Remote Input & Output (RIO) Module

User Manual

Part Number 609642, Revision A

Brooks Automation

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Table of Contents

1. Safety

Safety Setup

Brooks uses caution, warning, and danger labels to convey critical information required for the safe and proper operation of the hardware and software. Read and comply with all labels to prevent personal injury and damage to the equipment.

DANGER

Read the Safety Chapter

Failure to review the *Safety* chapter and follow the safety warnings can result in serious injury or death.

- All personnel involved with the operation or maintenance of this product must read and understand the information in this safety chapter.
- Follow all applicable safety codes of the facility as well as national and international safety codes.
- Know the facility safety procedures, safety equipment, and contact information.
- Read and understand each procedure before performing it.

Authorized Personnel Only

This product is intended for use by trained and experienced personnel. Operators must comply with applicable organizational operating procedures, industry standards, and all local, regional, national, and international laws and regulations.

Explanation of Hazards and Alerts

This manual and this product use industry standard hazard alerts to notify the user of personal or equipment safety hazards. Hazard alerts contain safety text, icons, signal words, and colors.

Safety Text

Hazard alert text follows a standard, fixed-order, three-part format.

- Identify the hazard
- State the consequences if the hazard is not avoided
- State how to avoid the hazard.

Safety Icons

- Hazard alerts contain safety icons that graphically identify the hazard.
- The safety icons in this manual conform to ISO 3864 and ANSI Z535 standards.

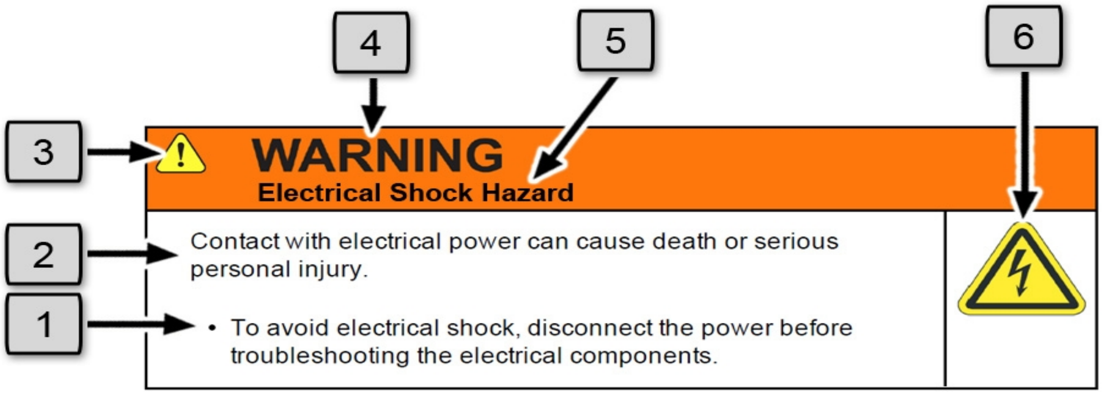
Signal Words and Color

Signal words inform of the level of hazard.

	Danger indicates a hazardous situation which, if not avoided, **will result in serious injury or death**. The Danger signal word is white on a red background with an exclamation point inside a yellow triangle with black border.
	Warning indicates a hazardous situation which, if not avoided, **could result in serious injury or death**. The Warning signal word is black on an orange background with an exclamation point inside a yellow triangle with black border.
	Caution indicates a hazardous situation or unsafe practice which, if not avoided, **may result in minor or moderate personal injury**. The Caution signal word is black on a yellow background with an exclamation point inside a yellow triangle with black border.
	Notice indicates a situation or unsafe practice which, if not avoided, **may result in equipment damage**. The Notice signal word is white on blue background with no icon.

Alert Example

The following is an example of a Warning hazard alert.



Number	Description
1.	How to Avoid the Hazard
2.	Source of Hazard and Severity
3.	General Alert Icon
4.	Signal Word
5.	Type of Hazard
6.	Hazard Symbol(s)

General Safety Considerations

WARNING
Software

Software is not safety rated. Unplanned motion can occur as long as power is supplied to the motors. Maximum torque could be momentarily applied that may cause equipment damage or personal injury.

- Only operate the robot with its covers installed.
- Guarantee that safety controller features are in place (for example, an emergency stop button and protective stop).
- Regularly test safety components to prove that they function correctly.

WARNING
Robot Mounting

Before applying power, the robot must be mounted on a rigid test stand, secure surface, or system application. Improperly mounted robots can cause excessive vibration and uncontrolled movement that may cause equipment damage or personal injury.

- Always mount the robot on a secure test stand, surface, or system before applying power.

WARNING
Do Not Use Unauthorized Parts

Using parts with different inertial properties with the same robot application can cause the robot's performance to decrease and potentially cause unplanned robot motion that could result in serious personal injury.

- Do not use unauthorized parts.
- Confirm that the correct robot application is being used.

WARNING

Magnetic Field Hazard

This product contains magnetic motors that can be hazardous to implanted medical devices, such as pacemakers, and cause personal harm, severe injury, or death.

- Maintain a safe working distance of 30 cm from the motor when with an energized robot if you use a cardiac rhythm management device.

CAUTION

Unauthorized Service

Personal injury or damage to equipment may result if this product is operated or serviced by untrained or unauthorized personnel.

- Only qualified personnel who have received certified training and have the proper job qualifications are allowed to transport, assemble, operate, or maintain the product.

CAUTION

Damaged Components

The use of this product when components or cables appear to be damaged may cause equipment malfunction or personal injury.

- Do not use this product if components or cables appear to be damaged.
- Place the product in a location where it will not get damaged.
- Route cables and tubing so that they do not become damaged and do not present a personal safety hazard.

CAUTION

Inappropriate Use

Use of this product in a manner or for purposes other than for what it is intended may cause equipment damage or personal injury.

- Only use the product for its intended application.
- Do not modify this product beyond its original design.
- Always operate this product with the covers in place.

CAUTION

Seismic Restraint

The use of this product in an earthquake-prone environment may cause equipment damage or personal injury.

- The user is responsible for determining whether the product is used in an earthquake prone environment and installing the appropriate seismic restraints in accordance with local regulations.

Mechanical Hazards

CAUTION

Pinch Point

Moving parts of the product may cause squeezing or compression of fingers or hands resulting in personal injury.

- Do not operate the product without the protective covers in place.

WARNING

Automatic Movement

Whenever power is applied to the product, there is the potential for automatic or unplanned movement of the product or its components, which could result in personal injury.

- Follow safe practices for working with energized products per the facility requirements.
- Do not rely on the system software or process technology to prevent unexpected product motion.
- Do not operate the product without its protective covers in place.
- While the collaborative robotics system is designed to be safe around personnel, gravity and other factors may present hazards and should be considered.

CAUTION

Vibration Hazard

As with any servo-based device, the robot can enter a vibratory state resulting in mechanical and audible hazards. Vibration indicates a serious problem. Immediately remove power.

- Before energizing, ensure the robot is bolted to a rigid metal chamber or stand.

Electrical Hazards

Refer to the specifications of the *Guidance Controller Quick Start Guide* for the electrical power.

DANGER

Electrical Shock Hazard

Contact with electrical power can cause personal harm and serious injury.

- To avoid electrical shock, disconnect the power before troubleshooting the electrical components.
- Check the unit's specifications for the actual system power requirements and use appropriate precautions.
- Never operate this product without its protection covers on.

WARNING

Electrical Burn

Improper electrical connection or connection to an improper electrical supply can result in electrical burns resulting in equipment damage, serious injury, or death.

- Always provide the robot with the proper power supply connectors and ground that are compliant with appropriate electrical codes.

WARNING

Electrical Fire Hazard

All energized electrical equipment poses the risk of fire, which may result in severe injury or death. Fires in wiring, fuse boxes, energized electrical equipment, computers, and other electrical sources require a Class C extinguisher.

- Use a fire extinguisher designed for electrical fires (Class C in the US and Class E in Asia).
- It is the facility's responsibility to determine if any other fire extinguishers are needed for the system that the robot is in.

NOTICE

Improper handling of the power source or connecting devices may cause component damage or equipment fire.

- Connect the system to an appropriate electrical supply.
- Turn off the power before servicing the unit.
- Turn off the power before disconnecting the cables.

Ergonomic Hazards

CAUTION

Heavy Lift Hazard

Failure to take the proper precautions before moving the robot could result in back injury and muscle strain.

- Use a lifting device and cart rated for the weight of the drive or arm.
- Only persons certified in operating the lifting device should be moving the product.

CAUTION

Tipover Hazard

This product has a high center of gravity which may cause the product to tip over and cause serious injury.

- Always properly restrain the product when moving it.
- Never operate the robot unless it is rigidly mounted.

CAUTION

Trip Hazard

Cables for power and communication and facilities create trip hazards which may cause serious injury.

- Always route the cables where they are not in the way of traffic.

Emergency Stop Circuit (E-Stop)

The integrator of the robot must provide an emergency stop switch.

WARNING

Emergency Stop Circuit

Using this product without an emergency stop circuit may cause personal injury.

- Customer is responsible for integrating an emergency stop circuit into their system.
- Do not override or bypass the emergency stop circuit.

Recycling and Hazardous Materials

Brooks Automation complies with the EU Directive 2002/96/EU Waste Electrical and Electronic Equipment (WEEE).

The end user must responsibly dispose of the product and its components when disposal is required. The initial cost of the equipment does not include cost for disposal. For further information and assistance in disposal, please email Brooks Automation Technical Support at support_preciseflex@brooksautomation.com.

2. Introduction to the Hardware

Overview

The Remote Input and Output (RIO) module (Figure 2-1) can add optically isolated digital input and output signals, analog inputs, and serial ports to any Guidance Controller. The RIO module connects to a controller via Ethernet and can be placed anywhere within the controller's local network. The RIO supports the MODBUS/TCP communications protocol and uses a variation of this to interface with a Guidance Controller. MODBUS/TCP is a "open" standard that is widely employed in industrial manufacturing environments to interconnect intelligent devices and intelligent sensors and is compatible with all standard Ethernet TCP/IP networks. An RIO can also be configured as a standalone controller or as a standard MODBUS/TCP slave device. The latter capability permits a PC that is executing MODBUS/TCP master software to directly connect to an RIO.

Figure 2-1: RIO Module

WARNING

The RIO contains unshielded 24VDC signals and pins. This product is intended to be mounted in a cabinet or machine chassis that is not accessible when power is turned on.

- Disconnect the electricity before servicing.

The Remote Input and Output (RIO) module can operate in one of two primary modes. It can act as a remote I/O expansion module for a Guidance Controller or a PC, or it can operate as an independent master controller that runs GPL programs in the same manner as a standard Guidance Controller.

As a remote I/O expansion module, the RIO executes its I/O Scanning Software and sends a MODBUS/TCP message to the master whenever an input changes. It also responds to any requests it receives from a master to access the RIO's various I/O ports. This mode of operation is selected by setting DataID 211 "GPL MODBUS/TCP master" to False.

As an independent master controller, the RIO can execute GPL programs that can control its local IO. These programs can also access other RIO boards or MODBUS/TCP slaves since, in this configuration, the RIO can function as a MODBUS?TCP master. In this mode of operation, the RIO can still be accessed as a MODBUS/TCP slave in the same manner as a Guidance Controller. This configuration is selected by setting DataID 211 "GPL MODBUS/TCP master" to True.

The Standard RIO module provides 32 optically isolated digital inputs and 32 optically isolated digital outputs and one RS-232 serial port. An enhanced version of the RIO adds 4 analog inputs, a second RS-232 port and one RS-422/485 port. Up to 4 RIO modules can be connected to a single controller.

All of the digital input lines can be jumpered as sinking or sourcing in blocks of 8 signals. Different versions of the RIO hardware must be purchased in order to obtain either all sinking or all sourcing digital output signals.

The RIO is an intelligent device and shares many of the software features available with the Guidance Controller. The software configuration is stored in the Configuration and Parameter Database that is accessed with pages viewed by a web browser. For detailed information on the web interface and the Parameter Database, see the *Software Setup* and *Introduction to Software* sections of the *Controller Software* chapter of the *PreciseFlex™ PreciseFlex Library*.

3. Installation, Configuration, and Software

Mounting and Installation

The Remote Input and Output module is an open frame device with exposed 24VDC and must be mounted inside of a cabinet or other enclosure. The mounting holes are shown in **Red** in Figure 3-1 with all dimensions in millimeters. The mounting holes are 4.2 mm in diameter and are designed for M3 screws. When the RIO is mounted with the Ethernet connector on the bottom and the DIO connectors on the top, a M3 standoff that is at least 16 mm in length should be used between the RIO and the mounting surface. There should be sufficient airflow across the top and bottom of this board to ensure that the components do not become excessively hot.

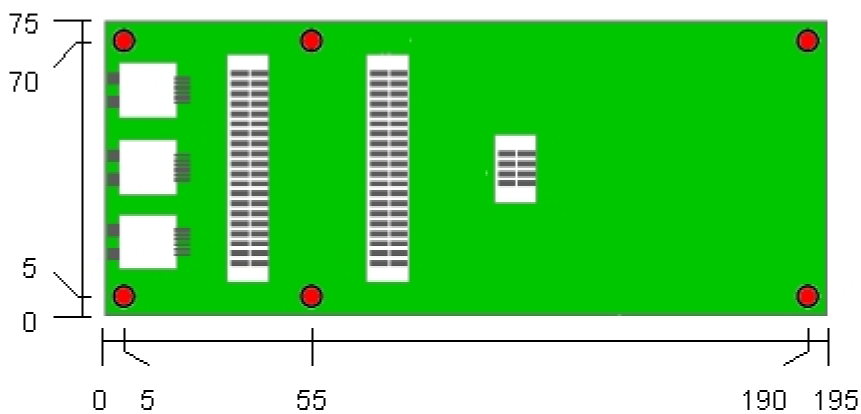


Figure 3-1: RIO Module Mounting Holes (in Red)

WARNING

The RIO contains unshielded 24VDC signals and pins. This product is intended to be mounted in a cabinet or machine chassis that is not accessible when power is turned on.

- Disconnect the electricity before servicing.

RIO Ethernet Configuration

The RIO module and the Guidance Controller communicate over a standard 10/100 Mb Ethernet network. Input and output signal states are communicated in messages that are periodically sent between the two devices. To facilitate setting up the Ethernet communications link, the RIO includes a built-in web server that provides access to the RIO's software configuration information.

Like most Ethernet devices, the RIO must have an Ethernet IP address/subnet mask assigned before it can be used. Initially, the RIO IP address/subnet is set to "192.168.0.101" and "255.255.255.0". If that information is acceptable on the network, no further network configuration is required. Otherwise, change the IP information by modifying the parameters. See Table 3-1.

For security purposes, restrict access to the RIO module to certain Controllers or MODBUS masters. Only IP addresses found in the "MODBUS master IP address" (DataID 560) array are allowed to connect with the RIO module. The default value of "255.255.255.255" means that security is disabled and any address can connect.

To access these values via the web interface of the RIO, go to **Setup > Parameter Database > Controller >**.

After these values are updated and saved to the flash disk, restart the RIO module to put the changes into effect.

Table 3-1: Parameter Table

Parameter Database ID	Parameter Name	Default Value	Description
420	Local IP address	192.168.0.101	IP address of the RIO module
421	IP subnet mask	255.255.255.0	IP address mask for the RIO module
422	IP gateway address	192.168.0.100	IP address of any network gateway
560	MODBUS master IP address	255.255.255.255	Array of IP addresses specifying the Controller or MODBUS master that can connect to this module

RIO and Guidance Controller Configuration

An RIO Slave Operation: Remote I/O Scanning

RIO modules are typically configured as slaves to provide additional remote digital I/O, analog inputs, and serial ports to a Guidance Controller. This mode of operation is specified by setting DataID 211 "GPL MODBUS/TCP master" on the RIO to True (the default setting).

When the RIO is configured as a slave, its built-in system software periodically scans the module's input signals at a fixed rate to check for any changes. If a change occurs, a message is sent to the master Controller, notifying it of the new input values. The scan period determines the minimum input pulse width that can be detected and also adds to the latency between when an input changes and when the Controller is notified of the change. The scan period must be set short enough to not miss input pulses, but must be long enough to not overwhelm the system with messages if the inputs change frequently. Normally, the scan period is set to 10 milliseconds.

The RIO does not poll output commands from the Controller, but relies on the Controller to notify the RIO whenever an output changes. The rate at which the Controller scans its outputs and sends messages to the RIO is configured on the Controller.

The RIO module also sends heartbeats to the Controller. If the Controller does not receive a message within a specified time, it assumes that an error has occurred and closes its connection. In this case the I/O points associated with the RIO become unavailable for I/O, and robot power is optionally disabled until communication with the RIO is reestablished.

The Controller also sends heartbeat messages at a slow rate to each RIO module, even if no outputs have changed. These messages allow the RIO modules to detect that the Controller is still connected and functioning. The heartbeat must occur often enough so the RIOs can detect failures in a timely manner, but slow enough to not waste too much time on the master Controller.

Table 3-2 shows the scanning parameters. To access these values on the RIO or the Controller as appropriate, go to the web interface for the proper device and select **Setup > Parameter Database > Controller > System DIO**. After these values are updated, save them to the flash disk. If using the default scanning parameters on all the RIO modules, use the defaults on the Controller.

Table 3-2: Scanning Parameters

Parameter Database ID	Parameter Name	Default Value	Description
550	Remote IO scan period in sec	0.010	**(Set on Controller and RIO)** The time period used by the local board to scan its local I/O. If any changed I/O values are detected during a scan, the new values are sent to the remote board (either a RIO module or the master Controller). The scan period determines the minimum input pulse width that can be detected by the local board, and also adds to the time between when an input changes and when the remote node is notified of the change. The scan period must be set short enough to not miss input pulses, but must be long enough to not overwhelm the system with messages if the inputs change frequently.
551	Remote IO heartbeat period in sec	0.500	**(Set on Controller and RIO)** The time period used by the local board to send its I/O state to the remote board (either a RIO module or the master Controller), even if no I/O have changed. Receiving this message notifies the remote node that this local board is alive. Typically set to less than one-half the value of "Remote IO max input time in sec" (DataID 552) on the remote module.
552	Remote IO max input time in sec	2	**(Set on Controller and RIO)** If the remote board (either a RIO module or master Controller) fails to send an update message within this time period, an error occurs. Typically set to > 2 times the value of "Remote DIO output heartbeat time in sec" (DataID 551) on the remote module.
553	Local IO error action	0 or 2	**(Set on Controller and RIO)** Determines the action taken if a communications error occurs. On the RIO module, 0 means freeze the outputs, 1 means clear the outputs. On a Controller, 0 and 1 are ignored. 2 means disable robot power and do not permit it to be enabled until communication with the RIO module is established.

RIO Slave Operation: Digital I/O Number Mapping

When a properly configured RIO module is connected to the local Ethernet network and enabled, additional general digital inputs and outputs become available on the master Controller (see Table 3-3). The correspondence between the RIO module I/O and the Controller signal numbers depends on the unit number of the RIO, as selected by the DIP switch settings on the RIO, and are independent of the Ethernet IP addresses of the Controller and RIO.

Table 3-3: Additional Digital Inputs and Outputs on Master Controller

RIO Unit	RIO DIP Switch 1234	Output Signals	Input Signals
1	0 0 0 0	101 - 196	10101 - 10196
2	1 0 0 0	201 - 296	10201 - 10296

RIO Unit	RIO DIP Switch 1234	Output Signals	Input Signals
3	0 1 0 0	301 - 396	10301 - 10396
4	1 1 0 0	401 - 496	10401 - 10496

A single RIO module contains 32 digital inputs and 32 digital outputs.

Guidance Controller Configuration

After the Ethernet IP address of the Remote I/O module has been configured, configure the Controller to recognize and connect to the RIO module.

Step	Action
1.	**Set the value of the "Remote IO module IP address" (DataID 555) database array to the IP address of the RIO module**. The array index chosen is not important for operation of the RIO module, but is used when accessing other parameter values in the following steps. Likewise, the IP address for the RIO can be arbitrarily selected and does not effect how the IO on the RIO are addressed from within application programs. By default, the first RIO address is set to "192.168.0.101".
2.	**Set the corresponding element of the "Remote IO module enable" (DataID 554) parameter array to "True" to enable scanning of the RIO device**. If this value is True when the parameter database is saved, the scanning begins automatically when the Controller is restarted. Setting this value to False stops the scanning of the corresponding RIO, and setting it back to True attempts to restart scanning. If a RIO module is connected to the network after the Controller is started, the "Remote IO module enable" (DataID 554) value must be toggled to False then True to initiate scanning of the RIO.
3.	**Note the value of the corresponding element of the read-only parameter array "Remote IO module unit" (DataID 556)**. If the RIO device was detected and is being scanned, this parameter value is the unit number (from 1 to 15) of the RIO module. If no RIO module is detected or an error occurs, this value is zero.

See Table 3-4. To access these values, go to the web interface of the Controller and select **Setup > Parameter Database > Controller > System DIO**. After these values are updated, save them to the flash disk.

Table 3-4: Controller Setup Parameters

Parameter Database ID	Parameter Name	Default Value	Description
554	Remote IO module enable	False	**(Set only on Controller)** Determines if the corresponding RIO module specified by a "Remote IO module IP address" (DataID 555) entry should be scanned by this Controller. When changed from True to False, disables the RIO module. When changed from False to True, attempts to begin scanning for the RIO module.
555	Remote IO module IP address	192.168.0.101	**(Set only on Controller)** Each entry specifies the IP address of a RIO module to be scanned. Scanning only occurs if the corresponding entry in "Remote IO module enable" (DataID 554) is set to True. The order of IP addresses in this array is not important.
556	Remote IO module unit	0 to 15	**(Read-only on Controller and RIO)** Indicates the status of the corresponding RIO module specified by the "Remote IO module IP address" (DataID 555). If 0, the RIO module is not being scanned. If > 0, the value indicates the RIO unit number, from 1 to 15.

Guidance Controller Remote Digital I/O Simulation

As a software development aid, digital IO signals for networked IO modules (RIO’s, MODBUS/TCP, EtherNet/IP) can be simulated in software. When an IO signal is simulated, its value can be read and written using the standard GPL instructions even though the hardware is not connected to the Controller. To enable software IO simulation, search the *PreciseFlex Library* for "I/O simulation map: count, signal > 579 (DataID).

RIO Operation as an Independent Master Controller

RIO modules can be configured to execute as a standalone master controller. In this mode of operation, the RIO acts much like a Guidance Controller in that it can execute GPL programs that can access all of the board's communication resources. However, there are a few restrictions:

- RIO masters cannot generate robot motions.
- RIO masters cannot be part of a PreciseFlex™ Servo Network.

In addition, external MODBUS/TCP masters cannot directly access a master RIO's I/O ports. Instead, the RIO operates like a Guidance controller and is a MODBUS/TCP slave to other MODBUS/TCP masters and communicates through an array of holding registers. (See the MODBUS/TCP section of the *PreciseFlex Library* for more information on this feature.) To configure an RIO as a master controller, the following DataID on the RIO must be set (Table 3-5):

Table 3-5: RIO DataID

Parameter Database ID	Parameter Name	Default Value	Description
211	GPL MODBUS/TCP master	TRUE for standard controllers, FALSE for RIO boards	If TRUE, an RIO board operates like a Guidance Controller and can act as a MODBUS/TCP master to access other RIO boards. This is always TRUE for Guidance controllers. For RIO boards, this value must be FALSE if the RIO is to act as a standard remote I/O board. This value can be set TRUE for RIO boards that act as intelligent controllers. If TRUE, this controller maps MODBUS/TCP slave requests to holding registers in DataID 561. If FALSE, this controller maps slave requests directly to I/O ports. The controller must be rebooted for changes to take effect.

4. Hardware Reference

Remote Input and Output Hardware Overview

The Remote Input and Output module provides a number of hardware interfaces that further enhance a Guidance Controller's ability to connect to external equipment. The interfaces and configuration hardware for this module include the following:

- Analog Input Connector
- Digital Input Connector
- Digital Output Connector
- Ethernet Connector
- Power Connectors
- RS-232 Connectors
- RS-422/485 Connector
- Sinking Versus Sourcing Input Jumpers
- RIO Unit Number DIP Switch).

WARNING

The RIO contains unshielded 24VDC signals and pins. This product is intended to be mounted in a cabinet or machine chassis that is not accessible when power is turned on.

- Disconnect the electric power when servicing the unit.

In the following sections, the software configuration of this module is described along with the pin outs for each of the connectors and the settings for the jumpers and switches.

Analog Input (Enhanced RIO only)

The enhanced version of the RIO contains 4 analog input channels on the base board. The Analog to Digital Converter accepts a +/-10 VDC signal and has a 12-bit resolution. The input impedance of the analog conversion circuit is 20,000 ohms. There is a 4 KHz noise filter on each input.

All of the inputs are read in from a single connector. The connector for these signals is a 8-pin Molex 71349-2002. The matching plug consists of a Molex plug together with a Molex clip that covers the plug and crimp pins that are inserted into the plug . See Figure 4-1 and Table 4-1.

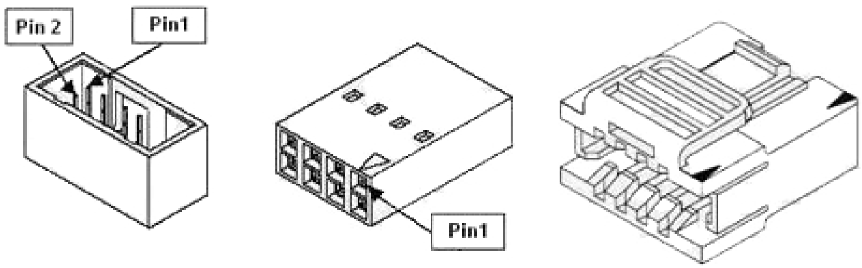


Figure 4-1: Molex Plug and Clip

Table 4-1: Pinouts

Pin	Description
1	GND
2	+/- 10VDC input signal 1
3	GND
4	+/- 10VDC input signal 2
5	GND
6	+/- 10VDC input signal 3
7	GND
8	+/- 10VDC input signal 4
User Plug Part No	Molex 22-55-2081 with Molex 15-04-5084 cover clip. The pins for this plug are 16-02-0103 and the Molex crimp tool is a 63811-1000.

Digital Input Signals

The RIO boards each support 32 optically isolated digital input signals. Depending upon the setting of the Sinking Versus Sourcing Inputs Jumpers, the inputs are configured as "sinking" or "sourcing" in groups of 8 signals.

If an input signal is configured as "sinking" (Figure 4-2), the external equipment must provide a 5VDC to 24VDC voltage to indicate a logical high value or no voltage for a logical low. This configuration is compatible with "sourcing" (PNP) sensors.

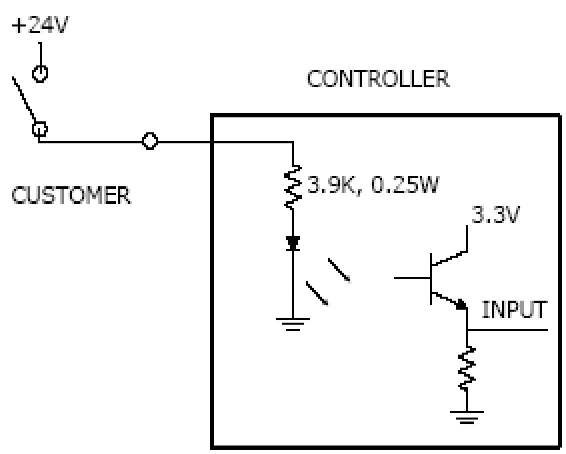


Figure 4-2: Sinking Input

If an input signal is configured as "sourcing" (Figure 4-3), the external equipment must pull the signal input pin to ground to indicate a logical high and must let the line float high to 24VDC to signal a logical low value. This configuration is compatible with "sinking" (NPN) sensors.

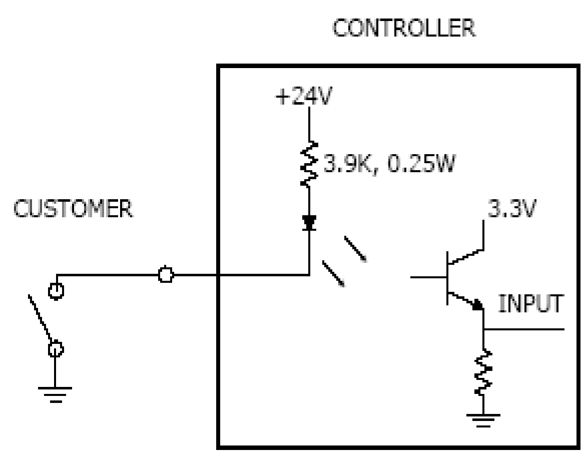


Figure 4-3: Sourcing Input

The connector for these signals is a 40-pin Molex 71349-2086 (Figure 4-4). The matching plug consists of a Molex plug together with a Molex clip that covers the plug and crimp pins that are inserted into the plug. Alternately, an IDC type plug can be used. The part numbers for these components are presented inTable 4-2.

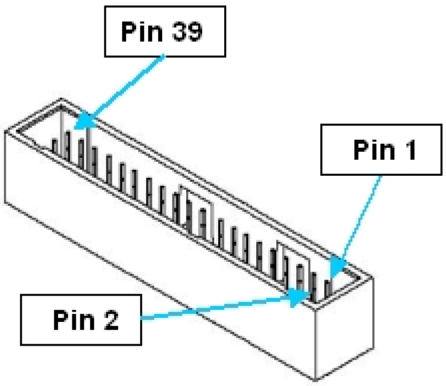


Figure 4-4: Molex Forty-Pin 71349-2086

Table 4-2: Components' Part Numbers

Signal	Pin	Pin	Signal
Input 1	1	2	Input 17
Input 2	3	4	Input 18
Input 3	5	6	Input 19
Input 4	7	8	Input 20
24VDC	9	10	GND
Input 5	11	12	Input 21
Input 6	13	14	Input 22
Input 7	15	16	Input 23
Input 8	17	18	Input 24
24VDC	19	20	GND
Input 9	21	22	Input 25
Input 10	23	24	Input 26
Input 11	25	26	Input 27
Input 12	27	28	Input 28
24VDC	29	30	GND

Signal	Pin	Pin	Signal
Input 13	31	32	Input 29
Input 14	33	34	Input 30
Input 15	35	36	Input 31
Input 16	37	38	Input 32
24VDC	39	40	GND
User Plug Parts	Molex 22-55-2401 with Molex 15-04-5404 cover clip. The pins for this plug are 16-02-0103 and the Molex crimp tool is a 63811-1000. Alternately, an IDC plug can be used, part # 746285-9.		

Digital Output Signals

The RIO boards each support 32 optically isolated digital output signals. Depending the type of RIO module purchased, all of the outputs are either "sinking" or "sourcing."

NOTE: Sourcing outputs is a special order configuration and the lead time might be very long.

If an output signal is "sinking" (Figure 4-5), the external equipment must provide a 5VDC to 24VDC pull-up voltage on the output pin and the RIO pulls this pin to ground when the signal is asserted as true. This configuration is compatible with "sourcing" (PNP) devices.

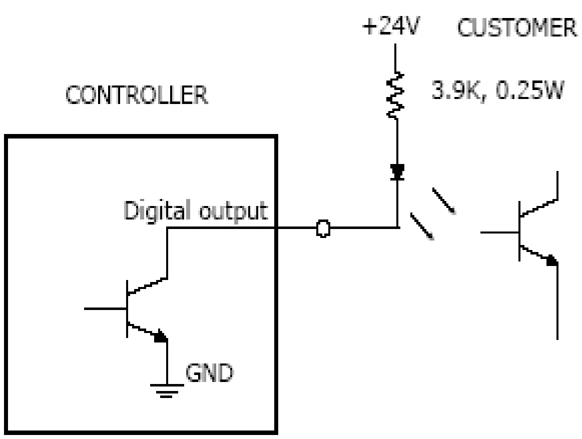


Figure 4-5: Sinking Output

If an output signal is "sourcing" (Figure 4-6), the external equipment must pull-down the output pin to ground and the RIO pulls this pin to 24VDC when the signal is asserted as true. This configuration is compatible with "sinking" (NPN) devices.

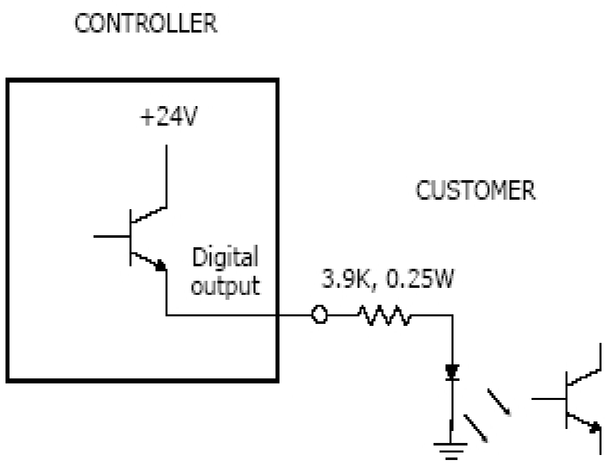


Figure 4-6: Sourcing Output

The connector for these signals is a 40-pin Molex 71349-2086 (Figure 4-7). The matching plug consists of a Molex plug together with a Molex clip that covers the plug and crimp pins that are inserted into the plug. Alternately, an IDC type plug can be used. The part numbers for these components are presented Table 4-3.

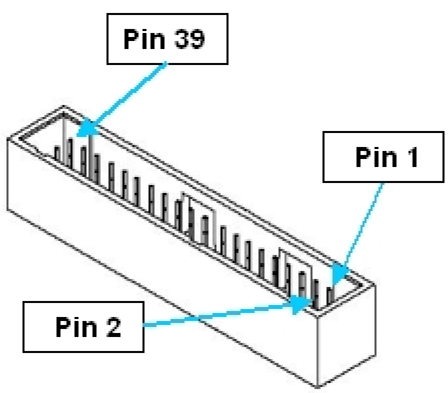


Figure 4-7: Forty-Pin Molex 71349-2086

Table 4-3: Part Numbers

Signal	Pin	Pin	Signal
Output 1	1	2	Output 17
Output 2	3	4	Output 18
Output 3	5	6	Output 19
Output 4	7	8	Output 20

Signal	Pin	Pin	Signal
24VDC	9	10	GND
Output 5	11	12	Output 21
Output 6	13	14	Output 22
Output 7	15	16	Output 23
Output 8	17	18	Output 24
24VDC	19	20	GND
Output 9	21	22	Output 25
Output 10	23	24	Output 26
Output 11	25	26	Output 27
Output 12	27	28	Output 28
24VDC	29	30	GND
Output 13	31	32	Output 29
Output 14 p>	33	34	Output 30
Output 15	35	36	Output 31
Output 16	37	38	Output 32
24VDC	39	40	GND
User Plug Parts	Molex 22-55-2401 with Molex 15-04-5404 cover clip. The pins for this plug are 16-02-0103 and the Molex crimp tool is a 63811-1000. Alternately, an IDC plug can be used, part # 746285-9.		

Ethernet Interface

A Guidance Controller communicates with a RIO by means of a 10/100 Mbit Ethernet port (Figure 4-8). This high-speed and robust means of communication ensures that the RIO data can be quickly and reliably accessed by a controller on the same Ethernet network.

Figure 4-8: Ethernet Port & Plug

See RIO Ethernet Configuration for information on configuring the IP address of the RIO and for setting other key communication parameters.

Power Connectors

The RIO requires 24VDC to power its logic and I/O functions. The Standard or Enhanced RIO requires 0.4 amps for logic power and a maximum of 3.2 amps if the outputs are sourcing, for a total of 3.6 amps.

There are two sets of 24VDC pins labeled J1 and J11. Power to the module should be provided on J1. J11 is used to daisy chain the 24VDC to additional RIO boards. These sets of power pins are shown in Figure 4-9 as seen from the side of the module with the Ethernet connector. See the pinouts in Table 4-4.

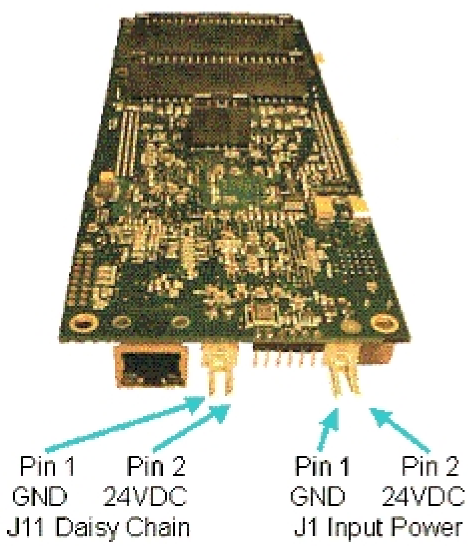


Figure 4-9: Power Pins

Table 4-4: Pinouts

Connector	Pin	Description
J1 - Power input for the RIO module	Pin 1	GND
	Pin 2	24VDC input
J11 - Daisy chain power output to additional RIO boards	Pin 1	GND
	Pin 2	24VDC output
User Plug Parts	Molex 09-50-3021 or 09-50-3081. In either case, the required pins are 08-50-0106 and the Molex crimp tool is a 63811-2200.	

RS-232 Serial Interfaces

The standard RIO has a single RS-232 serial port and the enhanced RIO module has two ports. Both ports support hardware as well as software flow control and use a RJ-11 modular jack, CablesNMor T23750. The matching plug is a standard RJ-11 phone plug, such as an Jameco 115617CH. See Figure 4-10 and Table 4-5.

In addition to serving as a general serial application channel, the first port can also be configured as the serial console port for the RIO.

When used as remote serial ports on the Guidance Controller connected to the RIO, these serial ports are named "/dev/comrxy" where "x" is the RIO unit number and "y" is the number of the RIO serial port.

Figure 4-10: RJ-11 Jack & Plug

Table 4-5: Pinouts

Pin	Description
1	CTS - clear to send
2	RTS - ready to receive
3	Ground
4	RXD - controller receive data
5	TXD - controller transmit data
6	Not Connected
User Plug Part No	RJ-11 phone plug

Sinking Versus Sourcing Inputs Jumpers

When referring to digital input signals, "sinking" and "sourcing" indicate whether the external equipment must connect the input signal to a voltage to indicate a logical high value (RIO is "sinking" the current) or the external equipment must connect the input signal to ground to indicate a logical high value (RIO is "sourcing" the current). While different versions of the RIO module must be purchased to support sinking versus sourcing digital output signals, the digital input signals can be configured as sinking or sourcing in blocks of 8 signals. This configuration is performed using four sets of three jumper posts (Figure 4-11).

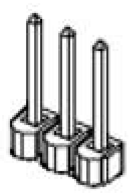


Figure 4-11: Three Jumper Posts

The location of these posts is illustrated at the start of this section and the sets of posts are identified by stenciled labels on the surface of the RIO. The posts are located on the surface of the RIO that includes the Ethernet connector.

Table 4-6 indicates how the pins of each set of posts that must be shorted ("jumpered") in order to achieve the specified configuration.

NOTICE

As shipped from the factory, all digital inputs are set to "sinking" by default.

Table 4-6: Shorting Pins of Posts Sets

Digital Input Signals	For Sinking Inputs	For Sourcing Inputs
Inputs 1 to 8	J5-3 TO J5-2	J5-2 TO J5-1 (*)
Inputs 9 to 16	J6-3 TO J6-2	J6-2 TO J6-1 (*)
Inputs 17 to 24	J12-3 TO J12-2 (*)	J12-2 TO J12-1
Inputs 25 to 32	J13-3 TO J13-2	J13-2 TO J13-1 (*)

An asterix (*) in the table above indicates the setting when the jumper is positioned so it is closer to the Ethernet connector. For example, to set Inputs 1 to 8 to sourcing, the J5 jumper should be positioned so it connects the two pins that are closest to the edge of the board that contains the Ethernet connector.

Unit Number DIP Switch

When a RIO module is connected to a Controller, its unit number determines how its digital input and output signals are mapped into the DIO signal numbers on the Guidance Controller. The Guidance signal numbers are used to access these I/O points in a GPL program from MotionBlocks and on web pages.

The unit number is selected by the DIP switch settings on the RIO base board. If the DIP switch is set to the "MODBUS/TCP" setting, the RIO will respond as a standard MODBUS/TCP slave device rather than a RIO peripheral to a Guidance Controller. See Figure 4-12.

Figure 4-12: 218-4LPST

When a switch is in the "ON" position, it reads a value of "0." *As shipped from the factory, all of the switches are in the "ON" position, which indicates RIO unit #1.* If the MODBUS/TCP configuration is selected, the RIO operates as a standard MODBUS/TCP slave device and can talk to any standard MODBUS/TCP master. In this mode, the RIO cannot communicate with a Guidance Controller. See Table 4-7.

Table 4-7: Dip Switch Table

RIO Unit	RIO DIP Switch 1234	Controller Output Signal Numbers	Controller Input Signal Numbers
1	0 0 0 0	101 - 196	10101 - 10196
2	1 0 0 0	201 - 296	10201 - 10296
3	0 1 0 0	301 - 396	10301 - 10396
4	1 1 0 0	401 - 496	10401 - 10496
MODBUS/TCP	1 1 1 1	None	None

Appendices

Appendix A: Product Specifications

Remote Input and Output (RIO) Module Specifications

General Specification	Range & Features
Interface to Guidance Controller	
Communications Interface	Interfaces via 10/100 Mbps Ethernet. Can be located anywhere within the local network of the Guidance Controller.
Communications Protocol	Supports the MODBUS/TCP communications protocol. Uses a variation of this protocol to interface to Guidance Controllers. Protocol is compatible with all standard Ethernet TCP/IP networks. Can be configured as a slave to standard MODBUS/TCP masters (cannot communicate with Guidance Controllers in this mode).
Scanning Rate	Scanning rate for changes in inputs configurable. New input data sent to controller when values changed. New output data received from controller when values changed. Typical scanning rates are 5-10msec.
Number of units	Up to 4 RIOs can be simultaneously interfaced to a Guidance Controller.
Input and Output Interfaces	
Ethernet Port	Standard and Enhanced RIO: One 10/100 Mbps Ethernet port
Serial Ports	Standard RIO: One RS-232 port with hardware flow control
	Enhanced RIO: Two RS-232 ports with hardware flow control, one RS-422/485 port
Digital Input Channels	Standard RIO, Enhanced RIO: • 32 optically isolated digital inputs • Configurable in banks of 8 as sinking or sourcing • 5VDC to 24VDC for logic high if sinking • 24VDC supplied for logic high if sourcing

General Specification	Range & Features
Digital Output Channels	Standard RIO, Enhanced RIO: • 32 optically isolated digital outputs • Sinking outputs is standard. Sourcing are a special order item. • 24VDC maximum pull up if sinking • 24VDC supplied if sourcing, 100mA maximum per channel
Analog I/O Channels	Standard RIO: None
	Enhanced RIO: 4 analog input channels, +/-10VDC, 12 bit ADC
General	
Size and Weight	75mm (W) x 195mm (L) x 28mm (H), 0.142 kg
Low Voltage Logic Power	24VDC required for logic and input/output functions: • Standard RIO: 0.4A minimum for logic plus 3.2A maximum if sourcing all digital outputs for a total of 3.6A. • Enhanced RIO: 0.4A minimum for logic plus 3.2A maximum if sourcing all digital outputs for a total of 3.6A.
Special Order Options	Both the Enhanced RIO and sourcing output signals are special order items. As such, the lead time for these options can be quite long and minimum order quantity requirements apply.