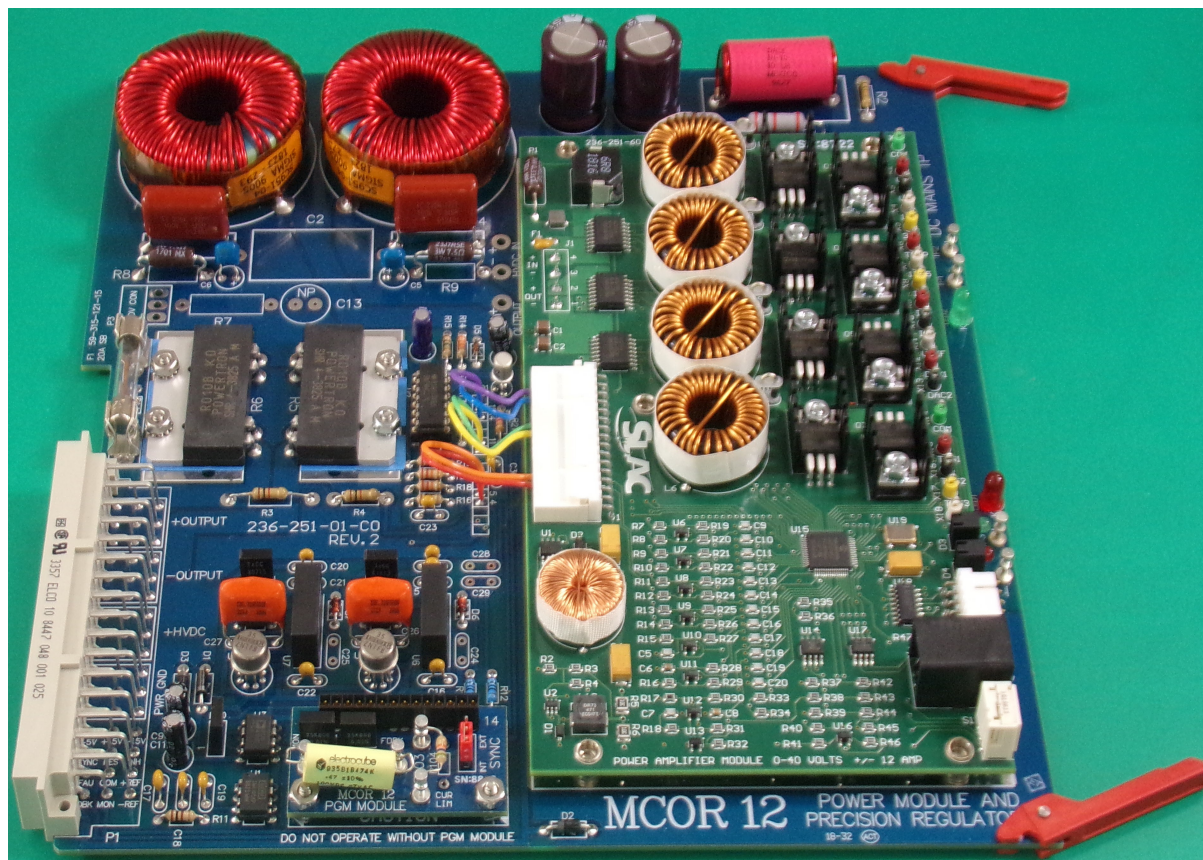# User's Manual

Magnet Corrector (MCOR12) Power Module

MCOR 12 User Manual Table of Contents

This document contains instructions on the use of the MCOR 12 Power Module

Reference Material:(available on BiRa.com)
MCOR Crate Operations Manual
EMCOR User Manual
MCOR 30 User Manual

Overview

The MCOR 12 (Magnet Corrector) power module is a precision bipolar and modular current amplifier designed to provide as much as ± 12 amps to any load. The output was designed for minimal zero-crossover distortion. While this manual will focus on the MCOR 12 model, it also applies to other MCOR models as well, since design and operation is very similar. Table 1 shows all models and maximum output current levels that this manual applies to.

The MCOR system uses a modular architechture consisting of a rack mounted crate capable of housing up to 16 MCOR 12 (and all other models shown in Table 1) modules, an EMCOR controller module designed to control and monitor all modules assigned to the crate, a single unipolar bulk supply, and a blower assembly designed to keep the crate and all modules from overheating. The modular architecture means that a single module can be quickly removed and replaced if necessary. The modules slide into the front of the crate using standard card rails and locking extractor handles to hold each module securely in the crate. The MCOR 12 model and all other models in Table 1 use the same amplifier module, but will use a different PGM module based on the model. A PGM module for an MCOR 12 module is shown below in Figure 1.


Figure 1- MCOR 12 PGM Module

Table 1- MCOR Models Available

MCOR Model	Current Range
MCOR1	-1.02A to +1.02A
MCOR1.5	-1.538A to +1.538A
MCOR2	-2.05A to +2.05A
MCOR6	-6.15A to +6.15A
MCOR7.5	-7.69A to +7.69A
MCOR9	-9.23A to +9.23A
MCOR12	-12.307A to +12.307A

Note that Table 1 does not list the MCOR 30 model, which is capable of outputting up to ±30 amps. See the MCOR 30 User Manual for more information.

A typical MCOR system diagram is shown below. The diagram illustrates that up to 16 MCOR 12 (and lower MCOR models) or 8 MCOR 30 modules can be loaded into the crate at the same time. It is also possible to mix and match different MCOR models into the crate if desired. The load connections for all MCOR module outputs are taken from the back of the crate (figure 1).

The new EMCOR controller module replaces the now obsolete C4 Interface module. The instructions contained in this document pertain only to the operation of MCOR 12 power modules using the EMCOR controller module. The EMCOR controller module must be installed in slot 00 (left most slot as shown in the diagram) of the crate. With the EMCOR module as the controller, the 'Bitbus' connector and J3 and J4 connectors on the back of the crate are not necessary and should not be used.
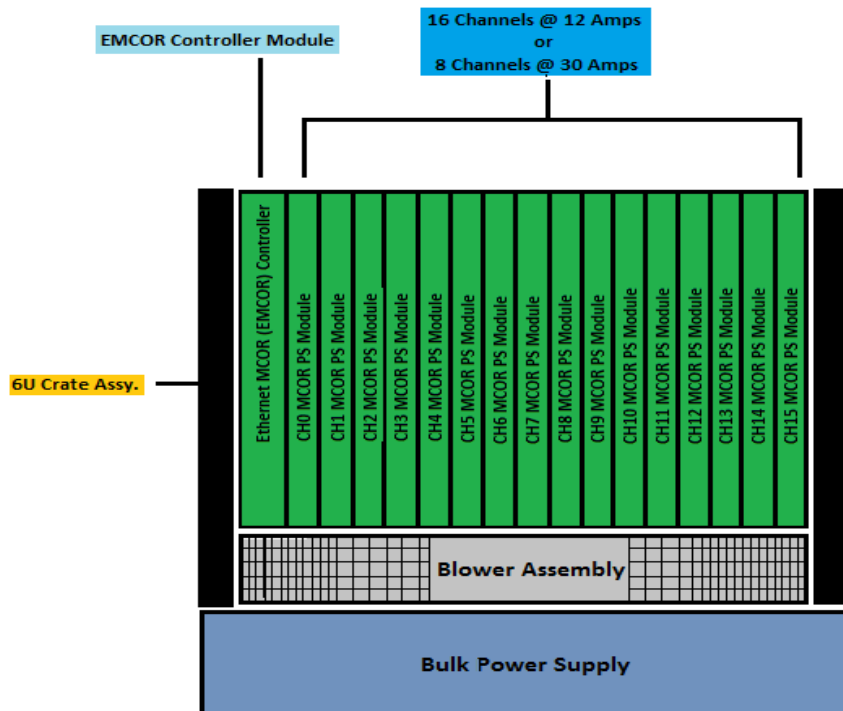
MCOR System Diagram-
Required components that make up an MCOR system include the 6U crate assembly, the EMCOR controller module, up to 16 MCOR 12 modules (and/or up to 8 MCOR 30 modules), a 2U blower assembly mounted to the bottom of the crate, and a single unipolar bulk supply. The requirements for the bulk supply will vary depending on various factors.

Setup

The MCOR crate, blower assembly, and bulk supply were designed to be mounted in a 19" test rack, with the blower assembly mounted immediately below the crate. There should be adequate space above the crate to ensure that cooling air from the blower assembly is allowed to freely circulate. The crate front panel cover should always be installed and closed during normal use, both for safety purposes and cooling purposes. The bulk supply will need to be mounted in close enough proximity to the crate so that the 180 Amp powerpole connector can be attached. If mounting the bulk supply in the 19" rack, use caution as the supply is very heavy and will need to be mounted using mounting connections from the front and rear of the rack assembly in order to safely support the supply.

The load connections (16 sets) on the rear of the crate (Figure 2) are also powerpole connections. Use only load cables that are capable of handling the required amount of current. BiRa systems will provide the cables in the quanity needed and desired length if requested.

Table 2 below shows the proper connections for each MCOR channel output. The back of the crate also indicates the channel numbers next to the output connectors. Each MCOR model shown in Table 1 will occupy 1 slot or channel in the crate, and each channel will use one set of output connectors as shown in Table 2.
Once the load connections have been established, it is highly recommended that each end of the load cable is labled with the appropriate channel number.

Table 2- **Crate Output Connectors** (looking at rear of crate, Pin # and Channel/Polarity)

J8		J7		J6		J5	
H—15+	A—12-	H—11+	A—8-	H—7+	A—4-	H—3+	A—0-
G—15-	B—12+	G—11-	B—8+	G—7-	B—4+	G—3-	B—0+
F—14+	C—13-	F—10+	C—9-	F—6+	C—5-	F—2+	C—1-
E—14-	D—13+	E—10-	D—9+	E—6-	D—5+	E—2-	D—1+

Additional Setup Information

BNC connector J1 (see figure 2 below) on the rear of the crate is the 'Ext. Interlock' connection. J1 was designed to be used with an external connection, which under normal conditions is a closed contact. If the J1 connection is left open, the outputs of all MCOR modules in the crate will be inhibited. If no external connection to J1 is needed, a simple short (or a closed switch) across J1 will allow normal operation of the MCOR crate and modules.

BNC connector J2 (also on the rear of the crate) can be used to remotely enable the output of the bulk supply used to power the MCOR modules. In order for this (optional) function to work, the bulk supply must have an analog connection that has enable connection inputs. When connected to J2 and a properly set up bulk supply, the EMCOR controller module will place a short across J2 with the proper software command, enabling the output of the bulk supply. This function is optional and the bulk supply output can be locally enabled as well. No connections to J2 are necessary in this event.

Selecting a Bulk Supply

When selecting a bulk supply for use with an MCOR 12 system, several factors must be taken into account. For MCOR 12 modules the required bulk supply voltage range is between 24V and 48V (note that a higher voltage range option is available on request). The voltage applied from the bulk supply should be high enough to ensure that compliance of the MCOR module is never reached, and so it must be determined based on the load and how much current is to be applied, what the normal voltage drop across the load is likely to be. It will also be necessary to evaluate the total power required by the load (or loads) so that the bulk supply will have the necessary current to supply all modules installed in the crate. Specifications included in **Appendix A** should be helpful in determining bulk supply requirements.
BiRa systems will be happy to provide recommendations for an appropriate bulk supply based on customer input if requested.
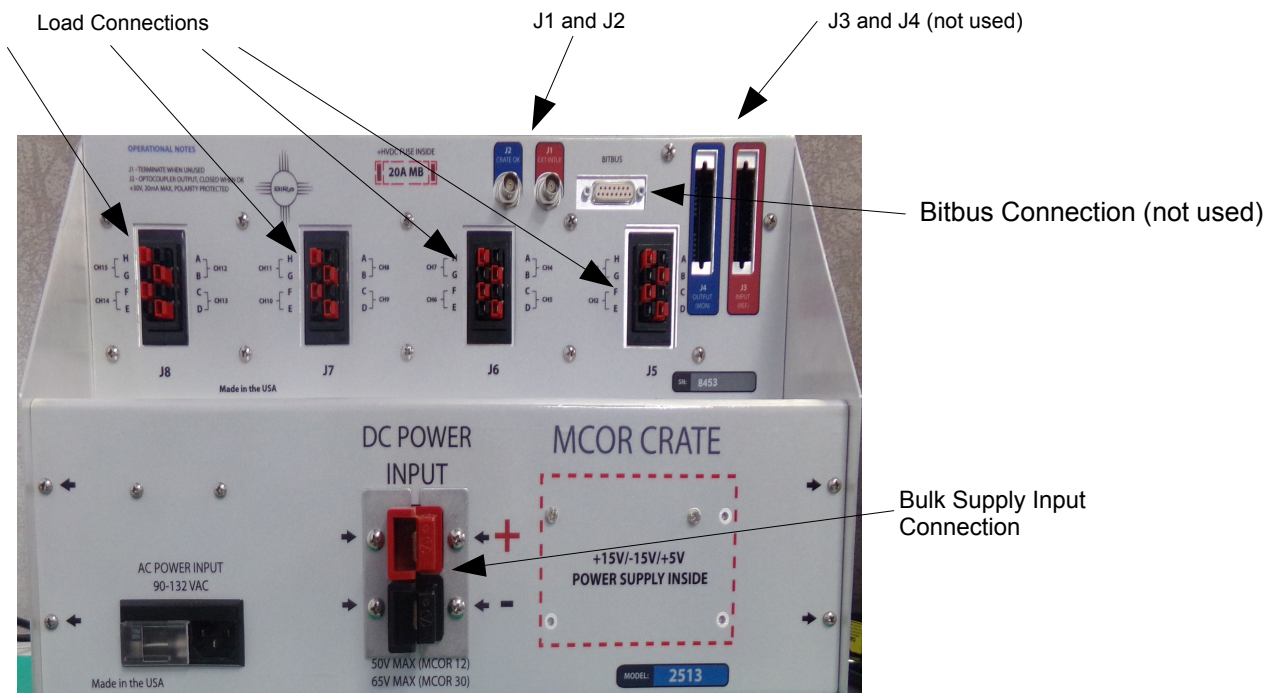
Figure 2- Crate Rear Panel

With the crate, blower assembly and bulk supply mounted and all appropriate connections made, the EMCOR controller module and MCOR magnet corrector power modules can be installed into the crate. It is recommended that the crate and blower assembly use a common power strip for AC power, ensuring that the blower assembly will always be on whenever the crate is. Note that the crate does not have a power switch, but some models of the blower assembly do, so it should be ensured that the blower assembly switch is in the 'On' position. Use the power switch on the power strip to control AC power and always make sure that power is not applied to the crate when installing and removing modules from the crate. Damage to the modules could occur if attempting to remove or install modules when power is applied to the crate.

Use ESD (Electro-static damage) safe handling precautions when installing and removing modules from the crate, since circuits on the modules are susceptible to ESD.

MCOR12 Operation

Before any programming of MCOR modules can occur, it will first be necessary to set up the bulk supply. It is recommended that the supply parameters are set prior to connecting the output of the supply to the crate input. This is to prevent any unsafe voltages from being applied that might damage the crate or MCOR modules. The bulk supply output should never be applied to the crate without first having power applied to the crate. With the supply disconnected from the crate input, adjust the output of the supply to the desired voltage (see specifications- the bulk supply must be set between 24 and 48V for MCOR 12 modules and all other models shown in Table 1). This can be done without the output of the supply enabled and it is advisable to review the bulk supply manufactures user manual before first attempting this. Determine the current limit necessary to operate the crate and all installed MCOR modules, and set the supply to this value (or slightly higher). Note that if overcurrent limit protection on the supply has not been enabled the supply will go into current limit when the limit has been reached, but will not shut the output of the supply off. Once the voltage and current levels have been set, the supply will need to be configured so that the output is not enabled when power is applied. Consult the owner's manual for instructions on how to accomplish this. When the output enable has been properly configured, turn off power to the supply, disconnect AC input power to the supply, and make the connections from the supply to the crate

ensuring that the proper polarity has been observed.

If it is desired to use software commands to enable and disable the bulk supply output, see the instructions below in **Appendix B**. Appendix B is an instruction sheet on how to operate the USB interface software.

With all necessary connections made to the crate and with all of the loads connected to their appropriate outputs, apply power to the crate and blower assembly. When power is first applied to the crate, the EMCOR module must first go through a **startup** sequence. Observe that when power is first applied to the crate the EMCOR front panel 'ok' green LED is lit. After a few seconds the lamp should go off and the red 'fault' LED will flash for about 5 seconds, pause for a couple of seconds, and then flash again for a couple of seconds. After this sequence, the green 'ok' LED will begin to slowly flash and will continue to flash until a program 'Configured' command is issued. It is normal for the red LED on the MCOR 12 module to flash briefly before going off (note that there is a red and a green LED on both the MCOR module, and on the amplifier module that is mounted to the MCOR module). Once the red LED on the MCOR module goes off and the EMCOR module has completed it's startup sequence, it is ok to enable the output of the bulk supply. When the output of the bulk supply is enabled the green LEDs on both the MCOR module and amplifier module should turn on.

If the red LEDs on either the MCOR module or the amplifier module are lit, there could be a problem with the crate or the MCOR module itself. If J1 on the back of the crate is left open, it will inhibit the output of any module in the crate and cause the red LED on the MCOR module to flash. Other issues that could cause the red LED on either the MCOR module or the amplifier module to be lit include the following conditions:

- S1 BCD switch is set to 0- it should normally be set to 9.
- J1 connection on the back of the crate has an open circuit across it creating an active inhibit command.
- Excessive module temperature.
- A missing PGM (programming) module.
- A hard short on either input to ground.

If a fault condition exists it must be resolved before output programming of the module or modules can occur.

If no fault conditions are observed and all conditions are normal as described, the MCOR 12 modules are ready for use. Consult the Appendix B section below for instructions on how to use the software for programming MCOR 12 modules with the EMCOR Controller module.

Appendix A- MCOR 12 Specifications

Parameter	Conditions	MIN	Typical	MAX	Units
HVDC Supply Bus					
Bulk Supply Operating Range		24		48 (see note 1)	V
Output					
Output Current Range	nominal	See Table I		See Table I	A
Output Current Noise + Ripple	0A Out (1 Ohm +10mh) Bulk = 30VDC		770		uA RMS
Output Current Noise + Ripple	6A Out (1 Ohm +10mh) Bulk = 30VDC		975		uA RMS
Compliance Voltage	Bulk Supply @30V Load=5 Ohm + 10mHenrys	>75% of DC mains			
Efficiency	@6A. Bulk supply =40V, Load=5 ohm + 10mHenry	>90%			
Current output setting resolution (with EMCOR Controller)	16 bit DAC ±10.2564V max	0.5			mA
Output current stability	Short Term (5 minutes) @12A using 5mH load. Bulk Supply set to 30V		30		ppm
Output current stability	Long Term (8 hours) @12A using 5mH load. Bulk Supply set to 30V		60		ppm
Thermal Cycle Temp. Stability	25C to 45C, 45C to 5C @12A		6		ppm/$^\circ$C
Dynamic Response					
Slew Rate Response					
MCOR 12 (0 to 6A, 1 Ohm +10mh)			.56A/ms		
Settling Time			60ms		
Input					
Reference Input	Impedance (Differential)		50K		Ohms
Voltage Range	EMCOR (16 bit DAC)	-10.2564		+10.2564	V

Note 1-High Voltage Option with Higher Bulk Supply Operating Voltage available on request

Appendix B- USB Interface Application Programming Instructions

The following instructions are for using the USB interface software application developed by SLAC (Stanford Linear Accelerator Center) for programming the EMCOR module for MCOR 12 modules (and all other modules shown in Table 1) populating the crate. Note that instructions for programming any MCOR 30 modules can be found in the MCOR 30 User's Manual. Note also that other software programs do exist for programming and monitoring MCOR modules using an ethernet interface and EPICS control software, also developed by SLAC. Those instructions are not included in this document, however more information can be found in the EMCOR User's Manual.

The USB interface program is GUI based but does not give real time information unless the application panel is manually refreshed. The program is capable of programming all 16 crate slots for outputs, and will also monitor the outputs of the separate 'Feedback' and 'Monitor' for all channels programmed. Use the following screen shots and instructions for programming and monitoring MCOR 12 outputs. Note that with no load connected to a particular set of output connections it will not be possible to monitor that channel's output.

Using a USB male type A connection attached to a PC and a USB type B male connector attached to EMCOR front panel connector J9, power on the crate and blower assembly and wait for the EMCOR to complete the startup process (see information on the **startup** sequence above in the MCOR 12 operation section). Open the USB software application by double clicking on the executable file '**MCOR.exe**'. The screen shown in screen shot 1 below should appear. Note that the display comes up with a serial number, which indicates that the application is talking to the EMCOR module. If no fault indications are present on any of the MCOR modules populating the crate, enable the output of the bulk supply by pressing the 'On' or 'Output' button (instructions can be found below on how to use the software application if desired to enable the bulk supply output). With the output of the bulk supply enabled all MCOR 12 modules in the crate should now have the green LED on the MCOR module lit. Note that the output amplifier module attached to the MCOR module should also have it's green LED lit. This is an indication that all MCOR modules in the crate are ready to be programmed.
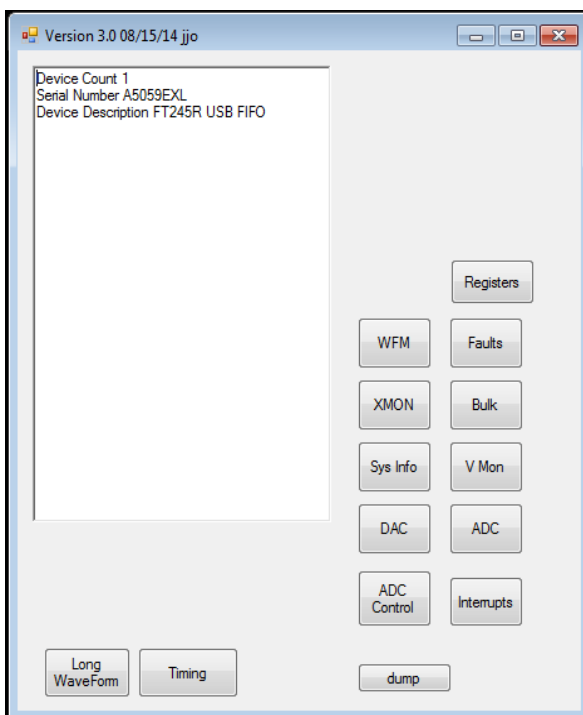
Screen shot 1- Main Panel

From the main panel seen in screen shot 1, open the 'Registers' panel and click the 'Refresh' button. The 'Registers' panel allows all of the parameters listed below (shown in the order listed from top to bottom) to appear for all 16 crate channels. Note that the 'Registers' panel does not allow any parameters to be set, just observed. 'Refresh' must be utilized before updated information will be displayed.

- Set Point
- Current Set Point
- Monitor ADC Reading
- Monitor Average ADC Reading
- Monitor Ripple Measurement (in uA)
- Feedback ADC Reading
- Feedback Average ADC Reading
- Feedback Ripple Measurement (in uA)
- Full scale DAC Set Point Current
- Full scale Monitor ADC Read Back Current
- Ramp Rate (amps/sec)
- Samples per Average
- Configuration/Status Register
- Full scale Feedback ADC Read back Current

Screen Shot 2- 'Registers' panel

From the Main panel open the 'DAC' channel and observe the following display.

Screen Shot 3- 'DAC' Panel

The 'DAC' panel is the display where all of the settings for all MCOR modules installed in the crate are made. At the top left of the panel is the 'Channel' pull-down menu. All 16 crate channels can be accessed through this menu to enter the desired programming data. First, select the appropriate channel and start by entering the 'DAC Full Scale Current'. The value to enter for the DAC Full Scale Current will be different depending on the model of MCOR occupying the channel. Use Table 3 below to determine that value. For an MCOR 12 for example, this value to enter will be 12.30768. Note that this value is 2.564% over the nominal value, since the DAC full scale voltage is actually 10.2564V. When this value is inserted into the window, the keyboard Enter key must be pressed. Next enter the 'Ramp Rate' value, in amps/second (range is .001 amps/second to 2147 amps/second) and press the keyboard enter key. Next, enter the 'Feedback ADC Full Scale Current' and 'Monitor ADC Full Scale Current' values (again, use Table 3 to determine these values) and press the enter key on the keyboard. Next, check the 'Configured' box on the display (once this button is checked the EMCOR module 'ok' green LED will stop flashing and will stay lit). The last entry to make is the actual desired current setpoint value. Make this entry in the 'Setpoint' window and hit enter on the keyboard. Once the value is entered, the output current for the channel entered will begin ramping until the setpoint current is reached (note that no value here can be entered unless the 'configured' box has been checked. The 'Setpoint' value can be fine tuned if desired but the minimum setting resolution is limited to .0005 amps (.5 milliAmps). The keyboard enter key must always be pressed after each entry in order for the setting to take effect.

Tip- If all MCOR modules installed in the crate are the same, then use the 'All' button under the 'Channel' pulldown menu and make the necessary entries just once. The 'Setpoint' entry, if different on each channel, can be made independently by going to the actual channel and making the 'Setpoint' entry there.

Table 3- Entry values for EMCOR USB software application

MCOR Model	Nominal Full Scale Current	Monitor ADC	Feedback ADC	DAC Full Scale Current
MCOR1	1A	1A	1A	1.02564A
MCOR1.5	1.5A	1.5A	1.5A	1.53846A
MCOR2	2A	2A	2A	2.05128A
MCOR6	6A	6A	6A	6.15384A
MCOR7.5	7.5A	7.5A	7.5A	7.6923A
MCOR9	9A	9A	9A	9.23076A
MCOR12	12A	12A	12A	12.30768A

Remotely Enabling/Disabling the Bulk Supply

The 'Bulk' panel shown in the screen shot below can be used to remotely enable/disable the bulk supply if desired. Using the 'Bulk' panel to enable/disable the output of the bulk supply is strictly optional. If it is more convenient to the user, the bulk supply can be enabled locally. Whether the bulk supply is enabled locally or with the software, it will need to be properly configured so that the output is only enabled when the crate and all modules are ready for bulk power to be applied. Note that it is not possible at this time to set any bulk supply parameters other than enabling/disabling the output.

Use the following instructions to configure the supply if using the application to enable/disable the bulk supply.

Use the 'PS On/Off' box on the 'Bulk Supply' panel to remotely enable and disable the bulk supply output. Before this setting can be used, the power supply must first be correctly configured. The supply must have enable in/out dry contact connections that will enable or disable the output when a short circuit connection is placed across the two designated pins of the power supply. Use the J2 BNC connection on the back of the crate attached to the 2 designated pins on the power supply to accomplish this.
Consult the owner's manual of the bulk supply on how to properly configure your supply so that the supply output can be remotely enabled. Before setting the switches to remotely activate the output, the supply must be set up so that the output is On, or enabled. Once that has happened, the supply can then be powered off and set to be remotely activated. When the supply is again powered on it should be in the enabled state, and can be controlled by the software. Note that even though the supply is in the enabled state on power on, this does not mean that the output of the supply is enabled or on. The output should be in the Off state so that the software can enable or turn the output on when desired.
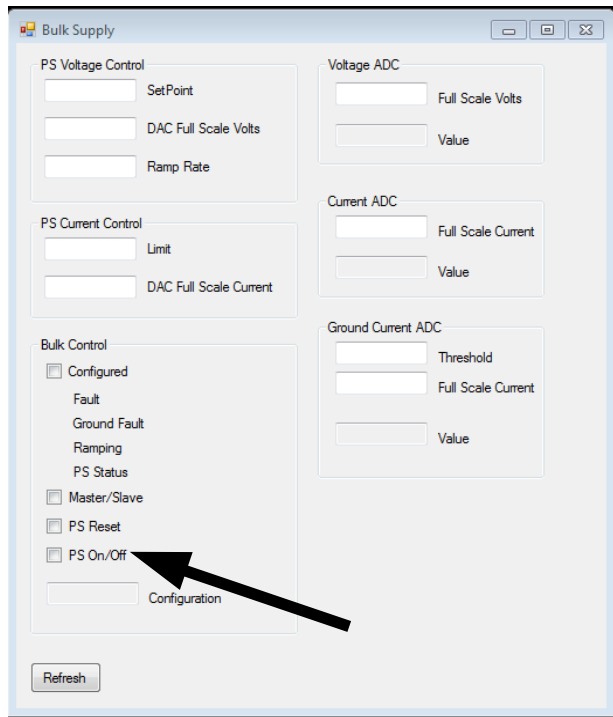
Screen Shot 4- Bulk Supply panel

Additional Features of the USB Application

The 'ADC Raw' panel will display just the following ADC parameters:
- Instantaneous Monitor and Feedback data for all 16 channels
- Average Monitor and Feedback for all 16 channels (based on a defined sample size)
- Ripple Monitor and Feedback for all 16 channels

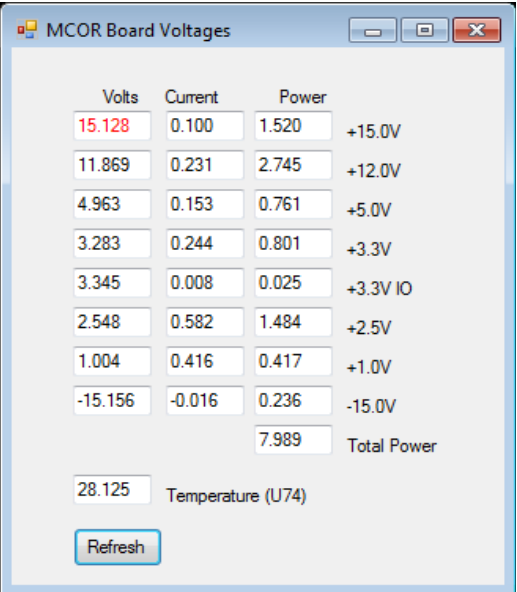Select 'ADC' from the main panel (see screen shot 5 below) to access this panel.

Screen Shot 5- ADC Panel

To get voltage and temperature information on the EMCOR module, select the 'V Mon' panel from the main panel, as shown in the screen shot below.

Volts	Current	Power	
15.128	0.100	1.520	+15.0V
11.869	0.231	2.745	+12.0V
4.963	0.153	0.761	+5.0V
3.283	0.244	0.801	+3.3V
3.345	0.008	0.025	+3.3V IO
2.548	0.582	1.484	+2.5V
1.004	0.416	0.417	+1.0V
-15.156	-0.016	0.236	-15.0V
		7.989	Total Power

28.125   Temperature (U74)

Refresh

Screen Shot 6- EMCOR board voltages