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Model 923

Data Logger

User Manual

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Document Revision History

Document Revision	Details of Revision	Author(s)	Date [yyyy-mm-dd]
Rev 1	Initial release.	A. Cabrera	2015-08-10
Rev 2	-Updated title page, headers and footers -Change all references of 4 analog channels to 2 -Update GUI images -Update board images to Rev4.0 -Update Analog Inputs section for 2 channel description -Add Adjustable Analog Input display to special features -Updated Serial Output Mode in Modbus table to show only Modbus RTU is supported	R. Sawler	2017-04-24

Reference Documents

Document Number	Document Title and Description
923-2004-00	Model 923 Data Logger Configuration Drawing

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ACRONYMS AND ABBREVIATIONS

ADC	Analog to Digital Converter
CRC	Cyclic Redundancy Check
ECL	Emitter Coupled Logic (Vcc = 0V)
EIA	Electronic Industries Association
ESD	Electrostatic Discharge
ESR	Electrical Slip Ring
FORJ	Fiber Optic Rotary Joint
FPSO	Floating Production, Storage and Offloading
HUMS	Health and Usage Monitoring System
I/O	Input/output
IC	Integrated Circuit
kbps	Kilobits Per Second
LED	Light Emitting Diode
MB	Megabytes
Mbps	Megabits Per Second
NRZ	Non-Return to Zero (bit signaling format)
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
PECL	Positive Emitter Coupled Logic (Vcc = +5 V)
P/N	Part Number
RPM	Revolutions Per Minute
SMT	Surface Mount Technology
SPI	Serial Peripheral Interface
TDM	Time Division Multiplexer / Multiplexing
TTL	Transistor-Transistor Logic
UART	Universal Asynchronous Receiver/Transmitter
uC	Microcontroller

1.0 Introduction

The Model 923 electronic data logger (923-EDL) is a compact and rugged data logging card used for product health monitoring in marine, industrial, and other harsh environments. When installed as an option in Focal™ systems such as electrical slip rings (ESRs) and FPSOs, it provides real-time access to diagnostic information as well as data storage for offloading at a later time. Typically mounted at the end of a ring stack, the 923-EDL collects data from an array of on-board sensors and stores it in nonvolatile flash memory.

The 923-EDL on-board sensors are capable of measuring temperature, relative humidity, ambient light, shock, vibration and rotation. Logging the total number of slip ring rotations allows tracking of slip ring usage for better planning of maintenance intervals. The environmental data collected can be used to establish baseline operational parameters and trend monitoring can be used in a health and usage monitoring system (HUMS) to identify potential problems before they become major faults. In addition to the on-board sensors, the 923-EDL provides expansion connectors that can be used to interface with up to two (2) thermocouples and up to two (2) single-ended analog channels.

Users can access on-board diagnostic information in real time via an RS-485 serial link using the sample Focal™ graphical user interface (GUI) software (based on the Microsoft® .NET Framework), or by using custom software configured as a Modbus RTU master device (e.g. ModScan32). A top view of the Model 923-EDL card is shown below.

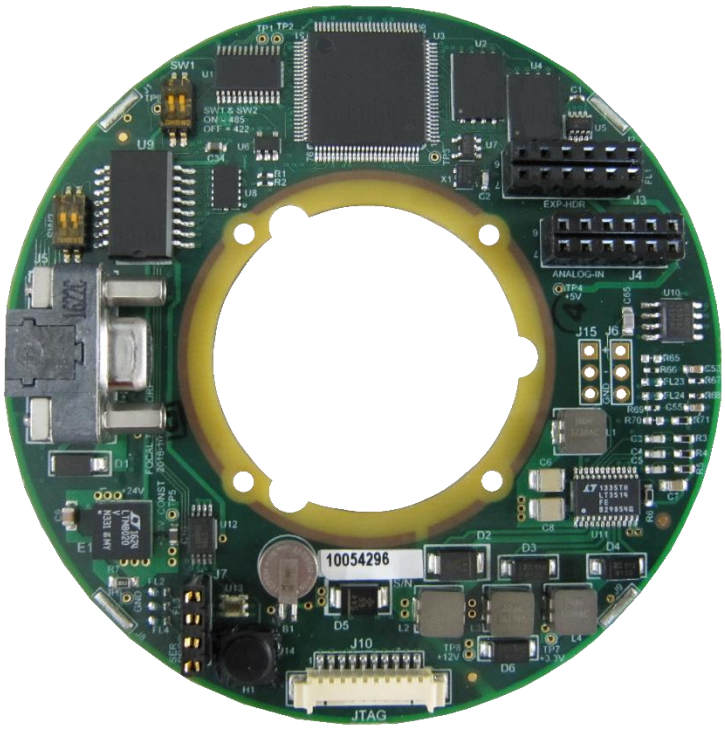


Figure 1-1: Model 923 Electronic Data Logger Card

This user's manual and the appropriate reference documents should be reviewed prior to installation or reconfiguration of the data logger system. Refer to system installation drawings and Model 923 configuration drawings for specific installation details.

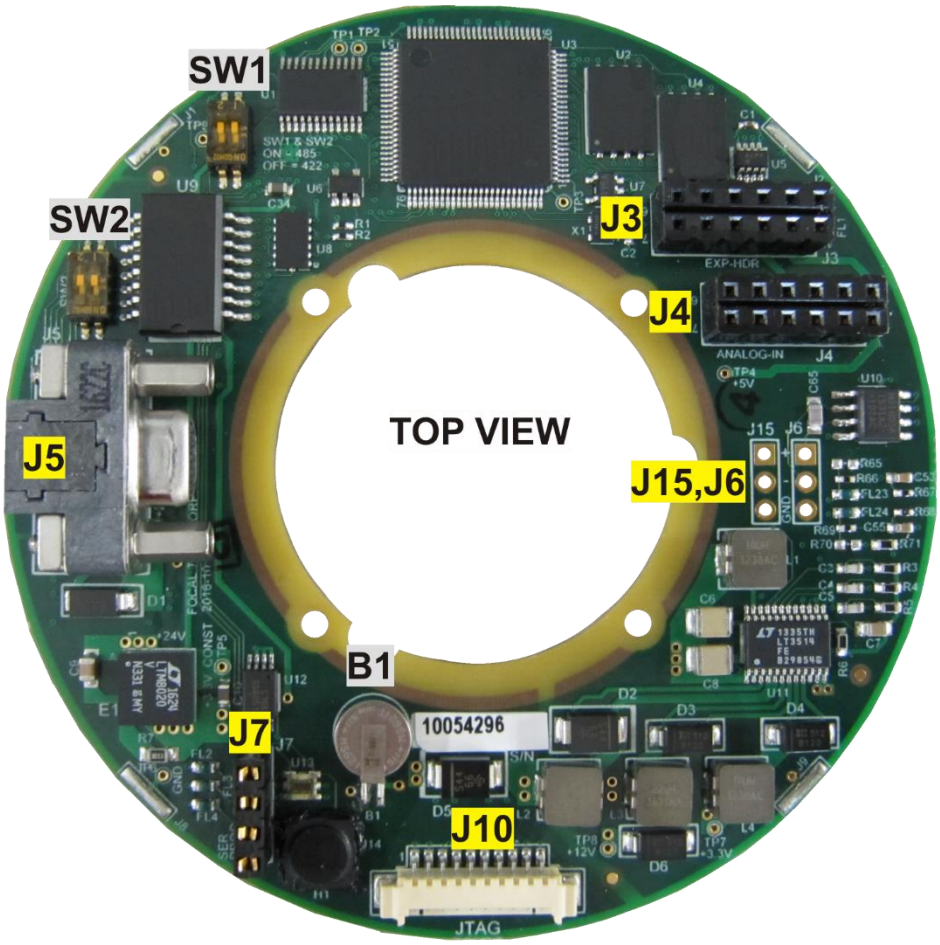
2.0 Specifications

Table 2-1: Specifications

ENVIRONMENTAL	VALUE	COMMENTS
Operating Temperature	-20°C to +70°C	
Storage Temperature	-40°C to +85°C	
Shock	30 g, 11 ms	Per ISO 13628-6 Q1 level
Vibration	5 g, 25 - 1000 Hz	Per ISO 13628-6 Q1 level
Humidity	5-95% RH	Non-condensing
MECHANICAL		
Dimensions	3.37” [86 mm] (NOM)	External diameter
Mounting	4 x #2 screw holes	Use with #2-56 standoffs
Weight	< 40 grams	
ELECTRICAL		
Input Voltage	+15 to +30 VDC	+24 VDC nominal Optional: +5 or +12 VDC (contact factory for details)
Current Draw	0.04 A (TYP)	With 24 VDC input
Power Dissipation	1.0 W (NOM), 2.0 W (MAX)	
Overvoltage Protection	36 VDC	
Reverse Polarity Protection	36 VDC	
Battery	3.3V lithium-Ion rechargeable	For real-time clock only
SENSORS		
Temperature Sensor	-40°C to +100°C	Accuracy +/- 1 °C
Humidity Sensor	5 - 95 % RH	
Light Sensor	λ = 300 to 1000 nm	Wavelength range
3-axis Accelerometer	+/- 200 g	
Rotation Sensor	Direction (CW, CCW), speed (rpm) and total revolutions	
Real Time Clock Accuracy	+/- 5 ppm	
Logging Flash Memory Size	32 MB	14 years logging at 60 min log interval
Thermocouple	-40°C to +100°C	K-type thermocouple
4 x Analog Input	0 to +3 VDC	10 bit, 200 Hz sampling
INTERFACES		
Diagnostic and control	2-wire RS-485 serial interface with ISO ground	115.2 Kbaud, Modbus RTU

3.0 Product Description

The 923-EDL card provides an array of on-board sensors and interfaces for external sensors. The card is typically installed at the factory inside Focal™ rotary products such as ESRs and FPSOs. With power applied to the 923-EDL, sensor data is logged automatically to on-board flash memory and simultaneously available in real time via an RS-485 serial link (J5) to a remote location. Key part locations are shown below.



REF.	DESCRIPTION (CONNECTORS)
J4	1 x 12-PIN CONN. FOR 2 x ANALOG INPUTS (SINGLE-ENDED)
J5	1 x 9-PIN MICRO-D CONNECTOR FOR POWER AND DIAGNOSTICS (RS-485)
J6, J15	2 x 3 PIN THERMOCOUPLE INTERFACES
J3, J7, J10	FACTORY USE ONLY

REF.	DESCRIPTION (OTHERS)
B1	3.3V LITHIUM-ION RECHARGEABLE BATTERY
SW1, SW2	FACTORY USE ONLY

Figure 3-1: Model 923-EDL Part Locations

3.1 Configuration Settings and Initial User Setup

The 923-EDL cards are configured at the factory and the user does not need perform any additional card configuration settings to start operating the card and obtain diagnostics data.

3.1.1 Configuration Settings

Table 3-1: Factory Default Card Configuration Settings (as-built)

Name	Parameter	Default Setting
Diagnostics Port (J5) (Hardware)		
Serial	Interface	RS-485
Termination	On-board 120 ohm Terminator Enabled / Disabled	120 ohm terminator enabled (installed)
On-Board Dip Switches SW1/2 (Hardware)		
SW1	Data port serial protocol	RS-485 (SW1[1:2] = ON, ON)
SW2	Data port serial protocol	RS-485 (SW2[1:2] = ON, ON)
Diagnostics (software)		
Modbus	Frame Format	RTU
	Node	1
	Baud Rate	115,200 Baud
	Supported Function Codes	Function Code 3: Read Holding Registers Function Code 6: Write Single Holding Register (other codes are not available)

User defined parameters via the diagnostics port:

- Log interval (1 – 120 minutes)
- Node ID (1 - 255)

3.1.2 Initial User Setup

The only initial user setup requirement to start logging sensor data is to power up the 923-EDL card with +24 VDC (nominal). In order to access real-time sensor data the user can connect to the card via the RS-485 port using the sample Focal™ GUI as shown in the figure below or a 3rd party Modbus RTU software configured as a master.

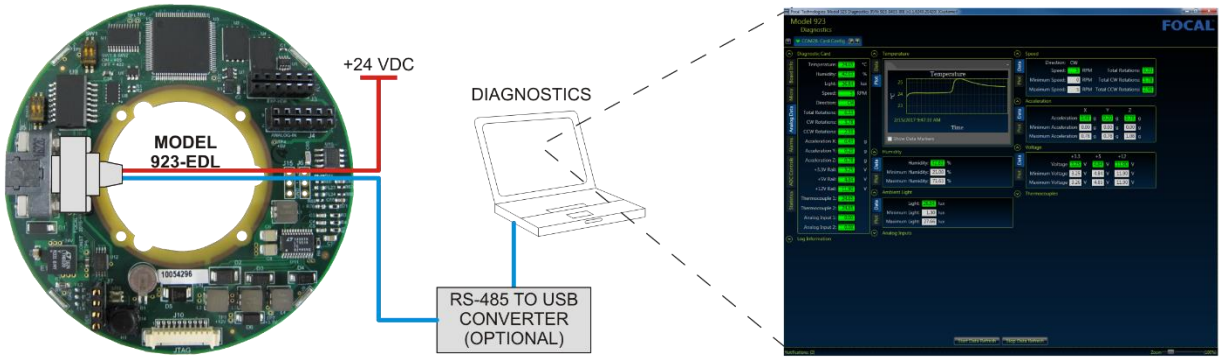


Figure 3-2: Model 923-EDL Typical Setup Connection Using a PC and Focal GUI

3.2 Data Logging

The 923-EDL uses a proprietary logging algorithm that enables the card to compute the maximum, minimum and average measurement of all the sensor parameters within the specified log interval. This allows the user to select longer log intervals without losing sight of critical events within the specified log interval. The data logging interval can be set between 1 to 120 minutes and it can be changed by the user by using Focal's GUI software through the data port J5.

The data obtained from the sensors is stored in the card's on-board 32 MB flash memory. This memory size allows up to 14 years' worth data to be stored when the log interval is set to 60 minutes.

3.3 Real Time Clock (RTC)

The 923-EDL has an on-board a real time clock (RTC) with an accuracy of ±5 ppm. An on-board, 3.3V rechargeable lithium-ion battery (B1) maintains the correct time even when the card is not powered for a period of up to four months. This real time clock is used as the time stamp when logging the sensor data into on-board flash memory. The time stamp will be reset to factory default if the battery has been drained – any data logged to the flash memory with a dead battery will be accurate, but the time stamp will start at 01/01/2000 00:00:00 (dd/mm/yyyy hh:mm:ss).

The on-board battery is recharged while the board is powered on. Note that the battery is intended solely to keep the RTC running, not to operate the entire data logger. Normally the RTC is operation even when there is no power applied to the card.

Note: The RTC is normally synchronized with a PC's clock. The factory clock used to synchronize the RTC has a time zone of UTC-04:00 (Atlantic Time Canada) and when connecting to the card using the sample GUI, the user will be prompted with the option to re-sync the RTC with the local PC or keep the factory default values. **It is recommended to re-synchronize the RTC at the time of final system installation.**

3.4 On-Board Sensors

The specifications for the on-board sensors of the Model 923-EDL card are given in section 2.0 of this document.

The 923-EDL obtains a new sample from the on-board sensors every 5 ms. Note that the accuracy of the temperature and humidity is for the sensors themselves and corresponds to the immediate vicinity of the sensors, which may deviate from the ambient air conditions inside the rotary product.

The card starts logging data at a user-defined log interval (1 to 120 minutes) as soon as it gets powered. After power-up the card calculates the maximum, minimum and average values read from all the sensors during the specified log interval and then saves this data to the on-board flash memory with a time stamp from the on-board real-time clock (RTC).

The real-time sensor data and the sensor data saved in flash can be accessed (downloaded) from the diagnostics port (J5) using the sample GUI (P/N: 923-0403-00) or using custom software configured as Modbus RTU master. The real-time raw data (non-formatted) of the on-board sensors is stored in Modbus registers.

Refer to section 7.0 of this document for details on how to convert Modbus sensor raw data into analog values for all the on-board sensors.

3.4.1 Temperature and Humidity Sensor

The card uses a capacitive type humidity sensor with integrated temperature sensor. A protective cap is placed over the sensor.

Do not expose the sensor to solvents or other corrosive liquids.

3.4.2 3-Axis Accelerometer Sensor (Shock and Vibration)

The 3-axis accelerometer provides measurements up to ±200 g. This sensor measures both dynamic acceleration resulting from motion or shock and static acceleration, such as gravity. Shock and vibration data obtained from this sensor are saved in the on-board flash memory and also into Modbus registers. The X, Y and Z direction raw values are stored as 16-bit values. The shock events are logged into the flash memory as 32 data points per axis (10 data points before the event and 22 data points after the event).

3.4.3 Ambient Light Sensor

The light sensor used is capable of operating in the infrared and visible light spectrum. Illuminance (ambient light level) in lux is derived using an empirical formula to approximate the human-eye response.

The illuminance measured is stored as a 16-bit raw value in Modbus registers for real-time diagnostics and it is stored as formatted data (lux) in the on-board flash.

Refer to the Modbus register map section of this document for details on the formulas to obtain the lux values.

3.4.4 Rotation Sensor (Turns Counter and Speed)

The on-board rotation sensor is used to measure the direction (CW and CCW), speed (rpm) and total revolutions. This sensor requires custom hardware and is currently intended to be used with Focal rotary products. Contact the factory for more details.

3.5 Interfaces

3.5.1 Thermocouple Inputs

The 923-EDL allows two (2) K-type thermocouples to be connected to 3 pin connectors J6 and J15. The card performs cold-junction compensation and the data output of each thermocouple is saved as an IEEE-754 32-bit floating point value in Modbus registers and also saved in the on-board flash memory.

3.5.2 Analog Inputs

The 923-EDL provides access to two (2) single-ended analog inputs via the 12-pin connector J4. The default input voltage range is dependent on a factory configurable resistor divider for each channel. The default configuration yields a maximum input on channel 1 of 14.76V. The maximum input on channel 2 is 4.95V.

Applying higher voltages to the analog channels could damage the analog input circuits.

The resolution of the ADC is 10-bit and the data is sampled at 200 Hz. Each ADC channel is calibrated at the factory using a scale factor (saved as an IEEE-754 32-bit floating point). The data output of each ADC and the scaler is stored in Modbus registers and in the on-board flash memory.

4.0 Hardware

The Model 923-EDL card has a 923-0203-00 PCB assembly (PCBA). The PCBA has an external diameter of 3.37” [8.55 cm] (nom) and an internal diameter of 1.43” [3.63 cm] (nom). The card assembly is typically installed on Focal™ rotary products such as electrical slip rings (ESRs) and FPSOs.

This PCBA is designed for interfacing with a 9-pin Micro-D connector, which is used to provide power to the card and access real-time and stored diagnostics information.

Top and side views of the Model 923-EDL PCBA are shown in the figure below. For more details, refer to configuration drawing 923-2004-00.

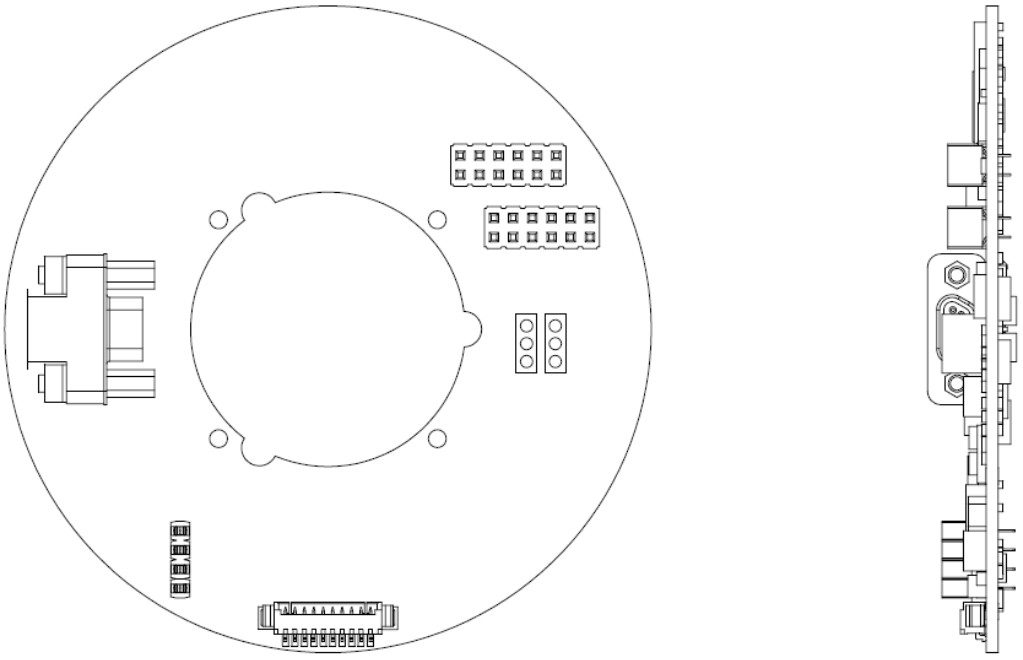


Figure 4-1: Model 923-EDL PCBA

4.1 General Board Handling

The PCBA does not require forced air convective cooling. Generally heat from the card is conducted through the mounting hardware.

Care must always be taken during the handling of PCBAs to ensure product integrity. The following guidelines should be adhered to in working with PCBAs:

- Always handle boards by the edges and do not touch any connectors or gold tabs.
- Handle boards at an ESD safe workstation with a clean surface.
- Never stack PCB assemblies on top of one another.
- Do not flex boards during handling or when mounted. The mounting surface needs to be flat and even such that the board is not flexed when bolted down.
- Do not cause unnecessary shock and vibration, such as dropping or rough handling of the boards.
- **Do not expose light, temperature and humidity sensors to solvents or other corrosive liquids**.

5.0 Electrical Connectors and Pin Descriptions

The 923-EDL card has three (3) connectors for customer access and a few others for factory programming and testing. A 9-pin Micro-D connector (J5) on the top side of the card provides access to the diagnostics data and is also used to power-up the board. Two three pin connectors (J6, J15) provide access to two thermocouple inputs, and a 12-pin receptacle (J4) provides access to two analog inputs.

Table 5-1: Connector/Mating Connector Part Numbers

Ref	Description	Manufacturer	Manufacturer Part Number	Mating Manufacturer Part Number
J5	9-Pin Micro-D	Molex	0836119006	ITT Cannon, MDM-9SSB, Micro-D,9-Pin, female
J4	12-Pin Rcpt. 0.100”	Samtec	CES-106-01-S-D	TSW-106-07-T-D

5.1 9-pin Micro-D Power and Data Connector (J5)

Pin locations and functions are shown below for the 9-pin Micro-D connector.

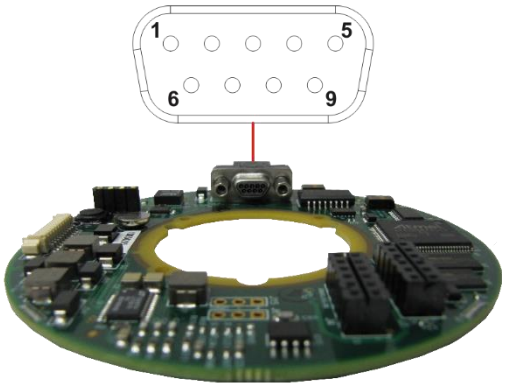


Figure 5-1: Micro-D (9-pin) Power & Data Connector (J5)

Table 5-2: Micro-D (9-pin) Connector (J5) Pin out

Pin	Function
1	RS-485+
2	RS-485-
3	ISO GND (for RS-485)
4	RESERVED
5	RESERVED
6	POWER
7	GND
8	RESERVED
9	RESERVED

5.2 Thermocouple Input Connectors (J6, J15)

The connectors used for thermocouple connections are shown below. The 3 holes have 0.100” spacing and the pinout described below. Thermocouple input 1 is connected to J6 and Thermocouple input 2 is connected to J15.

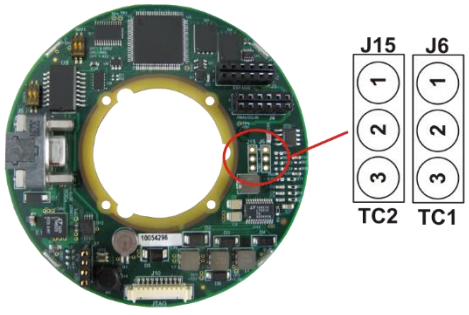


Figure 5-2: Thermocouple Input Connectors (J6, J15)

Table 5-3: Thermocouple Input (3-pin) Connector (J6, J15) Pinout

Pin	Function
1	Thermocouple T+
2	Thermocouple T-
3	Ground

Note: For K-type thermocouples
T+ is the yellow wire
T- is the red wire

5.3 12-Pin Analog Input Connector (J4)

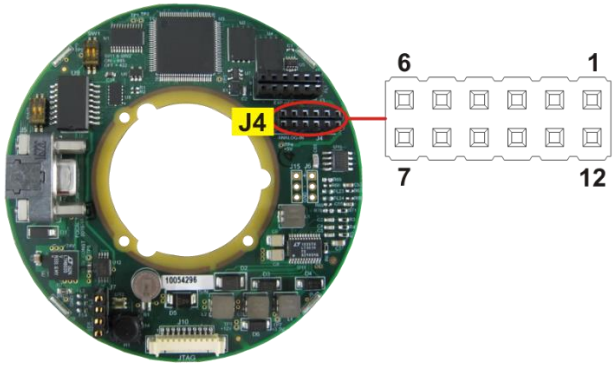


Figure 5-3: 12-pin Analog Input Connector (J4)

Table 5-4: Analog Input (12-pin) Connector (J4) Pin out

Pin	Function
1	OPEN (**DEFAULT**) OPTIONAL: +12VOUT OR +5VOUT (WITH HW MODS)
2	ANALOG INPUT CH1
3	GND
4	OPEN OPTIONAL: +12VOUT OR +5VOUT (WITH HW MODS) (**DEFAULT +5V**)
5	ANALOG INPUT CH2
6	GND
7	GND
8	RESERVED
9	OPEN (**DEFAULT**) OPTIONAL: +12VOUT OR +5VOUT (WITH HW MODS)
10	GND
11	RESERVED
12	OPEN (**DEFAULT**) OPTIONAL: +12VOUT OR +5VOUT (WITH HW MODS)

6.0 Functionality

The main function of the Model 923-EDL card is to collect data from several on-board sensors and external interfaces and store it in the on-board non-volatile flash memory. The data collected can then be used for further analysis and evaluation of the environment in which the card is installed. The data stored in flash memory is saved as analog values and further processing is not required to convert raw sensor data into analog values, as this task is performed by the on-board microcontroller.

The Model 923 also supports in-field programming via the J5 port, which can be used for future firmware upgrades.

6.1 Serial Diagnostic Interface

Remotely accessible, real-time diagnostic data and status information is available from the 923-EDL via the port J5. This information can be used to determine current health and to analyze long-term trending of critical parameters of the system being monitored (e.g. to estimate the remaining life of a Focal rotary product).

Diagnostic and status information is retrieved from the following:

1. Temperature, humidity, accelerometer, ambient light and rotation sensors (details of these sensors are provided in section 3.4).
2. A bank of analog to digital converters (ADCs), which monitor board voltage rails.
3. Board information which includes serial number (S/N), data code, assembly number, firmware version, cause of reset and I2C error count.
4. On-board Flash memory information such as memory usage and current write pointer location.

The serial RS-485 interface (connector J5) of the 923-EDL operates in Modbus RTU mode.

6.1.1 Modbus RTU

The user can communicate with the 923-EDL using the Modbus RTU protocol over the serial RS-485 interface (J5). The default (as-built) settings are shown in the table below.

Table 6-1: Modbus RTU Frame Format and 923-EDL Defaults

Name	Length (bits)	Function	Default Settings (923-EDL as-built)
Start	28	At least 3.5 character times of silence (mark condition)	28 bits min.
Address	8	Station (node) address	Node 1
Function	8	Indicates the function code	Function Code 3: Read Holding Registers Function Code 6: Write Single Holding Register (other codes are not available)
Data	n * 8	Data + length will be filled depending on the message type	All Modbus registers are 16-bit values
CRC	16	Cyclic Redundancy Check	CRC-16-ANSI (a.k.a. CRC-16-IBM)
End	28	At least 3.5 character times of silence between frames	28 bits min.

Note: The default node address can be changed using the sample GUI.

6.2 Diagnostics Software

6.2.1 Overview

Focal-Moog has created a sample .NET graphical user interface (GUI) to work with the 923-EDL in Modbus RTU mode. The 923-GUI (P/N: 923-0403-00) uses a serial connection to retrieve data from the 923-EDL using the Modbus RTU protocol. The GUI presents all data readings on a single window, as shown in the figure below. Live graphs of temperature, humidity, ambient light, rotational speed, etc., are provided as well as live readings from all sensors. Additional board identification information, such as card serial number, date code, etc., is also included.

Note: The GUI screenshots shown in this document might be updated from time-to-time to reflect new features or information added to the software. Contact the factory to obtain the latest version of the GUI.

Figure 6-1: 923-GUI

6.2.2 Installation

System Requirements

- PC with Intel Pentium or AMD processor
- 256 MB of RAM
- 20 MB of available hard disk space for the application and documentation.
- Supported Operating Systems: Windows 7 (64-bit)
- .NET Framework (minimum version 4.0)
- CD-ROM or DVD drive or USB port (to download the GUI)
- PC with an available RS-485 serial COM port. Note: A USB-to-RS-485 converter might be used.

Installation Procedure

1. Copy the contents of the GUI folder to a local folder in your PC.
2. For example: C:\Focal\Model923\GUI\Release
3. Open the "Release" folder.
4. Double click on the executable *.exe file to run the Model 923 Diagnostic Software.

6.2.3 Application Usage

In order to establish a successful diagnostics connection with the 923-EDL, the card must be powered on (typically with +24V at connector J5) and the physical data communication link must be valid (also via the J5 connector). The connection between the PC and the card's J5 port is via an RS-485 serial link. If the PC does not have an RS-485 port, then an external converter can be used (e.g. a USB-to-RS-485 converter). The list of available serial ports and their descriptions can be found by opening the PC's device manager (e.g. WIN+R (run) → devmgmt.msc).

6.2.3.1 Connection Manager

The communication parameters for each card must be configured using the Connection Manager. To remove a card configuration from the list, click the "X" button on the right of the card name. The Pen symbol can be clicked to edit the existing card configuration.

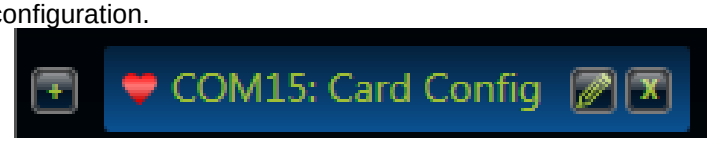


Figure 6-2: Connection Manager

6.2.3.2 Add a New Data Logger Configuration

To add a new card configuration to the list:
1. Click the button at the far left of the Connection Manager.
2. Enter a Description, Serial Port, Modbus Node and Refresh Interval for the new card, as depicted in the figure below.
3. Click “Save Configuration”.

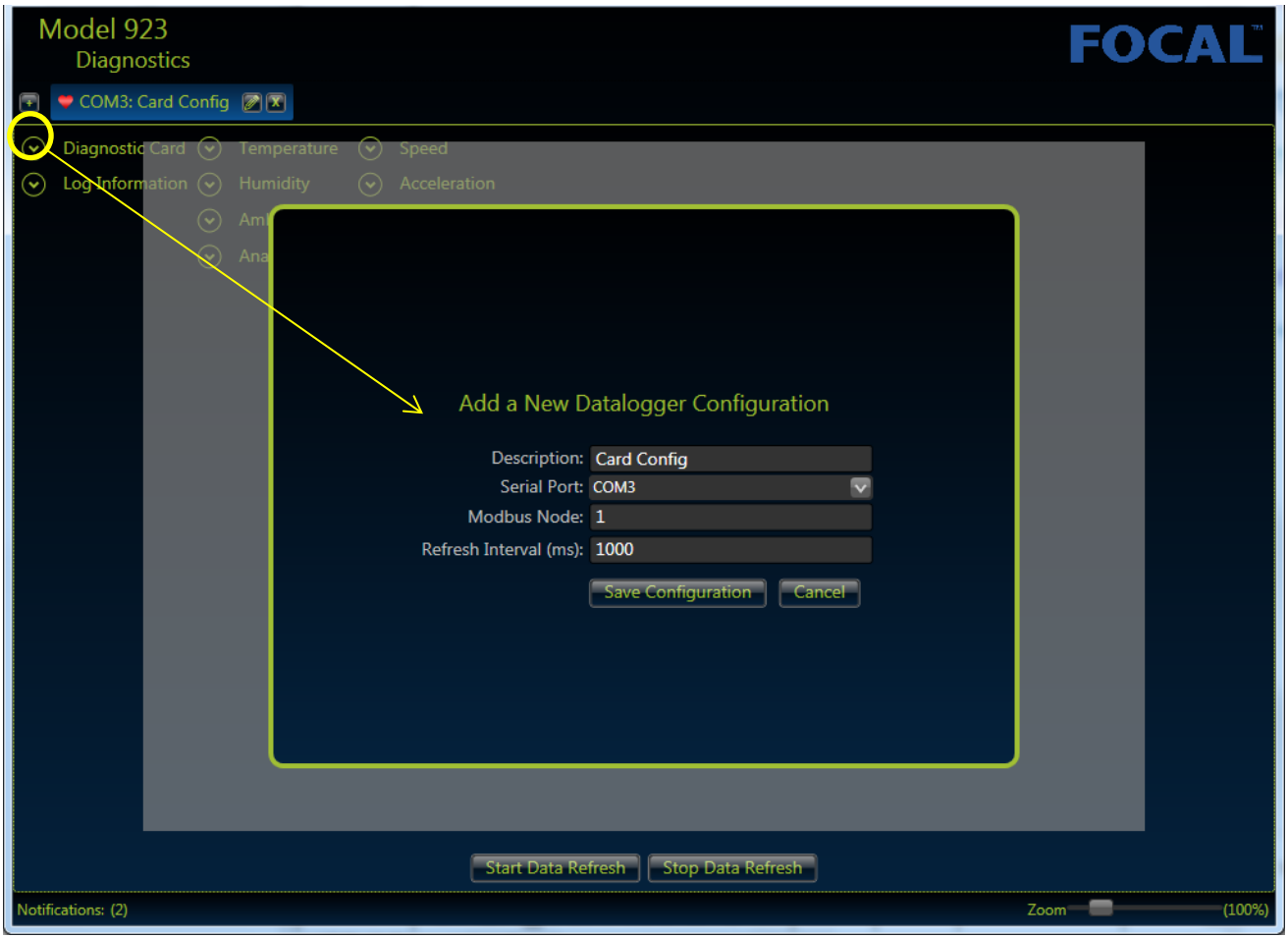


Figure 6-3: Add a New Data Logger Configuration

Notes:
1. It is recommended to set the “refresh interval” to >= 1000 ms.
2. The default node is 1.

6.2.3.3 Connect and Disconnect Diagnostic Communications

Click Start Data Refresh to begin retrieving data from the card.

Click Stop Data Refresh to disconnect from the card.

Note:
If on start up a configuration tab is already open, the configuration shown corresponds to the last configuration used. This configuration may not apply for the current system. This could result in connection failures to the 923-EDL. It is recommended that on start-up, any existing and unknown configuration tabs are closed and new configurations are added or ensure the same configuration is always used.

6.2.4 Special Features

6.2.4.1 Log Download

The GUI gives the user the ability to offload all the data on the 923-EDL into a .csv file. The time taken for the data offload is dependent on the amount of flash memory used on the 923-EDL. An estimated time for offload is given for user convenience. A valid serial connection with the 923-EDL is required for this feature. Controls for this feature can be seen in the image below.

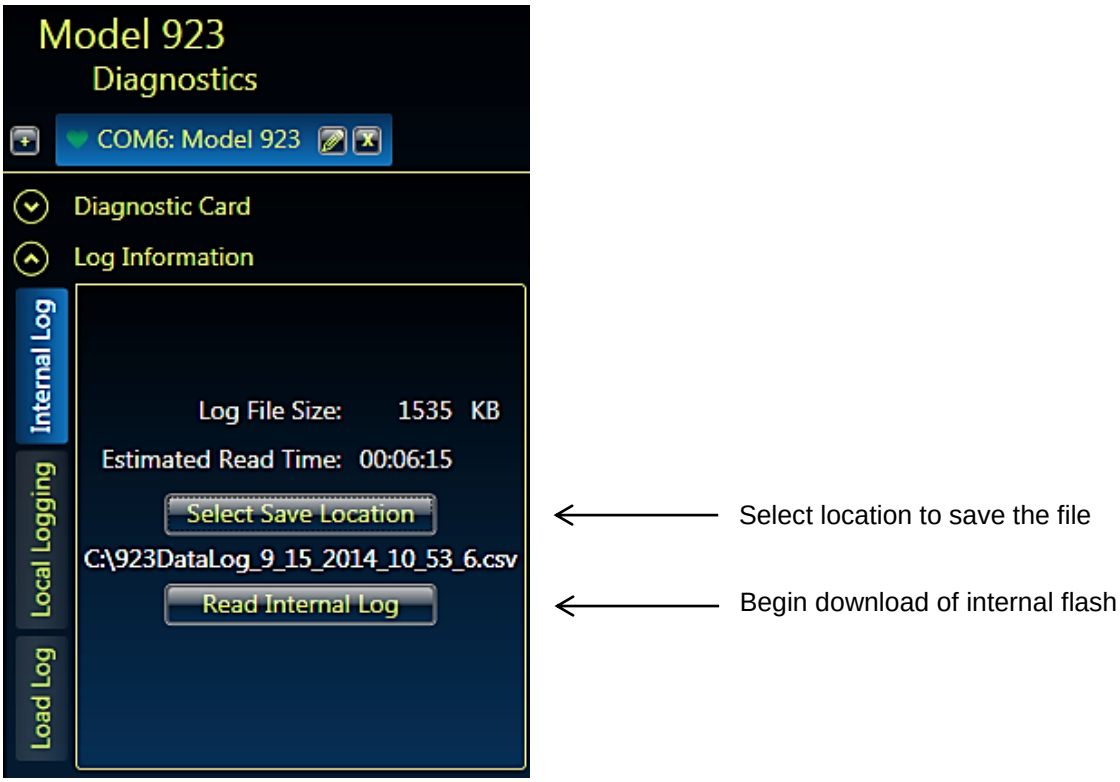


Figure 6-4: 923-GUI – Reading the Data from Flash (Internal Log)

6.2.4.1.1 Data Log File – Flash Memory Contents Example

File Name: 923DataLog_7_28_2015_11_48_27.csv

Static Data:

28/07/2015 - 11:48:39

Focal Technologies Model 923

Cause of Last Reset : Power-up

Serial Number : 10052055
Date Code : 2015-07-14
Assembly Number : 923-0203-00
FW Version : A0
DataLog Interval : 1 min
Baud Rate : 115200
Number of Magnets in the Rotary Encoder : 36
MODBUS Node ID : 1
Accelerometer Range : +\-200(g)
+3.3V Supply : 3.236 V
+12V Supply : 14.572 V
Memory Usage : 4.521%
Output Format : MODBUS RTU
Total Rotations : 4.417
Total CW Rotations : 2.444
Total CCW Rotations : 1.972
Total Bytes : 1517312
Read Time : 321.4(sec)

Sensor Data:

Header	Data
Date	23/07/2015
Time	09:05:07
3.3v Rail Max(V)	3.279
3.3v Rail Min(V)	3.261
3.3v Rail Avg(V)	3.272
5.0v Rail Max(V)	4.868
5.0v Rail Min(V)	4.85
5.0v Rail Avg(V)	4.861
12.0v Rail Max(V)	11.894
12.0v Rail Min(V)	11.877
12.0v Rail Avg(V)	11.881
Thermocouple 1 Max(degC)	28
Thermocouple 1 Min(degC)	27.75
Thermocouple 1 Avg(DegC)	27.922
Thermocouple 2 Max(degC)	30.031
Thermocouple 2 Min(degC)	29.812
Thermocouple 2 Avg(DegC)	30.505
Temperature Max(degC)	27.19
Temperature Min(degC)	27.126
Temperature Avg(DegC)	27.168
Humidity Max(%)	46.031
Humidity Min(%)	45.596
Humidity Avg(%)	45.685

Header	Data
ADC0 Max	1.6395
ADC0 Min	1.6335
ADC0 Avg	1.6365
ADC1 Max	1.6395
ADC1 Min	1.6335
ADC1 Avg	1.6365
ADC2 Max	1.6395
ADC2 Min	1.6335
ADC2 Avg	1.6365
ADC3 Max	1.6395
ADC3 Min	1.6335
ADC3 Avg	1.6365
Speed Max(rpm)	10
Speed Min(rpm)	0
Speed Avg(rpm)	1
Total Rotations	4.194

Header	Data
Acclerometer X Max(g)	1.078
Acclerometer X Min(g)	-0.196
Acclerometer X Avg(g)	0.637
Acclerometer Y Max(g)	0.392
Acclerometer Y Min(g)	-1.078
Acclerometer Y Avg(g)	0.049
Acclerometer Z Max(g)	2.254
Acclerometer Z Min(g)	0.588
Acclerometer Z Avg(g)	1.715
Ambient Light Max(lux)	9.124
Ambient Light Min(lux)	9.091
Ambient Light Avg(lux)	9.124
Card Status	NORMAL

Note: The data shown above is the transposed version of the actual *.csv log file. The .csv file is formatted as follows:

Date	Time	…	Card Status
DD/MM/YYYY	hh:mm:ss	…	<status>
DD/MM/YYYY	hh:mm:ss	…	<status>
:	:	:	:

6.2.4.2 Local Logging to PC

Local logging allows the user to save the data displayed by the GUI software to a .csv file in the local PC. Local logging is stopped when the GUI is closed.

6.2.4.3 Log Read-back

The GUI also has the ability to load a saved .csv file into the presentation fields. The fields populated with data include temperature, humidity, light, speed, acceleration and voltage. This will allow the user to analyze past data for trends by viewing the loaded data in the graph windows. Additionally, the GUI will display the maximum and minimum sensor values which were recorded in the loaded data, allowing the user to see if any spikes or dips occurred while logging. This is not a real time play-back feature. All data will be loaded in one instance for viewing. A valid serial connection with the 923-EDL is not required to use this feature. Controls for this feature can be seen in the image below.

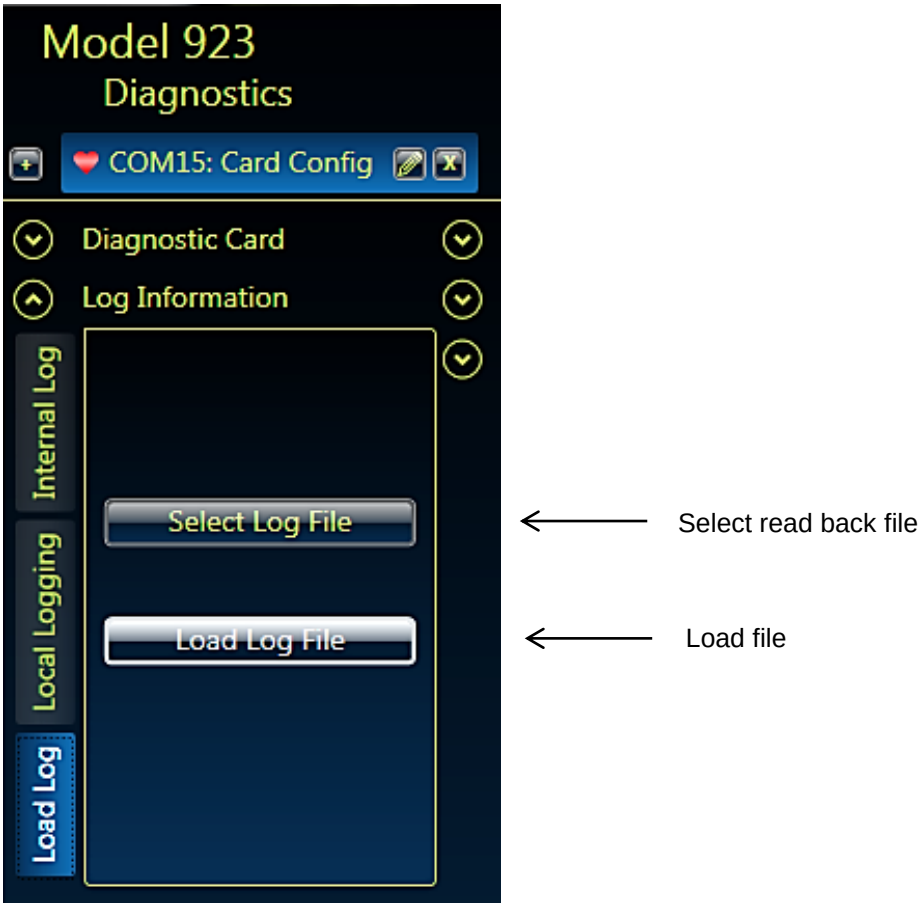


Figure 6-5: 923-GUI – File Read-back Function (Load Log)

6.2.4.4 Alarm Configurations

The GUI includes alarm levels for measured values. These alarm levels are configurable by the user in the alarms window shown in the figure below. Unsaved values are highlighted and current alarm levels can be restored at any point. The GUI provides the user the ability to change alarms, save alarm configurations as a .csv file, and upload previously saved alarm configuration files.

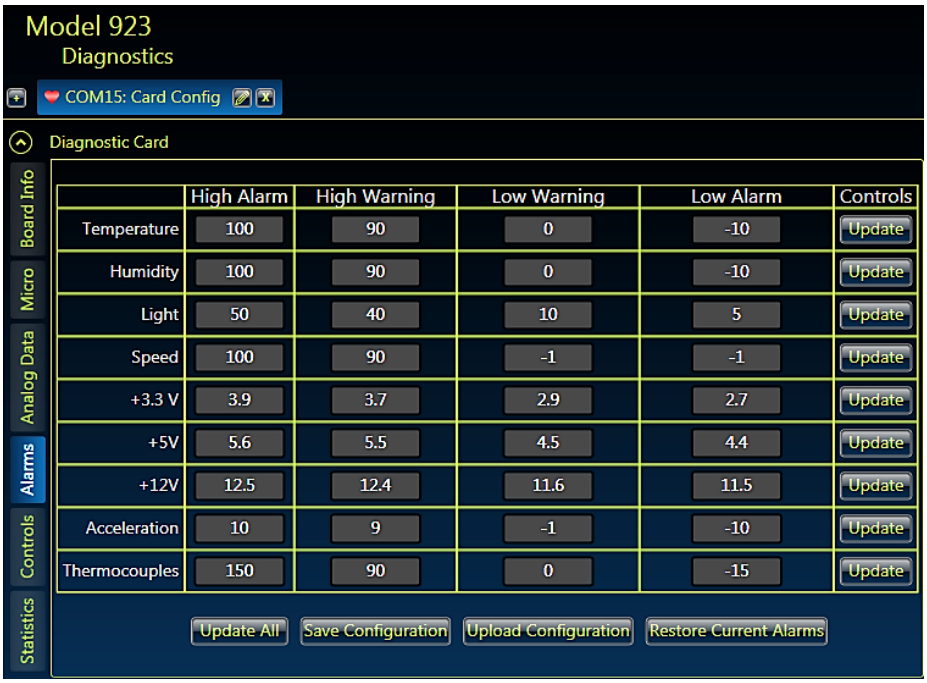


Figure 6-6: 923-GUI – Alarm Configuration

The default alarm levels used on GUI start-up are saved in a configuration file stored in the same directory as the run file. The file containing the alarm levels can be edited in a text editor or Excel so that the same alarm levels are loaded on each startup. The configuration file must be saved in .csv format.

> Alarm settings are saved in the local computer and are only applicable to the GUI – not the 923-EDL card. Any changes to the alarm values will only be reflected in the GUI, the 923 card will continue to operate normally regardless of the software alarm settings.

6.2.4.5 Time Synchronization

The 923-GUI allows the user to synchronize the 923-EDL real time clock (RTC) with the user's computer time. If time synchronization is enabled and a time discrepancy of greater than or equal to one (1) minute is measured, a prompt will be raised to ask the user if the 923-EDL RTC should be synchronized with the local computer (see figure below). By pressing "synchronize", the 923-EDL RTC will be synchronized with the PC clock and by pressing "Cancel" the time synchronization feature will be disabled. This window will timeout in 10 seconds and assume time synchronization is not desired.

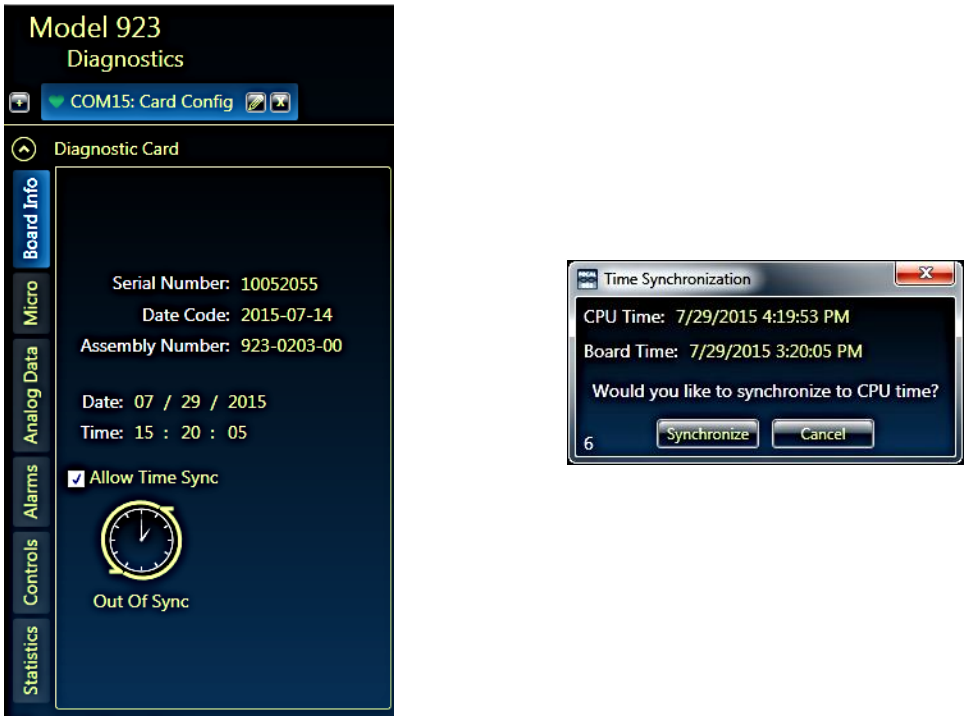


Figure 6-7: 923-GUI – Time Synchronization of 923-EDL RTC's with PC

6.2.4.6 Adjustable Analog Input Display

The 923-GUI allows the user to setup a customizable view for each of the measured analog inputs. This customizable view will allow the user to display specific units and alarms for each channel as well as applying an equation to the measured voltage to convert or scale the reading to different units. For example, if a user had a temperature sensor connected to analog input 1 where the measured temperature was calculated using the equation below, the equation can be entered into the GUI and the temperature will be displayed in the "Adjusted" tab of the Analog Inputs expander.

$$T = (Vo * 3) + 32$$

The equation and units for each channel are edited in the ADC Controls tab of the Diagnostic Card expander. In this tab the user can also set alarm and warning levels for the adjusted value. The alarm levels, units and equation are saved for each channel in an .xml file in the GUI release folder named ADCEquations.xml. The values are loaded from the .xml file each time the GUI is opened. This feature is exclusively a software feature meaning the data logged to the 923-EDL will still be saved as raw analog counts. Examples of the adjusted ADC values can be seen in the images below.

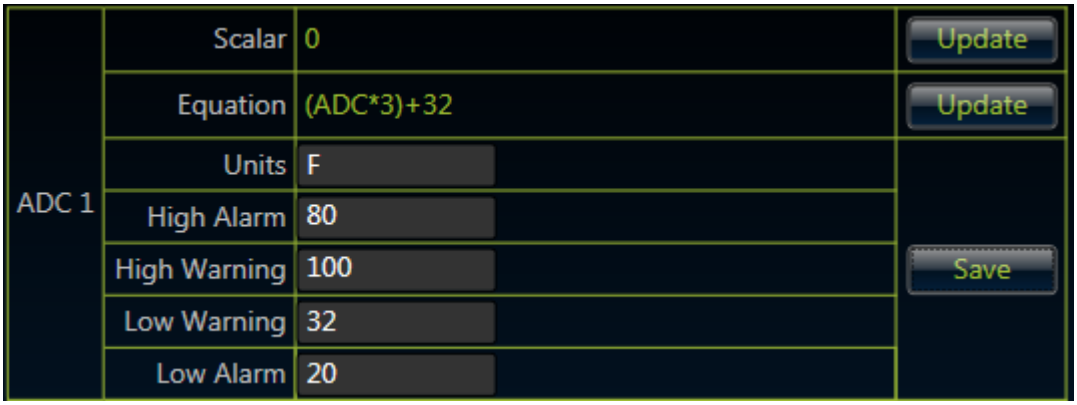


Figure 6-8: 923-GUI – ADC Controls

Figure 6-9: 923-GUI – Adjusted Analog Input

7.0 Register Maps

7.1 Modbus RTU Register Map

Board Diagnostics Information				
Register Number	**Bit**	**R/W**	**Description**	**Comments**
40001	15:0	R	Serial Output Mode	0: Reserved 1: Reserved 2: Reserved 3: Modbus RTU Mode
40002	15:8	R	Month	Date saved as ASCII
	7:0	R	Day	
40003	15:0	R	Year	
40004	15:8	R	Minutes	Time saved as ASCII
	7:0	R	Seconds	
40005	15:8	R	Reserved	
	7:0	R	Hour	
40006	15:0	R	Log Interval	In minutes (1-120)
40007	15:0	R	3.3 V ADC	`Voltage (V) = ModbusReg[40007] * 0.0058`
40008	15:0	R	5 V ADC	`Voltage (V) = ModbusReg[40008] * 0.0058`
40009	15:0	R	12 V ADC	`Voltage (V) = ModbusReg[40009] * 0.017578`
40010	15:0	R	Reserved	Reserved
40011	15:0	R	Temperature Sensor	See “On-board Sensor Registers” section.
40012	15:0	R	Humidity Sensor	
40013	15:0	R	Light Sensor [1]	
40014	15:0	R	Light Sensor [2]	
40015	15:0	R	RPM [1]	
40016	15:0	R	RPM [2]	
40017	15:0	R	Total Rotations [1]	
40018	15:0	R	Total Rotations [2]	
40019	15:0	R	CW Rotations [1]	
40020	15:0	R	CW Rotations [2]	
40021	15:0	R	CCW Rotations [1]	
40022	15:0	R	CCW Rotations [2]	
40023	15:0	R	Direction	
40024	15:0	R	Acceleration X	
40025	15:0	R	Acceleration Y	
40026	15:0	R	Acceleration Z	
40027	15:0	R	Micro Firmware Revision	
40028	15:0	R	Cause of Last Micro Reset	0: Power-Up 2: Watchdog 3: Software Power-up 4: User (NRST pin) 5: Brownout
40029	15:0	R	Number of Magnets	
40030	15:0	R	Reserved	
40031	15:0	R	Memory Pointer [1]	Current Location in the flash memory. This value does not include an offset at the beginning of the flash which stores factory use code.
40032	15:0	R	Memory Pointer [2]	
40033	15:0	R	Reserved	
40034	15:0	R	Reserved	
40035	15:0	R	I2C Error Counter	Reports the number of I2C errors occurred
40036	15:0	R	Reserved	
40037	15:0	R	Reserved	
40038	15:8	R	Thermocouple 1 Byte 1	Saved as IEEE 4 byte float value. (See “Sensor Data Conversion” section for details.)
	7:0		Thermocouple 1 Byte 0	
40039	15:8	R	Thermocouple 1 Byte 3	
	7:0		Thermocouple 1 Byte 2	
40040	15:8	R	Thermocouple 2 Byte 1	
	7:0		Thermocouple 2 Byte 0	
40041	15:8	R	Thermocouple 2 Byte 3	
	7:0		Thermocouple 2 Byte 2	

Board Diagnostics Information				
Register Number	**Bit**	**R/W**	**Description**	**Comments**
40042	15:0	R	Reserved	
40043	15:0	R	Analog Input Ch 1	See “On-board Sensor Registers” section.
40044	15:8	R	Analog Input Ch 1 Scalar Byte 1	
	7:0	R	Analog Input Ch 1 Scalar Byte 0	
40045	15:0	R	Analog Input Ch 1 Scalar Byte 3	
	7:0	R	Analog Input Ch 1 Scalar Byte 2	
40046	15:0	R	Analog Input Ch 2	
40047	15:8	R	Analog Input Ch 2 Scalar Byte 1	
	7:0	R	Analog Input Ch 2 Scalar Byte 0	
40048	15:0	R	Analog Input Ch 2 Scalar Byte 3	
	7:0	R	Analog Input Ch 2 Scalar Byte 2	
40049	15:0	R	Reserved	
40050	15:8	R	Reserved	
	7:0	R	Reserved	
40051	15:0	R	Reserved	
	7:0	R	Reserved	
40052	15:0	R	Reserved	
40053	15:8	R	Reserved	
	7:0	R	Reserved	
40054	15:0	R	Reserved	
	7:0	R	Reserved	
40055-40229	15:0	R	Reserved	

Board Information Registers				
Register Number	**Bit**	**R/W**	**Description**	**Comments**
40230	15:0	R	Serial Number [1]	Serial Number
40231	15:0	R	Serial Number [2]	
40232	15:0	R	Serial Number [3]	
40233	15:0	R	Serial Number [4]	
40234	15:0	R	Serial Number [5]	
40235	15:0	R	Serial Number [6]	
40236	15:0	R	Serial Number [7]	
40237	15:0	R	Serial Number [8]	
40238	15:0	R	Date Code [1]	Date Code
40239	15:0	R	Date Code [2]	
40240	15:0	R	Date Code [3]	
40241	15:0	R	Date Code [4]	
40242	15:0	R	Date Code [5]	
40243	15:0	R	Date Code [6]	
40244	15:0	R	Date Code [7]	
40245	15:0	R	Date Code [8]	
40246	15:0	R	Assembly Number [1]	Assembly Number
40247	15:0	R	Assembly Number [2]	
40248	15:0	R	Assembly Number [3]	
40249	15:0	R	Assembly Number [4]	
40250	15:0	R	Assembly Number [5]	
40251	15:0	R	Assembly Number [6]	
40252	15:0	R	Assembly Number [7]	
40253	15:0	R	Assembly Number [8]	
40254	15:0	R	PCB Number [1]	PCB Number
40255	15:0	R	PCB Number [2]	
40256	15:0	R	PCB Number [3]	
40257	15:0	R	PCB Number [4]	
40258	15:0	R	PCB Number [5]	
40259	15:0	R	PCB Number [6]	
40260	15:0	R	PCB Number [7]	
40261	15:0	R	PCB Number [8]	
40262-40517	15:0	R	Reserved	
40518	15:0	R	Log File Size Lower	32 bit value saved as ASCII
40519	15:0	R	Log File Size Upper	
40520-40799	15:0	R	Reserved	

Shock Event Registers				
Register Number	**Bit**	**R/W**	**Description**	**Comments**
40800	15:8	R	Stored Max Shock Value Byte 1	Max shock from most recent shock event. Saved as IEEE 4 byte float value. (See “Sensor Data Conversion” section for details.)
	7:0	R	Stored Max Shock Value Byte 0	
40801	15:8	R	Stored Max Shock Value Byte 3	
	7:0	R	Stored Max Shock Value Byte 2	
40802	15:8	R	Current Max Shock Value Byte 1	
	7:0	R	Current Max Shock Value Byte 0	
40803	15:8	R	Current Max Shock Value Byte 3	
	7:0		Current Max Shock Value Byte 2	
40804-40809	15:0	R	Reserved	
40810-40841	15:0	R	Shock Event X Data 0-31	See “On-board Sensor Registers” section.
40842-40873	15:0	R	Shock Event Y Data 0-31	
40874-40909	15:0	R	Shock Event Z Data 0-31	
40910-41050	15:0	R	Reserved	

7.1.1 On-board Sensor Registers

<table>
<tr><th colspan="5">On-board Sensor Information</th></tr>
<tr><th>Register Number</th><th>Bit</th><th>R/W</th><th colspan="2">Description</th></tr>
<tr><td colspan="5">Temperature Sensor</td></tr>
<tr><td>40011</td><td>15:0</td><td>R</td><td colspan="2">Temperature Sensor</td></tr>
<tr><td colspan="3">Equation

Temp = (ModbusReg[40011] * 0.0026812) – 46.5</td><td colspan="2">Example: Temp = 27.94 degC

Temperature = (27764 * 0.0026812) – 46.5
= 27.94</td></tr>
<tr><td colspan="5">Humidity Sensor</td></tr>
<tr><td>40012</td><td>15:0</td><td>R</td><td colspan="2">Humidity Sensor</td></tr>
<tr><td colspan="3">Equation

Humidity = (ModbusReg[40012] * 0.0019073) – 6</td><td colspan="2">Example: Humidity = 41.90%

Humidity = (25112 * 0.0019073) – 6
= 41.90</td></tr>
<tr><td colspan="5">Light Sensor</td></tr>
<tr><td>40013</td><td>15:0</td><td>R</td><td colspan="2">Light Sensor [1] (Ch1)</td></tr>
<tr><td>40014</td><td>15:0</td><td>R</td><td colspan="2">Light Sensor [2] (Ch2)</td></tr>
<tr><td colspan="3">Equations
Ratio = Ch2/Ch1

If 0 ≤ Ratio ≤ 0.52:
Luminance =
(0.0315*Ch1)-(0.0539*Ch1*((Ch2/Ch1)^1.4))

If 0.52 ≤ Ratio ≤ 0.65:
Luminance = (0.0229*Ch1)-(0.0291*Ch2)

If 0.65 ≤ Ratio ≤ 0.80
Luminance = (0.0157*Ch1)-(0.0180* Ch2)

If 0.80 ≤ Ratio ≤ 1.30
Luminance = (0.00338*Ch1)-(0.00260* Ch2)

If Ratio ≥ 1.30
Luminance = 0</td><td colspan="2">Example: Lum = 46.35 lux

Ch1 = 1748
Ch2 = 319

Ratio = 0.182494283

Luminance
= (0.0315 * 1748)-(0.0539 * 1748 * (Ratio^1.4))
= 46.35</td></tr>
<tr><td colspan="5">Rotation Sensor (Turns Counter and Speed)</td></tr>
<tr><td>40015</td><td>15:0</td><td>R</td><td>RPM[1] (bits 15:0)</td><td rowspan="8">Equations:
Formatted Data = Raw Data
Big endian.
Example:
The Modbus 32-bit value is already formatted and no further conversion is required.</td></tr>
<tr><td>40016</td><td>15:0</td><td>R</td><td>RPM [2] (bits 31:16)</td></tr>
<tr><td>40017</td><td>15:0</td><td>R</td><td>Total Rotations [1]</td></tr>
<tr><td>40018</td><td>15:0</td><td>R</td><td>Total Rotations [2]</td></tr>
<tr><td>40019</td><td>15:0</td><td>R</td><td>Clockwise Rotations [1]</td></tr>
<tr><td>40020</td><td>15:0</td><td>R</td><td>Clockwise Rotations [2]</td></tr>
<tr><td>40021</td><td>15:0</td><td>R</td><td>Counter Clockwise Rotations [1]</td></tr>
<tr><td>40022</td><td>15:0</td><td>R</td><td>Counter Clockwise Rotations [2]</td></tr>
<tr><td rowspan="9">40023</td><td>15:8</td><td rowspan="6">R</td><td>Reserved</td><td rowspan="6">Reserved</td></tr>
<tr><td>7</td><td>Reserved</td></tr>
<tr><td>6</td><td>Reserved</td></tr>
<tr><td>5</td><td>Reserved</td></tr>
<tr><td>4</td><td>Reserved</td></tr>
<tr><td>3</td><td>Reserved</td></tr>
<tr><td>2</td><td>R</td><td>Counter Clockwise Rotation</td><td>1=CCR detected. 0 = CCR not detected</td></tr>
<tr><td>1</td><td>R</td><td>Clockwise Rotation</td><td>1=CR detected. 0 = CR not detected</td></tr>
<tr><td>0</td><td>R</td><td>No Rotation</td><td>1=No Rotation detected. 0 = Rotation detected</td></tr>
<tr><td colspan="5">3-Axis Accelerometer (Shock and Vibration Sensor)</td></tr>
<tr><td>40024</td><td>15:0</td><td>R</td><td>Acceleration X</td><td></td></tr>
<tr><td>40025</td><td>15:0</td><td>R</td><td>Acceleration Y</td><td></td></tr>
<tr><td>40026</td><td>15:0</td><td>R</td><td>Acceleration Z</td><td></td></tr>
<tr><td>40810-40909</td><td>15:0</td><td>R</td><td>Shock Event X,Y,Z Data 0-31</td><td></td></tr>
</table>

On-board Sensor Information			
Register Number	**Bit**	**R/W**	**Description**

Equation
`Raw = ModbusReg[xxxxx]`
`If Raw > 32768`
`  Accel = (65536 – Raw) * 0.049 * -1`
`Else`
`  Accel = Raw * 0.049`
			Example: Acceleration = 0.748 g
			
			`Raw  = 16`
			`Accel = 16 * 0.049`
			`  = 0.748`

On-board Sensor Information			
Register Number	**Bit**	**R/W**	**Description**
ADC External Inputs CH1 – CH4			
40043-40054	15:0	R	Analog Input and Scalar Values for Channels 1-4

`Voltage (V) =`
`AnalogInputChX * AnalogInputScalarChx`
`Where ChX = Ch1,Ch2`
 	
`AnalogInputScalarChx =`
`BytesToFloat(`
`AnalogInputChX_ScalarByte3,`
`AnalogInputChX_ScalarByte2,`
`AnalogInputChX_ScalarByte1,`
`AnalogInputChX_ScalarByte0)`
 	
`See “Sensor Data Conversion” section for details.`
			Example: Voltage = 1.65V
			
			`Scalar = BytesToFloat(0x3B, 0x40, 0x30, 0x06)`
			`  = 0.00293255`
			
			`V = 562 * Scalar`
			`  = 1.65`

7.1.2 Sensor Data Conversion

7.1.2.1 IEEE 4 Byte Float Conversion (Bytes to Float)

```
BytesToFloat(byte3, byte2, byte1, byte0):

temp = (byte3<<24)|(byte2<<16)|(byte1<<8)|(byte0)
mantissa = (1 + (temp & 0x007FFFFF) * (2^-23))
exp = ((temp & 0x7F800000) >> 23) – 127
isPos = (((temp & 0x80000000) >> 31) == 0)

If isPos:
   Float = (2^exp) * mantissa
Else:
   Float = (-1 * ((2^exp) * mantissa))
```