

MPS2.0

Bi-directional, ultra-precision, universal MRI ramping power supply

1. Features

- Automated ramp-up/down and 18ch active shimming
- Rugged 20kg compact enclosure designed for repeated field deployment
- MRI compatible can be operated from MRI scan room
- Auto-ranging AC Input. 3ph+N 180 – 420VAC
- Bi-polar, bi-directional output stages ± 16 VDC
- Main output maximum current: 1000A
- 18ch shim output maximum current: 30A/ch.
- Current accuracy at 1000A: 50mA
- Current resolution in all modes: 0.1 mA
- Temperature compensated current output drift after 10min. stabilization: <5ppm/hour typical
- Maximum output absorption power: 2500W
- Quench protection from AC loss during ramp
- Over 4kV galvanic isolation from main - Loss-of-Phase detection and momentary AC loss protection
- Full temperature monitoring of power stages
- 2ch. precision digital voltage remote sensing
- 1ch Precision resistance sensing
- 2ch Ramp-lead cryo-temperature sensing
- Single wire Teslometer interface
- Field-sensing and auto-ramping capability
- Universal magnet interface adaptor
- Streamlined Interface for GE, Siemens and Philips MRI
- Custom ramping profiles and advanced features
- Ethernet, mini-usb, USB, USBc and wifi interfaces

2. General Description

The Kepler Series MPS2.0 is a specialized power converter that integrates a line filter, an isolated primary bus converter and eight bi-polar and bi-directional output stages. High power density is achieved using custom high frequency DC-DC converters and a monolithic dissipator architecture.

The primary bus converter monitors the incoming AC voltage and automatically configures its primary input stage to operate from a range of 180VAC to 420VAC ensuring compatibility with all MRI's Input power

configurations. The output stages consist of full bridge rectifiers that can deliver precision voltage and current controlled outputs of up to 1000A when operated in parallel mode or up to 30A/ch. in shim mode.

3. Control architecture

A centralized mixed Real-Time CPU and FPGA controller manages all power stage MOSFET switching sequences in real-time using an interleaved control scheme. The controller PWM sequencing is designed to minimize noise and current draw from the intermediary bus and runs effective MOSFET switching frequencies ranging from 1MHz to 20MHz depending on the operating mode.

Control resolution in the order of 0.1mA over the entire range is achieved by use of custom high frequency noise shaping PWM algorithms. The controller monitors temperature of the primary bus converters and MOSFET bridges and can perform emergency stage shutdowns.

4. Precision Sensing

Sensing loops incorporate real-time shunt temperature compensation to achieve minimal ambient temperature and self-heating drift dependency. Sensing voltage is fed into low noise amplifiers and converted by precision 24bit ADCs. Hardware and software implemented digital filters minimize noise fed into the control loop. The system delivers effective current/voltage control resolutions in the 0.1ppm range, absolute current accuracy of <100ppm and a current drift of < 5ppm/1h after stabilization.

5. Unique Application Features

The unit can operate from superconductive coil power in case of main power loss by reversing energy flows in the converters.

It also incorporates remote sensing lines for precision control of superconductor voltage and ramp-lead contact monitoring. Ramp lead temperature sensors allow monitoring of critical superconductor temperature during ramping procedures.

Finally, the entire design minimizes ferrous magnetic material and can be safely operated inside the MRI room.

SPECIFICATIONS - Table 1

Parameter	Notes/Test conditions	Min	Typ	Max	Unit
INPUT AND OUTPUT PARAMETERS					
Operating Line to Line Input voltage		180		420	VAC
Input Current				30	A
Frequency		45		65	Hz
Output Isolation from Main		4000			V
Adjustable Constant Voltage Range		-16		16	V
Adjustable DC Current Range - Parallel mode		0		1000	A
Adjustable DC Current Range - Shim mode		0		30	A
Inductive Load capability		0		300	H
Total output power	Typical Application power <2000W	0		4000	W
Load absorption Power		0		2500	W
Voltage Ripple			20		mVRMS
OUTPUT ACCURACY AND PRECISION					
Voltage absolute accuracy			± 50		ppm
Voltage Resolution			1		µV
Current Resolution	Typical effective resolution		100		µA
Current Accuracy - Parallel mode				± 50	mA
Current Accuracy - Shim mode				± 10	mA
Current Drift after 10min stabilization	Depending on operating mode	2	5	10	ppm/hour
Current Drift without stabilization				30	ppm/min.
Precision Remote Voltage Sensing accuracy			± 50		ppm
Resistance Sensor measurement range		1		20	kOhm
Resistor Sensor accuracy	Optional calibration up to 100ppm	1000		100	ppm
PERMANENT SWITCH HEATER OUTPUTS					
PSH Current Range		50		1000	mA
PSH Current Measurement Resolution			1		mA
PSH Current Programming Accuracy		1			%
PSH Voltage		0		30	V
Ripple		30			mVRMS
PHYSICAL AND ENVIRONMENTAL					
Weight of Electronics Enclosure			20		kg
Weight of the Enclosure + transport box			28		kg
Weight of cables set 1 + transport box 1 (GE Set)			30		kg
Weight of cables set 2 + transport box 2 (GE Set)			27		kg
Electronics enclosure dimensions			43x26x26		cm
Transport box physical dimensions			50x36x34		cm
Withstanding shipping temperature range		-40		70	Deg. C
Withstanding shipping relative humidity range		5		95	%