Model 643 Electromagnet Power Supply

Model 643 features

- Low noise
- Compact design
- CE mark certification
- ±70 A/±35 V, 2450 W
- Built-in fault protection
- Analog programming and IEEE-488 and USB interfaces
- Bipolar, linear, true 4-quadrant output
- 0.1 mA of programmed current resolution
- Can be modulated to frequencies up to 0.17 Hz at ±70 A

Introduction

The Model 643 electromagnet power supply is a linear, bipolar current source providing true 4-quadrant output, eliminating the need for external switching or operator intervention to reverse current polarity. The Model 643 is capable of supplying ±70 A/±35 V to a nominal 0.5 Ω, 0.5 H load, and the output can be modulated from an external source to frequencies up to 0.17 Hz at ±70 A. Internally programmed output provides 20-bit resolution, while externally programmed output provides unlimited resolution.

The compact, low noise design of the Model 643 makes it the ideal supply for use in laboratory settings. When combined with a Lake Shore EM4 4-inch electromagnet and Model 475 DSP gaussmeter, the Model 643 provides a versatile field control system ideal for a wide range of user defined applications. These include but are not limited to magneto-optical, magnetic hysteresis and susceptibility, and Hall effect measurements, as well as in-line annealing.

Output architecture

The Model 643 output architecture relies on low noise linear input and output stages. The linear circuitry of the Model 643 permits operation with less electrical noise than switch-mode electromagnet power supplies. The clean field background allows greater resolution and finer detail in results drawn from data taken during high sensitivity experiments. One key benefit of this architecture is CE compliance to the electromagnetic compatibility (EMC) directive, including the radiated emissions requirement.

The true 4-quadrant output capability of the Model 643 is ideal for sweeping through both positive and negative fields. Tightly integrated analog control of the 4-quadrant output provides smooth current change with very low overshoot. This eliminates the need for external switching or operator intervention to reverse the polarity, significantly simplifying system design. The transition through zero current is smooth and continuous, allowing the user to readily control the magnetic field as polarity changes. This is achieved without reversal contactors or relays, which would produce unintended field spikes and other discontinuities. As a result, field hysteresis and other biases are avoided in the experimental data.

Output programming

The Model 643 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. For internal programming, the Model 643 incorporates a proprietary 20-bit digital-to-analog converter (DAC) that is monotonic over the entire output range and provides resolution of 0.1 mA. External programming provides unlimited resolution.

The Model 643 generates extremely smooth and continuous ramps with virtually no overshoot. The digitally generated constant current ramp rate is variable between 0.1 mA/s and 50 A/s. To ensure smooth ramp rate, the power supply updates the high-resolution DAC 23.7 times per second. A low-pass filter on the output DAC smooths the transitions at step changes during ramping.

Output reading

The Model 643 provides high-resolution output readings. The output current reading reflects the actual current in the magnet, and has a resolution of 0.1 mA. The output voltage reading reports the voltage at the output terminals with a resolution of 0.1 mV. All output readings can be prominently displayed on the front panel and read over the computer interface.

Protection

The Model 643 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. In the event of water flow failure, flow sensors provide feedback to the Model 643 and output current is set to 0 A. Internal heat sink, cold plate, and transformer temperatures are also monitored. Warnings are displayed before temperature limits are exceeded and current is set to 0 A. If temperatures continue to increase over safety limits, the Model 643 turns off.

A proprietary circuit limits the power dissipated in the water-cooled cold plate should low resistance and high line conditions exist. The Model 643 protects itself if operated into resistances outside of nominal limits. By limiting current output, the power supply will safely operate into a shorted load, and it operates safely into high resistance loads by limiting voltage output. The Model 643 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.

Interfaces

The Model 643 includes both parallel IEEE-488 and universal serial bus (USB) computer interfaces that provide access to operating data, stored parameters, and remote control of all front panel operating functions. The USB interface emulates an RS-232C serial port at a fixed 57,600 baud rate, but with the physical connections of a USB. This allows you to download firmware upgrades, ensuring your power supply is using the most current firmware version with no need for any physical changes. The Model 643 also provides two analog monitors for output current and voltage. Each monitor is a buffered, differential, analog voltage representation of the signal being monitored. The current monitor has a sensitivity of 7 V/70 A output, while the voltage monitor has a sensitivity of 3.5 V/35 V output.

Display and keypad

The Model 643 incorporates a large 8-line by 40-character vacuum fluorescent display. Output current and output voltage readings are displayed simultaneously. Five front panel LEDs provide quick verification of instrument status, including ramping, compliance, fault, power limit, and computer interface mode. Error conditions are indicated on the main display along with an audible beeper. Extended error descriptions are available under the status key.

The keypad is arranged logically to separate the different functions of the power supply. The most common functions of the power supply are accessed using a single button press. The keypad can be locked in order to secure either all changes or just the instrument setup parameters allowing the supply output to be changed.

Model 643 specifications

Output

Type: Bipolar, 4-quadrant, DC current source
Current generation: Fully linear regulation with digital setting and analog control
Current range: ±70 A
Compliance voltage (DC): ±35 V nominal
Power: 2450 W nominal
Nominal load: 0.5 Ω, 0.5 H
Maximum load resistance: 0.6 Ω for ±70 A DC operation at +10% to -5% line voltage
Minimum load resistance: 0.4 Ω for ±70 A DC operation at +5% to -10% line voltage
Load inductance range: 0 H to 1 H
Current ripple: 5 mA RMS (0.007%) at 70 A into nominal load
Current ripple frequency: Dominated by the line frequency and its harmonics
Temperature coefficient: ±15 ppm of full scale/°C
Line regulation: ±60 ppm of full scale/10% line change
Stability (1 h): 1 mA/h (after warm-up)
Stability (24 h): 5 mA/24 h (typical, dominated by temperautre coefficient and line regulation)
Isolation: Differential output is optically isolated from chassis to prevent ground loops
Slew rate: 50 A/s into nominal load, 100 A/s maximum into a resistive load
Compliance voltage (AC): ±43 V at +10% to -5% line
Settling time: <1 s for 10% step to within 1 mA of output into nominal load
Modulation response: ≤0.17 Hz at ±70 A sine wave into nominal load, <0.02% THD; ≤1 Hz at ±10 A sine wave into nominal load, <0.05% THD; ≤10 Hz at ±1 A sine wave into nominal load, <0.10% THD
Attenuation: -0.5 dB at 10 Hz
Protection: Short circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, and over temperature
Connector: Two lugs with 6.4 mm (0.25 in) holes for M6 or 0.25 in bolts

Output programming

Internal current setting
Resolution: 0.1 mA (20-bit)
Settling time: 600 ms for 1% step to within 1 mA (of internal setting)
Accuracy: ±10 mA ±0.05% of setting
Operation: Keypad, computer interface
Protection: Programmable current setting limit

Internal current ramp
Ramp rate: 0.0001 A/s to 50.0000 A/s (compliance limited)
Update rate: 23.7 increments/s
Ramp segments: 5
Operation: Keypad, computer interface
Protection: Programmable ramp rate limit

External current programming
Sensitivity: 10 V/70 A
Resolution: Analog
Accuracy: ±10 mA ±1% of setting
Input resistance: 20 kΩ
Operation: Voltage program through rear panel, can be summed with internal current setting
Limits: Internally clamped at ±10.1 V and bandwidth limited at 40 Hz to protect output
Connector: Shared 15-pin D-sub

Readings

Output current
Resolution: 0.1 mA
Accuracy: ±10 mA ±0.05% of rdg
Update rate: 2.5 rdg/s display, 10 rdg/s interface

Output voltage (at supply terminals)
Resolution: 1 mV
Accuracy: ±5 mV ±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: 26 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: B-type USB connector
Software support: National Instruments LabVIEW™ driver (consult Lake Shore for availability)

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

Output voltage monitor
Sensitivity: 3.5 V/35 V
Accuracy: 1% of full scale
Noise: 1 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; jumper required if unused
Valve power output: 24 VAC at 1 A maximum, automatic or manual control
Connector: Shared 4-pin detachable terminal block; Flow switch and 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 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: 5500 VA max
Voltage and current: 200/208 VAC ±10%, 13 A/phase; 220/230 VAC ±10%, 12 A/phase; 380 VAC ±10%, 7 A/phase; 400/415 VAC ±10%, 6.5 A/phase
Protection: 3-phase thermal relay with adjustable current setting; two class CC 0.25 A fuses; over-voltage lockout circuit
Frequency: 50 Hz or 60 Hz
Configuration: 3-phase delta
Connector: 4-pin terminal block
Features: Soft start circuit, rear panel voltage selection indicator
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: 5.7 L (1.5 gal)/min minimum
Pressure range: 34 kPa (5 psi) to 552 kPa (80 psi)
Pressure drop: 10 kPa (1.5 psi) at 5.7 L (1.5 gal)/min minimum for power supply only
Temperature: 15 °C to 30 °C (non-condensing)
Connection: Two 10 mm (0.38 in) hose barbs
CAUTION: Internal condensation can cause damage to the power supply
Enclosure type: 7 U high, 19 in rack mount with integral rack mount ears (25 mm (1 in) air space required on each side for ventilation)
Size: 483 mm W × 310 mm H × 572 mm D (19 in × 12.2 in × 22.5 in) with handles removed
Weight: 74 kg (163 lb)
Shipping size: 635 mm W × 559 mm H × 736 mm D (25 in × 22 in × 29 in)
Shipping weight: 103.4 kg (228 lb)
Ambient temperature: 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C at reduced accuracy
Humidity: Non-condensing
Warm-up: 30 min at output current setting
Approvals: CE mark pending—low voltage compliance to EN61010-3, EMC compliance to EN55022-1

Ordering information

Part #	Description
643-204	Model 643 ±70 A ±35 V, 2.5 kW, 204/208 VAC
643-225	Model 643 ±70 A ±35 V, 2.5 kW, 220/230 VAC
643-380	Model 643 ±70 A ±35 V, 2.5 kW, 380 VAC
643-408	Model 643 ±70 A ±35 V, 2.5 kW, 400/415 VAC

Accessories included

6031	Two front handles
6032	Two rear handles
6051	Terminal block, 4-pin
6052	Terminal block, 8-pin
6252	15-pin D-sub mating connector, analog I/O
—	Hose clamps
—	Power cable strain relief (power cable not included)
—	Calibration certificate
119-056	Model 643 user manual

Accessories available

6201	1 m (3.3 ft long) IEEE-488 (GPIB) computer interface cable assembly
6261	3 m (10 ft) magnet cable kit, AWG 4
6262	6 m (20 ft) magnet cable kit, AWG 4
CAL-643-CERT	Instrument recalibration w/ certificate
CAL-643-DATA	Instrument recalibration w/ certificate & data
6041	Water flow switch
6042	Water valve

All specifications are subject to change without notice