CONTROL SCHEME FOR REMOTE OPERATION OF MAGNET POWER SUPPLIES FOR INFRARED FREE ELECTRON LASER

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Abstract

Infrared Free Electron Laser (IRFEL) is under development at MAASD, RRCAT Indore. The IRFEL machine consists of 90keV thermionic gun as electron source, beam transport line, 25MeV Linear Accelerator (LINAC) and an undulator magnet. There are fifty magnets on beam transport line. These magnets are energized by precision power supplies. These power supplies have local as well as remote control and will be located at equipment hall. The control room and equipment hall are at approximate distance of 300 m. We have planned a three layer structure for centralized operation of Beam Transport line Magnet Power Supplies (BTMPS). These layers are device interface layer, the equipment control layer and the presentation layer. Presentation layer is linked with equipment control layer on Ethernet. Whereas equipment control layer will be linked to device interface layer by RS-485. Device interface layer consist Magnet Power Supply Controllers (MPSC). Each MPSC has one master and five slave controllers linked on isolated SPI bus, which will control five BTMPS. We have developed slave controllers and a master as prototype of MPSC. This paper describes MPSC prototype and proposed control scheme.

INTRODUCTION

The Free Electron Laser (FEL) laboratory is developing Infrared Free Electron Laser (IRFEL) as part of their ongoing development activity. The machine is having a 90Kev thermionic gun as an electron source, beam transport line, 25Mev linear accelerator (linac) and an undulator magnet. The beam transport line for the FEL has two parts: a low energy part & a high energy part. Low energy part has solenoids to transport a beam from the thermionic gun to the linac entrance. A high energy beam transport line consisting of dipoles, quadrupoles and steering magnets for transporting beam from the linac exit to the entrance of the undulator. These magnets are energized by Beam Transport line Magnet Power Supplies (BTMPS). There are fifty numbers of such BTMPS. These BTMPS have local as well as remote control. BTMPS are located in equipment hall. BTMPS will be controlled from control room located at a distance of approximately 300 meters from equipment hall. These BTMPS are remotely operated by Magnet Power Supply Controller (MPSC) connected to control computer on RS-485 network. Inside MPSC, there is one master and five slave controllers linked on isolated SPI bus. Each MPSC is designed to control five BTMPS.

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BEAM TRANSPORT LINE MAGNET POWER SUPPLY (BTMPS)

Several types of magnets are required to transport the beam through beam line. For these magnets, numbers of supplies of various voltage and current ratings are required. We have listed power supply types and there important parameters in Table 1.

Table 1: BTMPS Parameters.

Magnetic element	Qty	Current rating	Voltage rating	Required Stability
Corrector Magnets	15	7 A	+/- 15V	100PPM
Dipole Bending Magnets	5	20 A	30V	100PPM
Quadurpole Magnets	15	13 A	+/- 15V	100PPM
Steering Magnets	15	10 A	+/- 10V	100PPM

Presently five power supply units are mounted in a 6U card frame. Hence there are ten such card frames, housing 50 supplies. Each power supply can be operated in local mode from front panel and in remote mode from PC. There is a 25-pin sub-D connector provided on the power supply which has digital & analog I/O signals for power supply remote operation. Each power supply has one analog input signal in the range of 0-10V to set the current output, 0-10V analog output signal which is proportional to set current. There are four digital inputs to power supply. These inputs are used to switch on power supply, to switch off power supply, one input to reset power supply faults and one for changing polarity of power supply current output. Power supply provides three digital status lines with galvanic isolation. They are ON/OFF indicator, Fault indicator, and Remote/Local indicator.

MAGNET POWER SUPPLY CONTROLLER (MPSC)

Keeping power supply configuration in mind we have designed MPSC in standard 3U card frame. Each MPSC card frame has five independent power supply controllers (slave controllers) and one master controller as shown in Figure 1. Master controller accepts command from PC located at control room via RS-485 port and then sends these commands to appropriate power supply controller over a local isolated SPI bus. We have planned to place these MPSC in 19” rack of 32U height. This implies 15

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power supplies and their controllers will be located in one 19” rack of 32U height.

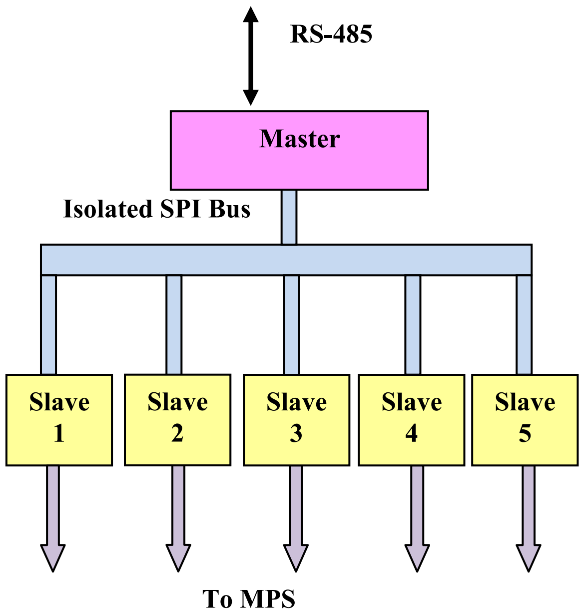

Figure 1: Block Diagram of proposed Magnet Power Supply Controller (MPSC).

SLAVE CONTROLLER

A slave controller as shown in Figure 2 provides required control and interface signal to operate magnet power supplies remotely.

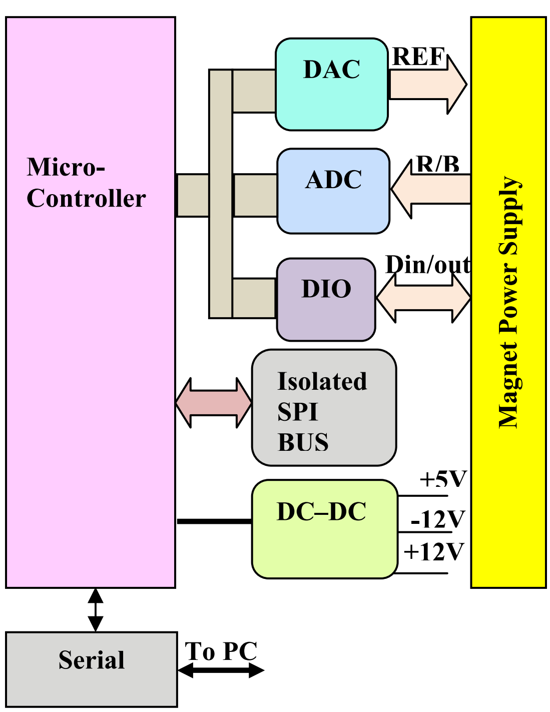

Figure 2: Block Diagram of Slave Controller.

It receives command from master controller and takes necessary actions. This card has a micro-controller [1] with 64K E^2PROM, 2K SRAM, 18-bit DAC [2], 15 bit ADC [3], 4 digital relay outputs and four digital inputs. It provides reference signal to set current output of power supply. Hence power supply ground and reference ground is common. Similarly current read back signal is sharing same ground as power supply ground. Since we are having five slave controllers in single chassis sharing a SPI communication bus, to avoid ground loops we have used an isolated SPI bus for communication. Each slave controller has local DC to DC converter which isolates ground from backplane power bus. This slave controller also has a RS-232 interface which was used while developing the software to download code.

Since current stability needed for power supply is of the order of 100 PPM we have used DAC with 18-bit resolution with analogue output stability of 2 PPM/ºC. The output of DAC is buffered with high accuracy low drift operational amplifier to maintain overall reference stability better than 50 PPM.

RESULTS

For testing the stability of power supply reference, DAC output was set to 2V and observed for whole day, it is within 50 PPM as shown in Figure 3.

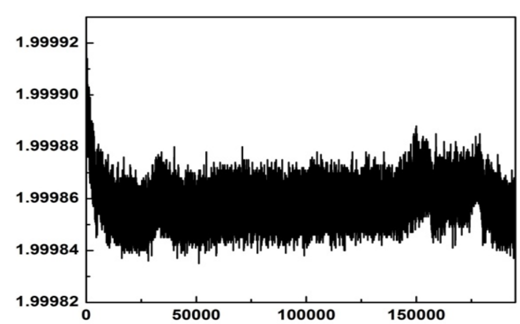

Figure 3: Voltage Drift vs. Time for enclosed systems.

CONCLUSION

The prototype of the MPSC has been designed and built. It has been tested for its reference stability performance for more than a week with 7-1/2 digit Keithley 2001 multi meter.

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