

Multi-Channel H-Bridge Controller

Introduction

The Multi-Channel H-Bridge Controller is a high-reliability digital control core for the magnet power supply systems of nuclear fusion devices. It was originally designed for the Poloidal Field (PF) coil power supply of the SUNIST-2 device, where it controls the state of the PF power supply H-bridges in order to precisely regulate the discharge waveform. The design is portable and can also be applied to other high-power pulsed power supply control scenarios, including CS power supplies, MC power supplies, and plasma acceleration.

The product uses a modular chassis-based design with an FPGA as its control core, and comprises six functional modules: the FPGA main control module, the communication module, the power supply module, the link module, the optical-port signal output module, and the signal acquisition module. All modules are interconnected through a backplane and are hot-swappable, which ensures reliable power delivery and signal transmission while keeping maintenance and upgrades convenient. In addition to controlling the output current waveform, the controller performs multi-point acquisition and real-time monitoring of voltage and current signals at various points in the power supply. The acquired signals are compared against preset thresholds to determine whether a fault exists at each monitoring point, thereby achieving fault localization and real-time protection, and safeguarding both the electrical supply and the equipment.



Composition

The complete controller uses a chassis-based structure in which the individual boards are interconnected through a backplane and are hot-swappable. The main boards are listed below:

Board	Function
Control board	ZYNQ 7020 core board
ADC acquisition board	Performs analog-to-digital acquisition of voltage / current signals
Optical-port board ×7	Each board contains a drive circuit and 6 optical ports
Power supply board	Supplies power to all boards

Parameter

Parameter	Specification
Control core	ZYNQ 7020
System architecture	Modular chassis-based
Optical signal transmission	Electrical signals are converted to optical signals through the optical ports for output , providing high isolation voltage and interference immunity, and remaining unaffected by transmission distance or speed
ADC acquisition	Two groups in total: 4 channels (24-bit) and 16 channels (12-bit)
Protective action	PWM is latched off when a threshold is exceeded; if any power supply experiences overvoltage or overcurrent, the PWM of both power supply sets is latched off
Trigger input	Optical-port trigger signal
Host communication	Modbus RTU / RS485
Fault indication	16-channel LED
Supported discharge modes	Current feedback / voltage feedback / no feedback

Multi-supply coordinated response	Switching of the discharge state between different power supplies is completed within milliseconds
Supply voltage	220 VAC
Dimensions	3U chassis (length × width × height: 44 × 20 × 13.5 cm; 48 × 20 × 13.5 cm including mounting ears)
Delivery form	Chassis-based unit

Application

The product is suitable for digital control and protection of nuclear fusion devices and high-power pulsed power supplies. Typical application scenarios include:

1. Poloidal Field (PF) coil power supply control
2. Central Solenoid (CS) power supply control
3. MC power supply control
4. Plasma acceleration power supply control
5. Real-time coordinated control of multiple power supplies
6. Triggering, fault detection, and protection of high-current IGBT converters
7. Nuclear fusion plasma experiments and discharge systems