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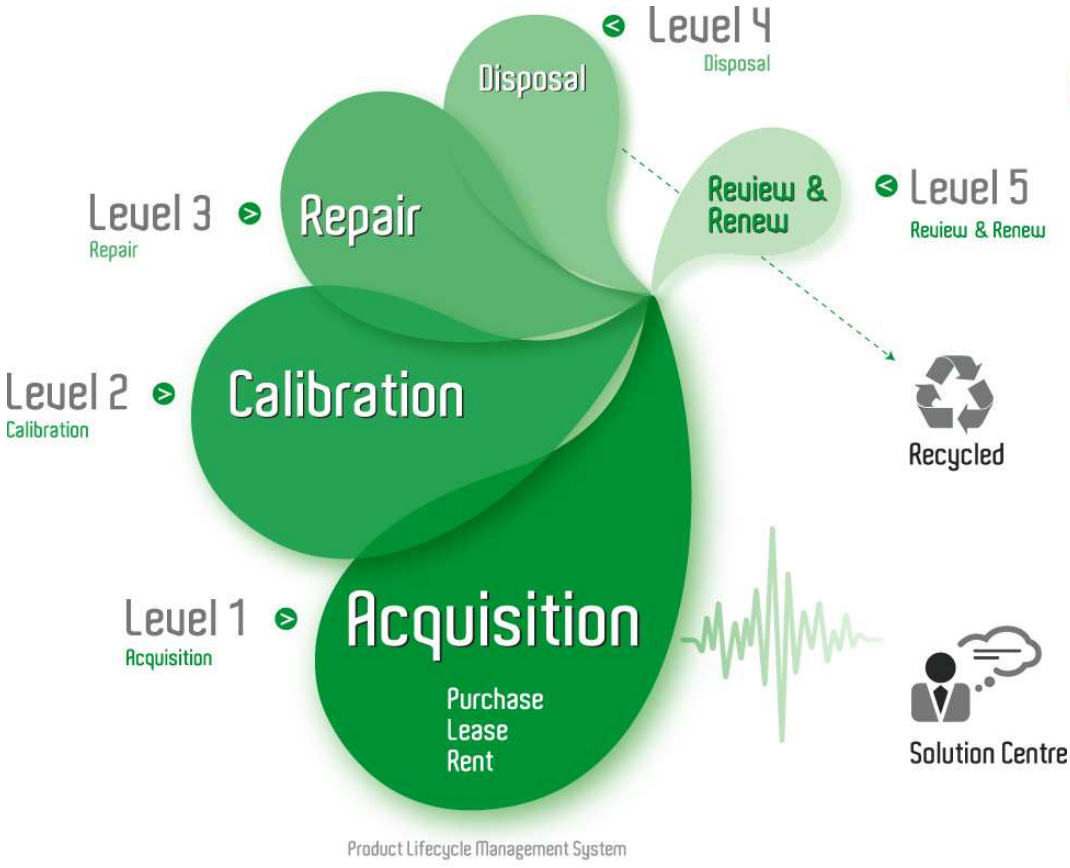

FEATURED PRODUCT - SERIES BOP HIGH POWER

Model BOP 10-75MG

FEATURES

- Full 4-quadrant, 1000 watt, source-sink operation.
- Energy recuperation, during sink-mode, through a bi-directional PFC circuit.
- Meets the EN61000-3-2 harmonic limits. A built-in EN55022 Class B input EMI filter is provided.
- High efficiency switch-mode operation.
- Output voltage from ±10V to ±100V.
- Full digital control with built-in standard GPIB. Understands SCPI and IEEE 488.2; VISA driver provided.
- Large graphic LCD, displays settings and actual output.
- Keypad control from front panel with menu to access functions.
- Calibration adjustments are made with the keypad and are stored in non-volatile memory. Calibration is password protected.
- CE; Complies with the requirements of the Low Voltage Directive 73/23/EEC and the Marking and Declaration Directive 93/28/EEC and the EMC Directive 89/336/EEC.

The BOP High Power are true 4-quadrant programmable voltage and current power supplies. 4-quadrant operation means that they are capable of both sourcing and sinking power. These bipolar power supplies pass smoothly through zero to provide true ± voltage and ± current. The BOP High Power use switch mode technology for low dissipation. To maintain low dissipation while sinking power from an active load, the BOP High Power recuperate the energy for reuse. The key to this is a bi-directional a-c input power factor correcting (PFC) circuit, which allows transparent energy interchange without dissipative sinking. The PFC circuit reduces the line harmonic distortion to a power factor greater than 0.97. The PFC works in both generation and recuperation modes.

The BOP High Power models produce 1000 watts of d-c power bi-directionally in six models from ±10V to ±100V.

The BOP High Power models are controlled digitally from a front-panel keypad or the standard remote GPIB interface to set voltage and current and the four limits (+ voltage, - voltage, + current and - current). A large LCD displays the settings, mode of operation and the actual output voltage and current. Additionally, the BOP High Power can be remotely controlled by an analog ±10V input. This mode is selected by the keypad from the menu, or remotely, through the IEEE 488 controller.

The BOP High Power models are suitable for driving large magnets or motors, and for exercising batteries. They are also suitable for characterizing solar cell arrays, and powering many electro-chemical reactions.

This KEPCO product is backed by a firm 5-YEAR WARRANTY

CE BOP High Power are CE marked per the Low Voltage Directive (LVD), EN61010-1.

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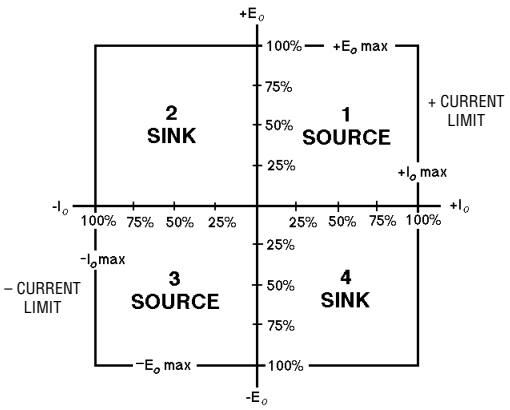
BOP HIGH POWER MODEL TABLE

MODEL	d-c OUTPUT RANGE		CLOSED LOOP GAIN		OUTPUT IMPEDANCE			
			VOLTAGE CHANNEL	CURRENT CHANNEL	VOLTAGE MODE		CURRENT MODE	
	E_o max.	I_o max.	G_V (V/V)	G_I (A/V)	SERIES R	SERIES L	SHUNT R	SHUNT C
1000 WATT								
BOP 10-75MG	± 10V	± 75A	1.0	7.5	0.13mΩ	.01µH	66.7Ω	6.0µF
BOP 20-50MG	± 20V	± 50A	2.0	5.0	0.4mΩ	.03µH	200Ω	2.0µF
BOP 36-28MG	± 36V	± 28A	3.6	2.8	1.3mΩ	0.1µH	640Ω	0.6µF
BOP 50-20MG	± 50V	± 20A	5.0	2.0	2.5mΩ	0.2µH	1250Ω	0.35µF
BOP 72-14MG	± 72V	± 14A	7.2	1.4	5.14mΩ	0.4µH	2570Ω	0.17µF
BOP 100-10MG	± 100V	± 10A	10.0	1.0	10.0mΩ	0.8µH	5000Ω	0.08µF

BOP HIGH POWER OUTPUT CHARACTERISTICS

SPECIFICATIONS		RATING/DESCRIPTION	CONDITION
Type of Stabilizer		Voltage/Current 4-quadrant	Switch mode
Switching Frequency		100KHz	Output stage
Source Adjustment Range	voltage	-100% to +100% of rating	
	current	-100% to +100% of rating	0-50ºC
Sink Adjustment Range	voltage	-100% to +100% of rating	Power recuperated For re-use
	current	-100% to +100% of rating	
Voltage Stabilization			
	source effect	0.05%	min-max
	load effect	0.1%	0-100% load current
	time effect (drift)	0.05%	0.5 - 24 hours
	temperature	0.05%/ºC	0-50ºC
	ripple and noise	2% $E_o$max p-p	Includes switching noise
Current Stabilization			
	source effect	0.05%	min-max
	load effect	0.2%	0-100% load voltage
	temperature	0.05%/ºC	0-50ºC
	ripple and noise	2% $I_o$max p-p	Includes switching noise
Error Sensing		0.25 volts per wire	Above rated output
Transient Recovery	maximum excursion	5% of nominal output	50% load step
	recovery time	200 µsec	Return within 0.1% of set voltage
Isolation	voltage	300V	Output to ground
Series Operation		Master/slave	Maximum of 3 units Up to 300V max
Parallel Operation		Master/slave	
Output Limiting		Voltage and current limited in four quadrants	
Output Stage Protection		Heatsink overtemperature Main switch overcurrent	Triggers latched shutdown protection of the output. Reset by digital control.
Input Stage Protection (PFC)		Overvoltage, undervoltage, overcurrent and overtemperature	Triggers latched shutdown protection of the PFC stage (input and output). Reset by digital control.

The High Power BOP has two primary control channels: voltage and current. Because either of these may be controlled from full plus setting to full minus setting, there can be no assurance that they will intersect in one of the two source quadrants to form a closed boundary as do conventional unipolar power supplies. To provide this essential closed operating boundary, four auxiliary limit channels are provided: plus voltage, minus voltage, plus current and minus current. These four are controllable from zero to the nominal values. Their control does not pass through zero as do the primary voltage and current channels. The intersection of whichever primary control channel is engaged by the load and the respective limit channel does form a closed boundary, and a variable load automatically crosses over from the primary to the limit.



Four quadrant operation from a Kepco BOP High Power power supply

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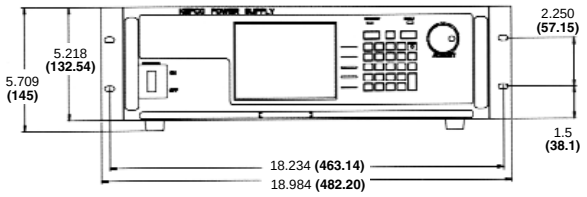
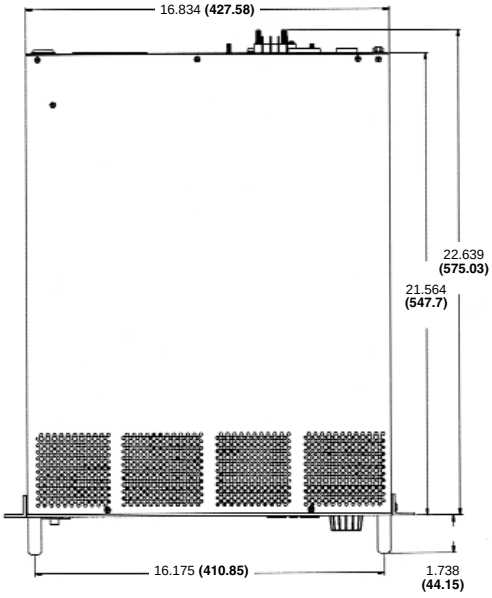
4-QUADRANT™

OUTLINE DIMENSIONAL DRAWINGS

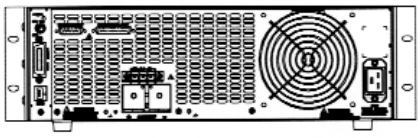
Fractional dimensions in light face type are in inches,
dimensions in bold face type are in millimeters.
Tolerance: ± 1/64" **(0.4)** between mounting holes
± 1/32" **(0.8)** other dimensions



FRONT VIEW



TOP VIEW



REAR VIEW

BOP HIGH POWER INPUT CHARACTERISTICS

SPECIFICATIONS		RATING/DESCRIPTION	CONDITION
a-c Voltage	nominal	230V a-c	Single phase
	range	176-264V a-c	
Frequency	nominal	50-60 Hz	>65 Hz, leakage exceeds spec
	range	47-65 Hz	
Current	176V a-c	9.5A	Maximum
	264V a-c	6.4A	Maximum
Power Factor		0.97	Minimum for both source and recuperation
Efficiency		65%	Minimum
Switching Frequency		80 KHz	PFC stage
EMC Compliance		EN61326-1 (1997)	Class A equipment
EMC Immunity To:			
	ESD	EN61000-4-2	Electrostatic discharge
	Radiated RF	EN61000-4-3	
	EFT	EN61000-4-4	Electrical fast transient/burst
	Surges	EN61000-4-5	
	Conducted RF	EN61000-4-6	
EMC Emissions	Conducted	EN61000-3-2 EN61000-3-3	Harmonics Fluctuation & flicker
	Conducted	EN55011/CISPR11	0.15-30 MHz
	Radiated	EN55011/CISPR11	30-1000 MHz
Leakage Current		3.5 mA	230V a-c 47-63 Hz
Insulation Coordination	Input	Installation Category II Overvoltage Category II	
	Output	Installation Category II Overvoltage Category II	
	Pollution degree	2	

BOP HIGH POWER GENERAL (ENVIRONMENTAL) SPECIFICATIONS

SPECIFICATIONS		RATING/DESCRIPTION	CONDITION
Temperature	operating	0 to +50ºC	Full rated load
	storage	-20 to +85ºC	
Cooling		Two internal fans	Exhaust to the rear
Humidity		0 to 95% RH	Non-condensing
Shock		20g, 11msec ±50% half sine	Non-operating
Vibration	5 -10 Hz	10mm double amplitude	3-axes, non operating
	10-55 Hz	2g	3-axes, non operating
Altitude		Sea level to 10,000 ft.	
Safety Certification	a-c power	UL 3101-1 and EN 61010-1	Pending

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BOP HIGH POWER PHYSICAL CHARACTERISTICS

SPECIFICATIONS		RATING/DESCRIPTION	CONDITION
Dimensions	English	5.25" x 19" x 21.5"	H x W x D
	metric	133.3 x 482.6 x 546.1 mm	
Weight	English	53 lbs	
	metric	24.1kg	
Connections			
Source Power		3-pin IEC connector	
Load Connections		Nickel-plated copper bus bars	
Analog Control Port		15-pin D female	
Slave Port		25-pin D female	
Primary Digital Port		24-pin GPIB connector	
Secondary Digital Ports		RS 232 and IEEE 1118 connectors	Mating connector included
External Trigger		3-pin phone jack	Mating connector included

BOP HIGH POWER PROGRAMMING/DISPLAY CHARACTERISTICS

SPECIFICATIONS		RATING/DESCRIPTION	CONDITION
Bandwidth	voltage channel	2 KHz minimum	
	current channel	1 KHz minimum	Into short circuit
Analog Control	voltage channel	-10V to +10V -1to +1 mA	Full range output
	current channel	-10V to +10V -1to +1 mA	
Digital Control	local	Panel-mounted keypad	Direct entry
	remote	IEEE 488-2 (GPIB)	SCPI
	remote	RS 232	
	remote	RS 485 (bitbus)	IEEE 1118
Display	front panel	4" backlit LCD displays all functions	
	remote	All parameters read back on all buses	

BOP HIGH POWER INTERFACE CHARACTERISTICS

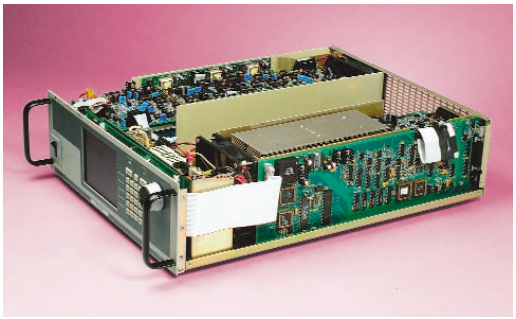
SPECIFICATIONS		RATING/DESCRIPTION
Waveform Support	Steps	1002
	Sequence list	512
	Step dwell time	250 µsec to 10 sec
Storage	Non-volatile	FLASH-type EEPROM 24Kbytes
	User setups	99
	Interface steps	99
	Waveform - Display	1024 steps
	Waveform - Interface	1800 steps
Programming Converter Resolution	Main channel	16 bits
	Limit channel	12 bits
Readback Resolution	Converter	16 bits
	Measurement rate	Default = 1ms range: 0.25-25ms
	Measurement array	64 samples

BOP High Power Control and Display

The High Power BOP employs a three-microprocessor architecture. One processor and its attendant programmable logic arrays is devoted to the display and the user-machine interface. A second is responsible for the remote digital interfaces: GPIB (IEEE 488-2), the single-address, multiple-instrument long-range serial bus (IEEE 1118/RS 485) and RS 232. The third processor handles analog functions. The three processors are connected by a 56 Kilo baud serial bus in full duplex and are optically buffered for SELV isolation. SELV means Safety Extra Low Voltage and represents the safe voltage levels that personnel may be exposed to. All Kepco products comply with the SELV rules for the separation and isolation of dangerous voltages.

The analog processor transmits the actual measured voltage and current to the interface and display processors. The display processor accepts input from the keypad and the encoder and sends this information to the display. The interface processor has a dual serial communications interface and a GPIB interface. A GPIB controller chip uses a hold-off scheme to provide the fastest interface with minimum latency.

The BOP High Power's display is a 320 x 240 pixel monochrome window that is capable of both analog and digital representations of the actual BOP output. Various BOP functions are accessed by soft keys. The right side of the display identifies the action associated with the five function keys. A HELP key provides an explanation of the display and the soft function keys during any of the submenus of the High Power BOP. Help is provided on the function keys, the BOP operation and on the interfacing to the analog port as well as the common causes for reported errors.



BOP High Power with cover removed

Below the soft keys are the setting values for the BOP. The main channel is displayed along with the appropriate limits. The limit control is selected from the settings menu and allows either a single limit or a pair of limits. The setting that is being controlled by the adjuster is highlighted. The left and right arrow keys are used to move from setting to setting.

The adjustment knob is always active in local mode. When turned, it changes the level of the main BOP channel and adjusts the output of the power supply. If the adjuster is depressed and turned, the adjustment of the output is in 0.0001 increments. Turning the knob without depressing it will adjust the indicated digits in the settings area of the display. The output is automatically updated by the settings ten times per second.

The BOP High Power units have 99 storage locations for settings memory. These stored settings are accessed locally using a highlighted list or through the remote interface using *SAV and *RCL commands as defined in IEEE 488-2. The display processor is provided with a separate program memory. This user-program memory can support a sequence of up to 128 discrete levels, with each step having a consistent dwell time. The dwell time is established from the front panel control during entry of the waveform. The display waveforms are executed once for a specific number of cycles (up to 255) or indefinitely until stopped. The display allows for the storage of up to 8 waveforms allowing a total count of 9 (8 saved, one in RAM). The interface processor also has a memory. A total of 1002 steps per program-list are supported. Each step can have a dwell time between 250 microseconds to 10 seconds. The list can be executed from beginning to end or from end to beginning. It also allows the list to be executed using a 512-step sequence. The lists can be executed either once or through an infinite count.

The RAM list is used for the execution of a waveform. The RAM list can be saved or recalled from memory with 16 different memory lists supported. The 16 different lists share a 1.5 Kilo-step memory space. The interface and analog processors provide the allocation support for these lists as required. The user memory space can also be accessed from the interface ports and a check sum for each list can be calculated and tested to provide an indication when the front panel user interface has been used to modify any user program.

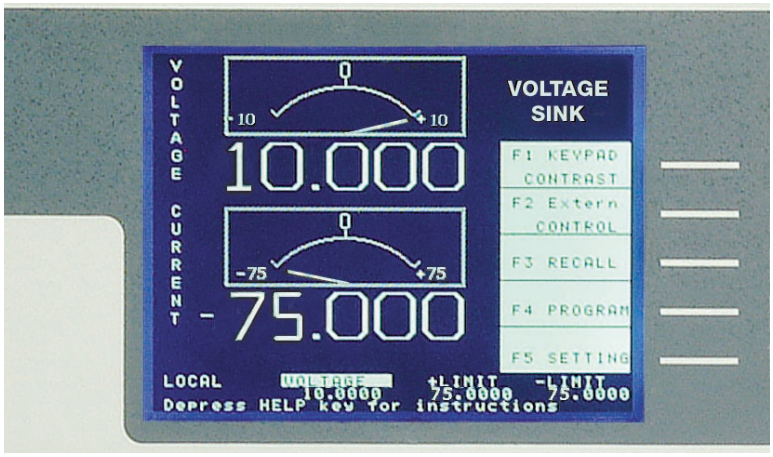
Display

The display of the BOP High Power instruments has several sections. The left side displays the present measured values of the output, the bottom three lines provide status readouts. The right side has the mode, the softkeys and the power supply's settings. The left side can display either a meter or a time-graph of measured settings will be either two or three numbers, one of which is highlighted. The leftmost number is the value of the main channel. It has a legend above it indicating either voltage or current. The other numbers are the limits. They have a title indicating the kind of limit.

Data Entry

Locally, either the rotary encoder knob or a digital keypad may control the output. Rotation of the encoder changes the units digit until the digits rollover from 9 to 0. Then the tens digit is controlled. The knob will decrement the digits as well and can change the sign. Depressing the adjuster changes the ten thousand digit of the output setting. Arrow keys on the keypad select which digit is to be controlled and is used to select, by highlighting, one of the limits for adjustment by the encoder. The numeric keys on the keypad also may be used for entry of values into the settings. When entering values from the keypad, the setting is applied to the output when the ENTER key is depressed. A mode key toggles the BOP's main channel between voltage and current mode.

In the SAVE/RECALL mode, highlighting one of the 99 saved settings activates its stored values, which are displayed above the softkeys. These keys provide an ability to save the current settings to the location or to recall previously stored settings and apply them to the output.



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Interfaces

The BOP High Power switching power supplies support three communications protocols. The primary interface is the GPIB (IEEE 488.2). The power supplies also support RS 232 at baud rates of 4.8, 9.6, 19.2 and 38.4 Kilo baud rates. The RS 232 supports both XON-XOFF and CTS/RTS protocols. The RS 485, Kepco's single address, multiple instrument serial bus (IEEE 1118) allows the BOP High Power units to be controlled from an MST 488-27, TMA 488-27 or Kepco's VXI controller, TMA VXI-27. Older models of these programmers may need to be updated to support these new models. Please consult factory. The BOP High Power units will operate with the current MST, MAT and the linear low-voltage BOP. The BOP High Power supports secondary addressing in this mode of operation. As an IEEE 1118 controller, the BOP High Power has the new INST:CAT:SAVE command to lock the configuration in the BOP's non-volatile memory. This allows the BOP to insure that all secondary controllers are operating and reports them to the controller when an error occurs during initialization.

The GPIB and serial interfaces primarily use the SCPI language: (Standard Commands for Programmable Instruments.) The BOP High Power units support the trigger system, including an external trigger input. They also support the LIST and Memory subsystems of the protocol. The SCPI interface is compatible with the BIT 4886 card (see page 55) and supports separate positive and negative limits. CIIL language support is provided for compatibility with the Kepco MAT series and other MATE system instruments. The GPIB interface provides for an SN emulation mode to provide a fast 12-bit control and also supports IEEE 488.2 commands, which start with the (*) character.

Waveforms

The BOP High Power models have the capability to make the output follow complex waveforms. These may be controlled from the front panel or the digital programming interfaces. A waveform is created by combining a series of amplitude steps, each having a dwell time that is adjustable between 250 microseconds to 10 seconds. By this means, sine, square and arbitrary waveforms may be synthesized. The values are programmed into the power supply for execution upon a trigger command. Waveforms may be repeated from 1 to 255 times or allowed to run continuously.

The front panel controls allow for the automatic creation of sine, half-sine, triangle or square waves and by combining these, make more complex patterns. The display allows for the viewing of the waveform and the modification of individual steps within the waveform. The RS-232 and GPIB interfaces, in addition to establishing the points in the waveform, can also establish the individual dwell times for each step. While the lists have 256 possible steps for both the user and the interface area, the interface provides for the capability to have the 1002 steps executed in a random order. This sequence capability allows for the creation of a waveform with 512 steps. This allows a user to establish a half waveform in the main list and using the sequence list, repeat individual steps first in a forward order and then in reverse order to create a complex waveform. The list can be enabled over the interface to be executed at the program command or it can be triggered either through the GPIB *TRG command or through the external trigger input. In addition to the waveform list support, the computer-controlled interfaces can also create a transient, changing the output for a fixed period and then returning to the original state.

Setups

The High Power BOP provides for quick changes from one set of conditions to another through the saved setup support. This capability provides 99 locations for both the front panel user and the interface controller to save a setting into memory and to quickly recall the state to the BOP. A saved setup maintains mode, main channel output level, the positive and negative limits and external control limit enables. To establish a state, the user can, from the front panel, depress as few as three keys to change the unit from one step to another. To select any of the 99 stored states, the user can use the adjustment knob, the arrow keys or enter the specific saved setup on the keypad. The display provides the list of the saved setups with the mode of operation and main channel operation to the user. The saved states for the user and the computer interfaces use separate memories so that the front panel cannot alter saved setups that are used by complex test programs.

Measurements

The output voltage and current channels are normally sampled every 1 millisecond. It automatically averages and updates the display every 64 milliseconds. A user can modify the sample and update rate through the computer interfaces.

External Reference (Analog Control)

An external reference, provided through the rear external port connector, allows for external analog control of the BOP. The external reference may be applied directly or can be attenuated and modulated by the digital controls. The BOP will limit its output based on the soft protection limits so that, in the event of a failure in the external reference, the output is protected.

External Limits

The external limits are digitally calibrated. The BOP samples the limit channel inputs and applies the proper limit levels at a 500 microsecond rate with the positive and negative limits being sampled alternately.

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