viii. Main Magnet Power Supplies

Overview

The RHIC Main Magnet Power Supplies (RMMPS) provide the current for the main dipole and main quad magnet strings. The main dipole and main quad magnet strings are separate electrical circuits; since there is a separate RMMPS for each circuit, and each ring, there are four RMMPS.

Each RMMPS has three major components, the Flat-top Power Module (FTPM), the Ramp Power Module (RPM), and the Output Circuit Compartment (OCC). The power modules supply the current to the magnet strings. The OCC houses the output filter, the quench protection components, the regulator and remote PLC monitoring. Figure 2-17 shows the main power supply block diagram and the interconnection of these sub-systems. Each of these sub-systems is described in a section below.

Sub-System Descriptions

Power Modules

There are two power modules for each RMMPS. Each power supply has one FTPM and one RPM connected in parallel. The two power modules for each RMMPS are 12-pulse, phase controlled power converters. Only one of these power modules is active at a given moment. The regulator selects the active power module based on the instantaneous current slope. When the current slope is low the FTPM is active. During a ramp, when the current slope is above a selected level, the RPM is active. This allows the power modules to be sized for the voltage necessary to maintain the required current slope. This approach provides low voltage ripple when the current is a constant value. The only major difference between the different types of power modules are the rectifier transformers. The RPM transformers are not sized for continuous operation. The voltage and current ratings of the modules are listed in Table 2-6.

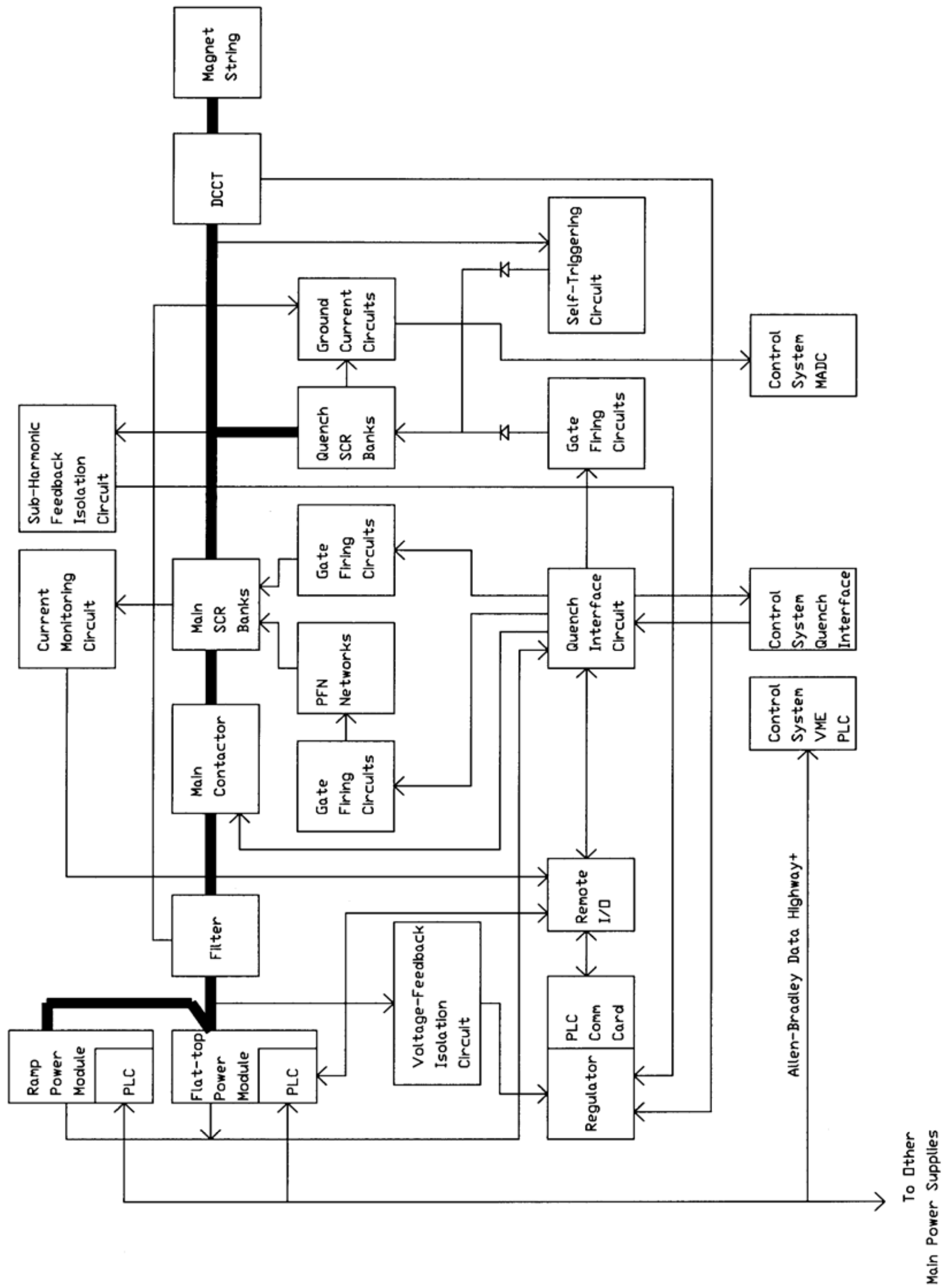

Fig. 2-17 Main Power Circuit Block Diagram

Table 2-6. Ratings of Power Modules

Power Module Type	Voltage Rating	Current Rating	Power Rating
Quad Flat-top	15 V	5500 A	82.5 kW
Quad Ramp	90 V	5500 A pk 3300 A rms	495 kW pk 297 kW
Dipole Flat-top	30 V	5500 A	165 kW
Dipole Ramp	400 V	5500 A pk 3300 A rms	2200 kW pk 1320 kW

Regulator

The regulators for the RMMPSs are digitally based using the TI320C30 Digital Signal Processor (DSP) as the computation engine. Figure 2-18 shows the overall configuration of the regulator. As indicated in the diagram one regulator controls two power modules.

The regulator has a Phase Locked Loop (PLL) that is locked to the power line. This PLL provides all the timing signals for the regulator. The DSP receives voltage, current, and sub-harmonic feedback through A/Ds that sample these parameters at 11520 Hz. The DSP uses this feedback and calculates a command count that is written to the digital firing cards. The digital firing cards use this command count to develop firing signals for the power module's SCRs. The SCR firing signals are sent to the power module's SCR gating circuits over fiber optic cables. There is a separate digital firing card for each power module attached to the regulator. The active power module is selected by enabling the output of its digital firing card.

The current command and the readbacks for the Real Time Data Link (RTDL) are exchanged over a fiber optic link between the waveform generator, in the control system chassis, and the Serial I/O Card in the regulators. This data is exchanged at 720 Hz. The regulator also communicates with a PLC through a PLC communications card. This card provides digital input and output that is used to control the regulator, and return status, through the control system. There is also a fiber optic lick to the RMMPS control computer. This computer provides program maintenance and diagnostic capabilities.

To insure the stability of the analog feedback circuits the regulator is housed in a temperature controlled enclosure. This enclosure uses thermoelectric modules that provide a temperature stability of +/- 0.2 °C.

The regulator sends analog readbacks to the control system's Multiplexed Analog to Digital Converter (MADC) system. These signals are used for diagnostics and are stored when the quench link goes down. The readbacks for the RMMPS are: reference setpoint, actual current, output voltage, current error, power supply ground current, quench ground current, flat-top power module output current, and the ramp power module output current.

Output Filter

The output filter reduces the current ripple in the magnet string by reducing the voltage ripple at the power module's commutation frequency of 720 Hz. The voltage reduction at 720 Hz is approximately 15 dB.

The output filter is a three pole passive RLC filter with a corner frequency of 90 Hz. This corner frequency insures that the filter's peaking is not at 60 Hz, or its harmonics.

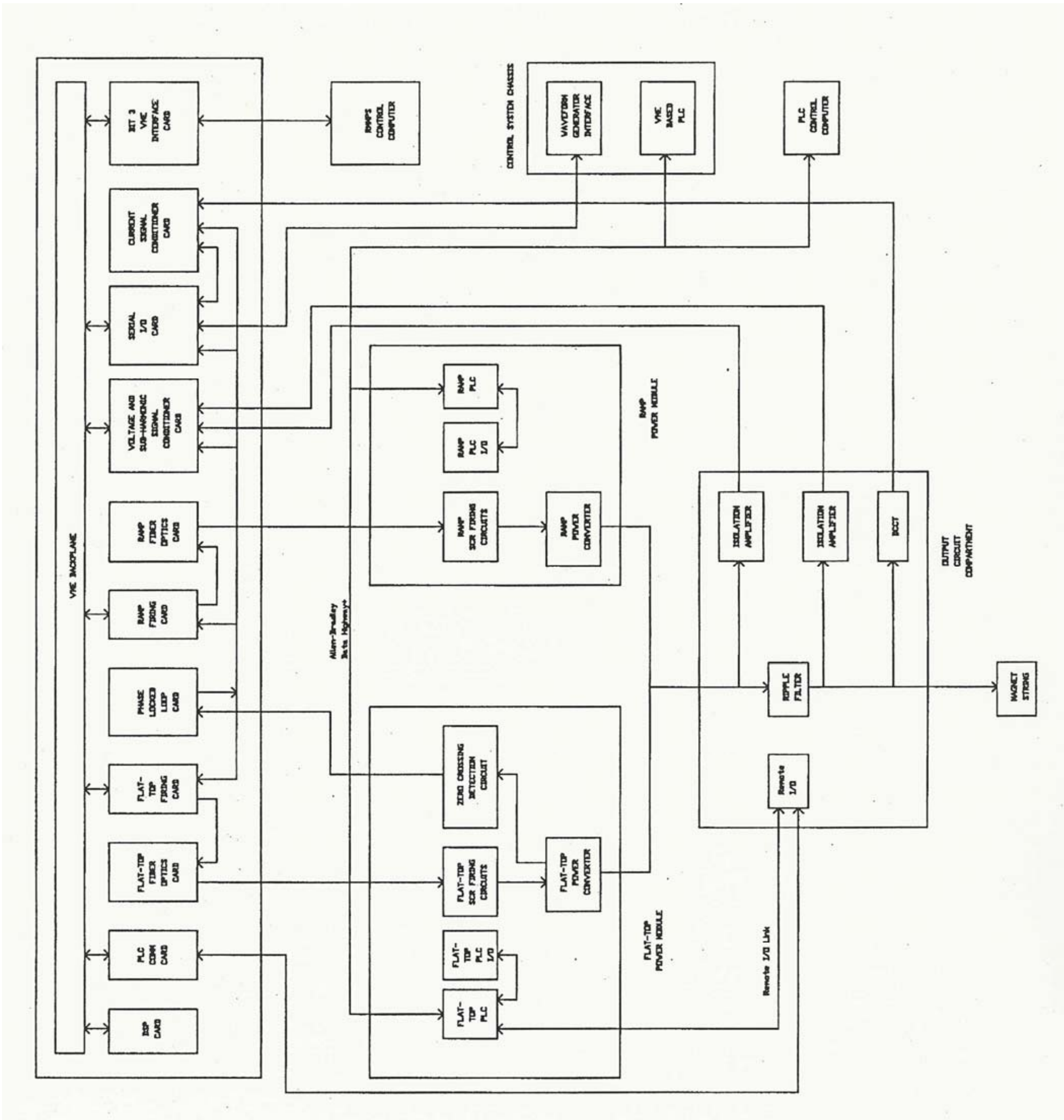

Fig. 2-18 Regulator Block Diagram

Quench Protection and Main Magnet Power Supply System

The quench protection system extracts the stored energy in the main magnet strings. The major system blocks are shown in Fig. 2-19 and are labeled: DC Contactor, Main SCR Firing Circuits, Pulse Forming Networks, and the Quench Control Interface.

The quench link signal, originating in the Control System Quench Interface, is an input to the Quench Control Interface Circuit in the OCC. This signal is a TTL high level during normal operation, it goes low to initiate the energy extraction. When this event occurs the Quench Control Interface Circuit (QCIC) immediately turns off the gate drive to the Main SCR Firing Circuits and triggers the Pulse Forming Network (PFN) attached to the Main SCRs. The PFN shuts off the Main SCRs, this action isolates the RMMPS from the magnet string. The QCIC then fires the Quench SCRs, and the magnet current is now diverted into stainless-steel resistors that extract the energy. The QCIC then opens the Main Contactor, which provides a mechanical backup to isolate the power supplies from the magnet string in the event the Main SCRs fail to open. The QCIC then turns the power modules off. If the QCIC or the Gate Firing Circuits attached to the Quench SCR Banks fail to trigger the Quench SCRs, the resultant voltage rise will trigger the Self-Triggering Circuit. This circuit provides a backup for the QCIC and will fire the Quench SCRs independently.

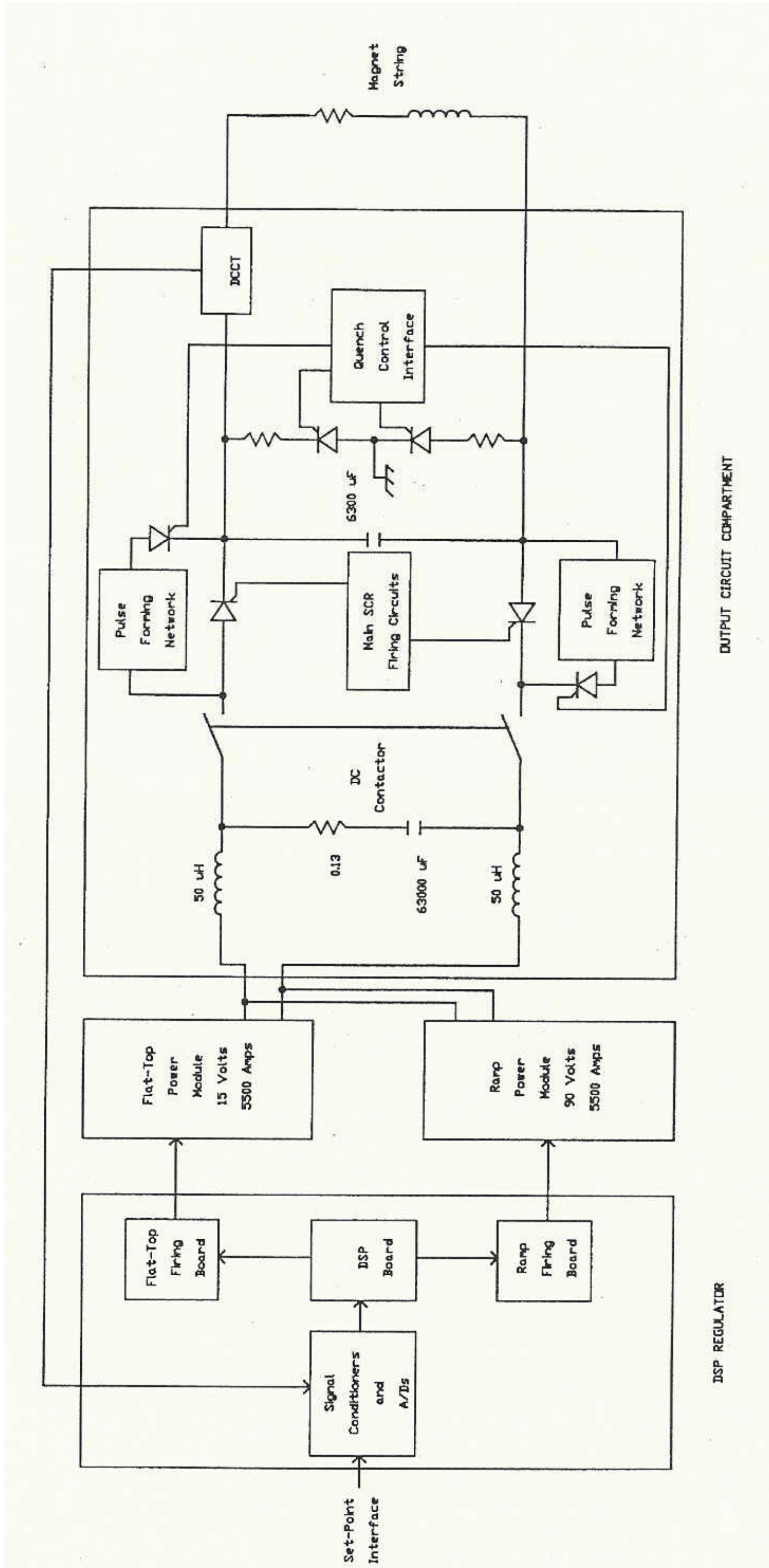

Fig. 2-19 Main Power Supply Block Diagram

PLC System

The PLC system provides status reporting, state control, and local protection of the RMMPS. Each power module contains an Allen-Bradley PLC-5/25. These PLCs are connected to an Allen-Bradley PLC-V5/40, which resides in the Control System Chassis, via the Allen-Bradley Data Highway + serial link. The FTPM PLCs are also connected to remote I/O in the OCCs. These connections tie all the regulators and all the power modules to the control system and provide the status reporting and state control functions.

The PLC-V5/40 collects the status from the power module PLCs and stores this information in dual-port RAM that is accessible to the control system's Front End Computer (FEC), which resides in the same chassis. The FEC can also write commands to this RAM. The PLC-V5/40 contains ladder logic that receives these commands from the control system, and then coordinates turning the power supplies on or off.

The PLC in each power module contains ladder logic that monitors various parameters in that power module. If a failure condition is detected the PLC opens the Master Interlock Relay (MIR) in the power module. Opening the MIR causes the power module to shut down and the power supply fail signal to be sent to the control system. This brings down the quench link signal which activates the quench sequence described above, providing an orderly shut-down of the RMMPS.

The Allen-Bradley Data Highway + also connects to a PLC control computer. This provides PLC ladder logic maintenance capabilities.