MAGNET CORRECTOR POWER SUPPLY CONTROLLER FOR LCLS-I

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Abstract

The MCOR 12 is a 16-channel modular architecture, precision magnet driver, capable of providing bipolar output currents in the range from –12A to +12A. A single, unregulated bulk power supply provides the main DC power for the entire crate. Currently the MCORs have a 1000ppm regulation on the B-field. The MCOR controller card upgrades, existing LCLS-I and future LCLS-II needed, controls for Magnet Corrector Power Supplies. The project shifts the existing functionality of the VME based DAC and SAM and an Allen Bradley PLC into a new slot-0 card residing in the MCOR chassis. Elimination of the VME crate and the PLC will free up rack space to be used in future. The new interface card has a long term stability of 100ppm and monitors ground fault currents and various other interlocks for the MCOR power supplies. The controller can interface to EPICS Channel Access and Fast Feedback system at SLAC using two Gigabit Ethernet ports and has an FPGA based EVR for getting "time stamps" from the Event Generator system at SLAC. The EPICS control system along with embedded diagnostic features will allow for enhanced remote control and monitoring of the power supplies.

INTRODUCTION

The MCOR (Magnet Corrector) Series is a multichannel corrector magnet driver system, capable of providing precision bi-polar output currents with minimal zero-crossover distortion. The MCOR design employs a modular architecture, consisting of a rack-mounted crate, with standardized slots for removable power modules, crate controller and diagnostics. A single, unregulated bulk power supply provides the main DC power for the entire crate. The MCOR power module is responsible for converting the unregulated DC bulk power into a precision bi-polar current source suitable for driving corrector magnets and beam line devices. The power modules are controlled using +10 to –10V FS analog command signals sent over the backplane from the control system. There are two types of available MCOR power modules: The MCOR12 (12A FS) and the MCOR30 as shown in Fig. 1 (30A FS). [1, 2] The MCOR30 uses a custom H-bridge configuration, operating in an overlapping volt-seconds feedback mode instead of a straight voltage mode to achieve a higher control bandwidth. The transfer function of input command voltage to output current is determined by resistor values on the programming (PGM) card. Each power module provides two independent measurements of its output current; one that closes the regulation loop, and another that returns an independent monitoring signal to the control system. [1, 2] Both of these independent current measurements are available to the control card for diagnostic purposes. [1, 2] The MCOR12 uses a commercial switch mode servo driver (The AMC 30A8) operating in a voltage feedback mode to regulate the output current. The MCOR 12 system as the name suggests is a 16-channel precision magnet driver, capable of providing bipolar output currents in the range from –12A to +12A. The output current can be adjusted smoothly through zero. [1, 2] The MCOR 12 employs a modular architecture, so that any individual channel is serviceable without disturbing the operation of adjacent channels in the same crate. This feature significantly improves the overall availability of the accelerator, since in most cases the beam lattice can tolerate the loss of a single corrector and continue to operate, but could not handle the loss of an entire crate of correctors during the repair effort. [1, 2]

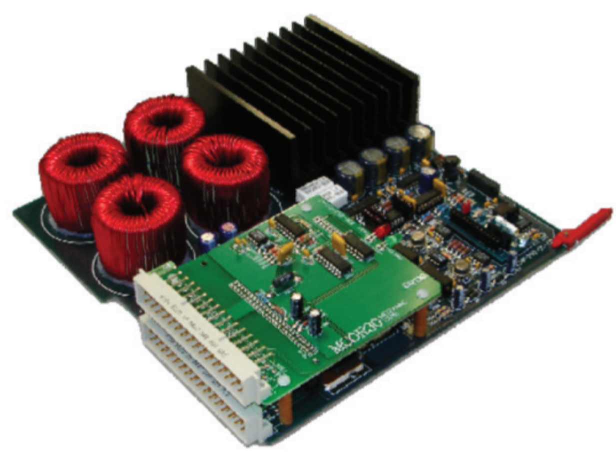

Figure 1: MCOR-30 Power Supply Card.

SYSTEM ARCHITECTURE

The LCLS Fast Feedback Loop Controller wants all MCOR controllers to be controllable at 120Hz (The MCOR Controller card must be able to write set points and read back at 120Hz). The MCOR Controller card must also receive set points in PVs from the Channel Access Network, but it is not necessary that it act on commands from both the Channel Access and the Fast Feedback Network at the same time. LCLS Users want to see the current set point ('desired value'), read back ('actual' value), and status of each channel, regardless of which network the set point command came from. LCLS Users want features like Calibration of the DACs,

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Ramping, Reset Interlocks, Ripple measurement for each MCOR corrector channel, so the controller card supports it. MCOR Controller card as shown in Fig. 2 has Gigabit Ethernet links to both Fast Feedback network and Channel Access to reduce latency. The MCOR Controller card has a long term temperature stability requirement of 0.01 % of maximum current for each MCOR channel. (100 ppm). The DAC accuracy for a desired set point is 0.1% [1000 ppm] of full scale output voltage. The MCOR controller card is able to operate within the ambient conditions 40 degree F to 122 Degree F (50 degree C).The controller card is able to read both the "Monitor" and "Feedback" analog outputs along with the digital "Fault" status from each MCOR module and an alarm is raised if any of the MCOR channels indicate a digital fault condition. There are 32 channels of 18 bit 100 KSps ADCs and 16 channels of 16 bit DAC outputs with settling time of less than 10uS interfaced to a Xilinx Virtex-5 FPGA. The controller card is able to do waveform capture and store for selected MCOR channel for diagnostics. The controller card incorporates an Event Receiver which is able to decode the LCLS Timing System [EVR] to provide timing information. The EVR supports Multi Mode/Single Mode and daisy chaining. The EVR may also have digital TTL outputs for triggering. MCOR Controller card monitors "GND fault current" and triggers an alarm if the GND fault current is not within limits (+/-25mA). It is able to read up to +/-100mA. The Bulk Power Supply is turned off if the GND fault current is not within limits. Beam Synchronous Acquisition (BSA) feature is also desired by LCLS, which is implemented on the EPICS IOC on board the controller card as a daughter card. The controller card uses a Computer On Module (COM) Express Type-2 daughter card as shown in Fig. 3 with an Intel Atom Processor to host the EPICS IOC. The COMX card communicates to a Xilinx Virtex-5 FPGA on the mother board to interface to all the DACs, ADCs, Digital Fault Signals, External Interlocks, Gigabit Ethernet and Voltage, Temp and Current Monitoring chips on the motherboard. The MCOR Controller runs a version of Linux-Real Time Operating system on the COMX based Intel Atom Processor. The Operating system is loaded on the Atom processor at boot-up using TFTP. Controller specific Board Support Package is then used to interface to EPICS. The block diagram is shown in Fig. 4.

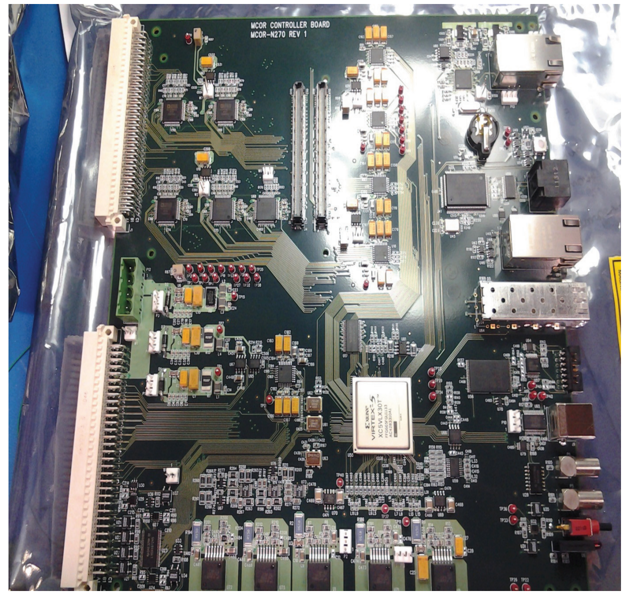

Figure 2: MCOR Controller Motherboard.

Figure 3: MCOR Controller COMX.

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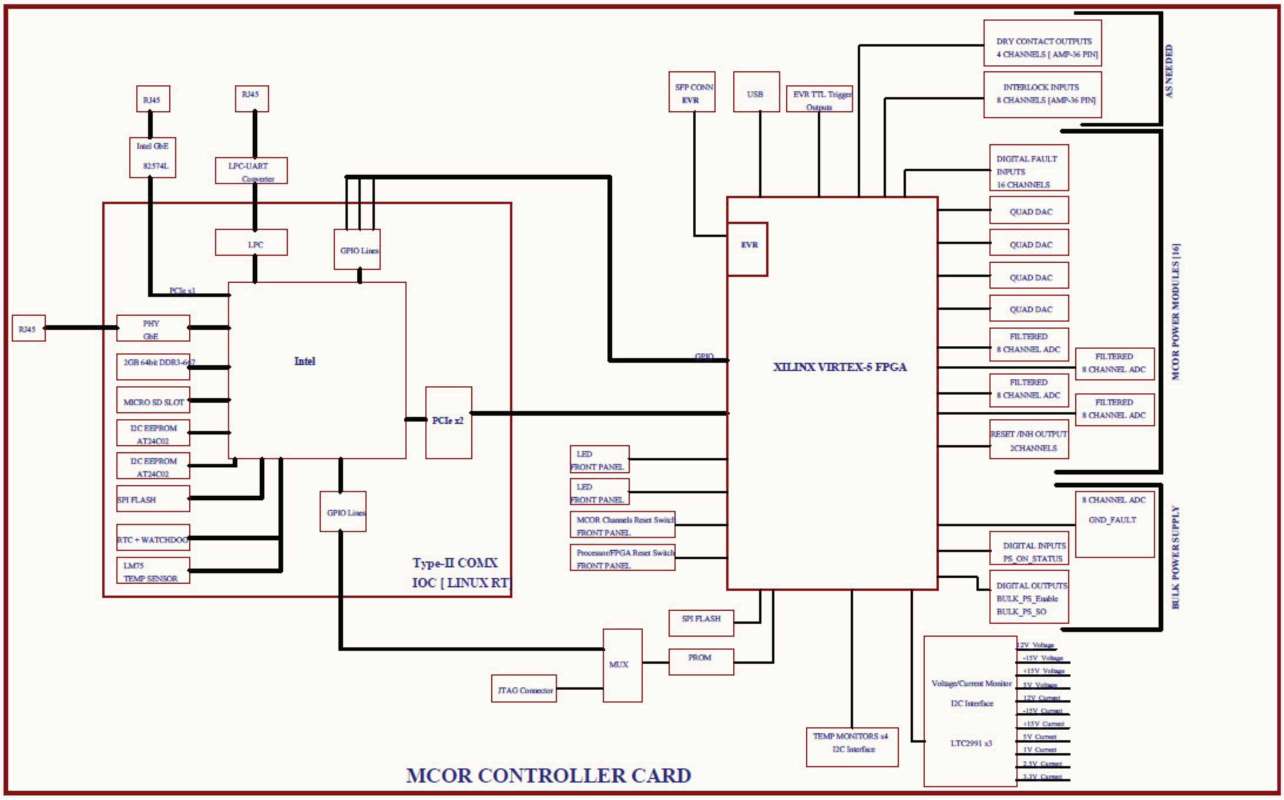

Figure 4: MCOR Controller card Detailed Block Diagram.

TEST AND RESULTS

The MCOR Controller was installed in LCLS-I gallery in Sector-28 of the Linac. Below is the result as shown in Fig. 5 that was obtained for 8 hours duration for MCOR-12 Power supply module.

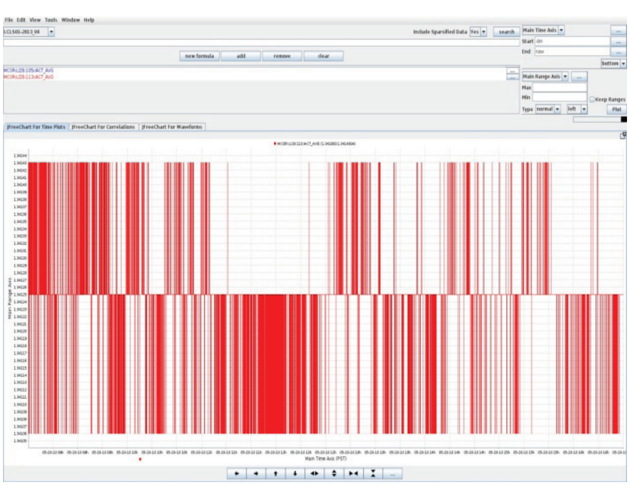

Figure 5: MCOR: LI28 Duration 8 Hrs, Iset: 1.34 A Iact Pk-Pk ripple 375uA.

CONCLUSION

The MCOR controller card upgrades, existing LCLS-I and future LCLS-II needed, controls for Magnet Corrector Power Supplies. The project shifts the existing functionality of the VME based DAC and SAM and an Allen Bradley PLC into a new slot-0 card residing in the MCOR chassis. The new interface card has a long term stability of 100ppm and monitors ground fault currents and various other interlocks for the MCOR power supplies. The controller can interface to EPICS Channel Access and Fast Feedback system at SLAC and has an FPGA based EVR for getting “time stamps” from the Event Generator system at SLAC. The EPICS control system along with embedded diagnostic features will allow for enhanced remote control and monitoring of the power supplies.

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[1] G.E. Leyh, et. al. .A Multi-Channel Corrector Magnet Controller,. PAC 95 and IUPAP, Dallas, Texas, 1-5, May 1995.

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