected for the ambient;
- HSOT- heatsink absolute over-temperature;
- FAN- for fan failure;
- SENSE- for remote sensing error.

Four flag signals, 15V CMOS compatible, are available at the EXT FLAG Port (see Table 2-5):

- ON FLAG- indicates whether the output is ON or OFF.
- /FAULT FLAG- indicates whether the unit is faulted or not.
- VM-/CM FLAG- indicates the mode of operation, voltage or current.
- LIMIT FLAG - whether the unit is operating in voltage limit or current limit mode.

1.5.17 STANDARDS

BOP models are designed and tested in accordance with NEMA Standard for Stabilized Power Supplies, d-c output, Publication No. PY-1.1972.

1.6 MECHANICAL SPECIFICATIONS

See Mechanical Outline Drawing, Figure 1-6.

1.7 EQUIPMENT SUPPLIED

Equipment supplied is listed in Table 1-4.

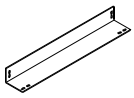
TABLE 1-4. EQUIPMENT SUPPLIED

ITEM	PART NUMBER	QUANTITY
Source Power Entry mating connector.	142-0381 (Kepco) (IEC 320)	1
Front panel INPUT mating connector	142-0599 (Kepco)	1
Rear Panel EXT CTRL Port mating connector	142-0535 (Kepco	1
Rear Panel EXT FLAG Port mating connector	142-0536 (Kepco	1

1.8 ACCESSORIES

Accessories (not supplied) are listed in Table 1-5.

TABLE 1-5. ACCESSORIES - NOT SUPPLIED

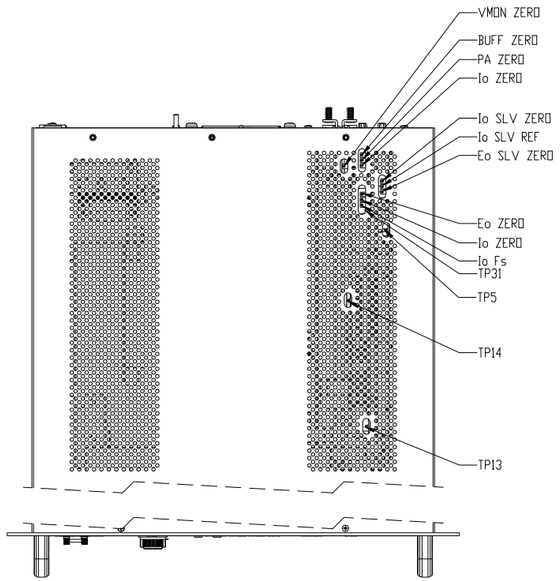
ITEM	FUNCTION	KEPCO PART NUMBER
Power Cord	Provides connection to 230V a-c mains via N6-20 plug,	118-1235
Mating Connector, Trigger	Mates with Trigger port.	142-0527 (Kepco) SP2501 (CUI Stack)
IEEE 1118 (BITBUS) Mating connector	Allows connection to IEEE 1118 (BITBUS) port.	142-0485 (Kepco) KMDLA-5P (Kycon Inc.)
IEEE 488 Cable, (1 meter long)	Connects BOP power supply to GPIB bus.	SNC 488-1
IEEE 488 Cable, (2 meter long)	Connects BOP power supply to GPIB bus.	SNC 488-2
IEEE 488 Cable, (4 meter longs)	Connects BOP power supply to GPIB bus.	SNC 488-4
RS 232 Cable Kit	Contains RJ11 to RJ45 Patch cord, RJ 45 Patch cord, two RS 232 adapters, one with male pins to connect to DTE equipment and one with female pins to connect to a PC (personal computer), two RS 232 Loop Back test Connectors (one 6-pin and one 8-pin) to test RS 232 communication and aid in isolating RS 232 communication problems.	KIT 219-0436
RS 232 Adapter (Male pins)	Allows RS 232 port to be connected to DTE equipment. (Supplied in KIT 219-0436.)	142-0487 (L-COM RA098M)
RS 232 Adapter (Female pins)	Allows RS 232 port to be connected to a PC (personal computer). (Supplied in KIT 219-0436.)	142-0506 (L-COM RA098F)
Master/Slave Cable Kit	When S Option is installed inside each master/slave unit, these cables allow identical BOP power supplies' signal and power interconnections to be configured for master-slave series or parallel operation.	See Note.
15-pin DSUB Connector	Mating connector for Analog Port Dsub 15 pin hood Dsub 15 pin male	 108-0374 (Tyco-Amp 207470-1) 142-0449(Amphenol 17S-DA15P)
Side Support “L” Bracket	L bracket mounts to vertical rails to provide additional support for rack-mounted models. 19.6 in. long x 2.3 in. high x 3.5 in. wide. Two (2) required per unit. 	128-1775
NOTE: The Master Slave Cable Kit is part of the S Option. Its structure depends on the number of units connected in series or in parallel.		

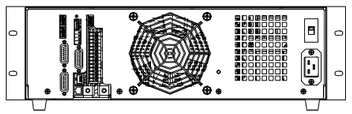
1.9 SAFETY

Service must be referred to authorized personnel. Using the power supply in a manner not specified by Kepco. Inc. may impair the protection provided by the power supply. Observe all safety precautions noted throughout this manual. Table 1-6 lists symbols used on the power supply or in this manual where applicable.

TABLE 1-6. SAFETY SYMBOLS

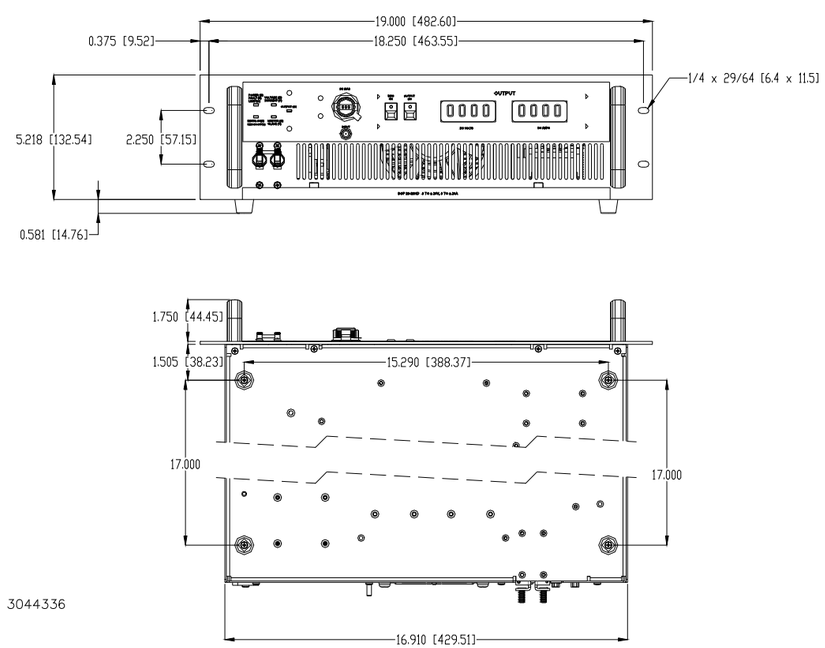
SYMBOL	Meaning
	WARNING! RISK OF ELECTRIC SHOCK!
	CAUTION: REFER TO REFERENCED PROCEDURE.
WARNING	INDICATES THE POSSIBILITY OF BODILY INJURY OR DEATH.
CAUTION	INDICATES THE POSSIBILITY OF EQUIPMENT DAMAGE.





REAR VIEW

NOTES:
1. THIS DRAWING IS USED FOR BOP-HD FULL RACK.
2. MATERIAL:
   A. CHASSIS AND BACK PLATE: No. 14 GA CRS
   B. FRONT PANEL: 1/8 THICK ALUMINUM
   C. COVER: No. 16 GA CRS
3. FINISH:
   A. CHASSIS AND BACK PLATE: CADMIUM PLATE WITH CHROMATE WASH
   B. FRONT PANEL: LIGHT GRAY PER FEDERAL STD 595 COLOR No. 26440
   C. COVER: CHARCOAL GRAY VINYL TEXTURE
4. RACK OR CABINET MOUNTIING: REMOVE (4) METAL FEET
5. (4) PLASTIC INSERTS FOR 1/4-20 THREAD CUTTING SCREWS 5/8 LONG (WITH 1/8 MOUNTING SURFACE THICKNESS)
6. IF INSTALLATION WITHOUT SLIDES IS DESIRED, THE UNIT MUST BE SUPPORTED BY A RIGID PLATFORM OR BY A FIXED BRACKET MOUNTED ON THE RACK
7. DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS
8. TOLERANCES:
   A. BETWEEN MOUNTING HOLES ±1/64 [0.4]
   B. ALL FRONT PANEL DIMENSIONS TO MIL-STD-189
   C. ALL OTHER DIMENSIONS ±1/32 [.8] EXCEPT AS NOTED



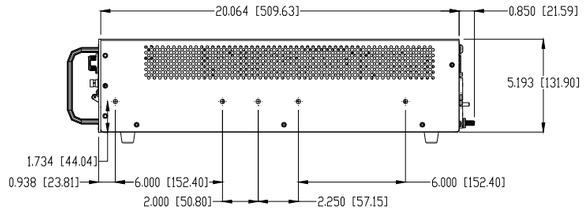


FIGURE 1-6. MECHANICAL OUTLINE DRAWING, BOP-H

SECTION 2 - INSTALLATION

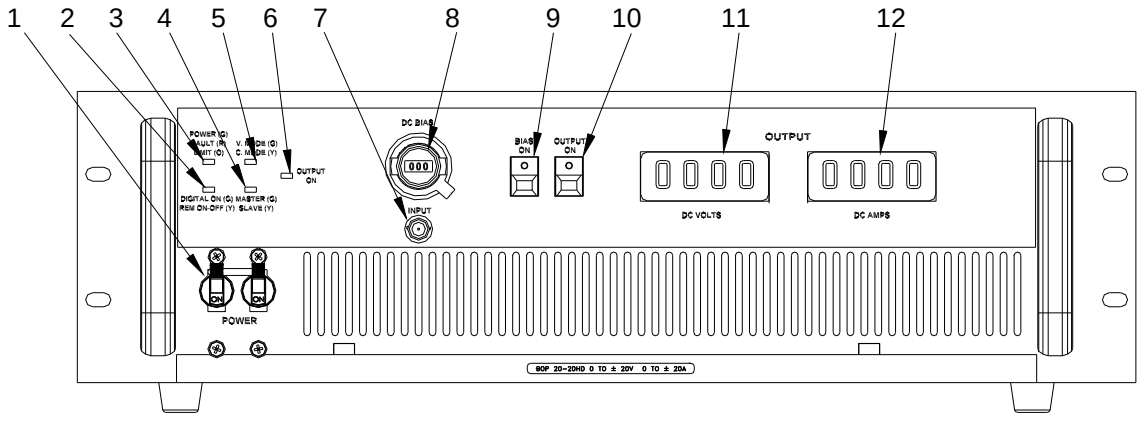
2.1 UNPACKING AND INSPECTION.

This instrument has been thoroughly inspected and tested prior to packing and is ready for operation. After careful unpacking, inspect for shipping damage before attempting to operate. Perform the preliminary operational check as outlined in PAR. 2.6. If any indication of damage is found, file an immediate claim with the responsible transport service.

2.2 TERMINATIONS, CONTROLS AND INDICATORS

a) Front Panel: Refer to Figure 2-1. See Table 2-1 for an explanation of terminations, controls and indicators.

b) Rear Panel: Refer to Figure 2-2 and Table 2-2 for an explanation of terminations, controls and indicators.



3044326

NOTE: See Table 2-1 for functions.

FIGURE 2-1. BOP TERMINATIONS AND CONTROLS, FRONT PANEL

TABLE 2-1. BOP FRONT PANEL TERMINATIONS AND CONTROLS

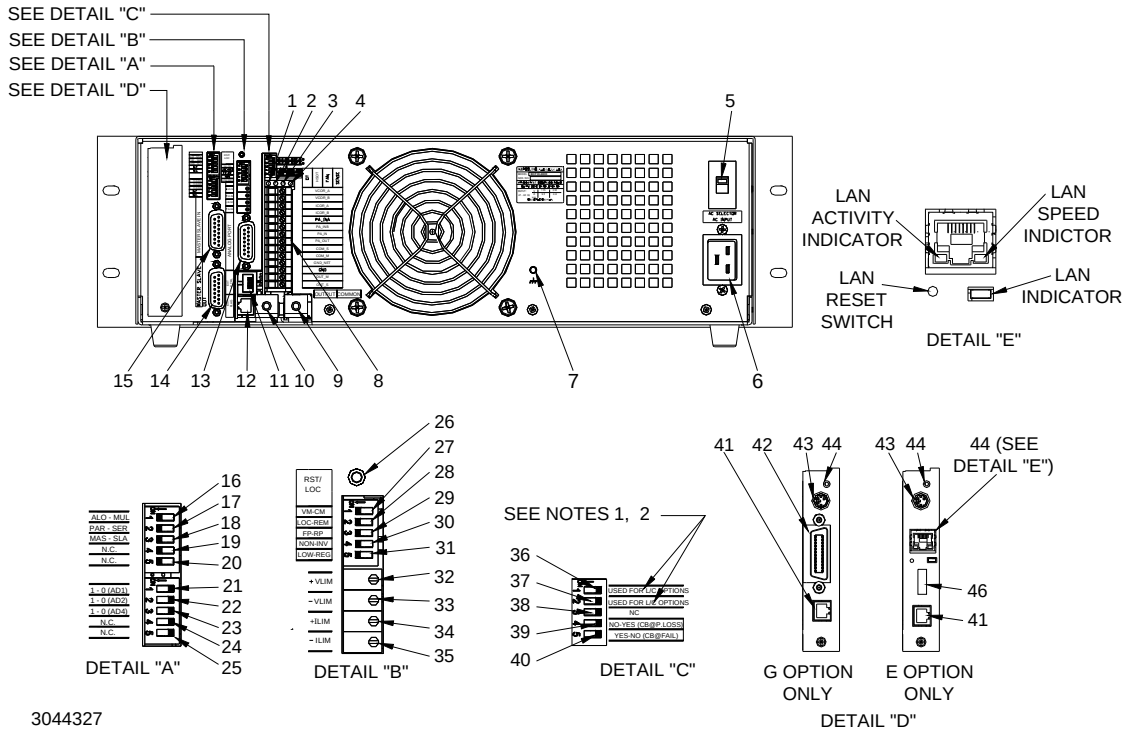
FIG. 2-1 INDEX NO.	NAME OF TERMINATION OR CONTROL	FUNCTION
1	A-C POWER circuit breaker	Apply AC input voltage to the unit (115V or 230V). Circuit breaker has 2-poles, a relay trip current coil and an isolated voltage trip coil. The current coil trips the breaker for input AC overcurrent. The voltage trip coil trips the breaker for wrong AC input setting and (if selected by rear microswitch settings) overtemperature/fan not running/ output sensing error/interlock/input power loss.
2	DIGITAL ON (G) REM ON-OFF (Y) indicator	Lights Green (G) when unit is entirely controlled (including on-off) by an active digital option (E or G Option). Lights Yellow (Y) when the FP-RP switch (28, Figure 2-2) is set to RP (rear panel) indicating output on-off is controlled using the corresponding signals of the EXTL CTRL Port (see Table 2-4). Not lit means output on-off is controlled by the front panel OUTPUT ON switch (6, Figure 2-1); this requires D Option (Display/front panel control) to be installed.

TABLE 2-1. BOP FRONT PANEL TERMINATIONS AND CONTROLS (CONTINUED)

FIG. 2-1 INDEX NO.	NAME OF TERMINATION OR CONTROL	FUNCTION
3	POWER (G) FAULT (R) LIMIT (O) indicator	Lights Green (G) when circuit breaker is on, AC voltage is present. and the unit is functioning properly. Lights Red (R) when unit is faulted. Fault indicates either Heat sink overtemperature, cooling air overtemperature, fan not running, output sensing error, external interlock or multiple units interlock. Using a rear panel microswitch, the above errors can also trip the AC POWER circuit breaker setting the input and limits to zero, and activating a temporary output crowbar for units with and without L option. Heat sink overtemperature, cooling air overtemperature, fan not running and output sensing errors are indicated by corresponding LEDs on rear panel. Lights Orange (O) when unit is in limit mode.
4	MASTER (G) SLAVE (Y) indicator	Lights Green (G) when unit is set as Master or for standalone. Lights Yellow (Y) when unit is set Slave. If S (Master-Slave) option is not installed, LED stays green. The Master- Slave/ Slave address number/ Parallel- Series settings are done using rear panel micro-switches associated with the Master- Slave option.
5	VOLTAGE (G) CURRENT (Y) indicator	Lights Green (G) when unit set to Voltage Mode (default setting). Lights Yellow (Y) when unit set to Current Mode. Operating Mode can be set using the rear panel VM-CM microswitch, If the rear REM-LOC microswitch is set to LOC. If the rear REM-LOC microswitch is set to REM, Mode is established by the remote isolated signal applied to EXT CTRL port (no signal = Voltage Mode), If a digital option (E or G option) is present and active, Mode is determined only by digital command.
6	OUTPUT ON indicator	Lights green when the output is ON (enabled), set by either local, remote analog or remote digital control. Not lit means the output is OFF (disabled).
7	INPUT connector	**Installed with D Option (Display/front panel control) only.** Differential input for programming output voltage in voltage mode, or output current in current mode. This input is in parallel with the rear panel input, available at ANALOG PORT (pins 11 and 4), The rear panel input is available for all options. **CAUTION: Use only one input at a time.**
8	DC BIAS multi-turn potentiometer and indicator/dial (0 to 999)	**Installed with D Option (Display/front panel control) only.** If enabled (see BIAS ON switch and OUTPUT ON switch), DC bias is added to programming signal, equivalent to a value from 0 to ± Nominal Voltage in voltage mode, or 0 to ±Nominal Current in current mode The DC BIAS appears at the output if OUTPUT ON switch is set to ON. The bias can also be added to the digital programming signal. Dial reading 499 represents zero bias value. **CAUTION: Check the dial before enabling the bias.**

TABLE 2-1. BOP FRONT PANEL TERMINATIONS AND CONTROLS (CONTINUED)

FIG. 2-1 INDEX NO.	NAME OF TERMINATION OR CONTROL	FUNCTION
9	BIAS ON pushbutton switch/indicator	**Installed with D Option (Display/front panel control) only.** If switched on, indicator lights green and bias established by DC BIAS pot is applied to programming input in use. If switched off, bias is disabled and indicator is off.
10	OUTPUT ON switch/indicator	**Installed with D Option (Display/front panel control) only.** If switched on, indicator lights green and the sum of the input and DC BIAS (if DC BIAS switch set to ON) signals is applied to the programming input in use. This switch is active if the rear FP-RP microswitch is set to FP (Front Panel). NOTE: For models with D Option, when the rear FP-RP microswitch is set to RP (Rear Panel), output on-off can be controlled using a remote isolated signal (no signal= Output ON) applied to EXT CTRL port. For models without the D Option, the isolated analog remote on-off controlling signal of the EXT CTRL Port is enabled automatically (no signal= Output ON), regardless of the FP-RP switch position. If a digital option (G or E Option) is present and active, output on-off status is determined only by digital control.
11	DC VOLTS back-lit LCD	**Installed with D Option (Display/front panel control) only.** Displays the output voltage (in Volts). Display functions for DC and very low frequency values.
12	DC AMPS back-lit LCD	**Installed with D Option (Display/front panel control) only.** Displays the output current (in Amps). Display functions for DC and very low frequency values.



NOTES:
1. See Table 2-2 for functions.
2. Nameplates reads as follows:
   Regular units, without L or C options: both index nos. 36 and 37 read USED FOR L/C OPTIONS.
   If C Option installed: index no. 36 reads C OPT - REG and index no. 37 reads NC.
   If L Option installed: index no. 36 reads L OPT - REG and index no. 37 reads NC.
   If LC Option installed: index no. 36 reads LC OPT - REG and index no. 37 reads C OPT - L OPT.

FIGURE 2-2. BOP TERMINATIONS AND CONTROLS, REAR PANEL

TABLE 2-2. BOP REAR PANEL TERMINATIONS AND CONTROLS

FIG. 2-2 INDEX NO.	NAME OF TERMINATION OR CONTROL	FUNCTION
CAUTION: Turn unit off before changing any rear panel switch setting		
1	OT indicator	Red LED lights when cooling air overtemperature fault detected.
2	HSOT indicator	Red LED lights when heat sink overtemperature fault detected.
3	FAN indicator	Red LED lights when cooling fan is not operating.
4	SENSE indicator	Red LED lights when remote error sense fault detected.
5	AC SELECTOR switch	Allows AC input voltage setting for either 115V or 230V a-c nominal. If set to 115V and applied voltage is 230V, input circuit breaker trips. The unit will not operate if set to 230V and applied voltage is 115V.

TABLE 2-2. BOP REAR PANEL TERMINATIONS AND CONTROLS (CONTINUED)

FIG. 2-2 INDEX NO.	NAME OF TERMINATION OR CONTROL	FUNCTION
CAUTION: Turn unit off before changing any rear panel switch setting		
6	AC INPUT inlet connector	Allows a-c source voltage to be applied to unit. Either 115V or 230V (±9%) nominal per AC SELECTOR switch setting , 47-63Hz. IEC 320 mating connector. (Kepco P/N 142-0381) is supplied.
7	Chassis Ground stud	Provides chassis ground connection point.
8	Control/Access terminal block	Provides terminals which allow control of the gain/DC amplification factor (see Figure 1-4), and the frequency bandwidth in voltage mode and in current mode. Also provides access terminals for local or remote sensing, grounding network connection, monitoring, preamplifier output monitoring and chassis-ground connection. See Table 2-3 for details.
9	COMMON output busbar terminal	Used to connect BOP output to load. Floating, by default, with max 500V DC or peak between COMMON terminal and chassis-ground. The COMMON terminal can be tied to chassis terminal for a grounded output.
10	OUTPUT output busbar terminal	
11	EXT CTRL 8-pin phone jack	Port for application of external controlling signals. See Table 2-4 for details.
12	EXT FLAG 6-pin phone jack	Port to allow access to monitoring signals and flags. See Table 2-5 for details.
13	ANALOG PORT DB15 socket-type connector	Analog I/O port for programming main channel (voltage or current) and ±limit channels. Also allows access to voltage and current monitoring signals and ±10V reference voltages. See Table 2-6 for details.
14	MASTER SLAVE OUT DB25 pin socket-type connector	**Installed with S Option (Master/Slave) only.** Enables the connection of multiple units in series or parallel (master-slave configuration). • Use a dedicated termination plug for the MASTER SLAVE IN connector of the master unit. • Use a dedicated termination plug for the MASTER SLAVE OUT connector of the last slave unit. • Use universal cables - model, unit rank and configuration independent - between MASTER SLAVE OUT connector of the master or slave unit and MASTER SLAVE IN connector of the slave unit (see Figures 5-1 and 5-2 for parallel configurations, Figures 5-3 and 5-4 for series configurations.
15	MASTER SLAVE IN DB25 pin socket-type connector	
16	ALO-MUL microswitch	**Installed with S Option (Master/Slave) only.** • When set to ALO (alone) configures unit as standalone unit. • When set to MUL (multiple) configures unit as part of a multiple unit master-slave system.
17	PAR-SER microswitch	**Installed with S Option (Master/Slave) only.** ALO - MUL switch must be set to MUL for this switch to function. • When set to PAR (parallel), configures unit to be in a parallel-connected master-slave system. • When set to SER (series), configures unit for to be in a series-connected master-slave system.
18	MAS-SLA microswitch	**Installed with S Option (Master/Slave) only.** ALO - MUL switch must be set to MUL for this switch to function. • When set to MAS (master) configures unit to be the master of a multiple unit system. • When set to SLA (slave) configures unit be a slave in a multiple unit system.
19	N.C.	Not Connected.
20	N.C.	Not Connected.

TABLE 2-2. BOP REAR PANEL TERMINATIONS AND CONTROLS (CONTINUED)

FIG. 2-2 INDEX NO.	NAME OF TERMINATION OR CONTROL	FUNCTION
		CAUTION: Turn unit off before changing any rear panel switch setting
21	1 - 0 AD1 microswitch	**Installed with S Option (Master/Slave) only.** Used to set a unique binary address for units of a multiple system. This allows a digital option (G or E Option) to properly monitor a system of multiple (up to eight) units. AD1 = binary Address 1 (2^0) AD2 = binary Address 2 (2^1) AD4 = binary Address 4 (2^2)
22	1 - 0 AD2 microswitch	
23	1 - 0 AD4 microswitch	
24	N.C.	Not Connected.
25	N.C.	Not Connected.
26	RST/LOC pushbutton switch	Clears/resets the unit's fault status indications. If the unit was under digital control, after depressing this switch the unit goes to local control.
27	VM-CM microswitch	Sets the mode of operation, VM (Voltage Mode) or CM (Current Mode) when LOC-REM switch (28, Figure 2-2) is set to LOC and a digital option (G or E option) is either not installed or not active. If a digital option is installed and active, VM/CM mode is controlled by computer commands
28	LOC-REM microswitch	Sets the type of control, LOC (local) or REM (remote), for Voltage mode//Current mode. • When set to LOC, the mode of operation is controlled by VM-CM switch (27, Figure 2-2). • When set to REM, the mode of operation is controlled using the corresponding signal of the EXTL CTRL Port (see Table 2-4)
29	FP-RP microswitch	If the D Option is not installed, the position of the switch is not relevant because on-off control is automatically by the corresponding signal of the EXT CTRL Port (no signal = output on, see Table 2-4). If the D Option is installed, this switch selects whether output on-off control is from the front panel (FP) or rear panel (RP). • When set to FP, output on-off is controlled by the front panel OUTPUT ON switch (10, Figure 2-1 and Table 2-1) • When set to RP, output on-off is controlled by the corresponding signal of EXT CTRL Port (see Table 2-4). The front panel DIGITAL ON/REM ON-OFF indicator lights yellow showing that output on-off is controlled by the remote on-off signal at the EXT CTRL Port. If a digital option (G or E Option) is installed and active, the output on-off control is done exclusively by computer commands and the front panel DIGITAL ON/REM ON-OFF indicator lights green.
30	NON-INV microswitch	Sets the unit's configuration to either • non-inverting (NON): output is same polarity of programming signal or • inverting (INV): output is opposite polarity of programming signal.
31	LOW-REG microswitch	Sets the unit's frequency bandwidth to either the regular (nominal) value or a low value that is approximately 3 times smaller. The frequency bandwidth reduction is applied to the unit's preamplifier.
32	+VLIM 10-turn trimpot	These trimpots allow local adjustment of ±voltage limit and ±current limit values. All programming references for limits (analog remote, local trimpots, digital) are active at the same time: the lowest setting controls the corresponding limit.
33	–VLIM 10-turn trimpot	
34	+ILIM 10-turn trimpot	
35	–ILIM 10-turn trimpot	

TABLE 2-2. BOP REAR PANEL TERMINATIONS AND CONTROLS (CONTINUED)

FIG. 2-2 INDEX NO.	NAME OF TERMINATION OR CONTROL	FUNCTION
CAUTION: Turn unit off before changing any rear panel switch setting		
36	USED FOR L/C OPTIONS	Microswitch not connected for regular units without L, C or LC Options
	C OPT - REG microswitch	**If C Option installed:** Used to enable C Option when set to C OPT or disable capacitive optimization (C Option) when set to REG.
	L OPT - REG microswitch	**If L Option installed:** Used to enable L Option when set to L OPT or disable inductive optimization (L Option) when set to REG.
	LC OPT - REG microswitch	**If LC Option installed:** Used to enable LC Option when set to LC OPT or disable capacitive and inductive optimization (LC Option) when set to REG. When set to LC OPT the C OPT - L OPT switch determines whether C Option or L Option is enabled.
37	USED FOR L/C OPTIONS	Microswitch not connected for regular units without L, C or LC Options.
	C OPT - L OPT microswitch	**If LC Option installed:** Allows selection of either capacitive optimization (C OPT) or inductive optimization (L OPT) if LC OPT - REG switch is set to LC OPT. No effect if LC OPT - REG switch is set to REG.
38	NC	Not Connected
39	NO-YES (CB@P.LOSS) microswitch	Determines whether the input circuit breaker trips upon input power loss. If set to YES (default), input circuit breaker trips upon power loss. If set to NO, the unit goes to local control once input power is restored and resumes its remote analog control operation. For the NO setting to be effective, the YES - NO (CB@FAIL) switch (see index no. 40) must also be set to NO position because some errors could trip the circuit breaker during a power down event.
40	YES-NO (CB@FAIL) microswitch	Determines whether the input circuit breaker trips upon fault. If set to YES, input circuit breaker trips upon fault. If set to NO (default), the input circuit breaker does not trip and the fault is displayed on OT, HSOT, FAN and SENSE indicators (1 through 4, Figure 2-2).
41	RS232 PORT connector	**Installed on G and E Option models only.** Used for remote digital control of the BOP via the RS 232 serial interface.
42	IEEE 488 (GPIB) PORT connector	**Installed on G Option models only.** Used for remote digital control of the BOP via the IEEE 488 (GPIB) interface

TABLE 2-2. BOP REAR PANEL TERMINATIONS AND CONTROLS (CONTINUED)

FIG. 2-2 INDEX NO.	NAME OF TERMINATION OR CONTROL	FUNCTION
		CAUTION: Turn unit off before changing any rear panel switch setting
43	TRIGGER input connector	**Installed on G and E Option models only.** May be used to initiate BOP output.
44	IEEE 1118 (BITBUS) PORT connector	**Installed on G and E Option models only.** If S Option is installed, used for communication between multiple identical BOP units connected in parallel or series master/slave configurations.
45	LAN PORT	**Installed on E Option models only.** Used for Remote control of the BOP via the LAN interface.
46	USB PORT connector	**Installed on E Option models only.** Used for remote digital control of the BOP via the USB interface.

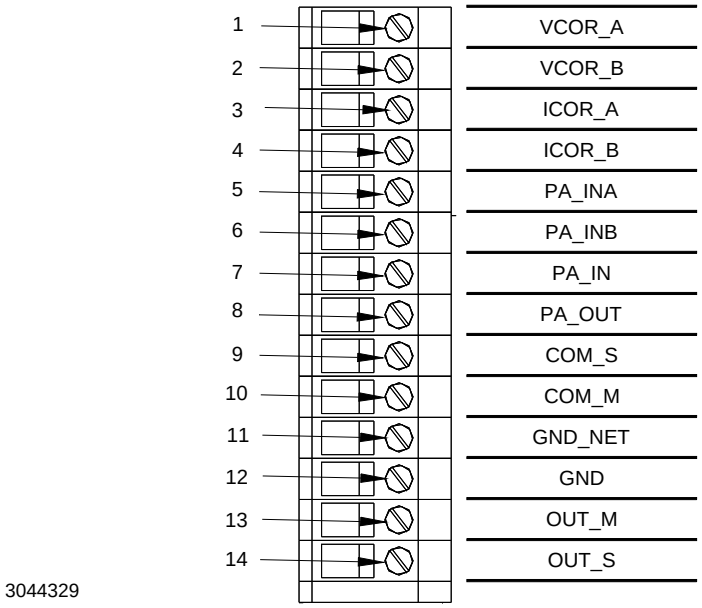
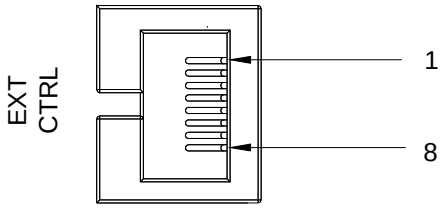


FIGURE 2-3. BOP CONTROL/ACCESS TERMINAL BLOCK

TABLE 2-3. BOP CONTROL/ACCESS TERMINAL BLOCK

FIG. 2-3 INDEX NO.	NAME OF SIGNAL	FUNCTION
1	VCOR_A	Used to connect a ceramic capacitor in the range of 1nF to 1uf, 50V, across terminals VCOR_A and VCOR_B to reduce the frequency bandwidth in voltage mode.
2	VCOR_B	
3	ICOR_A	Used to connect a ceramic capacitor in the range of 1nF to 1uf, 50V, across terminals ICOR_A and ICOR_B to reduce the frequency bandwidth in current mode.
4	ICOR_B	
5	PA_INA	• Used to connect a resistor (metal film, 0.25W, <25ppm/deg C) across terminals PA_INA and PA_INB to decrease preamplifier amplification factor from the default (1, for resistor value of 0 Ohms or wire jumper), to 0.1 amplification factor (for resistor value of 99k Ohms). • Used to connect a resistor (metal film, 0.25W, <25ppm/deg C) across terminals PA_INA and PA_IN to increase preamplifier amplification factor from the default (1, for open circuit), to 10 (for resistor value of 62 Ohms) (see Figure 1-4).
6	PA_INB	
7	PA_IN	
8	PA_OUT	Used to monitor preamplifier output.
9	COM_S	Common (Sense) - Connection between COM_S and COM_M establishes local sensing for common output. Used with OUT_S and OUT_M.
10	COM_M	Common (Monitor) - Used with OUT_M terminal to monitor local output voltage. See also GND_NET terminal below.
11	GND_NET	Grounding network terminal - Tied to chassis ground (GND) terminal through a series resistor-capacitor network. When connected to COM_M terminal (factory default) reduces common noise current flowing through the load. Connection to COM_M can be disconnected for full floating output.
12	GND	Chassis-ground terminal, used for output grounding.
13	OUT_M	Output Monitor - Used with COM_M to monitor local output voltage.
14	OUT_S	Output Sense - Connection between OUT_S and OUT_M establishes local sensing for power output. Used with COM_S and COM_M.

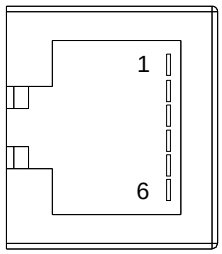


3044330

FIGURE 2-4. BOP EXTL CTRL PORT

TABLE 2-4. BOP EXTL CTRL PORT PIN ASSIGNMENTS

FIG. 2-4 PIN NO.	NAME OF SIGNAL	FUNCTION
1	+24V	Isolated +24V supply through 3.9k Ohms that can be used as supply voltage for external controls. Return is pin 8.
2	/ON-OFF_EXT (1)	External Output On-Off controlling input (if enabled by rear FP-RP switch), Referenced to pin 8 (chassis-GND), 5V/15V CMOS compatible, 100μsec response time, 5kVrms isolation vs output Output ON: Open or logic 0, Output OFF: Connection to pin1 or logic1,
3	/SD_EXT_OUT	External Shutdown input forces a failure, tripping the input circuit breaker if enabled by YES-NO (@FAIL) rear switch, (40, Table 2-2). Referenced to pin 8 (chassis-GND), 5V/15V/24V CMOS compatible, active low = logic 0, 100μsec response time, 5kVrms isolation vs output.
4	/RST_EXT	External Reset clears the faulting status (if faulting did not trip the input circuit breaker), Referenced to pin 8 (chassis-GND), 5V/15V/24V CMOS compatible, Active low= logic 0, 100μsec response time, 5kVrms isolation vs output.
5	VM-/CM_EXT	Controls external Voltage Mode- Current Mode if enabled by rear LOC-REM switch (27,Table 2-2). Referenced to pin 8 (chassis-GND), 5V/15V/24V CMOS compatible, 100usec response time, 5kVrms isolation vs output Voltage Mode = Open or logic 1 Current Mode = logic 0
6	N.C.	Not Connected.
7	24V_RET_LOCK	Input that enables the unit to shut-down/fail if the EXT CTRL connector is unplugged or if an external NC protection relay contact between pin 7 and pin 8 goes open. To activate this feature contact Kepco (change internal A1A1J9 floating jumper from 2+3 position to 1+2 position). After activating this feature, there must be less than 200 Ohms (or short circuit) between pin 7 and pin 8 for the unit not to fault.
8	24V_RET	Return for isolated 24V power supply and for EXT CTRL Port signals. This return is connected to the BOP chassis-GND.
(1) A relay contact between pin1 and pin 2 can be also used for output ON-OFF control.		



3044331

FIGURE 2-5. BOP EXTL FLAG PORT

TABLE 2-5. BOP EXTL FLAG PORT PIN ASSIGNMENTS

FIG. 2-5 INDEX NO.	NAME OF SIGNAL	FUNCTION
1	ON_FLAG	Flag output signal indicates output ON or OFF status, Referenced to pin 6 (isolated 15V supply return, tied to chassis-GND), 15V CMOS compatible, 50μsec response time, 5kVrms isolation vs output Output ON = logic 1 (+15V through 15k Ohms), Output OFF = logic 0 (saturated MOSFET transistor),
2	/FAULT_FLAG	Flag output signal indicates whether the unit is faulted or not, Referenced to pin 6 (isolated 15V supply return, tied to chassis-GND), 15V CMOS compatible, 50μsec response time, 5kVrms isolation vs output Unit not faulted = logic 1 (+15V through 15k Ohms), Unit Faulted = logic 0 (saturated MOSFET transistor)
3	VM-/CM FLAG	Flag output signal indicates whether unit is operating in voltage or current mode. Referenced to pin 6 (isolated 15V supply return, tied to chassis-GND), 15V CMOS compatible, 50μsec response time, 5kVrms isolation vs output Unit in voltage mode = logic 1 (+15V through 15k), Unit in current mode = logic 0 (saturated MOSFET transistor)
4	LIMIT_FLAG	Flag output signal indicates whether unit entered voltage limit or current limit mode, Referenced to pin 6 (isolated 15V supply return, tied to chassis-GND), 15V CMOS compatible, 50μsec response time, 5kVrms isolation vs output Unit in limit mode = logic 1 (+15V through 15k), Unit in normal operation = logic 0 (saturated MOSFET transistor)
5	N.C.	Not Connected.
6	24V_RET	Return for the isolated 24V and 15V power supplies and for the EXT FLAG Port signals. This return is connected to the BOP unit chassis-GND.

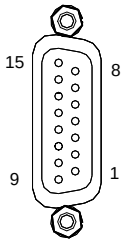


FIGURE 2-6. BOP ANALOG PORT

TABLE 2-6. BOP ANALOG PORT PIN ASSIGNMENTS

FIG. 2-6 INDEX NO.	NAME OF SIGNAL	FUNCTION
1	-10V	-10V reference voltage; return at pin 9
2	N.C.	Not Connected
3	CMON	Output current monitoring signal, 0 to ±10V for 0 to ± full scale nominal output current; return at pin 10
4	IN_POS	Pin 4 (IN_POS) and pin 11 (IN_NEG) are differential programming inputs for the main channel (either voltage or current). These inputs are in parallel with the front panel programming inputs provided with the D (Display/front panel control) Option. With the rear panel NON-INV switch set to NON position, a 0V to ±10V voltage between IN_POS and IN_NEG controls the output voltage in voltage mode between 0V to $\pm E_O$nom, or the output current in current mode between the 0A to $\pm I_O$nom.
5	–I_LIM_EXT (1)(2)	0V to +10V input voltage for programming negative current limit between -2% of full scale and -100.2% of full scale current; return at pin 12.
6	–V_LIM_EXT (1)(2)	0V to +10V input voltage for programming negative voltage limit between -2% of full scale and -100.2% of full scale voltage; return at pin 12.
7	N.C.	Not Connected
8	+10V	+10V reference voltage, return at pin 9.
9	Signal return	Return for pins 1 (–10V).and 8 (+10V).
10	Signal Return	Return for pins 3 (CMON) and 15 (VMON)
11	IN_NEG	pin 11 ((IN_NEG) and pin 4 (IN_POS) are differential programming inputs for the main channel (either voltage or current). These inputs are in parallel with the front panel programming inputs provided with the D Option (Display/front panel control) .
12	Signal return	Return for pins 5 (–I_LIM_EXT), 6 (–V_LIM_EXT), 13 (+I_LIM_EXT), and 14 (+V_LIM_EXT).
13	+I_LIM_EXT (1)(2)	0V to +10V input voltage for programming positive current limit between +2% of full scale and +100.2% of full scale current; return at pin 12.
14	+V_LIM_EXT (1)(2)	0V to +10V input voltage for programming positive voltage limit between +2% of full scale and +100.2% of full scale voltage; return at pin 12.
15	VMON	Output voltage monitoring signal, 0 to ±10V for 0 to ± full scale nominal output voltage; return at pin 10.

(1) If no signal is applied to the limits input, the limit value is established by the rear trimpots setting or (if installed) by a digital option.
(2) All the programming references for limits (analog remote, local trimpots, and digital commands) are active at the same time: the lowest setting controls the corresponding limit.

2.3 FACTORY DEFAULTS

At the front panel, the factory default setting for the DC Bias dial is 500, and the locking lever is set to “unlocked” (right position). Factory settings for the rear panel microswitches and terminal jumpers are defined in Figure 2-7.

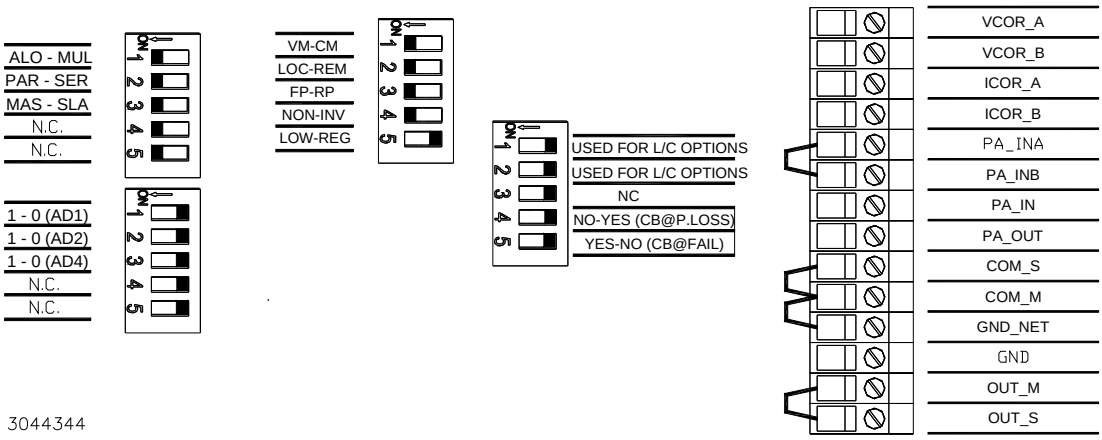


FIGURE 2-7. REAR PANEL DEFAULT SETTINGS, MICROSWITCHES AND JUMPERS

2.4 A-C INPUT REQUIREMENTS

This power supply is shipped wired for operation on a single phase, nominal 115V a-c line. For operation on 230V a-c source, set the AC SELECTOR switch (5, Figure 2-2) to 230V.

2.5 COOLING

The components in the BOP power supply rely on forced air cooling for the maintenance of their operating temperature. Side panel, front panel and (for bench operation) top of the case must be kept clear from all obstructions to ensure air circulation. Periodic cleaning of the interior of the power supply is recommended. **If the BOP is rack-mounted or installed into confined spaces, care must be taken that the ambient temperature (the temperature immediately surrounding the power supply) does not rise above 50°C (~122°F).**

2.6 PRELIMINARY CHECKOUT

A simple operating check after unpacking, and before permanent installation, is advisable to ascertain whether the BOP has suffered damage in shipment. Refer to Figures 2-1 through 2-2 and Tables 2-1 and 2-2 for the location and function of the operating controls and terminals. Proceed as follows:

1. With front panel AC POWER switch set to off position, verify that the front panel DC Bias dial is set to 500 and the locking lever in set to “unlocked” (towards the right).

2. Verify that the setup switches and jumpers at the rear panel are set to the factory default positions shown in Figure 2-7. This establishes the following default conditions:

   - Voltage Mode (VM) selected
   - Local Mode (LOC) - Voltage mode or current mode is determined by the rear panel VM - CM switch (27, Figure 2-2)
   - Front panel (FP) - OUTPUT ON switch (10, Figure 2-1) controls whether output is ON or OFF if D Option (Display/front panel control) installed. If D Option is not installed, the remote on-off control at EXT CTRL Port is automatically enabled.
   - Non-inverting - Output voltage will be the same polarity as the input voltage applied to the programming input, at either the front panel INPUT connector (7, Figure 2-1) or the rear panel analog port (pins 4 and 11) CAUTION: Only one input can be used at a time.
   - Preamplifier amplification factor set to 1 by the PA_INA to PA_INB wire jumper at rear terminal block.
   - Regular (REG) or nominal bandwidth selected
   - Non-inverting (NON) - Positive transfer factor selected.
   - Circuit breaker trips if input power lost
   - Circuit breaker does not trip if a fault detected
   - If S Option installed, ALO-MUL selects standalone (ALO). PAR-SER selects to parallel (PAR) and MAS-SLA selects master (MAS). AD1, AD2 and AD4 switches set to address 0 have no effect.

NOTE: **If E or G Option installed**, refer to associated Appendix for output voltage/current and output on-off control.
If D Option installed, use the DC BIAS control for output voltage/current control and OUTPUT ON/OFF switch for output on/off control.
If D Option not installed, the same tests described below can be done by applying an adjustable external 0V to ±10V floating voltage source between pin 4 and pin 11 of the rear panel Analog Port (see Table 2-6 for details) to control output voltage or current. Use the signal at pin 2 of the rear EXT CTRL Port to control output on/off (see Table 2-4 for details). Ignore references to front panel meters.

3. The following steps describe control using the D Option features. If D Option is not installed, use rear panel control as presented by Figure 2-8 for voltage mode and by Figure 2-9 for current mode. Instead of DC BIAS use an external voltage source adjusted to between 0V and ±10.05V; instead of BIAS ON or OUTPUT ON front panel switches use the external on-off switch S1_EXT shown in Figures 2-8 and 2-9.

   Refer to Figure 2-8 and connect a DVM, having a resolution and accuracy better than 0.001% of rated BOP output voltage, between rear OUT_S and COM_S terminals of the Terminal Block, using #22AWG wires.

CAUTION: Make sure that terminals screws are tight and that OUT_S to OUT_M and COM_S to COM_M wire-links remained connected for local sensing.

4. Set a-c circuit breaker/POWER switch (1, Figure 2-1) to ON.

CAUTION: DO NOT repeatedly toggle the POWER on/off switch as this may cause unit to fault. If actuator does not lock when released, wait a few seconds before trying again. The circuit breaker is "trip-free;" if overload exists, contacts cannot be held closed by actuator.

- Verify that front panel POWER (G)/FAULT (R)/LIMIT (O) indicator (3, Figure 2-1) lights green.
- Verify that DIGITAL (G)/REM ON-OFF indicator (2, Figure 2-1) is off if D Option is installed and lights yellow if D Option is not installed.
- Verify that MASTER (G)/SLAVE (Y) indicator (4, Figure 2-1) lights green.
- Verify that VOLTAGE (G)/CURRENT (Y) indicator (5, Figure 2-1) lights green.
- Verify that OUTPUT ON pushbutton switch inner indicator (10, Figure 2-1) lights green and after few seconds OUTPUT ON (G) indicator (6, Figure 2-1) lights green.
- Verify that DVM indicates 0V (with 0.01% of rated output tolerance) and front panel meters show 0.0V and 0.0A.

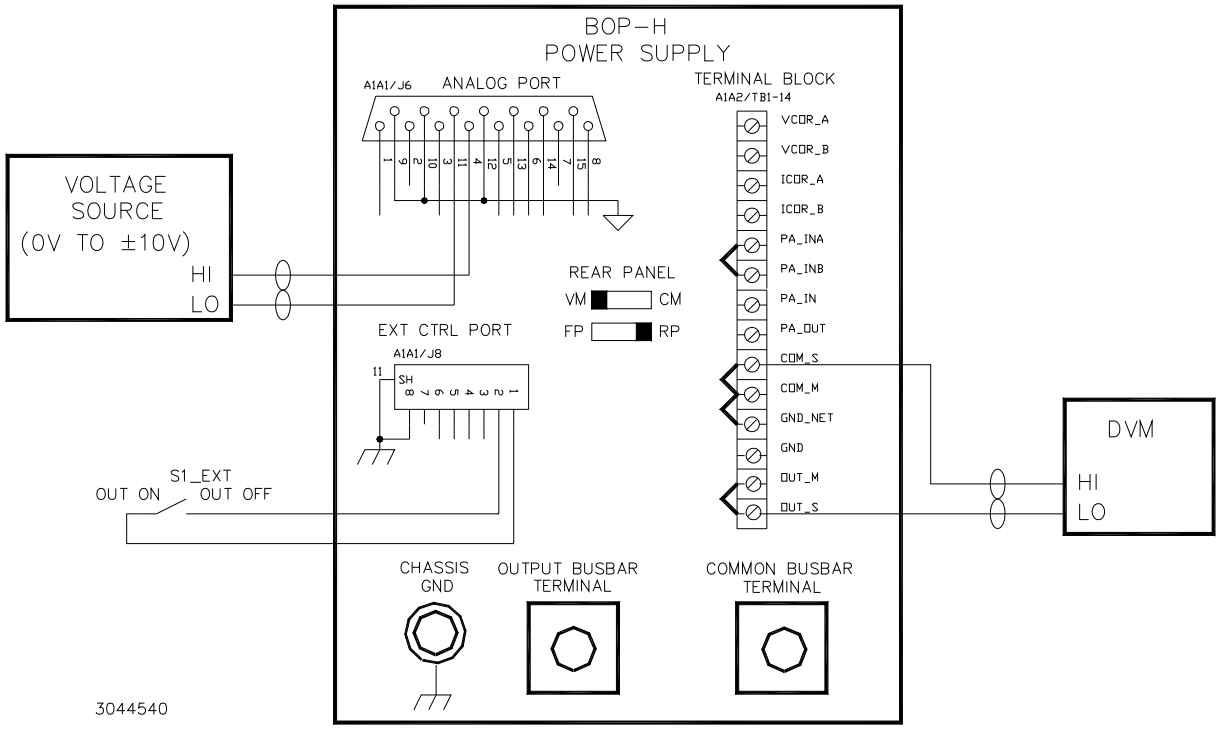


FIGURE 2-8. TEST SETUP FOR VOLTAGE MODE USING REAR PANEL INPUT AND CONTROL

NOTE: Steps 5 through 13 below check Voltage Mode functions.

5. Press the BIAS ON pushbutton switch (9, Figure 2-1) and verify that the inner indicator lights green. For a DC BIAS dial setting of **499**, both front panel voltmeter and external DVM show a voltage very close to zero (tolerance 0.5% of rating).

    a. Rotate the BIAS ON dial to its full CW (clockwise) position and verify that the output voltage shown by front panel voltmeter (see Table 1-2 for front panel voltmeter accuracy specification) and output voltage shown by the external DVM goes from zero to +1.005 times the rated output voltage value.

    b. Press BIAS ON switch and verify that its light goes off and the output voltage goes to zero.

    c. Press BIAS ON again and verify its light goes on and the output voltage reverts to the previous value.

6. Press OUTPUT ON switch and verify that its light, as well as OUTPUT ON indicator both go off.

    a. Verify that DVM indicates 0V (with 0.01% of rated output tolerance) and front panel display shows 0.0V and 0.0A.

    b. Press OUTPUT ON switch again and verify that both OUTPUT ON switch and OUTPUT ON indicators revert to on, and output voltage reverts to the previous value.

7. Slowly rotate the rear +VLIM trimpot (32, Figure 2-2) CCW (counterclockwise) and verify that at some point the output voltage begins to decrease and the front POWER (G)/FAULT (R)/LIMIT (O) indicator lights orange, showing that the unit goes into voltage limit mode.

8. Verify that when +VLIM trimpot is at full CCW position, the output voltage is approximately zero (+0.2% of rated output).

9. Return +VLIM trimpot to full CW position.

10. Rotate DC BIAS dial to full CCW position and verify that the output voltage shown by front panel voltmeter and by the external DVM goes from +1.005 times the rated value, through zero to -1.005 times the rated output voltage value.

11. Slowly rotate rear -VLIM trimpot (33, Figure 2-2) CCW and verify that at some point output voltage begins to decrease in absolute value and the front POWER (G)/FAULT (R)/LIMIT (O) indicator lights orange, showing that the unit goes into voltage limit mode.

12. Verify that when -VLIM trimpot is at full CCW position, the output voltage is approximately zero (-0.2% of rated output).

13. Return -VLIM pot to full CW position. Return the DC BIAS dial to read 499. Press OUTPUT OFF switch. Set a-c circuit breaker/POWER switch (1, Figure 2-1) to OFF.

NOTE: Steps 14 through 28 below check Current Mode functions.

14. Set the rear panel VM-CM switch (17, Figure 2-2) to CM position.

15. Refer to Figure 2-9 (using the rear panel for input and control) and connect a precision current measuring shunt across the OUT and COM output busbar terminals. The shunt must be rated for nominal BOP output current, with 0.001% accuracy. Connect a DVM to the shunt's sensing terminals. The DVM resolution and accuracy must be better than 0.001% of current shunt voltage corresponding to the BOP rated output current.

CAUTION: Make sure that terminals screws are tight and that OUT_S to OUT_M and COM_S to COM_M wire-links remained connected for local sensing.

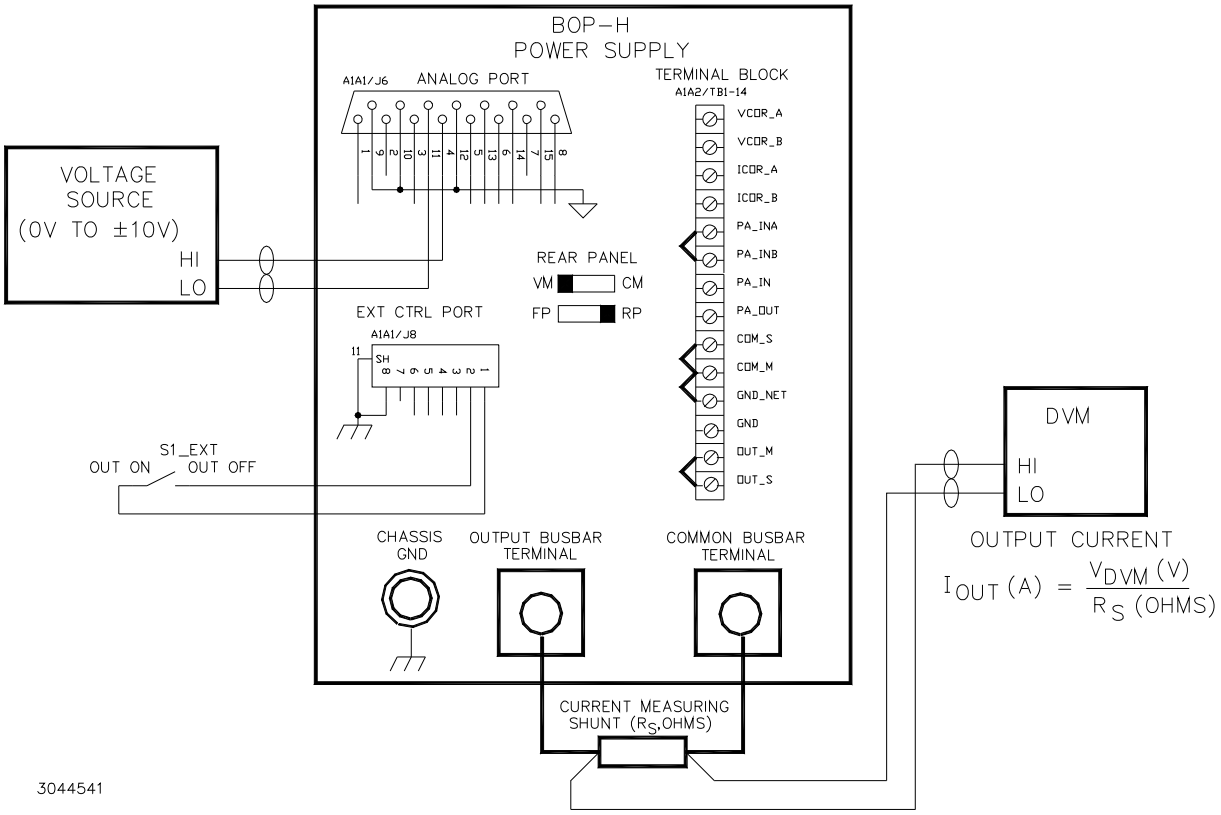


FIGURE 2-9. TEST SETUP FOR CURRENT MODE USING REAR PANEL INPUT AND CONTROL

16. Set a-c circuit breaker/POWER switch (1, Figure 2-1) to ON.

CAUTION: DO NOT repeatedly toggle the POWER on/off switch as this may cause unit to fault. If actuator does not lock when released, wait a few seconds before trying again. The circuit breaker is "trip-free" - if overload exists, contacts cannot be held closed by actuator.

- Verify that front panel POWER (G)/FAULT (R)/LIMIT (O) indicator (3, Figure 2-1) lights green.
- Verify that DIGITAL (G)/REM ON-OFF indicator (2, Figure 2-1) is off if D Option is installed and lights yellow if D Option is not installed.
- Verify that MASTER (G)/SLAVE (Y) indicator (4, Figure 2-1) lights green.
- Verify that VOLTAGE (G)/CURRENT (Y) indicator (5, Figure 2-1) lights yellow.
- Verify that OUTPUT ON pushbutton switch inner indicator (10, Figure 2-1) lights green and after few seconds OUTPUT ON (G) indicator (6, Figure 2-1) lights green.

17. Verify that DVM indicates 0A (with 0.01% of rated output tolerance) when calculated using I_{OUT} (A) = V_{DVM} (V) / R_{SHUNT} (Ohms) and front panel display shows 0.0V and 0.0A.

18. Press the BIAS ON pushbutton switch (9, Figure 2-1) and verify that the inner indicator lights green. For a DC BIAS dial setting of **499**, both front panel ammeter and calculations using I_{OUT} (A) = V_{DVM} (V) / R_{SHUNT} (Ohms) show a current very close to zero (tolerance 0.5% of rating).

    a. Rotate the BIAS ON dial to its full CW position and verify that the output current shown by front panel ammeter (see Table 1-2 for front panel ammeter accuracy specification) and calculated using I_{OUT} (A) = V_{DVM} (V) / R_{SHUNT} (Ohms) using voltage shown by the external DVM goes from zero to +1.005 times the rated output current value.

    b. Press BIAS ON switch and verify that its light goes off and the output current goes to zero.

    c. Press BIAS ON again and verify its light goes on and the output current reverts to the previous value.

19. Press OUTPUT ON switch and verify that its light, as well as OUTPUT ON indicator both go off.

20. Verify that DVM and front panel display indicate output current goes to 0A.

21. Press OUTPUT ON switch again and verify that both OUTPUT ON switch and OUTPUT ON indicators revert to on, and output current reverts to the previous value.

22. Slowly rotate the rear +ILIM trimpot (35, Figure 2-2) CCW (counterclockwise) and verify that at some point the output current begins to decrease and the front POWER (G)/FAULT (R)/LIMIT (O) indicator lights orange, showing that the unit goes into current limit mode.

23. Verify that when +ILIM trimpot is at full CCW position, the output current is approximately zero (+0.2% of rated output).

24. Return +ILIM trimpot to full CW position.

25. Rotate DC BIAS dial to full CCW position and verify that the output current shown by front panel ammeter and by the external DVM goes from +1.005 times the rated value, through zero to -1.005 times the rated output current value.

26. Slowly rotate rear -ILIM trimpot (34, Figure 2-2) CCW and verify that at some point output voltage begins to decrease in absolute value and the front POWER (G)/FAULT (R)/LIMIT (O) indicator lights orange, showing that the unit goes into current limit mode.

27. Verify that when -ILIM trimpot is at full CCW position, the output current is approximately zero (-0.2% of rated output).

28. Return -ILIM pot to full CW position. Return the DC BIAS dial to read 499. Press OUTPUT OFF switch. Set a-c circuit breaker/POWER switch (1, Figure 2-1) to OFF.

2.7 INSTALLATION

NOTE: For all installations into confined spaces, care must be taken that the temperature immediately surrounding the unit does not exceed the maximum specified ambient temperature (50° C).

Refer to the Mechanical Outline Drawing, Figure 1-6. The unit is delivered with the Fixed Angle Brackets and Chassis Side Support Bars installed. For bench operation, both of these components may be removed.

The unit may be installed into standard (19-inch) equipment racks, or onto any other flat surface after removing the four (4) bottom aluminum feet. If chassis slides are not used, the BOP may be installed onto any flat surface by means of the provided plastic mounting inserts on the bottom of the BOP chassis.

NOTE: If slide installation (as described below) is not desired, other means of supporting the unit in the rear must be provided (additional rear brackets or a solid platform, for example) since the front angle brackets alone are not sufficient to support the full weight of the unit.

2.7.1 SLIDE INSTALLATION.

The Chassis Slide Support Bars of the BOP are pre-drilled to accept Jonathan Series 110 QD slides. The slides listed in Table 2-7 can be accommodated.

TABLE 2-7. CHASSIS SLIDE MOUNTING HOLES

MODEL	KEPCO P/N	MOUNTING HOLES USED (SEE FIGURE 2-10)				
		A	B	C	D	E
110 QD-20-2	108-0067	X	X	O	X	DR
110 QD-22-2	108-0156	X	O	X	O	X
110 QD-24-2	108-0192	X	O	X	O	DR

KEY: X = Hole Used
O = Hole Not Used
DR = Hole must be drilled into chassis part of slide, each side, 0.199 in. dia., 16-1/4 in. from “A” hole.

To install the slides, refer to Figure 2-10 and proceed as follows:

1. Remove screws “A” through “E” from left and right chassis slide support bars. (Do not discard).

2. Determine the required hole-pattern for the selected slide model from Table 2-7.

3. Drill the “E” hole into both left and right chassis sections of slide if required.

4. Mount the chassis section of the slide to the left and right side of the BOP as shown in Figure 2-10. Use the same 10-32 x 1/2” mounting screws removed in step 1.

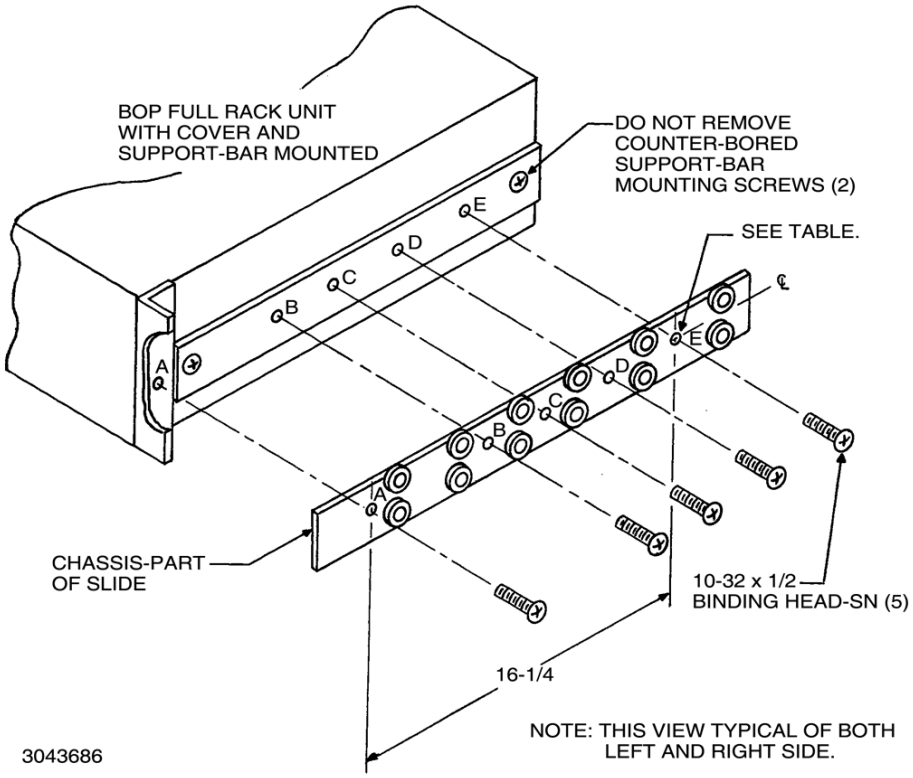


FIGURE 2-10. SLIDE INSTALLATION ON FULL-RACK UNITS

2.8 LOAD CONNECTION

Load connections to the BOP power supply are achieved via the OUTPUT and COMMON terminals located on the rear panel (8 and 9, Figure 2-2). Sense connections (OUT_S and COM_S) are made from the control/access terminal block (see Figure 2-3 and Table 2-3).

2.8.1 LOAD CONNECTION, LOCAL SENSING

The basic interconnections between the BOP and the load using local sensing are shown in Figure 2-11 .

The load wire size for the 2-wire connection shown should be rated for the nominal output current of the BOP and tied together to keep parasitic inductance low and to reduce possible “pick-up” from stray magnetic fields. The basic 2-wire connection is useful where the voltage drop in the load wires is small or of minor consequence, as for example, operation in constant current mode.

2.8.2 LOAD CONNECTION, REMOTE SENSING

The basic interconnections between the BOP and the load using remote sensing are shown in Figure 2-12 using the rear panel. This is the recommended load connection for all applications requiring minimum load effect across a remote load. Remove the local sensing wire jumpers between OUT_S and OUT_M and between COM_S and COM_M. A twisted or shielded pair of wires (No. 22 AWG) are connected from the BOP sensing terminals (OUT_S and COM_S) to the load. Make sure that all wires and wire jumpers connected to the rear terminal block and its are properly tightened. This remote error sensing technique will compensate for load wire voltage drops up to 0.25 volts per wire.

NOTE: Observe polarities: the COMMON sensing wire must go to the COMMON load wire, the OUTPUT sensing wire must go to the OUTPUT load wire.

NOTE: The following explanation of AC and DC grounding can apply to any Kepco power supply even though this text applies specifically to BOP Series.

2.8.3 A-C GROUND

The metal cases of electronic equipment which are operated from the a-c power line must be kept at ground potential at all times. If a 3-wire line cord cable (made using the supplied mating connector for the BOP AC inlet) is used in combination with a properly grounded a-c power outlet, this is taken care of automatically. If a non-grounded outlet is used, the case must be earth-grounded separately. A separate GROUND terminal is provided for this purpose on the rear of the BOP.

The GROUND terminal is connected to chassis of the unit and to the local earth-ground potential through the A-C power line cord. It can be used a) as a grounding point for the output of the unit (COMMON terminal), and b) for doubling the a-c power cord earth-ground connection if necessary by providing a separate connection to the local earth-ground point.

In conclusion, if the application needs to have its common/ return point tied to earth-ground, for the best noise and stability performance, make the common/return at only ONE of the following: a) BOP, b) load, c) a device connected to the BOP output, d) a programming device.

2.8.4 D-C GROUND

Specified ripple and noise figures listed in Table 1-2 for operational power supplies are valid only with the COMMON side of the BOP output tied (by default) with a wire jumper to the GROUNDING NETWORK and through this to an earth-ground point as shown in Figures 2-11 and 2-12.

CAUTION: If the programming device return is tied to earth-ground, leave the BOP output floating. Otherwise, instability and inaccuracy will occur.

If the application requires, the COMMON of the BOP may be floated up to 420V d-c (or peak) off chassis-ground. For this case, due to the common mode noise current flowing through a higher impedance, the resulting ripple/noise will be larger than published specifications. If the application must be grounded, connect a single return/common point of the application (including programming device, BOP and load) to earth-ground. The exact location of the best return earth-ground point must be carefully selected for minimum ripple/noise output.

The GROUNDING NETWORK terminal is tied to GROUND (chassis) terminal through a paralleled capacitor-resistor (high value capacitor) network. Connecting the GROUNDING NETWORK terminal to the COMMON terminal reduces common noise current flowing through the load.

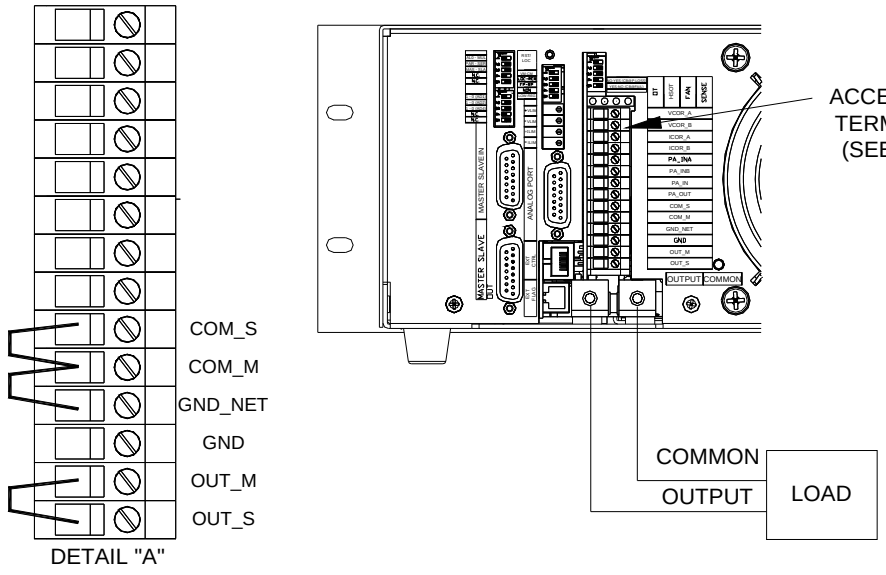
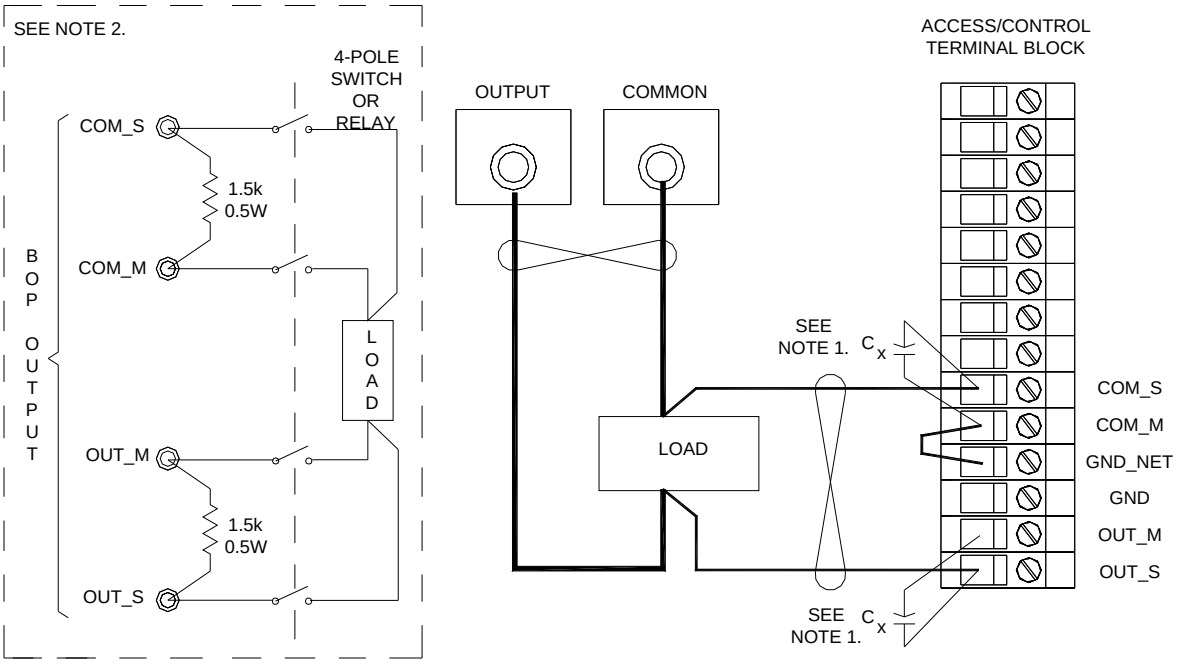


FIGURE 2-11. LOAD CONNECTION USING LOCAL SENSING AT REAR PANEL, OUTPUT FLOATING



NOTES:
1. For applications requiring very long connections to the load, additional external capacitors (C_X) should be connected as shown to compensate for lead inductance of connecting wires.
2. For applications requiring manually switched or relay-driven output connections, external resistors must be connected as shown. all connections must be made and broken simultaneously.
3. Use separate properly rated twisted pair wires for output power and output sensing connections

3044334

FIGURE 2-12. LOAD CONNECTION USING REMOTE SENSING AT BOP REAR PANEL

2.9 COOLING

The power devices used within the power supply are maintained within their operating temperature range by means of internal heat sink assemblies and by two cooling fans. Periodic cleaning of the power supply interior is recommended. Do not obstruct any vents on the unit. If the power supply is located within a confined space, take care that the ambient temperature, which is the temperature of the air immediately surrounding the power supply, does not rise above the specified limits (see Table 1-2).

2.10 SETTING UP THE UNIT

The following paragraphs describe the connections and initial BOP setup needed to operate in the desired mode.

2.10.1 SETUP FOR ANALOG CONTROL

With power off, configure the microswitches on the rear panel as follows (see Table 2-2 for details):

1. Configure the mode of operation, voltage (VM) or current (CM), using the rear VM-CM switch (27, Figure 2-2), while the LOC-REM switch (28, Figure 2-2) is set to LOC.
   - VM = Voltage Mode
   - CM = Current Mode

   If the mode must be set remotely, set the LOC-REM switch to REM, then use a 15V CMOS compatible signal at EXT CTRL Port pin 5 to set the desired mode (no signal = VM, see Table 2-4 for details).

2. If D Option (Display/front panel control) is installed, configure the output ON-OFF control using the rear panel FP-RP switch (29, Figure 2-2).
   - FP (default) = front panel OUTPUT ON pushbutton-switch controls output is on or off.
   - RP (or if the D Option is not installed) = output on-off controlled by a 15V CMOS compatible signal applied to EXT CTRL Port, pin 3 (no signal = output on; see Table 2-4 for details).

3. Use the rear NON-INV switch (30, Figure 2-2) to configure the input-output transfer factor sign. This setting affects both VM and CM modes of operation.
   - NON (default) = positive transfer factor
   - INV = negative transfer factor.

   The input programming voltage can be applied either at the front panel INPUT connector (7, Figure 2-1) if D Option is installed, or at the ANALOG Port, pins 4 and 11 (see Table 2-6 for details). Since these inputs are in parallel, use only one of them.

   If the D Option is installed, the NON-INV switch is also applicable to the internal DC BIAS signal. If used, the DC BIAS signal is summed with the external programming signal (if applied).

4. Set rear LOW-REG switch (31, Figure 2-2), for best dynamic specs (frequency bandwidth and response time
   - REG (default) = regular
   - LOW = frequency bandwidth approximately three times lower.

   The LOW setting affects both VM and CM modes of operation as it reduces the frequency bandwidth of the common Preamplifier.

   For both LOW-REG settings, the frequency bandwidth can be reduced for stable operation when driving reactive loads:

   a. Voltage mode: add ceramic capacitor between VCOR_A and VCOR_B of terminal block (8, Figure 2-2). See Figure 2-3 and Table 2-3 for details.

   b. Current mode: add ceramic capacitor between ICOR_A and ICOR_B of the terminal block (8, Figure 2-2). See Figure 2-3 and Table 2-3 for details.

5. Configure the rear NO-YES (CB@P.LOSS) switch (39, Figure 2-2) to determine whether the input circuit breaker will trip upon input power loss.
   - YES (default) = input circuit breaker trips upon input power loss
   - NO = input circuit breaker does not trip upon input power loss.

   If this switch is set to NO, the YES-NO (CB@FAIL) switch (40, Figure 2-2) must also to be set to NO. See Table 2-2 for details.

6. Configure the rear YES-NO (CB@FAIL) switch (40, Figure 2-2) to determine whether the input circuit breaker will trip for power supply failures. See Table 1-2 (Protections) for failure details.
   - YES = input circuit breaker to trip for power supply's failures
   - NO (default) = input circuit breaker does not trip for power supply's failures

2.11 MULTIPLE UNIT CONFIGURATIONS (S OPTION REQUIRED)

See Section 5.

SECTION 3 - OPERATION

3.1 INTRODUCTION

BOP Bipolar Operational Power Supplies can be used in a great variety of applications. As a precision voltage or current source, the BOP-H output can be controlled locally (if the D Option is installed) by means of the front panel DC BIAS control or by a voltage signal applied to the front INPUT connector or by means of a voltage source or by a resistive type of control using the rear panel features, or by an optional digital interface (G or E Option). Independently adjustable or remotely programmable limit circuits for both output voltage and output current protect a sensitive load from any overvoltage or overcurrent.

NOTE: Before using the BOP in any application, please refer to Section 2 to get acquainted with the operating controls, a-c power requirements and information on load connections and grounding. Front and rear panel components identified by index numbers in parentheses are shown in Figures 2-1 and 2-2, respectively.

3.2 POWER SUPPLY BASICS

As a Bipolar Amplifier, the BOP output responds to such input signals as sine, square or triangular waves. A single built-in differential pre-amplifier used for voltage mode operation or for current mode operation, permits

- The summing of the DC Bias signal (if D Option is installed), with a remote analog programming signal, with digital programming signal, with master-slave related programming signal.
- Changing the unit's transfer factor sign and its absolute value.
- Changing the unit's controlling parameter between voltage, current, resistance."

3.2.1 SAFETY PRECAUTIONS

Detailed examples of the more popular applications are described in the following paragraphs. Before actual operation, however, the following safety precautions must be carefully considered.

WARNING

Exercise care in making all connections to and from the BOP terminals. Remove a-c power from the BOP before making any connections.

Wires and/or cables connected from the BOP terminals to external components or programming devices must be properly insulated and securely terminated on both sides to make accidental touch impossible.

The BOP chassis must be safety-grounded to a reliable a-c source earth-ground. A safety-ground may be established by using a grounded a-c power outlet or, if the latter is not available, by means of a separate wire from the provided GROUND terminal to a reliable a-c source earth-ground point.

WARNING

The COMMON output terminal of the BOP can be either grounded or floating, depending on the application. Additional precautions must be taken to make any user access to the output terminals impossible.

The BOP must always have sensing configured. For voltage mode choose either local sensing (see PAR 2.8.1) or remote sensing (see PAR 2.8.2) as desired. For current mode use local sensing.

3.2.2 ACTIVE PROGRAMMING SOURCES

External programming sources (Signal Generators, etc.) or reference sources should have temperature coefficients and drift specifications comparable to (or better than) the BOP Power Supply.

3.2.3 EXTERNAL LEADS

Shielded pair or twisted pair cable should be used for the unit's rear pane programming input at the ANALOG Port. If shielded pair is used, connect the shield to the BOP GND terminal of the rear panel Terminal block. If the D Option is installed, always use a shielded pair cable attached to the twinax BNC plug included as accessory with the unit. The wires should be soldered to the plug's isolated pins, while the shields go to the BNC metal part. Always use a shielded cable or a twisted pair with insulation rated for at least 300V a-c.

Output leads must be voltage-rated for at least the maximum BOP output voltage and current. Twisted pair wires are recommended for output power and output sense wiring.

3.3 POWER SUPPLY OPERATION

The following paragraphs present procedures and setups used to operate the BOP power supply.

3.3.1 TURNING THE POWER SUPPLY ON

The status of the unit upon power-up depends on the configuration of the four 5-segment power-up switches on the rear panel (see Figure 2-2, Details A, B and C, and Table 2-2).

The following power-up switches must be configured before turning the unit on:

- VM - CM (see Table 2-2, item 27 for details)
- LOC - REM (see Table 2-2, item 28 for details)
- FP - RP (see Table 2-2, item 29 for details)
- NON - INV (see Table 2-2, item 30 for details)
- LOW - REG (see Table 2-2, item 31 for details)
- NO-YES (CB@P.LOSS) (see Table 2-2, item 39 for details)
- YES-NO (CB@FAIL) (see Table 2-2, item 40 for details)

- If S Option (Master/Slave) is installed, (see Table 2-2, items 16, 17, 18, 21, 22 and 23 to to configure the ALO - MUL, PAR - SER, MAS - SLA, AD1, AD2 and AD4 switches.
- If L Option installed, see Table 2-2, item 36 to configure L-REG, switch.
- If C Option installed, see Table 2-2, item 36 to configure C-REG, switch.
- If LC Option, installed, see Table 2-2, items 36 and 37 to configure LC-REG and C - L switches.
- If a digital option (G or E Option) an additional DIP switch on the G or E Option assembly must be configured to establish baud rate/GPIB address upon power up.

3.3.2 SIMPLIFIED APPLICATION AND TEST SETUP REQUIREMENTS

Procedures on the following pages show how to use the four programmable circuits of the BOP:

- (±) Current (I_O) Limit Circuits: and PAR. 3.3.6.
- (±) Voltage (E_O) Limit Circuits: see PAR. 3.3.7.
- Voltage Control Channel with Current Limiting: see PAR. 3.3.8.
- Current Control Channel with Voltage Limiting: see PAR. 3.3.9.

3.3.3 SETTING OPERATING MODE (VOLTAGE OR CURRENT)

The BOP has one main channel- that can be allocated to either voltage mode or current mode, and four limit channels, +VLIM, -VLIM, +ILIM, and -ILIM.

When the rear panel LOC-REM switch (28, Figure 2-2) is set to LOC (local), the operating mode is determined by the setting of the VM-CM switch (27, Figure 2-2),

When the rear panel LOC-REM switch (28, Figure 2-2) is set to REM (remote), the operating mode is determined by the VM-/CM_EXT signal at pin 5 of the EXTL CTRL port (see Table 2-4).

If an optional digital interface (G or E Option) is installed and active, the main channel is determined by the digital interface and the LOC-REM and VM-CM switches have no effect.

3.3.4 EXTERNAL VOLTAGE MONITOR

Use Voltage Monitoring signal VMON at pin 15 of the Analog Port (13, Figure 2-2) for external voltage monitoring. The range of this signal is 0 to ±10V equivalent to 0 to ± rated output voltage. The Voltage Monitoring signal is buffered by an op-amp. This stage is protected against short-circuit by the intrinsic protection of the op-amp.. The return for VMON signal is pin10.

3.3.5 EXTERNAL CURRENT MONITOR

Use Current Monitoring signal CMON at pin 3 of the Analog Port (13, Figure 2-2) for external current monitoring. The range of this signal is 0 to ±10V equivalent to 0 to ± rated output current. The Current Monitoring signal is buffered by an op-amp. This stage is protected against short-circuit by the intrinsic protection of the op-amp.. The return for CMON signal is pin10.

3.3.6 SETTING CURRENT LIMITS

Current limits function when the unit operates in voltage mode to limit the output current to a user-defined value. Positive and negative current limits are independent and may be set to different values. There are two methods of setting current limits, depending on whether the D Option (Display/front panel control) is installed. See PAR. 3.3.6.1 if the D Option is installed; see PAR. 3.3.6.2 if the D Option is NOT installed,

3.3.6.1 SETTING CURRENT LIMITS WITH D OPTION INSTALLED

If the D Option is installed, current limit adjustments can be done from the front panel with no additional test equipment required. Proceed as follows:

1. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

2. Connect short-circuit (rated for the unit's nominal output current) between the OUTPUT (10, Figure 2-2) and COMMON (9, Figure 2-2) rear panel terminals.

3. Set the unit to voltage mode by setting the rear panel VM-CM switch (27, Figure 2-2) to VM and set LOC-REM switch (28, Figure 2-2) to LOC (local operation).

4. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to ON.

5. Turn DC BIAS front panel pot (8, Figure 2-1) to full CW (clockwise), then press front panel BIAS ON switch (9, Figure 2-1) for bias on (green indicator lit).

6. While monitoring the front panel OUTPUT DC AMPS meter (12, Figure 2-1), adjust the rear panel +ILIM trimpot (33, Figure 2-2) to the desired positive current limit value.

7. Turn DC BIAS front panel pot (8, Figure 2-1) to full CCW (counterclockwise).

8. While monitoring the front panel OUTPUT DC AMPS meter (12, Figure 2-1), adjust the rear panel –ILIM trimpot (34, Figure 2-2) to the desired negative current limit value.

9. Press front panel BIAS ON switch (9, Figure 2-1)for bias off (indicator not lit).

10. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

11. Remove the short-circuit from OUTPUT and COMMON terminals at the rear panel.

3.3.6.2 SETTING CURRENT LIMITS WITHOUT D OPTION

If the D Option is not installed, current limit adjustments require the following:
(a) 4-terminal precision current-measuring shunt, rated for unit's nominal output current
(b) DVM with resolution and accuracy of 0.001%, minimum

1. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

2. Connect 4-terminal shunt (see (a) above between the OUTPUT (10, Figure 2-2) and COMMON (9 Figure 2-2) rear panel terminals.

3. Connect DVM (see (b) above) between the shunt's measuring terminals, with DVM's hot terminal connected to the shunt's power terminal that is connected to the rear panel OUTPUT terminal (10, Figure 2-2).

4. Set the unit to voltage mode by setting the rear panel VM-CM switch (27, Figure 2-2) to VM and set LOC-REM switch (28, Figure 2-2) to LOC (local operation).

5. Set the rear panel FP-RP switch (29, Figure 2-2) to RP.

6. Make the following connections at rear panel ANALOG Port:
   pin 8 (+10V) to pin 4 (IN_POS)
   pin 12 (Signal return/ground) to pin 11 (IN_NEG)

7. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to ON.

8. While monitoring the DVM, adjust the rear panel +ILIM trimpot (34, Figure 2-2) to the desired positive current limit value.

9. Turn off the input circuit breaker, then remove connection at rear panel ANALOG Port between pin 8 (+10V) and pin 4 (IN_POS), then connect pin 1 (-10V) to pin 4 (IN_POS)

10. Turn on the input circuit breaker, then while monitoring the DVM, adjust the rear panel –ILIM trimpot (35, Figure 2-2) to the desired negative current limit value.

11. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

3.3.7 SETTING VOLTAGE LIMITS

Voltage limits function when the unit operates in current mode to limit the output voltage to a user-defined value. Positive and negative voltage limits are independent and may be set to different values. There are two methods of setting voltage limits, depending on whether the D Option is installed. See PAR. 3.3.7.1 if the D Option is installed; see PAR. 3.3.7.2 if the D Option is NOT installed,

3.3.7.1 SETTING VOLTAGE LIMITS WITH D OPTION INSTALLED

If the D Option is installed, voltage limit adjustments can be done from the front panel with no additional test equipment required. Proceed as follows:

1. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

2. Remove any load connected between the OUTPUT (10, Figure 2-2) and COMMON (9, Figure 2-2) rear panel terminals.

3. Set the unit to current mode by setting the rear panel VM-CM switch (27, Figure 2-2) to CM and set LOC-REM switch (28, Figure 2-2) to LOC (local operation).

4. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to ON.

5. Turn DC BIAS front panel pot (8, Figure 2-1) to full CW (clockwise), then press front panel BIAS ON switch (9, Figure 2-1) for bias on (green indicator lit).

6. While monitoring the front panel OUTPUT DC VOLTS meter (11, Figure 2-1), adjust the rear panel +VLIM trimpot (32, Figure 2-2) to the desired positive voltage limit value.

7. Turn DC BIAS front panel pot (8, Figure 2-1) to full CCW (counterclockwise).

8. While monitoring the front panel OUTPUT DC VOLTS meter (11 Figure 2-1), adjust the rear panel –VLIM trimpot (35, Figure 2-2) to the desired negative voltage limit value.

9. Press front panel BIAS ON switch (9, Figure 2-1) for bias off (indicator not lit).

10. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

3.3.7.2 SETTING VOLTAGE LIMITS WITHOUT D OPTION

If the D Option is not installed, voltage limit adjustments require the following:
(a) DVM for measuring the output voltage with minimum 0.001% resolution and accuracy
(b) 4-terminal precision current-measuring shunt, rated for unit's nominal output current.

1. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

2. Remove any load connected between the OUTPUT (10, Figure 2-2) and COMMON (9, Figure 2-2) rear panel terminals.

3. Connect DVM (see (a) above) between OUT_S and COM_S terminals of terminals of the Control/Access Terminal block (7, Figure 2-2) at the rear panel.

4. Set the unit to current mode by setting the rear panel VM-CM switch (27, Figure 2-2) to CM and set LOC-REM switch (28, Figure 2-2) to LOC (local operation).

5. Set the rear panel FP-RP switch (29, Figure 2-2) to RP.

6. Make the following connections at rear panel ANALOG Port:
   pin 8 (+10V) to pin 4 (IN_POS)
   pin 12 (Signal return/ground) to pin 11 (IN_NEG)

7. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to ON.

8. While monitoring the DVM, adjust the rear panel +VLIM trimpot (34, Figure 2-2) to the desired positive voltage limit value.

9. Turn off the input circuit breaker, then remove connection between pin 8 and pin 4 at rear panel ANALOG Port, then connect pin 1 (-10V) to pin 4 (IN_POS).

10. Turn on the input circuit breaker, then while monitoring the DVM, adjust the rear panel –VIM trimpot (35, Figure 2-2) to the desired negative voltage limit value.

11. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

12. Remove the 4-terminal shunt from OUTPUT and COMMON terminals at the rear panel.

3.3.8 VOLTAGE MODE OPERATION WITH CURRENT LIMITING.

The BOP may be used as a stabilized (d-c) source of positive or negative voltage with output current limiting (for either polarity) pre-selected for the application at hand.

The programming signal can be applied at either the front panel (if D Option is installed) or the rear panel. Proceed as follows:

1. Program positive and negative voltage and current limit values (see PAR. 3.3.6 and 3.3.7).

2. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

3. Connect the load across the rear panel OUTPUT and COMMON terminals, using wires rated for the nominal output current; tie the wires together to avoid a radiating loop. If the load is heavily capacitive, C Option is recommended. If the load is mildly capacitive, application stability can be improved by either reducing the internal preamplifier bandwidth (set rear panel LOW-REG (31, Figure 2-2) switch to LOW position), or reducing the overall voltage loop bandwidth in voltage mode by connecting a ceramic cap (1nF to 1μF) between VCOR_A and VCOR_B terminals of the Control/Access Terminal block (8, Figure 2-2) at the rear panel

4. Set the unit to voltage mode by setting the rear panel VM-CM switch (27, Figure 2-2) to VM and set LOC-REM switch (28, Figure 2-2) to LOC (local operation).

5. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to ON.

6. if the D Option is installed and a local DC bias is needed, then press front panel BIAS ON switch (9, Figure 2-1) for bias on (green indicator lit), and adjust the required bias using the front panel DC BIAS pot (8, Figure 2-1). If bias is not needed, press front panel BIAS ON switch for bias off (indicator not lit).

7. Apply the external programming signal (0 to ±10V, frequency within the unit's frequency bandwidth) either at the front panel (if D Option installed) or rear panel:

   Front Panel (requires D Option). Apply the programming signal to the front panel INPUT twinax BNC type connector. This connector is present only if D Option is installed. Use two #24AWG wires in a shielded cable, terminated with a twinax plug.

   If DC bias is used, keep in mind that the bias will be added at the output to the output signal generated by the external programming signal. If the programming signal, in combination with the load value, causes the unit to reach its current limit level, the output voltage and current will be clamped, while the front panel POWER (G)/ FAULT (R)/ LIMIT (O) LED (3, Figure 2-1) will light orange to indicate a limit has been reached.

   Rear Panel. Apply the programming signal to the Analog Port connector (13, Figure 2-2) using pins 4 and 11 (differential input). Positive at pin 4 produces a positive output at OUTPUT terminal (10, Figure 2-2) referenced to COMMON terminal (9, Figure 2-2). Use a #24AWG twisted pair wire cable for programming signal connection.

8. Turn the output on (enabled) and off (disabled) from either the front panel (if D Option installed) or using a remote on-off signal.

   Front Panel (requires D Option). Set the rear panel FP-RP switch (29, Figure 2-2) to FP position then press the OUTPUT ON switch (10, Figure 2-1) as desired to turn the output on (switch lights green) or off (switch not lit). Output status is shown by the front panel OUTPUT ON light (6, Figure 2-1), that lights green for on, not lit for off.

   Remote On-Off Signal. Set the rear panel FP-RP switch (29, Figure 2-2) to RP position, then apply the on-off control signal to the rear panel EXT CTRL connector (11, Figure 2-2) pin 2 referenced to pin 8: logic 0 for on, logic 1 (5V/15V CMOS compatible) for off.

3.3.9 CURRENT MODE OPERATION WITH VOLTAGE LIMITING.

The BOP may be used as a stabilized (d-c) source of positive or negative current with output voltage limiting (for either polarity) pre-selected for the application at hand.

The programming signal can be applied at either the front panel (if D Option is installed) or the rear panel. Proceed as follows:

1. Program positive and negative voltage and current limit values (see PAR. 3.3.6 and 3.3.7)

2. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to off.

3. Connect the load across the rear panel OUTPUT (10, Figure 2-2) and COMMON (9, Figure 2-2) terminals, using wires rated for the nominal output current; tie the wires together to avoid a radiating loop. If the load is heavily inductive, L Option is recommended. If the load is mildly inductive, application stability can be improved by either reducing the internal pre-amplifier bandwidth (set rear panel LOW-REG (31, Figure 2-2) switch to LOW position), or reducing the overall voltage loop bandwidth in current mode by connecting a ceramic cap (1nF to 1μF) between ICOR_A and ICOR_B terminals of the Control/Access Terminal block (8, Figure 2-2) at the rear panel.

4. Set the unit to current mode by setting the rear panel VM-CM switch (27, Figure 2-2) to CM and set LOC-REM switch (28, Figure 2-2) to LOC (local operation).

5. Set AC POWER circuit breaker/switch (1, Figure 2-1) on the front panel to ON.

6. if the D Option is installed and a local DC bias is needed, then press front panel BIAS ON switch (9, Figure 2-1) for bias on (green indicator lit), and adjust the required bias using the front panel DC BIAS pot (8, Figure 2-1). If bias is not needed, press front panel BIAS ON switch for bias off (indicator not lit).

7. Apply the external programming signal (0 to ±10V, frequency within the unit's frequency bandwidth) either at the front panel (if D Option installed) or rear panel:

   Front Panel (requires D Option). Apply the programming signal to the front panel INPUT twinax BNC type connector. This connector is present only if D Option is installed. Use two #24AWG wires in a shielded cable, terminated with a twinax plug.

   If DC bias is used, keep in mind that the bias will be added at the output to the output signal generated by the external programming signal. If the programming signal, in combination with the load value, causes the unit to reach its voltage limit level, the output voltage and current will be clamped, while the front panel POWER (G)/ FAULT (R)/ LIMIT (O) LED (3, Figure 2-1) will light orange to indicate a limit has been reached.

   Rear Panel. Apply the programming signal to the Analog Port connector (13, Figure 2-2) using pins 4 and 11 (differential input). Positive at pin 4 produces a positive output at OUT-PUT terminal (10, Figure 2-2) referenced to COMMON terminal (9, Figure 2-2). Use a #24AWG twisted pair wire cable for programming signal connection.

8. Turn the output on (enabled) and off (disabled) from either the front panel (if D Option installed) or using a remote on-off signal.

   Front Panel (requires D Option). Set the rear panel FP-RP switch (29, Figure 2-2) to FP position then press the OUTPUT ON switch (10, Figure 2-1) as desired to turn the output on (switch lights green) or off (switch not lit). Output status is shown by the front panel OUTPUT ON light (6, Figure 2-1), that lights green for on, not lit for off.

   Remote Signal. Set the rear panel FP-RP switch (29, Figure 2-2) to RP position, then apply the on-off control signal to the rear panel EXT CTRL connector (11, Figure 2-2) pin 2 referenced to pin 8: logic 0 for on, logic 1 (TTL, CMOS 5V or 24V) for off.

3.3.10 USING THE BOP AS A VOLTAGE AMPLIFIER

If, instead of the d-c control signal (see PAR. 3.3.8), an a-c signal voltage is applied to the Voltage Programming Input terminals, the BOP functions as a bipolar amplifier. As an amplifier, the BOP voltage gain is set on each BOP model so that (as with the d-c control signal) a bipolar a-c input signal with an amplitude of 0V to 20V (peak-to-peak) will drive the BOP output through its specified (±) output voltage range. All other dynamic specifications are given in Table 1-2.

The BOP can be used to amplify, sum or scale a variety of waveshapes, some of which are illustrated in Figure 3-1. All input signals are shown 180° out of phase with their corresponding output waveshapes when the NON-INV switch (30, Figure 2-2) on the rear panel is set to INV . The latter can be readily produced in phase (i.e. with the output wave taking the same direction as the input signal) by setting the NON-INV switch on the rear panel is set to NON.

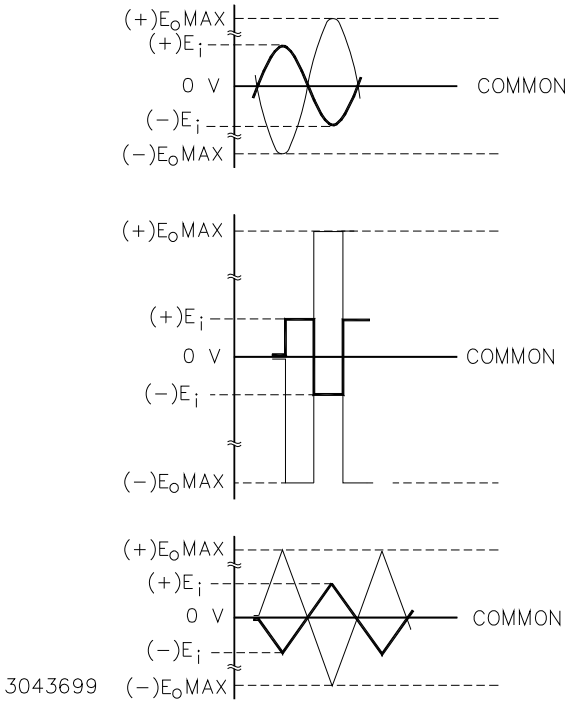


FIGURE 3-1. GRAPHS OF POSSIBLE INPUT/OUTPUT WAVESHAPES

3.3.11 USING THE BOP AS A CURRENT AMPLIFIER

In order to amplify an external "current" signal (I_{ext}), the signal must be converted into voltage, using a resistor (R_b) with a known value having a) a very low parasitic series inductance, b) a very low temperature coefficient and c) a power rating much higher than the its dissipation at maximum I_{ext} value. For proper operation $(I_{ext})(R_b) \leq 10V$.

With the BOP set in current mode, the load current/ BOP output will be

$I_{load} = (I_{ext})(R_b)(Ki\_bop)$
Ki_bop is the BOP Transfer Factor in current mode
where
$Ki\_bop = (I_{Onom})/(10)$ (A/V)

I_{Onom} is the BOP nominal output current."

3.3.12 BOP CONTROLLED BY AN EXTERNAL RESISTANCE

If an external variable resistance (R_{ext}) is connected at rear panel Terminal Block between PA_IN and PA_OUT, then for a fixed reference voltage (absolute value $|E_r| \leq 10V$) applied at BOP front panel INPUT connector (if the D Option is installed), or at the rear panel ANALOG PORT), the output voltage of the BOP (E_O) operating in voltage mode will change with the external resistance as follows:

$$E_O = (E_r)(R_{ext})(R_f) / (R_{ext} + R_f)$$

where R_f is the internal pre-amplifier feedback resistor (10k, 0.1%). For E_r, one can use the internal +10V or -10V reference voltages available at the rear panel ANALOG Port. For example, if R_{ext} is a 100k Ohms variable resistance, when using one of the internal reference voltages, the BOP output voltage will change between E_O = 0V for R_{ext} = 0 Ohms to $E_O = (0.909)(E_{Onom})$. As the above formula shows, the output voltage is not directly proportional to the programming/ controlling resistor.

3.4 SERIES/PARALLEL MASTER/SLAVE CONNECTIONS

For a discussion of series and parallel connections as well as details regarding the S Option used for master/slave configurations, refer to PAR. 5.1

SECTION 4 - CALIBRATION

4.1 INTRODUCTION

WARNING

Hazardous voltage is present within the unit when powered on while the cover is removed. Removal of the cover is permitted only by authorized Service personnel. Cover removal is only needed if the top cover does not have cutouts to allow access to trimpots and test points. Procedures and instructions found in this section are to be performed by authorized Service personnel only.

Calibration and adjustment procedures for the BOP are listed in Table 4-1. The locations of all internal controls are illustrated In Figure 4-1. Start the calibration with the rear panel switches set to their default position (see Figure 2-7). These switch settings may be changed during the calibration process.

Throughout the calibration E_O or I_O represents the BOP output voltage or current, respectively while E_{Onom} or I_{Onom} represents the nominal value of output voltage or current for each BOP model.

TABLE 4-1. INTERNAL ADJUSTMENTS AND CALIBRATIONS

Reference Designation	Control Name	Purpose	Adjustment Procedure
A1A1R3	BUFFER ZERO	Input Buffer Zero Adjustment	PAR. 4.3.1
A1A1R33	PA ZERO	Preamplifier Zero Adjustment	PAR. 4.3.2
A1A2R12	VMON & VFBK ZERO	Voltage Monitor and Voltage Feedback Zero (1) Adjustment	PAR. 4.3.3
A1A1R112	E_O ZERO	Output Voltage Zero Adjustment	PAR. 4.3.4
A1A1R118	I_O SENSE ZERO	Output Current Sensing Zero Adjustment	PAR. 4.3.5
A1A1R113	I_O ZERO	Output Current Zero Adjustment	PAR. 4.3.6
A1A1R72	I_O FS	Full Scale Output Current Calibration	PAR. 4.3.7
A5R24	PAR SLV I_O REF ZERO	Parallel Slave Output Current Reference Zero Adjustment	PAR. 4.4.1
A5R17	PAR SLV I_O ZERO	Parallel Slave Output Current Zero Adjustment	PAR. 4.4.2
A5R28	SER SLV E_O ZERO	Series Slave Output Voltage Zero Adjustment	PAR. 4.4.3
(1) Voltage Feedback adjustment for models with $E_{Onom} \leq 10V$ only.			

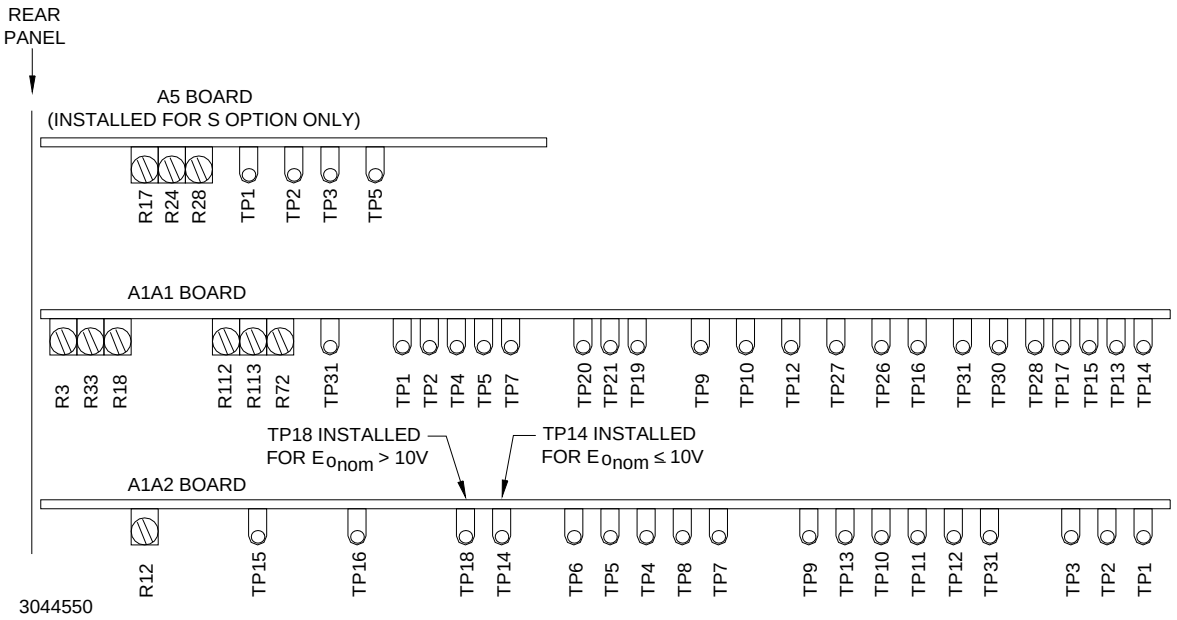


FIGURE 4-1. LOCATIONS OF CALIBRATION ADJUSTMENTS AND TEST POINTS, TOP VIEW, COVER REMOVED

4.2 TEST EQUIPMENT REQUIREMENTS

Table 4-2 lists sense resistors recommended for measuring current and includes Kepco and Manufacturer's part numbers. The value of the sense resistor chosen should be known with 0.001% accuracy. If other than a recommended sense resistor is to be used, it must be rated for at least 100W power dissipation (actual power dissipation will be less than 10W). The thermal coefficient of the sense resistor chosen should be 10 ppm/°C or better.

The digital voltmeter (DVM) used to measure output voltage and the voltage across the current sensing resistor should have at least six digits, multiple ranges, the smallest resolution must be at least one microvolt and the accuracy must be at least 0.001%.

To calibrate the external programming capabilities of the BOP a DC reference voltage with the following minimum specifications is required.

- Value: 0.0V ±0.01mV and 10.0V ±0.01mV (either positive and negative or floating)
- Stability: better than 10^{-5}
- Internal Impedance: better than 0.1 Ohms
- Output Current: >0.5mA when sourcing, >0.15mA when sinking

TABLE 4-2. SUGGESTED SENSE RESISTORS

MODEL	VALUE	KEPCO PART NO.	MANUFACTURER	MANUFACTURER PART NO.
BOP 5-80H BOP 10-40H BOP 20-20H BOP 36-12H	0.001 OHM	115-3033	ISOTEK	RUG-Z-R001-0.1 TK10
BOP 50-4H BOP 72-6H BOP 100-4	0.01 OHM	115-2997	ISOTEK	RUG-Z-R010-0.1 TK10
NOTE: Selected sense resistor must be mounted on a heatsink with a minimum surface area of 36 square inches to maintain thermal stability during calibration; forced cooling is recommended. Kepco Heatsink P/N 136-0451 will provide adequate cooling for the sense resistor.				

4.3 INTERNAL ADJUSTMENTS AND CALIBRATIONS

See Figure 4-1 for location of adjustment controls. For complete calibration of the unit it is recommended that the adjustments be done in the order presented.

NOTES: 1. These controls are factory calibrated. Recalibration is necessary only if components related to the circuitry involving these controls have been replaced or if there are indications that the unit is out of calibration.

2. Before using the BOP in any application, please refer to Section 2 to get acquainted with the operating controls, a-c power requirements and information on load connections and grounding.

3.If there are no access holes in the top cover to access adjustments, top cover removal is required: remove seven (7) screws on each side, two (2) screws at top (front) and three (3) screws at top (rear).

4. Perform all calibration adjustments after 15 to 30 minute, warm-up time, with no load at the output.

4.3.1 BUFFER ZERO (A1A1R3)

This adjustment sets the output offset of the BOP input differential buffer to zero

1. Turn BOP off and set the factor transfer sign, either inverting or non-inverting,

2. Without a load connected to the BOP output, place a short circuit across the BOP input, at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11..

3. Set BOP to voltage mode.

4. Connect the DVM to the rear panel Terminal Block between PA_INA and COM_S terminals.

5. Locate A1A1R3 (see Figure 4-1).

6. Turn on BOP. Wait five minutes, then adjust R3 for 0V ±0.01mV on the DVM.

7. Turn off BOP.

4.3.2 PREAMPLIFIER ZERO (A1A1R33)

This adjustment sets the output offset of the BOP preamplifier to zero.

1. Turn BOP off and configure the preamplifier: set amplification factor as desired, set the transfer factor sign either inverting or non-inverting.

NOTE: Whenever Preamplifier configuration is changed, this Zero control R33 should be readjusted

2. Without a load connected to the BOP output, place a short circuit across the BOP input (at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11.).

3. Set BOP to Voltage Mode.

4. Connect the DVM to the Rear Terminal Block between PA_OUT and COM_S.

5. Locate the Preamplifier Zero control R33 (see Figure 4-1).

6. Turn on BOP. Wait five minutes, then adjust R33 for 0V ±0.01mV on the DVM.

7. Turn off BOP.

4.3.3 VOLTAGE MONITOR AND FEEDBACK ZERO (A1A2R12)

For models with E_{Onom} > 10V this adjustment sets the voltage monitor offset of the BOP to zero. For models with $E_{Onom} \leq$ 10V this adjustment sets the voltage monitor offset plus the voltage feedback signal to zero.

1. Turn off BOP.

2. Without a load connected to the BOP output, place a short circuit across the BOP input (at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11.).

3. Set BOP to Voltage Mode.

4. For models with E_{Onom} > 10V connect DVM to test point A1A1TP13, referenced to rear panel Terminal Block COM_S terminal.

   For models with $E_{Onom} \leq$ 10V connect the DVM to test point A1A2TP14, referenced to the rear panel Terminal Block COM_S terminal.

5. Locate A1A2R12 trimpot (see Figure 4-1).

6. Turn on BOP. Wait five minutes, then adjust R12 for 0V ±0.01mV on the DVM.

7. Turn off BOP.

4.3.4 OUTPUT VOLTAGE ZERO ADJUSTMENT (A1A1R112)

This adjustment sets the output voltage offset to zero.

1. Turn off BOP.
2. Without a load connected to the BOP output, place a short circuit across the BOP input (at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11.).
3. Set BOP to Voltage Mode.
4. Connect a digital voltmeter to the rear panel Terminal Block at OUT_S terminal referenced to COM_S terminal.
5. Locate R112 trimpot (see Figure 4-1).
6. Turn on BOP. Wait five minutes, then adjust R112 for output voltage of 0V ± (0.00001 x E_{Onom})V
7. Turn off BOP.

4.3.5 OUTPUT CURRENT SENSING ZERO ADJUSTMENT (A1A1R18)

This adjustment sets the output offset of the BOP current sensing amplifier to zero.

1. Turn off BOP.
2. Without a load connected to the BOP output, place a short circuit across the BOP input (at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11.).
3. Set BOP to Voltage Mode.
4. Connect a digital voltmeter to test point A1A1TP31, referenced to the rear panel Terminal Block at COM_S terminal.
5. Locate R18 trimpot. (see Figure 4-1).
6. Turn on BOP. Wait 5 minutes, then adjust R18 for output voltage of 0V ± 0.01mV
7. Turn off BOP.

4.3.6 OUTPUT CURRENT ZERO ADJUSTMENT (A1A1R113)

This adjustment sets the output current offset to zero.

1. Turn off BOP.
2. Without a load connected to the BOP output, place a short circuit across the BOP input at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11.

3. Set BOP to Current Mode.

4. Connect a precision current measuring shunt between BOP OUTPUT and COMMON output power terminals.

5. Connect DVM to the shunt's sensing terminals with the DVM return terminal connected to the same shunt sensing terminal that is connected to the BOP COMMON power terminal.

6. Locate R113 trimpot (see Figure 4-1).

7. Turn on BOP. Wait five minutes, then adjust R113 for output current of 0A ± (0.00001 x I_{Onom})A. Calculate the output current as (DVM voltage in volts)/(Shunt resistance in Ohms).

8. Turn off BOP.

4.3.7 OUTPUT CURRENT FULL SCALE CALIBRATION (A1A1R72)

This adjustment calibrates output current to its full scale (nominal) value.

1. Turn off BOP.

2. At the BOP front panel INPUT connector (if D Option is installed) or at the rear panel ANALOG INPUT port, apply a +10V ± 0.01mV external programming voltage.

3. Set BOP to Current Mode by setting VM-CM switch at the rear panel to CM

4. Connect precision current measuring shunt between BOP OUTPUT and COMMON output power terminals.

5. Connect DVM to the shunt's sensing terminals with the DVM return terminal connected to the same shunt sensing terminal that is connected to the BOP COMMON power terminal.

6. Locate R72 trimpot (see Figure 4-1).

7. Turn on BOP. Wait five minutes, then adjust R72 for output current of I_{Onom} ± (0.00001 x I_{Onom})A. Calculate the output current as (DVM voltage in volts)/(Shunt resistance in Ohms).

8. Turn off BOP.

4.4 S OPTION CALIBRATIONS AND ADJUSTMENTS

If a multiple unit configuration output is inaccurate even though the individual units are properly calibrated, use the following procedures to calibrate the multiple unit combination.

The Master-Slave S Option has three zero adjustments that work to calibrate the master/slave combination. Two are for parallel master/slave configurations and on is for a series connected master/slave configurations These adjustments are factory calibrated. However, if required, they can be performed as follows after first ensuring that the individual units are properly calibrated.:

4.4.1 PARALLEL SLAVE OUTPUT CURRENT REFERENCE ZERO (A5R24)

This adjustment sets the offset of a parallel-connected Slave differential buffer circuit (used for the current reference coming from the master) to zero.

1. Turn off power to both master and slave BOP units.

2. Connect the units in a parallel configuration: refer to PAR. 5.3.1 and 5.3.2 to set the master and slave initial settings. Refer to PAR. 5.3.3 for connections if using local sensing; refer to PAR. 5.3.4 for connections if using remote sensing.

3. Without a load connected to the parallel-connected configuration output, place a short circuit across the BOP master input (at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11.).

4. Set BOP master to Voltage Mode by setting VM-CM switch at the rear panel to VM.

5. Connect a DVM to slave test point A1A1TP5, referenced to slave rear terminal block COM_S terminal.

6. Locate A5R24 trimpot (see Figure 4-1)..

7. Turn on both master and slave. Wait five minutes, then adjust A5R24 at the slave for 0V ± 0.01mV. as shown on DVM

8. Turn off both master and slave.

4.4.2 PARALLEL SLAVE OUTPUT CURRENT ZERO (A5R17)

This adjustment sets the parallel-connected Slave output current to zero.

1. Turn off power to both master and slave BOP units.

2. Connect the units in a parallel configuration: refer to PAR. 5.3.1 and 5.3.2 to set the master and slave initial settings. Refer to PAR. 5.3.3 for connections if using local sensing; refer to PAR. 5.3.4 for connections if using remote sensing.

3. Connect precision current measuring shunt in series with the wire connecting master OUTPUT to slave OUTPUT.

4. Place a short-circuit at the master output, between OUTPUT and COMMON, using a wire properly current rated for expected short circuit current.

5. Without a load connected to the parallel configuration output, place a short circuit across the master BOP input (at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11.).

6. Set master to Current Mode by setting VM-CM switch at the rear panel to CM.

7. Connect a DVM to the shunt's sensing terminals with the DVM return terminal connected to the same shunt sensing terminal where the slave BOP OUTPUT is connected.

8. Locate R17 trimpot. (see Figure 4-1).

9. Turn on both master and slave. Wait five minutes, then adjust A5R17 at the slave for 0A ± (0.00001 x I_{Onom})A.

10. Turn off both master and slave.

4.4.3 SERIES SLAVE OUTPUT VOLTAGE ZERO (A5R28)

This adjustment sets the offset of the Slave input circuit (used for the voltage reference coming from the master) to zero.

1. Turn off power to both master and slave BOP units.

2. Connect the units in a series configuration: refer to PAR. 5.4.1 and 5.4.2 to set the master and slave initial settings. Refer to PAR. 5.4.3 for connections if using local sensing; refer to PAR. 5.4.4 for connections if using remote sensing.

3. Without a load connected to the series configuration output, place a short circuit across the master input (at either the front panel INPUT twinax BNC type connector if D Option is installed or the rear panel Analog Port connector (13, Figure 2-2), pins 4 and 11.).

4. Set master to Voltage Mode by setting VM-CM switch at the rear panel to VM

5. Connect DVM to the slave rear terminal block OUT_S terminal referenced to COM_S terminal.

6. Locate R28 trimpot. (see Figure 4-1).

7. Turn on both master and slave. Wait five minutes, then adjust A5R28 for 0V ± (0.00001 x E_{Onom})V. as shown on the DVM

8. Turn off both master and slave.

SECTION 5 - S OPTION - SERIES/PARALLEL MASTER/SLAVE

5.1 INTRODUCTION

Voltage sources, such as batteries, cells or stabilized d-c power supplies can be readily series-connected, but normally they can not be paralleled. Even small differences in their terminal potential would cause large, damaging, circulating currents. By complementary reasoning, current sources can easily be paralleled, but not series-connected.

There are two basic methods which are commonly used for the series or parallel connection of stabilized d-c power supplies. The first method is the “Automatic” series or parallel connection by which the power supply outputs are simply connected together, in series or parallel, as required. The “Automatic” method presents no problems as long as it is confined to series connection with voltage sources, or to parallel connection with current sources. The proper settings for automatic series and parallel connection are as follows:

Automatic series connection:

VM-CM Mode switches of all BOP’s set to VM.
Set ±Current Limit for one BOP lower than ±Current Limit for the others.

Automatic parallel connection:

VM-CM Mode switches of all BOPs set to CM.
Set ±Voltage Limit for one BOP lower than ±Voltage Limit for the others.

The second method for series or parallel connection of two or more units is the “Master/Slave” configuration, by which a designated Master supply controls the output of one or more Slave units. This control method permits control of the common output by a single unit - the Master. Since this method presents the least problems for either series or parallel connections and since it is readily implemented with BOP power supplies, it is the recommended method for this kind of operation; it requires the S Option to be installed and is described below.

5.2 MULTIPLE UNIT CONFIGURATIONS (S OPTION REQUIRED)

Parallel and series configurations of identical BOP-H units increase the rated voltage and current range of the power supply. Up to five BOP-H units can be connected in parallel to increase the current: $I_{MAX\ (one\ unit)} \times N_P = I_{MAX\ (parallel\ combination)}$ where N_P = number of units in parallel. Similarly, up to three units can be connected in series to increase the voltage: $E_{MAX\ (one\ unit)} \times N_S = E_{MAX\ (parallel\ combination)}$ where N_S = number of units in series.

Multiple unit configurations require the appropriate Interconnection Kit (see Table 1-5). Even though it is possible to connect up to five units in parallel and three units in series, consult factory to configure more than two units. The interconnection cables required for configuring two units are shown in Figure 5-1 for parallel with local sensing, Figure 5-2 for parallel with remote sensing, Figure 5-3 for series with local sensing and Figure 5-4 for series with remote sensing.

5.2.1 CONFIGURING MULTIPLE UNITS - GENERAL RULES

Before connecting the units in parallel or in series, turn off all units and remove any previous interconnections between units as well as connections to the load. The following are general rules that apply to multiple unit configurations of BOP-H power supplies:

- Multiple units should all have the same options installed, except that the master may have G, E or D Options installed even if the slaves do not.

- Use the cables indicated by Figures 5-1 thru 5-4 for interconnections between units.
- Except for the S Option switches, the rear panel switches of the slave should be set to the default settings (see PAR. 2.3). The unit will be set automatically to the proper mode of operation
- Except for the S Option switches, set the Master unit rear switches as needed for your application.
- Set rear panel YES-NO (@FAIL) switch to the NO (default) position for all units
- The rear panel NO-YES (@P.LOSS) switch can be set to either YES (default) or NO. Use the same setting for all units.
- Be aware that the digital control for the Master unit is summed with the analog remote programming signal (if applied) and with the DC BIAS programming signal (if D Option is installed and DC BIAS is enabled).
- If all units have either the digital G or E Option installed and it is desired that the system be controlled digitally, then install an interconnection cable (consult Kepco) between the units' rear IEEE1118 ports; also set the rear address switches of the S-option as follows:
  Master: AD1 = 0AD2 = 0AD4 = 0
  Slave: AD1 = 1AD2 = 0AD4 = 0
- For proper interconnection cable routing place the Master unit on top of the Slave unit.
- Refer to PAR. 2.8 for load wiring recommendations.
- Refer to PAR. 2.8.3 for a-c ground and PAR. 2.8.4 for d-c ground recommendations.
- Connect all units to the same single-phase AC source.

5.3 PARALLEL MASTER/SLAVE CONFIGURATIONS

5.3.1 MASTER INITIAL SETTINGS (PARALLEL)

Before connecting the units in parallel, designate one unit as the Master and make the following initial settings as described below:

1. If the Master has the D Option installed, then at the rear panel set FP-RP switch to FP (front panel) position for output on-off control from the front panel. The output can be then controlled using the front panel DC BIAS control and/or using an analog control signal applied to the front panel INPUT connector.

   If the Master does not have the D Option installed, or if remote on-off control is desired, set the FP-RP to RP (Rear Panel) position to use the EXT CTRL Port for output on-off control and the ANALOG Port (13, Figure 2-2) for output control. The simplest way to control output on/off when using the analog control source at the rear ANALOG Port is to use a switch between EXT CTRL Port pin 1 and pin 2 (open = output on) as shown in Figures 5-1 (local sensing) and 5-2 (remote sensing).

2. Set the rear panel LOC-REM switch to LOCal position, and use the VM-CM switch to set the required mode of operation for the configuration: VM for voltage mode (as shown in Figure 5-1) or CM for current mode.

3. Unless there are specific requirements for the transfer factor sign, leave the rear panel NON-INV rear switch in the NON (default) position for a positive transfer factor.

4. Leave the rear panel LOW-REG switch in the REG (default) position for the regular (large frequency) bandwidth. If a lower bandwidth is required to stabilize the application, set the LOW-REG switch to the LOW position.

5. Leave NO-YES(@P.LOSS) in the YES (default) position.

6. Leave YES-NO(@FAIL) in the NO (default)position.

7. Set the rear panel ALO-MUL switch to MUL (MULtiple) position

8. Set the rear panel PAR-SER switch to PAR (PARallel) position.

9. Set the rear panel MAS-SLA switch to MAS (MASter) position.

10. Set the rear panel AD1, AD2 and AD4 switches to 0.

11. For local sensing refer to Figure 5-1 and leave the wire links in place connecting OUT_S to OUT_M and connecting COM_S to COM_M at the rear terminal block.

    For remote sensing refer to Figure 5-2 and remove the wire links from OUT_S to OUT_M and from COM_S to COM_M at the rear terminal block.

5.3.2 SLAVE INITIAL SETTINGS (PARALLEL)

Before connecting the two units in parallel, designate one unit as the Slave and make the following initial settings as described below:

1. If the Slave has the D Option installed, leave the DC BIAS switch set to OFF position. Do not apply any signal to the front panel INPUT connector.

2. Do not apply any control signal to the corresponding output control input of the ANALOG port.

3. Do not exercise or apply output on-off controls to the Slave unit

NOTE: The rear panel VM-CM switch position is ignored for the slave. Voltage Mode (VM) or Current Mode (CM) is determined automatically by the parallel or series configuration setting.

4. Leave rear panel NON-INV switch set to NON (default) position.

5. Leave rear panel LOW-REG switch set to REG (default) position.

6. Leave rear panel NO-YES(@P.LOSS) switch set to YES (default) position.

7. Leave rear panel YES-NO(@FAIL) switch se to NO (default) position.

8. Set rear panel ALO-MUL switch to MUL (MULtiple) position

9. Set rear panel PAR-SER switch to PAR (PARallel) position.

10. Set rear MAS-SLA switch to SLA (SLAve) position.

11. Set rear panel AD1, AD2 and AD4 switches to 0, however if the unit is under digital control (via G or E Option), set AD1 to 1.

12. At the rear panel terminal block leave wire links connecting OUT_S to OUT_M and COM_S to COM_M in place and remove the COM_M to GND_NET wire link (see Figure 5-1 for local sensing or Figure 5-2 for remote sensing.

5.3.3 LOCAL SENSING CONNECTIONS (PARALLEL)

The following instructions are used to connect two units in a parallel master/slave configuration using local sensing as shown in Figure 5-1.

1. At the master, install termination 195-0123 into MASTER SLAVE IN connector (15, Figure 2-2).

2. At the slave, install termination 195-0124 into MASTER SLAVE OUT connector (14, Figure 2-2).

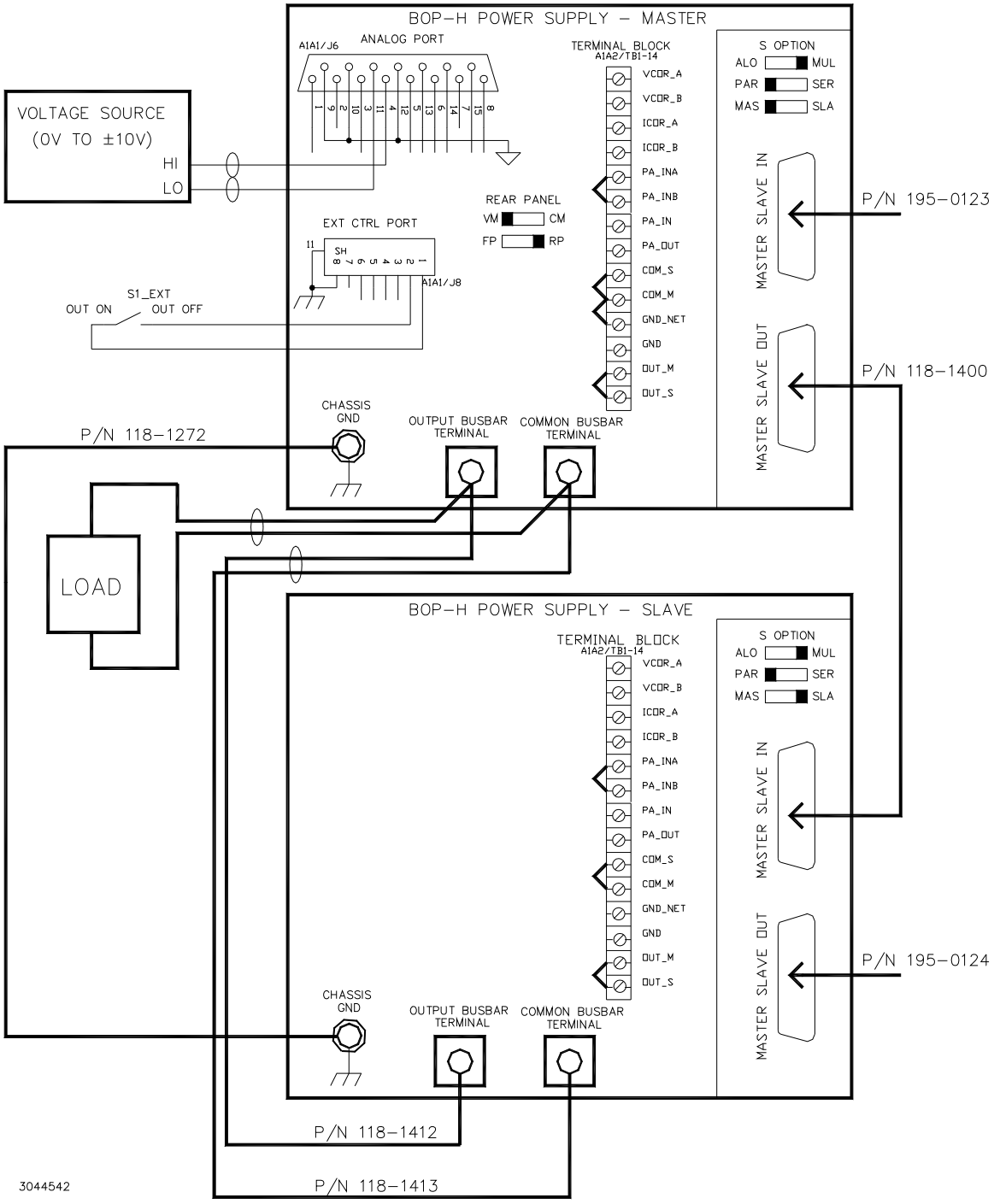
3. Using either end of cable 118-1400, connect MASTER SLAVE OUT on master to MASTER SLAVE IN on slave.

4. Use cable 118-1413 to connect Master COMMON terminal (9, Figure 2-2). with Slave COMMON terminal.

5. Use cable 118-1412 to connect Master OUTPUT terminal (10, Figure 2-2). with Slave OUTPUT terminal.

6. Use cable 118-1272 to connect Master CHASSIS-GND terminal stud (7, Figure 2-2). with Slave CHASSIS-GND terminal stud.

7. Connect the load to the Master OUTPUT (10, Figure 2-2) and COMMON (9, Figure 2-2) terminals, using a pair of wires tied together and rated for the configuration’s total current.



NOTE: Consult factory for configurations requiring more than two units in parallel.

FIGURE 5-1. PARALLEL CONFIGURATION, LOCAL SENSING, TYPICAL

5.3.4 REMOTE SENSING CONNECTIONS (PARALLEL)

The following instructions are used to connect two units in a parallel master/slave configuration using remote sensing as shown in Figure 5-2.

1. Perform steps 1 through 7 of PAR. 5.3.4 above.

2. Verify that wire links between OUT_S and OUT_M (see 8, Figure 2-2) and between COM_S and COM_M on the master have been removed as specified in PAR. 5.3.1, step 11 for remote sensing.

3. Using a #22AWG wire pair, connect the Master OUT_S terminal (see 8, Figure 2-2) to the same Load terminal where the wire from Master OUTPUT (10, Figure 2-2) is connected and connect the Master COM_S terminal to the same Load terminal where the wire from Master COMMON (9, Figure 2-2) is connected.

5.3.5 PARALLEL CONFIGURATION OPERATION

The following instructions describe how to operate a parallel-connected master/slave configuration.

NOTE: All static specifications presented in Table 1-2 referring to ratings are applicable to the parallel configuration.

1. Turn on the Master A-C POWER circuit breaker (1, Figure 2-1) and then the Slave input circuit breaker.

2. After a few seconds the BOP configuration is operational, able to be programmed either by the Master DC BIAS control (8, Figure 2-1) if D Option is installed, or by a remote analog programming signal applied to the Master ANALOG PORT (13, Figure 2-2) at the rear panel.

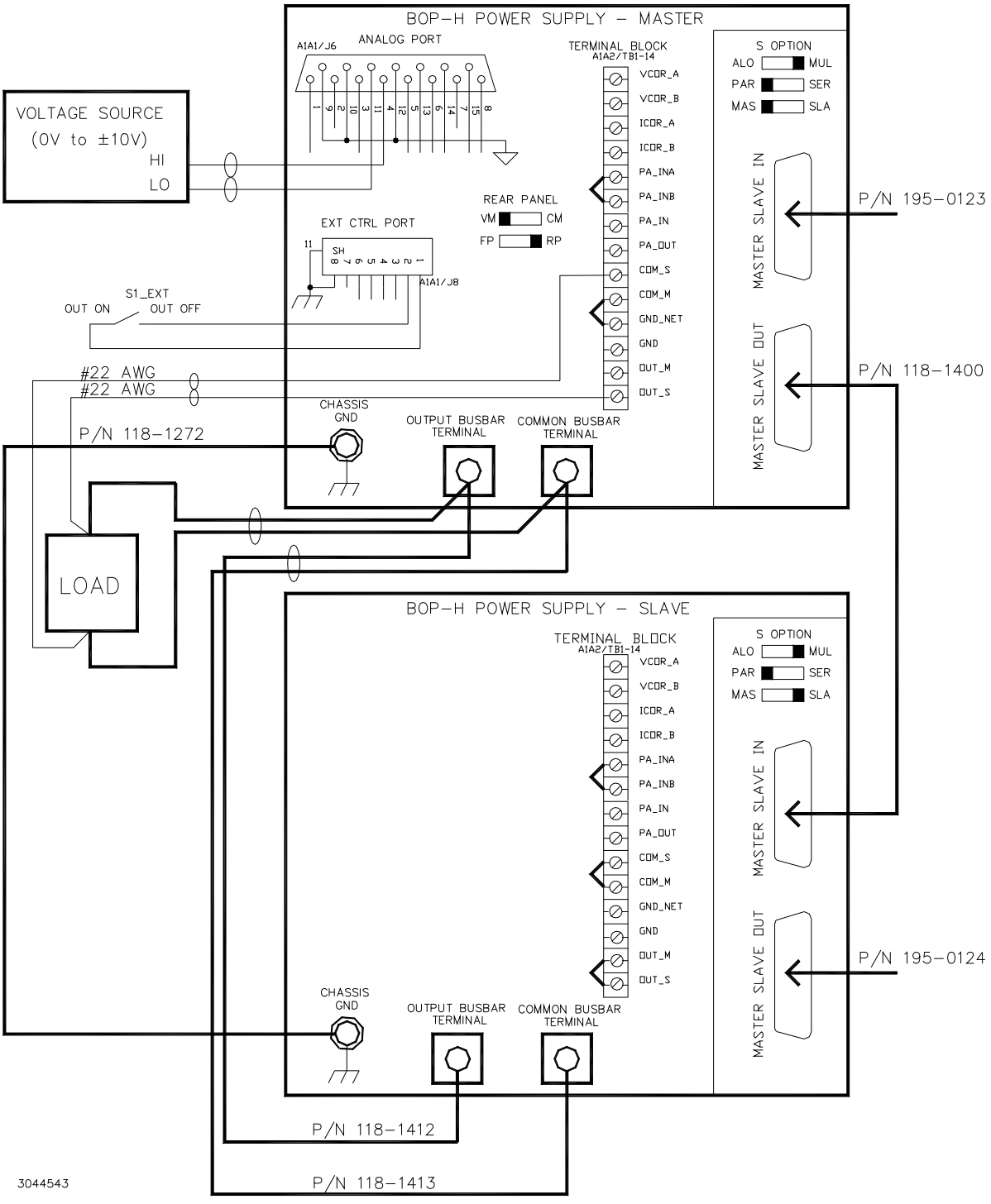
3. To monitor the configuration's output voltage for voltage mode and local sensing, use a DVM connected between the Master's OUT_S and COM_S terminals.

   For voltage mode and remote sensing, the configuration's output voltage can be also monitored by connecting a DVM to the load terminals where the sensing wires are attached.

NOTE: Theoretically, the 3-dB frequency bandwidth for a parallel configuration changes as follows:

- For voltage mode (resistive load): because the slave is in current mode, the configuration bandwidth is the BOP bandwidth in current mode.

- For current mode (short-circuit): configuration bandwidth is 0.707 of the BOP bandwidth in current mode.



NOTE: Consult factory for configurations requiring more than two units in parallel.

FIGURE 5-2. PARALLEL CONFIGURATION, REMOTE SENSING, TYPICAL

5.4 SERIES MASTER SLAVE CONFIGURATIONS

5.4.1 INITIAL MASTER SETTINGS (SERIES)

Before connecting the two units in series, designate one unit as the Master and make the following initial settings as described below:

1. If the Master has the D Option installed, then at the rear panel set FP-RP switch to FP (front panel) position for output on-off control from the front panel. The output can be then controlled using the front panel DC BIAS control and/or using an analog control signal applied to the front panel INPUT connector.

   If the Master does not have the D Option installed, or if remote on-off control is desired, then set the FP-RP to RP (Rear Panel) position to use the EXT CTRL Port for output on-off control and the ANALOG Port (13, Figure 2-2) for output control. The simplest way to control output on/off when using the analog control source at the rear ANALOG Port is to use a switch between EXT CTRL Port pin 1 and pin 2 (open = output on) as shown in Figures 5-1 (local sensing) and 5-2 (remote sensing).

2. Set the rear panel LOC-REM switch to LOCal position, and use the VM-CM switch to set the required mode of operation for the configuration: VM for voltage mode (as shown in Figure 5-1) or CM for current mode.

3. Unless there are specific requirements for the transfer factor sign, leave the rear panel NON-INV rear switch in the NON (default) position for a positive transfer factor.

4. Leave the rear panel LOW-REG switch in the REG (default) position for the regular (large frequency) bandwidth. If a lower bandwidth is required to stabilize the application, set the LOW-REG switch to the LOW position.

5. Leave NO-YES(@P.LOSS) in the YES (default) position.

6. Leave YES-NO(@FAIL) in the NO (default)position.

7. Set the rear panel ALO-MUL switch to MUL (MULtiple) position

8. Set the rear panel PAR-SER switch to SER (SERies) position.

9. Set the rear panel MAS-SLA switch to MAS (MASter) position.

10. Set the rear panel AD1, AD2 and AD4 switches to 0.

11. For local sensing refer to Figure 5-3 and leave the wire links in place connecting OUT_S to OUT_M and connecting COM_S to COM_M at the rear terminal block.

    For remote sensing refer to Figure 5-4 and remove the wire link from COM_S to COM_M at the rear terminal block.

5.4.2 INITIAL SLAVE SETTINGS (SERIES)

Before connecting the two units in series, designate one unit as the Slave and make the following initial settings as described below:

1. If the Slave has the D Option installed, leave the DC BIAS switch set to OFF position. Do not apply any signal to the front panel INPUT connector.

2. Do not apply any control signal to the corresponding output control input of the ANALOG port.

3. Do not exercise or apply output on-off controls to the Slave unit

NOTE: The rear panel VM-CM switch position is ignored for the Slave. Voltage Mode (VM) or Current Mode (CM) is determined automatically by the parallel or series configuration setting.

4. Leave rear panel NON-INV switch set to NON (default) position.

5. Leave rear panel LOW-REG switch set to REG (default) position.

6. Leave rear panel NO-YES(@P.LOSS) switch set to YES (default) position.

7. Leave rear panel YES-NO(@FAIL) switch se to NO (default) position.

8. Set rear panel ALO-MUL switch to MUL (MULtiple) position

9. Set rear panel PAR-SER switch to SER (SERies) position.

10. Set rear MAS-SLA switch to SLA (SLAve) position.

11. Set rear panel AD1, AD2 and AD4 switches to 0, however if the unit is under digital control (via G or E Option), set AD1 to 1.

12. For local sensing, at the rear panel terminal block leave in place wire link connecting OUT_S to OUT_M and remove wire link connecting COM_S to COM_M and COM_M to GND_NET (see Figure 5-3).

    For remote sensing, at the rear panel terminal block remove wire links connecting OUT to OUT_S, COM to COM_S and COM_M to GND_NET (see Figure 5-4).

5.4.3 LOCAL SENSING CONNECTIONS (SERIES)

The following instructions are used to connect the two units in a series master/slave configuration using local sensing, as shown in Figure 5-3.

1. At the master, install termination 195-0123 into MASTER SLAVE IN connector (15, Figure 2-2).

2. At the slave, install termination 195-0124 into MASTER SLAVE OUT connector (14, Figure 2-2).

3. Using either end of cable 118-1400, connect MASTER SLAVE OUT on master to MASTER SLAVE IN on slave.

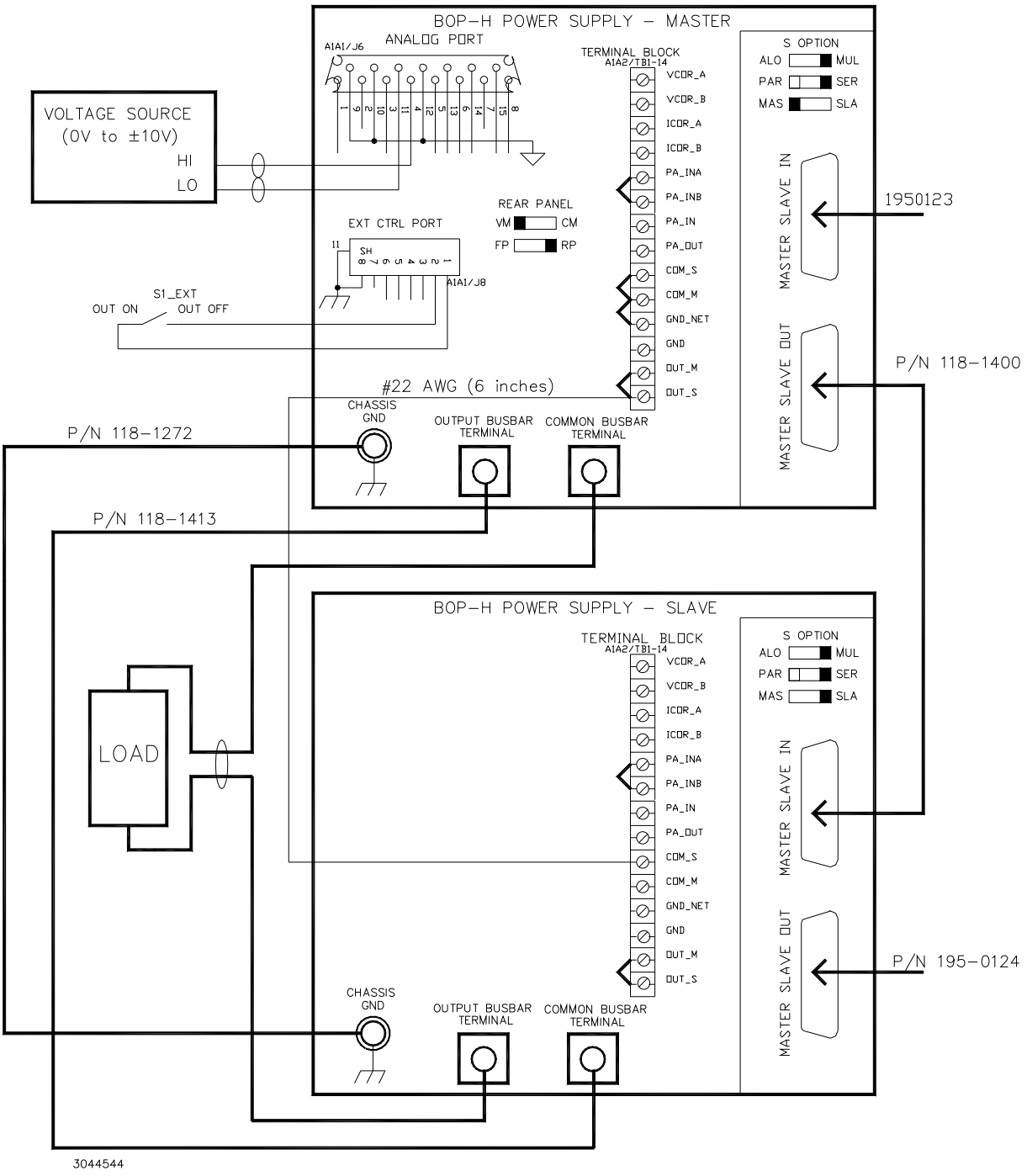
4. Use cable 118-1413 to connect Master OUTPUT terminal (10, Figure 2-2).with Slave COMMON terminal (9, Figure 2-2).

5. Remove COM_S to COM_M and COM_M to GND_NET wire links at rear terminal block of Slave.

6. Connect Master OUT_S terminal to Slave COM_S terminal using a #22AWG wire (6in long).

7. Use cable 118-1272 to connect Master CHASSIS-GND terminal stud (7, Figure 2-2). with Slave CHASSIS-GND terminal stud.

8. Connect the load to the Slave OUTPUT (10, Figure 2-2) and Master COMMON (9, Figure 2-2) terminals, using a pair of wires tied together and rated for the configuration's total current.



NOTE: Consult factory for configurations requiring more than two units in series.

FIGURE 5-3. SERIES CONFIGURATION, LOCAL SENSING, TYPICAL

5.4.4 REMOTE SENSING CONNECTIONS (SERIES)

The following instructions are used to connect the two units in a series master/slave configuration using remote sensing, as shown in Figure 5-4.

1. Perform steps 1 through 8 as specified in PAR. 5.4.3 above.

2. Verify that wire links between COM_S and COM_M (see 8, Figure 2-2) on the Master have been removed.

3. Verify that wire link from OUT_S to OUT_M, COM_S to COM_M and COM_M to GND_NET (see 8, Figure 2-2) on the Slave has been removed as specified in PAR. 5.4.2, step 12.

4. Use a #22AWG wire pair to connect the Slave OUT_S terminal to the same Load terminal where the wire from Slave OUTPUT is connected and connect the Master COM_S terminal to the same Load terminal where the wire from Master COMMON is connected.

5.4.5 SERIES CONFIGURATION OPERATION

The following instructions describe how to operate a series-connected master/slave configuration.

1. Turn on the Master A-C POWER circuit breaker (1, Figure 2-1) and then the Slave input circuit breaker.

2. After a few seconds the BOP configuration is operational, able to be programmed either by the Master DC BIAS control (8, Figure 2-1) if D Option is installed, or by a remote analog programming signal applied to the Master ANALOG PORT (13, Figure 2-2) at the rear panel.

3. To monitor the configuration's output voltage for voltage mode and local sensing, use a DVM connected between the Slave OUT_S and Master COM_S terminals

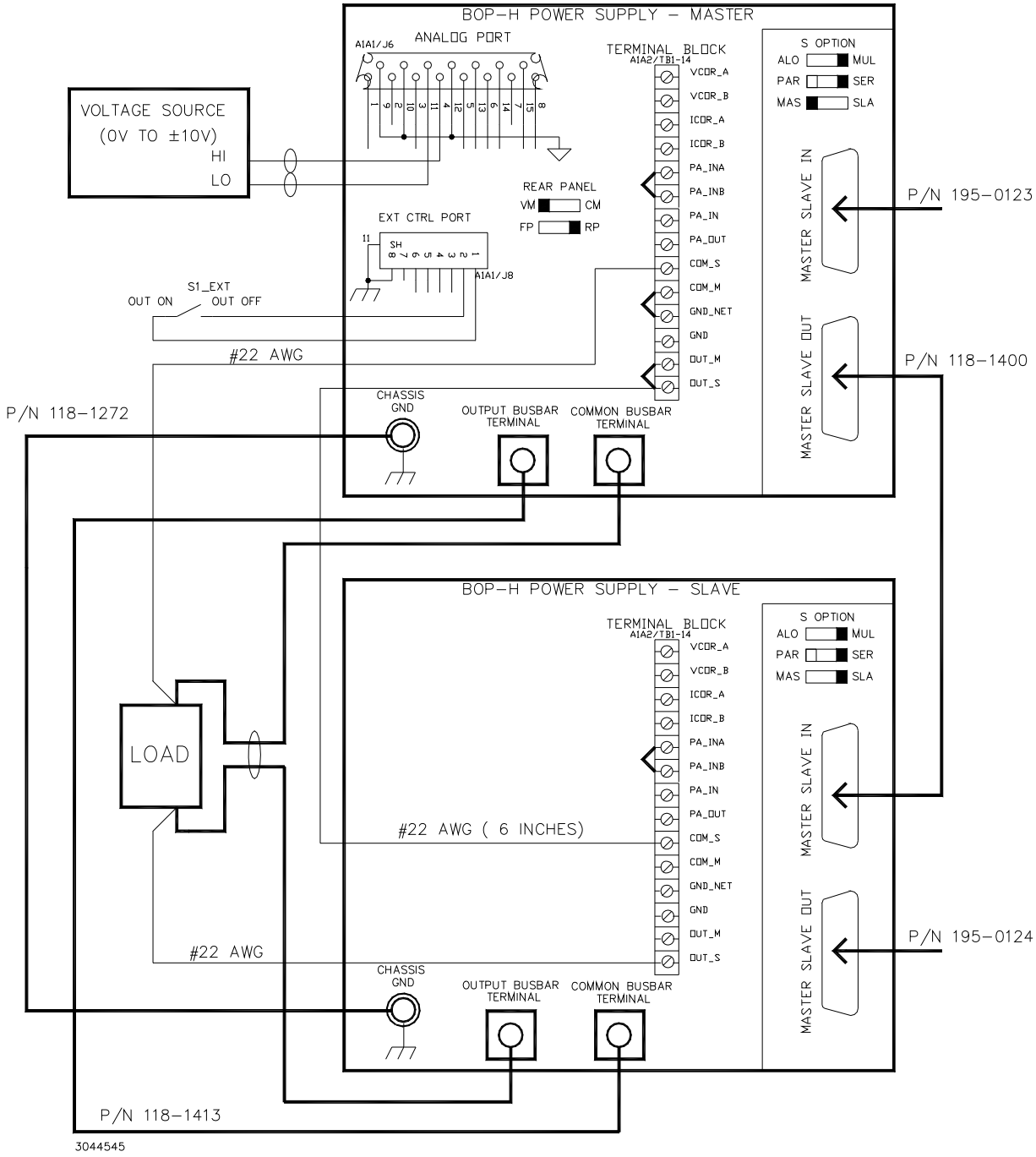
   For voltage mode and remote sensing, the configuration's output voltage can be also monitored by connecting a DVM to the load terminals where the sensing wires are attached.

4. To monitor the configuration’s output current connect a precision current measuring shunt in series with the load.

NOTE: All the BOP static specifications presented in Table 1-2 referenced to the configuration's ratings are applicable to the series configuration. Theoretically, the 3-dB frequency bandwidth for a series configuration changes as follows:

- For voltage mode (resistive load) the configuration bandwidth is as follows:
  - for two in series: 0.707 of the individual BOP bandwidth in voltage mode.
  - for three in series: 0.5 of the individual BOP bandwidth in voltage mode.

- For current mode (short-circuit): the configuration bandwidth is the BOP bandwidth in current mode.



NOTE: Consult factory for configurations requiring more than two units in series.

FIGURE 5-4. SERIES CONFIGURATION, REMOTE SENSING, TYPICAL

5.5 TOTAL OUTPUT VOLTAGE AND CURRENT OF FOR MULTIPLE UNITS

For parallel or series configurations of units that all have a digital option (G or E Option installed), the master unit will report (digitally) the system's output voltage and output current. If the D Option is installed, the front panel display of each unit will present that unit's output voltage and current.

For parallel or series configurations of units without a digital option installed, the system's output voltage and output current can be obtained as follows:

- For a parallel configuration the voltage is common to all units, so the master will display the system's output voltage and, by multiplying the master's displayed current by the number of units, the system's output current can be determined.

- For a series configuration the current is common to all units, so the master will display the system's output current and, by multiplying the master's displayed voltage by the number of units the system's output voltage can be determined.

NOTE: Multiple unit configurations require that all individual units be properly calibrated. (Units shipped from Kepco have been factory-calibrated.) Refer to Section 4 to calibrate the individual units prior to connecting them in parallel or series. Using calibrated units ensures that the multiple unit configuration is calibrated. However, if the multiple unit configuration still produces an inaccurate output, refer to S Option calibration, see PAR.

5.6 MULTIPLE UNIT FAULT RESPONSE/RECOVERY

The following list explains how the multiple units respond to faults/failures and how to recover if a fault occurs.

- The MASTER/SLAVE interconnections combine the units' faults/errors in an OR function, so if any one of the units faults, the entire multiple unit configuration will fault/shut down.

- If any of the MASTER SLAVE IN and MASTER SLAVE OUT connectors on any unit is not plugged in, or becomes unplugged during operation, the entire BOP configuration will fail/shut down.

- If any of the BOP units has an input power loss, depending on the setting of the rear panel NO-YES (@P.LOSS) switch, all the units will either trip their input circuit breakers (YES), or they will fail/shut down (NO).

- If the Master BOP unit receives a shutdown (/SD_EXT_OUT) signal at EXT CTRL Port, pin 3, then the entire BOP configuration will fail/ shut down (see Table 2-4 for details).

- If the BOP Master unit has the interlock feature enabled, then either if the EXT CTRL Port cable is unplugged or if the cable's interlock contacts are open (by an external failure), then the entire BOP configuration will fail/shut down. See Table 2-4, pin 7 for details.

- If the unit was configured to not trip the input circuit beakers upon failure, to recover after a failure, either turn off and then turn on the input circuit breaker for all units, or send the reset command /RST_EXT via EXT CTRL Port pin 4 (see Table 2-4 for details).

5.7 S OPTION CALIBRATION

Refer to PAR. 4.4 for S Option calibration.