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MKS Communications Module™/ Programmable Automation Controller 100 User Manual



For AS11870G-02/AS11870G-03

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About this Manual

This manual is designed to serve as a guideline for the installation, setup, operation and basic maintenance of the PAC 100 Control Platform AS11870G-02/AS11870G-03. The information contained within this manual, including product specifications, is subject to change without notice. Observe all safety precautions and use appropriate procedures when handling the PAC product and its related software.

Technology protected by U.S. patent numbers 7,620,516 and 6,993,404.

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Revision History

Revision	Description of changes	Date
0.1	First release	
0.2	Second release	10/06/2015
0.3	Reformatted, performed editorial improvements, moved Modbus and EtherCAT information to *MKS PAC 100 Modbus EtherCAT Addendum* document.	5/5/2017
0.4	Corrected dimensions of modular components (PAC100, CM, slices)	07/20/2017

Revision method:
Rev **X.Y**

X = 'major revision' - Any change that affects functional safety shall affect this numeral and will require re-assessment by the certification body

Y = 'minor' revision' - Any change that does not affect functional safety should be recorded by this numeral which will not require re-assessment by the certification body.

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1. General Information

The MKS PAC 100™ is a control platform that merges the features of Programmable Logic Controllers (PLC) and Industrial Personal Computers (IPC), to create an open standard, networked, programmable, flexible, and scalable PAC, all in a modular, DIN rail mountable plastic enclosure. Compared to standard PLCs and IPCs, MKS PACs provide a more compact, customizable, high-performance, and cost-effective programmable control solution for a variety of control and automation tasks.

The PAC 100 can be implemented as a comprehensive control platform for a single location or tool or as an intelligent distributed node on a manufacturing line, providing localized and high speed I/O control while managing logic locally. MKS PACs can be used to manage all I/O control requirements with the ability to handle detailed execution tasks with various commonly used programming languages.

The PAC 100 can interface directly with all MKS I/O modules, or “slices,” via the MKS System bus, or it can be used in a distributed control system (DCS) supporting various Fieldbus interfaces with other MKS I/O modules or other off-the-shelf slave nodes.

There are multiple control and data monitoring interfaces for the PAC 100 where the PAC acts like one of the two following options, or as a standalone controller.

- Modbus/TCP Slave
- EtherCAT Slave

The PAC 100 supports IEC 61131-3 programming languages such as ladder logic, structured text, sequential function charts for recipe and logic development, and also provides extremely fast communication between modules for highly coordinated and deterministic control.

MKS Controls Workbench™ (CWB) software can be used with the PAC 100. CWB provides a simple, integrated solution for device configuration, process monitoring, data storage, system diagnostics, and autotuning.

1.1 Conventions used in this User Manual

WARNING	**The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.**
CAUTION	**The CAUTION sign highlights information that is important to the safe operation of the system, or to the integrity of your files.**
Note	**The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.**

Loops The number of Proportional-Integral-Derivative (PID) loops (48) available on the PAC 100 via Modbus is 48. These comprise 34 loops with Process Data Objects (PDOs) included and 14 loops with no PDO data, but which are still accessible via Service Data Objects (SDO).

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Zones The number of zones equals the number of physical outputs available. Configuration of each zone includes selecting inputs from the inputs available and the PID loops, and selecting the output for the zone from the available outputs.

On screen buttons or menu items appear in bold and italics.
Example: Click ***OK*** to save the settings.

Keyboard keys appear in brackets.
Example: [ENTER] and [CTRL]

Text entered into a text box or command line interface appears in Courier font.
Example: Enter `netstat`

Pages with additional information about a specific topic are cross-referenced within the text, displayed in italic Times font, and hyperlinked.
Example: (See *section xxx*)

1.2 Safety Information

The product described in this manual is operated with high voltages which can cause severe injury. It is essential that the user become thoroughly familiar with the contents of this manual prior to using the product. If used properly, the information contained in this manual will not only promote reliable system performance, but will also encourage a safe operating or service environment for all individuals.

Certain safety-related considerations must be observed before installing, operating, or servicing this equipment. Symbolic and/or textual labels and markings are used in and/or on the equipment, as well as in this product manual, to convey and/or identify such important information. Among other things, this information is provided to alert equipment operators and service personnel to hazardous conditions that may result in personal injury and/or damage to the equipment. Please look for these labels and markings and follow their direction.

Only personnel trained in the procedures and safety messages outlined in this manual should install, operate or maintain this equipment. When using the product, be sure to follow the safety procedures outlined by your facility.

1.2.1 Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

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GROUNDING THE PRODUCT

This product is grounded through the grounding conductor of the power. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting it to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electrical shock.

GROUND AND USE PROPER ELECTRICAL FITTINGS

Dangerous voltages are contained within this instrument. All electrical fittings and cables must be of the type specified, and in good condition. All electrical fittings must be properly connected and grounded.

USE THE PROPER POWER CORD

Use only a power cord that is in good condition and which meets the input power requirements specified in the manual.

USE THE PROPER POWER SOURCE

This product is intended to operate from a power source that does not apply more voltage between the supply conductors, or between either of the supply conductors and ground, than that specified in the manual.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

VOLTAGE DANGER

Voltage hazard is present in the cable and in the unit when unit is switched on.

THERMAL HAZARD

To avoid overheating, do not cover the unit.

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1.2.2 Symbols Found on the Unit

Table 1 describes symbols that may be found in and/or on the equipment either as silk-screened markings or as part of adhesive labels and/or in this manual to identify important instructions.

Table 1—Symbols Found on the Unit

On (Supply) IEC 60417, No. 5007	 Off (Supply) IEC 60417, No. 5008	 Earth (ground) IEC 60417, No. 5017	 Protective earth (ground) IEC 60417, No. 5019
 Frame or chassis IEC 60417, No. 5020	 Equipotentiality IEC 60417, No. 5021	 Direct current IEC 60417, No. 5031	 Alternating current IEC 60417, No. 5032
 Both direct and alternating current IEC 60417, No. 5033	 Class II equipment IEC 60417, No. 5172	 Three-phase alternating current IEC 60417, No. 5032	
 Caution, see accompanying documents	 Caution, risk of electrical shock IEC 60417, No. 6042	 Caution, hot surface IEC 60417, No. 5041	

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2. Introduction

The MKS Programmable Automation Controller (PAC) merges the features of Programmable Logic Controllers (PLC) and Industrial Personal Computers (IPC) to create an open standard, networked, programmable, flexible, and scalable PAC, all in a modular, DIN rail-mountable plastic enclosure. MKS PACs provide a more compact, customizable, high performance, and cost effective programmable control solution for a variety of control and automation tasks.



Figure 1—PAC 100 System

The **MKS Communications Module (CM)** can be implemented as a standalone unit supporting manual, remote control capabilities with the MKS Controls Workbench application, with built in data logging and process monitoring, or it can be implemented over a variety of fieldbuses to support distributed I/O applications, where the MKS CM is integrated with a PLC/PAC. MKS CM can directly interface to all MKS Automation Platform I/O slices via the MKS System Bus or EtherCAT, creating a scalable distributed I/O system. The MKS Controls Workbench (CWB) software application can be used with the MKS CM Communications & Fieldbus Coupler Module. CWB provides a simple, integrated solution for device configuration, process monitoring, data storage, system diagnostics, and autotuning. Related information can be found at https://www.mksinst.com/MKSCM.

The **MKS PAC100**, one of two PACs offered by MKS, provides open and fully programmable automation control, remote or distributed I/O, multi-zone temperature control, and remote process control, easily interfacing with existing MKS subsystems and Instruments including: Mass Flow Controllers (MFCs), direct pressure gauges, indirect pressure gauges, etc. Related information can be found at https://www.mksinst.com/MKSPACs.

The PAC100 supports an IEC 61131-3 programming interface for recipe and logic development and also provides extremely fast communication between modules for highly coordinated and deterministic control. Related information can be found at https://www.mksinst.com/Multiprog.

MKS Controls Workbench (CWB) software can be used with MKS PACs. CWB provides a simple, integrated solution for device configuration, process monitoring, data storage, system diagnostics, and autotuning.

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2.1 Features and Benefits

The MKS PAC 100 CPU and MKS Communications & Fieldbus Coupler Module (CM) offer these features and benefits:

- The MKS PAC 100 is a fully programmable controller that supports the standard IEC 61131–3 environment for seamless code portability without locking the user into a specific programming environment or vendor software.
- The MKS CM provides all the I/O capabilities and identical specifications of the PAC 100 in a cost-effective unit, but without the IEC 61131-3 programmability.
- The MULTIPROG programming environment has Express (Free) and Pro (Paid) versions available.
- The MKS Program template library supports common process applications and Function block library supports various MKS devices for plug-and-play implementation.
- The PAC 100 provides open standards support, interoperability with other devices and components, and improved performance compared to traditional PLCs and IPCs.
- The PAC 100 and CM can be interfaced seamlessly with Human Machine Interface (HMI) supporting OPC UA or Modbus TCP/IP.
- Multiple MKS PAC offerings can be customized to specific applications.

2.2 PAC 100 System Ordering Information

Table 2 provides an example of the options available for a PAC 100 or CM system. Module ordering information is also provided in the module sections.

Table 2—Example PAC 100 Hardware Installation

MKS Part No.	Model	Remarks
AS11870G-03	MKS PAC 100	Modbus TCP/IP
AS11870G-05	MKS PAC 100	EtherCAT
AS11870G-02	MKS CM	Modbus TCP/IP
AS11870G-04	MKS CM	EtherCAT
AS11870G-10	MKS Coupler Module	EtherCAT
AS11880G-11	AIO module	Removable Terminal connector. Voltage inputs, Voltage outputs
AS11880G-31	AIO module	Removable Terminal connector. Current inputs, Voltage outputs
WA01100-02	Connector for Auxiliary Power Input	Molex 43645-0300
AS11893G-02	DIO module	Removable Terminal connector. 0–24 V, source
AS11893G-11	DIO module	Removable Terminal connector. 0–24 V, sink
CN02215	Analog/Digital I/O connector (spare)	Phoenix Contact p/n 1790632

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MKS Part No.	Model	Remarks
AS11890G-02	Mass Flow Controller	15 pin D-Sub
AS11890G-11	Mass Flow Controller	9 pin D-Sub
WA01100-02	Connector for Auxiliary Power Input	Molex 43645-0300
AS11900G-03	Pressure Input Module	15-pin D-Sub
WA01100-02	Connector for Auxiliary Power Input	Molex 43645-0300
AS11893G-41	PWM module	Removable Terminal connector. Phoenix Contact p/n 1790632
AS11899G-01	MKS Serial Communication Module	RS-232/RS-422/RS-485
AS11860G-40	TEMP module, RTD or TC	Input type=PT 100, any TC, Terminal connector
AS11860G-50	TEMP module, RTD or TC	Input type=PT 1000, any TC, Terminal connector
AS11860G-60	TEMP module, RTD or TC	Input type=PT 100, any TC, Removable Terminal
AS11860G-70	TEMP module, RTD or TC	Input type=PT 1000, any TC, Removable Terminal
AS11840G-01	PWR module	For providing additional power for I/Os
CN01573	I/O Power connector for PWR	Weidmuller p/n 180305000
CN00644G	Power connector for CPU, PWR (spare)	Weidmuller p/n 1691120000
CKRD2420	External 20 A SSR with DC control	Crydom

2.3 MKS PAC 100 CPU Specifications

Criteria	Specifications
Dimensions	35 mm x 125 mm x 92.3 mm (W x H x D)

Environmental Specifications

Criteria	Specifications
Operating Temperature	0 to +45° C
Storage	–40 to +85° C
Humidity	5 to 95% non-condensing
Altitude	Up to 2000 meters
MTBF minimum	>10 years @ 80% confidence level (87K Hours @ 80% confidence level)

Communication Protocol Specifications

Protocols Supported	Slave
Modbus/TCP	Yes
EtherCAT	Yes
Profibus	Coming soon

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Devicenet	Coming soon

Technical Specifications

Criteria	Specifications
Processor	ARM Cortex-M4, 100 MHz
OS	RTOS
Code Space	1 MB
Internal RAM	256 MB
Expandable Memory	Micro SD, 1 or 2 GB
Fieldbus Master	N/A
IEC61131-3 Support	Yes
C/C++ Support	No
Interfaces	USB OTG, 1 x RJ45 (Ethernet) 10/100 Mbits/s
Physical User Interface	LEDs
OPC Server Enabled	No
I/O Interface	L-Bus
Maximum number of I/O modules that be connected to the PAC 100 (excluding power modules)	20
Number of loops	48
Number of models	2
Power Supply	19–32 VDC for DC I/O, Max 5 A 19–32 VDC for DC CORE, Max 5 A

2.4 MKS CM Specifications

An asterisk (*****) following a specification denotes a difference from the PAC 100.

Criteria	Specifications
Dimensions	35 mm x 125 mm x 92.3 mm (W x H x D)

Environmental Specifications

Criteria	Specifications
Operating Temperature	0 to +45° C
Storage	–40 to +85° C
Humidity	5 to 95% non-condensing
Altitude	Up to 2000 meters
MTBF minimum	>10 years @ 80% confidence level (87K Hours @ 80% confidence level)

Communication Protocol Specifications

Protocols Supported	Slave
Modbus/TCP	Yes
EtherCAT	Yes

Technical Specifications

Criteria	Specifications
Processor	ARM Cortex-M4, 100 MHz
OS	RTOS

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Code Space	No *
Internal RAM	No *
Expandable Memory	No *
Fieldbus Master	N/A
IEC61131-3 Support	No *
C/C++ Support	No
Interfaces	USB OTG, 1 x RJ45 (Ethernet) 10/100 Mbits/s
Physical User Interface	LEDs
OPC Server Enabled	No
I/O Interface	L-Bus
Maximum number of I/O modules that can be connected to the PAC 100 (excluding power modules)	20
Number of loops	48
Number of models	2
Power Supply	19–32 VDC for DC I/O, Max 5 A 19–32 VDC for DC CORE, Max 5 A

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3. PAC 100 and CM Hardware Description

This section describes the PAC 100, the Communications/Fieldbus Coupler Module (CM) hardware, the peripheral modules within the MKS Automation Platform, and the interface with the network over Modbus/TCP or EtherCAT.

Products include:

- PAC 100 CPU module
- Communications/Fieldbus Coupler Module (CM)
- Peripheral modules, also called slices

Information provided includes product descriptions and instructions for assembling, wiring, and configuring a PAC 100- or CM-based system.



Note

This user manual is based on general market configuration and software at the time of this writing. Customer's specific configuration, layout, I/O counts, and functional features may differ. Please contact MKS for specific feature and information on customized PAC products.



WARNING

Follow all applicable electrical codes when mounting and wiring any electrical device.



Caution

Never attempt to "Hot Connect" or "Hot Swap" the components of the MKS Automation platform (i.e., do NOT connect or detach the slices while they are powered on). This can damage the PACs and slices, and is not covered by your product warranty.

Always turn off or disconnect all power before attempting to service your PAC system.



Caution

In order to guarantee proper operation and prevent damage to the product, ensure that the chassis ground is properly attached for the application.

3.1 PAC 100 CPU and Communications Module (CM) Features

The PAC 100 is a fully programmable controller that supports the standard IEC 61131-3 environment for seamless code portability without locking the user into a specific programming environment or vendor software.

The CM provides all the I/O capabilities and identical specifications of the PAC 100, but without the IEC 61131-3 programmability.

These two products have the following features:

- Four CPU status LEDs

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- Two front-panel power connectors
- Two EtherCAT connectors
- EtherCAT IP address switches
- 1 x RJ45 (Ethernet) 10/100 Mbits/s, Auto MDI-X
- USB OTG connector
- CPU reset switch
- IP address reset switch

Additionally, the PAC 100 and CM have power / data connectors on the right side (if you face the module) for interfacing to MKS slices. Figure 2 shows the front panel of the PAC 100 or CM.



Figure 2—Front Panel of PAC 100 / CM

3.1.1 CPU LED Indicators

These LEDs are shown in Figure 2, and Table 3 lists their functions.

Table 3—PAC 100 LED Descriptions

LED	LED Indication	Definition
24V IO	Solid Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.
RUN (used only in EtherCAT mode)	Off	INIT Mode
	Blinking Green (6 Hz)	Boot
	Blinking Green (3 Hz)	Pre-Op
	Blinking Green (1 Hz)	Safe-Op
	Solid Green	OP Mode

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LED	LED Indication	Definition
	Solid Red	EtherCAT connection issue
ERR (used only in EtherCAT mode)	Off	EtherCAT has finished initializing with no errors.
	Blinking Red (1.5 Hz)	EtherCAT has a connection problem when the CPU is in OP mode. Also, the RUN LED flashes at 1 Hz.
STAT	Blinking Green	System bus is initializing, and no errors have occurred.
	Blinking Amber	System bus is initializing, and an NVRAM error was detected.
	Solid Green	System bus completed initialization with no errors.
	Solid Amber	System bus completed initialization, and an NVRAM error was detected.
	Blinking Red	System bus initialization failed
	OFF	FPGA error

3.1.2 Power Supply Wiring

The PAC 100 has two 24 V power inputs—one for powering the I/O, and another for powering the CPU. The user should use separate and isolated 24 V power supplies, one for the CPU and another one for the I/O slices. The CPU requires 5 A maximum current, and the I/O requires 12 A maximum current. The power supplied by these two connectors is transmitted to the other I/O slices through the power/data connectors.

The PAC 100 can power as many as five I/O slices in most cases, depending on the I/O current requirements. If additional power is needed, a Power module can be plugged to the right of the last slice in a device chain (if you face the module). The PWR slice then powers the slices to the right of it, not the slices to its left. Contact the Automations and Control solutions group at A&CS_Support@mksinst.com if you have any questions.

The CPU and I/O power input connectors are identical. Figure 3 shows the CPU power input connector. Table 4 gives the power connector pinout.

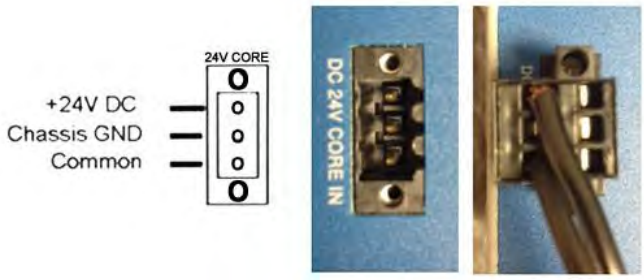


Figure 3—CPU Power In

Table 4—Power Connector Pinout

Pin (Pin 1 starts at top)	Description
1	+24 VDC
2	N/C
3	24 VDC_COM

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Figure 4 shows a representative example of the power connector.

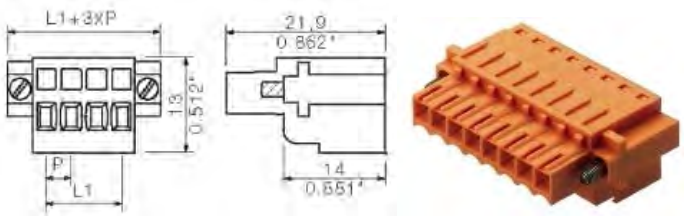


Figure 4—CN00644 CPU Power Connector (example)

3.1.3 EtherCAT Connector

The two front-panel EtherCAT connectors provide connectivity for PAC 100 devices configured to use this interface. When EtherCAT is used, standard Ethernet connectivity is disabled.

Note — **The Controls Workbench application currently does not support EtherCAT.**

3.1.4 EtherCAT ID Select Switches

The three EtherCAT ID Select selector switches on the front of the controller allow setting the ECAT ID for the PAC 100 slave device. Note that these are used only when the PAC 100 is communicating over EtherCAT.

3.1.5 Ethernet Connector

The front-panel Ethernet connector provides a 10/100BaseT Ethernet port with Auto MDI-X capability. This can be connected to other Ethernet devices directly or through a hub or router without needing a crossover cable or adapter. As with all Ethernet devices, hot-swapping of the Ethernet cable is permissible.

The Ethernet port uses a standard shielded RJ45 connector with two LEDs in the connector. The left LED indicates the connection speed. Solid green indicates a 100 Mbps connection. Off indicates a 10 Mbps connection. The right LED indicates the connection status. Flashing green indicates that a connection has been established. Off indicates that no connection is present.

The default IP address of the PAC 100 is 192.168.1.3. To change this address, see *Section 5.3.1, Changing an IP Address*.

3.1.6 USB Port

The USB connector can be used to display diagnostics messages on the PAC 100. This will be functional in a future version of PAC 100.

3.1.7 CPU Reset

This recessed button accessible from the front panel is used for resetting the PAC 100.

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3.1.8 IP Address Reset

This recessed button accessible from the front panel is used for resetting the IP address of the PAC 100 to its default IP address of 192.168.1.3. The functionality will be implemented in a future version of the firmware.

3.1.9 I/O Slices for the PAC 100

The PAC 100 can use the following slices:

- Analog Input/Output module (AIO)
- Digital Input/Output module (DIO)
- Mass Flow Controller module (MFC)
- Pressure Input module (PRESS)
- Pulse Width Modulation module (PWM)
- Power module (PWR)
- Serial module (SERIAL)
- Temperature Input module (TEMP)

These slices are described in the following sections.

3.2 Analog Input/Output (AIO) Module

The MKS Analog Input/Output (AIO) module provides a compact, high-density solution for integrating analog input and output channels with MKS PAC 100 or CM modules.

Each AIO slice can support as many as eight analog inputs and four analog outputs. Two versions of the AIO slice are available. One version provides for voltage inputs and current outputs. The other version provides for current inputs and voltage outputs. Figure 5 shows the AIO slice with the optional Phoenix connector installed. The Phoenix connector allows inserting wires (16–24 ga) directly into the slice, simplifying wiring. This connector can easily be removed and replaced.

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Figure 5—Analog Input/Output (AIO) Slice

Figure 6 shows the front panel of the AIO slice with the Phoenix connector removed.

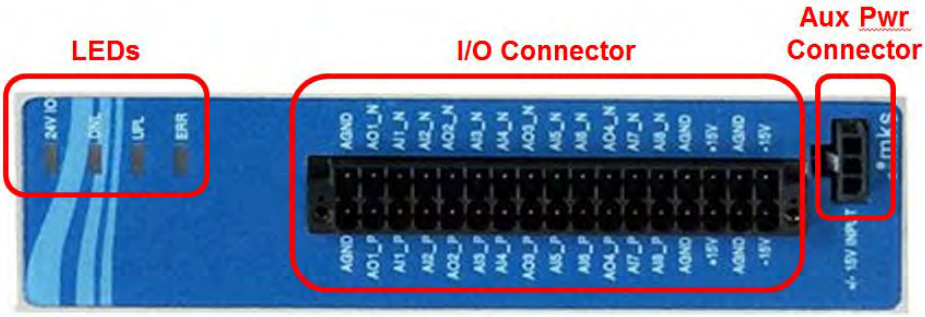


Figure 6—Front Panel of AIO Slice

The voltage input and output options (AS11880G-03 for EtherCAT and AS11880G-12 for System Bus) support single-ended and differential voltages. The choice between the two is made based on noise immunity and GND scheme. Signal ranges typically are ±10 V, 0–10 V, or 0–5 V, depending on the resolution and full scale definition for the connected device.

The current input and voltage output options (AS11880G-22 for EtherCAT and AS11880G-32 for System Bus) support current input signals such as 0–20 mA and 4–20 mA. Analog input signals from temperature sensors or current transformers (CTs) can be used as inputs, for example. Signal ranges typically are ±10 V, 0–10 V, or 0–5 V, depending on the resolution and full scale definition for the device that is being connected. The maximum current for each voltage output is 5 mA.

Each AIO slice has an auxiliary three-pin power input on the front of the module that gives the option to wire in additional power for devices that require ±15 V. This wiring for this connector is ***optional*** and is not needed for the AIO slice to function.

Caution

The ±15 V auxiliary power connector can power multiple devices that use this voltage, as long as the devices draw less than 1.1 A overall.

Any devices that draw more than 1.1 A overall cannot be powered using the three-pin connector. They will require a separate ±15 V power supply.

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3.2.1 AIO LED Description

The AIO slice has four LEDs on the front panel to show its operational status. Figure 7 shows the LEDs on the AIO slice, and Table 5 lists their functions.

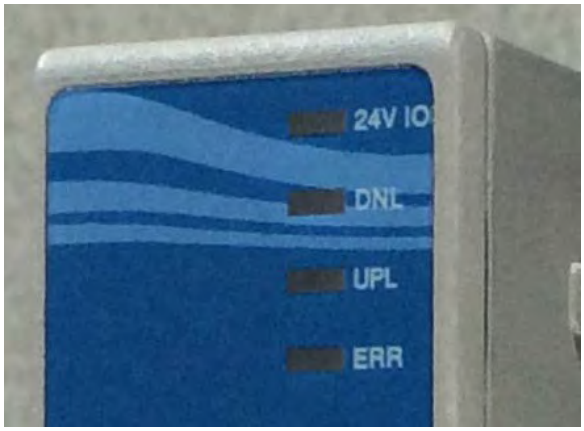


Figure 7—AIO LEDs

Table 5—AIO LED Descriptions

LED	LED Indication	Definition
24V IO	Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.
DNL	Flashing Green	System bus communication in progress.
	Red	System bus communication error has been detected.
UPL	Flashing Green	System bus communication in progress.
	Off	This module is the last in the series of slices.
ERR	Off	Status is OK.
	Flashing Red	Error detected.

3.2.2 Analog I/O Wiring

Figure 8 shows the AIO connections.

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Pin #	Signal	Pin #	Signal
A1	AGND	B1	AGND
A2	AO1_P	B2	AO1_N
A3	AI1_P	B3	AI1_N
A4	AI2_P	B4	AI2_N
A5	AO2_P	B5	AO2_N
A6	AI3_P	B6	AI3_N
A7	AI4_P	B7	AI4_N
A8	AO3_P	B8	AO3_N
A9	AI5_P	B9	AI5_N
A10	AI6_P	B10	AI6_N
A11	AO4_P	B11	AO4_N
A12	AI7_P	B12	AI7_N
A13	AI8_P	B13	AI8_N
A14	AGND	B14	AGND
A15	+15V	B15	+15V
A16	AGND	B16	AGND
A17	-15V	B17	-15V



Figure 8—AIO Connections

Table 6 shows the respective pinouts for the two kinds of slice.

Table 6—Pinouts for Voltage Output and Current Output AIO Slices

Pinout for Voltage Output Slice				Pinout for Current Output Slice			
Pin #	**Signal**	**Pin #**	**Signal**	**Pin #**	**Signal**	**Pin #**	**Signal**
A1	AGND	**B1**	AGND	**A1**	AGND	**B1**	AGND
A2	AOV1+	**B2**	AOV1–	**A2**	AOC1	**B2**	AGND
A3	AI 0+	**B3**	AI 0–	**A3**	AI 0+	**B3**	AI 0–
A4	AI 1+	**B4**	AI 1–	**A4**	AI 1+	**B4**	AI 1–
A5	AOV2+	**B5**	AOV2–	**A5**	AOC2	**B5**	AGND
A6	AI 2+	**B6**	AI 2–	**A6**	AI 2+	**B6**	AI 2–
A7	AI 3+	**B7**	AI 3–	**A7**	AI 3+	**B7**	AI 3–
A8	AOV3+	**B8**	AOV3–	**A8**	AOC3	**B8**	AGND
A9	AI 4+	**B9**	AI 4–	**A9**	AI 4+	**B9**	AI 4–
A10	AI 5+	**B10**	AI 5–	**A10**	AI 5+	**B10**	AI 5–
A11	AOV4+	**B11**	AOV4–	**A11**	AOC4	**B11**	AGND
A12	AI 6+	**B12**	AI 6–	**A12**	AI 6+	**B12**	AI 6–
A13	AI 7+	**B13**	AI 7–	**A13**	AI 7+	**B13**	AI 7–
A14	AGND	**B14**	AGND	**A14**	AGND	**B14**	AGND
A15	+15V	**B15**	+15V	**A15**	+15V	**B15**	+15V
A16	AGND	**B16**	AGND	**A16**	AGND	**B16**	AGND
A17	–15V	**B17**	–15V	**A17**	–15V	**B17**	–15V

Each AO (either voltage or current output) consists of two pins: AO_OUT*P* (positive) and AO_OUT*N* (negative), as shown in Figure 9.

On the voltage output AIO slices, pins B2, B5, B8, and B11 are voltage outputs that share the signals on pins A2, A5, A8, and A11. On the current output AIO slice, pins B2, B5, B8, and B11 are all tied to analog ground (AGND).

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The difference in pinouts is because the voltage output AIO slices deliver differential voltage outputs, and the current output AIO slices deliver a current that is referenced to AGND.

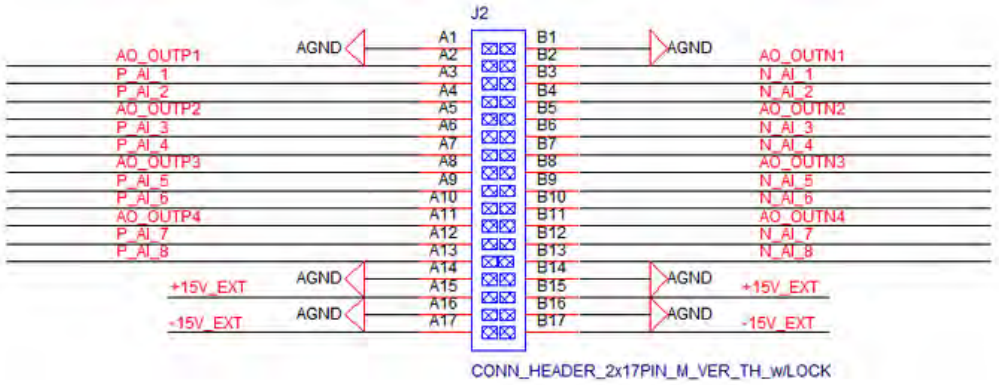


Figure 9—Schematic, Connector on AIO Slice

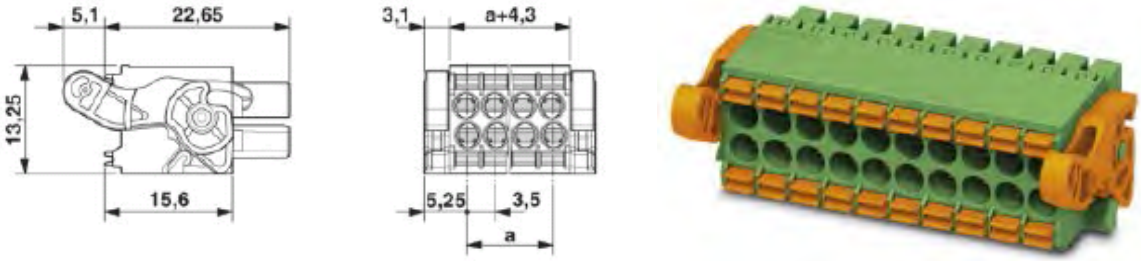


Figure 10—Representative Dimensioning of Phoenix I/O Connector

The AIO slice also has the option to wire in additional power (for devices that need ±15 V) directly through the three-pin ±15 V connector (P1).

The ±15 V from the three-pin connector is routed to pins A14, A16, B14, and B16 (AGND) as well as to A15, A17, B15, and B17 (+15 V_EXT) on the external connector. Devices that need power can be powered up using these pins on the external connector. Figure 11 shows the three-pin auxiliary power input connector. Table 7 provides the pinout for the three-pin auxiliary power connector.

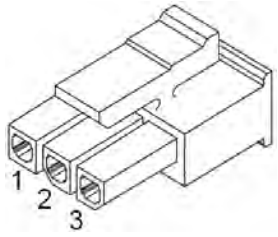


Figure 11—Auxiliary Power Input Connector

Table 7—Auxiliary Power Input Connector Pinout

Pin	Description
1	+15 VDC
2	Ground
3	–15 VDC

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3.2.3 AIO Specifications

Table 8 lists the specifications for the AIO slice, and Table 9 provides ordering information for the AIO slice.

Table 8—AIO Module Specifications

Analog I/O Module Specifications	
Number of Inputs	8 (differential only)
ADC Native Resolution	16 bits, irrespective of the user-selected range
Input & Output Ranges	Voltage: 0–5 V, 0–10 V , ±5 V, ±10 V Current: 0–20 mA , 4–20 mA (Factory configurable between voltage and current)
Sampling Rate for AI	6.25 kHz (160 µs for all 8 channels)
Minimum Precision	14 noise-free bits for 95% of readings over full voltage range
Input Voltage Measurement Range	–10 V to +9.9997 V
Minimum Common Mode Voltage Range	±8 V
Minimum Input Common Mode Rejection Ratio (CMRR)	50 dB, 0–1 kHz
Minimum Input Impedance	10 MΩ
Anti-alias HW Filtering	200 Hz ±20%, 6 dB/octave minimum
Pull Down Resistors on + and – Inputs	10 MΩ to AGND
DAC Native Resolution	16 bits
Number of Outputs	4, differential or single-ended, configured by the user
Output Voltage Range	–10 V to 9.9997 V
Output Accuracy at 25°C Ambient	±1.2 mV measured at I/O connector with 2 kΩ load
Output Accuracy Temperature Drift (20° C–35° C)	0.02% of output value
Maximum Output Current	5 mA, into a 2 kΩ, 10 nF load
Maximum Power Consumption per Module	Assuming all AOs are current outputs @20 mA ≥ 24V_IO@ 0.25 A, 24V_CORE@ 0.15 A
Dimensions	35 mm x 125 mm x 92.3 mm (W x H x D)
Mounting	DIN rail and wall mount options
Protection	ESD to IEC 61000-4-2 ±4 kV contact, short to 24 V, +15 V, or –15 V
Certifications	RoHS, CE
Operating Temperature	0° to +55° C
Storage	–40° to +85° C
Humidity	5 to 95% non-condensing
Altitude	Up to 2000 meters

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Table 9—AIO Ordering Information

MKS p/n	Description	MFG	MFG p/n
AS11880G-03	AIO, Voltage Inputs/Current Outputs, EtherCAT bus	MKS	AS11880G-03
AS11880G-12	AIO, Voltage Inputs/Current Outputs, MKS System bus	MKS	AS11880G-12
AS11880G-22	AIO, Current Inputs/Voltage Outputs, EtherCAT bus	MKS	AS11880G-22
AS11880G-32	AIO, Current Inputs/Voltage Outputs, MKS System bus	MKS	AS11880G-32
CN02215	Analog/Digital I/O connector	Phoenix Contact	1790632
WA01100-02	Connector for Auxiliary Power Input		

3.3 Digital Input/Output (DIO) Module

The MKS Digital Input/Output (DIO) slice provides a compact, high-density solution for integrating digital input and output channels with MKS PAC or CM modules.

Each DIO slice supports 12 digital inputs and 12 digital outputs. The DIO slice supports 0–24 VDC voltage inputs and outputs (source and sink types). Figure 12 shows the DIO slice with the optional Phoenix connector installed. The Phoenix connector allows inserting wires (16–24 ga) directly into the slice, simplifying wiring. This connector can easily be removed and replaced. The maximum current per digital output (DO) is 200 mA.



Figure 12—Digital Input/Output (DIO) Slice

Figure 6 shows the front panel of the DIO slice with the Phoenix connector removed.

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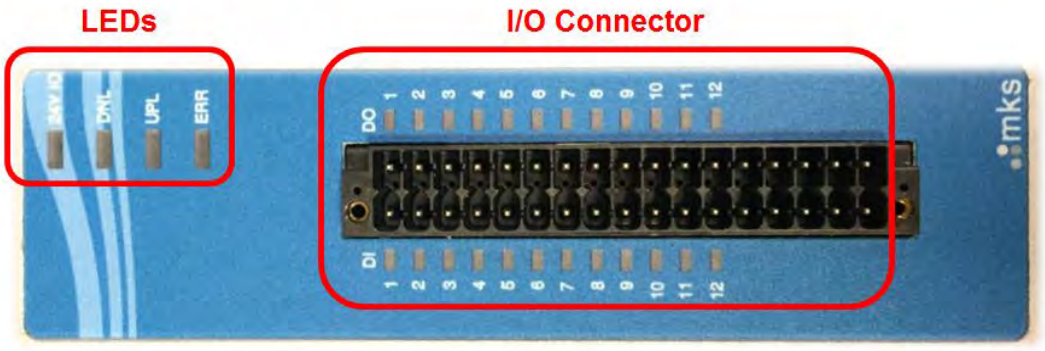


Figure 13—Front Panel of DIO Slice

The DIO slice comes in two configurations: sourcing inputs and outputs, and sinking inputs and outputs. Figure 14 and Figure 15 show the sourcing and sinking I/O, respectively.

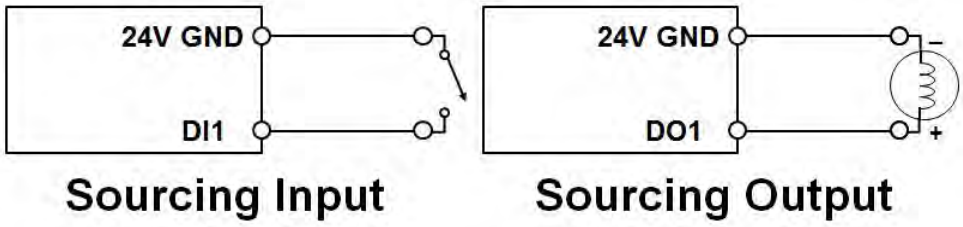


Figure 14—DIO Slice, Sourcing I/O

The sourcing inputs and outputs are active high inputs and outputs respectively (0 V normal state, 24 V when triggered).

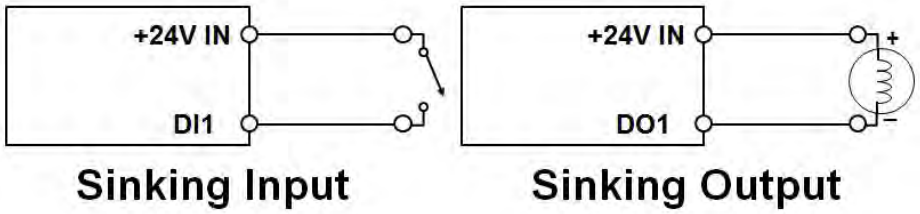


Figure 15—DIO Slice, Sinking I/O

The sinking inputs and outputs are active low inputs and outputs respectively (24 V normal state, 0 V when triggered).

Figure 16 shows how sourcing and sinking inputs and outputs are connected between various pieces of equipment.

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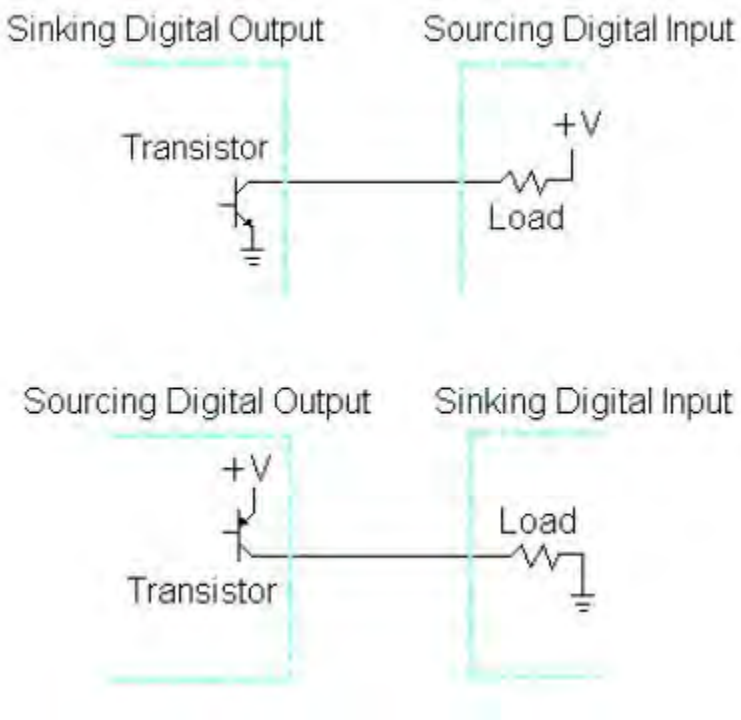


Figure 16—Sink vs. Source

3.3.1 DIO LED Description

The DIO slice has four LEDs on the front panel to show the slice's operational status, and 12 pairs of LEDs that show the logical value of each input or output on the channels. Figure 13 shows the LEDs on the DIO slice, and Table 10 describes the meaning of each LED.

Table 10—DIO LED Descriptions

LED	LED Indication	Definition
Status LEDs		
24V IO	Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.
DNL	Flashing Green	System bus communication in progress.
	Red	System bus communication error has been detected.
UPL	Flashing Green	System bus communication in progress.
	Off	This module is the last in the series of slices.
ERR	Off	Status is OK.
	Flashing Red	An error has been detected.
Channel LEDs		
DI*n*/ DO*n*	Off	Associated input or output is logic low (0).
	Green	Associated input or output is logic high (1)

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3.3.2 DIO Wiring

Each DIO slice supports 12 digital inputs and 12 digital outputs. The +24 V power must be supplied by an external source via these connectors. All the 24 GNDs are on one net. Digital inputs (DIs) are routed to A1 to A12, and digital outputs (DOs) are routed to B1 to B12. Figure 16 shows the DIO connections, and Table 11 lists the connections for the source and sink versions of the slice.

Label	Signal	Pin #	Label	Signal	Pin #
1	DIN1	A1	1	DO1	B1
2	DIN2	A2	2	DO2	B2
3	DIN3	A3	3	DO3	B3
4	DIN4	A4	4	DO4	B4
5	DIN5	A5	5	DO5	B5
6	DIN6	A6	6	DO6	B6
7	DIN7	A7	7	DO7	B7
8	DIN8	A8	8	DO8	B8
9	DIN9	A9	9	DO9	B9
10	DIN10	A10	10	DO10	B10
11	DIN11	A11	11	DO11	B11
12	DIN12	A12	12	DO12	B12
na	GND/24V	A13	na	GND/24V	B13
na	GND/24V	A14	na	GND/24V	B14
na	GND/24V	A15	na	GND/24V	B15
na	GND/24V	A16	na	GND/24V	B16
na	GND/24V	A17	na	GND/24V	B17



Figure 17—DIO Front Connector

Table 11—Pinouts for Source and Sink Slices

Pinout for Source DIO Slice				Pinout for Sink DIO Slice			
Pin #	**Signal**	**Pin #**	**Signal**	**Pin #**	**Signal**	**Pin #**	**Signal**
1	DIN1	**1**	DO1	**1**	DIN1	**1**	DO1
2	DIN2	**2**	DO2	**2**	DIN2	**2**	DO2
3	DIN3	**3**	DO3	**3**	DIN3	**3**	DO3
4	DIN4	**4**	DO4	**4**	DIN4	**4**	DO4
5	DIN5	**5**	DO5	**5**	DIN5	**5**	DO5
6	DIN6	**6**	DO6	**6**	DIN6	**6**	DO6
7	DIN7	**7**	DO7	**7**	DIN7	**7**	DO7
8	DIN8	**8**	DO8	**8**	DIN8	**8**	DO8
9	DIN9	**9**	DO9	**9**	DIN9	**9**	DO9
10	DIN10	**10**	DO10	**10**	DIN10	**10**	DO10
11	DIN11	**11**	DO11	**11**	DIN11	**11**	DO11
12	DIN12	**12**	DO12	**12**	DIN12	**12**	DO12
	GND		GND		+24 V		+24 V
	GND		GND		+24 V		+24 V
	GND		GND		+24 V		+24 V
	GND		GND		+24 V		+24 V
	GND		GND		+24 V		+24 V

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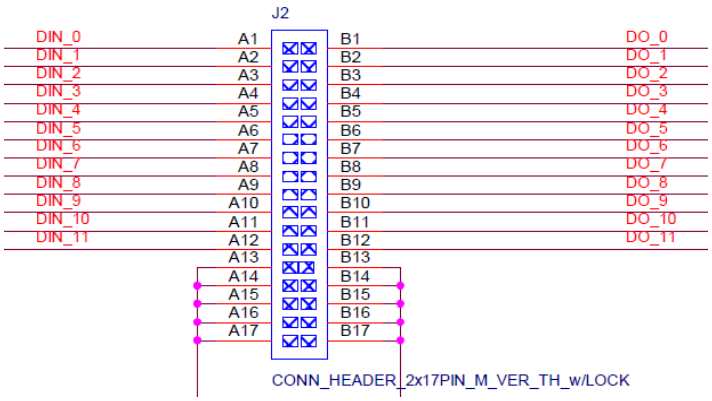


Figure 18—Schematic, Connector on DIO Slice

Note

Pins A13 to A17 and B13 to B17 are GND for the Source slice.
Pins A13 to A17 and B13 to B17 are +24 V for the Sink slice.

3.3.3 DIO Specifications

Table 12 lists the specifications for the DIO module, and Table 13 provides ordering information for the DIO module.

Table 12—DIO Specifications

Digital I/O Module Specifications	
Number of Inputs	12
Input Type	Sink or Source
Sink Input	
Logic Level	24 VDC ±5%
Input Current, Max ON	4.7 mA
Input Current, Max OFF	2.25 mA (10.7 V)
Input Current, Min ON	3.3 mA (4.5 V)
Nominal Load Impedance	6 kΩ
Source Input	
Logic Level	24 V
Input Current, Max ON	4.7 mA
Nominal Load Impedance	6 kΩ
Input Low Voltage Range ON	15 V (2.5 mA)
Input High Voltage Range OFF	12.8 V (2.15 mA)
Debounce Filter	Fixed to 4 cycles of DI Refresh Rate (10.8 µsec)
Input Isolation	2.5 kV RMS
DI refresh rate	10 µs or 1 ms
Protection	ESD to IEC 1000-4-2 ±4 kV contact, DC + 5%, each channel
Number of Outputs	12
Output Type	Open collector sink/source
Pull up/down Value	22 kΩ
Logic Level	24 VDC (8 VDC–30 VDC)
Sink Output	
Minimum Available Current Sink (ON)	200 mA
Maximum Leakage Current (OFF)	0.1 mA (output tied to 24 V)

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Digital I/O Module Specifications	
Maximum Voltage Drop (ON)	Maximum 1.1 V @ 200 mA
Minimum Thermal Current Limit (ON)	1 A per bank of 6
Max Thermal Current Limit (ON)	2 A per bank of 6
Maximum Inductive Load Energy, Cycled @1 Hz	60 mJ
Source Output	
Minimum available current source (ON)	200 mA
Maximum leakage current (OFF)	0.1mA (output tied to Ground)
Output High Voltage	Minimum 23.7 V @ 200 mA
Minimum thermal current limit (ON)	1 A per bank of 6
Maximum thermal current limit (ON)	2 A per bank of 6
Maximum inductive load energy, cycled @1 Hz	60 mJ
Input Isolation	2.5 kV RMS
Max Update Rate	25 µs (see note below)
Protection	ESD to IEC 61000-4-2 ±4 kV contact, short to +24 VDC, 24 V inductive load switching (each channel)
Power Consumption	@ 200 mA ≥ 24 V_IO@ 2.5 A, 24V_CORE@ 0.15 A per module, assuming all DOs are loaded
Operating Temperature	0 to 55°C, with 2°C upper limit reduction per 1000 ft. above sea level
Storage Temperature	–40°C to 85°C
Humidity	5–85 % non-condensing
Altitude	0–10,000 ft. above sea level
Dimensions	35 mm x 125 mm x 92.3 mm (W x H x D)
Mounting	DIN rail and wall mount options

Table 13—DIO Ordering Information

MKS p/n	Description	MFG	MFG p/n
AS11893G-02	DIO, 0–24 V, source	MKS	AS11893G-02
AS11893G-11	DIO, 0–24 V, sink	MKS	AS11893G-11
CN02215	Analog/Digital I/O connector	Phoenix Contact	1790632

3.4 Mass Flow Controller (MFC) Module

The MKS Mass Flow Controller (MFC) module provides a compact, high-density solution for integrating mass flow controllers with the MKS PAC 100 or CM modules.

MFC slices support either 15- or 9-pin analog mass flow controllers. The MFC slice has a direct 1:1 pin mapping of the MKS MFCs, so connected mass flow controllers are fully powered and controlled through the MFC slice. Each MKS MFC slice supports integrating four MKS mass flow controllers. Figure 18 shows the 15-pin MFC. The maximum current per analog output (AO) is 250 mA.

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Figure 19—15-pin MFC Slice

Each MFC slice has an auxiliary three-pin power input connector on the front of the slice that gives the option to wire in additional power for attached MFCs or other devices that require ±15 V or ±24 V. The wiring for this connector is ***optional*** and is not needed for the MFC module to function.

Caution

The auxiliary power connector can power multiple devices that use this voltage, as long as the devices draw less than 1.1 A overall.

Any devices that draw more than 1.1 A overall cannot be powered using the three-pin connector. They will require a separate power supply.

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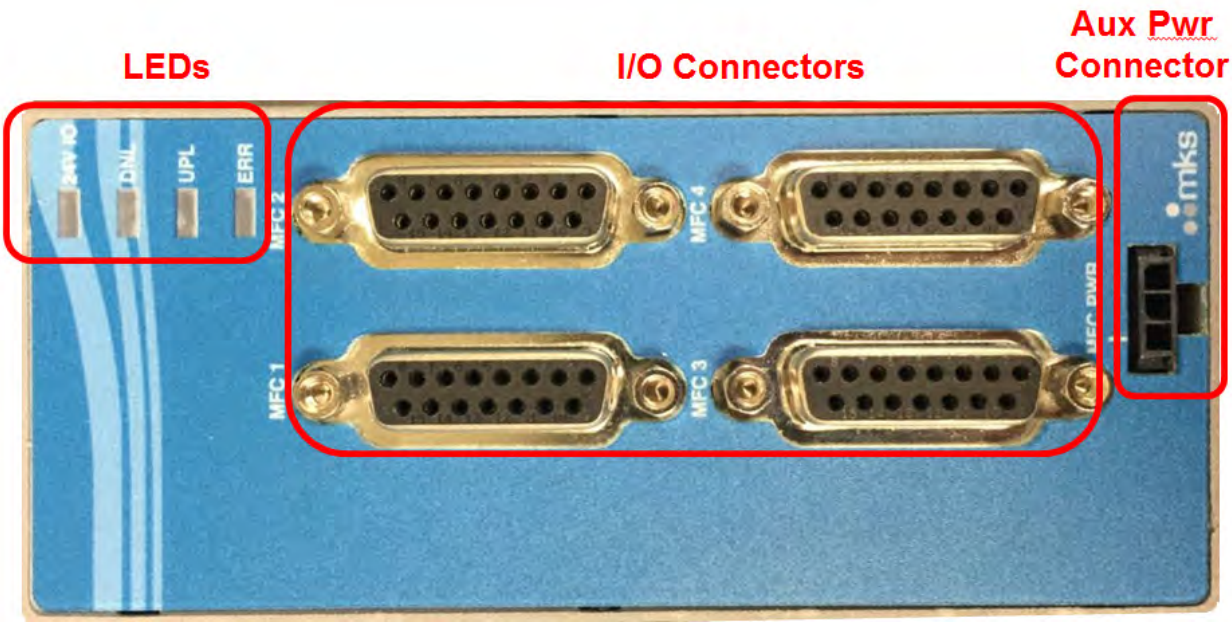


Figure 20—Front Panel of MFC Slice

3.4.1 MFC LED Description

The MFC slice has four LEDs on the front panel to show the slice's operational status. Table 14 describes the functions of these LEDs.

Table 14—MFC LED Descriptions

LED	LED Indication	Definition
24V IO	Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.
DNL	Flashing Green	System bus communication in progress.
	Red	System bus communication error has been detected.
UPL	Flashing Green	System bus communication in progress.
	Off	This module is the last in the series of slices.
ERR	Off	Status is OK.
	Flashing Red	Error detected.

3.4.2 MFC I/O Wiring

MFC slices support either 15- or 9-pin analog mass flow controllers. All four connectors on each MFC share the same pinout, either DB15F or DB9F, shown in Figure 20. The MFC slice has a direct 1:1 pin mapping of the MFCs, so connected mass flow controllers are fully powered and controlled through this slice.

Table 15 provides the connector pinout for the 15-pin MFC slice. All four connectors on the 15-pin MFC slice share the same pinout.

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Table 15—Pinout for 15-pin MFC

PIN #	MFC Function	MFC Controller I/O
1	Valve Test Point	AI
2	Flow Signal Output	AI
3	Valve Close	DO
4	Valve Open	DO
5	Power Supply Common	Power
6	No Connection	
7	+15 to +24 VDC Power	Power
8	Setpoint Input	AO
9	Zero Function	DI
10	Optional Input	AI
11	Signal Common	Signal Common
12	Signal Common	Signal Common
13	No Connection	
14	Pressure Signal Output	AI
15	Chassis GND	

Table 16 provides the connector pinout for the 9-pin MFC slice. All four connectors on the 9-pin MFC slice share the same pinout.

Table 16—Pinout for 9-pin MFC

PIN #	MFC Function	MFC Controller I/O
1	Valve Open/Close	DO
2	Flow Signal Output (0 to +5 VDC)	AI
3	+15 to +24 VDC Power	Power
4	Power Supply Common Digital Ground	Power
5	No Connection	No Connection
6	Set Point Input (0 to +5 VDC)	AO
7	Signal Common	AIO/DIO COM
8	Signal Common COM.	AIO/DIO COM
9	Pressure Signal Output or Valve Test Point	AI (depending on the MFC model can)

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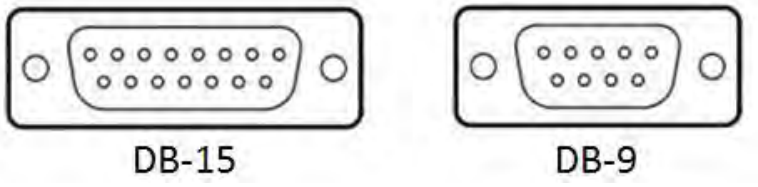


Figure 21—MFC I/O Connectors

Figure 21 shows the three-pin auxiliary power input connector. Table 17 provides the pinout for the three-pin auxiliary power input connector. This pinout is the same for both the 9-pin and 15-pin MFC slices.

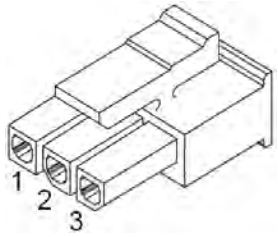


Figure 22—MFC Auxiliary Power Input Connector

Table 17—MFC Auxiliary Power Input Connector Pinout

Pin	Description
1	+15 or +24 VDC
2	Ground
3	–15 or –24 VDC

3.4.3 MFC Specifications

Table 18 lists the specifications for the MFC. Table 19 provides ordering information for the MFC slice.

Table 18—MFC Specifications

Mass Flow Controller Module Specifications	
Timing	Valve override 100 ms + response time (Digital Output)
Power Requirement	24 V ±5%
Max Power Consumption	Assuming each MFC consumes 250 mA and all AOs are fully loaded ≥24 V_IO@1.5 A, 24 V_CORE@ 0.15 A
Auxiliary Power Supply	24 or 15 VDC ±5% This input powers MFCs connected through their I/O connector. Each power output to the MFC should be protected separately.
Digital Output	
Number of DO Channels	12 (3 for each MFC: valve open, valve close, flow zero)
Logic Level and I/O Type	5 V TTL tri state DO for valve override function Active HIGH and LOW. HIGH opens MFC control valve LOW closes the valve and floating allows for set point to control. 5 V TTL Active LOW for valve close Valve open or Flow zero functions referenced to signal ground.

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Mass Flow Controller Module Specifications	
Min available current ON	6 mA
Max Leakage Current OFF	30 µA
Max Voltage Drop when ON	0.2 V into 30 kΩ Impedance
Protection	5 V TVS, resettable fuse (25 mA PTC)
Analog Input	
Number of AO Channels.	16 single-ended, 4 for each MFC: Valve test point, Flow signal output, Optional input, Pressure output
ADC Native Resolution	14 bits
Voltage Range	–2 V to 14 V
Sampling Rate	6.25 kHz (160 µsec , for all 16 channels) (ADC oversampling is set to x32)
Min Input CMRR	50 dB, 0–1 kHz
Max Error Over Full Range	±0.05% of FS (over 20° C– 30° C)
Max Integral Non-linearity	±2 LSB (14-bit @ 14 V)
Min Input Impedance	150 kΩ
Anti-alias HW Filtering	200 Hz ±20%, 6dB/octave minimum
Protection	ESD to IEC 61000-4-2 ±4 kV contact, short to 24 V, +15 V, or –15 V
Analog Output	
Number of AO Channels	4 single-ended (1 for each MFC: Set Point Input)
DAC Native Resolution	14 bits
Range	Voltage : 0–5 V @ 13 bits, 0-10 V @ 14 bits
Output Accuracy at 25°C Ambient	±0.1% of FS @5 V, ±0.05% of FS @10 V
Output Accuracy Temp Drift	32 ppm/°C typical (20° C - 30° C)
Max Output Current	5 mA, into a 2 kΩ, 10 nF load
Settling Time	±2.5 mV in 1 ms into 2 kΩ, 10 nF load
Protection	ESD to IEC 61000-4-2 ±4 kV contact, short to 24 V, +15 V, or –15 V
Certifications	UL, CE, RoHS
Operating Temperature	0 to +55° C
Storage	–40 to +85° C
Humidity	5 to 85% non-condensing
Altitude	Up to 2000 meters
Dimensions	52.5 mm x 125 mm x 92.3 mm (W x H x D)
Mounting	DIN rail

Table 19—MFC Ordering Information

MKS p/n	Connector
AS11890G-02	MFC, 15-pin D-Sub
AS11890G-11	MFC, 9-pin D-Sub
WA01100-02	Connector for Auxiliary Power Input

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3.5 Pressure Input Module

The MKS Pressure Input module provides a compact, high-density solution for interfacing pressure devices with the PAC 100 or CM modules.

Pressure Input slices support 15-pin analog Baratrons®, transducers, Convectrons®, Piranis, piezos, and more. The Pressure Input slice has a direct 1:1 pin mapping to the pressure devices, so connected pressure devices are fully powered and controlled through the Pressure slice. Each MKS Pressure Input slice supports integrating four MKS pressure devices.



Figure 23—Pressure Input Slice

Each Pressure Input slice has an auxiliary three-pin power input connector on the front of the slice that gives the option to wire in additional power for attached pressure sensors or other devices that require ±15 V or ±24 V.

Caution

The auxiliary power connector can power multiple devices that use this voltage, as long as the devices draw less than 1.1 A overall.

Any devices that draw more than 1.1 A overall cannot be powered using the three-pin connector. They will require a separate power supply.

3.5.1 Pressure Input LED Description

The Pressure Input slice has four LEDs on the front panel to show the slice's operational status. Figure 23 shows the LEDs on the Pressure Input slice. Table 20 describes the functions of these LEDs.

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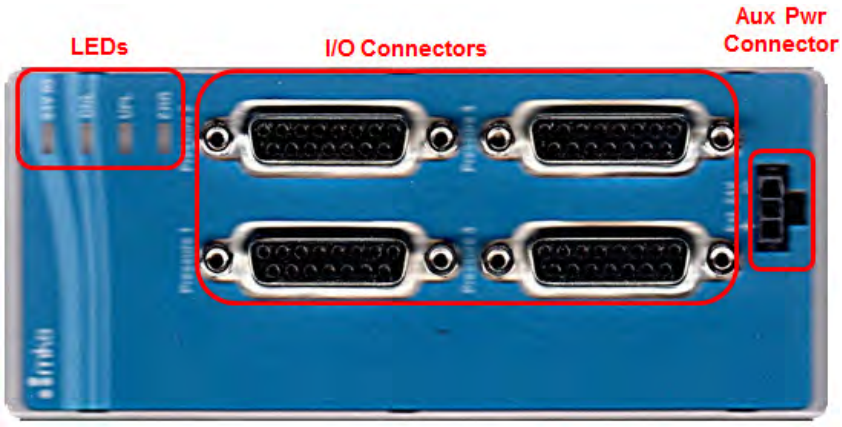


Figure 24—Front Panel of Pressure Input Slice

Table 20—Pressure Input Slice LED Descriptions

LED	LED Indication	Definition
24V IO	Solid Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.
DNL	Blinking Green	System bus communication in progress.
	Solid Red	System bus communication error has been detected.
UPL	Blinking Green	System bus communication in progress.
	Off	This module is the last in the series of slices.
ERR	Off	Status is OK.
	Blinking Red	Error detected.

3.5.2 Pressure Input Slice I/O Wiring

The Pressure Input slice has a direct 1:1 pin mapping to the 15-pin pressure devices, so all connected devices are fully powered and controlled through this slice. Each Pressure Input slice supports integrating four devices. Figure 23 shows the Pressure Input slice connectors.

Table 21 provides the pinout for the Pressure Input slice's I/O connector, and Figure 23 shows the pin numbering on the connector. All four connectors share the same pinout.

Table 21—Pinout for Pressure Input Slice I/O Connector

Pin	Description
1	—
2	Analog In 0–10 VDC
3	—
4	—
5	Power Supply Common
6	–15 VDC Power
7	+15 VDC Power
8	—
9	—
10	—
11	—
12	Pressure Output Return

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Pin	Description
13	—
14	—
15	Chassis GND

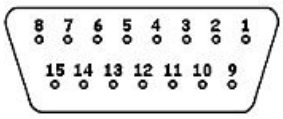


Figure 25—DB15F Connector Pinout

Figure 25 shows the three-pin auxiliary power input connector. Table 22 provides the pinout for the three-pin auxiliary power input connector. The wiring for this connector is ***optional***.

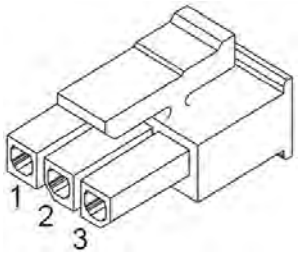


Figure 26—Auxiliary Power Input Connector

Table 22—Pressure Input Slice Auxiliary Power Input Connector

Pin	Description
1	+15 or +24 VDC
2	Ground
3	–15 or –24 VDC

3.5.3 Pressure Input Module Specifications

Table 23 lists the specifications for the Pressure Input slice. Table 24 provides ordering information for the Pressure Input slice.

Table 23—Pressure Input Module Specifications

Pressure Input Module Specifications	
No. of Inputs	4, Single Ended (1 for each pressure signal input)
ADC native resolution	14 bits
Range	Voltage: 0–10 V @ 13 bit
Sampling Rate	6.25 kHz (160 µs for all 4 channels)
Min input CMRR	50 dB, 0–1 kHz
Max error over full range	±0.15% of Full Scale (20° C to 30° C)
Minimum Input Impedance	1 MΩ
Anti-alias HW filtering	200 Hz ±20%, 6 dB/octave minimum

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Pressure Input Module Specifications	
Protection	ESD to IEC 61000-4-2 ±4 kV contact, short to 24 V, +15 V, or –15 V
Input Voltage	24 VDC
Power Consumption	24 V Core: 3.5 W 24 V I/O: Max 120 W when all 4 pressure devices consume 0.8 A max each from ±15 V power supply)
Max Current Delivery per connector	0.8 A
AI latency and repeatability	Response Time: 300 µs ±10%
Operational Environment	
Temperature	0 to 40° C, with 2° C upper limit reduction per 1000 ft. above sea level **Note:** At 40° C ambient, power consumption of the ±15 V power supply should be limited to 100 W (3.3 A @ both ±15 V).
Storage Temperature	–40° C to 75° C
Humidity	5–95% non-condensing
Altitude	up to 2000 meters
MTBF	10 years at 80% confidence level
Dimensions	52.5 mm x 125 mm x 92.3 mm (W x H x D)
Mounting	DIN rail and wall mount options
Note: The Pressure Input slice should be located as the last module (right-most module) in a stack.	

Table 24—Pressure Input Module Ordering Information

MKS p/n	Description
AS11900G-03	15-pin D-Sub
WA01100-02	Connector for Auxiliary Power Input

3.6 Pulse Width Modulating (PWM) Module

The MKS Pulse Width Modulating (PWM) slice provides a compact, high-density solution for interfacing solid state relays (SSRs) for integrating Pulse Width Modulating (PWM) outputs with the MKS PAC 100 or CM module, or with the MultiTherm™ 2000.

Each PWM slice supports 12 digital inputs and 12 PWM outputs. PWM outputs are typically used in temperature control applications, where the PWM output interfaces to an SSR driving a heater. The maximum current per output is 200 mA. The digital inputs are SINK (24 V normal state, 0 V when triggered).

Figure 6 shows the front panel of the PWM module with the optional Phoenix connector installed. This connector allows inserting wires (16–24 ga) directly into the module, simplifying wiring. This connector can easily be removed and replaced.

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Figure 27—Front Panel of PWM Module

Figure 27 shows the front panel of the PWM module with the Phoenix connector removed.

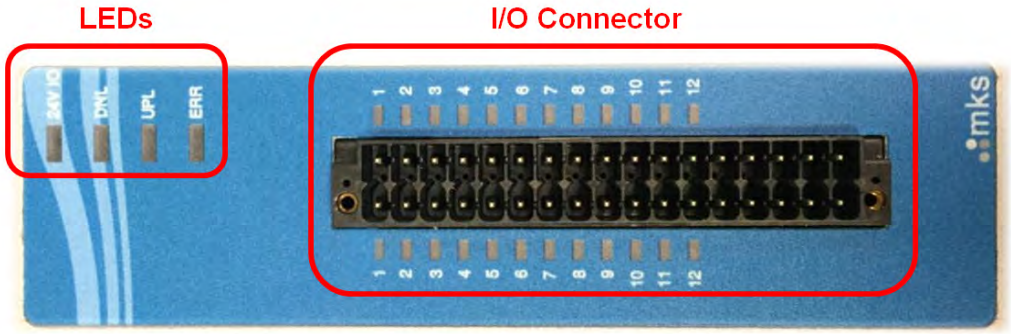


Figure 28—Front Panel of PWM Module

3.6.1 PWM LED Description

The PWM slice has four Status LEDs on the front panel to show the module's operational status, and 12 pairs of LEDs that show the logical value of each input or output on the channels. Table 25 describes these LEDs.

Table 25—PWM LED Descriptions

LED	LED Indication	Definition
Status LEDs		
24V IO	Solid Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.

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DNL	Flashing Green	System bus communication in progress.
	Solid Red	System bus communication error has been detected.
UPL	Flashing Green	System bus communication in progress.
	Off	This module is the last in the series of slices.
ERR	Off	Status is OK.
	Flashing Red	Error detected.
Channel LEDs		
Input *n*	Solid Green	An input is connected to the channel.
Output *n*	Flashing Green	Flashes whenever 24 V output is sent to an SSR.

3.6.2 PWM I/O Wiring

Each PWM slice supports 12 digital inputs and 12 digital outputs. Inputs and outputs are routed as shown in Figure 28.

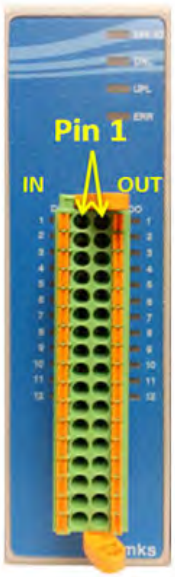


Figure 29—PWM Front Connector

Note

Pins A13 to A17 and B13 to B17 are GND for the Source slice.
Pins A13 to A17 and B13 to B17 are +24 V for the Sink slice.

Table 26—Pinouts for Source and Sink PWM Slices

Pinout for Source PWM Slice				Pinout for Sink PWM Slice			
Pin #	**Signal**	**Pin #**	**Signal**	**Pin #**	**Signal**	**Pin #**	**Signal**
1	DIN1	**1**	DO1	**1**	DIN1	**1**	DO1
2	DIN2	**2**	DO2	**2**	DIN2	**2**	DO2
3	DIN3	**3**	DO3	**3**	DIN3	**3**	DO3
4	DIN4	**4**	DO4	**4**	DIN4	**4**	DO4

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Pinout for Source PWM Slice				Pinout for Sink PWM Slice			
Pin #	Signal	Pin #	Signal	Pin #	Signal	Pin #	Signal
5	DIN5	**5**	DO5	**5**	DIN5	**5**	DO5
6	DIN6	**6**	DO6	**6**	DIN6	**6**	DO6
7	DIN7	**7**	DO7	**7**	DIN7	**7**	DO7
8	DIN8	**8**	DO8	**8**	DIN8	**8**	DO8
9	DIN9	**9**	DO9	**9**	DIN9	**9**	DO9
10	DIN10	**10**	DO10	**10**	DIN10	**10**	DO10
11	DIN11	**11**	DO11	**11**	DIN11	**11**	DO11
12	DIN12	**12**	DO12	**12**	DIN12	**12**	DO12
	GND		GND		+24 V		+24 V
	GND		GND		+24 V		+24 V
	GND		GND		+24 V		+24 V
	GND		GND		+24 V		+24 V
	GND		GND		+24 V		+24 V

3.6.3 PWM Specifications

Table 27 lists the specifications for the PWM module. Table 28 provides ordering information for the PWM module.

Table 27—PWM Specifications

PWM Specifications	
Number of Inputs	12
Input Type	Sink or Source
Sink Input	
Logic Level	24 VDC ±5%
Input Current, Max ON	4.7 mA
Input Current, Max OFF	2.25 mA (10.7 V)
Input Current, Min ON	3.3 mA (4.5 V)
Nominal Load Impedance	6 kΩ
Source Input	
Logic Level	24 V
Input Current, Max ON	4.7 mA
Nominal Load Impedance	6 kΩ
Input Low Voltage Range ON	15 V (2.5 mA)
Input High Voltage Range OFF	12.8 V (2.15 mA)
Debounce Filter	Fixed to 4 cycles of DI Refresh Rate (10.8 µs)
Input Isolation	2.5 kV RMS
DI refresh rate	10 µs or 1 ms
Protection	ESD to IEC 1000-4-2 ±4 kV contact, DC +5%, each channel
Number of Outputs	12
Output Type	Open collector sink/source

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PWM Specifications	
Pull up/down Value	22 kΩ
Logic Level	24 VDC (8 VDC–30 VDC)
Heater Control Method	0 = Synchronized Random Fire SCR 1 = Synchronized PWM zero cross 2 = PWM zero cross / no AC, 50 Hz 3 = PWM zero cross / no AC, 60 Hz
Output Resolution	0.01% Full Scale power
Sink Output	
Minimum Available Current Sink (ON)	200 mA
Maximum Leakage Current (OFF)	0.1 mA (output tied to 24 V)
Output low Voltage (ON)	Maximum 1.1 V @ 200 mA
Minimum Thermal Current Limit (ON)	1 A per bank of 6
Max Thermal Current Limit (ON)	2 A per bank of 6
Maximum Inductive Load Energy, Cycled @1 Hz	60 mJ
Source Output	
Minimum available current source (ON)	200 mA
Maximum leakage current (OFF)	0.1mA (output tied to Ground)
Output High Voltage	Minimum 23.7 V @ 200 mA
Minimum thermal current limit (ON)	1 A per bank of 6
Maximum thermal current limit (ON)	2 A per bank of 6
Maximum inductive load energy, cycled @1 Hz	60 mJ
Input Isolation	2.5 kV RMSs
Max Update Rate	25 µs (see note below)
Protection (each channel)	ESD to IEC 61000-4-2 ±4 kV contact, short to +24 VDC, 24 V inductive load switching (each channel)
Power Consumption (per module)	@ 200 mA ≥ 24 V_IO@ 2.5 A, 24V_CORE@ 0.15 A per module, assuming all DOs are loaded
Operational Environment Temperature	0 to 55°C, with 2°C upper limit reduction per 1000 ft. above sea level
Storage Temperature	–40°C to 85°C
Humidity	5–85 % non-condensing
Altitude	up to 2000 meters
Dimensions	35 mm x 125 mm x 92.3 mm (W x H x D)
Mounting	DIN rail and wall mount options
Note: System refresh data depends on CPU process data time tick that is currently for Low Cost CPU 1 ms.	

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Table 28—PWM Ordering Information

MKS p/n	Description
AS11893G-41	PWM w/ Terminal Block
CN02215	Phoenix connector

3.7 Power (PWR) Module

MKS Power Supply (PWR) modules are a compact solution for supplying power to the MKS Automation Platform. PAC 100s and CMs can run off of a standalone power supply. Whenever more than five I/O slices are connected to a PAC 100, an additional PWR module needs to be added.



Caution **If the power module and the PAC 100 are powered from separate power supplies, the power module needs to be powered up first, and then the PAC needs to be powered up.**

Each PWR module requires two 24 VDC power inputs—one rated at 5 A for the Core, and one rated at 12 A for the I/Os. Figure 29 shows the PWR module. Figure 30 shows the front-panel features.

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Figure 30—PWR Module



Figure 31—Front Panel of PWR Module

3.7.1 PWR LED Description

As shown in Table 29, the PWR slice has two status LEDs on its front panel. Table 29 describes their functions.

Table 29—PWR LED Descriptions

LED	LED Indication	Definition
24V IO	Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.
24V	Green	Power is being delivered to the CPU through the System bus.
	Red	Error delivering power.

3.7.2 PWR Wiring

The PWR slice has two 24 V power inputs—one for powering the I/O, and another for powering the CPU. The user should use separate and isolated 24 V power supplies, one for the CPU and

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another one for the I/O slices. The CPU requires 5 A maximum current, and the I/O requires 12 A maximum current.

The normal configuration on a PAC 100 or CM system is to plug the PWR slice to the right of the first five slices (excluding a PAC 100 or CM) in a device chain. When plugged into the right side of a slice, the PWR slice powers only the slices to the right of it, not the slices to its left.

Figure 31 and Figure 32 show the CPU and I/O power input connectors. Table 30 gives the power connector pinout.

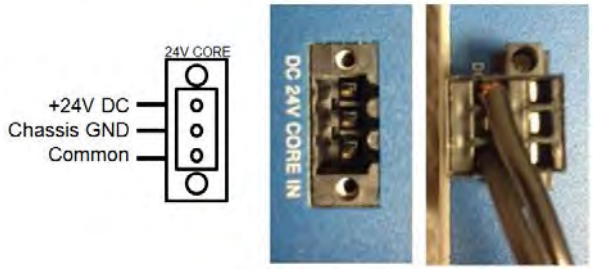


Figure 32—CPU Power In

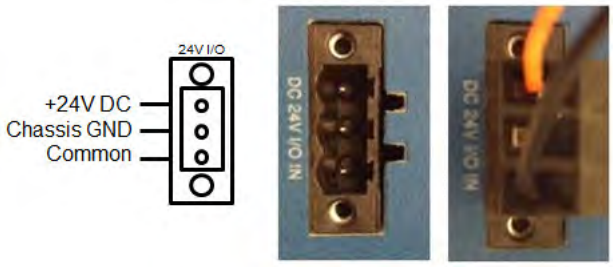


Figure 33—I/O Power In

Table 30—Power Connector Pinout

Pin 1 Starts at Top	Description
1	+24 VDC
2	N/C
3	24 VDC_COM

Figure 33 and Figure 34 show representative examples of the power connectors.

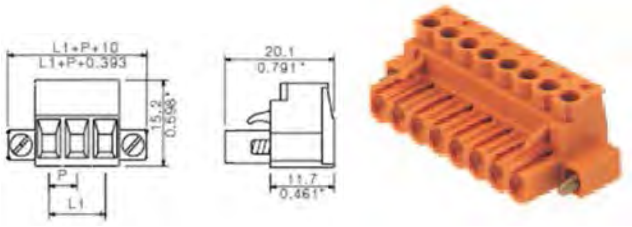


Figure 34—CN01573 I/O Power Connector (example)

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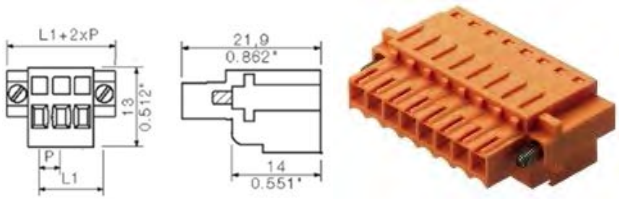


Figure 35—CN00644 CPU Power Connector (example)

3.7.3 PWR Module Specifications

Table 31 lists the specifications for the PWR module. Table 32 provides ordering information for the PWR module.

Table 31—PWR Specifications

MKS Power Module Specifications	
I/O Power (3-pin connector P1)	
Number of MKS PAC I/O slices supported by one PWR module	5 (recommended) 20 Maximum
Voltage	18–30 VDC
Current Rating	12 A (max) Fast Electronic Over current protection shutdown @ 12.5 A @ 2 ms Fast blow fuse @ 15 A (trip 30 A @ 2 ms)
CPU Core Power (3-pin connector P2)	
Voltage	18–30 VDC
Current Rating	5 A (max) Fast Electronic Over current protection shutdown @ 5 A @ 2 ms Poly fuse 30 V @ 5 A
Physical Characteristics	
Dimensions	35 mm x 125 mm x 92.3 mm (W x H x D)
Operating Temperature	0° C to 50° C
Storage Temperature	–40° C to 85° C
Humidity	5–95% (non-condensing)
Altitude	Up to 2000 meters
Compliance	
Vibration/shock resistance	Conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos	IP 40 or higher
Approvals	CE

Table 32—PWR Module Ordering Information

MKS p/n	Description	MFG	MFG p/n
AS11840G-02	PWR, 24 VDC Power Supply	MKS	AS11840G-02
CN01573	I/O Power connector	Weidmuller	180305000
CN00644G	CPU Core power connector	Weidmuller	1691120000

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3.8 Serial Communication Module

The MKS Serial Communication module provides a compact, high-density solution for integrating serial devices with the MKS PAC 100 or CM modules.

MKS Serial Communication slices support a variety of communication standards to interface any type of serial device with the MKS automation platform. Each Serial Communication slice provides four 9-pin D-Sub connectors (DB9M) to support serial-compatible devices including RS-232, RS-422/RS-485 (4-wire), and RS-485 (2-wire).

The Serial Communication slice has a direct 1:1 pin mapping to industry-standard serial devices, so connections to these devices are managed through the slice.



Figure 36—Serial Communication Module

3.8.1 Serial Communication Module Front Panel Description

Figure 36 shows the features on the front panel of the Serial Communication slice. The slice has four status LEDs, and each of the four serial ports has two LEDs associated with it. Table 33 shows the meaning of these LEDs.

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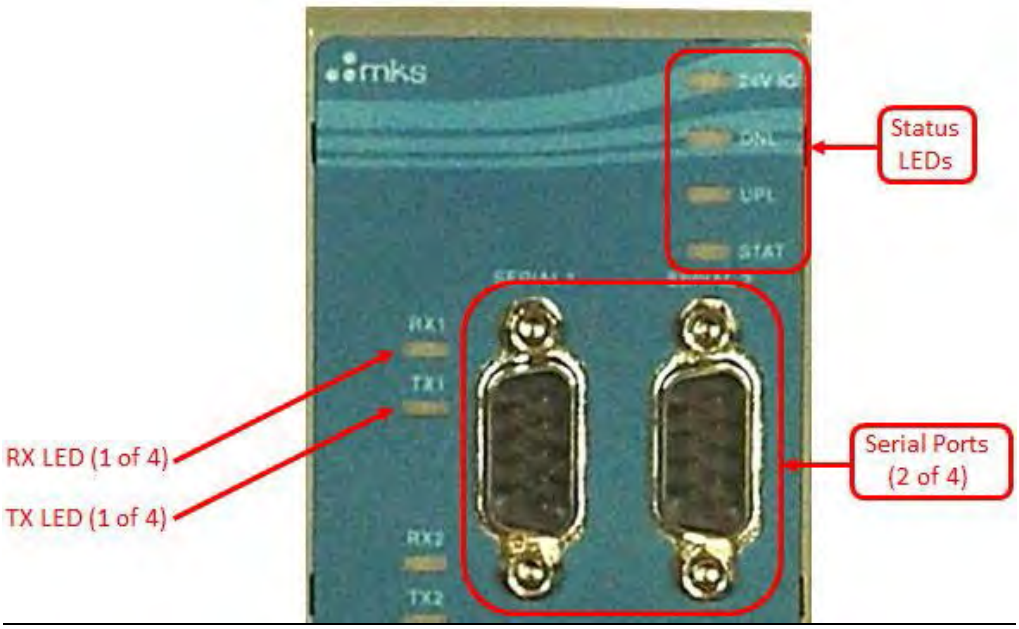


Figure 37—Features on Serial Communication Slice

Table 33—Serial Communication Slice LED Descriptions

LED	LED Indication	Definition
Status LEDs		
24V IO	Solid Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.
DNL	Flashing Green	System bus communication in progress.
	Solid Red	System bus communication error has been detected.
UPL	Flashing Green	System bus communication in progress.
	Off	This module is the last in the series of slices.
STAT	Off	Status is OK.
	Flashing Red	Error detected.
Channel LEDs		
TX*n*	Flashing Green	Flashes during serial data transmission.
RX*n*	Flashing Green	Flashes during serial data reception.

3.8.2 Serial Communication Slice Wiring

Table 34 provides the connector pinout for the Serial Communication slice. All four connectors share the same pinout, DB9M, shown in Figure 37.

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Table 34—Pinouts for Serial Communication Slice

PIN #	RS-232	RS-422/RS-485 (4-wire)	RS-485 (2-wire)
1	—	—	—
2	RxD	RxD+(A)	—
3	TxD	TxD+(A)	Data+(A)
4	—	—	—
5	Ground	Ground	Ground
6	—	—	—
7	RTS	TxD-(B)	Data-(B)
8	CTS	RxD-(B)	—
9	—	—	—

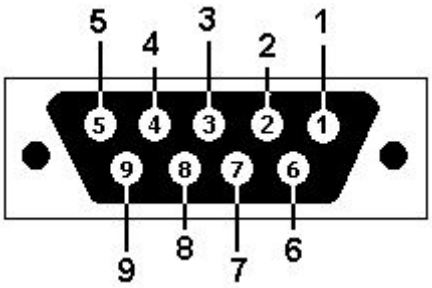


Figure 38—DB9M Pinout

3.8.3 Serial Communication Module Specifications

Table 35 lists the specifications for the Serial Communication module. Table 36 provides ordering information for the Serial Communication module.

Table 35—Serial Communication Module Specifications

Serial Communication Module Specifications	
Number of Ports	4
Connector	9-pin D-Sub Male (similar to MKS CN00030G)
Serial Standards	RS-232/RS-422/RS-485 (support for RS-485 full & half duplex) **Note:** every 2 ports share the same signal configuration for half/full duplex
Tx/Rx FIFO Buffer Size	128 bytes
Maximum Speed Support for RS-485	6.9 Mbps
Serial Signals	
RS-232	TxD, RxD, RTS, CTS, Ground
RS-422	Tx+, Tx–, Rx+, Rx–, Ground
RS-485 four-wire	Tx+, Tx–, Rx+, Rx–, Ground
RS-485 two-wire	Data+, Data–, Ground
Serial Communication Parameters	
Data Bits	5, 6, 7, 8

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Serial Communication Module Specifications	
Stop Bits	1, 1.5, 2
Parity	None, Even, Odd, Space, Mark
Flow Control	RTS/CTS and DTR/DSR (RS-232 only), XON/XOFF
Max Baud Rate	7.5 Mbps for RS-485, 500 Kbps for RS-232
Power Requirements	
Input Voltage	24 VDC
Power Consumption	24 V CORE: 3.5 W 24 V I/O: 4 W
Operational Environment	
Temperature	0 to 55° C, with 2°C upper limit reduction per 1000 ft. above sea level
Storage Temperature	-40° C to 85° C
Humidity	5-85% non-condensing
Altitude	up to 2000 meters
Dimensions	52.5 mm x 125 mm x 92.3 mm (W x H x D)
Mounting	DIN rail and wall mount options

Table 36—Serial Communication Module Ordering Information

MKS p/n	Description
AS11899G-01	MKS Serial Communication Module (RS-232/RS-422/RS-485)

3.9 Temperature Input (TEMP) Module

The Temperature Input (TEMP) module provides a compact, high-density solution for integrating temperature inputs with the MKS Automation Platform PAC or CM modules, or the MultiTherm™ 2000.

The TEMP slice supports interfacing thermocouple inputs (all TC types) or Resistance Temperature Detector (RTD) type PT 100 or PT 1000 inputs with the MKS Automation Platform. Each TEMP slice supports eight temperature inputs.

Figure 38 shows the front panel of the TEMP slice.

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Figure 39—TEMP Slice Front Panel

3.9.1 TEMP LED Description

The TEMP slice has four LEDs on the front panel to show the slice's operational status, and one LED for each of the eight thermocouple inputs to show the channel's operational status (not shown). Figure 39 shows the LEDs on the TEMP slice, and Table 37 lists their functions.

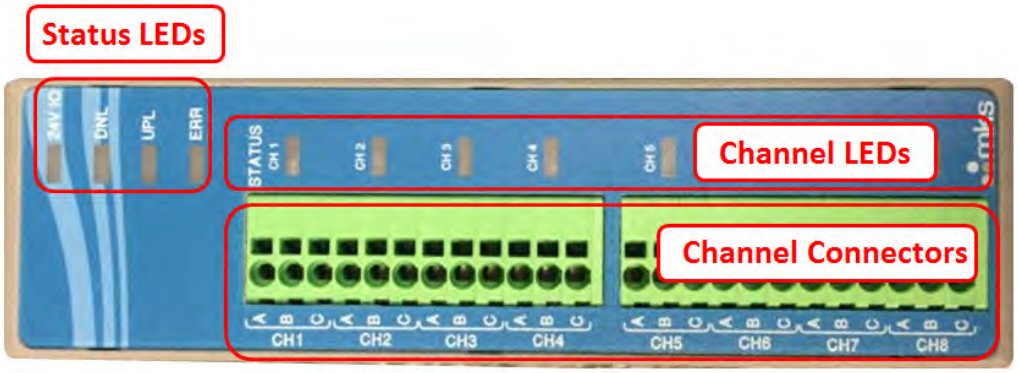


Figure 40—TEMP LEDs

Table 37—TEMP LED Descriptions

LED	LED Indication	Definition
Slice Status LEDs		
24V IO	Solid Green	Power is being delivered to I/Os through the System bus.
	Red	Error delivering power.

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LED	LED Indication	Definition
DNL	Flashing Green	System bus communication in progress.
	Solid Red	System bus communication error has been detected.
UPL	Flashing Green	System bus communication in progress.
	Off	This module is the last in the series of slices.
ERR	Off	Status is OK.
	Flashing Red	Error detected
Channel Status LEDs		
CH*n*	Off	No sensor attached.
	Solid Green	Sensor attached and functioning properly.
	Solid Red	ADC or Cold Junction sensor fault. Raw AI reading outside of valid range for configured type.

3.9.2 TEMP I/O Wiring

The TEMP PT 100 (–200º C to 715º C) and TEMP PT 1000 (–200º C to 850º C) temperature input slices feature eight sensor channels that support two RTD types (PT 100 or PT 1000) with either two-wire or three-wire connections, and different types of thermocouples (J, K, N, S, B, T, E, and R).

Each zone on the PT 100 or PT 1000 TEMP input slice reads the temperature using thermocouples or two-wire or three-wire RTD (PT 100 and PT 1000) sensors. Each RTD type has internal linearization capability. The linearization feature that converts resistance to temperature is implemented by using 2nd-order polynomial equation.

Figure 40 shows a TEMP slice connector, and Figure 41 shows wiring for thermocouple and RTD sensors. Refer to the Connector pin-outs for the appropriate wiring setup. The TEMP slice can accept as many as eight RTD or thermocouple inputs. Table 38 shows how to wire the sensors to the channel connector.



Note

The shorter the leads for the RTDs, the better the accuracy. Refer to the RTD manufacturer specification for maximum operating length.

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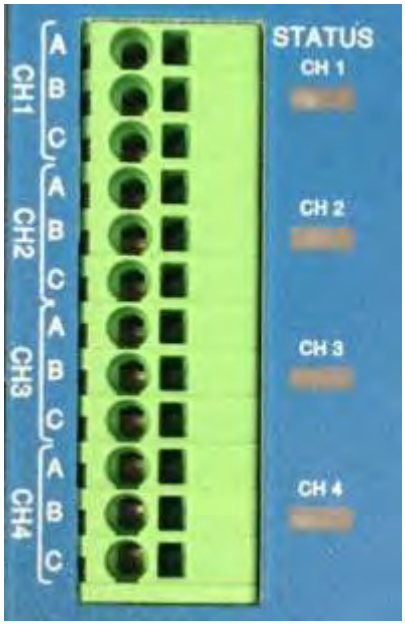


Figure 41—TEMP Slice Connector

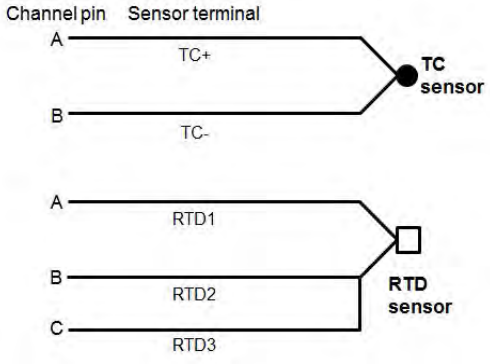


Figure 42—Sensor Connections

Table 38—Sensor Connections to TEMP Channel

	Channel *n*		
Sensor Type	**A**	**B**	**C**
RTD	RTD1 supply signal	RTD2 common return	RTD3 common return
Thermocouple	TC + wire 1	TC – wire 2	Not used

A two-wire RTD sensor can be converted to a three-wire RTD sensor by adding an additional common return lead.

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3.9.3 TEMP Specifications

Table 39 lists the specifications for the TEMP module. Table 40 provides ordering information for the TEMP module.

Table 39—TEMP Specifications

Temperature Input Module Specifications	
Number of Inputs	8
ADC Native Resolution	16 bits
Thermocouple Type (configurable)	2-wire thermocouples (J, K, T, E, R) 3-wire resistance temperature detectors (RTDs): PT 100 (–200º C to 715º C) or PT 1000 (–200º C to 850º C)
Input Stability	0.08º C for RTDs, 0.1º C for T/C's
Input Resolution	0.01º C (input dependent)
Control Accuracy	0.1º C (input dependent)
Sample Rate	Configurable from 1.6 Hz to 13 Hz
Main Power Supply	24 V
Maximum Power Consumption per Module	24V_IO@ 0.25 A, 24V_CORE@ 0.15 A
Temperature	0 to 55º C, with 2º C upper limit reduction per 1000 ft. above sea level
Storage Temperature	–40º C to 85º C
Humidity	5–85% non-condensing
Altitude	0–10,000 ft. above sea level
Shock	30 G, 11 ms duration, half-sine shock pulse
Vibration	2.5 G acceleration over 5–300 Hz sine wave, 1 octave/min sine sweep
EMC Emissions	EN 61000-6-2: 2005
EMC Immunity	EN 61000-6-4: 2007
Dimensions	35 mm x 125 mm x 92.3 mm (W x H x D)
Mounting	DIN rail and wall mount options

Table 40—TEMP Ordering Information

MKS p/n	Input	Input Type	Connector
AS11860G-40	RTD or TC	PT 100 RTD, any TC	Terminal
AS11860G-50	RTD or TC	PT 1000 RTD, any TC	Terminal
AS11860G-60	RTD or TC	PT 100 RTD, any TC	Removable Terminal
AS11860G-70	RTD or TC	PT 1000 RTD, any TC	Removable Terminal

3.10 Installation and Wiring

This chapter describes how to connect the PAC modules to each other and on a DIN rail (optional). It also describes the wiring information on the I/O and CPU modules.

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WARNING — **Follow all applicable electrical codes when mounting and wiring any electrical device.**

Caution — **Do not attempt to "Hot Connect" or "Hot Swap" the components of the MKS Automation platform (i.e., do NOT connect or detach the modules while they are powered on). This can damage the PACs and modules, and is not covered by your product warranty.**

Always turn off or disconnect all power before attempting to service your PAC system.

Caution — **In order to guarantee proper operation and prevent damage to the product, ensure that the chassis ground is properly attached for the application.**

3.11 Installation

This section describes assembling and installing your PAC 100 system. Figure 42 shows a typical PAC 100 system stack.



Figure 43—PAC 100 System

The PAC 100 mounts on a standard 35 mm DIN rail system. Make sure there is sufficient side clearance for ventilation to maintain an ambient operating temperature of 0° C to 50° C.

CAUTION — **Ensure that the PAC 100 system hardware is installed in a drip-free and relatively dust-free environment.**

Your PAC 100 system needs to be assembled in the following order:

- The CPU must be the left-most module.
- The I/O slices must be installed to the RIGHT of the CPU.
- If a Pressure Input slice is installed, it must be the right-most slice in the stack.

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- If five or more I/O slices are attached, insert an additional PWR module (see Figure 43), or verify that the total power draw for all I/O slices is less than 12 A.
- The PAC 100 can use a maximum of 20 I/O slices (not including additional PWR modules).

A PWR module needs to be added for each five slices attached to a PAC 100. PWR slices provide power only to “downstream” slices, that is, slices connected to the right of the PWR slice. Figure 43 shows one possible configuration.

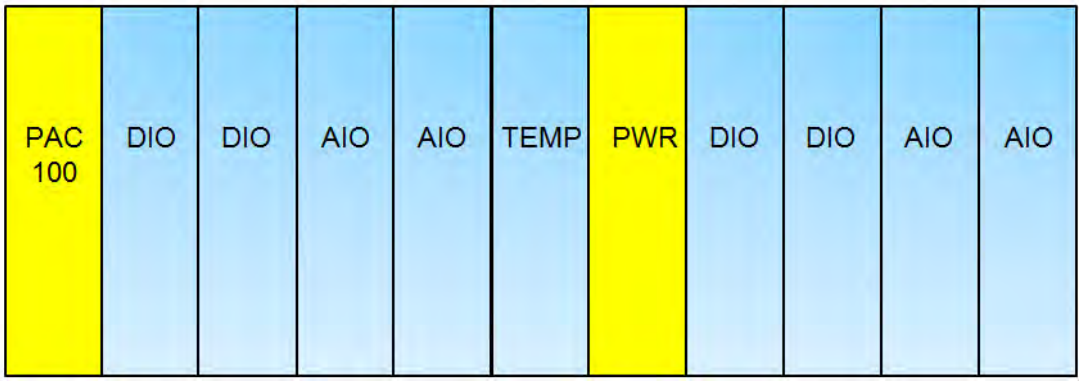


Figure 44—PWR Module Inserted After Five I/O Slices

The CPU module comes with a cover (highlighted in Figure 44) to protect the L-bus connector. Remove this connector by using a small flat head screwdriver and pressing on the tabs to first get one side loose. Then get the other side loose.



Figure 45—Removing the L-bus Connector Cover

Slices can be connected to each other by firmly pushing the modules together as shown in Figure 45.

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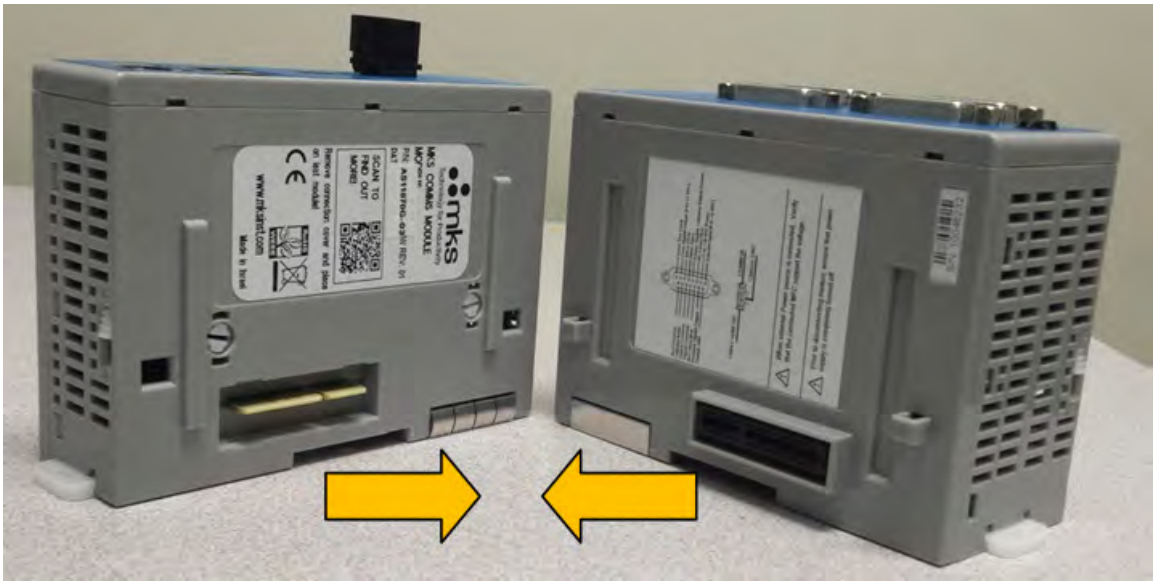


Figure 46—Connecting a PAC 100 to Another Module

For a PAC 100-based system, place the PAC 100 on the left-hand end of the stack, and attach the other slices to its right side. Carefully apply firm pressure for each connection.



Figure 47—Locking Switch

Lock each connection together by pushing down on the locking switch highlighted in Figure 46. This switch, located on each side of the slices, ensures that they do not get disconnected easily.

Note

The locking switches must be up (unlocked) before slices (modules) can be joined.

The right-hand side of a slice has two white slotted knobs recessed into the case. These knobs are connected to the locking switches, and can be used instead of the switches to lock or unlock the slices.

Figure 47 shows an assembled stack containing a PAC 100, a TEMP slice, an AIO slice, and a DIO slice. This is a possible combination for a MultiTherm™ 2000.

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Figure 48—Assembled PAC 100 Stack

Once the CPU and the I/O slices have been securely connected together into a stack, they can be mounted on a DIN rail after pulling out the white plastic clip on the bottom of each slice. Figure 48 shows this clip.



Figure 49—PAC 100 DIN Rail Clip

Figure 49 shows the back view of a PAC 100 stack after the locking switches have been depressed. This stack is ready to be installed on a DIN rail.

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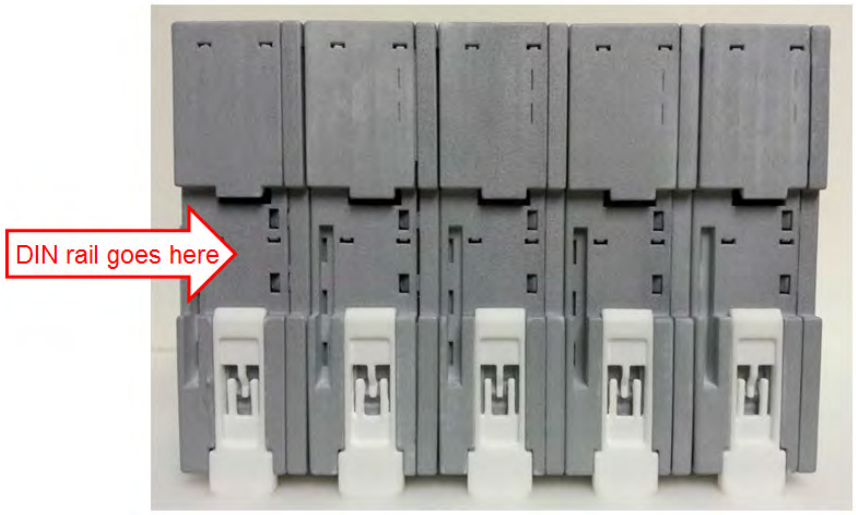


Figure 50—PAC 100 Stack, Back View

The PAC system stack mounts to a standard 35 mm DIN rail by hanging it on the rail, and then securing the white clips. Orientation is optional, but is easiest on a horizontal DIN rail with the top of the stack facing up.

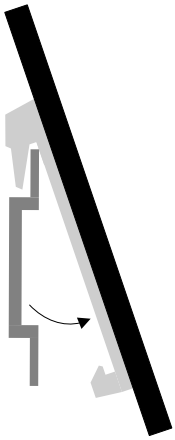


Figure 51—SLQM DIN Rail Mounting

Once the stack is placed on the DIN rail, push all the white clips back in to secure the stack to the rail. Now your PAC 100 stack is ready for wiring.

3.12 Wiring

The following sections provide a brief synopsis of connections to the PAC 100 and its attached I/O slices. See *Chapter 3, PAC 100 and CM Hardware Description*, for more details on CPU and slice wiring.

3.12.1 PAC 100 and CM Connections

This subsection lists the available connections on the PAC 100 and the CM that need to be wired for proper operation.

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3.12.1.1 Power Inputs

The PAC 100 CPU and the CM have two 24 V power inputs—one for powering the I/Os, and another for powering the CPU. You need to use separated and isolated 24 V power supplies, one for the CPU and one for the I/O. If you have additional PWR slices, each one needs to have separated and isolated 24 V power supplies as well. See *Section 3.7.2, PWR Wiring*, for details on connecting the PAC 100 or CM to power.

3.12.1.2 EtherCAT Connectors

The PAC 100 CPU and the CM have two connectors for EtherCAT: ECAT IN, and ECAT OUT, which use standard RJ45-style connectors and cabling. These ports are used when the modules are configured for running EtherCAT. Do not use either of these ports as an Ethernet connection.



Note **The Controls Workbench software does not support EtherCAT.**

3.12.1.3 Ethernet Port

The 10/100BaseT Ethernet port has Auto MDI-X capability, and it can be connected to other Ethernet devices directly or through a hub or router without needing a crossover cable or adapter. This port uses standard RJ45-style connectors and cabling. As with all Ethernet devices, hot-swapping of the Ethernet cable is permissible.

Use this port when your PAC 100 or CM system is configured to run Modbus. One example of this configuration is if your PAC 100 is configured as a MultiTherm 2000 running Controls Workbench.

3.12.1.4 USB Port

The PAC 100 and the CM have one USB port that uses a USB Type A connector. The USB connector can be used to display diagnostics messages on the PAC 100. This will be functional in a future version of PAC 100.

3.12.2 AIO Wiring

The AIO slices are available as voltage-in, current-out (VICO) or current-in, voltage-out (CIVO) devices.

Each analog output (either voltage or current output) consists of two pins: AO_OUTp (power) and AO_OUTn (ground). Each AIO slice also has the option to wire in additional power (for devices that need ±15 V) directly through the three-pin ±15 V connector (P1).

The ±15 V from the three-pin connector gets routed to pins A14, A15, A16 and A17 as well as pins B14, B15, B16 and B17 on the external connector. Devices that need power can be powered up using these pins on the external connector.



Caution **The ±15 V auxiliary power connector can power multiple devices that use this voltage, as long as the devices draw less than 1.1 A overall.**

Any devices that draw more than 1.1 A overall cannot be powered using the three-pin connector. They will require a separate ±15 V power supply.

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The optional Phoenix connector simplifies making connections to the AIO slice. For more details, please see *Section 3.2, Analog Input/Output (AIO) Module*.

3.12.3 DIO Wiring

The DIO slice connects to sink or source digital inputs, and provides sink or source digital outputs. The output voltage from each channel is either a 24 V SINK or 24 V SOURCE signal, depending on the model chosen.

For example, if you want to connect the first output channel of the DIO slice to a solid-state relay (SSR), the DO_1 (output) and B13 (common) pins need to be connected to the Control inputs of the SSR.

The optional Phoenix connector simplifies making connections to the DIO slice. For more details, please see *Section 3.3, Digital Input/Output (DIO) Module*.

3.12.4 MFC Wiring

The MFC slice connects directly to MFC devices using a straight-through pin configuration, allowing connecting with an MFC device using a straight-through cable. MKS MFCs and MFC slices are available in 9-pin and 15-pin configurations. Use of 9- to 15-pin adapter cables is not supported by MKS at this time.

For more details, please see *Section 3.4, Mass Flow Controller (MFC) Module*.

3.12.5 Pressure Input Wiring

The Pressure Input slice connects directly to pressure devices using a straight-through pin configuration, allowing connecting with a pressure device using a straight-through cable.

If a Pressure Input slice is installed, it must be the right-most slice in the stack. For more details, please see *Section 3.5, Pressure Input Module*.

3.12.6 PWM Wiring

The PWM slice connects to sink or source digital inputs, and provides sink or source PWM outputs. The output voltage from each channel is either a 24 V SINK or 24 V SOURCE signal, depending on the model chosen.

To connect the first output channel of the PWM slice to a solid-state relay (SSR), the DO_1 (output) and B13 (common) pins need to be connected to the Control inputs of the SSR.

The optional Phoenix connector simplifies making connections to the PWM slice. For more details, please see *Section 3.6, Pulse Width Modulating (PWM) Module*.

3.12.7 PWR Wiring

The PAC 100 and the CM require an additional PWR module (power supply) any time more than five I/O slices are connected to it. Each PWR module requires a 24 VDC power supply and provides 12 A current for the I/O slices.

Each PWR module has two 24 V power inputs on the module—one for powering the I/Os and another for powering the electronics on the module itself. You need to use separated and isolated 24 V power supplies, one for the CPU and one for the I/O.

Note	**The PWR module does not have the same connector configuration as the PAC 100 CPU module.**

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The PWR slice provides power only to “downstream” slices, that is, slices connected to its right. When fewer than five I/O slices are connected in the stack, a PWR module is not needed.

For more details, please see *Section 3.7, Power (PWR) Module*.

3.12.8 Serial Wiring

The Serial Communication slice provides four DB9M ports supporting RS-232, RS-422/RS-485 (4-wire), and RS-485 (2-wire) communications. Use an appropriate serial cable to connect the Serial Communication slice to other serial devices.

For more details, please see *Section 3.8, Serial Communication Module*.

3.12.9 TEMP Wiring

The TEMP module provides eight channels for connecting type J, K, N, S, B, T, E, and R thermocouples; and PT 100 or PT 1000 type Resistance Temperature Detectors (RTDs) to your PAC 100 system. Two- and three-wire sensors are supported.

Connect the thermocouple positive wire (TC+) or RTD supply signal (RTD1) to pin A of the TEMP channel. Connect the thermocouple return wire (TC–) or the RTD common return (RTD2) to pin B of the TEMP channel. If a three-wire RTD is used, connect the RTD common return (RTD3) to pin C of the TEMP channel.

For more details, please see *Section 3.9, Temperature Input (TEMP) Module*.

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4. Programming the PAC 100

The PAC 100 has a Modbus TCP/IP interface for programming with the following:

- MULTIPROG software with IEC61131-3 compliant development environment for IEC programming capabilities
- Labview

In addition, the MKS PAC100 can be controlled manually using MKS Controls Workbench (CWB).

The MKS CM lacks programming support, but can be programmed in Labview or controlled manually in CWB. For more details, refer to https://www.mksinst.com/docs/UR/MKSAutomationPlatform-programmability.aspx .

4.1 IEC 61131-3 Programming Interface

The PAC 100 supports the following programming languages using MULTIPROG Express and Pro 5.5:

- Ladder Logic
- Structured Text
- Function Block Diagrams
- Instruction List
- Sequential Function Charts

Limitations of the programming for the MKS PAC family depend upon two things:

- MKS PAC version
- MULTIPROG version

Depending on how extensive the PLC logic is, you can choose to program in MULTIPROG Express or Pro. The versions are compared in Table 41. For more details, refer to the software details page at https://www.phoenixcontact-software.com/en/iec-61131-control/programming-systems/multiprog-5.

Table 41—MULTIPROG 5.5 Support

Specification	MULTIPROG Pro	MULTIPROG Express
Nodes in the project tree	8000	8000
Configurations/resources in Project tree	100 / 100	1 / 1
Program instances per resource	1000	11
Tasks per resource	16	5
Program instances per task	500	15
Global variables/local variables per POU	30000/15000	5000/1500
Included libraries	32	32
POUs in one project (including POUs of libraries)	2000	256
Number of supported IOs per project	128 Kb	128 Kb
I/O groups	200	200

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4.2 Controls Workbench (CWB)

The Controls Workbench (CWB) software product supports Modbus TCP/IP connectivity to provide data exchange and seamless integration into a Modbus network. CWB must be installed on a PC that is on the same network as the PAC 100 or CM. CWB can be used for configuration, process monitoring, plotting, data export, auto-tuning, and remote manual control of your connected MKS devices. For more details on CWB, refer to the *Controls Workbench User Manual* located in the Documents and Downloads section at http://www.mksinst.com/product/product.aspx?ProductID=1479

4.3 Labview

Virtual Instruments (VIs) for the CM/PAC 100 and I/O modules are available. Please contact your local MKS Sales representative or MKS Automation and Control Solutions Applications Engineers for the VIs.

4.4 Telnet Interface

The PAC 100 has an available Telnet interface. The serial port is used to send all legally required copyright messages, current version information, and hardware configuration information during the PAC 100's power-up sequence.

The PAC 100 has a Web server interface available through a Telnet Client like Microsoft Telnet, Tera Term, etc. However, this interface is intended for authorized personnel for debug, diagnostic purposes. The web server also provides access to a proprietary command line interface, with specific commands to display advanced or detailed status information, and control of configuration parameters. These same parameters can also be accessed through a Modbus TCP connection or EtherCAT connection.

4.5 List of Commonly Used Shell Commands

The most commonly used shell commands are listed in Table 42.

Table 42—Commonly Used Shell Commands

Useful shell commands	Description	Usage example	Example output
tc_rd <subcommand> <args>	Reads information from the controller application. The command shows all available options and usage if no subcommand or arguments are given.		
tc_wr <subcommand> <args>	Writes configuration to the controller application. The command shows all available options and usage if no subcommand or arguments are given.		

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Useful shell commands	Description	Usage example	Example output
tc_rd input_raw_temp	Shows the converted temperatures for all input channels.	**tc_rd input_raw_temp**	**shell>tc_rd input_raw_temp** Read Input Raw Temperature: Chnl 0 Raw Temperature: 158.328247 Chnl 1 Raw Temperature: 0.000000 Chnl 2 Raw Temperature: 0.000000 Chnl 3 Raw Temperature: 0.000000 Chnl 4 Raw Temperature: 0.000000 Chnl 5 Raw Temperature: 0.000000 Chnl 6 Raw Temperature: 0.000000 Chnl 7 Raw Temperature: 0.000000 Chnl 8 Raw Temperature: 0.000000 Chnl 9 Raw Temperature: 0.000000 Chnl 10 Raw Temperature: 0.000000 Chnl 11 Raw Temperature: 0.000000 Chnl 12 Raw Temperature: 0.000000 Chnl 13 Raw Temperature: 0.000000 Chnl 14 Raw Temperature: 0.000000 Chnl 15 Raw Temperature: 0.000000 Chnl 16 Raw Temperature: 0.000000
tc_wr thermocouple_type <input> <type>	Chooses the thermocouple type for an input channel: J = 1 (default) K = 0 Takes effect immediately.	**tc_wr thermocouple_type 0 1**	**shell> tc_wr thermocouple_type 0 0** **shell>** **shell> tc_rd thermocouple_type** Read Input Chnl TC Type Configuration: Chnl 0 TC Type: 0(K) Chnl 1 TC Type: 1(J) Chnl 2 TC Type: 1(J) Chnl 3 TC Type: 1(J) Chnl 4 TC Type: 1(J) Chnl 5 TC Type: 1(J) Chnl 6 TC Type: 1(J) Chnl 7 TC Type: 1(J) Chnl 8 TC Type: 1(J) Chnl 9 TC Type: 1(J) Chnl 10 TC Type: 1(J) Chnl 11 TC Type: 1(J) Chnl 12 TC Type: 1(J) Chnl 13 TC Type: 1(J) Chnl 14 TC Type: 1(J) Chnl 15 TC Type: 1(J) Chnl 16 TC Type: 1(J)
tc_wr snsr_cfg <type>	Chooses the AFE sensor type for ALL channels: 0 = Thermocouple (default) 1 = RTD	**tc_wr snsr_cfg 1**	**shell> tc_wr snsr_cfg 0** **u8 sensor cfg: 0**

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Useful shell commands	Description	Usage example	Example output
tc_wr smp_rate <rate>	Chooses the AFE sample rate for ALL channels: 0x0 = 1.67 Hz 0x1 = 3.30 Hz 0x2 = 6.51 Hz 0x3 = 12.66 Hz (Default) 0x4 = 23.81 Hz 0x5 = 42.92 Hz 0x6 = 71.43 Hz 0x7 = 107.53 Hz	**tc_wr smp_rate 3**	
tc_wr pwm_cfg <type>	Chooses digital output format for ALL channels 2 = Zero Cross w/o AC 50 Hz 3 = Zero Cross w/o AC 60 Hz (default)	**tc_wr pwm_cfg 2**	**shell> tc_wr pwm_cfg 2** **u8 pwm_cfg : 2**
tc_wr ctrl_ch_in <cfgloop> <input_ch>	Assigns an input channel to the process value of control loop.	**tc_wr ctrl_ch_in 4 1**	
tc_wr ctrl_ch_out <cfgloop> <output_ch>	Assigns an output channel to the manipulated value of control loop channel.	**tc_wr ctrl_ch_out 4 1**	
tc_wr scaling_gain <cfgloop> <gain>	Sets the gain of the output of a control loop. (Default = 1.0)	**tc_wr scaling_gain 5 1.23**	
tc_wr scaling_offset <cfgloop> <offset>	Sets the offset of the output of a control loop (Default = 0.0)	**tc_wr scaling_offset 6 0.98**	
tc_wr setpoint_src <cfgloop> <srcloop>	Sets the source of the setpoint for a control loop (0 for srcloop = setpoint from shell/Fieldbus)	**tc_wr setpoint_src 2 1**	
tc_rd max_conv	Gets all the maximum conversion value for all temperature input channels		
tc_wr max_conv <input ch> <value>	Sets the maximum conversion value for the temperature input channel (NOTE: AIO Slice only supports this option)		
tc_rd min_conv	Gets all the minimum conversion value for all temperature input channels		
tc_wr min_conv <input ch> <value>	Sets the minimum conversion value for the temperature input channel (NOTE: AIO Slice only supports this option)		
tc_rd slice_cfg	Gets 32-bit slice cfg value for all slices		

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Useful shell commands	Description	Usage example	Example output
tc_wr slice_cfg <slice#> <value>	Sets 32-bit slice cfg value for the slice (slice# starts @ 1)		
tc_rd dev_cfg	Device Configuration now includes pidrecover.	**tc_rd dev_cfg**	**shell>tc_rd dev_cfg** Read Device Configuration: pidrecover: 0 CT enable: 0 loop time: 100 protocol: 1
tc_wr pidrecover <value>	Global enable/disable of PID control mode and control state recovering on reboot. Control mode and state are stored in NVRAM.	**tc_wr pidrecover 1**	**shell> tc_wr pidrecover 1** **u8 pidrecover : 1**
tc_rd sync_assign	Reads Sync Assignments for Power Output capable slices that support sync assignment	**tc_rd sync_assign**	Slice Sync Input Assignment Configuration: --- Slice 01 --- DO 01 = DI 01 DO 02 = DI 02 DO 03 = DI 03 DO 04 = DI 04 DO 05 = DI 05 DO 06 = DI 06 DO 07 = DI 07 DO 08 = DI 08 DO 09 = DI 09 DO 10 = DI 10 DO 11 = DI 11 DO 12 = DI 12
tc_wr sync_assign <decimal value:DigOutCh#> <16bit hex value: MSB = SlicePos, LSB = DigInCh#> **SlicePos = {1, Number of slices on bus}** **DigOutCh#(for DIO Slice) = {1,12}** **DigInCh# (for DIO Slice) = {1,12}**	Write/Cfg Sync Assignments for Power Output capable slices that support sync assignment	**tc_wr sync_assign 1 0x0302**	
eclr_wr boot <bootmode value>	Sets the boot mode for the eCLR (PLC)	**eclr_wr boot 1**	0 = Cold boot 1 = Warm boot 2 = Idle 3 = Exit
eclr_rd boot	Gets the boot mode for the eCLR (PLC)	**eclr_rd boot**	
tc_wr ctrl_type <loop> <control type value>	Sets the control type for the loop.	**tc_rd ctrl_type 1 3**	0 = PID 1 = MPC Ctrl 1st 2 = MPC Ctrl 2nd 3 = Model Master 4 = Model Slave

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Useful shell commands	Description	Usage example	Example output
shm_read <type> <offset> <elements>	Reads from PLC shared memory space	**shm_read float 0 10**	Where **<type>** is one of HEX (2 bytes), INT, UINT, FLOAT, LONG, DOUBLE **<offset>** the offset in the shared memory buffer (aligned to **<type>** size) where to read (0 indexed). **<elements>** the number of elements to be read
shm_write <type> <offset> <element_1> <element_2> … <element_n>	Writes into PLC shared memory space	**shm_write float 128 123.456**	Where **<type>** is one of HEX (2 bytes), INT, UINT, FLOAT, LONG, DOUBLE **<offset>** the offset in the shared memory buffer (aligned to **<type>** size) where to write (0 indexed) **<element_1>** the first element to be written **<element_2**> the second element to be written **<element_n**> the *n*th element to be written

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5. Quick Start

This chapter provides information for getting started with your PAC 100 or CM system, including powering up your system, network configuration, programming your PAC 100, and troubleshooting.

5.1 Powering up the PAC 100 or CM

This section provides a summary of the tasks necessary to power up your PAC 100 or CM system.

Caution — **Always turn off or disconnect all power before attempting to service your PAC system.**

1. Install and wire the I/O modules according to *Chapter 3.10, Installation and Wiring*.
2. Power the CPU by connecting +24 V to the 'DC 24V CORE IN' power connector on the PAC 100 on the power supply module shown in *Figure 31*
3. Power the I/O by connecting +24 V to the 'DC 24V I/O IN' power connector on the PAC 100 on the power supply module shown in *Figure 32*.
4. Depending on whether I/Os on the slices connected to the PAC 100 need to be powered through the auxiliary power connector, additional external power supplies may be required.

Note — **Analog ±15 V for Analog modules and 24 V for Digital I/O are supplied over the system bus.**

5. A Power module (PWR) needs to be used when more than five I/O slices are connected to the PAC 100.

Once the CPU and all slices are assembled and wired, power up the system.

5.2 Network Configuration

The PAC 100 and CM network settings are factory configured as shown in Table 43:

Table 43—Default TCP/IP Settings

Parameter	Settings
IP Address	192.168.1.3
Subnet mask	255.255.255.0
Default Gateway	None

To connect via Ethernet, the following are required:

- Laptop or PC with this software
  - Tera Term Pro or equivalent Telnet client
  - Multiprog Express/Pro, if programming the PAC 100
- Ethernet cable connected directly from the PC or through a hub, router, or switch to the PAC

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Attach an Ethernet cable between the LAN port on the PAC or CM and your computer, or use a hub to build a small network. Your computer must be on the same subnet as the PAC. Ethernet cables can safely be connected and disconnected when your PAC system is turned on.

5.3 Connecting to a PAC 100 over Telnet

The following describes how to connect to a PAC 100 or CM using Telnet.

- **The PAC has a static IP of 192.168.1.3** so the PC from where you're trying to connect needs to also have a static IP to be setup. Navigate to the ***Network and Sharing Center***. Or just right-click in the bottom right of your desktop where you see the Wi-Fi icon, and click on ***Network and Sharing Center***. See Figure 51.

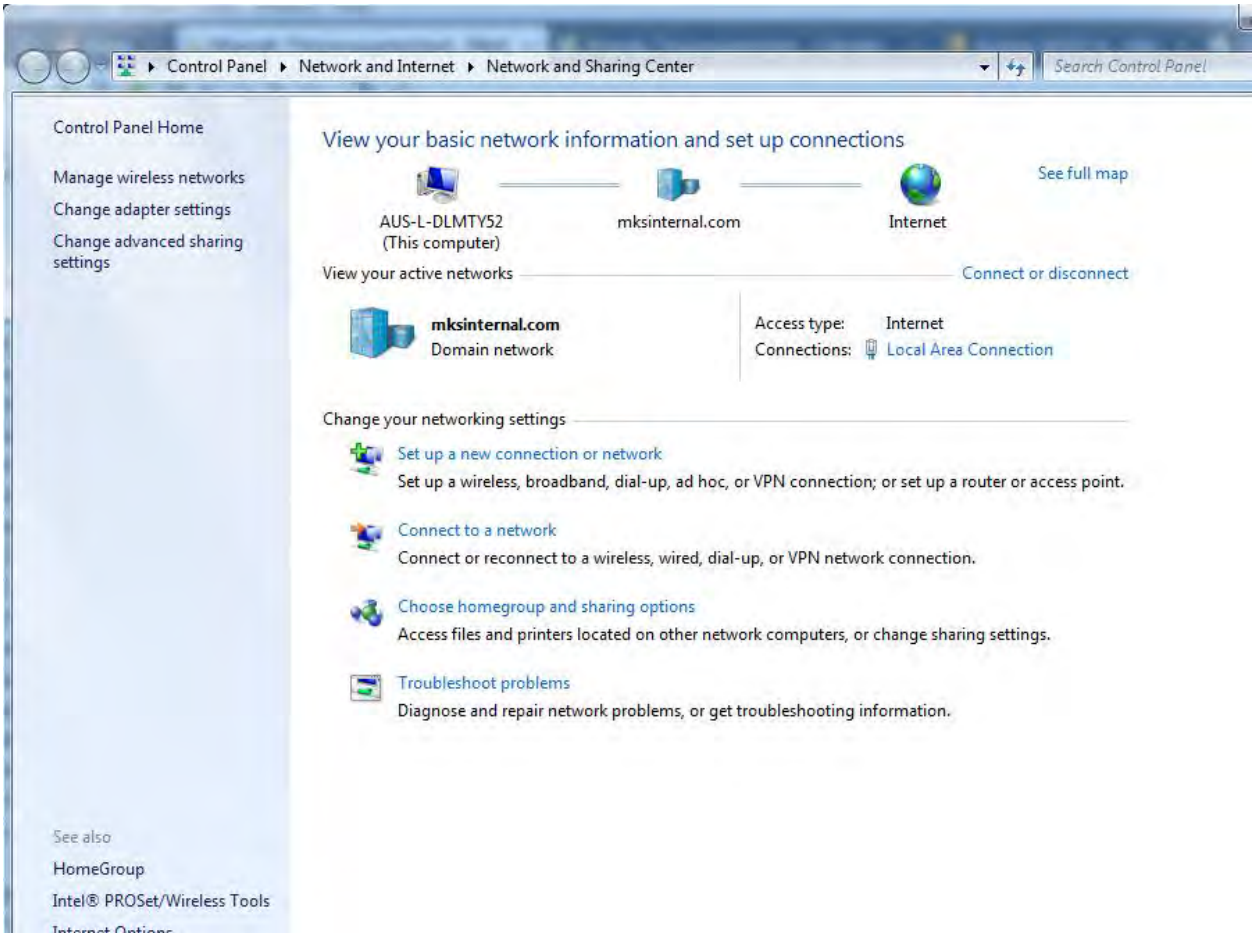


Figure 52—Network and Sharing Center

- Click on ***Change adapter settings***.
- Right-click on ***Local Area connection*** and click on ***Properties***. Click on ***Internet Protocol version 4***. See Figure 52.

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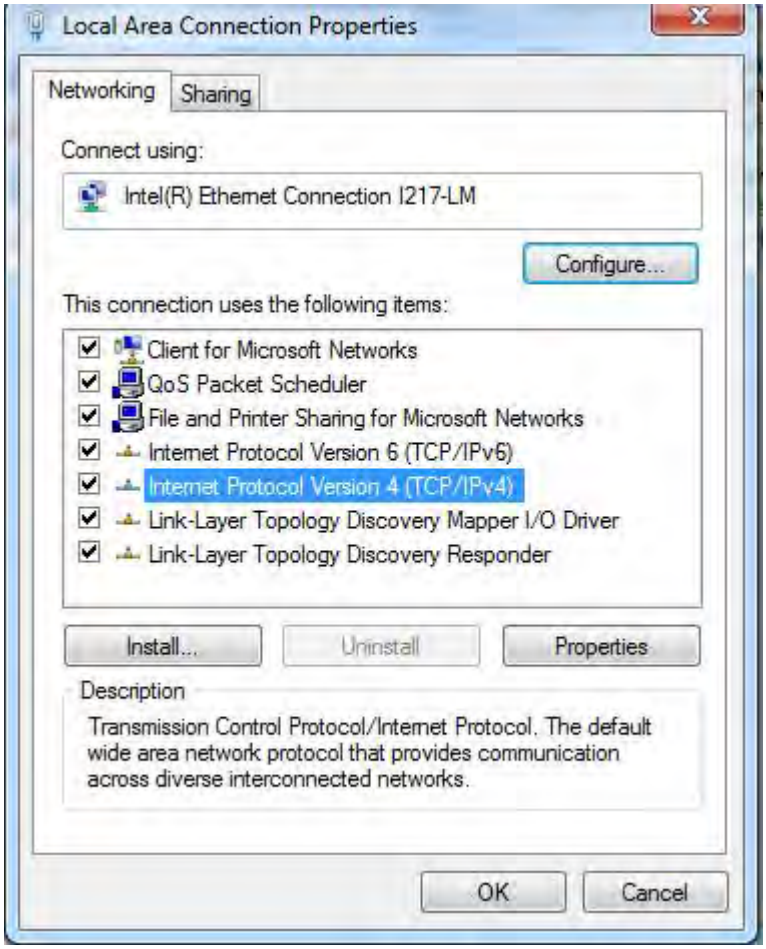


Figure 53—Local Area Connection Properties

- For the Local Area connection, enter an IP address of 192.168.1.1 with a Subnet mask of 255.255.255.0. See Figure 53. This IP can also be set to any other address like 192.168.1.20.

  The only address it cannot be set to is 192.168.1.3, since this is the IP address for the PAC 100.

Now you are ready to connect to the PAC 100 over Telnet or Modbus TCP/IP.

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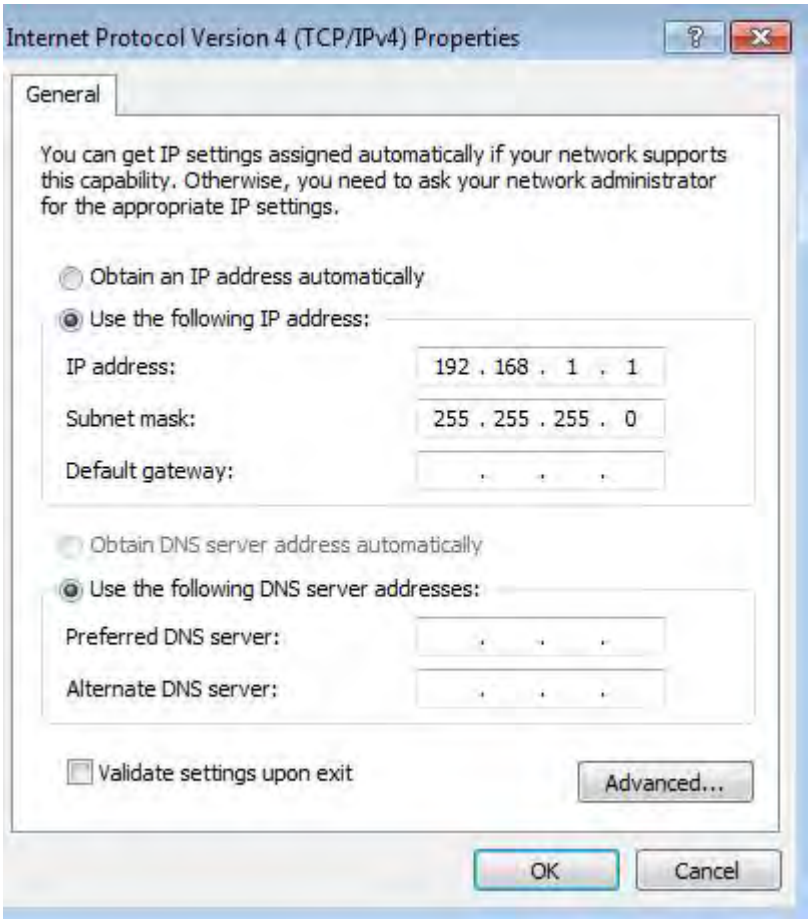


Figure 54—IPv4 Properties

5.3.1 Changing an IP Address

To change the IP address on a PAC 100 or CM, use the following procedure.

1. On the windows PC, open a Telnet client and type in:

   ```
   telnet 192.168.1.3
   ```

   or the IP address of the device. Remember that you can always reset the IP address of the device using the front-panel switch.
2. Once you are connected, enter the `ipsave` command followed by the desired IP address, the desired subnet mask, and the desired gateway. The gateway parameter is optional; the other two are required. For example:

   ```
   ipsave 192.168.1.3 255.255.255.0
   ```

3. Enter `nvsave` to save these parameters.
4. Enter `reset` to reset your device. The Telnet connection is dropped when the new IP address is saved and the device is reset.
5. Test your connection to the device with the `ping` command.

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Figure 54 shows a Telnet session in which an IP address is changed.

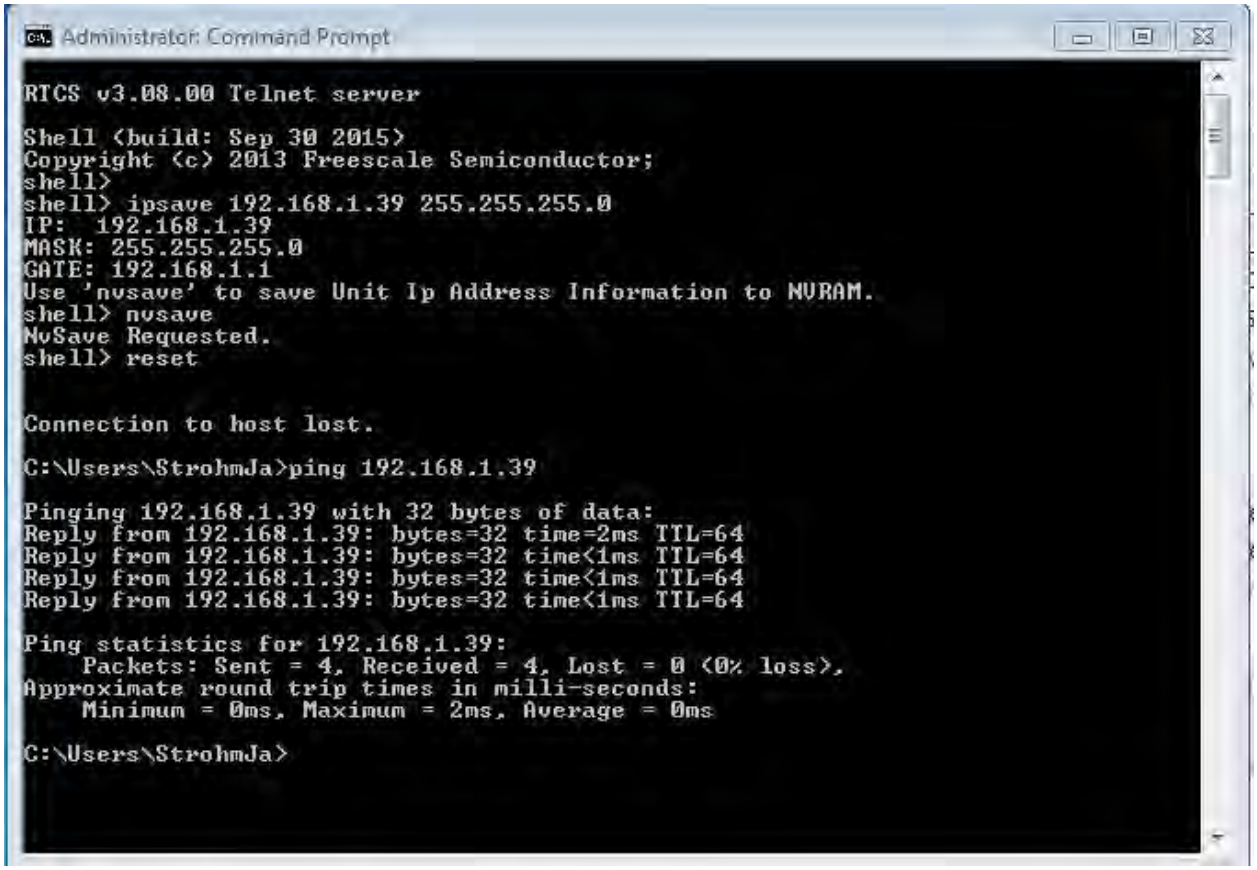


Figure 55—Changing an IP Address

5.3.2 Changing the Fieldbus Protocol

The following describes how to change the Fieldbus protocol.

1. On the windows PC, open a Telnet client and enter:

   `telnet 192.168.1.3`

   or the current IP address of the device.
2. Enter `tc_rd dev_cfg` to display the current Fieldbus protocol of the PAC 100 (Modbus TCP/IP or EtherCAT).

   `1` indicates it is set up for Modbus TCP/IP
   `0` indicates it is set up for EtherCAT
3. Enter `tc_wr protocol` and the Fieldbus protocol you desire.

   Enter `1` for Modbus TCP/IP
   Enter `0` for EtherCAT
4. Enter `nvsave` to save these parameters.
5. Enter `reset` to reset your device. The Telnet connection is dropped when the new IP address is saved and the device is reset.
6. If desired, test your connection to the device with the `ping` command.

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Note	**If the PAC 100 has been set up for EtherCAT, the Telnet interface will not be available until the Fieldbus is changed back to Modbus.**

To change the Fieldbus from EtherCAT to Modbus TCP/IP (Ethernet), do the following:

1. Change the Fieldbus type object (0xF503:09) to 1 (Modbus/TCP) in TwinCAT or through any other EtherCAT master.
2. Then perform an ***nvsave*** by changing the NVSAVE (0xFBF2:01) string to ***evas***.
3. Power cycle the PAC 100 to restart in Modbus-TCP mode.

5.3.3 Commonly Used Telnet Commands

Once you are connected, the most commonly used Telnet commands are listed as follows. For more details, refer to the *MKS PAC 100™ Modbus & EtherCAT Addendum* for the full list of Telnet commands available.

- **ping** — This command tests for a connection with the PAC 100.
  Usage: `ping <ip address>`

- **reset** — This command forces a soft reset on the PAC 100.
  Usage: `reset`

- **nvdata** —This command reads the contents of NVRAM.
  Usage: `nvdata`

- **nvsave** — This command causes the current state of NVRAM to be saved.
  Usage: `nvsave`

- **netstat** — This command displays network statistics.
  Usage: `netstat`

- **ipsave** — This command modifies the unit's IP address.
  Usage:
  For Static IPs: `ipsave <ip address> <net mask>`
  For DHCP: `ipsave 0` . To read back the DHCP IP address, mask, and gate, reset the unit and note the IP address displayed in the Tera Term log during startup.

- **ipquery** — This command displays the stored IP address used on boot.
  Usage: `ipquery`

- **help** — This command displays information about shell commands mentioned in this section
  Usage: `help <command>`

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5.4 Programming the PAC 100

In order to connect to the PAC 100 through the IEC 61131-3 programming interface with Multiprog, refer to the PAC Programmer's Manual for Multiprog.

In order to connect to the PAC 100 through the Controls Workbench interface, refer to the *Controls Workbench User Manual*.

In order to connect to the PAC 100 through the Labview interface, please contact your local MKS Sales representative or MKS Automation and Control Solutions Applications Engineers for the VIs.

5.5 Troubleshooting Network Configuration

Make sure your PC or laptop has the same subnet as the PAC 100 or CM. The factory default subnet for MKS devices is 255.255.255.0.

Ensure that all Ethernet cable connections are inserted correctly and the Ethernet cable is the Ethernet port (marked "LAN") on the PAC 100.

From your PC command prompt, type `ping 192.168.1.3` and see if the PAC 100 replies. If there is no reply, please check your network configuration, cable connection, PC's IP address setting, and whether the correct NIC card is used. Contact Applications at the MKS Automation & Control Solutions product group for more assistance.

Email: A&CS_support@mksinst.com

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