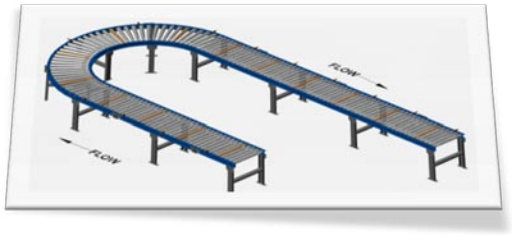
PULSEROLLER

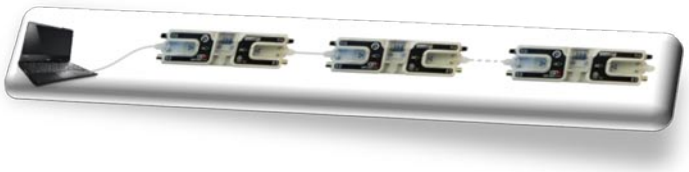
MOTIONLINX

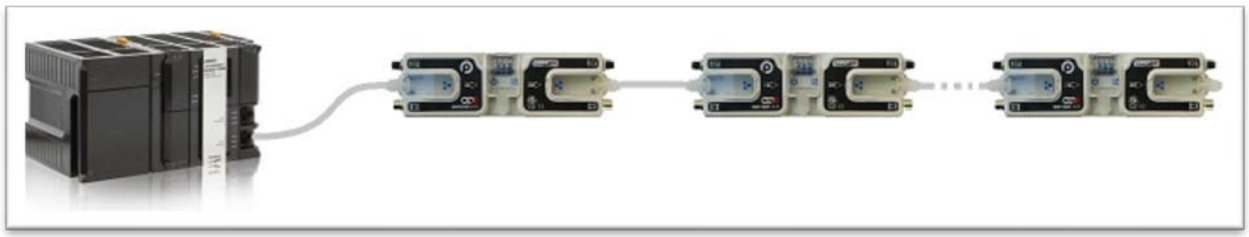
MotionLinx-Ai User's Guide

Version 1.6

November 2017







Publication ML-1000

MotionLinx module firmware and functionality is protected by U.S. and international patents.
For complete patent information visit www.pulseroller.com/patents

GLOSSARY OF TERMS

Ai	The patented technology used to control a DC motor with external commutation over a standard M8 4-pin connector.
ConveyLinx	Conveyor controls architecture based upon modular distributed devices connected via Ethernet network.
MotionLinx-Ai	A member of the ConveyLinx family running the EtherCAT industrial protocol for communication. This module uses the Ai technology to control up to two Senergy-Ai MDRs. Profnet IO, EthernetIP and ModBus TCP are not supported by *MotionLinx-Ai*
EtherCAT	An industrial protocol developed by Beckhoff Automation. Requires a special EtherCAT switch
Hall Effect Sensor	Special sensor embedded within the brushless DC motor of an **MDR** used to provide motor rotor position feedback to the motor controller
M8	This is the type of a particular connector , which has four connector pins and is used on the ***MotionLinx-Ai*** modules for both sensor connectors and MDR connectors
LED	**L**ight **E**mitting **D**iode – In the context of this document, **LED's** are used on the **ERSC** to provide visual indication of module status
MDR	**M**otorized **D**rive **R**oller or **M**otor **D**riven **R**oller - Brushless DC motor and gearbox assembly integrated into a single conveyor roller.
NPN / PNP	Electronics term that indicates the type of transistor circuit used for a logical input or output for controllers. **NPN** devices will provide a common or ground connection when activated and a **PNP** device will provide a logic voltage connection when activated.
PGD	Senergy-Ai motor and gearbox assembly with standard mounting face and universal shaft. PGD device can be used for more general purpose applications compared to MDR.
PLC	**P**rogrammable **L**ogic **C**ontroller – A wide variety of industrial computing devices that control automatic equipment
IP54	The **IP Code (International Protection Marking)** specifies the device's degree of resistance to intrusions, dust and water. IP54 certified device must be fully protected from splashed water , dust particles and completely protected from contact
Senergy-Ai	PulseRoller brand proprietary motor control platform that provides electronic intelligence inside the motor that can be read by **ConveyLinx-Ai** and ***MotionLinx-Ai*** control modules. The connection from the motor to the controller is via 4-Pin **M8** style connector.
TwinCAT	The integrated engineering and runtime PC based programming environment created and distributed by Beckhoff. It allows the user to create hardware configuration and PLC tasks. The engineering part of the environment is PC-based and runs on almost any system. The runtime (PLC tasks) part, however runs only on 32 bit Intel CPUs or 64 bit Intel CPUs with enabled VT-X feature. For our examples we use TwinCAT3.
Beckhoff Automation GmbH & Co. KG	The developer of the EtherCAT protocol and the TwinCAT software

SYMBOL CONVENTIONS

This symbol indicates that special attention should be paid in order to ensure correct use as well as to avoid danger, incorrect application of product, or potential for unexpected results

This symbol indicates important directions, notes, or other useful information for the proper use of the products and software described herein.

IMPORTANT USER INFORMATION

MotionLinx-Ai modules contain ESD (Electrostatic Discharge) sensitive parts and components. Static control precautions are required when installing, testing, servicing or replacing these modules. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference any applicable ESD protection handbook. Basic guidelines are:

- Touch a grounded object to discharge potential static
- Wear an approved grounding wrist strap
- Do not touch connectors or pins on component boards
- Do not touch circuit components inside the equipment
- Use a static-safe workstation, if available
- Store the equipment in appropriate static-safe packaging when not in use

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes, and standards

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Insight Automation Inc. does not assume responsibility or liability (to include intellectual property liability) for actual use based on the examples shown in this publication

SUMMARY OF CHANGES

The following table summarizes the changes and updates made to this document since the last revision

Revision	Date	Change / Update
1.0	August 2016	Initial Release
1.1	November 2016	Updates for firmware 1.2
1.2	January 2017	Added Appendix C for Power Supply sizing
1.3	January 2017	Updated Appendix B - IOX-2 Output power connection and PNP Only
1.5	July 2017	Updated Object Dictionary for firmware 1.5
1.6	November 2017	Updated Object Dictionary for firmware 1.7 and Appendix B

GLOBAL CONTACT INFORMATION

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SUMMARY OF HARDWARE CHANGES

The following table summarizes the changes and updates made to this document since the last hardware revision.

Hardware Revisions		
Revision	**Date**	**Change / Update**
1.0	August 2016	Initial Release

TABLE OF CONTENTS

PREFACE

WHO SHOULD USE THIS MANUAL?

This manual is intended for users who need basic product information and simple application procedures to implement *MotionLinx-Ai* modules to Senergy Ai motors.

You should have a basic understanding of electrical circuitry and familiarity with relay logic, BLDC motors, etc. If you do not, obtain the proper training before using this product.

PURPOSE OF THIS MANUAL

The purpose of this manual is to:

- Identify the components and ports available on a module
- Provide guidelines for proper installation and wiring
- Provide examples of basic inter-module connections
- Introduce the TwinCAT software tool and provide instructions to configure and modify parameters.

NOT INCLUDED IN THIS MANUAL

Because system applications vary; this manual assumes users and application engineers have properly sized their power distribution capacity per expected motor loading and expected operational duty cycle. Please refer to motor manufacturer's documentation for power supply sizing recommendations.

INTRODUCTION TO MOTIONLINX®

Each *MotionLinx-Ai* control module provides connection for up to 2 Senergy-Ai motors (MDR or PGD) and up to 4 digital inputs. Each module is equipped with an In/OutT EtherCAT Slave Controller to allow multiple *MotionLinx-Ai* modules to be connected in series to form an EtherCAT network. A network of multiple *MotionLinx-Ai* modules could, for example, be easily applied as an integrated MDR conveyor control solution. In this example, each *MotionLinx-Ai* module can accommodate up to 2 Senergy Ai MDRs and 2 photo-sensors to provide control for up to 2 conveyor zones.

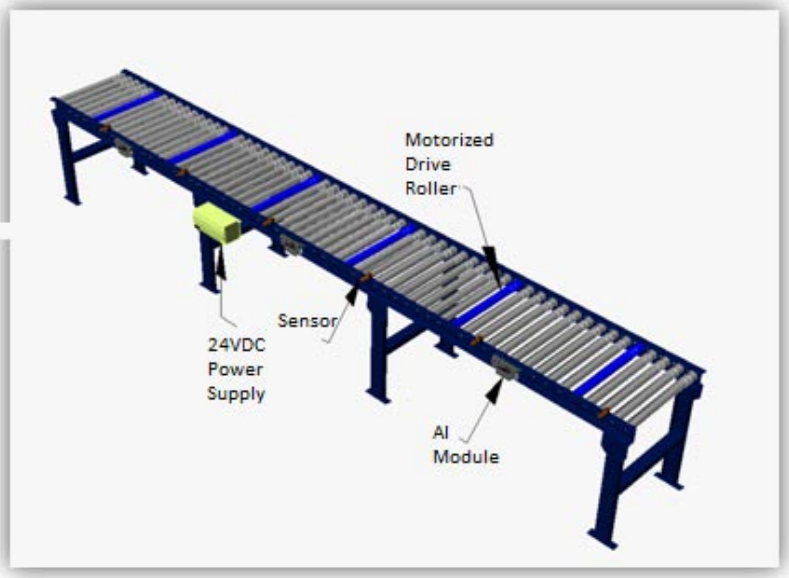
FIGURE 1 – ETHERCAT NETWORK OF MOTIONLINX-AI MODULES

As with any EtherCAT based system, the slave devices require a master controller to direct their operation. *MotionLinx-Ai* modules on their own provide no automatic function or control of motor or inputs without being directed by a master controller.

TYPICAL CONVEYOR SYSTEM COMPONENTS

Although *MotionLinx-Ai* is not limited to conveyor applications, these are common. The following are the typical components required for a *MotionLinx-Ai* controlled conveyor installation:

- ✓ *MotionLinx-Ai* modules
- ✓ MDRs – one or two per *MotionLinx-Ai*
- ✓ Photo-sensors – one or two per *MotionLinx-Ai*
- ✓ 24VDC Power Supplies



MotionLinx-Ai Module Features

Each individual *MotionLinx-Ai* module has the following features:

- ✓ Built-in EtherCAT Slave Controller switch
- ✓ Modular M8 (female) style connection ports for photo-sensors
- ✓ Modular M8 (male) style connectors for Senergy Ai MDR or PGD devices
- ✓ 24VDC power connection with separate power supplies for logic and motors
- ✓ Context-sensitive multi-color LED indicators
- ✓ Thermal and over-current protection for Senergy-Ai motor
- ✓ Automatic PNP/NPN detection for photo-sensor
- ✓ Programmable option for push-pull type sensor
- ✓ Proportional / Integral (PI) motor speed regulation
- ✓ Three motor braking method options
- ✓ Adjustable acceleration and deceleration capability
- ✓ IP54 compliant

The first sections of this manual will describe in detail the hardware and connectivity requirements for *MotionLinx-Ai* modules and the software configuration procedures for simple linear conveyor installation.

The latter sections of this manual will describe the connectivity and data made available to a TwinCAT based master controller.

MotionLinx-Ai Module Hardware Overview

MotionLinx-Ai modules are designed to be installed and integrated onto the mechanical equipment close to the motor being controlled. Please refer to *Appendix A – Module Specifications* page 43 for module dimensions and mounting details.

The *MotionLinx-Ai* module is a controller for up to 2 Senergy-Ai motors. Each *MotionLinx-Ai* provides connection points for 2 Senergy-Ai motor units (typically a Motorized Drive Roller or Pulse Gear Drive) as well as connection points for sensor device and/or digital I/O, and connection point for the EtherCAT network.

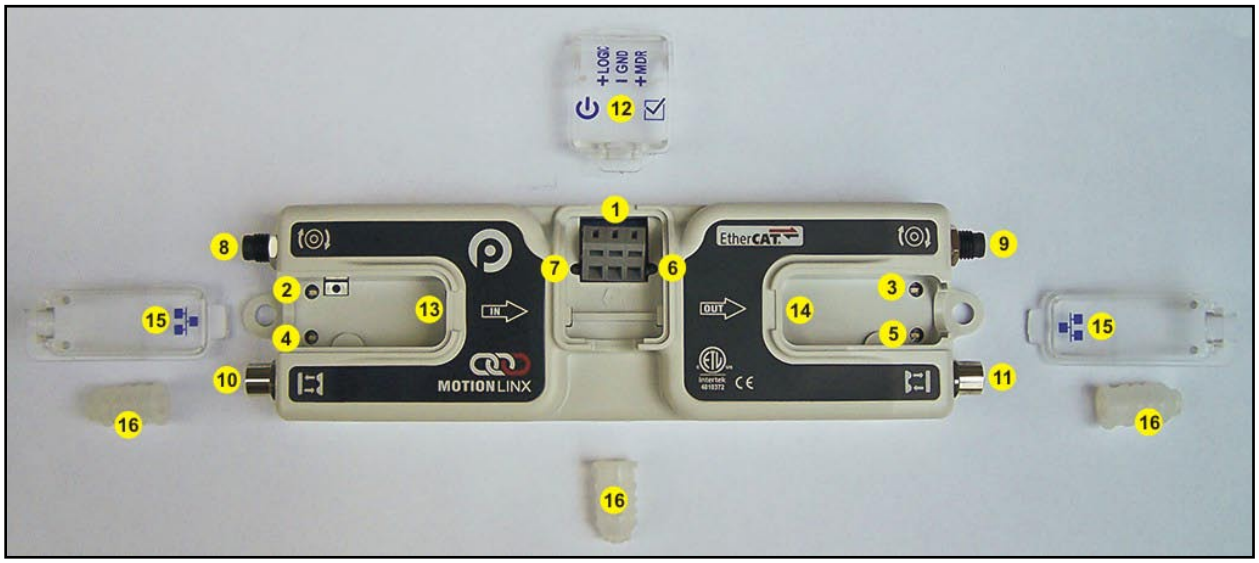


FIGURE 2 – MOTIONLINX-AI MODULE HARDWARE FEATURES IDENTIFICATION

Item	Description
1	24VDC Power Terminals with separate connections for Logic and Motors
2 & 3	Motor Left LED & Motor Right LED – Motor status indicators
4 & 5	Left Sensor & Right Sensor Status LED Indicators
6	Module EtherCAT Status LED Indicator
7	Module Power LED Indicator
8 & 9	Motor Left and Motor Right - 4-pin M8 style connector for MDR connection
10 & 11	Sensor Left and Sensor Right – M8 style connector for sensor device connection
12	RemovableIP54 Power Compartment Cover
13 & 14	Link IN and Link OUT – RJ-45 style Ethernet network connection between modules
15	Removable IP54 Ethernet RJ-45 Port Compartment Cover – Left and Right
16*	IP54 Protection Shrouds for Ethernet cabling and power wiring

* Indicates items shipped unattached to the module but included in the module's box

The "left" and "right" naming convention for the module ports is based upon facing the module as shown.

HARDWARE CONNECTIONS

MOTOR LEFT AND MOTOR RIGHT PORTS

Both of these ports utilize a 4-pin M8 male receptacle. Each receptacle is mechanically keyed to assure proper orientation upon plugging in.

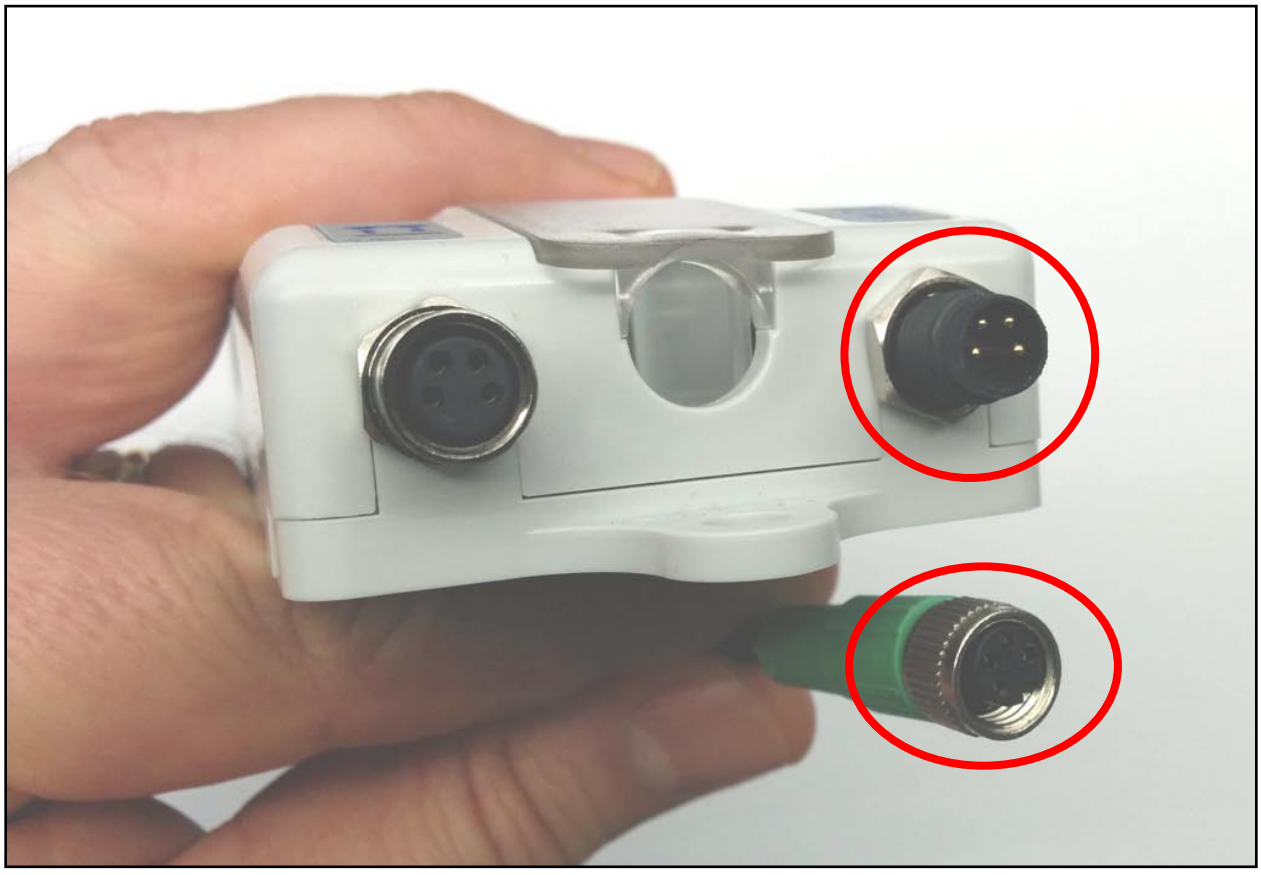


FIGURE 3 - M8 MALE RECEPTACLE AND SENERGY-AI FEMALE CONNECTOR

Sensor Left and Sensor Right Ports

Each sensor port is a standard M8 Female receptacle with the following pin-out:

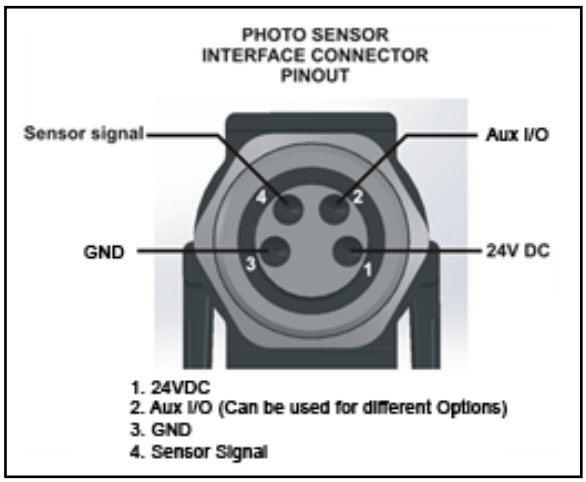


FIGURE 4–MOTIONLINX-AI SENSOR PORT DIAGRAM

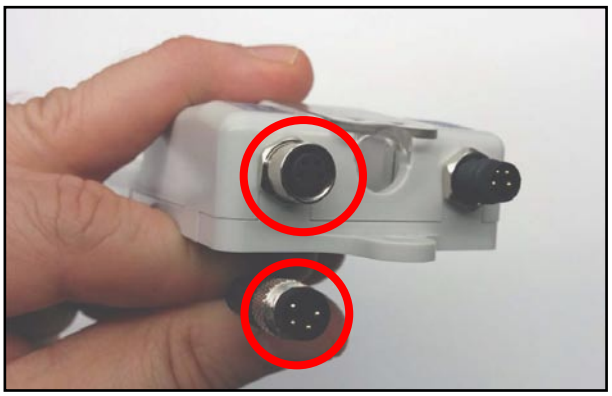


FIGURE 5 – MOTIONLINX-AI FEMALE SENSOR PORT AND MATING SENSOR'S MALE CONNECTOR

The signals are defined by the following chart:

Pin	Signal	Description
1	24V DC	Module 24VDC Supply
2	Aux I/O	I/O Signal – Digital Input signal connection
3	GND	Module DC Common
4	Sensor Signal	Logical Input for Sensor's state output – Auto detect for NPN or PNP

Please refer to Appendix B - IOX-2Breakout Module beginning on page 47 for details on connecting and wiring devices for access to Aux I/O Pin 2 signals

ETHERNET IN (LEFT) AND ETHERNET OUT (RIGHT) PORTS

Both of these ports are standard RJ-45 jacks conforming to standard Ethernet connection pin-out. In order to maintain IP54 rating; Ethernet cables need to be equipped with protective shrouds. Figure 6 shows Ethernet cables installed using shrouds to protect the RJ-45 connectors on the Ethernet cables. Each module is shipped with 3 shrouds.

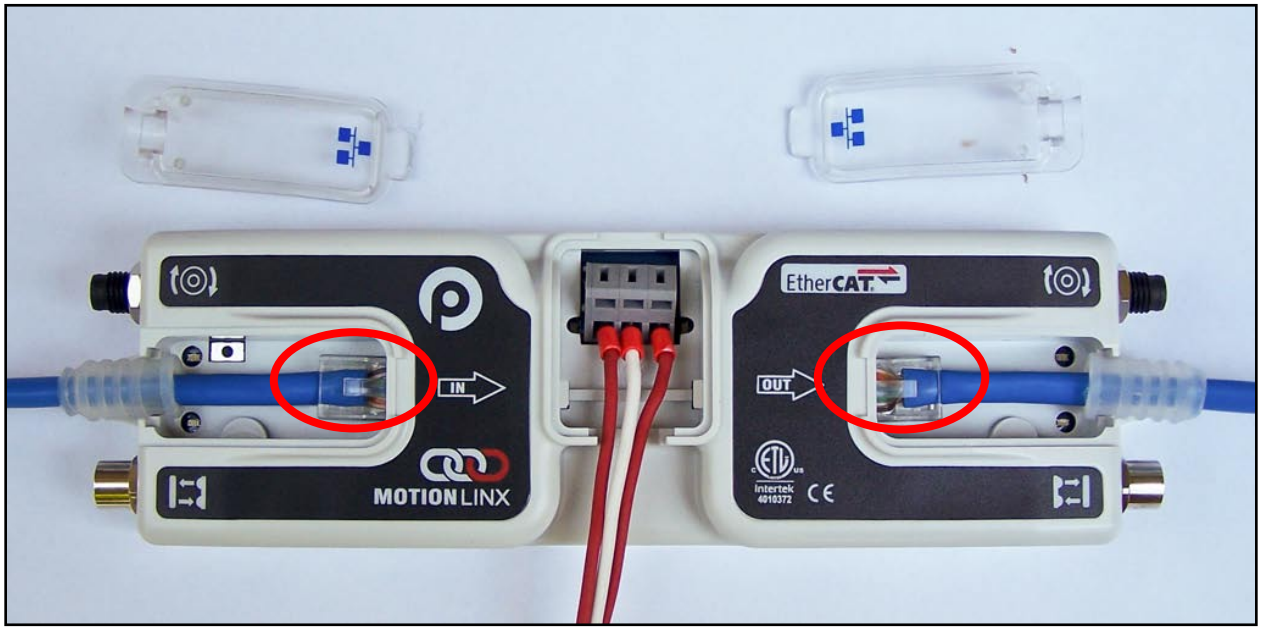


FIGURE 6 – MOTIONLINX-AI WITH LEFT & RIGHT ETHERNET CABLES (COVERS REMOVED)

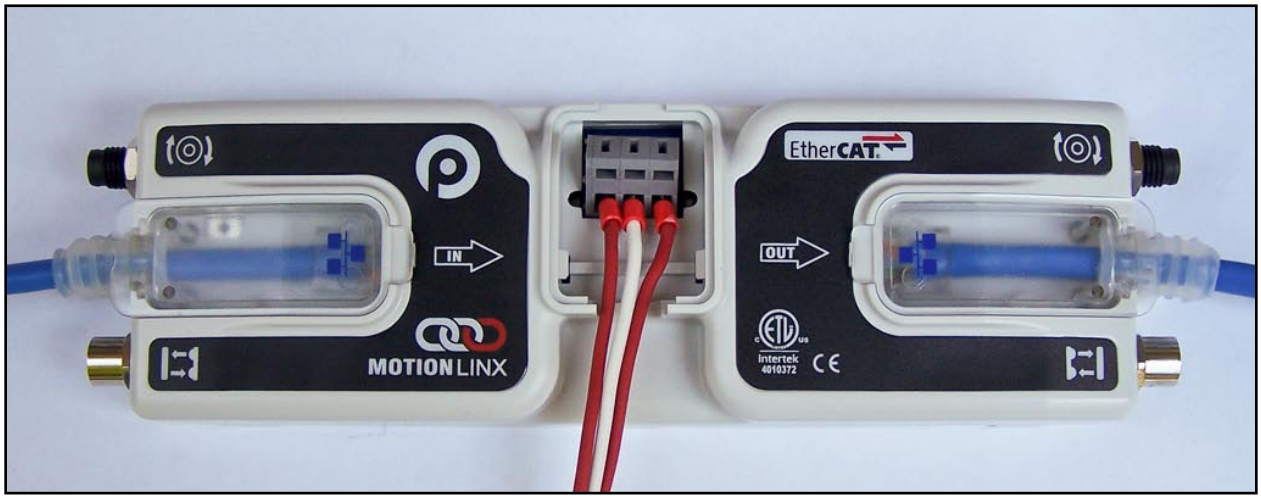


FIGURE 7 - ETHERNET CABLES CONNECTED WITH COVERS ATTACHED

IP54 protective shroud requires a special tool to properly install the shroud onto the RJ-45 connector. Figure 8 shows Phoenix Contact item 2891547 FL IP 54 Assembly Tool.

This tool must be purchased separately

FIGURE 8 - PHOENIX CONTACT ETHERNET SWITCH 2891547 FL IP 54 ASSEMBLY TOOL

FIGURE 9 - TOOL SHOWN WITH PROPER SET STOP POSITION

FIGURE 10 - PROTECTIVE SHROUND PLACED ON TOOL

FIGURE 11 - SHROUND STRETCHED WITH TOOL

FIGURE 12 - INSERTING RJ-45 END THROUGH SHROUD

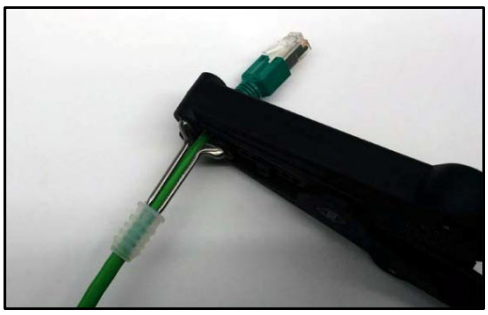


FIGURE 13 - SHROUD REMOVED FROM TOOL PINS

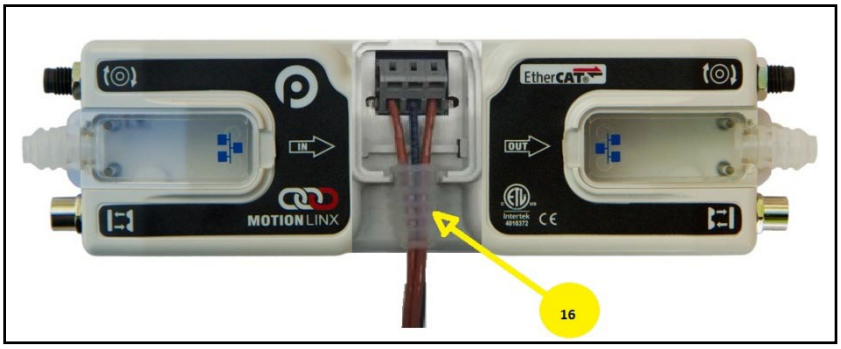
All Ethernet cables for connections between modules are recommended to be shielded. Failure to use shielded cables may result in data loss and unexpected results. Shown above are Ethernet cables with sealing shrouds required for IP54 compliance.

POWER CONNECTIONS

IP54 INSTALLATION

Item 16 as depicted in Figure 2 may be unattached to the module when shipped and are included in the module's shipping box. These items are used to maintain an IP54 installation of the power and Ethernet wiring.

Power wires are fed through the protective shroud (Item 16). The wire terminals are standard cage-clamp style.



Once wiring has been completed the power wiring compartment is then sealed by snapping into place the Power Compartment Cover (Item 12).

LOGIC AND MDR POWER

The *MotionLinx-Ai* module is designed to allow for separate power connections for module logic and motor power so that these can be powered by separate power supplies. For example, the motor power supply can be switched off by an emergency stop control system so that all motors have power removed. With the motor power separately switched off; the logic power supply can remain on so that the module's communications can remain active and report status to networked supervisory control system(s). Figure 15 shows a diagram for separate logic and MDR power supplies and Figure 14 shows a diagram for a single power supply for both logic and MDR power. Note that powering the MDR terminal also powers the Logic.

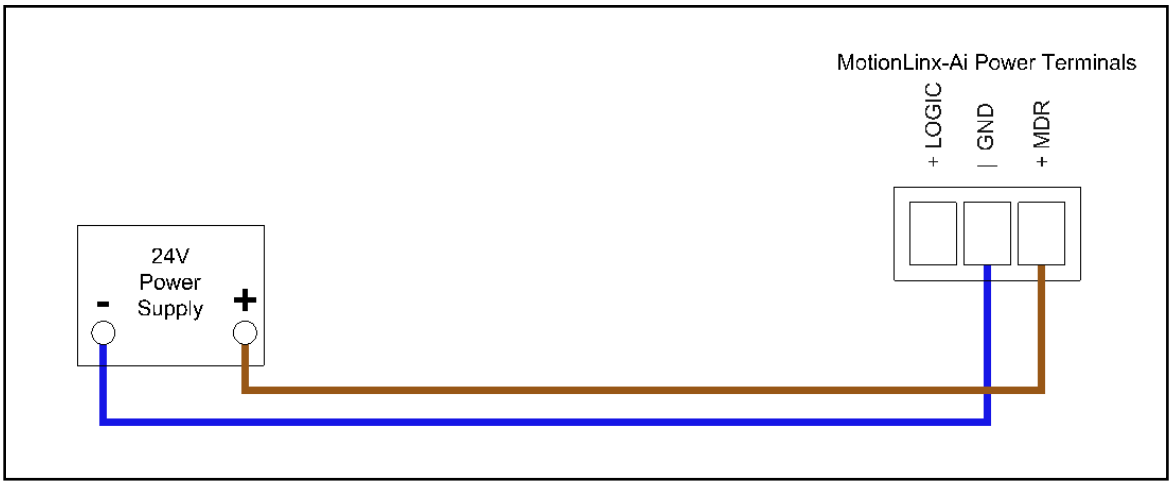


FIGURE 14 - CONNECTION FOR SINGLE MDR AND LOGIC POWER SUPPLY

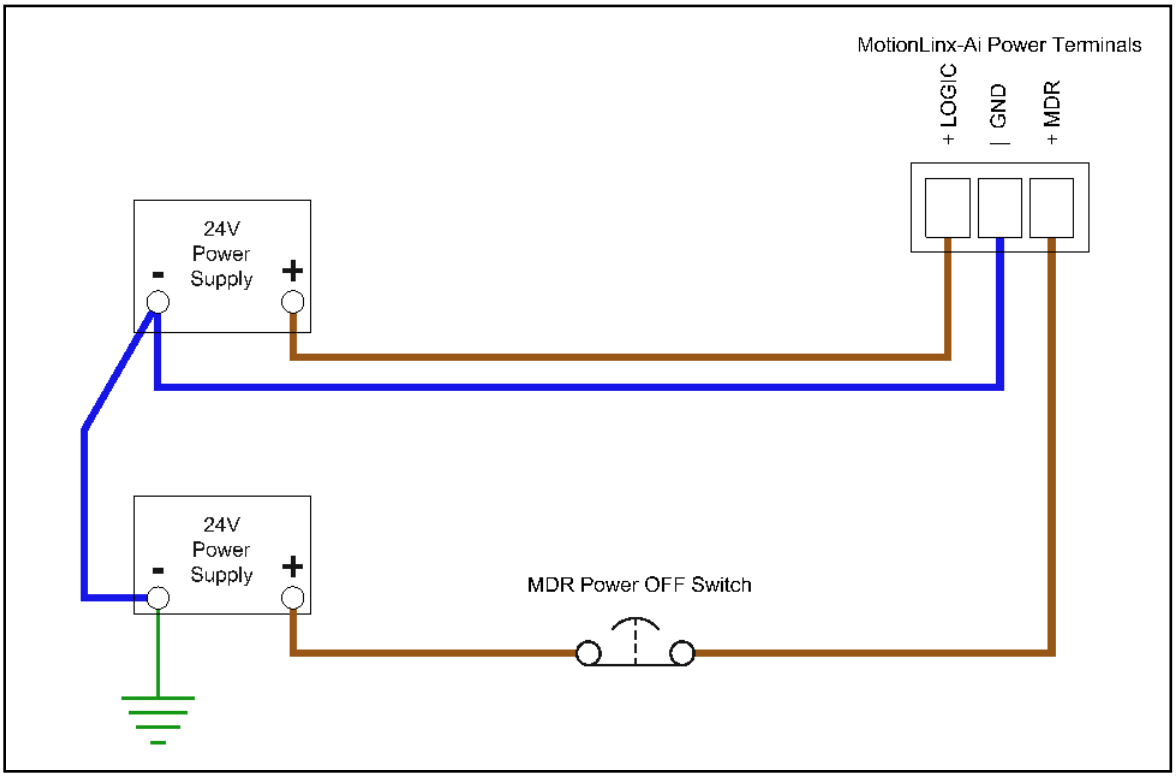


FIGURE 15 - TYPICAL CONNECTION FOR SEPARATE MDR AND LOGIC POWER SUPPLIES

Power Supply Common Grounding

Whether logic and MDR are powered together or separately; the DC common ("-") connections on all power supplies should be connected together. One of the power supplies should have its DC common connected to ground. Avoid connecting more than one power supply DC common to ground because this can lead to unintended grounding loops. Figure 16 and Figure 17 show single and separate power supply connections respectively and their DC common connections and grounding connection.

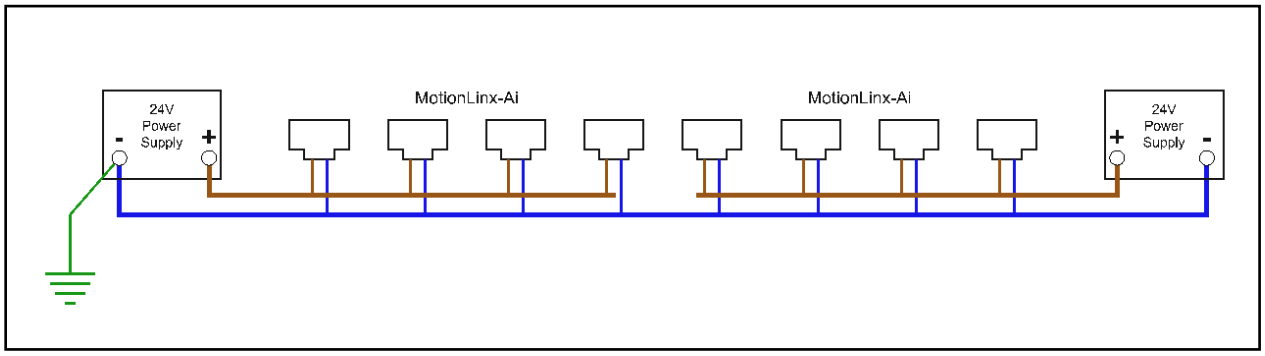


FIGURE 16 – SINGLE POWER SUPPLY CONNECTION WITH DC COMMONS TIED TOGETHER AND TO GROUND

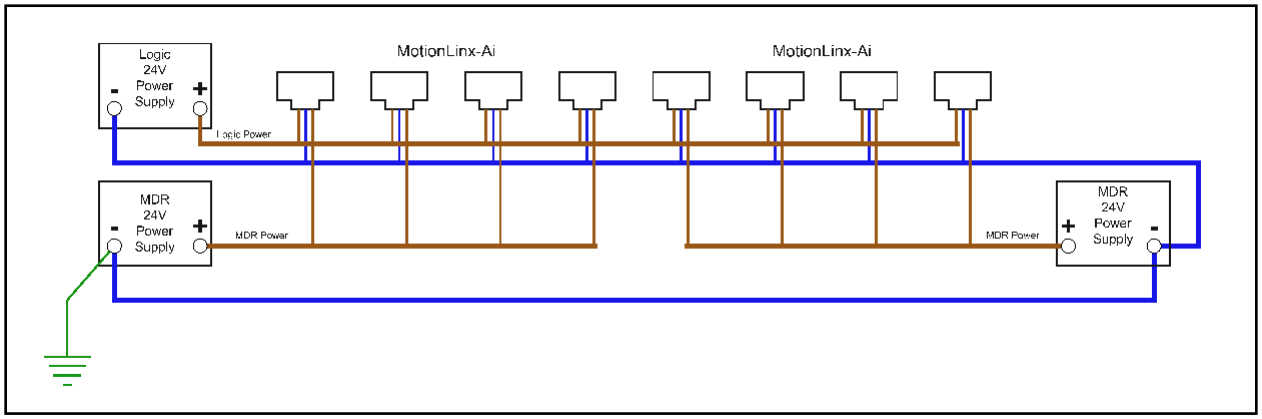


FIGURE 17 - DUAL POWER SUPPLY CONNECTION WITH DC COMMONS TIED TOGETHER AND TO GROUND

Please refer to Appendix C – Power Supply Loading on page 51 for power supply details

This document assumes the user is aware of motor power requirements for the application and that the user and/or installer have properly sized 24VDC power supplies and wiring based upon all applicable codes and standards. This document also assumes installation will follow proper equipment grounding practices. "DC common or -"**on all power supplies should always be connected to ground.** Improper power supply sizing and/or improper grounding practices may produce unexpected results.

MOTOR DIRECTION DEFINITION

The *MotionLinx-Ai* module uses a Clock-Wise (CW) and Counter Clock-Wise (CCW) motor rotation definition. The reference for this distinction is based upon viewing the MDR or PGD from the cable exit end of the device as depicted below in Figure 18.

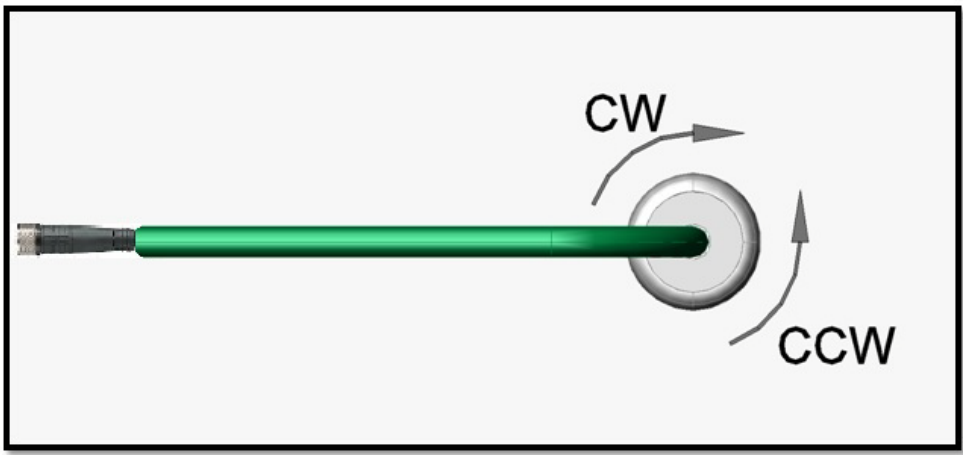


FIGURE 18 - MOTOR ROTATION DIRECTION CONVENTION

The default direction for an Ai motor connected to MotionLinx-Ai will be CW

STATUS INDICATORS

MotionLinx-Ai module status is indicated by several LED's. All LED's with the exception of the Ethernet Link and Activity LEDs are multi-coloured and context sensitive. The following chart indicates the various meanings of all *MotionLinx-Ai* LED indicators. Please refer to Figure 2 on page 13 for the item number locations on the module. The following list defines the various LED states:

Slow Blink	1 Hz	500 msec on / 500 msec off
Fast Blink	2.5 Hz	200 msec on / 200 msec off
Slow Flash	2 Hz	250 msec on / 250 msec off
Fast Flash	10 Hz	50 msec on / 50 msec off
Single Flash	-	200 msec on / 1000 msec of

COMMUNICATIONS

Indicator	LED State	Description
Ethernet IN (Left) Link & Ethernet OUT (Right) Link	OFF	No connection established
	Solid Green	Connection is established
	Blinking Green	When data transmission activity is occurring

NETWORK & MODULE FUNCTION

The Module Status indicator LED is dual color Green and Red. The Green color indicates the EtherCAT network status and the Red color indicates the Error status of the module. Each color has different states to indicate various conditions as shown:

Indicator	LED	LED State	Description
Module Status	Green	Off	EtherCAT is in INIT state
		Fast Blink	EtherCAT is in PRE-OP state
		Single Flash	EtherCAT is in SAFE-OP state
		On	EtherCAT is in OPERATIONAL state
		Fast Flash	EtherCAT is in BOOTSTRAP state
	Red	Off	EtherCAT is working
		Fast Blink	General Configuration Error
		Single Flash	Local Error
		On	Critical Communication or application error
		Fast Flash	Boot Error

MOTORS

Indicator	Item	LED State	Description
Motor Left & Motor Right	2 & 3	OFF	Motor is not running and no faults detected
		Solid Green	Motor is connected and running
		Solid Red	• If Motor is running, indicates current limit • If Motor is stopped, indicates motor is not connected properly or is overheated • Power supply is under 18V or above 30V
		Slow Blink Red	Motor is overloaded and *MotionLinx-Ai* is limiting current to reduce temperature
		Slow Flash Red	Motor short circuit detected between at least two of the phase windings

SENSORS

Indicator	Item	LED State	Description
Sensors	4 & 5	Solid Amber	MotionLinx Ai is booting up
		Solid Green	Sensor Input energized
		Solid Red	Aux Input energized
		Slow Blink Red	Missing sensor

POWER

Indicator	Item	LED State	Description
Power	7	Solid Blue	Power supply is connected and voltage is within acceptable range
		Slow Blink Blue	Motor's power is under 18V

INTEGRATING MOTIONLINX-AI WITH TWINCAT

INTRODUCTION

MotionLinx-Ai requires an EtherCAT master controller for operation. The EtherCAT master controller contains all program logic and configuration data to instruct each individual *MotionLinx-Ai* module to operate its connected motor(s) and to read digital input data from connected sensor devices. This guide uses the TwinCAT IDE from Beckoff Automation for all examples shown. However, any compatible EtherCAT Integrated Development Environment (IDE) software should follow the same basic steps for module identification and configuration.

This guide assumes you have some working knowledge of EtherCAT systems and the TwinCAT IDE software. Please consult Beckoff's TwinCAT documentation for further details.

ESI FILES

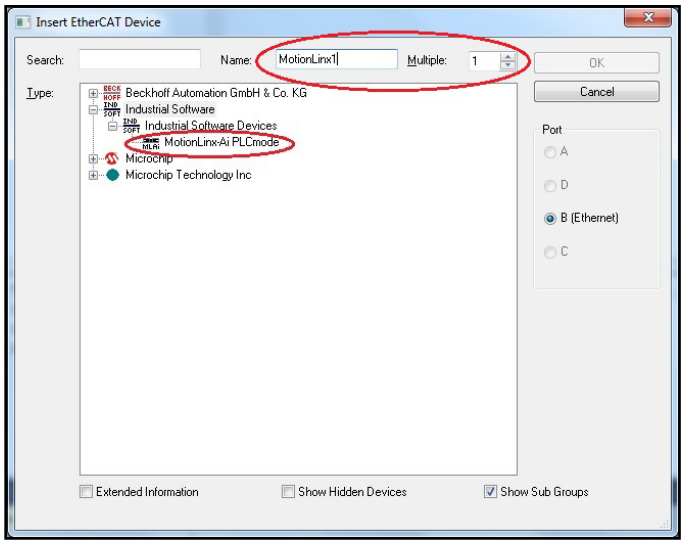
Any EtherCAT IDE software will require an EtherCAT Slave Information (ESI) file for MotionLoinx-Ai to be installed in order to have the proper configuration data. The latest *MotionLinx-Ai* ESI file will be available in the downloads section of pulseroller.com. Once downloaded from the website; you must place the file in proper folder in the the TwinCAT installation. In our example, the TwinCAT installation on our PC was made to the default location:

C:\TwinCAT\3.1\Config\IO\EtherCAT

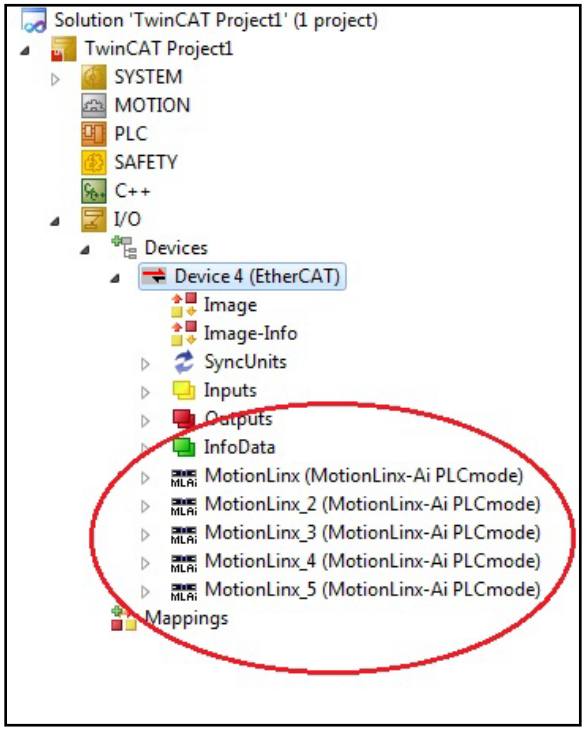
ADDING MOTIONLINX DEVICES IN A PROJECT SOLUTION

Once you have installed the ESI file in your TwinCAT IDE and created your project solution; the next step is to add an instance of the *MotionLinx-Ai* ESI for each individual MotionLinx device you need to control. In our example, we called our solution "Test project".

From the Insert EtherCAT Device window, you select the device type you want to insert and then enter the name you want to give the device. In this example we entered "MotionLinx1" as the device name.



When you have inserted the desired quantity of individual *MotionLinx-Ai* modules, you can expand your project tree to see the individual devices. In our example we inserted 5 *MotionLinx-Ai* modules



On-Line Method

You can also connect your TwinCAT PC to a physical network or devices and scan the physical network for devices and they will be automatically added to your project solution in the order they are connected in the network topology. Please refer to your TwinCAT documentation on the details of scanning your network for devices.

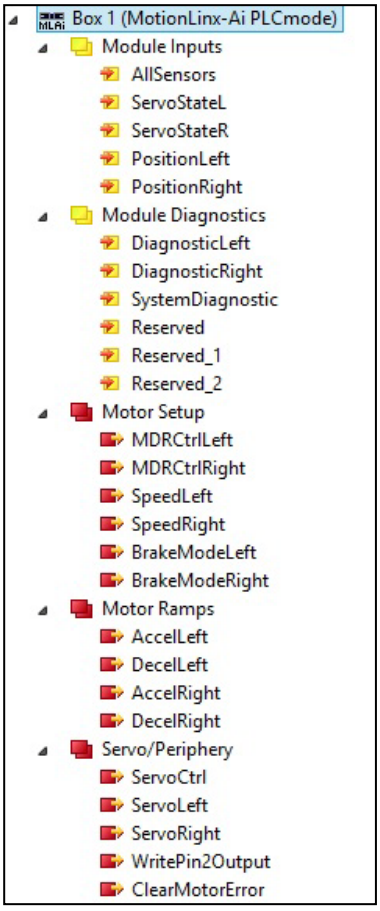
MOTIONLINX AI DATA OBJECTS

The data exchange between remote *MotionLinx-Ai* devices and the PC based TwinCAT controller is CanOpen over EtherCAT (CoE). This protocol provides for cyclic data exchange between a "Master" controller (PC based TwinCAT) and multiple "Slave" devices (*MotionLinx-Ai* modules). The data object types supported by *MotionLinx-Ai* are CoE Process Data Objects (PDOs) and Service Data Objects (SDOs). PDOs are subdivided into Transmit and Receive typs. *MotionLinx-Ai* provides 3 "Recieve" PDOs for which the master controller sends data to a given *MotionLinx-Ai* slave device. *MotionLinx-Ai* provides 2 "Transmit" PDOs for which the slave device sends data to the master controller.

Please consult CoE documentation for further details of CanOpen network protocol definition.

For each *MotionLinx-Ai* device in your project, you can expand the tree in TwinCAT to see each of these PDOs.

In the expanded tree you can see the 2 Transmit PDOs and the 3 Receive PDOs with their respective data elements or "SubIndex". The following sections of this guide will define the usage of each of these data elements.



TRANSMIT PDOS

There are two transmit PDOs provided by the *MotionLinx-Ai* module. This is the data that originates from the *MotionLinx-Ai* module that is made available as input to the master controller.

TRANSMIT PDO0 – MODULE INPUTS (OBJECT 0X1A00)

This chart shows the data sent by a *MotionLinx-Ai* on Transmit PDO0.

SubIndex	*Index*	*Data Type*	*Data Description*
SubIndex 1 All Sensors	**Index 0x3000 SubIndex 0**	**INT**	Bitwise Value - Read only bit 00 = Left Sensor Port – Aux Input bit 01 = Reserved bit 02 = Right Sensor Port – Aux Input bit 03 = Reserved bit 04 = Left Sensor Port – Sensor Input bit 05 = Reserved bit 06 = Right Sensor Port – Sensor Input bit 07 thru bit 14 = Reserved bit 15 = 2 sec on / 2 sec off heartbeat See *Appendix B - IOX-2Breakout Module* for details on how to connect to Aux input
SubIndex 2 Servo State Left Motor	**Index 0x3001 SubIndex 0**	**SINT**	Bit 0: Servo Command Status 1 = Last Servo Run Command Complete 0 = Servo Command in Process Bit 1: Servo Reset Status Echoes state of Left Motor Servo Command bit 0 Bit 2: Servo Command Status Echoes state of Left Motor Servo Command bit 1
SubIndex 3 Servo State Right Motor	**Index 0x3006 SubIndex 0**		
SubIndex 4 Servo Position Left Motor	**Index 0x3002 SubIndex 0**	**INT**	Signed integer value that indicates the current position of the Left Motor in relation to its "0" position • For MDR the value is in mm • For PGD the value is in motor pulses
SubIndex 5 Servo Position Right Motor	**Index 0x3002 SubIndex 0**	**INT**	Signed integer value that indicates the current position of the Right Motor in relation to its "0" position • For MDR the value is in mm • For PGD the value is in motor pulses

TRANSMIT PDO1 – MODULE DIAGNOSTICS (OBJECT 0X1A01)

This chart shows the data sent by a *MotionLinx-Ai* on Transmit PDO1.

SubIndex	*Index*	*Data Type*	*Data Description*	
SubIndex 1 Module Diagnostic Left Motor	**Index 0x3001 SubIndex 0**	**INT**	Bitwise Value – See *Note* ①	
SubIndex 2 Module Diagnostic Right Motor	**Index 0x3005 SubIndex 0**	**INT**	bit 00 = Motor Status bit 01 = Motor Status bit 02 = Port in Digital Mode bit 03 = Reserved bit 04 = Reserved bit 05 = Board Overheat bit 06 = Over-Voltage bit 07 = Low Voltage	bit 08 = Overheated bit 09 = MaxTorque bit 10 = Short Circuit bit 11 = Motor Not Connected bit 12 = Overloaded bit 13 = Motor Stalled bit 14 = Hall Sensor Error bit 15 = Motor Not Used
SubIndex 3 System Diagnostic	**Index 0x3013**	**Byte**	bit 00 = Logic voltage is below 14V bit 01 = Left Motor set speed is greater than the max. allowed speed for the attached motor bit 02 = Left Motor set speed is less than the min. allowed speed for the attached motor bit 03 = Right Motor set speed is greater than the max. allowed speed for the attached motor bit 04 = Right Motor set speed is less than the min. allowed speed for the attached motor bit 05 = Reserved bit 06 = Reserved bit 07 = Reserved	

NOTE ①

Bits 0 and 1 are used in combination to provide 4 possible states for motor status. The following chart defines the bit values for these states:

Motor Status bit 0 and bit 1		
Bit 1	*Bit 0*	*Description*
0	0	Motor not running, standard or servo braking applied
0	1	Motor running in CCW Direction
1	0	Motor running in CW Direction
1	1	Motor not running and no braking applied (free to spin)

RECEIVE PDOS

There are 3 receive PDOs utilized by the *MotionLinx-Ai* module. This is the data that originates from the master controller that is received by the *MotionLinx-Ai* module.

RECEIVE PDO0 – MOTOR SETUP (OBJECT 0X1600)

SubIndex	*Index*	*Data Type*	*Data Description*
SubIndex 1 Motor Control Left	**Index 0x2000 SubIndex 0**	**SINT**	Bit 0: ON = Run Command OFF = Stop Command Bit 1: OFF = Run in Configured Direction ON = Run opposite of Configured Direction
SubIndex 2 Motor Control Right	**Index 0x200C SubIndex 0**	**SINT**	
SubIndex 3 Motor Speed Left	**Index 0x2001 SubIndex 0**	**INT**	Integer value to set the motor speed • For MDR the value is in mm/sec • For PGD the value is in motor RPM
SubIndex 4 Motor Speed Right	**Index 0x2002 SubIndex 0**	**INT**	
SubIndex 5 Brake Mode Left	**Index 0x200F SubIndex 0**	**SINT**	Integer Value to set the motor braking method See *Note* ④
SubIndex 6 Brake Mode Right	**Index 0x2010 SubIndex 0**	**SINT**	

RECEIVE PDO1 – MOTOR RAMPS (OBJECT 0X1601)

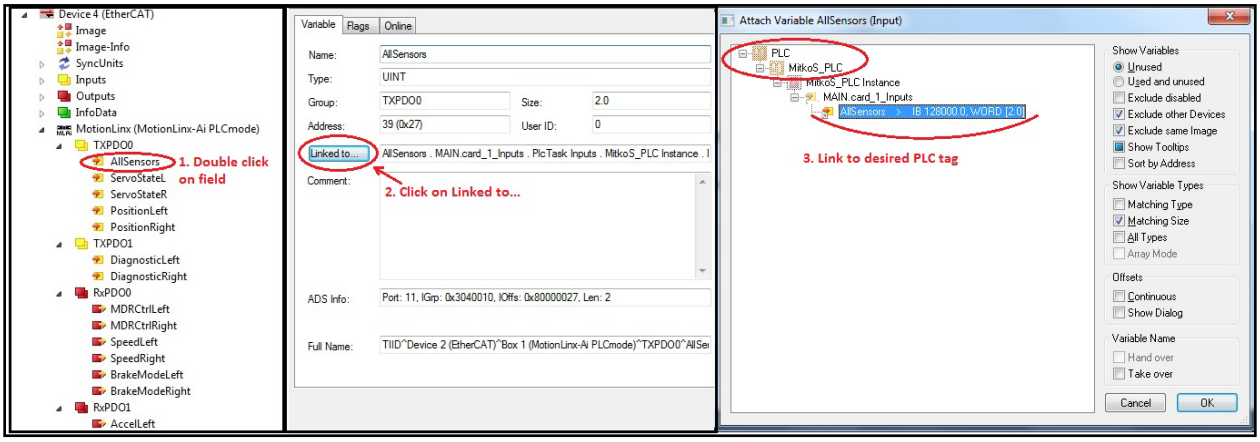
SubIndex	*Index*	*Data Type*	*Data Description*
SubIndex 1 Motor Acceleration Left	**Index 0x2003 SubIndex 0**	**INT**	Integer value to set the acceleration and deceleration for each motor • For MDR the value is in mm • For PGD the value is in motor pulses
SubIndex 2 Motor Deceleration Left	**Index 0x2004 SubIndex 0**	**INT**	
SubIndex 3 Motor Acceleration Right	**Index 0x2005 SubIndex 0**	**INT**	
SubIndex 4 Motor DecelerationRight	**Index 0x2006 SubIndex 0**	**INT**	

RECEIVE PDO2 – SERVO/PERIPHERY (OBJECT 0X1602)

SubIndex	Index	Data Type	Data Description
SubIndex 1 Servo Control	**Index 0x2007 SubIndex 0**	**INT**	Bit 0: Reset Command Left Motor 1 = Set Current Position as "0" Bit 1: Servo Run Command Left Motor 1 = Run Motor from current position value to value in Set Motor Servo Left SubIndex Bit 8: Reset Command Right Motor 1 = Set Current Position as "0" Bit 9: Servo Run Command Right Motor 1 = Run Motor from current position value to value in Set Motor Servo Right SubIndex All other bits reserved
SubIndex 2 Set Motor Servo Left	**Index 0x2008 SubIndex 0**	**INT**	Signed integer value to move to on the next Servo Run Command Left Motor • Values are in mm for MDR • Values are in motor pulses for PGD • Valid values are from -32767 to +32767
SubIndex 3 Set Motor Servo Right	**Index 0x2009 SubIndex 0**	**INT**	Signed integer value to move to on the next Servo Run Command Right Motor • Values are in mm for MDR • Values are in motor pulses for PGD • Valid values are from -32767 to +32767
SubIndex 4 Set Sensor Port Pin 2 Outputs	**Index 0x2011 SubIndex 0**	**Byte**	If either or both Sensor ports have been configured as Outputs this numerical value controls their digital state: 0 = Both OFF 1 = Energize Left Sensor Port Pin 2 Only 2 = Energize Right Sensor Port Pin 2 Only 3 = Energize Both
SubIndex 5 Clear Motor Error	**Index 0x2012 SubIndex 0**	**Byte**	Numerical value to clear a motor error on either or both Motor Ports: 1 = Clear Motor Error If there is a motor error present, MotionLinx must see a transition from 0 to 1 to clear the error. Maintaining a constant value of 1 will not automatically clear a motor error if it occurs.

USING PDO DATA

Once each device has been added to your project; you need to link the desired PDO objects from each *MotionLinx-Ai* device to Tag variables you create in your PLC task. You then read/write to your PLC Tag Variables to access and control each *MotionLinx-Ai* module's functions.



SERVICE DATA OBJECTS (SDOS)

SDOs are used for data that is not intended to be cyclic like PDOs. The use of SDOs can be thought of as "lower priority" and are invoked on an "as needed" basis. For *MotionLinx-Ai*, there are 4 SDOs recognized:

- Configuration
- Service Read Object
- Left Motor Data
- Right Motor Data

CONFIGURATION SDO – INDEX 0X4000

The following table defines each item in the Configuration SDO

SubIndex	*Data Type*	*Data Description*
SubIndex 01 **Sensor Polarity**	**INT**	Bitwise Value bit 00 = Left Sensor Port – Aux Input bit 01 = Reserved bit 02 = Right Sensor Port – Aux Input bit 03 = Reserved bit 04 = Left Sensor Port – Sensor Input bit 05 = Reserved bit 06 = Right Sensor Port – Sensor Input bit 07 thru bit 15 = Reserved See *Note* ②
SubIndex 02 **Sensor Debounce**	**INT**	Value in msec. Specifies the time after a leading or trailing edge of the signal for which any other transitions are ignored.
SubIndex 03 **Push-Pull Sensor Type**	**INT**	Bitwise Value bit 00 = Left Sensor Port Inputs bit 01 = Right Sensor Port Inputs bit 02 thru bit 15 = Reserved bit = ON: Both Inputs on the port are set to Push-Pull bit = OFF: Both inputs on the port are set to NPN/PNP Auto-Detect
SubIndex 04 **Motor Type Left**	**INT**	Integer value to set the motor type See *Note* ③
SubIndex 05 **Motor Type Right**	**INT**	
SubIndex 06 **Brake Mode Left**	**INT**	Integer Value to set the motor braking method See Note ④
SubIndex 07 **Brake Mode Right**	**INT**	
SubIndex 08 **Motor Speed Left**	**INT**	Integer value to set the motor speed • For MDR the value is in mm/sec • For PGD the value is in motor RPM
SubIndex 09 **Motor Speed Right**	**INT**	

SubIndex	Data Type	Data Description
SubIndex 0A InOrOutPin2	**INT**	Integer value to set the function of the Left and/or Right Sensor Port Pin2 1 = Use Left Sensor Port Pin 2 as OUTPUT 2 = Use Right Sensor Port Pin 2 as OUTPUT 3 = Use Both Left and Right Sensor Port's Pin 2 as OUTPUT
SubIndex 0B Left Motor Slave	**INT**	Integer value to set the function of the Left Motor 0 = Left Motor will maintain its own separate control from the Right Motor 1 = Left Motor will "slave" to Right Motor.
SubIndex 0C Right Motor Slave	**INT**	Integer value to set the function of the Right Motor 0 = Right Motor will maintain its own separate control from the Right Motor 1 = Right Motor will "slave" to Left Motor.

NOTE ②

In this SDO register, when a given bit is set to 1; the logical state of the corresponding bit in the All Sensors object of PDO0 is inverted. This also inverts the LED state displayed on the module.

This is provided as a convenience for the master controller programmer. For example, the master controller could have re-useable code or routines that expect a photo sensor to have its electrical signal ON when it is "blocked". Let's say on a given *MotionLinx-Ai* module, you need to connect a photo sensor whose electrical signal is OFF when "blocked". Instead of modifying the program logic in each and every place this input is used; you can simply change its logical polarity with this SDO register. This logical polarity setting also affects the LED state.

For example, by default when the Left Sensor input is electrically energized, its corresponding LED illuminates green and bit 4 of the All Sensors PDO register is a 1. If you set bit 4 in the SDO Sensor Polarity register; when the Left Sensor input is electrically energized, bit 4 of the All Sensors PDO is 0 and its corresponding LED is off.

NOTE ③

The values for motor type are as follows

Value	Motor Type	Description
0	ECO Plus	See *Appendix C – Power Supply Loading* on page 51 for details on Motor Types
1	ECO	
2	Boost	
3	Boost 8	

NOTE ④

The following table defines the MDR Braking Methods available:

Value	Method	Description
0	**Normal**	Standard Dynamic braking - MDR power circuit in *MotionLinx-Ai* is internally connected during motor stop sequence to provide backward energy to bring rotor to a stop. When *MotionLinx-Ai* has detected that the motor has stopped; all winding current is shut off from the motor windings. This is the industry standard braking method and is the default factory setting for all *MotionLinx-Ai* modules
1	**Free**	MDR power circuit in *MotionLinx-Ai* is internally disconnected to allow rotor to "free spin" until its mechanical load brings it to a stop.
2	**Servo Brake**	When a motor is commanded to stop; the *MotionLinx-Ai* utilizes the motor's Hall Effect sensors to determine the position of the rotor and will inject current into the motor windings to maintain rotor position.

Please note that for Servo Brake modes, the motor circuitry supplies power to the motor to keep it in position. The more torque required to hold the motor rotor position will result in more current being supplied. Prolonged braking at higher torque values can result in motor over current and/or over heating conditions.

SERVICE READ OBJECT SDO – INDEX 0X4001

The following table defines each item in the Service Read Object SDO

SubIndex	*Data Type*	*Data Description*
SubIndex 01 Motor Voltage	**INT**	Motor voltage value in mV *Example: 24000 = 24V*
SubIndex 02 Logic Voltage	**INT**	Logic voltage value in mV *Example: 23500 = 23.5V*
SubIndex 03 Sensor Detect	**INT**	Integer value indicating if Sensor Port circuitry detects a device connected 0 = No devices detected on either Left or Right Sensor Ports 1 = Device detected on Left Sensor Port 2 = Device detected on Right Sensor Port 3 = Device detected on both Left and Right Sensor Ports
SubIndex 04 Left Motor Temperature	**INT**	Numerical value of temperature in °C: • High Byte = Motor Sensor Temperature • Low Byte = Controller Driver Sensor Temperature
SubIndex 05 Right Motor Temperature	**INT**	
SubIndex 06 Left Motor Current	**INT**	Motor current value in mA
SubIndex 07 Right Motor Current	**INT**	
SubIndex 08 Left Motor Max Speed	**INT**	Numerical value of maximum speed: • For Motor Rollers the value is in mm/sec • For PGD value is in RPM x 10
SubIndex 09 Right Motor Max Speed	**INT**	
SubIndex 0A Left Motor Real Speed	**INT**	Numerical value of current motor running speed: • For Motor Rollers the value is in mm/sec • For PGD value is in RPM x 10
SubIndex 0B Right Motor Real Speed	**INT**	
SubIndex 0C Left Motor Frequency	**INT**	Numerical value of current motor running frequency in Hz
SubIndex 0D Left Motor Frequency	**INT**	
SubIndex 0E Left Motor PWM	**INT**	Current motor running PWM in % of maximum allowed *Example: 800 = 80%*
SubIndex 0F Right Motor PWM	**INT**	

Motor Data Left & Motor Data Right SDO – Index 0x4100 / 0x4101

The Motor Data SDOs make the Ai motor data available to the master controller. Each Ai motor (MDR or PGD) has internal memory that is written upon final manufacturing. This data includes serial number, manufacture date, roller dimensions, etc. The following table identifies each element available in these SDOs. Please note that the data for the Left Motor is at Index 0x4100 and the data for the Right Motor is at index 0x4101.

Sub Index	Item	Data Type	Data Description
1	**Production ID**	**INT**	Sequence number for the items manufactured on the manufacture day
2	**Customer ID**	**SINT**	Customer code
3	**Roller Type**	**SINT**	ASCII value indicating roller type: • A = Standard • T = Tapered • W = Wash down rated (IP66) • Z = Freezer rated (-30°C)
4	**Motor Type**	**SINT**	Value indicating Motor Type • 0 = MDR • 1 = PGD
5	**Tube Diameter**	**SINT**	Tube diameter in millimeters (not applicable for PGD)
6	**Speed Code / Gearbox**	**SINT**	Value indicating gear reduction • Value is the Speed Code if type is MDR • Value is Gear Ratio if PGD
7	**Interlock**	**SINT**	ASCII value indicating roller to roller connection: • A = Straight • B = V-Pulley • G = Grooved • H = Micro-V Pulley
8	**Manufacture Month**	**SINT**	Numerical value of the month of manufacture (1 thru 12)
9	**Manufacture Year**	**SINT**	Numerical value of the last two digits of the year of manufacture
10	**Shaft**	**SINT**	Internally coded numerical value
11	**Tube Material**	**SINT**	ASCII value indicating roller to roller connection: • A = Steel • B = 3mm Black Rubber • J = Stainless Steel • Q = 2mm PVC Sleeve • W = 3mm Urethane • Z = Zinc
12	**Motor Length**	**INT**	MDR length in mm
13	**Manufacture Day**	**SINT**	Day of the month when manufactured (1 thru 31)
14	**Assembly Country**	**SINT**	Numerical value indicating place of manufacture • 0 = Europe • 1 = Japan • 2 = USA
15	**Time**	**DINT**	The amount of elapsed time in minutes the motor has been running
16	**Time Current Limit**	**DINT**	The amount of time in minutes the motor has been running at current limit
17	**Time Overheat**	**DINT**	The amount of time in minutes the motor has been running overheated
18	**On/Off Cycles**	**DINT**	The number of times the motor has been cycled on and off
19	**Over Voltage Count**	**DINT**	The number of times the module voltage has exceeded 30V
20	**Under Voltage Count**	**DINT**	The number of times the module voltage has fell below 18V

MOTIONLINX-AI FILE OVER ETHERCAT

The *MotionLinx-Ai* supports the FoE (File-over-EtherCAT) protocol for file transfer over EtherCAT network. This protocol is used for two purposes:

To upgrade the firmware of the *MotionLinx-Ai*

To upload/upgrade the ESI file of the on board EtherCAT slave controller switch

Please note that the firmware version must match the firmware version referenced in the ESI file in order for the MotionLinx –Ai module to properly operate.

MOTIONLINX-AI FIRMWARE UPGRADE

Module firmware upgrades can only be installed with the TwinCAT software. The TwinCAT software will allow you to upgrade one, several, or all modules on your network.

Firmware upgrade files, when available, can be downloaded from Pulseroller.com

Once you have downloaded the firmware file (it will always have a .bin file extension); place it in an accessible folder on your PC. In TwinCAT, select the device or devices you want to upgrade and perform "Firmware Upgrade" as shown in Figure 19.

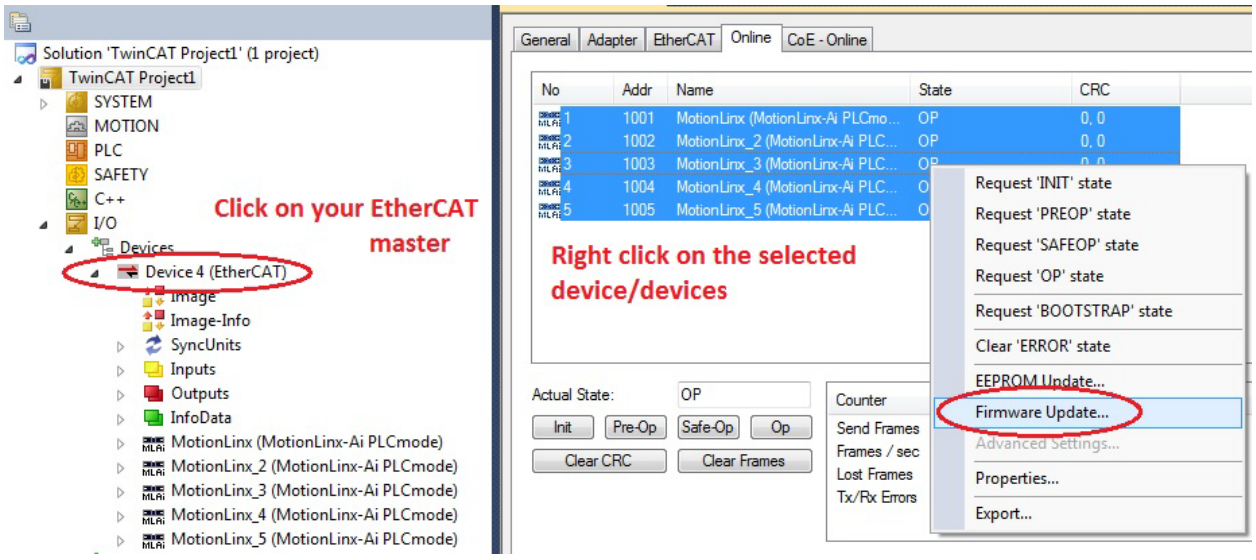


FIGURE 19 - FIRMWARE UPGRADE EXAMPLE

When you select "Firmware Upgrade" a browsing window will appear. Navigate to where you placed the downloaded file and select. Please note you will have to enter a password (49) to complete the upgrade as shown in Figure 20.

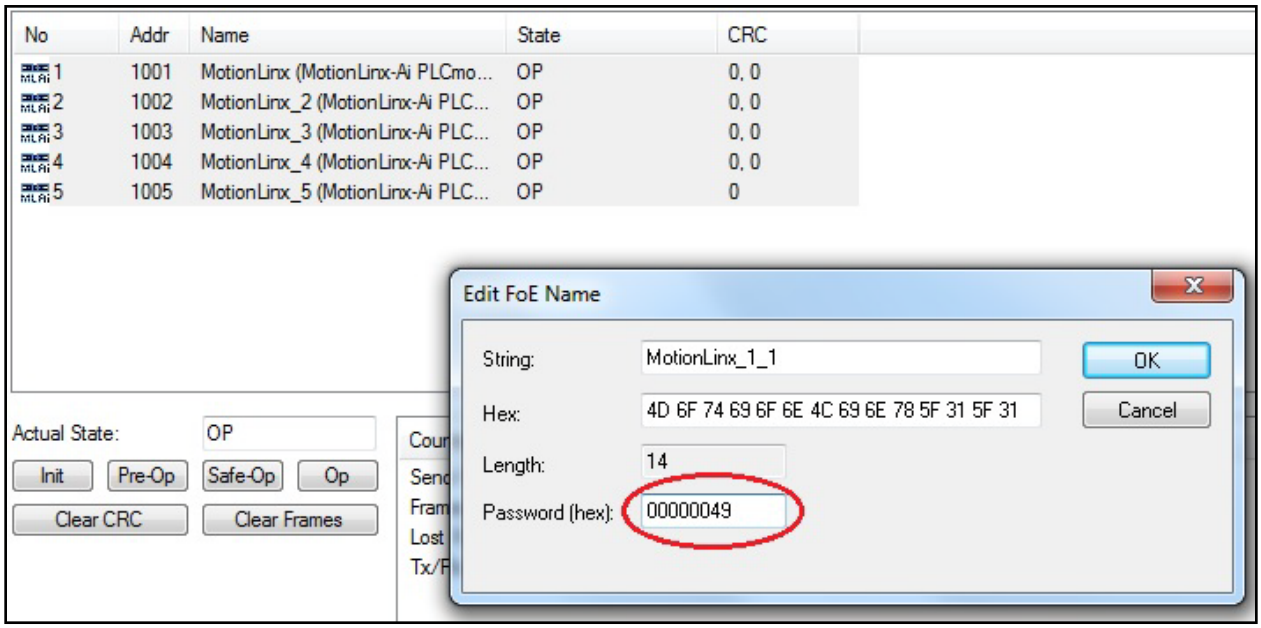


FIGURE 20 - FIRMWARE UPGRADE EXAMPLE WITH PASSWORD

MOTIONLINX-AI ESI FILE UPGRADE

Similar to the module firmware upgrade, the ESI upgrade follows the same procedure except you select "EEPROM Update" from the menu as shown in Figure 21.

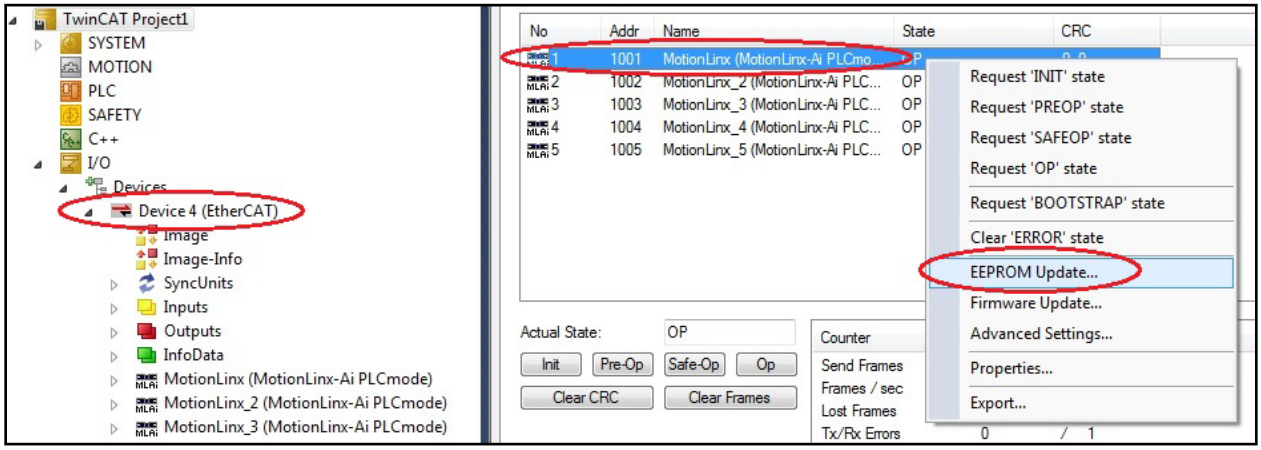
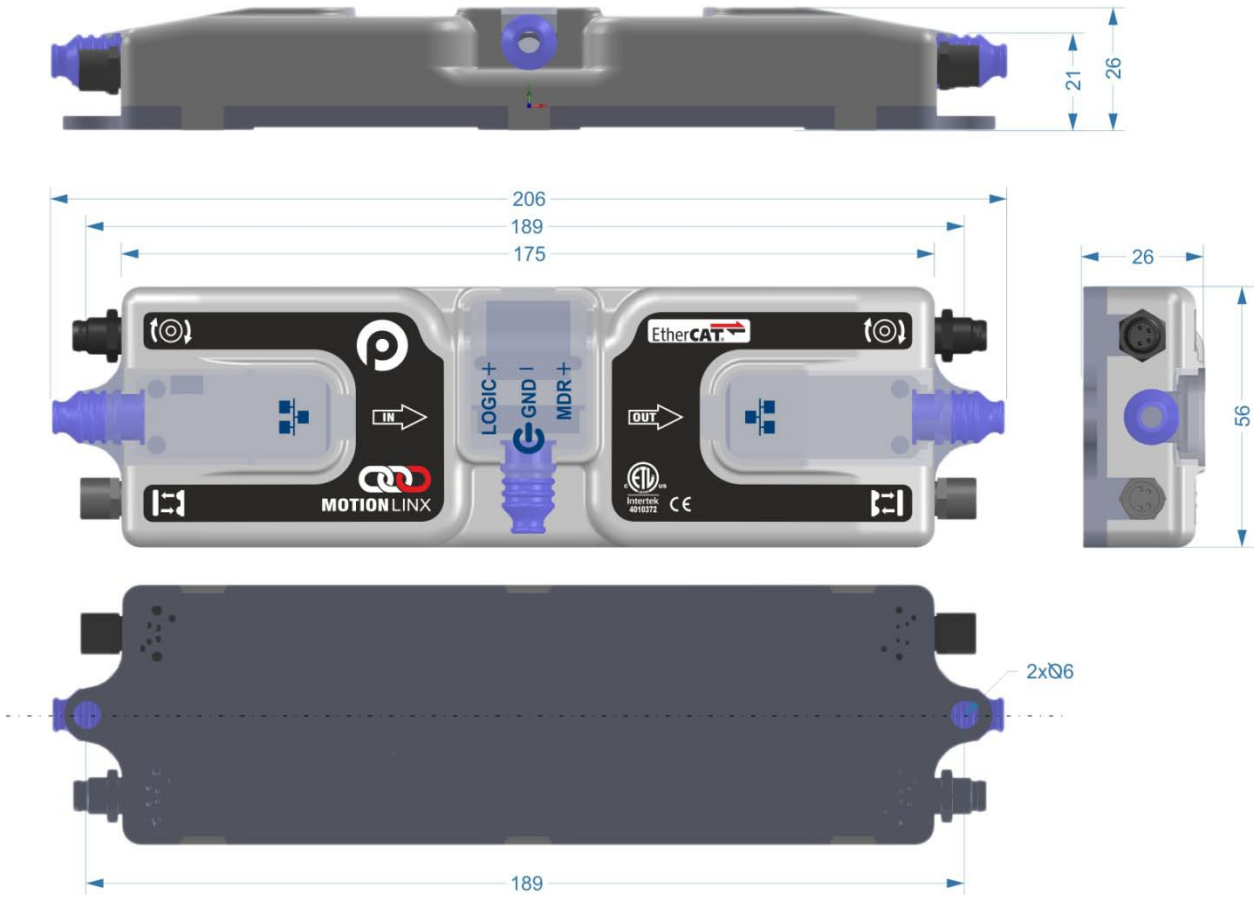


FIGURE 21 - ESI FILE UPGRADE EXAMPLE

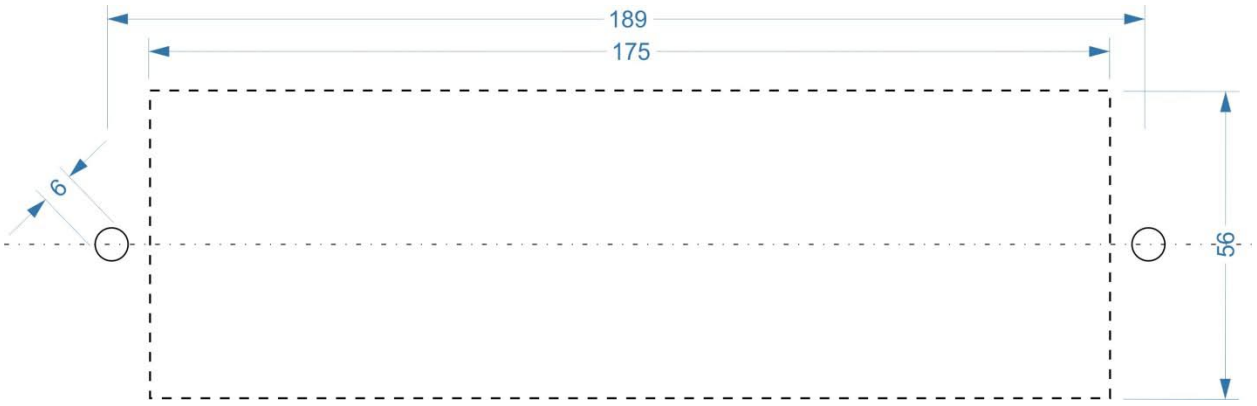
APPENDIX A – MODULE SPECIFICATIONS

DIMENSIONS

Dimensions in mm



MOUNTING DIMENSIONS



ENVIRONMENTAL AND ELECTRICAL

Power supply Voltage	24.0V +/- 10 %
Standby current consumption	less than 120mA
Motor Starting Current	8A or lower
Motor Rated Current Torque-On-Demand	up to 8A
Minimum Operating Voltage	21V
Maximum Operating Voltage	30V
Storage temperature	-40C to 120C(-40F to 248F)
Ambient Operating temperature	0C to 50C(32F to 122F)
Humidity	5% to 95% non-condensing
Vibration	0.152 mm (0.006 in.) displacement, 1G peak
Mechanical Shock	20G peak for 10ms duration (1.0 ms)
Enclosure IP Rating	IP54
Maximum peak current	21.5A*
Maximum motor start current	12A

*This is the maximum current that will be allowed by the hardware over current protection circuitry. Onboard firmware limits the amount of current based on the quantity and motor types connected.

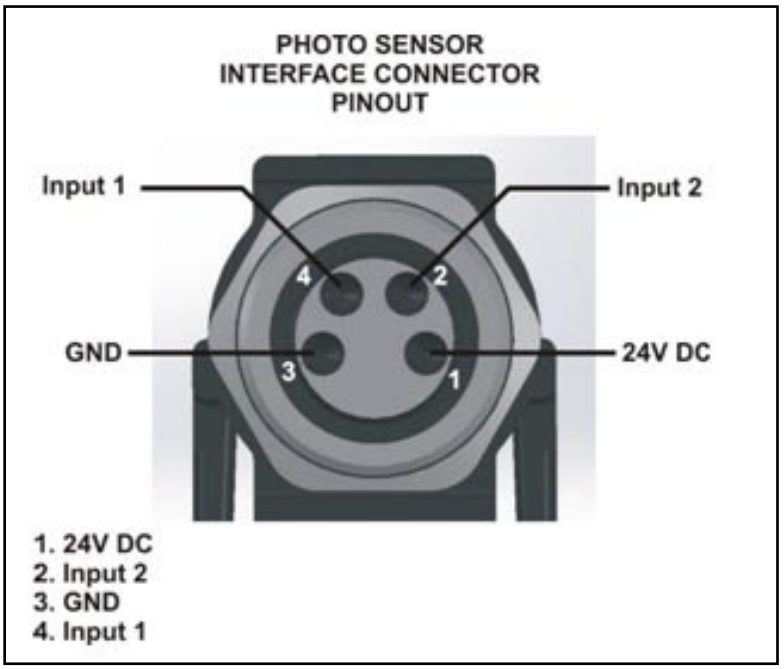
SENSOR PORT

Inputs	• PNP/NPN Auto-sensing (Default) • 4 per module - 2 inputs per sensor port • Programmable Push-Pull selectable
Minimum ON current	1.5mA
Maximum OFF current	0.4mA

Sensor port inputs are auto-sensing for the connected circuit type of either PNP or NPN. Please note that both sourcing and sinking current will activate the input.

Both Left and Right Sensor ports are protected by a single 200mA resettable fuse. Combined current between Left and Right ports cannot exceed 200mA.

Both Left and Right Sensor ports utilize load detection circuits between the +24V (Pin 1) and Gnd (Pin 3). This circuit provides input to the processor such that sensor detected status can be known. Short circuit between Pin 1 and Pin 3 can cause damage to the load detection circuit and render this function inoperable.



Motor Ports

Supported Motor Types	Senergy-Ai
PWM frequency*	25 kHz +/- 0.1%
Maximum starting current	8A
Maximum rated current Torque-On-Demand	up to 8A
Motor Protection**	• Coil-to-coil short circuit detection • Coil-to-Vcc short circuit detection • Overheating detection • Over-voltage detection • Undervoltage detection • Stall detection

*The PWM frequency is firmware version dependent.

**During normal operation as an MDR port, the internal protection circuitry is not capable of detecting a short-circuit between a BLDC coil output and ground and such a short-circuit will cause damage to the high-side bridge transistors.

Ethernet Specification

- 2 port integrated EtherCAT switch . Port A and Port B are marked on the chassis.
- 100Mb network speed
- Back pressure flow control support

Supported Industrial Ethernet protocols

- EtherCAT

APPENDIX B - IOX-2BREAKOUT MODULE

The IOX-2breakout module provides a convenient plug and play means to separate the Sensor (Input 1) and Aux Input (Input 2) signals on the *MotionLinx-Ai* module's Sensor Port. The IOX-2 utilizes M8 style connection headers so you can connect your M8 style sensors as well as M8 style cable (or additional sensor) for access to the Aux Input Pin 2 signal. The IOX-2 also contains wire terminal access for the Aux Input Pin 2 signals for complete flexibility.

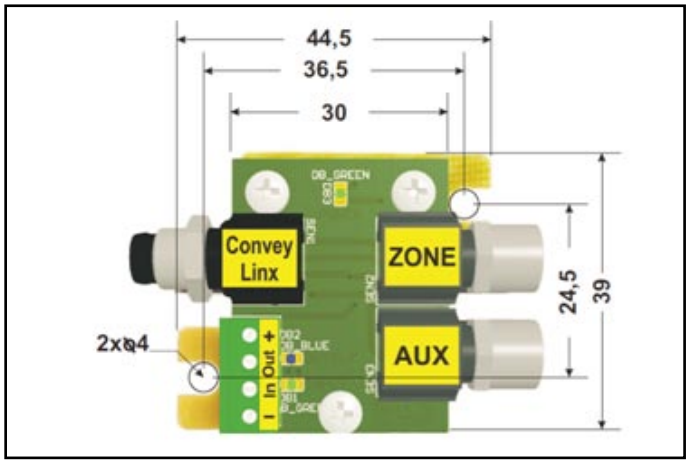


FIGURE 22 - IOX-2 MODULE (DIMENSIONS IN MM)

The following figures illustrate the typical usage and connection details for *MotionLinx-Ai* applications

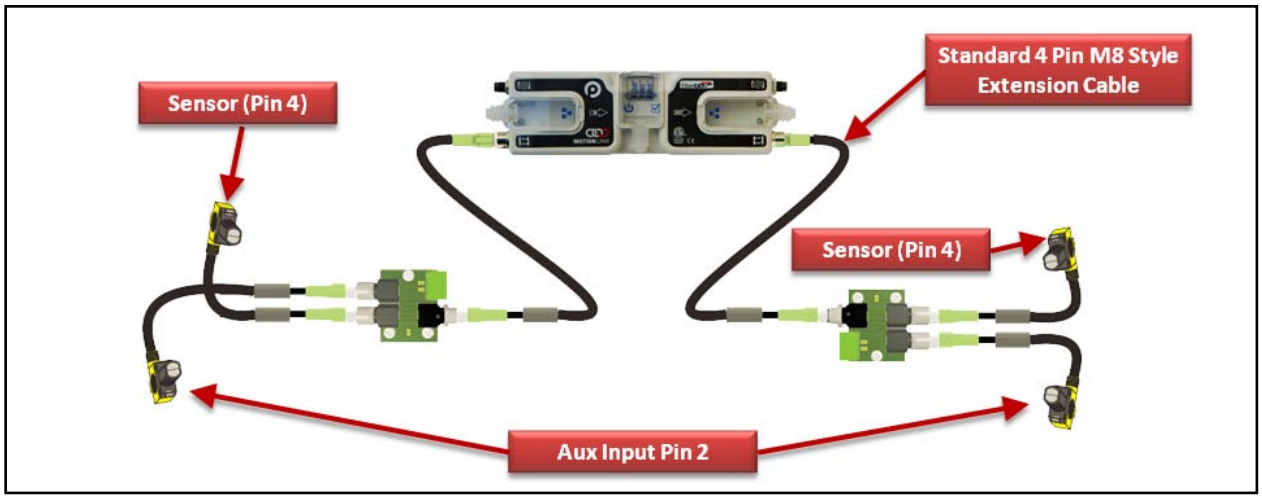


FIGURE 23 – 4 M8 SENSORS CONNECTED WITH 2 IOX MODULES

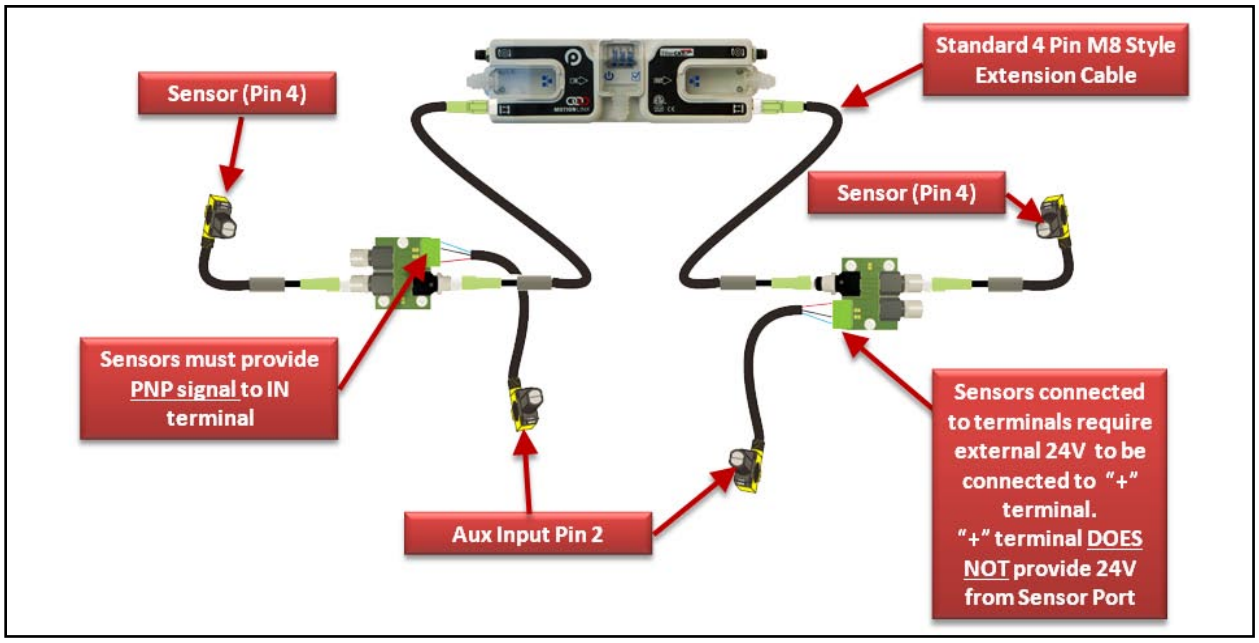


FIGURE 24 – 2 M8 SENSORS AND 2 SENSORS WIRED TO TERMINALS

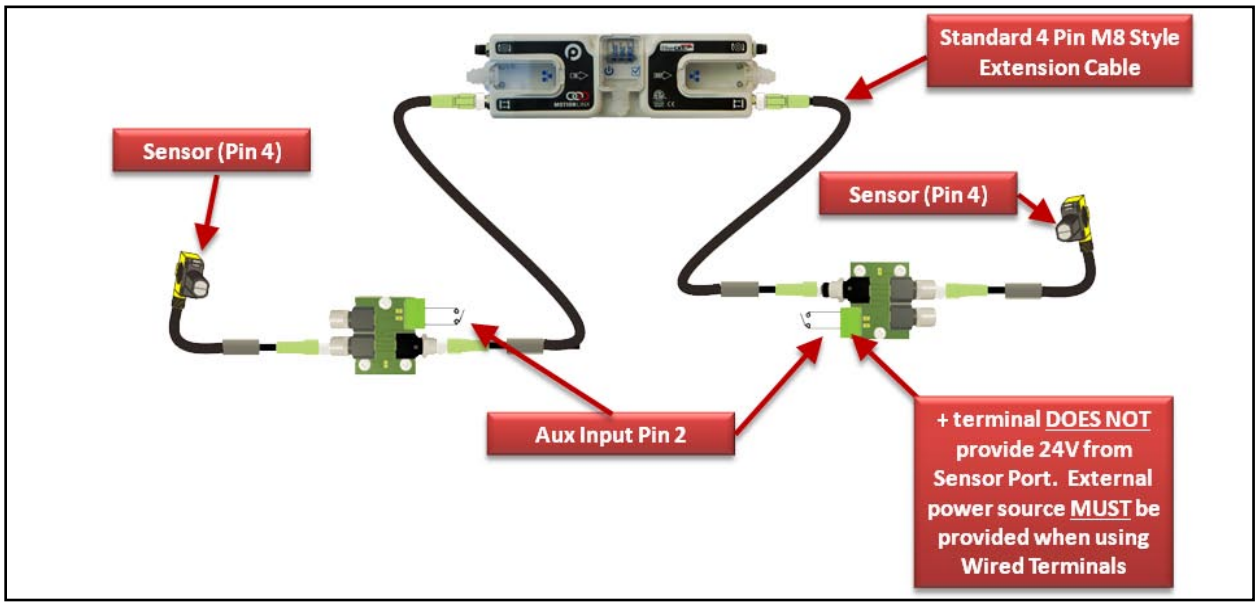


FIGURE 25 – 2 M8 SENSORS AND 2 SWITCH CONTACTS WIRED TO TERMINALS

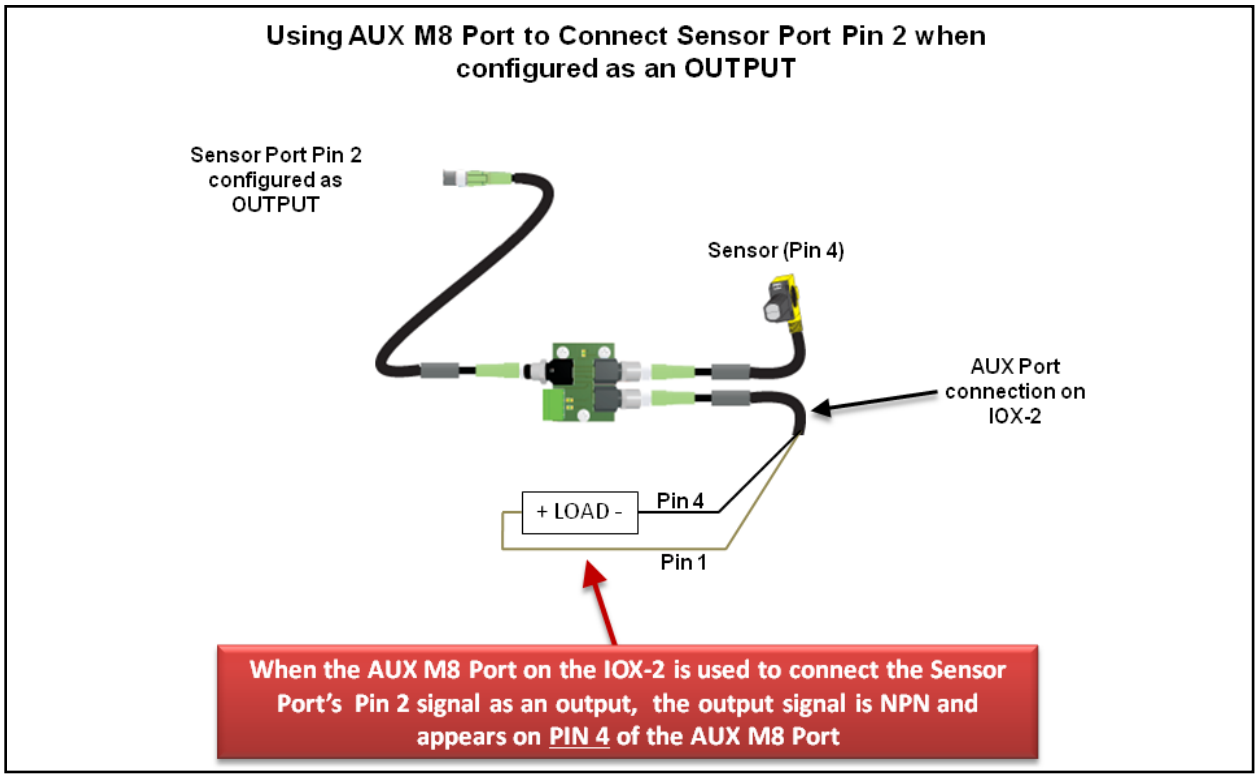


FIGURE 26 - AUX M8 PORT USED WHEN SENSOR PORT PIN2 IS CONFIGURED AS OUTPUT

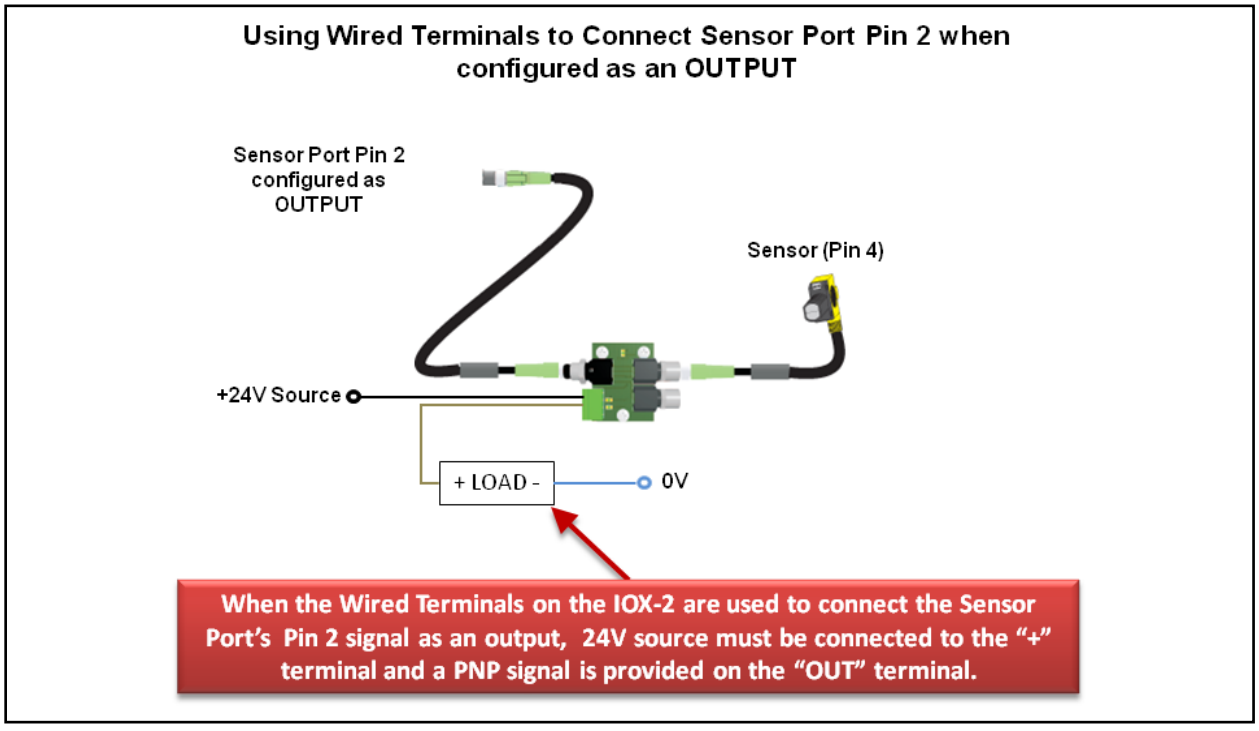


FIGURE 27 - USING WIRED TERMINALS FOR SENSOR PORT PIN 2 CONFIGURED AS AN OUTPUT

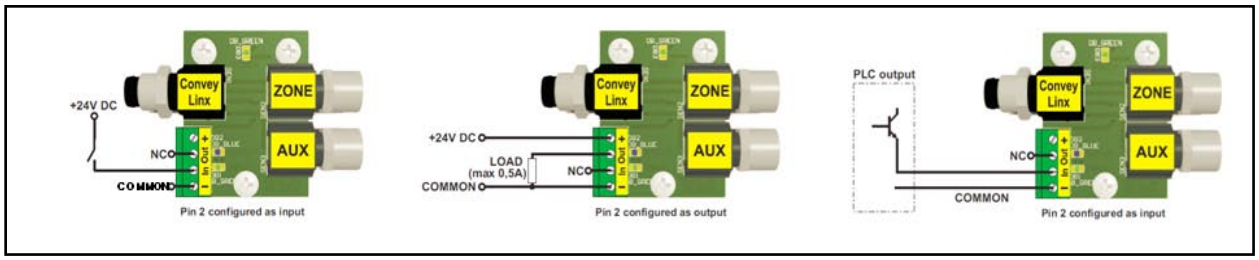


FIGURE 28 - TYPICAL CONNECTION WIRING DIAGRAMS

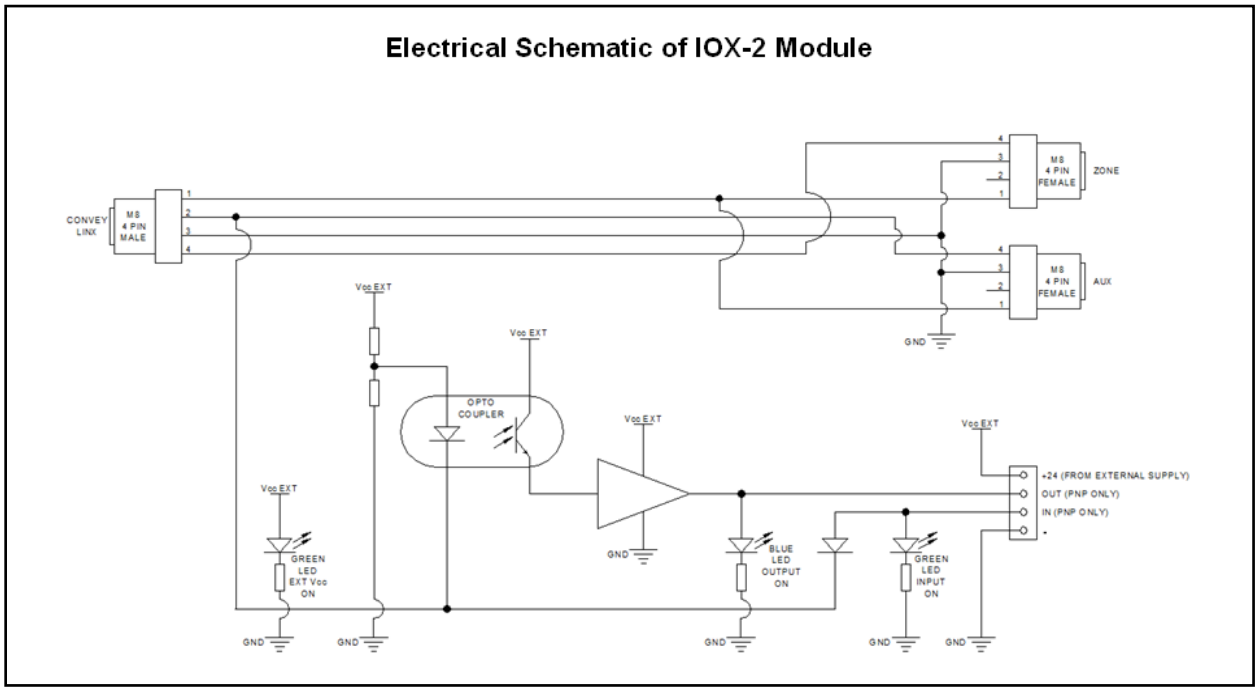


FIGURE 29 - ELECTRICAL SCHEMATIC OF IOX-2 MODULE

APPENDIX C – POWER SUPPLY LOADING

The current loading on the power supply for a group of MotionLinx modules depends upon the Motor Type selected. Each of the motor types available has an associated rated current that the motor will draw at rated torque and maximum speed. Each motor type also has an associated allowed current draw that is available for a period of time upon the initial starting of the motor. Theses current values and starting times are shown in the following chart:

	ECO	*ECO Plus*	*Boost*	*Boost 8*
Power supply load per Motor Port at rated torque at maximum speed	2.5 A	2.5 A	3.5 A	3.5 A
Power supply load per Motor Port during motor starting period	3.0 A	4.1 A	5.0 A	8.0 A
Duration of motor starting period	5.0 sec.	No time limit	1.5 sec	3.0 sec

Please note that the current values shown are per Motor Port, so if both Motor Ports are being used on a given MotionLinx module, the current load seen by the power supply for that module will be double the value shown.

NOTES:

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Publication ML-1000 Rev 1.6 – November 2017