ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Find the *Kepco BOP-100-2D* at our website: ***Click HERE***

RETURN TO INDEX

SERIES **BOP**



Analog Meters
Model BOP 50-2M (top) and BOP 100-4M (bottom)
100, 200 and 400 Watt Linear High-Speed Amplifiers



Digital Meters
Model BOP 20-5D (top) and BOP 72-6D (bottom)
100, 200 and 400 Watt Linear High-Speed Amplifiers

BOP, while fully rated power supplies, are also high-powered operational amplifiers with full 4-quadrant, bipolar operation. Their output is capable of both sustained d-c and the replication of arbitrary a-c waveforms.

In Kepco's BOP, the voltage and current outputs can be controlled smoothly and linearly through the entire rated plus and minus ranges, passing smoothly through zero with no polarity switching.

BOP are high speed power operational amplifiers that can be used to provide dynamically agile voltage for test and simulation. They are *not* general purpose power supplies. By the nature of the bipolar high speed design, they do not have any energy-storage noise discriminating output capacitors. To realize the full high speed potential of BOP, the load characteristics should be mainly resistive. If the load is capacitive, (>0.1 microfarad), the BOP must be slowed to avoid oscillation. This is accomplished in voltage mode by increasing the value of the feedback capacitance. Special terminals on the user port are available to slow the BOP for optimum current-mode stability into inductive loading.

KEPCO, INC. • 131-38 Sanford Avenue • Flushing, NY 11352 USA • Tel: (718) 461-7000 • Fax: (718) 767-1102
Email: hq@kepcopower.com • **www.kepcopower.com/bop.htm**

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

BOP MODEL TABLE

MODEL(1) (5)	d-c OUTPUT RANGE E_o max.	I_o max.	CLOSED LOOP GAIN VOLTAGE CHANNEL G_V (V/V)	CURRENT CHANNEL G_I (A/V)	OUTPUT IMPEDANCE VOLTAGE MODE SERIES R	SERIES L(2)	CURRENT MODE SHUNT R	SHUNT C (3)
100 WATT								
BOP 20-5M	± 20V	± 5A	2.0	0.5	80μΩ	20μH	40kΩ	0.05μF
BOP 50-2M	± 50V	± 2A	5.0	0.2	0.5mΩ	100μH	50kΩ	0.05μF
BOP 100-1M	± 100V	± 1A	10.0	0.1	2.0mΩ	200μH	100kΩ	0.05μF
200 WATT								
BOP 20-10M	± 20V	± 10A	2.0	1.0	40μΩ	50μH	20kΩ	0.1μF
BOP 36-6M	± 36V	± 6A	3.6	0.6	120μΩ	50μH	36kΩ	0.1μF
BOP 50-4M	± 50V	± 4A	5.0	0.4	0.25mΩ	100μH	50kΩ	0.05μF
BOP 72-3M	± 72V	± 3A	7.2	0.3	0.48mΩ	200μH	72kΩ	0.05μF
BOP 100-2M	± 100V	± 2A	10.0	0.2	1.0mΩ	200μH	100kΩ	0.05μF
BOP 200-1M(4)	± 200V	± 1A	20.0	0.1	4.0mΩ	1.2mH	200kΩ	0.03μF
400 WATT								
BOP 20-20M	± 20V	± 20A	2.0	2.0	20μΩ	50μH	20kΩ	0.2μF
BOP 36-12M	± 36V	± 12A	3.6	1.2	60μΩ	50μH	36kΩ	0.2μF
BOP 50-8M	± 50V	± 8A	5.0	0.8	125μΩ	100μH	50kΩ	0.15μF
BOP 72-6M	± 72V	± 6A	7.2	0.6	240μΩ	200μH	72kΩ	0.1μF
BOP 100-4M	± 100V	± 4A	10.0	0.4	500μΩ	200μH	100kΩ	0.1μF

(1) For factory installed digital interfaces add appropriate suffix. See page 55.
(2) For determining dynamic impedance in voltage mode.
(3) For determining dynamic impedance in current mode.
(4) Same size as 400W models.
(5) To specify digital display, substitute the suffix letter "D" for the suffix letter "M."

FEATURES

- Source and sink 100% of their current rating. See Figure 1.
- Separate control circuits for voltage and current with automatic crossover to current and voltage limits.
- All controls and flag signals accessible through a 50-terminal user-port at the rear.
- Zeroable preamplifier available for scaling and summing external signals.
- Optional digital displays. Specify by substituting the suffix "D" in place of the "M."

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

For high power bipolar power supplies, see Series BOP High Power, page 44.

For high voltage bipolar power supplies, see Series BOP-HV, page 56.

The tabulation of the effective series resistance and inductance in voltage mode, and the effective shunt resistance and shunt capacitance in current mode, is done to allow a calculation of the output impedance versus frequency.

BOP accept plug-in cards for remote digital control

- BIT 4882 provides 12-bit IEEE 488.2 talk-listen control with SCPI support.
- BIT 4886 provides 16-bit IEEE 488.2 talk-listen control with SCPI support.
- BIT TMA-27 connect BOP to Kepco's single-address multiple instrument serial bus for long range (>300m) control from IEEE 488.2, RS 232 or VXI-based hosts.
- BIT 488B or BIT 488D offer listen-only GPIB support in binary or Hex format.

Cards may be factory installed. See page 55 for appropriate suffix designations.

VXI plug&play member

AN ISO 9001 COMPANY
KEPCO®
THE POWER SUPPLIER™
SINCE 1946

KEPCO, INC. • 131-38 Sanford Avenue • Flushing, NY 11352 USA • Tel: (718) 461-7000 • Fax: (718) 767-1102
Email: hq@kepcopower.com • www.kepcopower.com/bop.htm

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

4-QUADRANT™

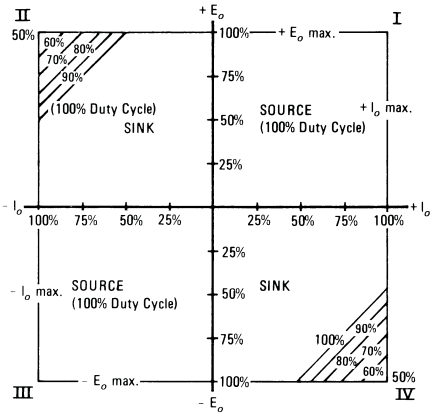


FIGURE 1
Output Source-Sink plot

TABLE 1
Source current measured worst case, 125V a-c.

MODEL	CURRENT (Amps)
BOP 20-5M	2.6
BOP 20-10M	5.5
BOP 20-20M	11.0
BOP 36-6M	5.1
BOP 36-12M	10.6
BOP 50-2M	2.6
BOP 50-4M	4.8
BOP 50-8M	9.5
BOP 72-3M	5.0
BOP 72-6M	10.8
BOP 100-1M	2.6
BOP 100-2M	4.8
BOP 100-4M	9.2
BOP 200-1M	5.5

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

BOP GENERAL SPECIFICATIONS

SPECIFICATION	RATING/DESCRIPTION	CONDITION
INPUT		
a-c Voltage	95-113, 105-125, 190-226, 210-250V a-c	User selectable
Current	See Table 1	Max load, 115V a-c
Frequency	47-65Hz	Range
OUTPUT		
d-c Output	Bi-direction, series pass	Transistor (1)
Type of stabilizer	Automatic crossover	Voltage/current
Voltage	0 to 100% of rating (bipolar)	Adjustment range for temp 0-55°C
Current	0 to 100% of rating (bipolar)	
Sink	See source/sink plot	Duty cycle
Error Sense	0.5V per load wire	Voltage allowance
Isolation Voltage	500V d-c or peak	Output to ground
Leakage Current	<5 microamperes	rms at 115V a-c 60Hz
Output to Ground	<50 microamperes	p-p at 115V a-c 60Hz
Series Connection	500V	Max voltage off ground
Parallel Connection	Current sharing	Use master-slave connection
OVP	Not available	
CONTROL		
Type — Voltage / Current	Variable input, fixed gain	
Voltage/ Current — Local	10-turn zero-center pot	
Remote Analog	-10V to +10V	
Local Digital	Serial bus or GPIB or VXI	Optional internal BIT card
Remote Digital	Use SN or SNR interface	
Bounding	±Volt/current local	Four screwdriver trimmers
	±Volt/current remote	0 to 10 volts
Dynamics	See dynamic spec table	Fast only
User Amplifiers	Uncommitted gain 20K	Two provided
References	±10 volts, 1mA	Two provided
Options (built-in) For user added card refer to "BIT" models page 55	GPIB hex card	Suffix -488B
	GPIB BCD card	Suffix -488D
	Long range serial card/VXI	Suffix -TMA
	Talk-listen 4882 card (SCPI)	Suffix -4882
	Talk-listen 4886 card (SCPI)	Suffix -4886
	Serial RS 232	Suffix -232
MECHANICAL		
Input Connection	Detachable IEC type 3-wire	All models
Output Connections	Front signal/output	Binding posts
	Rear user port	50-terminal connector
	Rear output	Barrier strip
Meters	Two 2½" horiz., 2% zero center analog	Front panel
Indicators	Four LEDs	Voltage/Current/Bounding
Mounting (in std 19" racks)	Use RA 37 rack adapter	¾ rack size
	Mounting "ears" supplied	Full rack size
Cooling	Forced air	Exhaust to rear
Dimensions (HxWxD) add 2½" to rear for connector — inches	5 7/32 x 12 17/32 x 17 9/64	¾ rack size
Dimensions (HxWxD) add 2½" to rear for connector — mm	132.6 x 318.3 x 435.4	
Dimensions (HxWxD) add 2½" to rear for connector — inches	5 7/32 x 19 x 20 5/64	Full rack size
Dimensions (HxWxD) add 2½" to rear for connector — mm	132.6 x 482.6 x 510	
Finish; Fed Std 595	Light gray, color 26440	Front panel
Weight (packed for shipment)	47lb (21.4Kg)	¾ rack size (100W)
	53lb (24.1Kg)	¾ rack size (200W)
	76lb (34.5Kg)	Full rack size

(1) 200V model uses FET.

AN ISO 9001 COMPANY
KEPCO®
THE POWER SUPPLIER™
SINCE 1946

KEPCO, INC. • 131-38 Sanford Avenue • Flushing, NY 11352 USA • Tel: (718) 461-7000 • Fax: (718) 767-1102
Email: hq@kepcopower.com • www.kepcopower.com/bop.htm

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

BOP DYNAMIC SPECIFICATIONS

MODEL	BANDWIDTH (d-c to f_{-3dB}) KHz (minimum) Mode V	BANDWIDTH (d-c to f_{-3dB}) KHz (minimum) Mode I	RISE & FALL TIME 10%-90% µsec (maximum) Mode V	RISE & FALL TIME 10%-90% µsec (maximum) Mode I	LARGE SIGNAL FREQUENCY (min) RESPONSE, KHz Mode V	LARGE SIGNAL FREQUENCY (min) RESPONSE, KHz Mode I	SLEWING RATE (minimum) Mode V	SLEWING RATE (minimum) Mode I	RECOVERY STEP LOAD µsec (maximum) Mode V	RECOVERY STEP LOAD µsec (maximum) Mode I
100 WATT										
BOP 20-5M	18	12	20	30	17	13	5V/µsec	0.15A/µsec	25	10
BOP 50-2M	18	12	20	30	17	13	5V/µsec	0.15A/µsec	25	10
BOP 100-1M	18	11	17	22	18	11	11V/µsec	70mA/µsec	40	25
200 WATT										
BOP 20-10M	18	6	20	60	17	7	2V/µsec	0.4A/µsec	80	20
BOP 36-6M	16	13	20	27	15	14	3V/µsec	0.5A/µsec	50	35
BOP 50-4M	23	14	14	25	15	11	4.5V/µsec	0.25A/µsec	40	30
BOP 72-3M	20	15	18	26	17	12	10V/µsec	0.15A/µsec	30	30
BOP 100-2M	22	15	18	26	17	12	10V/µsec	0.15A/µsec	30	30
BOP 200-1M	4.0	2.5	110	150	4.0	2.5	5V/µsec	15mA/µsec	150	120
400 WATT										
BOP 20-20M	9.5	10	35	35	8	10	1V/µsec	1.25A/µsec	100	75
BOP 36-12M	20	10	16	30	19	10	4V/µsec	0.75A/µsec	50	30
BOP 50-8M	16	10	22	35	24	11	7.5V/µsec	0.5A/µsec	40	30
BOP 72-6M	19	9.5	18	40	20	11	9V/µsec	0.4A/µsec	50	20
BOP 100-4M	18	14	22	30	16	10	10V/µsec	0.25A/µsec	40	30

BOP STATIC SPECIFICATIONS

INFLUENCE QUANTITY		OUTPUT EFFECTS(1) VOLTAGE MODE TYPICAL	OUTPUT EFFECTS(1) VOLTAGE MODE MAXIMUM	OUTPUT EFFECTS(1) CURRENT MODE TYPICAL	OUTPUT EFFECTS(1) CURRENT MODE MAXIMUM	PREAMPLIFIER(4) OFFSETS ΔE_{io}	PREAMPLIFIER(4) OFFSETS ΔI_{io}	REFERENCE ± 10V
Source (min.-max.)		<0.0005%	0.001%	<0.002%	0.005%	<5µV	<1nA	<0.0005%
Load (NL-FL)		<0.001%	0.002%	<0.5mA	1mA	—	—	<0.0005%
Time (8-hour drift)		<0.005%	0.01%	<0.01%	0.02%	<20µV	<1nA	<0.005%
Temp., per °C		<0.005%	0.01%	<0.01%	0.02%	<20µV	<1nA	<0.005%
Ripple and Noise (2)	rms	<1mV	3mV(5)	<0.01%	0.03%	—	—	—
	p-p(3)	<10mV	30mV(5)	<0.1%	0.3%	—	—	—

(1) Output effects, expressed as a percentage, are referred to the maximum rated output voltage or current.
(2) Measured with the common terminal grounded so that the common mode current does not flow through the load.
(3) Peak-to-peak ripple is measured over a 20Hz to 10MHz bandwidth.
(4) The output effect can be calculated by the relationship:
$\Delta E_O = \pm\Delta E_r\ (R_f/R_i) \pm \Delta E_{iO}(1+R_f/R_i) \pm \Delta I_{iO}(R_f)$ where R_f is the feedback resistor, and R_i is the input resistor from the reference, E_r.
(5) For BOP 200-1M the maximum ripple and noise is 5mV rms and 50mV p-p.

The tabulated offsets, more particularly their change as a function of source, time and temperature, allow a user to calculate performance of the uncommitted amplifier(s) with user specified input and feedback components. The formula for this is given in the static specifications table footnote.

With compliments
Helmut Singer Elektronik
www.helmut-singer.de info@helmut-singer.de
fon +49 241 155 315 fax +49 241 152 066
Feldchen 16-24 D-52070 Aachen Germany

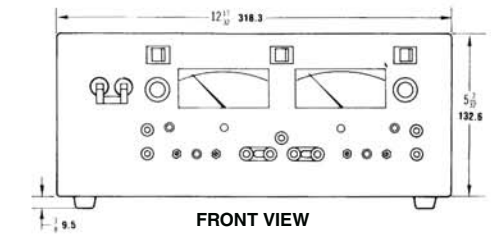
AN ISO 9001 COMPANY
KEPCO®
THE POWER SUPPLIER™
SINCE 1946

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

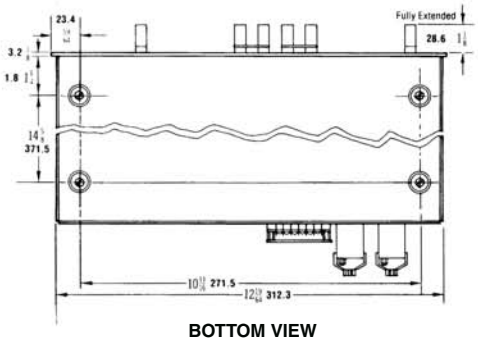
OUTLINE DIMENSIONAL DRAWINGS

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

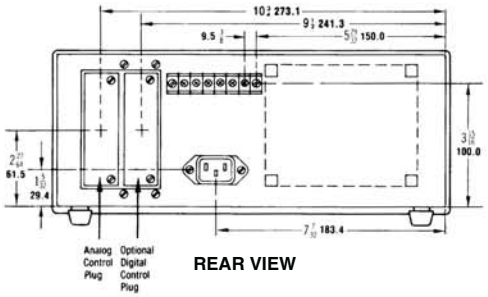
100 & 200 WATT MODELS (THREE-QUARTER RACK)



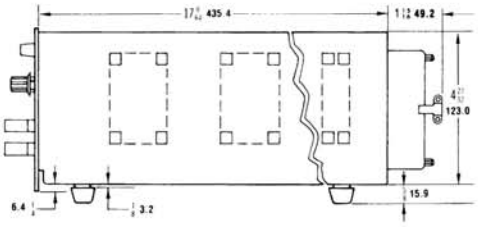
FRONT VIEW



BOTTOM VIEW

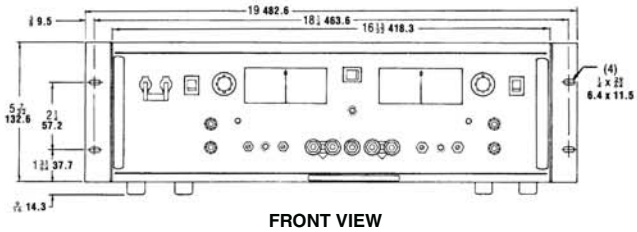


REAR VIEW

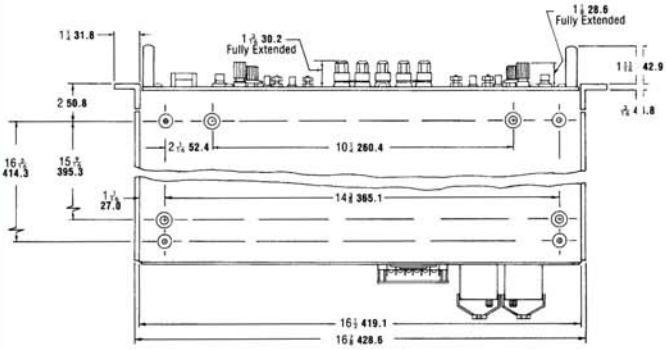


SIDE VIEW

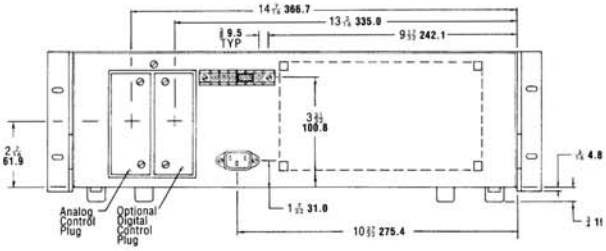
400 WATT MODELS (FULL RACK) AND BOP 200-1M



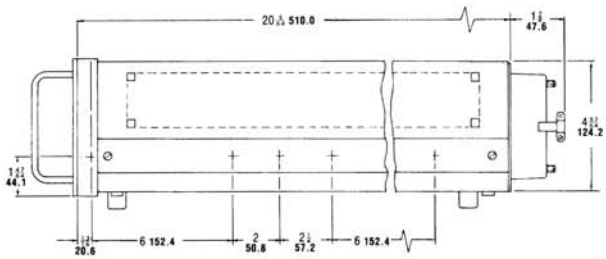
FRONT VIEW



BOTTOM VIEW



REAR VIEW



SIDE VIEW

BOP 3/4 rack width power supplies can be rack mounted using RA 37. See page 77.

KEPCO, INC. • 131-38 Sanford Avenue • Flushing, NY 11352 USA • Tel: (718) 461-7000 • Fax: (718) 767-1102
Email: hq@kepcopower.com • www.kepcopower.com/bop.htm

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

The expanded bandwidth of power supplies with fast-programming capabilities, compared to conventional power supplies, is achieved by circuit changes including the removal of output and feedback capacitors which serve as gain-roll-off networks and restabilizing the control loop by means of lag networks. This section lists high voltage "OPS" models and bipolar "BOP" models which are exclusively wide band power amplifiers.

A different class of fast programmable power supply are the "ATE" and "BHK" series, listed elsewhere in this catalog. These models have the unique ability to be user-configured for either fast-programmable or conventional operation. When configured for fast-programable operation, the comments below are applicable.

The ability to respond to fast control signals is accompanied by several constraints which must be fully appreciated by potential users of fast programmable power supplies.

1. There is some increase in the *unprogrammed output deviation specification* (ripple and noise). To minimize this increase, the construction of fast programmable units is distinguished from conventional power supplies by a greater emphasis on shielding and component placement to minimize noise pickup. In actual applications, such power supplies require greater attention to such details as ground loop avoidance, shielding, use of twisted pairs, wire routing, etc.
2. A conventional power supply responds slowly to input signals and its dynamic stability is governed by the large output capacitor. As a result, its unity gain crossover frequency is at a very low frequency and the phase margin (a measure of stability) is very large. A conventional power supply therefore represents a very stable closed-loop system even with reactive loads, since any additional phase-shift introduced by the load is at a frequency far away from the unity gain crossover frequency (See Fig. 1).

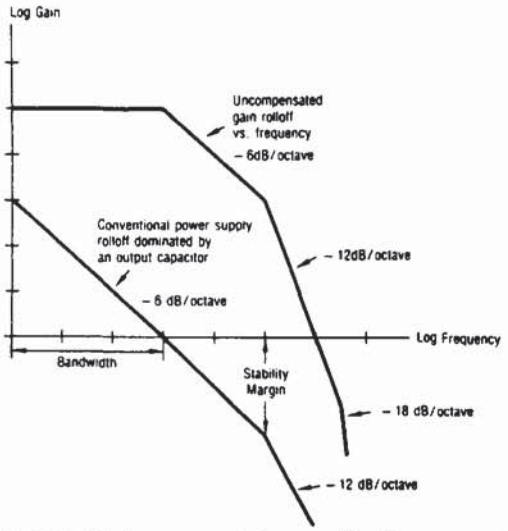


Figure 1: Gain-frequency plot, conventional power supply showing narrow bandwidth, large stability margin

3. Fast programmable power supplies and convertible models in their fast-programmable mode are far less tolerant of load reactance. Since bandwidth has been vastly increased, the unity gain crossover frequency lies at a much higher frequency and therefore the stability margin has correspondingly decreased (See Fig. 2).

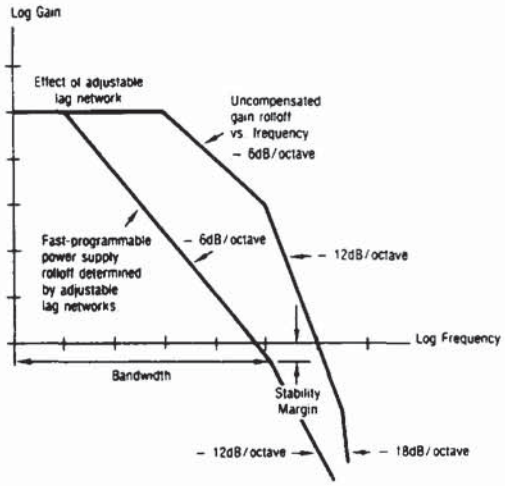


Figure 2: Gain-frequency plot, fast programmable power supply showing increased bandwidth, and reduced stability margin

A fast programmable power supply, although stable with resistive loads, may become unstable with reactive loads. The reason is the additional phase-shift introduced by a reactive load at its output. This may shift the power supply's response curve precariously close to the unity gain crossover frequency and thereby reduce the stability margin. As a result, the power supply may, with reactive loads, exhibit instability or even oscillatory behavior. For stable operation of a fast programmable power supply, the reactive load characteristics must be

A major part of the specifications for the various fast programmable models is devoted (as might be expected) to *dynamics*.

Under this heading there are specifications for:

- The maximum slewing rate.
- Programming time constant.
- Frequency response.
- Voltage recovery for step-load current.
- Current recovery for step-load voltage.
- Output impedance (versus frequency).

These specifications are designed to give a profile of the responses to various dynamic stimuli in both the time and frequency domains.

Special terms used in these specifications are defined in the glossary section.

With compliments
Helmut Singer Elektronik
www.helmut-singer.de info@helmut-singer.de
fon +49 241 155 315 fax +49 241 152 066
Feldchen 16-24 D-52070 Aachen Germany
Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

BOP™

bipolar operational voltage stabilizer

The Bipolar Operational Power Supply, combines the capabilities of fast-programmable power supplies, like the ATE, with a bidirectional complementary-symmetry output stage that can respond in either direction from zero. The BOP is, in effect, a large, d-c coupled, inverting power amplifier. It is made in a bench/system-rack form with a single control-channel equipped with a patch-board panel for easy access to the control functions.

these KEPCO products are backed by a firm 5-Year Warranty

MODEL TABLE

MODEL	d-c OUTPUT RANGE VOLTS	AMPS.	CURRENT SINK	OUTPUT IMPEDANCE VOLTAGE MODE SERIES R	SERIES L	CURRENT MODE[1] SHUNT R	SHUNT C	a-c SOURCE CURRENT at 125V a-c	SIZE	SHIP WGT lbs.	kg.
BOP 15-20M	+15 to −15	+20 to −20	±4A	0.2 mΩ	25 μH	1750 Ω	10.0 μF	8.0A	C	94	42.7
BOP 36-1.5M	+36 to −36	+1.5 to −1.5	±0.3A	5 mΩ	10 μH	23 kΩ	0.22 μF	1.6A	A	27	12.3
BOP 36-5M	+36 to −36	+5 to −5	±1A	1.5 mΩ	15 μH	7 kΩ	0.75 μF	4.6A	B	52	23.6
BOP 72-1.5M	+72 to −72	+1.5 to −1.5	±0.3A	10 mΩ	20 μH	23 kΩ	0.17 μF	3.2A	C	64	29.1
BOP 72-5M	+72 to −72	+5 to −5	±1A	3 mΩ	30 μH	7 kΩ	0.56 μF	9.2A	C	94	42.7

[1]External current sensing using a 1-volt current sensing sample.

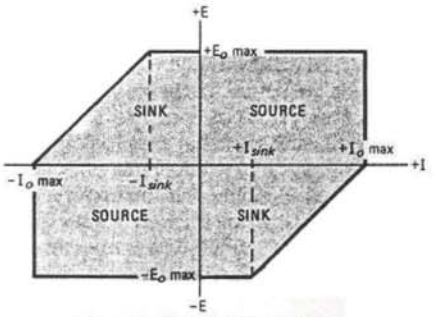


Figure 1: 4-quadrant operation.

STATIC SPECIFICATIONS

INFLUENCE QUANTITY		AMPLIFIER OFFSETS VOLTAGE ΔE_{io}	CURRENT ΔI_{io}	REFERENCES 6.2V ± 5%
SOURCE VOLTAGE (min.-max.):		<0.1 mV	<10 nA	0.0005%
LOAD (No load—full load):		<1.0 mV	<10 nA	—
TIME (8-hour drift):		<0.1 mV	<50 nA	0.005%
TEMPERATURE, Per °C:		<0.08 mV	<50 nA	0.005%
RIPPLE and NOISE:[3]	rms	<0.01% of E_o — or 3 mV[2]		—
	p-p[4]	<0.05% of E_o — or 15 mV[2]		—

[2]Whichever is greater.
[3]One terminal must be grounded, or connected so that the common mode current does not flow through the load or, in current mode, through the current- sensing resistor.
[4]Peak-to-peak ripple is measured over a 20 Hz to 10 MHz bandwidth.

VOLTAGE CONTROL CHANNEL

OUTPUT RANGE: The unique character of the BOP, its ability to operate with either positive or negative output, bidirectionally, as a source, is enhanced by its ability to function as a limited *sink*. BOP is a "*sink*" when the polarity of its voltage does not agree with the direction of its current—it absorbs energy.

If voltage and current are plotted orthogonally, as in Figure 1, quadrants I and III are the source quadrants, II and IV are sink quadrants. The operating region of a BOP is defined by the shaded portion of the output characteristic.

CONTROL/PROGRAMMING: BOP models have a front panel patch board with a built-in vernier voltage feedback rheostat and bipolar reference. Output voltage is controlled by controlling the reference potentiometer from the plus (+) to the minus (−) reference through zero. The output voltage is proportioned to the selected reference by the feedback rheostat. The patch board construction makes it easy to sum or substitute other potentials at the input and to substitute external feedback to stabilize current or such physical phenomena as heat, speed, force, or electrochemical action.

OFFSETS: The equivalent offset voltage and current variations for BOP are tabulated for the effect of source changes, load, temperature, and time. Calculate their effect on the output by the relationship:

$$\Delta E_o = \pm \Delta E_r (R_f/R_i) \pm \Delta E_{io} (1 + R_f/R_i) \pm \Delta I_{io} (R_f)$$

where R_f is the feedback rheostat and R_i is the input resistor from the reference, E_r.

OFFSET NULLING: The initial or bias part of the main control channel's voltage offset (E_{io}) and current offset (I_{io}) can be nulled (zeroed) by built-in trimmers.

REFERENCES: A pair of ±6.2V ±5%, 1 milliampere references referred to the common/sense terminal are provided for offsetting or biasing purposes.

GAIN: The open-loop d-c gain is in excess of 35,000 volts/volt.

CURRENT STABILIZATION

The BOP is equipped with a pair of built-in current-sensing and feedback arrangements for protective limiting. They are set for approximately 110% of the rated current in both directions and are not adjustable.

For the precision control of current, bidirectionally, the feedback to the main control channel can be reconfigured so as to sample the drop across an external current-sensing resistor in the common output lead.

DYNAMICS

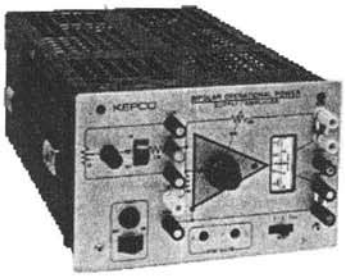
Each BOP is equipped with an internal, fast/slow selector switch. The slow position restricts the bandwidth so that the BOP can drive reactive loads without restriction. The slow position is recommended for low frequency or d-c application to discrimminate against higher frequency pick-up noise.

OUTPUT IMPEDANCE: Expressed as a function of frequency, the output impedance is a measure of dynamic stabilization. As a voltage stabilizer, the d-c and low frequency value is given by the load effect. At frequencies above the stabilizer's cutoff, the impedance increase with frequency becomes asymptotic to the tabulated characteristic series inductance. As a current stabilizer, the impedance decrease above the stabilizer's cutoff frequency becomes asymptotic to the tabulated characteristic shunt capacitance. The table gives these values for each BOP model.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

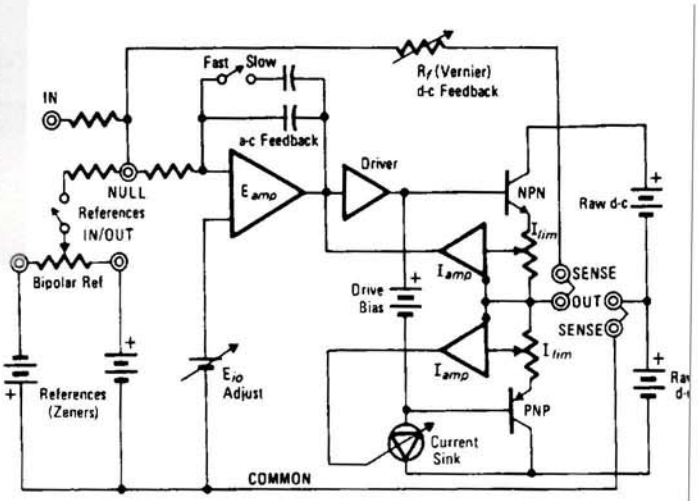


Model BOP 15-20M
(Size C-"full-rack")



Model BOP 36-1.5M
(Size A-"half-rack")

SIMPLIFIED SCHEMATIC DIAGRAM



DISTORTION: For a small signal (2 volts peak-to-peak, no load), harmonic distortion is less than 0.5%.

BANDWIDTH/PROGRAMMING SPEED: The dynamics of the BOP output may be expressed in both the time domain (as its response to a step-program) or in the frequency domain (bandwidth for large and small signals). These figures are tabulated below.

DYNAMIC SPECIFICATION	MODE SWITCH	BOP 15-20M	BOP 36-1.5M	BOP 36-5M	BOP 72-1.5M	BOP 72-5M
BANDWIDTH	FAST	13 kHz	13 kHz	13 kHz	13 kHz	13 kHz
(d-c to f_{-3dB})	SLOW	0.6 kHz	1 kHz	1 kHz	1 kHz	1 kHz
PROGRAMMING	FAST	12 μsec	12 μsec	12 μsec	12 μsec	12 μsec
TIME CONSTANT*	SLOW	250 μsec	150 μsec	150 μsec	150 μsec	150 μsec
LARGE SIGNAL	FAST	25 kHz	20 kHz	20 kHz	20 kHz	20 kHz
FREQUENCY RESPONSE	SLOW	1 kHz	3 kHz	3 kHz	2 kHz	2 kHz
SLEWING RATE	FAST	2V/μsec	4.8V/μsec	4.8V/μsec	9V/μsec	9V/μsec
	SLOW	0.1V/μsec	0.7V/μsec	0.7V/μsec	0.9V/μsec	0.9V/μsec
TRANSIENT RECOVERY (Step Load Change) Voltage	FAST	50 μsec	50 μsec	50 μsec	50 μsec	50 μsec
	SLOW	500 μsec	500 μsec	500 μsec	500 μsec	500 μsec
Current	FAST	50 μsec	50 μsec	50 μsec	50 μsec	50 μsec
	SLOW	1 msec	500 μsec	500 μsec	500 μsec	500 μsec

*Input feedback set for gain = 10.

STABILITY & LOAD REACTANCE: The BOP power supply behaves like a wideband amplifier, or, as a 1st order (single breakpoint) closed loop feedback system. The phase-gain versus frequency characteristic is determined by the f_{-3dB} breakpoint (corner) frequency, as indicated in the dynamic specification table. The closed loop gain is given by: $\frac{E_O \text{ (setting)}}{6}$.

The unity gain crossover frequency, with 90° phase margin, is a relatively high frequency, and the power supply, although stable with a resistive load, may become unstable and even oscillate into reactive loads. The additional phase shift, created by a reactive load (RC in voltage mode and L/R in current mode) with a breakpoint approaching the unity gain crossover frequency, will cause the BOP's dynamic response to exhibit a peak and even sustain oscillation. If the load's breakpoint is at a frequency much below the BOP's, the power supply will be stable, but the frequency response will be governed by the load's time constant.

GENERAL

SERIES/PARALLEL: Units may be connected in series for added voltage, using a master/slave interconnection. They cannot be used in parallel.

ISOLATION FROM GROUND: The circuit and output terminals of BOP have no d-c connection to ground, and may be floated up to 500 volts (d-c or peak) off ground. The common mode current from output to ground is less than 5 microamperes rms, 50 microamperes, peak-to-peak at 115V a-c, 60 Hz.

SOURCE POWER REQUIREMENTS: Units are factory-wired for 105–125V a-c, 50–65 Hz power. A simple jumper change will reconfigure the input for 210–250V a-c, 50–65 Hz. The two ±36V BOP models (in a half-rack package) are protected by a fuse. The two ±72V models and the ±15V unit (in the full-rack size) are protected by a circuit breaker. All models incorporate a "low-source" voltage monitor which trips an internal clamp at turn-off (precluding overshoot). A timing circuit delays reapplication of source power for approximately 2 seconds.

TEMPERATURE RATINGS:

Storage: −40°C to +85°C.

Operating: −20°C to +65°C. Cooling is by built-in, sealed-bearing blowers exhausting to the rear. Full output current is delivered at +65°C. No derating, or external heat sink is required.

STANDARDS: BOP models are designed and tested in accordance with NEMA standard PY-1-1972 and IEC recommendation 478 (parts 1-4).

TERMINALS: BOP models are equipped with a 10-terminal patch board providing convenient access to the signal input, output, feedback, and reference points. The front panel connections are duplicated on a rear-mounted barrier-strip.

METERS: Half-rack models use a single 2-inch recessed meter for reading d-c volts and amperes and a-c (rms) volts. Accuracy is ±3%. The full-rack models have independent 3-inch recessed meters with ±2% accuracy.

MOUNTING: The "full-rack" sized models have accessory flanges for direct installation in standard 19-inch racks. Half-rack sized models may be mounted in RA-24 rack adapter.

DIMENSIONS: (English in inches, metric in mm.)
See dimensional drawings.

English Measure:
Size A: $5^{7}/_{32}$H x $8^{11}/_{32}$W x $12^{7}/_{8}$D*
Size B: $5^{7}/_{32}$H x $8^{11}/_{32}$W x $17^{1}/_{8}$D*
Size C: $5^{7}/_{32}$H x $16^{1}/_{2}$W** x $17^{1}/_{64}$D*

Metric Measure:
Size A: 132.6 H x 211.9 W x 327.0 D*
Size B: 132.6 H x 211.9 W x 441.3 D*
Size C: 132.6 H x 419.1 W** x 432.2 D*

*behind panel.
**with "ears" standard 19" panel width.

FINISH: *Panel:* Light gray color 26440, Fed. Std. 595.
Case: Charcoal gray texture.

Special terms used in these specifications are defined in the glossary section.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

BOP™

4- quadrant voltage/current stabilizer

These low-voltage bipolar power supplies offer full, programmable control over *both* voltage and current with a mode selector. The power supply is bounded in all four quadrants by four fully adjustable, programmable boundary limits. The wide-band BOP offers two operational preamplifiers for scaling, summing and signal processing.

MODEL TABLE

MODEL	d-c OUTPUT RANGE E_o max.	I_o max.	CLOSED LOOP GAIN VOLTAGE CHANNEL G_V (V/V)	CURRENT CHANNEL G_I (A/V)	OUTPUT IMPEDANCE VOLTAGE MODE SERIES R	SERIES L	CURRENT MODE SHUNT R	SHUNT C	SHIP. WGT lbs	kg.
BOP 20-10M	± 20V	±10A	2.0	1.0	40 μΩ	50 μH	20 kΩ	0.1 μF	51	23
BOP 36-6M	± 36V	± 6A	3.6	0.6	120 μΩ	50 μH	36 kΩ	0.1 μF	51	23
BOP 50-2M	± 50V	± 2A	5.0	0.2	0.5 mΩ	100 μH	50 kΩ	0.05 μF	48	22
BOP 50-4M	± 50V	± 4A	5.0	0.4	0.25 mΩ	100 μH	50 kΩ	0.05 μF	51	23
BOP 72-3M	± 72V	± 3A	7.2	0.3	0.48 mΩ	200 μH	72 kΩ	0.05 μF	51	23
BOP 100-1M	±100V	± 1A	10.0	0.1	2.0 mΩ	200 μH	100 kΩ	0.05 μF	48	22
BOP 100-2M	±100V	± 2A	10.0	0.2	1.0 mΩ	200 μH	100 kΩ	0.05 μF	51	23

STATIC SPECIFICATIONS

INFLUENCE QUANTITY		OUTPUT EFFECTS[1] VOLTAGE MODE TYPICAL	MAXIMUM	CURRENT MODE TYPICAL	MAXIMUM	PREAMPLIFIER OFFSETS ΔE_{io}	ΔI_{io}	REFERENCE ± 10V
SOURCE VOLTAGE (min.-max.):		<0.0005%	0.001%	<0.002%	0.005%	<5μV	<1nA	<0.0005%
LOAD (No Load—full load):		<0.001%	0.002%	<0.5mA	1mA	—	—	<0.0005%
TIME (8-hour drift):		<0.005%	0.01%	<0.01%	0.02%	<20μV	<1nA	<0.005%
TEMPERATURE, per °C:		<0.005%	0.01%	<0.01%	0.02%	<20μV	<1nA	<0.005%
RIPPLE and NOISE:[2]	rms	<1mV	3mV	<0.01%	0.03%	—	—	—
	p-p[3]	<10mV	30mV	<0.1%	0.3%	—	—	—

(1) Output effects, expressed as a percentage, are referred to the maximum rated output voltage or current.

(2) Measured with the common terminal grounded so that the common mode current does not flow through the load.

(3) Peak-to-peak ripple is measured over a 20 Hz to 10 MHz bandwidth.

These BOP are equipped with a panel-mounted "mode" switch which selects either bipolar voltage control or bipolar current control. Separate control circuits are activated for each mode.

VOLTAGE CONTROL CHANNEL

OUTPUT RANGE: The output is smoothly and linearly adjustable—or programmable—from −100% to +100% of the rated voltage. The voltage passes smoothly through zero without any polarity switching. The BOP power supply is a source for 100% of its current rating at any voltage setting and can sink (absorb) up to 100% of its current rating, with duty cycle derating (see figure 1). The BOP is a source when its voltage polarity and current direction are like that of a battery. BOP is a sink when the voltage polarity and current direction are like that of a resistor. Please refer to the plot of voltage vs. current, Figure 1.

CONTROL/PROGRAMMING: The voltage control channel is controlled by means of a 10-turn bipolar control mounted on the front panel. A pair of binding posts allow an external control signal to be either summed with or substituted for the panel control. A ± 10 volt input signal is required for ± full scale voltage output. The external control signal can also be connected through a multi-pin rear connector.

The input signals are applied through a built-in operational preamplifier (Preamp A) whose scaling components are accessible. This amplifier may be configured by a user to scale, sum, invert or integrate the control signals.

DIGITAL CONTROL: Please refer to the description of the accessory interface cards.

CURRENT CONTROL CHANNEL

OUTPUT RANGE: −100% to +100% of the current rating adjustable smoothly through zero. The BOP can act as either a source or a sink.

CONTROL/PROGRAMMING: The current control channel is controlled by means of a 10-turn bipolar control mounted on the front panel. A separate pair of binding posts allow an external control signal to be either summed with or substituted for the panel control. A ± 10 volt input signal is required for ± full scale current. The external control signal can also be connected through a multi-pin rear connector.

The input signals are applied through a built-in operational preamplifier (Preamp B) whose scaling components are accessible. This amplifier may be configured to scale, sum, invert or integrate the control signals.

DIGITAL CONTROL: Please refer to the description of the accessory interface cards.

SPECIFICATIONS APPLICABLE FOR VOLTAGE & CURRENT PREAMPLIFIER OFFSETS: The Static Specifications table lists the equivalent offset voltage variation (ΔE_{io}) and offset current variation (ΔI_{io}) referred to the summing junction of the preamplifiers A and B. These offsets may be used to calculate the

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

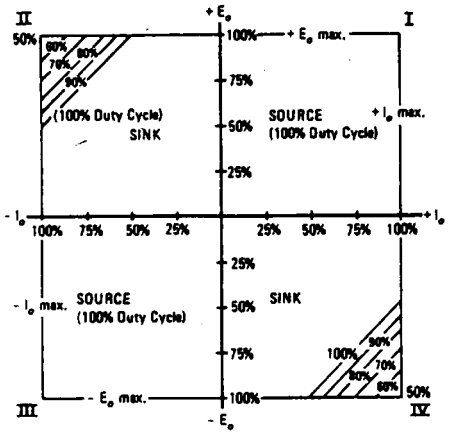
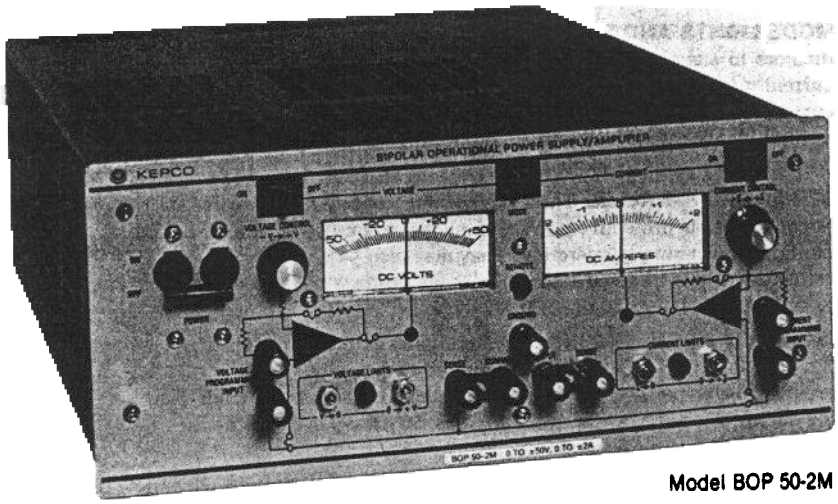


Figure 1: Output Source-Sink plot

NOTE: The values for $\pm E_{o\ max}$ and $\pm I_{o\ max}$ are listed in the model table.



Model BOP 50-2M

output effects for programming means that employ external preamplifier input and feedback values. The output effects for the built-in gain-feedback values are tabulated in the Static Specifications table

The expression for calculating the effect of the offset variations is:

$$\text{(Voltage mode) } \Delta E_o = G_v[\pm \Delta E_{io}(1 + R_f/R_i) \pm \Delta I_{io}R_f]$$

$$\text{(Current mode) } \Delta I_o = G_i[\pm \Delta E_{io}(1 + R_f/R_i) \pm \Delta I_{io}R_f]$$

where the closed loop gain is G_v in voltage mode and G_i in current mode.

$$G_v = E_{o\ max}/10\ (V/V)$$

$$G_i = I_{o\ max}/10\ (A/V)$$

R_f and R_i are, respectively, the feedback and input resistances used around the preamplifiers. If the internal references (E_r) are used, add a term into the brackets equal to $G(E_r) = \pm \Delta E_r (R_f/R_i)$ for the effect of reference variations.

OFFSET NULLING: A control is provided for zeroing the offset voltage of the voltage and current amplifiers and preamplifiers.

REFERENCES: A pair of ±10V, 1 mA references referred to the common terminal are provided for control purposes.

GAIN: The closed-loop gain of the bipolar voltage and current amplifiers are listed above. The voltage preamplifier and current preamplifier each offer a minimum of 20,000 V/V open loop gain. With their internal input/feedback elements they function as unity gain inverting amplifiers.

DYNAMICS

BANDWIDTH/PROGRAMMING SPEED: The dynamics of the BOP output may be expressed in both the time domain (as its response to a step-program) or in the frequency domain (bandwidth). These figures are tabulated below.

OUTPUT IMPEDANCE: Expressed as a function of frequency, the output impedance is a measure of dynamic stabilization. As either a voltage or current stabilizer, the d-c and low frequency value is given by the load effect. As a voltage stabilizer at frequencies above the stabilizer's cutoff, the impedance increase with frequency becomes asymptotic to the tabulated characteristic series inductance. As a current stabilizer, the impedance decrease above the stabilizer's cutoff frequency becomes asymptotic to the tabulated characteristic shunt capacitance. The model table gives these values for each BOP model.

STABILITY & LOAD REACTANCE: The BOP power supply behaves like a wideband amplifier, or, as a 1st order (single breakpoint) closed loop feedback system. The phase-gain versus frequency characteristic is determined by the f_{-3dB} breakpoint (corner frequency), as indicated in the dynamic specification table. The closed loop gain is given in the Model table.

The unity gain crossover frequency, with 90° phase margin, is a relatively high frequency, and the power supply, although stable with a resistive load, may become unstable and even oscillate into reactive loads. The additional phase shift, created by a reactive load (RC in voltage mode and L/R in current mode) with a breakpoint approaching the unity gain crossover frequency, will cause the BOP's dynamic response to exhibit a peak and even sustain oscillation. If the load's breakpoint frequency is much below the BOP's, the power supply will be stable, but the frequency response will be governed by the load's time constant.

BOUNDING:

LIMITS: Each BOP is equipped with four adjustable boundary limits: $+E_{LIMIT}$, $-E_{LIMIT}$, $+I_{LIMIT}$ and $-I_{LIMIT}$. These are screwdriver controlled by counter-rotating front panel controls. Additionally, the limits are programmable by 0 to 10V control signals (a single control can program the limits symmetrically, or separate control signals can be used to obtain assymetrical limits).

Dynamic Specification	Mode Switch	BOP 20-10M	BOP 36-6M	BOP 50-2M	BOP 50-4M	BOP 72-3M	BOP 100-1M	BOP 100-2M
Bandwidth (d-c to f-3 db)	Voltage	3 kHz	1.8 kHz	4.5 kHz	2.8 kHz	2 kHz	4 kHz	3 kHz
	Current	3 kHz	1.8 kHz	3 kHz	2.8 kHz	2 kHz	3 kHz	3 kHz
Programming Time Constant	Voltage	50 µsec	85 µsec	35 µsec	55 µsec	80 µsec	40 µsec	50 µsec
	Current	50 µsec	85 µsec	50 µsec	55 µsec	80 µsec	50 µsec	50 µsec
Large Signal Frequency Response	Voltage	3.3 kHz	1.9 kHz	5.5 kHz	3 kHz	2.1 kHz	4.7 kHz	3.3 kHz
	Current	3.1 kHz	1.9 kHz	3.1 kHz	3 kHz	2.1 kHz	3.5 kHz	3.3 kHz
Slewing Rate	Voltage	0.4V/µsec	0.4V/µsec	1.7V/µsec	0.9V/µsec	0.9V/µsec	3V/µsec	2V/µsec
	Current	200 mA/µsec	70 mA/µsec	40 mA/µsec	75 mA/µsec	40 mA/µsec	22 mA/µsec	40 mA/µsec
Transient Recovery (Step Load Change)	Voltage	150 µsec	250 µsec	140 µsec	180 µsec	300 µsec	150 µsec	200 µsec
	Current	30 µsec	30 µsec	30 µsec	30 µsec	30 µsec	40 µsec	30 µsec

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

GENERAL

MODE LIGHTS AND FLAGS: There are (4) front panel LED indicators to signal operation in either bipolar voltage or bipolar current modes, or operation against either the voltage limit or the current limit. Each mode lamp corresponds to a flag signal, TTL compatible, that provides a logic "0" to the rear connector when operation occurs in its mode.

SERIES AND PARALLEL: These BOP models contain means to interconnect their protective circuits to allow for series, parallel or multiple power supply operation. They may also be connected together in various tracking modes. Series operation is permitted up to the 500V isolation voltage.

ISOLATION FROM GROUND: The circuit and output terminals of the BOP have no d-c connections to ground and may be floated up to 500V (d-c or peak) off ground. The common mode current from the output to ground is less than 5 μA rms, 50 μA p-p at 115 V a-c, 60 Hz.

SOURCE POWER REQUIREMENTS: Units are factory-wired for 105–125V a-c, 50–60 Hz power. Simple jumper changes will reconfigure the input for 95–113V a-c or 190–226V a-c or 210–250V a-c. The primary circuit is protected by a circuit breaker.

TEMPERATURE RATINGS: **Storage:** – 40°C to + 85°C
Operating: 0°C to + 55°C
Cooling is by built-in forced air blower exhausting to the rear.

STANDARDS: BOP models are designed and tested in accordance with NEMA standard PY-1-1972 and IEC recommendation 478 (parts 1-4).

TERMINALS: All BOP models are equipped with front panel binding posts for bipolar programming inputs. Binding posts are provided on the front panel for common, output and the two sense terminals. The outputs are accessible also at the rear on a barrier strip. A rear plug provides access to the BOP's control functions (mates with PC–15, supplied).

METERS: A pair of 2½" ± 2% recessed meters are provided. They are zero center meters reading ± voltage and ± current.

MOUNTING: Units can be rack mounted using either model RA 24 or RA 37 adapters. They occupy 3/4 of the available rack space.

DIMENSIONS: (English in inches, metric in mm.)
English measure: 5 7/32H x 12 17/32W x 17 9/64D (behind panel)
Metric measure: 132.6H x 318.3W x 435.4 D
Add 2½" (63.5 mm) for connector protrusion.

FINISH: *Panel:* Light gray, color 26440, Fed. Std. 595.
Case: Charcoal gray texture.

OPTIONS (add identifying numbers as a suffix to model number):

Suffix "—488-B": Digital programming card BIT 488-B. Makes it possible to control the BOP output by means of digital input signals from the IEEE-488 or GPIB bus. Input coding is binary, 12 bits resolution for the main channel and 8 bits resolution for the limit channel.

Suffix "—488-D": Digital programming card BIT 488-D for the same use as BIT 488-B. Input coding used isASCII, while the data format has decimal notation with 3 digit resolution for the main channel and 2 digits resolution for the limit channel.

Suffix "—500-B": Digital programming card BIT 500-B makes it possible to control the BOP output by means of digital input signals from paralled data transfer bus. Input coding is binary, with 12 bits resolution for the main channel and 8 bits resolution in the limit channel.

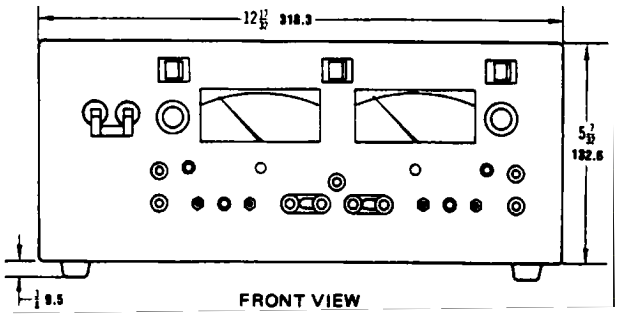
Suffix "—500-D": Digital programming card BIT 500-D for the same use as BIT 500-B. Input coding is BCD with 3 digit resolution for the main channel and 2 digit resolution in the limit channel.

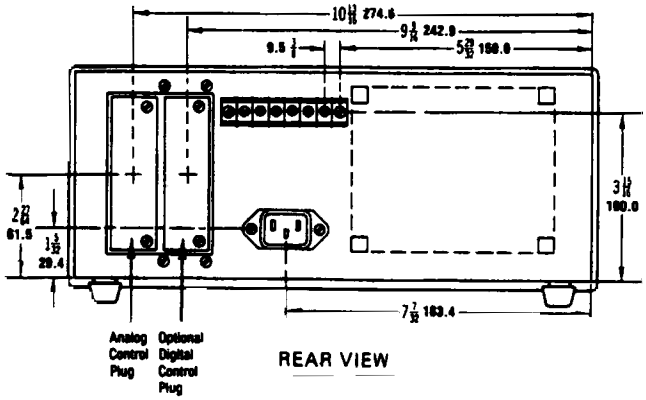
NOTE: The digital interface cards can be ordered separately for field installation into a properly equipped BOP.

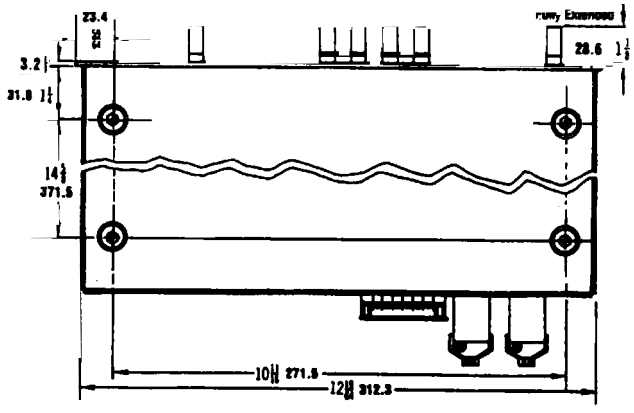
OUTLINE DIMENSIONAL DRAWINGS

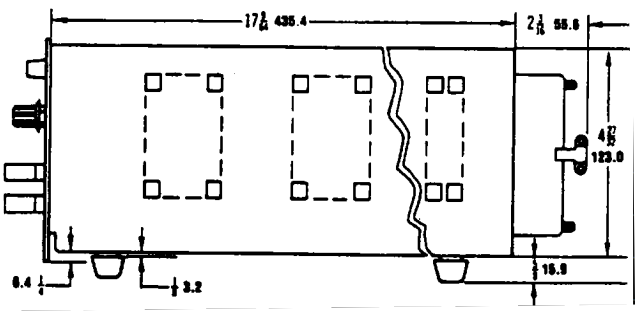
Fractonal dimensions in light face type are in inches.
Dimensions in bold face type are in milimeters.

Tolerance:
± 1/64 (0.4) between mounting holes
± 1/32" (0.8) other dimensions.

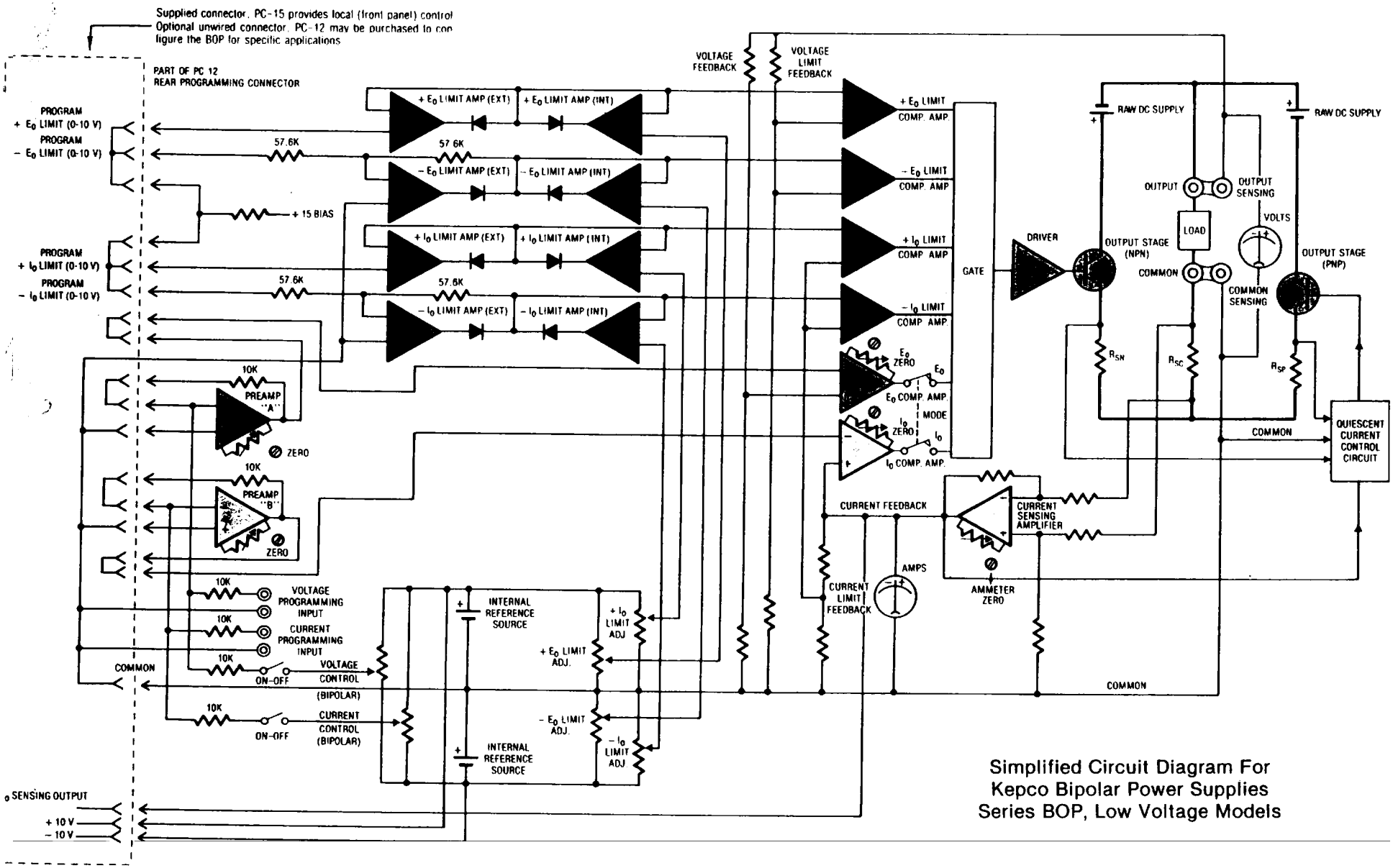








Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com



Simplified Circuit Diagram For
Kepco Bipolar Power Supplies
Series BOP, Low Voltage Models

KEPCO, INC. • 131-38 SANFORD AVENUE FLUSHING, N.Y. 11352 U.S.A. • (212) 461-7000 • TWX #710-582-2631 • Cable: KEPCOPOWER

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP