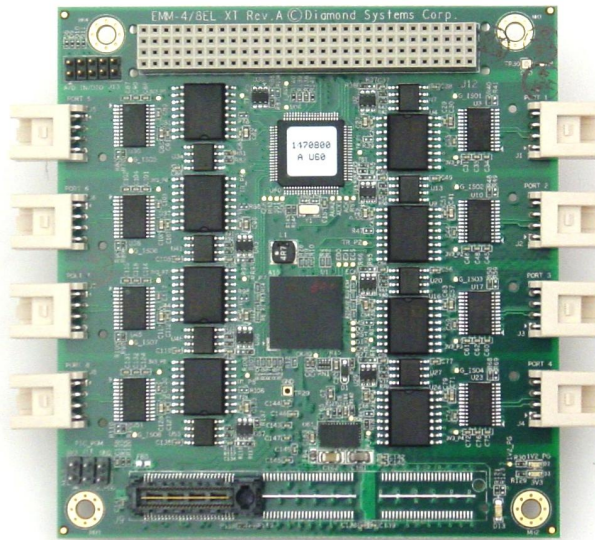




# Emerald-MM-8EL-XT

PCI/104-Express 4- or 8-Port Multi-Protocol Serial Port Module  
With Opto-isolation

Rev A.02 January 2016



Revision	Date	Comment
A.00	8/21/2014	Initial release
A.01	11/20/2014	Minor update to pin out
A.02	1/8/2016	New versions of Linux supported

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# 1. IMPORTANT SAFE HANDLING INFORMATION



## WARNING!

### ESD-Sensitive Electronic Equipment

Observe ESD-safe handling procedures when working with this product.

Always use this product in a properly grounded work area and wear appropriate ESD-preventive clothing and/or accessories.

Always store this product in ESD-protective packaging when not in use.

### *Safe Handling Precautions*

This board contains a high density connector with many connections to sensitive electronic components. This creates many opportunities for accidental damage during handling, installation and connection to other equipment. The list here describes common causes of failure found on boards returned to Diamond Systems for repair. This information is provided as a source of advice to help you prevent damaging your Diamond (or any vendor's) embedded computer boards.

**ESD damage** – This type of damage is usually almost impossible to detect, because there is no visual sign of failure or damage. The symptom is that the board eventually simply stops working, because some component becomes defective. Usually the failure can be identified and the chip can be replaced. To prevent ESD damage, always follow proper ESD-prevention practices when handling computer boards.

**Damage during handling or storage** – On some boards we have noticed physical damage from mishandling. A common observation is that a screwdriver slipped while installing the board, causing a gouge in the PCB surface and cutting signal traces or damaging components.

Another common observation is damaged board corners, indicating the board was dropped. This may or may not cause damage to the circuitry, depending on what is near the corner. Most of our boards are designed with at least 25 mils clearance between the board edge and any component pad, and ground / power planes are at least 20 mils from the edge to avoid possible shorting from this type of damage. However these design rules are not sufficient to prevent damage in all situations.

A third cause of failure is when a metal screwdriver tip slips, or a screw drops onto the board while it is powered on, causing a short between a power pin and a signal pin on a component. This can cause overvoltage / power supply problems described below. To avoid this type of failure, only perform assembly operations when the system is powered off.

Sometimes boards are stored in racks with slots that grip the edge of the board. This is a common practice for board manufacturers. However our boards are generally very dense, and if the board has components very close to the board edge, they can be damaged or even knocked off the board when the board tilts back in the rack. Diamond recommends that all our boards be stored only in individual ESD-safe packaging. If multiple boards are stored together, they should be contained in bins with dividers between boards. Do not pile boards on top of each other or cram too many boards into a small location. This can cause damage to connector pins or fragile components.

**Power supply wired backwards** – Our power supplies and boards are not designed to withstand a reverse power supply connection. This will destroy each IC that is connected to the power supply (i.e. almost all ICs). In this case the board will most likely will be unrepairable and must be replaced. A chip destroyed by reverse power or by excessive power will often have a visible hole on the top or show some deformation on the top surface due to vaporization inside the package. **Check twice before applying power!**

**Overvoltage on digital I/O line** – If a digital I/O signal is connected to a voltage above the maximum specified voltage, the digital circuitry can be damaged. On most of our boards the acceptable range of voltages connected to digital I/O signals is 0-5V, and they can withstand about 0.5V beyond that (-0.5 to 5.5V) before being damaged. However logic signals at 12V and even 24V are common, and if one of these is connected to a 5V logic chip, the chip will be damaged, and the damage could even extend past that chip to others in the circuit

## 2. INTRODUCTION

### 2.1 Description

The Emerald-MM-8EL-XT is a family of PCIe/104 OneBank serial cards offering 4 or 8 serial ports with or without opto-isolation. The module is based on a high speed UART with 256-byte TX/RX FIFOs and auto RS-485 transmit control. The EMM-8EL-XT fits a wide variety of embedded serial I/O application needs.

Each port is independently isolated with an ADUM5402 isolated power + signal chip plus additional isolators for control signals. All features are programmable, including protocol and RS-485 line termination. An onboard microcontroller interfaces to the GPIO pins on the UART and provides control of the configuration options. The microcontroller also manages staggered turn-on of the ADUM5402 devices to limit power-on inrush current. All configurations are stored in the microcontroller's flash memory and are automatically reloaded on power-up. The board is in the PCI/104-Express form factor with the PCIe/104 one bank bus connector for cost reduction.

#### Functions

- ◆ 8 or 4 RS-232/422/485 serial ports with programmable protocol
- ◆ Data rates: RS-232 mode up to 1Mbps  
RS-422/485 modes up to 10Mbps
- ◆ XR17V358/XR17V354 PCIe interface UART with 256-byte FIFOs
- ◆ Models available with or without opto-isolation
- ◆ SP336 multi-protocol transceivers with high speed, ESD, and open-circuit protection
- ◆ RS-422/485 termination programmable
- ◆ +/-15KV ESD protection on all serial ports
- ◆ Independent 2500VRMS isolation port by port with individual I/O connectors for each port
- ◆ Staggered turn-on of isolated power devices for reduced power-on inrush current
- ◆ 8 digital I/O or analog input lines
- ◆ PClex1 host interface using PCIe/104 "OneBank™" connector supports both Type 1 and Type 2
- ◆ Onboard microcontroller to manage all configuration options with flash memory for configuration storage and automatic recall
- ◆ Latching connectors for increase ruggedness
- ◆ Comprehensive software suite enables easy configuration and control

#### Operating System Support

- ◆ Linux versions 2.6.16 through 3.13
- ◆ Windows XP & 2000
- ◆ Windows Vista and 7

#### Mechanical, Electrical, Environmental

- ◆ PCI/104-Express form factor 3.55" x 3.775"
- ◆ -40°C to +85°C ambient operating temperature
- ◆ MIL-STD-202G shock and vibration compatible
- ◆ Power input: +5VDC +/- 5%

## 2.2 Models

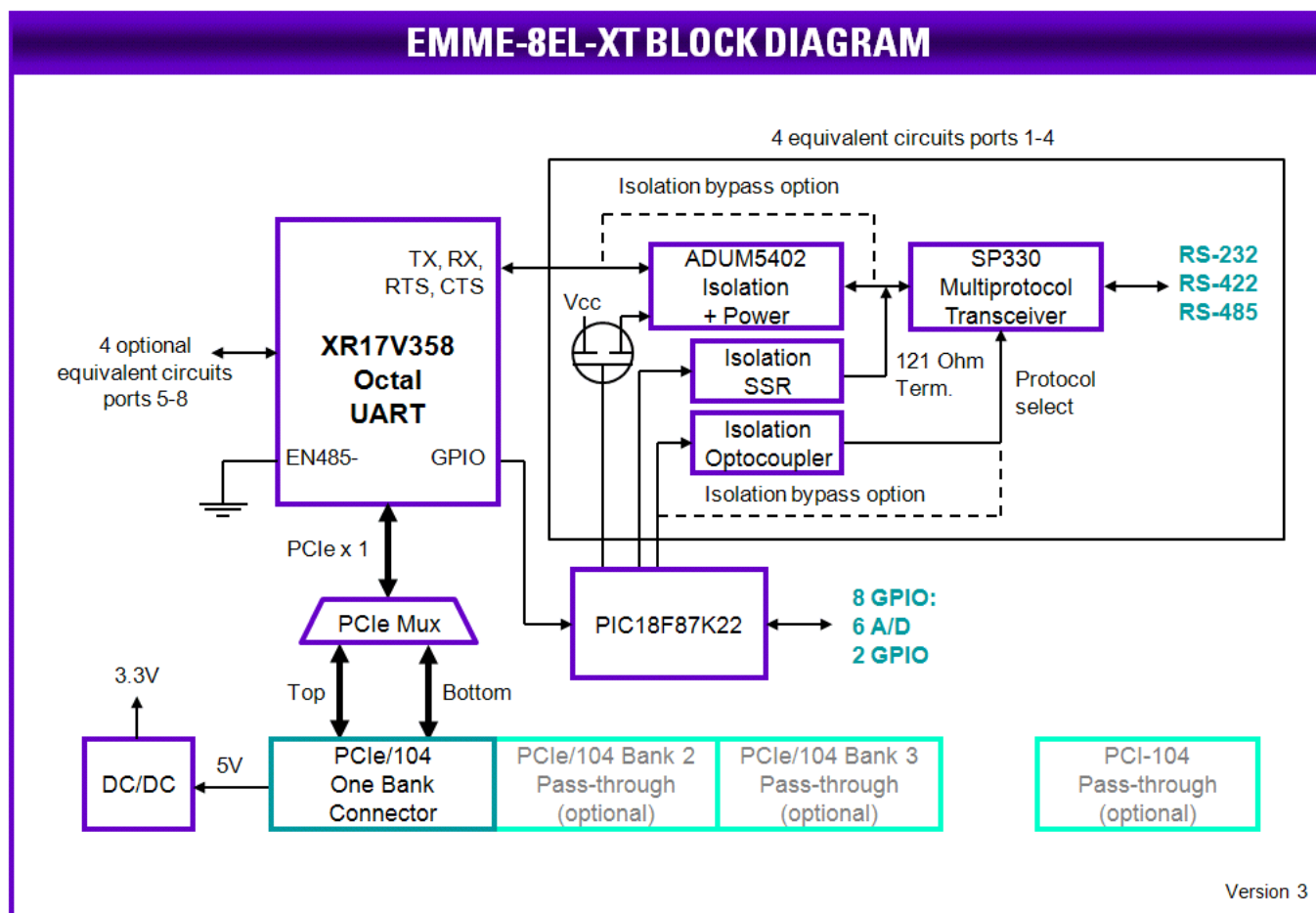
The following Emerald-MM-8EL-XT models and cable kits are available.

Model	# of Ports	Isolation	Cable Kits	Description
EMM-8EL-XT	8	Yes	CK-EMM-8EL	8 serial cables, 1 digital/analog cable
EMM-4EL-XT	4	Yes	CK-EMM-4EL	4 serial cables, 1 digital/analog cable
EMM-8E-XT	8	No		
EMM-4E-XT	4	No		

As a customization option, Emerald-MM-8EL supports the full PCIe/104 three bank form factor definition, both Type 1 and Type 2. Contact Diamond Systems for more information on this option. Minimum order quantities apply.

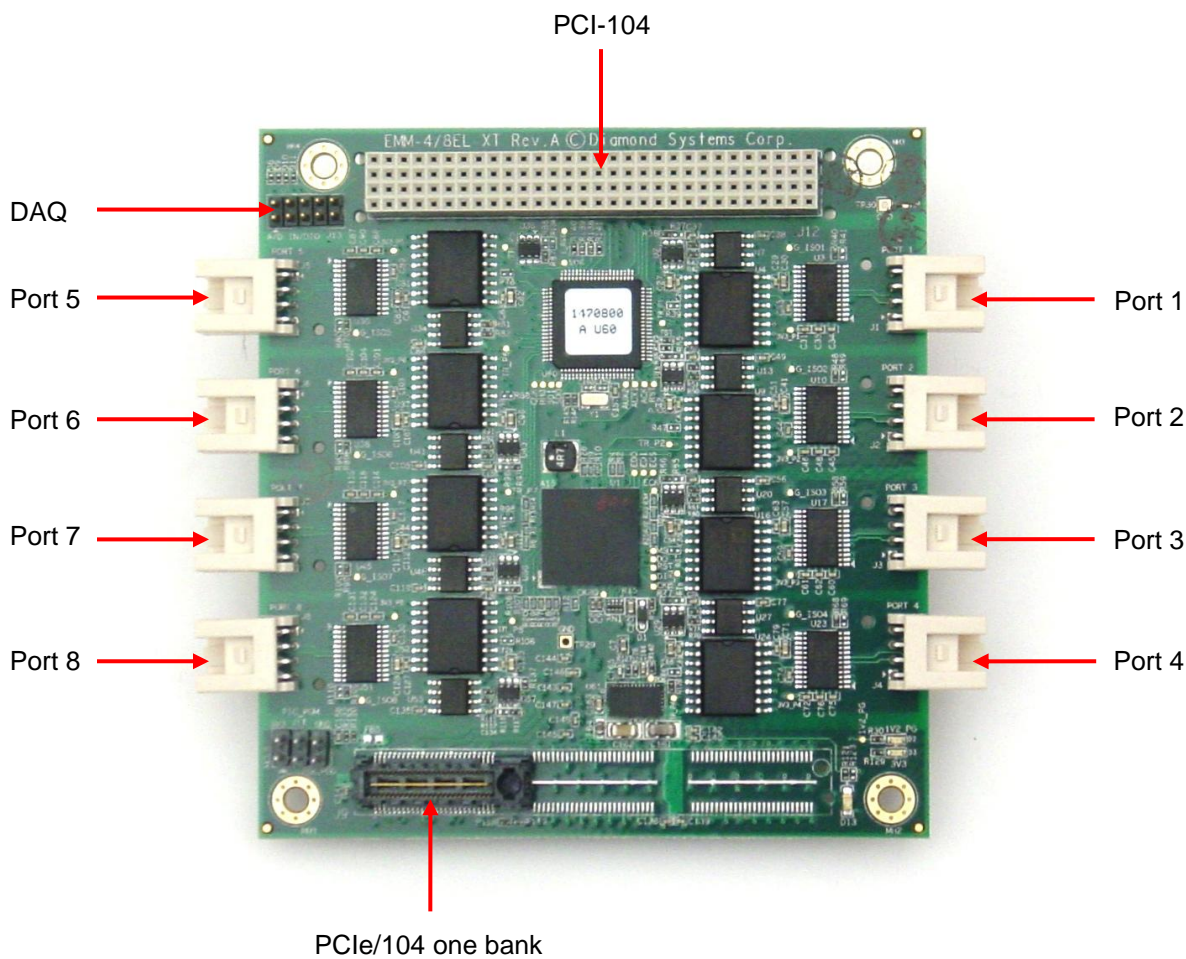
## 2.3 Functional Block Diagram

The Emerald-MM-8EL-XT block diagram is shown below.



## 2.4 Board Layout

The Emerald-MM-8EL-XT connector locations are shown below.



## 2.5 Connector Summary

The following tables list the Emerald-MM-8EL-XT board connectors.

<b>Connector</b>	<b>Description</b>
Port 1-8	Serial ports 1-8 connectors
DAQ	Data acquisition connector
PCI-104	PCI-104 bus connector
PCIe/104	PCIe one bank bus connector



### 3. CONNECTORS

This section describes the connectors on the Emerald-MM-8EL-XT module.

#### 3.1 Serial Ports 1-8 (Port 1-8)

The 4 or 8 serial ports are provided on miniature 10-pin headers with 1 port per header. Ports 1-4 are located on the right side of the board, and ports 5-8, if installed, are located on the left. The pin definition depends on the serial protocol selected. All ports have identical pinouts as shown below.

##### RS-232 Configuration:

NC	1	2	NC
TXD	3	4	RTS
RXD	5	6	CTS
NC	7	8	Iso Gnd

##### RS-422 Configuration:

NC	1	2	NC
TX-	3	4	TX+
RX+	5	6	RX-
NC	7	8	Iso Gnd

##### RS-485 Configuration:

NC	1	2	NC
Data -	3	4	Data +
NC	5	6	NC
NC	7	8	Iso Gnd

#### Connector Part Number / Description

JST S08B-PUDSS-1 2x4 2mm pitch through hole right angle locking pin header, standard

#### 3.2 Data Acquisition (DAQ)

Eight GPIO signals from the microcontroller are made available on a 10 pin header for auxiliary GPIO / A/D functions. All the A/D capable pins are grouped together at the top of the connector near the analog ground pin.

A Gnd	1	2	GPIO0 / A/D0
GPIO1 / A/D1	3	4	GPIO2 / A/D2
GPIO3 / A/D3	5	6	GPIO4 / A/D4
GPIO5 / A/D5	7	8	GPIO6 / A/D6
GPIO7	9	10	D Gnd

#### Connector Part Number / Description

2x5 2mm pitch through-hole connector with 4mm high posts and gold flash plating

### 3.3 PCI-104 Bus

The PCI-104 (PCI) bus connector is provided on the top side to enable the mounting of additional I/O boards. The PCI connector is non-stack through (top side only) and is located in the standard PCI-104 location. Its pinout is as defined in the *PC/104-Plus* specification available on [www.pc104.org](http://www.pc104.org). The  $V_{IO}$  pins are jumper-selected and are protected with a polyswitch resettable fuse.

### 3.4 PCIe/104 Bus

The PCIe/104 connector follows the PCIe/104-Express standard. This one bank connector is connector A with the following pin out.

USB-OC-	1	T A B	2	PCIe Reset-
+3.3V	3		4	+3.3V
USB 5+	5		6	USB 6+
USB 5-	7		8	USB 6-
Gnd	9		10	Gnd
PCIe 4 T+	11		12	PCIe 1 T+
PCIe 4 T-	13		14	PCIe 1 T-
Gnd	15		16	Gnd
	17		18	
	19		20	
Gnd	21		22	Gnd
PCIe 1 R+	23		24	PCIe 0 R+
PCIe 1 R-	25		26	PCIe 0 R-
Gnd	27		28	Gnd
	29		30	
	31		32	
Gnd	33		34	Gnd
PCIe 4 Clk+	35		36	PCIe 1 Clk+
PCIe 4 Clk-	37		38	PCIe 1 Clk-
+5V_SB	39		40	+5V_SB
	41		42	
	43		44	
Gnd	45		46	
SMB Data	47		48	
SMB Clk	49		50	
SMB Alert-	51		52	



---

## 4. KEY SUBSYSTEMS

### 4.1 UART

The UART is the Exar XR17V358/XR17V354 octal/quad UART with PCIe interface. These UARTs feature several advanced features:

- 256-byte TX/RX FIFOs for better reliability and lower system overhead during high-speed transmission
- Auto RS-485 transmit mode for compatibility with standard RS-232 drivers. This is accomplished by tying the EN485- pin on the XR17V358/354 to ground.
- High speed data rates: 1Mbps in RS-232, 10Mbps in RS-422 / RS-485

### 4.2 Serial Protocol Transceivers

The transceivers are SP336 with RS-232, RS-422, and RS-485 protocol capability. Each serial port uses its own transceiver for opto-isolation purposes. Each port's protocol is selected with 2 data lines from the onboard microcontroller.

### 4.3 Isolation

Isolation is provided via several methods:

- The serial port signals are isolated via an Analog Devices ADUM5402 power+signal device that provides power for the isolated transceivers plus isolation of the TX, RX, RTS, and CTS signals. These isolator devices exhibit significant inrush current on power-up, so they are powered up one by one with a programmable delay between devices to limit peak inrush current to just one device instead of 4 or 8. The power-on control is provided by an onboard microcontroller driving a FET that switches the +5V supply to the ADUM5402.
- The two protocol configuration control signals are isolated via a separate dual opto-isolator.
- The RS-485 121-ohm termination resistor is enabled via a photoMOS solid state relay with very low on resistance. The SSR is controlled with a data line from the onboard microcontroller.

Isolation of serial port signals and protocol select signals can be bypassed with the installation of 0-ohm resistors. The RS-485 termination isolator is required and cannot be eliminated.

### 4.4 Microcontroller

All configuration is done via an onboard microcontroller which interfaces to the host via a custom serial interface using the UART's GPIO lines. The microcontroller is configured using a series of registers that provide control over the various options. The microcontroller contains built-in flash memory which is used to store the configuration for automatic reload on power-up or reset. The microcontroller manages several configuration features:

- Serial port protocol: RS-232, RS-422, and RS-485, independently programmable port by port
- RS-485 121-ohm termination resistor enable / disable
- Turn-on timing of ADUM5402 isolated power devices
- Board configuration readback (number of ports and isolation / non-isolation)
- Programmable blue LED
- Heartbeat to indicate circuit alive
- Auxiliary data acquisition circuit on 10-pin I/O header with ESD protection

Application software is provided to communicate with the microcontroller and configure all features on the board.

## 4.5 Host Bus Interface

The Emerald-MM-8EL family interfaces to the host SBC via a single PCIe x1 link on bank 1 of the PCIe/104 connector, supporting both Type 1 and Type 2. The module implements the PCIe/104-Express one bank connector and the board layout supports the installation of the full-size 3-bank connector on the top and bottom sides.

The PCIe lanes on the first bank are shifted according to the requirements of PCIe/104, and a multiplexor selects lane 0 or lane 3 depending on whether the board is installed above or below the host SBC. All signals on banks 2 and 3 are passed straight through between bottom and top.

As a customization option, Emerald-MM-8EL supports the full PCIe/104 three bank form factor definition, both Type 1 and Type 2. Contact Diamond Systems for more information on this option. Minimum order quantities apply.

## 4.6 Power Supply

Power is obtained from the +5V tab on bank one of the PCIe/104 connector. The module generates all other required voltages from the +5V input.

# 5. CONSOLE CONFIGURATION

The Emerald-MM-8EL-XT comes with software to manage and store configurations using the on-board microcontroller. The PIC microcontroller is used to manage several functions on the board:

- ◆ Serial interface to host for configuration and control
- ◆ Controlled turn-on of isolated power supplies to limit inrush current
- ◆ Serial protocol selection of the SP336 multiprotocol transceivers
- ◆ 120 ohm line termination for RS-422/485 protocols
- ◆ Heartbeat to provide indication of device activity
- ◆ LED control
- ◆ Board configuration readback
- ◆ GPIO / A/D signals on 10-pin I/O connector

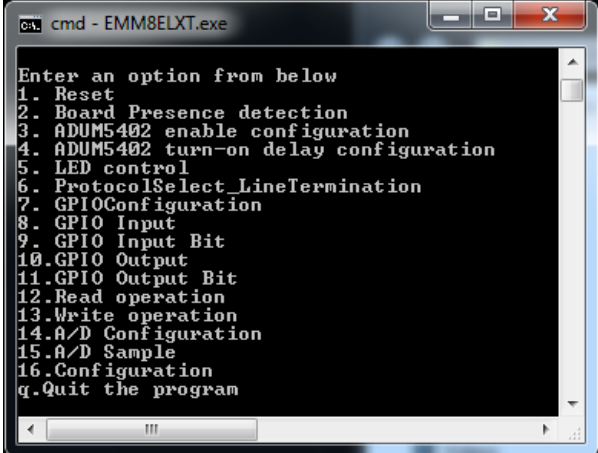
The microcontroller interfaces to the host via eight GPIO pins on the Exar XR17V358 PCIe UART. Refer to the XR17V358 datasheet for details on programming these registers. The registers must be configured for the correct direction at the start of the program.

The program provides a text-based user interface that can be ported to Windows and Linux. It provides a menu of options to configure and control the board. The program displays the menu and asks for a selection by number. After the selection is made, the program jumps to the code to execute that function. After execution is complete, the program returns to the main menu, and the sequence repeats.

## 5.1 Software Functions

A command line interface (CLI) software program provides a simple and direct method for configuring the Emerald-MM-8EL. The main screen of the CLI program is shown at the right.

Descriptions of the available CPI functions are provided below.



```

cmd - EMM8ELXT.exe

Enter an option from below
1. Reset
2. Board Presence detection
3. ADUM5402 enable configuration
4. ADUM5402 turn-on delay configuration
5. LED control
6. ProtocolSelect_LineTermination
7. GPIOConfiguration
8. GPIO Input
9. GPIO Input Bit
10. GPIO Output
11. GPIO Output Bit
12. Read operation
13. Write operation
14. A/D Configuration
15. A/D Sample
16. Configuration
q. Quit the program
  
```

### Reset

When this command is selected, the program will drive the reset pin on the UART interface high, and then bring it low. The PIC should undergo its reset sequence. The program waits for Ack to go low and reports an error if it fails to go low within a given time interval.

### Presence Detection

This feature confirms the PIC on the board is present and responding. When this command is selected, the program will do the following:

1. Check for Ack low.
2. Drive Sync high.
3. Check for Ack high.
4. Drive Sync low.
5. Check for Ack low.

If the sequence succeeds, the program reports board is present and responding, otherwise board is unresponsive.

### Configuration Readback

The program performs two steps:

1. It reads the configuration register and reports its value and interpretation.
  - 00 = 4 ports, no isolation
  - 01 = 4 ports, isolation
  - 10 = 8 ports, no isolation
  - 11 = 8 ports, isolation
2. The program reads the software revision at address 0x3F and reports its value.

### ADUM5402 Enable Configuration

The user enters enable/disable selections for each of the 8 ports and presses OK. The host transmits the selected configuration to the board's power enable register.

### ADUM5402 Turn-on Delay Configuration

The user enters values for the initial turn-on delay and the inter-port turn-on delay in milliseconds, and then presses OK. The host transmits the selected configuration to the board's turn-on delay and inter-port delay registers (a total of 2 transmissions).

---

### LED Control

The user selects On or Off and presses OK. The host transmits the selected configuration to the board's LED register.

### Protocol Select and Line Termination

The program sequences through all 8 ports one at a time, numbered 0-7. For each port, the user enters the desired protocol. If the protocol is RS-422 or RS-485, the program asks for line termination enable/disable and the user enters that option. Once all 8 port configurations are entered, the program transmits the configuration data to the board in succession (a total of 8 transmissions).

### GPIO Configuration

The user enters the direction configuration byte and direction byte. The program writes the two bytes to the board in the configuration register and direction register.

### GPIO Input

The program reads the 8 GPIO lines and returns their values. Only the bits which are set for digital input are valid.

### GPIO Output

The user enters the desired output value in Hex. The program writes the value to the output register. Only the bits which are set for digital input are valid.

### Read/Write RAM/Flash register

The user selects RAM or Flash, address in Hex, and data in Hex if a write operation. The program executes the given command. This command may be used to directly write to any valid RAM or Flash register. It therefore provides an alternative method to perform various functions above. It also provides a way to read/write unassigned registers.

### Configuration

Configuration settings include the serial port configuration and the serial port power-on settings. They do not include the PIC I/O configuration (A/D vs. GPIO and GPIO direction). These settings must be done individually with other program commands or by the user's application program. On power-up or reset, the PIC I/O is always set to GPIO and input direction by default.

Configuration is done by editing a configuration file in a text editor and giving it a unique name. This file may then be used to configure boards in a production environment. A board's configuration may also be read back and stored in a file to be used on other boards.

### Load configuration from file

The user enters a path and filename. The program loads the file and displays the configuration data with appropriate formatting. This data becomes the new current configuration in the program. If the file is not found an error message is returned. This is the only way to modify the program's "current configuration."

### Display current configuration

The current configuration is displayed with appropriate formatting.

### Store configuration to RAM

The program stores the current configuration to the RAM registers on the board. The current configuration must previously have been loaded from a file.

### Store configuration to board Flash

The program stores the current configuration to the Flash registers on the board. The current configuration must previously have been loaded from a file.

### Read RAM and Flash configuration from board

The program reads all RAM and Flash registers on the board and displays the two sets of configuration data with appropriate formatting (RAM / Flash, address in hex, data in hex). This is a readback operation only. The current configuration is not changed.

### Store RAM configuration to board Flash

The program stores the current RAM configuration settings to the Flash registers in the board. The current configuration is unaffected.

### Store RAM configuration to file

The user enters a path and filename. The program reads the current RAM configuration settings and saves them to the given file. If an error occurs an error message is returned. The current configuration is unaffected.

### Store Flash configuration to file

The user enters a path and filename. The program reads the current Flash configuration settings and saves them to the given file. If an error occurs an error message is returned. The current configuration is unaffected.

The recommended sequence of operations for configuring the board is:

1. Load configuration from file
2. Store configuration to Flash
3. Store configuration to RAM
4. Exit

## 5.2 Configuration File

The program uses configuration files (.ini files) to maintain configuration settings and configure boards. It has the capability to read and write new configuration files in order to save multiple configurations.

Configuration settings include the serial port configuration and the serial port power-on settings. They do not include the PIC I/O configuration (A/D vs. GPIO and GPIO direction). These settings must be done individually with other program commands or by the user's application program. On power-up or reset, the PIC I/O is always set to GPIO and input direction by default.

The configuration file format supports the use of comments to separate sections and explain data. A line beginning with / is a comment line and is ignored by the program. Blank lines are ignored by the program. Any text in a line preceded by a / is also a comment and is ignored by the program. Configuration files created by the program are not required to include any comments.

Configuration file contents are as follows (all comments are optional and are for illustration purposes only):

/ Serial port configuration data for registers 0-7 (both RAM and Flash)

Port0cfg=xx / Each value is in the range 0-7; bits 0-1 = protocol, bit 2 = line termination

Port1cfg=xx

Port2cfg=xx

Port3cfg=xx

Port4cfg=xx

Port5cfg=xx

Port6cfg=xx

Port7cfg=xx

/ Isopower configuration data for registers 38-3A (RAM and Flash)

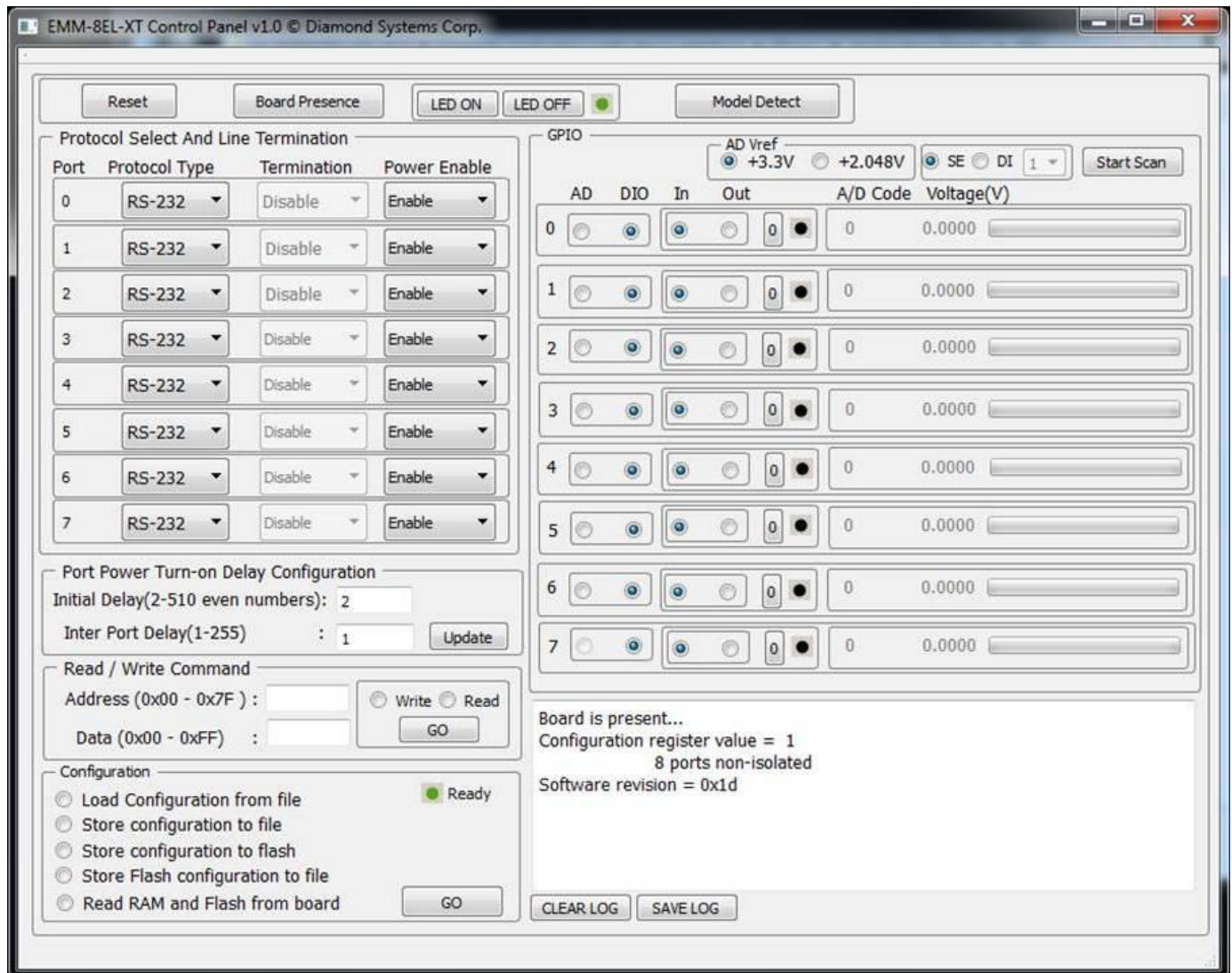
PowerOnDelay=xx / register 38

InterDeviceDelay=xx / register 39

PowerEnable=xx / register 3A

## 6. GUI CONSOLE CONFIGURATION

A web-based graphical configuration utility program is also provided that allows access to the functions of the software driver via an easy-to-use GUI. Please refer to section 5.1 for a description of the various features and fields.





## 7. SOFTWARE DRIVER

The software driver can be used to control or read back the features on the EMM-8EL-XT. Linux and Windows compiled libraries are provided to customers for use with these operating systems. The driver is also provided in C source code so it can be integrated into other operating systems.

### Driver Function List

EMM8EL_GetConfig()	Returns the board's complete configuration data from the controller's flash
EMM8EL_SetConfig()	Stores a complete configuration dataset into the on-board controller's flash and/or RAM
EMM8EL_SerialPortConfig()	Configures a serial port for protocol and termination
EMM8EL_SerialPortEnable()	Configures the serial ports for enable/disable
EMM8EL_SerialPowerConfig()	Configures the power-on timing of the serial port isolators
EMM8EL_IOConfig()	Configures the aux I/O for A/D or DIO; for DIO the direction is also defined
EMM8EL_ADConfig()	Configures the A/D reference voltage and differential channel
EMM8EL_ADConvert()	Performs an A/D conversion
EMM8EL_DIOInput()	Reads all DIO bits configured for input arranged in a byte
EMM8EL_DIOInputBit()	Reads one DIO bit configured for input
EMM8EL_DIOOutput()	Sets all DIO bits configured for output
EMM8EL_DIOOutputBit()	Sets one DIO bit configured for output
EMM8EL_LED()	Controls the user-controllable LED
EMM8EL_CreateConfigFile()	Creates a configuration file which can be used by the console or GUI program
EMM8EL_Write()	Writes a byte to the on-board controller's flash or RAM
EMM8EL_Read()	Reads a byte from the on-board controller's flash or RAM
EMM8EL_Reset()	Resets the on-board controller and causes a reload of all configuration settings
EMM8EL_Status()	Detects the status of the controller / verifies that it is listening, and returns the model configuration (CFG pins) and software revision number

All configuration or read back functions which have both RAM and flash registers are user selectable for either or both RAM or flash for configuration or for read back.

## 8. SPECIFICATIONS

Number of ports	4 or 8
Protocols	RS-232/422/485 software programmable
Maximum baud rate	RS-232: 1Mbps RS-422/485: 10Mbps
UART	16550 compatible octal UART 256-byte TX/RX FIFOs
Transceivers	SP330 multiprotocol transceivers, one per port
Termination	Programmable RS-422/485 termination
Isolation	Independent 2500VRMS isolation port by port
ESD	+/-15KV protection on each port
Onboard microcontroller	PIC with flash to manage and store configurations
Inrush current	Staggered turn-on of isolated devices for reduced power on current
Analog/digital I/O	8 programmable digital I/O lines 7 can be configured for 12-bit analog input lines Programmable analog input ranges: 0-2.048V or 0-3.3V
Host interface	PCIex1 host interface using PCIe/104 connector
Connectors	Latching connectors for increased ruggedness
Input power	+5VDC +/-5%
Power consumption	160mA typical at 5V with all outputs unloaded
Software drivers	Windows 7, XP, 2000, and Vista Linux versions 2.6.16 through 3.13
Operating temperature	-40°C to +85°C
Operating humidity	5% to 95% non-condensing
Shock	MIL-STD-202G compatible
Vibration	MIL-STD-202G compatible
MTBF	579,352 hours at 20°C
Dimensions	3.55" x 3.775" (90mm x 96mm) Conforms to PCIe/104 "OneBank" form factor supporting both Type 1 and Type 2
Weight	71g (2.5oz)
RoHS Compliant	Yes