



KEPCO'S BOP FAMILY OF FOUR QUADRANT BIPOLAR POWER SUPPLIES

BOP 200W and 400W (Linear)

M MODELS: Standard - Analog Meter
 200W Models: 20V, 36V, 50V, 100V, 200V
 400W Models: 20V, 36V, 50V, 72V, 100V

D MODELS: Digital Meter

L MODELS: Optimized for Inductive Loads
 C MODELS: Optimized for Capacitive Loads
 -4886 MODELS: GPIB Control

BOP 40W High Voltage (Linear)

500V, 1000V

BOP 1KW (Switch-Mode)

MG MODELS: Standard
 6V, 10V, 20V, 25V, 36V, 50V, 72V, 100V

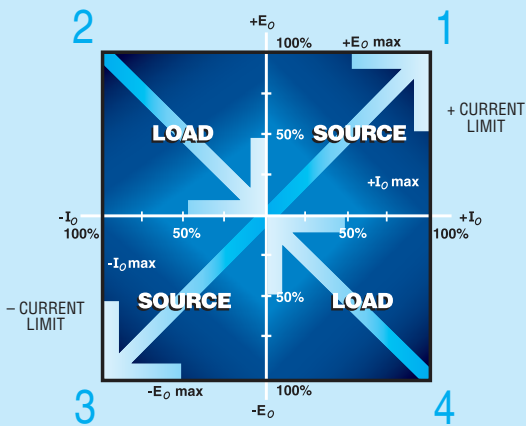
GL MODELS: Optimized for Very Low Ripple and Noise
 20V, 36V, 50V



WHAT IS A 4 QUADRANT POWER SUPPLY?

Conventional d-c power supplies operate in a single quadrant of the voltage-current axis, delivering stabilized and adjustable d-c voltage or current to a load. They may be voltage stabilized, meaning that the current varies with the load, or they may be current stabilized, meaning that the voltage varies with the load.

Kepeco's BOP operate in all four quadrants of the voltage-current axis, therefore their output may swing seamlessly from negative to positive voltage and the output current may also swing from positive to negative values. The result of this is that BOP will function as a source or a sink, meaning it will either deliver power to a load or absorb power from a load. In order to do that, the BOP is built as a power amplifier with a bipolar output, having a frequency bandwidth much larger than a regular power supply. The frequency bandwidth is model and option dependent.



FOUR-QUADRANT OPERATION FROM A KEPCO BOP POWER SUPPLY

In quadrant 1 of the volt-ampere axis, both voltage and current are positive so the BOP power supply is able to deliver power to a load. In quadrant 3 both are negative and the BOP is also a source. In quadrants 2 and 4, however, the voltage and current are of opposite polarity. In these two quadrants the BOP will act as a sink, absorbing power. **The sinking may be transient in nature as BOP absorbs energy stored in reactive elements or it may be steady state, when for example, BOP controls the discharge of a battery or acting as an electronic load, constant current for an external voltage source, or a constant voltage for an external current source.**

BOP 1KW (Switch-Mode)

Using switch-mode technology for low dissipation when sinking power from an active load, the BOP 1KW 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 internal sinking.



The BOP 1KW has two primary control channels: voltage or current. Either of these may be controlled from full plus setting to full minus setting. To assure that they will intersect in one of the two source quadrants to form a closed boundary as do conventional unipolar power supplies, four auxiliary limit channels are provided: plus voltage, minus voltage, plus current and minus current. These four are controllable from a very small value 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 channel to the limit channel.



BOP 1KW MODEL TABLE

| MODEL | d-c OUTPUT RANGE | | CLOSED LOOP GAIN | | OUTPUT IMPEDANCE | | | |
|------------------|------------------|------------------|--|--|------------------|----------------|--------------|---------------|
| | VOLTAGE V d-c | CURRENT A d-c | VOLTAGE CHANNEL G _V (V/V) | CURRENT CHANNEL G _I (A/V) | VOLTAGE MODE | | CURRENT MODE | |
| | | | | | SERIES R mΩ | SERIES L μH | SHUNT R Ω | SHUNT C μF |
| 1000 WATT | | | | | | | | |
| BOP 6-125MG | 0 to ±6 | 0 to ±125 | 0.6 | 12.5 | 0.05 | 1.5 | 24 | 1150 |
| BOP 10-75MG | 0 to ±10 | 0 to ±75 | 1.0 | 7.5 | 0.13 | 2.0 | 67 | 976 |
| BOP 20-50MG | 0 to ±20 | 0 to ±50 | 2.0 | 5.0 | 0.40 | 8.3 | 200 | 371 |
| BOP 25-40MG | 0 to ±25 | 0 to ±40 | 2.5 | 4.0 | 0.63 | 15.8 | 313 | 165 |
| BOP 36-28MG | 0 to ±36 | 0 to ±28 | 3.6 | 2.8 | 1.30 | 25 | 640 | 103 |
| BOP 50-20MG | 0 to ±50 | 0 to ±20 | 5.0 | 2.0 | 2.50 | 50 | 1250 | 55 |
| BOP 72-14MG | 0 to ±72 | 0 to ±14 | 7.2 | 1.4 | 5.14 | 104 | 2570 | 33 |
| BOP 100-10MG | 0 to ±100 | 0 to ±10 | 10.0 | 1.0 | 10.0 | 163 | 5000 | 16 |

NOTE: When connecting active loads, the steady-state voltage of the active load must not exceed the maximum voltage rating of the BOP. Otherwise the overvoltage protection will shut down the power supply.



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BOP 1KW FEATURES

- Full 4-quadrant, 1000 watt, source-sink operation.
- Energy recuperation, during sink-mode, through a patented bi-directional PFC circuit.
- Meets the EN61000-3-2 harmonic limits. A built-in EN55011 Class A input EMI filter is provided.
- High efficiency switch-mode operation.
- Output voltage from $\pm 6V$ to $\pm 100V$.
- Full digital control with built-in standard GPIB. Compatible with IEEE 488.2. Accepts standard SCPI commands. VISA driver provided. Also supports RS 232 bus.
- Large graphic LCD, displays settings and output voltage and current.
- Keypad control from front panel with menu to access functions.
- Calibration adjustments are made via the remote interface or locally from 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, the Marking and Declaration Directive 93/28/EEC, and the EMC Directive 89/336/EEC.
- Built-in complex waveform generator.
- Parallel (max. 5 units) or Serial (max. 3 units) connection of identical units. Parallel and Series connecting cables are required; contact factory for pricing.

YOU CAN MODEL MANY REAL-WORLD PHENOMENA IN WHICH POLARITY OR DIRECTION IS AN ISSUE

**RIGHT/LEFT UP/DOWN HOT/COLD
CLOCKWISE/COUNTERCLOCKWISE
CHARGE/DISCHARGE FORWARD/REVERSE**

APPLICATIONS FOR KEPCO'S BOP 1KW

**Automotive
Battery and Motor
Simulation and Testing**

**Wafer Deposition
and Electroplating**

**Magnet Applications
Particle Beam Correctors and Injectors,
Medical Imaging, etc.**

Solar Panel Research and Testing

**For full specs, visit our Web site at
www.kepcopower.com/bophi.htm**

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BOP 1KW 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 | |
| | range | 47-63 Hz | |
| Current | 176V a-c | 9.5A (7.5A)* | Maximum |
| | 264V a-c | 6.4A (4.4A)* | Maximum |
| Power Factor | source | 0.99 | Nominal output power Complies with EN 61000-3-2 |
| | sink | 0.97 | |
| Efficiency | | 65% (56%)* | Minimum when sourcing |
| Switching Frequency | | 70 KHz $\pm 5\%$ (50KHz $\pm 5\%$)* | Active PFC for source and sink |

* BOP 6-125MG and BOP 10-75MG only.

BOP 1KW PROGRAMMING/DISPLAY CHARACTERISTICS

| SPECIFICATIONS | | RATING/DESCRIPTION | CONDITION |
|-----------------|---|--|---|
| Analog Control | voltage or current main channel | -10V to +10V | Full range output |
| | \pm voltage and \pm current protection limit channel | +0.05V to +10V | 0.5% to 100% of nominal range |
| Digital Control | local | Panel-mounted keypad | Direct entry |
| | remote | IEEE 488-2 (GPIB) | SCPI |
| | remote | RS 232 | |
| | remote | RS 485 (BITBUS) | Used for series and parallel configurations |
| Display | front panel | 4" backlit LCD displays all functions | |
| | remote | All parameters read back on RS 232 and GPIB buses | |

BOP 1KW GENERAL (ENVIRONMENTAL) SPECIFICATIONS

| SPECIFICATIONS | | RATING/DESCRIPTION | CONDITION |
|----------------|-----------|----------------------------------|-----------------------|
| Temperature | operating | 0 to +50°C | Full rated load |
| | storage | -20 to +85°C | |
| Cooling | | Two internal fans | Exhaust to the rear |
| Humidity | | 0 to 95% RH | Non-condensing |
| Shock | | 20g, 11msec $\pm 50\%$ 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. | |

BOP 1KW 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 | |

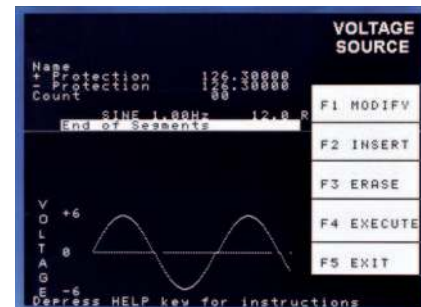
BOP 1KW OUTPUT CHARACTERISTICS

| SPECIFICATIONS | | RATING/DESCRIPTION | CONDITION |
|---------------------------------------|---------------------|---|---|
| Type of Stabilizer | | Voltage/Current 4-quadrant | Switch mode |
| Switching Frequency | | 100KHz \pm 5% | Output stage |
| Source Adjustment Range | voltage | -100% to +100% of rating | 0-50°C |
| | current | -100% to +100% of rating | |
| Sink Adjustment Range | voltage | -100% to +100% of rating | 0-50°C, recuperated energy is sent back into line for general reuse |
| | current | -100% to +100% of rating | |
| Voltage Stabilization in Voltage Mode | source effect | 0.05% of rating | min-max input voltage |
| | load effect | 0.1% of rating | 0-100% load current |
| | time effect (drift) | 0.02% of rating | 0.5 - 8 hours |
| | temperature effect | 0.02%/°C of rating | 0-50°C |
| | ripple | 2% E _O max p-p | Includes switching noise |
| | noise | 0.2% E _O max rms | |
| Current Stabilization in Current Mode | source effect | 0.05% of rating | min-max input voltage |
| | load effect | 0.2% of rating | 0-100% load current |
| | time effect (drift) | 0.02% of rating | 0.5 - 8 hours |
| | temperature effect | 0.02%/°C of rating | 0-50°C |
| | ripple | 2% I _O max p-p | Includes switching noise |
| | noise | 0.2% I _O max rms | |
| Error Sensing | | 0.25 volts per wire | Above rated output |
| Transient Recovery in Voltage Mode | maximum excursion | 5% of nominal output | nominal voltage, 50% load step |
| | recovery time | 200 μ sec | Return within 0.1% of set voltage |
| Output Common Mode Voltage | | 300V | Output to chassis ground |
| Series Operation | | Master/slave | Maximum of 3 identical units, up to 300V max. |
| Parallel Operation | | Master/slave | Maximum of 5 identical units |
| Output Protection Limiting | | Voltage and current limited in four quadrants | |
| Output Stage Protection | | Output overvoltage/overcurrent, heat sink overtemperature, switchers overcurrent | Triggers latched shutdown protection of the output module and PFC stage. Recover by cycling power off, then on or by pressing RESET at the front panel |
| Input Stage Protection (PFC) | | Internal overvoltage, undervoltage, overcurrent, heat sink overtemperature, fan inoperative | Trips circuit breaker to shut off unit |
| | | Input circuit breaker overcurrent | |
| Small Signal Bandwidth | voltage channel | 2 KHz maximum | Into nominal resistive load |
| | current channel | 800 Hz maximum (600 Hz Maximum) (1) | Into short circuit |
| Rise/Fall Time | voltage channel | 250/200 μ sec | Into nominal resistive load |
| | current channel | 0.7/1.2 mSec | Into short circuit |

(1) BOP 6-125MG only.

BOP 1KW ALLOW FOR AUTOMATIC CREATION AND DISPLAY OF VARIOUS WAVEFORMS AND COMPLEX PATTERNS

The 1000-watt models have an internal waveform generator that allows a user to combine segments of a sinusoidal waveform, triangular waveform, a ramp, a saw tooth waveform and a square 50% duty cycle pulse, plus d-c to create a variety of arbitrary waveforms. 3,933 of points per basic waveform can be programmed with arbitrary phase relationships. The resulting waveshape can be repeated from 1 to 255 times. The waveshape can also be executed indefinitely until a stop command is received. The waveshape graphics are displayed on the front panel-mounted LCD display, which also shows both settings and actual d-c output values. The programmed waveshapes can be used to control either voltage or current with both positive and negative values. It is possible to reproduce an a-c sinusoid with differing degrees of distortion or dropouts for test purposes. Alternatively, varying amounts of "noise" can be added to a d-c output to gauge the effect on a test subject.



Sine Waveform



Triangle Waveform



Complex Sine Waveform

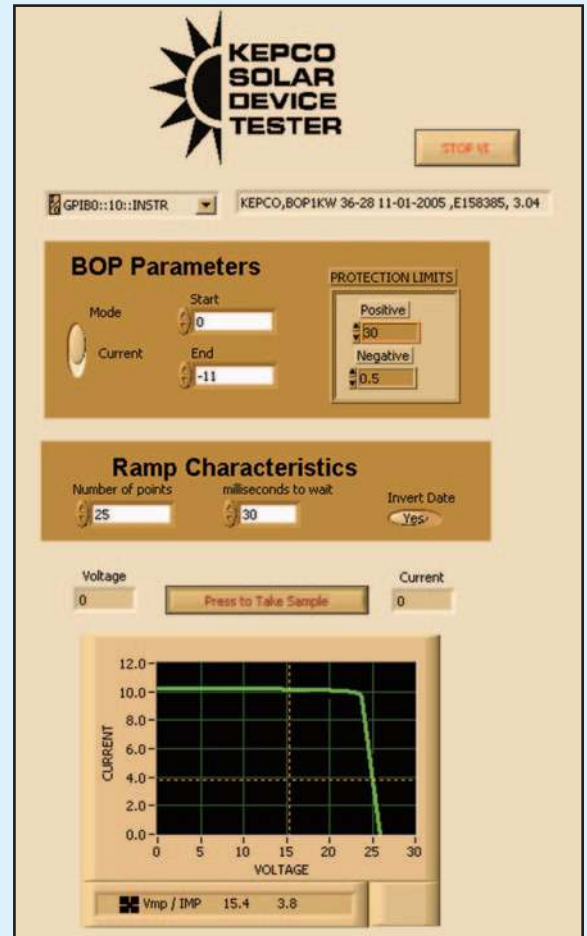
For full specs, visit our Web site at www.kepcopower.com/bophi.htm

USING KEPCO BOP 1KW FOR SOLAR DEVICE TESTING

The Kepco BOP 1KW provides a one-step solution for test and characterization of solar cells and solar panels. A free LabView subvi allows rapid characterization of the solar device using only the BOP 1KW, eliminating the need for separate DVMs to measure voltage and current. The subvi is designed for both I-V Trace and Dark I-V testing, and can be plugged in or easily adapted to existing LabView test applications, even those previously using two DVMs. This solution offers lower cost, greater throughput and increased ROI when testing solar devices.

BOP 1KW SOLAR DEVICE TESTING FEATURES AND BENEFITS

- SOLAR DEVICE TESTING - Both I-V Trace and Dark I-V Tests supported.
- FLEXIBILITY - KEPCO BOP 1KW LabView Driver allows Solar Device testing while maintaining full functionality of the BOP 1KW Instrument Power Supply features.
- FASTER THROUGHPUT - 20mS per point.
- ROI - Test setups are quick and easy, require no special programming for synchronization, require no dedicated engineering resources to design and/or maintain components comprising a custom solution.
- LOWER COST AND SIMPLICITY - No need to purchase, maintain and calibrate two DVMs - Simplifies calibration, test setup and operation; no trigger connections needed.
- RELIABILITY - With all triggering and measurements done within BOP 1KW there are no synchronization or noise issues.
- PROVEN TECHNOLOGY - Enhancement of proven BOP 1KW technology.
- ENERGY CONSERVATION - Employs energy recuperation as well as active Power Factor Correction (PFC).



Demonstration Application Interface Showing User Inputs and Rendered I-V Curve Output

BOP 1KW GL SERIES OPTIMIZED FOR VERY LOW RIPPLE AND NOISE

The BOP-GL series models are a standard modification of the 1KW that have been optimized for exceptionally low current ripple and noise and improved stability (drift and temperature), making them ideal for driving inductive loads such as large magnets or motors. These bipolar power supplies pass smoothly through zero without switching to provide true \pm voltage and \pm current.

BOP-GL 1000 WATT MODEL TABLE

| MODEL | d-c OUTPUT RANGE | | CLOSED LOOP GAIN | | RIPPLE AND NOISE | |
|------------------|--------------------|--------------------|--------------------|--------------------|------------------|----------------|
| | E_0 MAX V d-c | I_0 MAX A d-c | VOLTAGE CHANNEL | CURRENT CHANNEL | VOLTAGE rms | CURRENT rms |
| 1000 WATT | | | | | | |
| BOP 20-50GL | 0 to ± 20 | 0 to ± 50 | 2.0 | 5.0 | 0.02% | 0.01% |
| BOP 36-28GL | 0 to ± 36 | 0 to ± 28 | 3.6 | 2.8 | 0.02% | 0.01% |
| BOP 50-20GL | 0 to ± 50 | 0 to ± 20 | 5.0 | 2.0 | 0.02% | 0.01% |

NOTE: When connecting active loads, the steady-state voltage of the active load must not exceed the maximum voltage rating of the BOP. Otherwise the overvoltage protection will shut down the power supply.

For other volt-ampere combinations, consult factory.



BOP 40W HIGH VOLTAGE (Linear)

The Kepco Model BOP 500M and BOP 1000M are high voltage power sources, up to $\pm 500V$ or $\pm 1000V$, respectively.



For full specs, visit our Web site at www.kepcopower.com/bophv.htm.

These combine the capabilities of fast programmable power supplies with a Class A output stage, which can respond bi-directionally from zero. They can be operated in either a "voltage stabilizing" or "current stabilizing" mode. To realize the full high speed potential of the BOP HV, the load characteristics should be mainly resistive. Load capacitance and inductance up to $0.01\mu F$ and $0.5mH$ can be tolerated without performance deterioration.



BOP HIGH VOLTAGE MODEL TABLE

| MODEL ⁽³⁾ | d-c OUTPUT RANGE | | CLOSE LOOP GAIN | | OUTPUT IMPEDANCE | | | |
|----------------------|------------------|------------|-----------------------------|------------------------------|-----------------------|--------------------------------------|----------------------|-------------------------------------|
| | E_o max. | I_o max. | VOLTAGE CHANNEL G_V (V/V) | CURRENT CHANNEL G_I (mA/V) | VOLTAGE MODE SERIES R | VOLTAGE MODE SERIES L ⁽¹⁾ | CURRENT MODE SHUNT R | CURRENT MODE SHUNT C ⁽²⁾ |
| BOP 500M | $\pm 500V$ | $\pm 80mA$ | 50 | 8.0 | 0.05Ω | 5mH | $100M\Omega$ | $0.3\mu F$ |
| BOP 1000M | $\pm 1000V$ | $\pm 40mA$ | 100 | 4.0 | 0.2Ω | 50mH | $400M\Omega$ | $0.4\mu F$ |

- (1) For determining dynamic impedance in voltage mode.
 (2) For determining dynamic impedance in current mode.
 (3) To specify digital display, substitute the suffix "DM" for "M."

BOP 200W AND 400W (Linear)

The BOP 200W and 400W are high-speed 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. 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 200W AND 400W FEATURES

- Source 100% and sink 50% of the output power rating.
- Separate control circuits for voltage and current with automatic crossover between main channel and limit channel.
- Controls and flag signals accessible through a 50-terminal port at the rear.
- Zeroable preamplifier available for scaling and summing external signals.
- Optional digital control via GPIB or RS232. Add suffix -4886.
- Parallel and Series connection of identical models.
- Mounting in standard 19" racks
 RA 37: 3/4 rack size
 Mounting "ears" supplied: full rack size

BOP 200W AND 400W MODEL TABLE

| MODEL ^{(1) (5)} | d-c OUTPUT RANGE | | CLOSED LOOP GAIN | | OUTPUT IMPEDANCE | | | |
|---------------------------|------------------|---------------|-----------------------------|-----------------------------|---------------------|---------------------------------|--------------------|--------------------------------|
| | VOLTAGE V d-c | CURRENT A d-c | VOLTAGE CHANNEL G_V (V/V) | CURRENT CHANNEL G_I (A/V) | VOLTAGE MODE | | CURRENT MODE | |
| | | | | | SERIES R m Ω | SERIES L μH ⁽²⁾ | SHUNT R K Ω | SHUNT C μF ⁽³⁾ |
| 200 WATT | | | | | | | | |
| BOP 20-10M | 0 to ± 20 | 0 to ± 10 | 2.0 | 1.0 | 0.04 | 40 | 20 | 0.05 |
| BOP 36-6M | 0 to ± 36 | 0 to ± 6 | 3.6 | 0.6 | 0.12 | 20 | 36 | 0.03 |
| BOP 50-4M | 0 to ± 50 | 0 to ± 4 | 5.0 | 0.4 | 0.25 | 50 | 50 | 0.02 |
| BOP 100-2M | 0 to ± 100 | 0 to ± 2 | 10.0 | 0.2 | 1.0 | 60 | 100 | 0.03 |
| BOP 200-1M ⁽⁴⁾ | 0 to ± 200 | 0 to ± 1 | 20.0 | 0.1 | 4.0 | 1200 | 200 | 0.03 |
| 400 WATT | | | | | | | | |
| BOP 20-20M | 0 to ± 20 | 0 to ± 20 | 2.0 | 2.0 | 0.02 | 10 | 20 | 0.5 |
| BOP 36-12M | 0 to ± 36 | 0 to ± 12 | 3.6 | 1.2 | 0.06 | 50 | 36 | 0.4 |
| BOP 50-8M | 0 to ± 50 | 0 to ± 8 | 5.0 | 0.8 | 0.125 | 100 | 50 | 0.15 |
| BOP 72-6M | 0 to ± 72 | 0 to ± 6 | 7.2 | 0.6 | 0.24 | 200 | 72 | 0.1 |
| BOP 100-4M | 0 to ± 100 | 0 to ± 4 | 10.0 | 0.4 | 0.5 | 200 | 100 | 0.1 |

- (1) Optional digital control via GPIB or RS232. Add suffix -4886.
 (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."

APPLICATIONS FOR KEPCO'S BOP 200W AND 400W

**Automotive
 Battery and Motor Simulation and Testing**

Wafer Deposition and Electroplating

**Magnet Applications
 Beam Steering, Medical Imaging, etc.**

Solar Panel Research and Testing

For full specs, visit our Web site at www.kepcopower.com/bop.htm.

OPTIMIZE BOP 200W AND 400W FOR DRIVING INDUCTIVE LOADS TO 1 HENRY

As an option (L suffix), Kepco's 200W (except BOP 200-1M) and 400W BOP models may be optimized for driving inductive loads. These BOP units are designed to operate in a stable manner in Current or Current Limit Mode for loads up to 1 Henry. They are also stable with any R-L series load combination.

To prevent voltage limit operation, the equivalent impedance of the R-L series load at the working frequency, must be lower than the nominal resistive load value (nominal output voltage/nominal output current).

All specifications of the unit in voltage mode are unchanged from the standard model. The specifications listed in the table to the right are for inductive load models in Current Mode. All other specifications are identical to the standard BOP.

In current mode the bandwidth of the BOP is reduced when operating with a resistive load. Correspondingly, the rise and fall time of the unit is increased (model dependent). Further, it is possible to reduce the bandwidth in current mode in a predictable way, using one customer installed component on the rear programming connector of the BOP (see Bandwidth Correction Chart).

APPLICATIONS FOR KEPCO'S BOP INDUCTIVE LOAD MODELS

Motor Testing

Testing of Magnetic Components
Coils, Speakers, etc.

Industrial Applications with
Inductive Loads

Driving CRT Coils

Cryogenic Applications

Correcting Magnets for
Medical Imaging or
Particle Accelerators

For more information on the
BOP Inductive Load Models visit
www.kepcopower.com/bop-ind.htm

BOP INDUCTIVE LOAD SPECIFICATIONS

| MODEL / SPECIFICATION (1) | BANDWIDTH (DC TO F-3dB) | | RISE/FALL TIME (2) | RECOVERY TIME CONSTANT AT STEP LOAD (3) | LOAD EFFECT RESISTIVE LOAD, NOMINAL (4) |
|-------------------------------------|-------------------------|---------------------|--------------------|---|---|
| | RESISTIVE LOAD, NOMINAL | INDUCTIVE LOAD, 2mH | | | |
| 200 WATT | | | | | |
| BOP 20-10ML 0 to ±20V, 0 to ±10A | 11.2 KHz | 4.1 KHz | 35µS | 220µS | 12 ppm/Hz |
| BOP 36-6ML 0 to ±36V, 0 to ±6A | 12 KHz | 5 KHz | 30µS | 210µS | 4 ppm/Hz |
| BOP 50-4ML 0 to ±50V, 0 to ±4A | 1.43 KHz | 1.8 KHz | 245µS | 280µS | 20 ppm/Hz |
| BOP 100-2ML 0 to ±100V, 0 to ±2A | 3.5 KHz | 5.0 KHz | 84µS | 250µS | 47 ppm/Hz |
| 400 WATT | | | | | |
| BOP 20-20ML 0 to ±20V, 0 to ±20A | 12 KHz | 2.5 KHz | 33µS | 180µS | 3 ppm/Hz |
| BOP 36-12ML 0 to ±36V, 0 to ±12A | 12.7 KHz | 6.8 KHz | 28µS | 100µS | 3 ppm/Hz |
| BOP 50-8ML 0 to ±50V, 0 to ±8A | 10.6 KHz | 4.9 KHz | 31µS | 200µS | 7 ppm/Hz |
| BOP 72-6ML 0 to ±72V, 0 to ±6A | 2.6 KHz | 2.7 KHz | 125µS | 200µS | 50 ppm/Hz |
| BOP 100-4ML 0 to ±100V, 0 to ±4A | 1.2 KHz | 1.7 KHz | 220µS | 280µS | 70 ppm/Hz |

For digital meters, substitute the letter D for M when ordering - example: BOP 20-10DL.
For GPIB control of the BOP, add the suffix 4886 after the letter L in the model name - example: BOP 20-10ML4886.

- (1) All specifications listed are for inductive load models in Current Mode. All other specifications are identical to the standard BOP.
- (2) 10% - 90%, nominal resistive load.
- (3) Short-circuit, nominal resistive load.
- (4) Load effect increases nonlinearly with frequency from the typical 0.5 mA in DC full scale (same as the standard unit) at the average rate listed.

BOP INDUCTIVE LOAD - BANDWIDTH CORRECTION

| MODEL | EXTERNAL CAPACITOR (ACROSS PINS 16 AND 18 OF PC 12 PROGRAMMING CONNECTOR) | | | | | | |
|-----------------|--|---------|----------|----------|----------|----------|----------|
| | 0.01 µF | 0.02 µF | 0.05 µF | 0.1 µF | 0.2 µF | 0.5 µF | 1 µF |
| 200 WATT | | | | | | | |
| BOP 20-10ML | 4.1 KHz | 2.3 KHz | 1.0 KHz | 0.57 KHz | 0.27 KHz | 0.11 KHz | 0.06 KHz |
| BOP 36-6ML | 4.0 KHz | 2.5 KHz | 1.0 KHz | 0.55 KHz | 0.25 KHz | 0.12 KHz | 0.06 KHz |
| BOP 50-4ML | 1.4 KHz | 1.2 KHz | 0.7 KHz | 0.47 KHz | 0.25 KHz | 0.11 KHz | 0.06 KHz |
| BOP 100-2ML | 1.8 KHz | 1.4 KHz | 0.8 KHz | 0.51 KHz | 0.27 KHz | 0.11 KHz | 0.06 KHz |
| 400 WATT | | | | | | | |
| BOP 20-20ML | 4.0 KHz | 2.4 KHz | 1.0 KHz | 0.57 KHz | 0.30 KHz | 0.12 KHz | 0.07 KHz |
| BOP 36-12ML | 4 KHz | 2.4 KHz | 1 KHz | 0.57 KHz | 0.27 KHz | 0.11 KHz | 0.06 KHz |
| BOP 50-8ML | 3.6 KHz | 2.1 KHz | 0.93 KHz | 0.54 KHz | 0.29 KHz | 0.12 KHz | 0.06 KHz |
| BOP 72-6ML | 1.75 KHz | 1.3 KHz | 0.75 KHz | 0.47 KHz | 0.26 KHz | 0.11 KHz | 0.06 KHz |
| BOP 100-4ML | 1.0 KHz | 0.8 KHz | 0.6 KHz | 0.4 KHz | 0.23 KHz | 0.11 KHz | 0.06 KHz |



OPTIMIZE BOP 200W AND 400W FOR DRIVING CAPACITIVE LOADS TO 10 MILLI-FARADS

As an option (C suffix), Kepco's 200 Watt (except BOP 200-1M) and 400 Watt BOP models may be optimized for driving capacitive loads.

These BOP units are designed to operate in a stable manner in voltage or voltage limit mode for capacitive loads up to 10mF. They are also stable when driving any R-C parallel combination where load R is \geq nominal value and C is \leq 10mF. Load R (nominal value) = nominal output Voltage/nominal output Current (e.g., BOP 36-6MC, R = 36/6 = 6 Ohms). To prevent current limit operation, the equivalent impedance of the R-C parallel load circuit at the working frequency must be greater than the nominal R value.

Static specifications representing accuracy for various influence parameters are identical to the standard BOP models. Ripple and noise specifications are better (approximately 50% lower) for the C option units compared to the standard BOP.

In voltage mode, with a resistive load, the bandwidth of the BOP Capacitive Load is reduced versus the standard model, while the response time is increased (except the 20V model: see Specifications Chart). The frequency response variations can be practically eliminated by reducing the bandwidth in voltage mode in a predictable manner using an internal user-installed component to increase the internal compensation capacitance (see Bandwidth Correction Chart).

In Current Mode the dynamic specifications are almost identical for all BOP C option models: 3-dB bandwidth of 4.9kHz and rise/fall time of 72 μ sec (lower bandwidth and higher rise/fall time than the standard BOP models).

APPLICATIONS FOR KEPCO'S BOP CAPACITIVE LOAD MODELS

Solar Cell/Panel
Research and Testing

Driving and Testing
Piezo-Electric Devices

Capacitor Testing

Driving and Testing
Capacitive Transducers

Industrial or Lab Applications
with Capacitive or
Capacitive-Resistive Loads

BOP CAPACITIVE LOAD SPECIFICATIONS

| MODEL / SPECIFICATION (1) | BANDWIDTH (DC TO F-3dB) | | RISE/FALL TIME (4) | RECOVERY TIME AT STEP LOAD (5) |
|---|-----------------------------|---------------------------------|--------------------|--------------------------------|
| | RESISTIVE LOAD, NOMINAL (2) | CAPACITIVE LOAD, 10 μ F (3) | | |
| 200 WATT | | | | |
| BOP 20-10MC 0 to \pm 20V, 0 to \pm 10A | 12 KHz | 14 KHz | 32 μ S | 100 μ S |
| BOP 36-6MC 0 to \pm 36V, 0 to \pm 6A | 13.5 KHz | 16.3 KHz | 32 μ S | 95 μ S |
| BOP 50-4MC 0 to \pm 50V, 0 to \pm 4A | 11.5 KHz | 15 KHz | 35 μ S | 100 μ S |
| 400 WATT | | | | |
| BOP 20-20MC 0 to \pm 20V, 0 to \pm 20A | 4.8 KHz | 5.3 KHz | 75 μ S | 225 μ S |
| BOP 36-12MC 0 to \pm 36V, 0 to \pm 12A | 13.5 KHz | 16 KHz | 30 μ S | 95 μ S |
| BOP 50-8MC 0 to \pm 50V, 0 to \pm 8A | 9 KHz | 11 KHz | 38 μ S | 160 μ S |
| BOP 72-6MC 0 to \pm 72V, 0 to \pm 6A | 6.5 KHz | 8.3 KHz | 60 μ S | 184 μ S |
| BOP 100-4MC 0 to \pm 100V, 0 to \pm 4A | 6.0 KHz | 8.0 KHz | 66 μ S | 190 μ S |

For digital meters, substitute the letter D for M when ordering - example: BOP 20-20DC.

For GPIB control of the BOP, add the suffix 4886 after the letter C in the model name - example: BOP 20-20MC4886.

- (1) All specifications listed are for capacitive load models in Voltage Mode.
- (2) For BOP 20-20MC, DC: nonuniformities of the frequency response creates a larger 3-dB bandwidth for the resistive load than for the standard BOP.
- (3) Nonuniformities of the frequency response for the standard 10 μ F load create a larger 3-dB bandwidth than for the resistive load.
- (4) 10% - 90%, with nominal resistive load.
- (5) Load between infinity and nominal resistive values.

BOP CAPACITIVE LOAD - BANDWIDTH CORRECTION

| MODEL | INTERNAL USER-INSTALLED CAPACITOR | | | | | | |
|-----------------|-----------------------------------|---------|---------|---------|---------|---------|---------|
| | 1 nF | 2.2 nF | 4.7 nF | 15 nF | 33 nF | 47 nF | 100 nF |
| 200 WATT | | | | | | | |
| BOP 20-10MC | 11.5 KHz | 9 KHz | 7.5 KHz | 3.5 KHz | 2.2 KHz | 1.3 KHz | 0.5 KHz |
| BOP 36-6MC | 12.1 KHz | 10 KHz | 7.8 KHz | 3.5 KHz | 2.2 KHz | 1.4 KHz | 0.5 KHz |
| BOP 50-4MC | 11 KHz | 9 KHz | 7 KHz | 3 KHz | 1.5 KHz | 1 KHz | 0.5 KHz |
| 400 WATT | | | | | | | |
| BOP 20-20MC | 4.6 KHz | 4.4 KHz | 3.2 KHz | 1.3 KHz | 0.7 KHz | 0.6 KHz | 0.5 KHz |
| BOP 36-12MC | 12 KHz | 10 KHz | 7.6 KHz | 3.5 KHz | 2.2 KHz | 1.4 KHz | 0.5 KHz |
| BOP 50-8MC | 8.5 KHz | 8 KHz | 6.5 KHz | 4.5 KHz | 3 KHz | 1.5 KHz | 0.5 KHz |
| BOP 72-6MC | 6.5 KHz | 6.0 KHz | 5.3 KHz | 2.7 KHz | 1.4 KHz | 0.9 KHz | 0.5 KHz |
| BOP 100-4MC | 6.0 KHz | 5.4 KHz | 4.2 KHz | 2.5 KHz | 1.5 KHz | 1.1 KHz | 0.5 KHz |

The listed bandwidth values are for C option units in Voltage Mode, nominal resistive load.

For more information on the BOP Capacitive Load Models visit www.kepcopower.com/bop-cap.htm

