



Model 648 Bipolar Magnet Power Supply



Model 648 features

- Low noise
- CE mark certification
- $\pm 135\text{ A}/\pm 75\text{ V}$, 9.1 kW
- Built-in fault protection
- Bipolar, linear, 4-quadrant output
- 1 mA of programmed current resolution
- Analog programming and IEEE-488 and USB interfaces





Introduction

The Model 648 electromagnet power supply is a robust, fault-tolerant 9 kW supply optimized for powering large 7 or 10 in research electromagnets. It is specifically designed for high precision laboratory use requiring extremely low electrical noise. The linear design removes undesirable higher frequency noise typical of switch mode power supplies. Eliminating the need for external switching or operator intervention to reverse current polarity, the Model 648 uses convenient bipolar, 4-quadrant operation. It is capable of supplying $\pm 135 \text{ A}/\pm 75 \text{ V}$ to a nominal 0.5 Ω , 0.5 H load. The Model 648 is built to last with a rugged design, integrated fault protection, and a simple, clean interior electronic design.

This robust power supply is developed to minimize downtime. It uses worry-free water cooling for quiet efficient operation compared to air-cooled power supplies. The seamless water lines only have external junctions, eliminating internal water leaks. In addition, safety interlocks ensure that cooling water is always flowing to the supply while operating. Magnet water can also be interlocked into the power supply if desired. Internal software controls manage water usage intelligently.

Output architecture

The low electrical noise design of the Model 648 makes it the ideal power supply for use with large electromagnets in high precision laboratory settings, ensuring greater resolution and finer detail in data taken during highly sensitive measurements. Because low noise is critical to measurement systems, the Model 648 implements both a linear design and bipolar architecture. Linear magnet power supplies have several advantages over switch mode power supplies, primarily smooth field generation that is nearly free from offending electromagnetic signatures. The bipolar, 4-quadrant operation required to safely operate an inductive load provides clean transitions through zero without discontinuities.

Output programming

The Model 648 output current is programmed internally via the keypad or the computer interface, externally by analog programming input, or by the sum of the external and internal settings. External programming via analog input signal provides analog resolution. The Model 648 generates extremely smooth and continuous ramps — the digitally generated constant current ramp rate is variable between 0.1 mA/s and 50.000 A/s. To ensure a smooth ramp rate, the power supply updates the high-resolution DAC 12.3 times per second.

Output reading

The Model 648 provides high-resolution output current readings that reflect the actual current in the magnet, and have a resolution of 1 mA. The output voltage reading reports the voltage at the output terminals with a resolution of 1 mV. All output readings can be prominently displayed on the front panel and read over the computer interface.

Protection

The Model 648 provides built-in protection against short circuit, open circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, over temperature, and abrupt change of the external programming input. A proprietary circuit limits the power dissipated in the water-cooled cold plate should low resistance and high line conditions exist. The Model 648 protects itself if operated into resistances outside of nominal limits. By limiting current output, it will safely operate into a shorted load, and operate safely into high resistance loads by limiting voltage output. The Model 648 is also protected against power loss under full operation and nominal magnet load. Both low and high power line conditions are reported on the front panel display.



Specifications

Output

Type: Bipolar, 4-quadrant, DC voltage/current source
Current generation: Fully linear regulation with digital setting and analog control
Current range: ± 135 A nominal
Compliance voltage (DC): ± 75 V
Power: 9.1 kW nominal
Nominal load: 0.5 Ω , 0.5 H
Maximum load resistance: 0.55 Ω for ± 135 A DC operation at +10% to -5% line voltage
Minimum load resistance: 0.41 Ω for ± 135 A DC operation at +5% to -10% line voltage
Load inductance range: 0 H to 1 H
Current ripple: 10 mA RMS (0.007%) at 135 A into nominal load
Current ripple frequency: Dominated by the line frequency and its harmonics
Temperature coefficient: ± 50 ppm of full scale/ $^{\circ}$ C
Line regulation: ± 75 ppm of full scale/10% line change
Stability (1 h): 2 mA/h (after warm-up, internal setting)
Stability (24 h): 10 mA/24 h (typical, internal setting, dominated by temperature coefficient and line regulation)
Isolation: Differential output is optically isolated from chassis to prevent ground loops
Slew rate: 50 A/s into nominal load (dominated by magnet characteristics), 100 A/s maximum into a resistive load
Settling time: < 1 s for 10% step to within 1 mA of output into nominal load
Harmonic distortion: ≤ 0.1 Hz at ± 135 A sine wave into resistive load, $< 0.02\%$ THD; ≤ 10 Hz at ± 10 A sine wave into resistive load, $< 0.30\%$ THD
Attenuation: -0.5 dB at 10 Hz (external programming input)
Protection: Short circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, and over temperature
Connector: Two lugs with 8.64 mm (0.34 in) holes for M8 or 5/16 in bolts

Output programming

Internal current setting

Resolution: 1.0 mA (20-bit)
Settling time: 600 ms for 1% step to within 1 mA (of internal setting)
Accuracy: ± 20 mA $\pm 0.05\%$ of setting
Operation: Keypad, computer interface
Protection: Programmable current setting limit

Internal current ramp

Ramp rate: 0.1 mA/s to 50,000 A/s (compliance limited)
Update rate: 12.3 increments/s
Ramp segments: 5
Operation: Keypad, computer interface
Protection: Programmable ramp rate limit

External current programming

Sensitivity: 10 V/135 A
Resolution: Analog
Accuracy: ± 20 mA $\pm 1\%$ of setting
Input resistance: 20 k Ω differential, 50 k Ω common-mode
Operation: Voltage program through rear panel, can be summed with internal current setting
Limits: Internally clamped at ± 10.1 V and bandwidth limited -3 dB at 40 Hz (2 pole, low pass filter)
Connector: Shared 15-pin D-sub

Readings

Output current

Resolution: 1.0 mA
Accuracy: ± 20 mA $\pm 0.05\%$ of rdg
Update rate: 2.5 rdg/s display, 10 rdg/s interface

Output voltage (at supply terminals)

Resolution: 1.0 mV
Accuracy: ± 10 mV $\pm 0.05\%$ of rdg
Update rate: 2.5 rdg/s display, 5 rdg/s interface

Front panel

Display type: 8-line by 40-character graphic vacuum fluorescent display module
Display readings: Output current, output voltage, and internal water temperature
Display settings: Output current and ramp rate
Display annunciators: Status and errors
LED annunciators: Fault, Compliance, Power Limit, Ramping, Remote
Audible annunciator: Errors and faults
Keypad type: 20 full-travel keys
Keypad functions: Direct access to common operations, menu-driven setup
Power: Green flush ON and red extended OFF push buttons

Interface

IEEE-488.2 interface

Features: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1
Reading rate: To 10 rdg/s
Software support: National Instruments LabVIEW™ driver (consult Lake Shore for availability)

USB interface

Function: Emulates a standard RS-232 serial port
Baud rate: 57,600
Reading rate: To 10 rdg/s
Connector: Type B USB connector
Software support: National Instruments LabVIEW™ driver (consult Lake Shore for availability)

Output current monitor

Sensitivity: 7 V/135 A
Accuracy: $\pm 1\%$ of full scale
Noise: 5 mV RMS
Source impedance: 20 Ω
Connector: Shared 15-pin D-sub

Output voltage monitor

Sensitivity: 7 V/70 V
Accuracy: 1% of full scale
Noise: 2 mV RMS
Source impedance: 20 Ω
Connector: Shared 15-pin D-sub

Power supply cooling water

Remote enable input: TTL low or contact closure to enable output; used for mandatory 1 gal/min flow switch (included)
Connector: 2-pin detachable terminal block connector
Valve power output: 24 VAC at 1.5 A maximum, automatic or manual control
Connector: 2-pin detachable terminal block connector
 Water valve optional

Magnet cooling water

Remote enable input: TTL low or contact closure to enable output; jumper required if unused
Valve power output: 24 VAC at 1.5 A maximum, automatic or manual control

Connector: Shared 4-pin detachable terminal block
 Flow, temperature switch, and water valve not included

Auxiliary

Emergency stop: Requires 1 A, 24 VAC normally closed (NC) contact to enable power-up; jumper required if unused
Fault output: Relay with normally open (NO) or normally closed (NC) contact, 30 VDC at 1 A
Remote enable input: TTL low or contact closure to enable output; jumper required if unused
Connector: Shared 8-pin detachable terminal block; Emergency stop and inhibit switches not included

General

Line power

Power: 15.5 kVA max
Voltage and current: 200 VAC $\pm 10\%$, 41 A/phase; 208 VAC $\pm 10\%$, 40 A/phase; 220 VAC $\pm 10\%$, 38 A/phase; 230 VAC $\pm 10\%$, 37 A/phase; 380 VAC $\pm 10\%$, 23 A/phase; 400 VAC $\pm 10\%$, 21 A/phase; 415 VAC $\pm 10\%$, 21 A/phase
Protection: 3-phase thermal relay with adjustable current setting; two class CC 2 A fuses; over-voltage lockout circuit
Frequency: 50 Hz or 60 Hz
Configuration: 3-phase delta
Connector: 4-pin terminal block;
 Line voltage must be specified at time of order but is field reconfigurable; cable from power supply to facility power not included

Cooling water

Flow rate: 7.6 L (2.0 gal)/min minimum
Maximum pressure: 552 kPa (80 psi)
Pressure drop: 159 kPa (23 psi) at 7.6 L (2.0 gal)/min minimum for power supply and mandatory flow switch
Temperature: 15 $^{\circ}$ C to 30 $^{\circ}$ C (non-condensing)
Connection: Two 12.7 mm (0.5 in) hose barbs
CAUTION: Internal condensation can cause damage to the power supply
Enclosure type: Custom 19 in rack cabinet
Size: 559 mm W \times 673 mm D \times 1054 mm H (22 in \times 26 in \times 42 in)
Weight: 225 kg (495 lb)
Shipping size: 914 mm W \times 1168 mm D \times 1219 mm H (36 in \times 46 in \times 48 in)
Shipping weight: 281 kg (620 lb)
Ambient temperature: 15 $^{\circ}$ C to 35 $^{\circ}$ C at rated accuracy, 5 $^{\circ}$ C to 40 $^{\circ}$ C at reduced accuracy
Humidity: Non-condensing
Warm-up: 30 min at output current setting
Approvals: CE mark—low voltage compliance to EN61010-1, EMC compliance to EN61326-1

Ordering information

Part number	Description
648	Model 648—specify 200 VAC, 208 VAC, 220 VAC, 230 VAC, 380 VAC, 400 VAC, or 415 VAC

All specifications are subject to change without notice