4-quadrant magnet power supply

MACAO [±3.5 A; ±160 V] – HCRPAEM

MACAO is an isolated switched mode power supply working in four-quadrant operation mode. It can provide positive or negative current to the magnet with cycling operation and recovering magnet energy. MACAO is designed to fit in a 19-inch rack with a height of 3U. Up to ten MACAO can be mounted in a 19-inch rack, including control distribution (figure 2). MACAO includes FGC3 control boards, to ensure a high precision current control with two DCCTs, in the range of 50 ppm of accuracy.

Principle Schematics

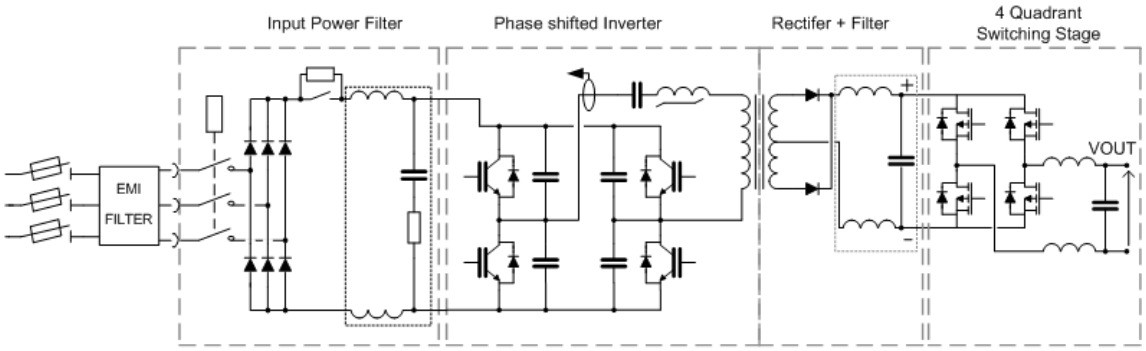

Figure 1: Schematic

Power Ratings

Rating		Value	Unit
Output current	cycling or DC operation	±3.5	A
Output voltage	cycling or DC operation	±150	V
Number of phase	3P+N+PE AC connection	3	
Input voltage		400	V_{RMS}
Input current		<1	A
Isolation class	Isolation level to ground	3	kVAC
Power factor		>0.9	
Efficiency		>75%	
Switching frequency		50	kHz
Load resistance		0.0001…45	Ω
Load inductance		0…1000	mH

Table 1: Power Ratings

Mechanical Characteristics

Characteristics		
Size	Height x Width x Depth	134 x 535 x 650 mm
Weight		20 kg
IP	Electrical enclosure protection	IP21
Cooling		Forced-air cooling

Table 2: Mechanical Characteristics

MACAO Current Control

MACAO includes a FGC3 control board in the front panel. MACAO can be controlled locally with a computer through FGC3 USB interface or more generally through a front-end computer connected by FGC ETHER interface (ETHERNET cable).

Parameter		Value	Unit
Output current acquisition frequency		10	kHz
Current reference sampling frequency		10	kHz
Current control algorithm	CClibs included in FGC3 software		
Output Voltage ripple	50 – 100Hz	1	mVrms
	300Hz	2	mVrms
	50kHz	60	mVrms
	100kHz	40	mVrms
Current precision performance	Short term stability (20 min)	10	ppm
	stability (12h)	50	ppm
	Long term stability (1 year)	200	ppm
	Noise (500Hz bandwidth)	50	rms ppm
Setting current resolution		1	ppm

Table 3: Current control performance

MACAO magnet protection

MACAO includes a magnet protection with three key rules, always ensure external protection system to stop the power supply, stop the power supply in a safe way through a crowbar system and monitor earth current. The earth system, placed at the negative output, will stop the power supply if the linkage current is above 50mA.

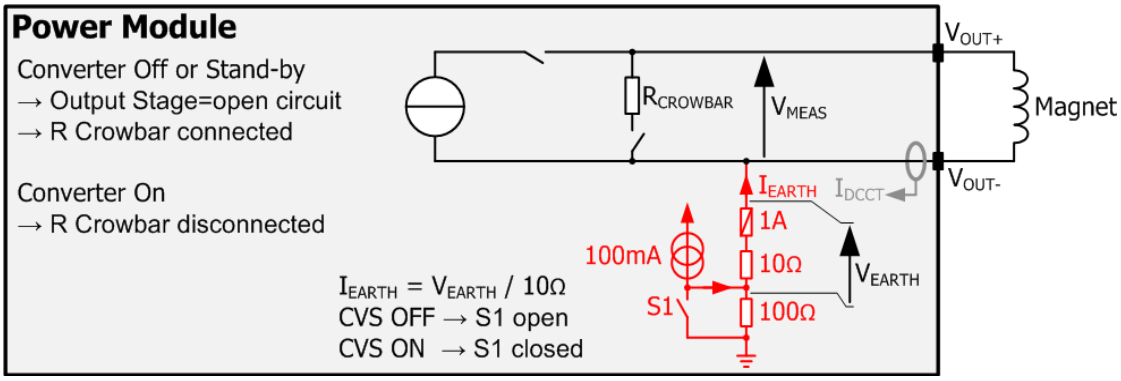

Figure 2: Magnet protection

MACAO interfaces

External interlocks can stop the power supply through three connectors (Veto Access, Magnet interlock and BIS). Hardwire status are available for external systems.

Parameter	Value	Description
VETO ACCESS	Burndy UTO-010-4S-21T	1: veto access+ (input) 2: veto access- (input) 3: power on state+ (output, dry contact) 4: power on state- (output, dry contact)
Beam Interlock System (BIS)	Burndy UTO-016-19S-21T	1: BIC serial power+ (input) 2: WIN 1A BIC+ (output, current source) 3: WIN 1A BIC- (output, current source) 4: WIN 1B BIC+ (output, current source) 5: WIN 1B BIC- (output, current source) 6: WIN 2A BIC+ (output, current source) 7: WIN 2A BIC- (output, current source) 8: WIN 2B BIC+ (output, current source) 9: WIN 2B BIC- (output, current source) 10: WIN 3A BIC+ (output, current source) 11: WIN 3A BIC- (output, current source) 12: WIN 3B BIC+ (output, current source) 13: WIN 3B BIC- (output, current source) 14: WIN 4A BIC+ (output, current source) 15: WIN 4A BIC- (output, current source) 16: WIN 4B BIC+ (output, current source) 17: WIN 4B BIC- (output, current source) 18: BIC serial power- (input) 19: GND
MAGNET INTLK	Burndy UTO-014-12S-21T	1: Powering failure+ (output, dry contact) 2: Powering failure- (output, dry contact) 5: PC connect+ (output, bridge) 6: PC connect- (output, bridge) 7: PC fast abort+ (input) 8: PC fast abort- (input) 11: PC permit+ (input) 12: PC permit- (input)

Table 4: Rear connector interfaces

MACAO rack integration

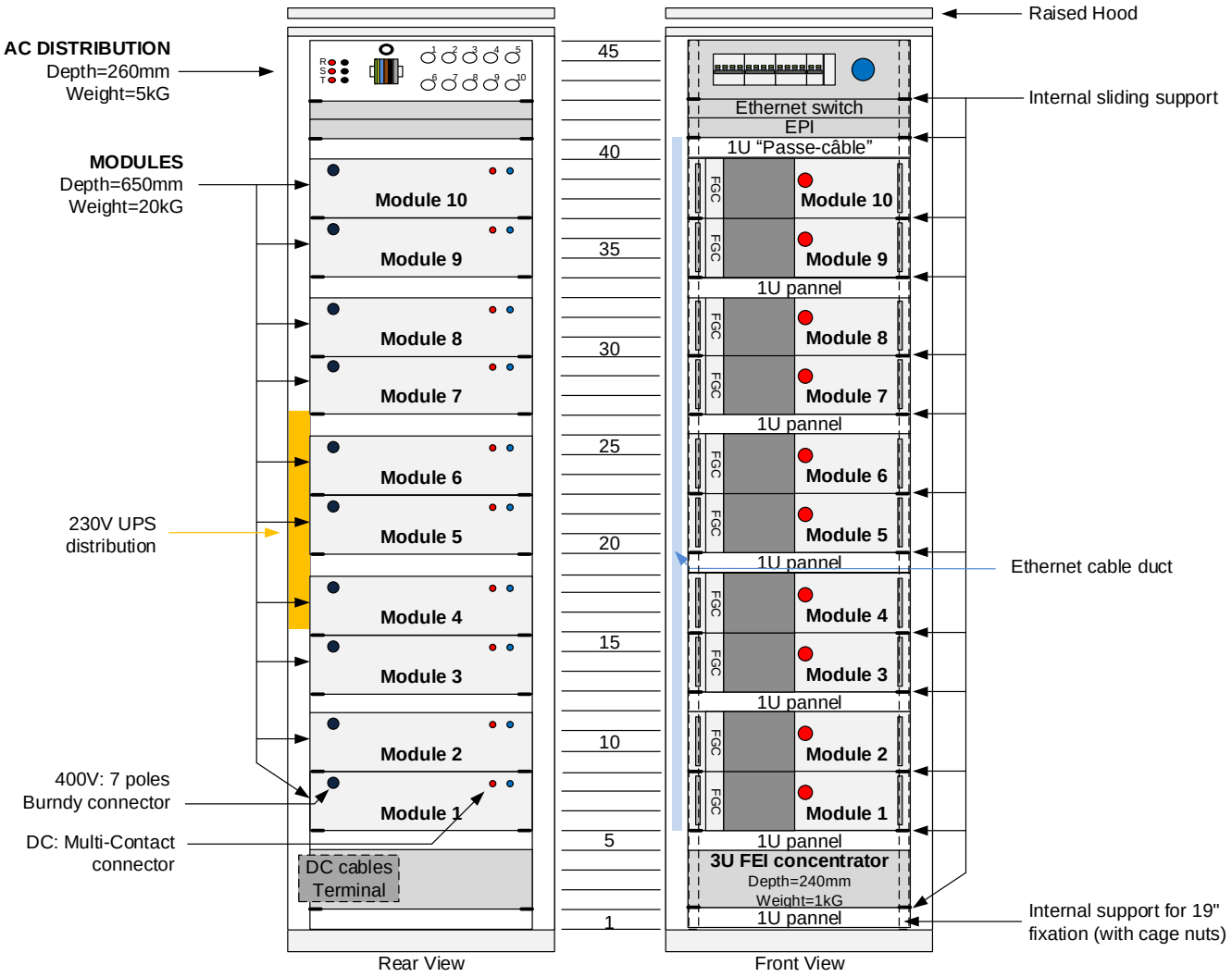

Figure 3: MACAO rack with 10 units