PRECISION, 32 CHANNEL POWER SUPPLY SYSTEM*

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Abstract

A modular, multichannel current regulator system has been developed to power the low current correction and focusing magnets used for beam transport. The basic module consists of a relay rack housing four card crates with eight regulators per crate. The rack also contains a utility chassis and common power supplies. Each regulator card includes a communications microprocessor and a temperature controlled analog circuit block containing precision reference, serial DAC, shunt resistor and error amplifier. The regulators are linear, bipolar units capable of furnishing up to 10 amps at 20 volts with less than 0.01% ripple and drift.

Introduction

The block diagram of a typical system is shown in Figure 1. Although all 32 channels are shown in the diagram, initially some of the regulator slots in the rack will be left open for future additions due to more magnets or higher power requirements.

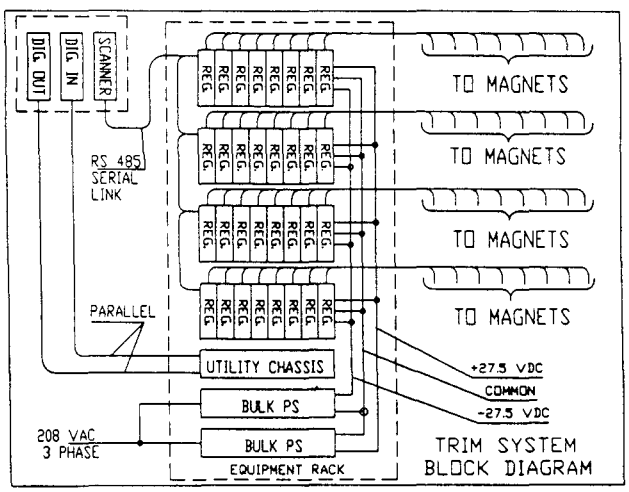

Figure 1. Trim System Block Diagram.

Although only the corrector dipoles require a bipolar output, all of the regulators have this capability. This allows all of the current regulation needs to be handled by one design. Having only one regulator design kept the initial development effort down, made the configuration of the systems very versatile, made a more economical buy possible and will make maintenance easier.

Because of the relatively tight packaging requirements, a large blower was added on top of the rack. The blower pulls filtered, ambient air through louvres in the back door and up through four levels of regulator modules. A drawing of the mechanical rack is shown in Figure 2.

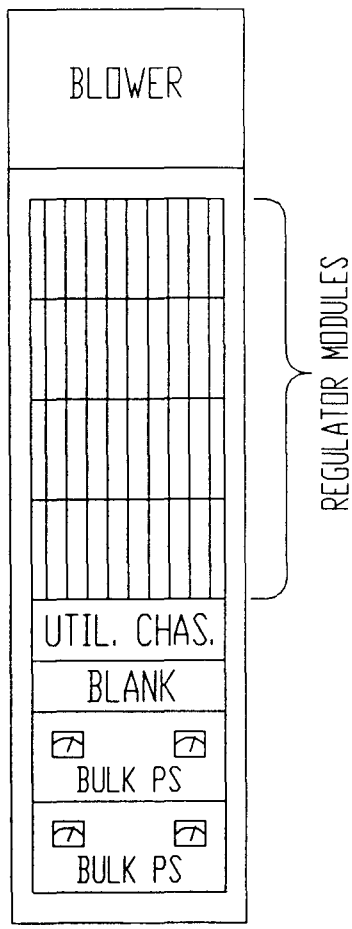

Figure 2. Mechanical Rack Drawing.

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Three-phase 208 VAC power enters at the top of the rack through a line filter located in the blower housing. Because of concerns about coupling stray AC fields through the regulators, the AC feed wires going down to the bulk power supplies are run in steel conduit as far as possible.

DC power from the bulk power supplies is distributed through bus bars, fuses and #8 wires to the custom backplanes. Each branch circuit handles four regulators and is capable of furnishing 40 amps.

The #10 wires from the regulator outputs terminate at the bottom of the rack on terminal blocks mounted on a DIN rail. The magnets are fed from these terminal blocks with paired #10 wires.

A utility chassis houses a PLC (Programmable Logic Controller) which provides rack thermal monitoring, interlock control and interface logic. The PLC interfaces with the main control system through CAMAC digital input and output modules. The utility chassis also houses several miscellaneous power supplies needed for bias and control.

Monitor and control of a rack system is handled by a 32 node, RS-485, multidrop serial link. One master scanner located in a CAMAC crate is linked to all 32 regulators through connectors on the back planes. Each regulator has an on-board microprocessor to handle communications as well as do local diagnostics.

Detailed Descriptions

Card Cage

As much as possible standard Eurocard components were used for the card cage. The primary deviations from standard are a greater depth and side panels that form the main supports for all four of the cages and result in one large assembly instead of four independent card cages.

Bulk Power Supply

Two bulk power supplies are used in each rack, with one of the units furnishing up to +320 amps and the other furnishing as much as −320 amps. The power supplies are commercially available 10 kW, high frequency switchers requiring 3 phase, 208 VAC input power. By using switching rather than thyristor technology, the size and weight of the power supplies was reduced significantly.

Utility Chassis

A utility chassis is used to house the miscellaneous power supplies and control functions that are needed to make a fully functioning rack. A 5 volt logic supply, two small bias supplies and a 24 VDC control power supply are located here. A small PLC provides local control logic and rack monitoring. This PLC monitors rack temperatures, airflow and door interlock status. Digital monitor and control signals are exchanged with the main control system through digital input and output CAMAC modules.

Regulator Module

A simple circuit diagram of the 200 watt regulator module is shown in Figure 3. The output stage uses complementary darlingtons to keep the drive requirements down. Base drive for the output stage is furnished by amplifier U1. The crucial current sensing and amplification is done by the analog block. This is a temperature regulated, surface mount device which includes a serial DAC, precision voltage reference, precision shunt resistor, shunt pre-amp and error amplifier. All critical analog functions are handled here. A simple schematic of the analog block is shown in Figure 4.

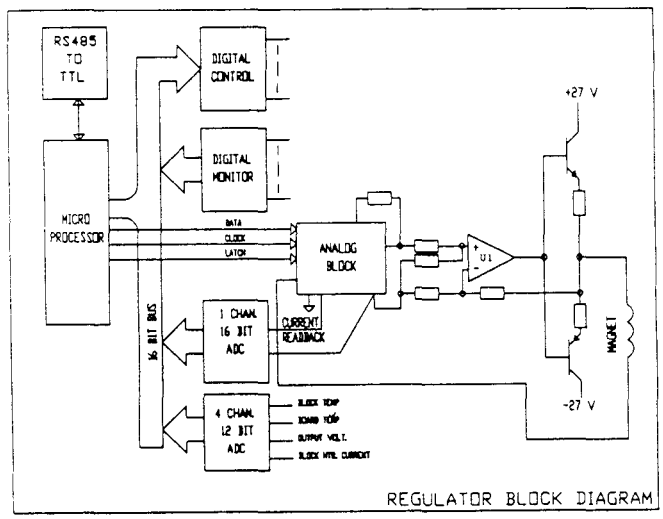

Figure 3. Regulator Block Diagram.

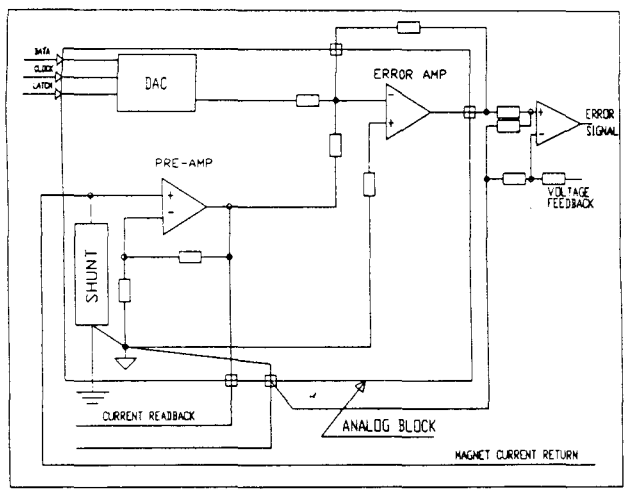

Figure 4. Precision Analog Block.

Monitor and Control

Because of the relatively stringent 100 ppm output noise and drift specification, the monitor and control of the regulator is handled entirely by a full duplex serial communications link. This greatly reduces the chance of coupling ground loop or other noise into the input stages of the regulator.

An on-board communications microprocessor drives the 16 bit serial DAC located on the analog block, monitors the 16 bit current readback ADC, monitors a 12 bit, 4 channel, general purpose ADC and handles digital I/O functions on the printed circuit board. Both of the ADC's are slow, dual slope integrating devices.

The serial link is designed to achieve a scan cycle time of 50 milliseconds or less with 32 nodes on the network. Because the microprocessor is used for communications only 1/32 of the available time, there is considerable time open to do on-board diagnostics and control. Possible examples are controlled ramping of the output current and monitoring of the output voltage allowing calculation of the magnet coil resistance.

The microprocessor is an 8 bit Motorola device with 4K of on-chip ROM. About 2K of the ROM is used for the basic communications and control tasks, leaving 2K for further diagnostics and control. The code was written in assembly language.

The 32 node, RS-485 serial link is driven by a 32 channel scanner module. The scanner is a commercially available, double wide CAMAC module that functions entirely as a communications controller. The communications microprocessor interfaces with the CAMAC system through dual ported memory.

Performance

These current regulators were able to meet a 24 hour, 100 ppm noise and drift specification over an ambient temperature swing of 40°C during tests in an environmental chamber. The temperature coefficient over the 40°C swing was 1 ppm per degree C. The 100 ppm specification includes power line ripple as well as low frequency noise. It is unlikely that any of the service buildings will see a 40°C temperature swing over any 24 hour period after warm up, so the installed systems should be able to match the performance shown in the regulator board tests.

Summary

A straightforward and versatile power supply system has been designed to drive the low power corrector and focusing magnets in the accelerator beam transport system. A simple bipolar regulator module furnishes 10 amps at 20 volts. Common bulk power supplies furnish pre-regulated power for the regulator cards. Current low frequency noise, drift and ripple are within a 100 ppm envelope. Monitor and control of the regulator modules is handled with an RS-485 compatible serial link driven by a 32 channel CAMAC scanner module.