MKS Programmable Automation Controller 100™ User Manual AS11870G-03

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Preface

About this manual

This manual is designed to serve as a guideline for the installation, setup, operation and basic maintenance of the PAC Control Platform. 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.

Table of Contents

Revision History

Revision	Description of changes	Date
1.0	First Release	10/06/15

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

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 standards, networked, programmable, flexible, and scalable PAC, all in a modular, DIN rail mountable plastic enclosure. Compared to standard PLC's and IPC's, MKS PACs provide a more compact, customizable, high performance, and cost effective programmable control solution for a variety of control and automation tasks.

MKS PACs 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 logic locally. MKS PACs can be used to manage all IO control requirements with the ability to handle detailed execution tasks with various, commonly-used programming languages (supports an IEC 61131-3 programming interface such as ladder logic, structure text, sequential function charts for recipe & logic development) and also provide extremely fast communication between modules for highly coordinated and deterministic control.

MKS PACs can interface directly with all MKS I/O 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.

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.

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

- Modbus/TCP Slave
- EtherCAT™ Slave

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 higlights information that is important to the safe operation of the PAC, 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 PID loops (48) available on the PAC 100 via Modbus. Maximum number of Loops with PDO included=34. 14 with no PDO Data included, which are still accessible via SDO.**
Zones	**The number of zones=number of physical outputs available. Configuration of each zone includes selecting the inputs from the available inputs available, 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]

Pages with additional information about a specific topic are cross-referenced within the text.
Example: (See page xxx)

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.

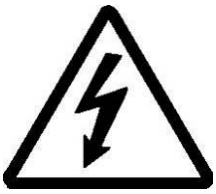
Symbols

The following symbols appear 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 instruction.

Exclamation Point within a Triangle

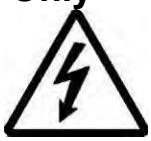
The “exclamation point within a triangle” symbol (reference ISO Publication 3864, No. B.3.1) is used in and/or on the equipment to alert the installer, operator, or service personnel to the presence of important related installation, operation, and/or service instructions and to direct such personnel to the product manual for that information. This symbol is also used within the product manual itself to identify important instructions.

Lightning Bolt within a Triangle



The “lightning bolt within a triangle” symbol (reference IEC Publication 417, Symbol No. 5036, and ISO Publication 3864, No. B.3.6) is used in this manual to alert the user, operator or service personnel to the presence of un-insulated voltage within the enclosure of sufficient magnitude to constitute a risk of electric shock. This symbol is used within the product manual itself to identify important operating and/or maintenance instructions, which, if not followed carefully, could result in personal injury or even death.

Service by Qualified Personnel Only



Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by the MKS support center only.

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.

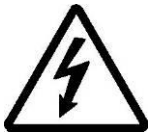
Use the Proper Power Source

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.

High Voltage Danger



High voltage is present in the cable and in the unit when unit is switched on.

Thermal Hazard

Do not cover the unit to avoid overheating.

2. Introduction

2.1 General

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

MKS PACs 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 logic locally. MKS PACs can be used to manage all IO control requirements with the ability to handle detailed execution tasks with various, commonly-used programming languages (supports an IEC 61131-3 programming interface for recipe & logic development) and also provide extremely fast communication between modules for highly coordinated and deterministic control.

MKS PACs can interface directly with all MKS I/O 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.

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.

F**EATURES & BENEFITS:**

- The MKS PACs are fully programmable controller supports standard IEC 61131-3 environment for seamless code portability and no locking you into a specific programming environment or vendor software.
- There are both 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 & play implementation.
- The PACs provide Open standards support, interoperability with other devices & components, and improved performance compared to a traditional PLC & IPC's.
- Also, the PACs can be seamlessly interfaced with Human Machine Interface (HMI), supporting OPC UA or Modbus TCP/IP.
- They work Fieldbus master for control via EtherCAT, Modbus TCP/IP, Ethernet IP.
- Multiple MKS PAC offerings can be customized to specific applications.

3. Ordering information

3.1 Part Numbers

Part Number	Model	Fieldbus Master	Fieldbus Slave
AS11850G-02	MKS PAC 1000	Modbus TCP/IP	Modbus TCP/IP
AS11850G-01	MKS PAC 1000	EtherCAT	Modbus TCP/IP
AS11870G-03	MKS PAC 100	N/A	Modbus TCP/IP
AS11870G-11	MKS PAC 100	N/A	EtherCAT
AS11893G-02	DIO module	0-24V, source	Terminal connector
AS11893G-11	DIO module	0-24V, sink	Terminal connector
AS11880G-11	AIO module	Voltage inputs, Voltage outputs	
AS11880G-31	AIO module	Current inputs, Voltage outputs	
AS11860G-40	RTD or TC	Input type=PT 100, any TC	Terminal connector
AS11860G-50	RTD or TC	Input type=PT1000, any TC	Terminal connector
AS11860G-60	RTD or TC	Input type=PT 100, any TC	Removable Terminal
AS11860G-70	RTD or TC	Input type=PT1000, any TC	Removable Terminal
AS11840G-01	Power module		
AS11890G-02	15 pin D-Sub Quote Only		
AS11890G-11	9 pin D-Sub		
1691120000	Power plug for CPU module (spare) from Weidmuller		
CKRD2420	External 20A SSR with DC control (Crydom)		

4. PAC 100 CPU Specifications

Criteria	Specifications
Dimensions	W 35mm x D 95mm x H 125mm

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
Devicenet	Coming soon

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) 10/100Mbits/s
Physical User Interface	LED's
OPC Server Enabled	No
I/O Interface	L-Bus
Maximum number of IO modules that be connected to the PAC 100 (excluding the power modules)	20
Number of loops	48
Number of models	2

Power Supply	19VDC – 32VDC for DC I/O Max – 5Amp 19VDC – 32VDC for DC CORE Max – 5Amp

5. Hardware Description

This section describes the PAC hardware setup and the interface with the network over Modbus/TCP or EtherCAT™.

This section describes the following features

- Modules
- IP Reset Switch
- ECAT ID Select
- LED Indicators

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

5.1 Modules

5.1.1 PAC 100 CPU Module

- USB OTG
- 1 x RJ45 (Ethernet) 10/100Mbits/s
- LED for Status
- IP Address Switches
- Reset
- IP Reset

Figure 1 – Front panel for CPU module

The PAC100 uses a bootloader just like PAC 100 2000 product. You must have the bootloader programmed in order to boot the unit.

5.1.2 Temperature Input Module

The AFE PT 100 and AFE PT1000 temperature input modules feature 8 sensor channels (2 RTD types (PT-100, PT100, 2 wire and 3 wire connection) or different types of Thermocouples (J, K, N, S, B, T, E, R)). and support up to 8 inputs.

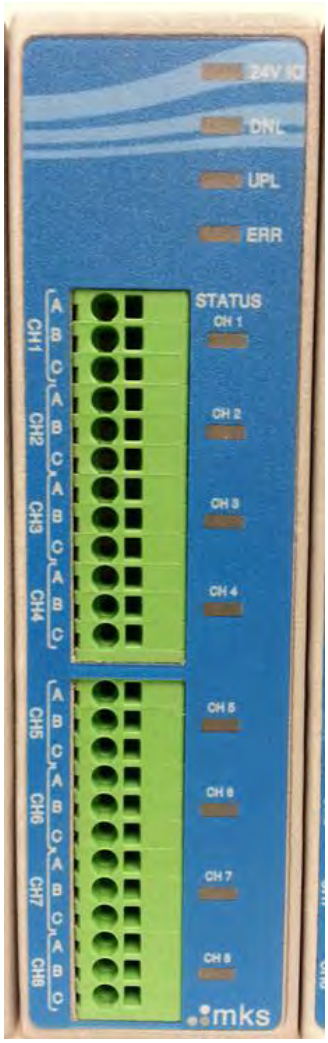
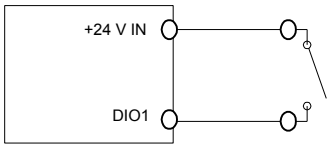


Figure 3- Front panel of AFE module

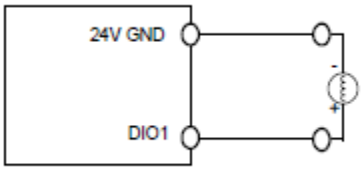
5.1.3 PWM Output Module

The PWM output module will provide a power output/synchronization input for the PAC 100. The PWM unit could be used to support virtually any size external SSRs, either zero cross type or phase type SSRs. The PWM module supports 0 - 24VDC voltage outputs. Each module has 12 digital inputs SINK and 12 outputs SOURCE.

Figure 2- Front panel of PWM module



Sinking input



Sourcing output

Each PWM module also has the option to wire in additional power for the IOs on the module directly.

5.1.4 AIO Module

Each module can support up to 8 analog inputs and 4 analog outputs. Each AIO module can support up to 8 analog inputs and 4 analog outputs. There are different hardware options for the module capable of supporting single ended voltages and differential voltages. The choice between the two is made based on noise immunity and GND scheme. Signal ranges typically are +/-10V or 0-10V or 0-5V which depends on the resolution and full scale definition for the device. The module can also support current signals such as 0-20ma, 4-20ma. Each AIO module also has the option to wire in additional power for devices that require +/-15V using the 3 pin connector on the module.

Figure 4- Front panel of AIO module

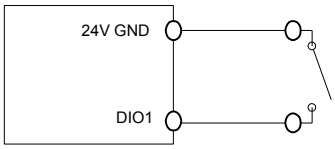
Note: Analog input signals can used for temperature sensors or CT inputs. Analog output of 4-20mA or 0-10V can be used to provide control signals for SCR drivers.

5.1.5 DIO Module

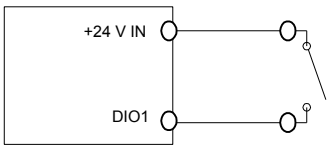
MKS DIO modules provide a compact and high density solution for integrating digital input and output channels with MKS PAC or CM modules. Each DIO module supports 12 digital inputs and 12 digital outputs. The DIO module supports 0 - 24VDC voltage inputs and output (source and sink types). Each module has 12 digital inputs and 12 digital outputs.

Figure 5- Front panel of DIO module

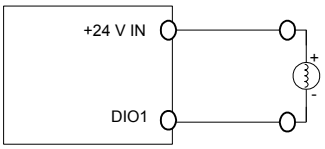
The PWM module comes in 2 configurations- Sink Inputs, Outputs and Source inputs,outputs.



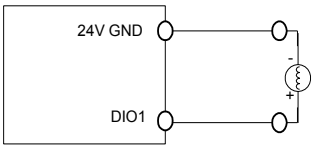
Sourcing Input



Sinking Input



Sinking Output



Sourcing Output

5.1.6 MFC Module

MKS MFC mass flow controller modules provide a compact and high density solution for integrating MKS MFC's with the MKS Automation Platform PAC or CM modules. MFC modules support either 15 or 9 pin analog mass flow controllers. The MFC Module has a direct 1:1 pin mapping of the MFC's, so connected mass flow controllers that are fully powered and controlled through the MFC slice. Each MKS MFC Module supports integrating 4 MKS mass flow controllers.

5.1.7 Power module

MKS PWR Power Supply Modules are a compact solution for supplying additional power to the MKS Automation Platform. This is needed anytime more than 5 IO modules are connected to the PAC. Each PWR module requires a 24 VDC power supply and provides 12A current. The PWR Power Supply Module is required to power to the MKS Automation Platform PAC family.

5.1.8 IP Reset

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

5.1.9 ECAT ID SELECT

There are 3 selector switches for setting up the ECAT ID for the MultiTherm slave device on the front of the controller. Note that these are used only when the MultiTherm is communicating over EtherCAT.

5.2 LED Indicators

This section refers to the wiring for the different connectors on the PAC 100 and IO modules.

- DNL (Downlink) and UPL (Uplink) will be flashing Green during system bus communication. If the module is last in the series, the UPL LED will be OFF.

- CPU 24V I/O LED will be solid Green if power is being delivered to IOs through System bus in normal operation. Will display RED if there is an error delivering power.

5.2.1 CPU LEDs

Figure 10- LEDs on CPU module

LED	Stat LED Indication	Definition
24V IO	Solid Green	power is being delivered to IOs through System bus
	Red	Error delivering power.
RUN	Off	INIT Mode
	Blinking Green (6Hz)	Boot
	Blinking Green (3Hz)	Pre-Op
	Blinking Green (1Hz)	Safe-Op

	Solid Green	OP Mode
	Solid Red	ECAT connection issue.
ERR	Off	ECAT is Done Initializing and No Errors
	Blinking Red (1.5Hz)	ECAT connection issue when CPU is in OP mode. Will also be coupled with RUN LED flashing at 1 Hz.
STAT	Blinking Green	System Bus is in the Process of Initializing and No Errors
	Blinking Amber	System Bus is in the Process of Initializing and NVRAM Error Occurred
	Solid Green	System Bus is Done Initializing and No Errors
	Solid Amber	System Bus is Done Initializing and NVRAM Error Occurred
	Blinking Red	System Bus Initialization Failed
	OFF	FPGA Error
	TBD	System Bus Runtime Error

5.2.2 Temperature Input Module LEDs

Figure 12- LEDs on Temperature Input module

Each channel has a single LED associated with it.

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
Off	No sensor attached

- DNL (Downlink) and UPL (Uplink) will be flashing Green during system bus communication. If the module is last in the series, the UPL LED will be OFF.
- CPU 24V I/O LED will be solid Green if power is being delivered to IOs through System bus in normal operation. Will display RED if there is an error delivering power.

5.2.3 PWM Output Module LEDs

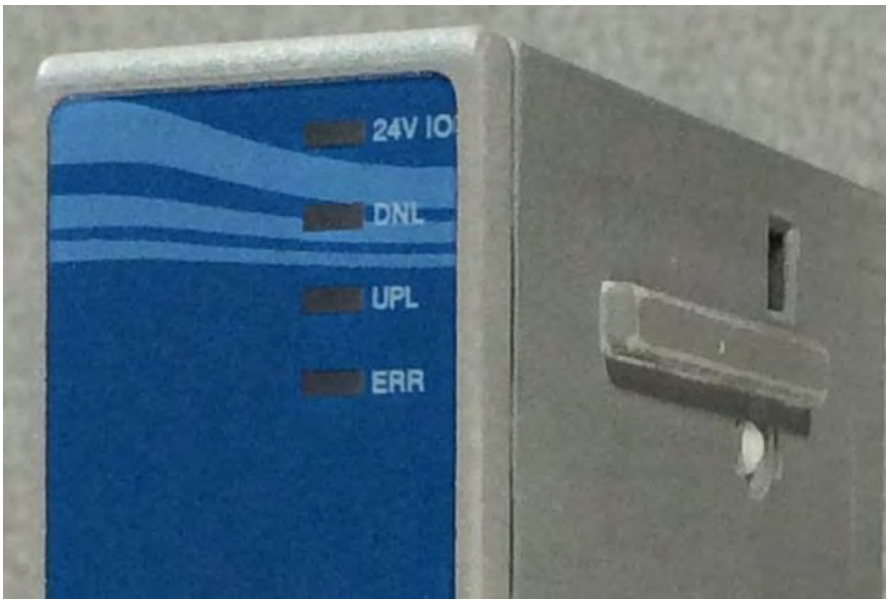
Figure 11- LEDs on PWM Output module

Each input and output has a single LED associated with it.

Off	Associated Input or output is logic low (0).
Solid Green	Associated Input or output is logic high (1).

- The Channel LED will be flashing whenever 24V PWM output is being sent to the external SSR.
- DNL (Downlink) and UPL (Uplink) will be flashing Green during system bus communication. If the module is last in the series, the UPL LED will be OFF.
- CPU 24V I/O LED will be solid Green if power is being delivered to IOs through System bus in normal operation. Will display RED if there is an error delivering power.

5.2.4 AIO Module



- DNL (Downlink) and UPL (Uplink) will be flashing Green during system bus communication. If the module is last in the series, the UPL LED will be OFF.
- CPU 24V I/O LED will be solid Green if power is being delivered to IOs through System bus in normal operation. Will display RED if there is an error delivering power.

5.2.5 DIO Module LEDs

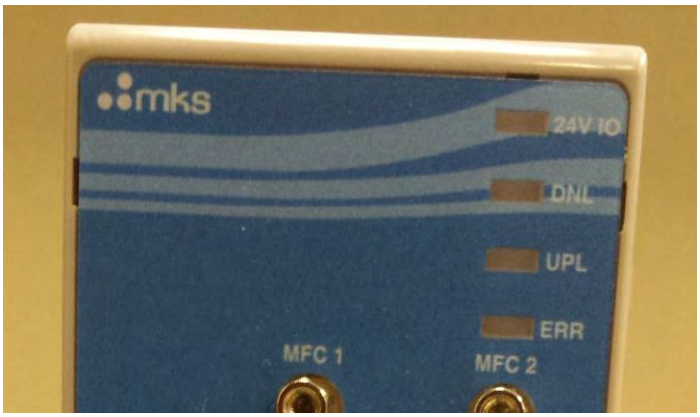
Figure 11- LEDs on PWM Output module

Each input and output has a single LED associated with it.

Off	Associated Input or output is logic low (0).
Solid Green	Associated Input or output is logic high (1).

- The DI LED will switch on when an input is connected to the channel.
- The DO LED will be flashing whenever 24V output is being sent to the external SSR.
- DNL (Downlink) and UPL (Uplink) will be flashing Green during system bus communication. If the module is last in the series, the UPL LED will be OFF.
- CPU 24V I/O LED will be solid Green if power is being delivered to IOs through System bus in normal operation. Will display RED if there is an error delivering power.

5.2.6 MFC Module LEs



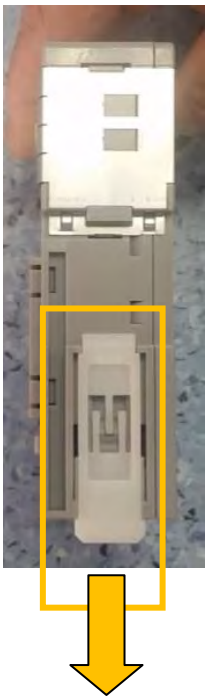
6. Installation and Wiring

This section describes how to connect the modules to each other and on a din rail (optional). It also describes the wiring information on the IO and CPU modules.

6.1 Installation

- The CPU modules comes with a cover highlighted below 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.

- The CPU and IO modules can be first mounted on a Din rail after pushing out the plastic clip.



- Once all the modules have been placed, they can be connected to each other by pushing the modules together as shown below.

- Lock the connections down by pushing down on the locking switch highlighted below. This will ensure the modules do not get disconnected easily.

6.2 Wiring

6.2.1 PAC 100 connector

There are two 24V power inputs to the CPU module-one for powering the IOs and another for powering the electronics on the CPU PCB. The user will need to use separated and isolated 24V power supplies, one for CPU and one for I/O.

P3 (Pin1 starts at top)	DESCRIPTION
1	+24VDC
2	N/C
3	24VDC_COM

P4 (Pin1 starts at top)	DESCRIPTION
1	+24VDC
2	N/C
3	24VDC_COM

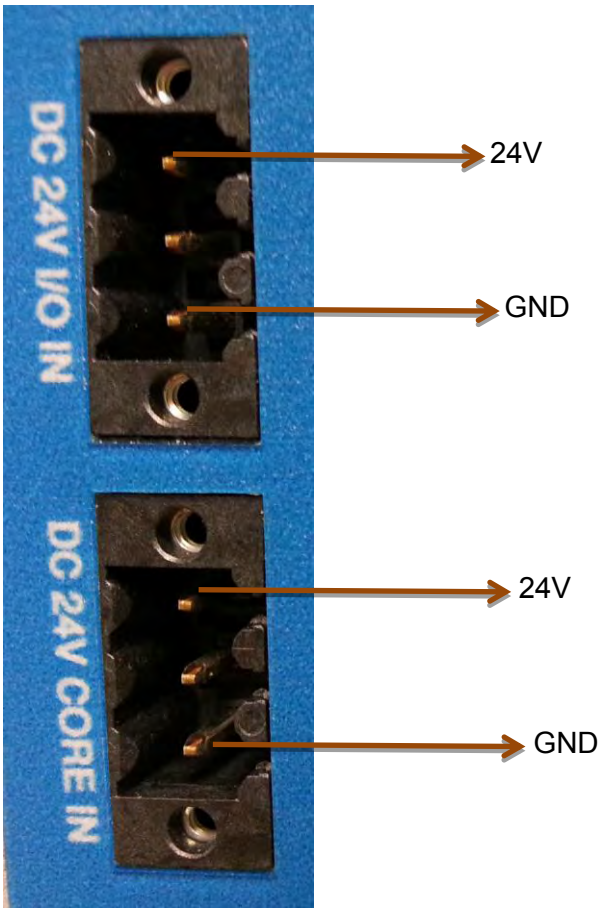


Figure 8- Power connectors on CPU module

6.2.2 ECAT and Modbus Connectors

The CPU module has 2 connectors for EtherCAT- ECAT IN and OUT. These ports are supposed to be used if the Modules are configured for running EtherCAT. There is one LAN connector for a Modbus connection. This port is supposed to be used if the Modules are configured for running Modbus.

Figure 9- USB, EtherCAT and LAN ports on CPU module

6.2.3 USB

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.

6.2.4 Temperature Input Connector

Each zone on the PT 100 or PT1000 Temperature input module reads the temperature using Thermocouples or 2-wire or 3-wire RTD (PT100 and PT1000). Each RTD type has internal linearization capability. The linearization feature converting resistance to the temperature is implemented by using 2nd order polynomial equation.

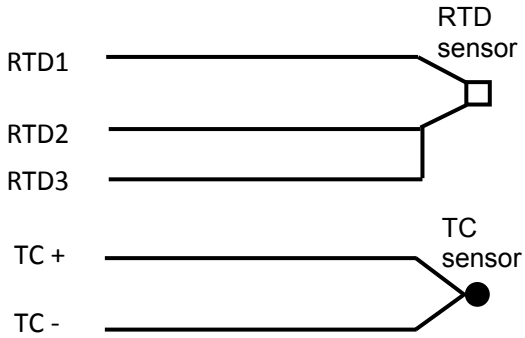
Refer to the Connector pin-outs for the appropriate wiring setup. Overall, the module can accept up to 8 RTD's (PT100, PT0000) or Thermocouple inputs on each Temperature input module.

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

Note - A 2 wire RTD can be converted to a 3 wire RTD for connecting to the PT 100 or PT1000 Temperature input module.

Figure 5- Connector on AFE module

Ch #1		
A	B	C3
RTD1 Supply signal	RTD2 Common return	RTD3 Common return
TC + wire 1	TC - wire 2	N/A Not used



6.2.5 PWM Output Connector

The heater connections on J5 use a Weidmuller pluggable terminal block with a push-in type of termination - the part number can be found in the **Error! Reference source not found.** section. The output voltage from each channel is a pulse width modulated 24V signal. This is provided as a control input to an external DC or AC SSR.

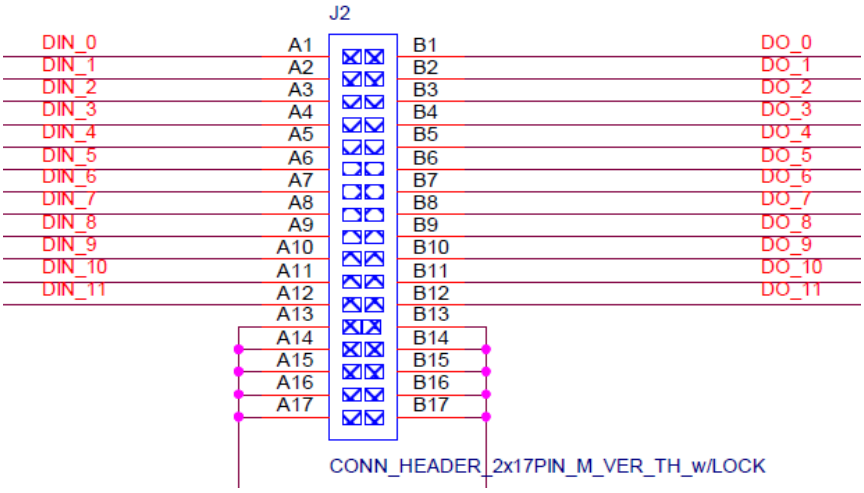


Figure 6- Connector on PWM module

Note - A13-A17 and B13-B17 provide the 24VCOM signals.

For example, if an external SSR needs to be connected to the first Output channel on the PWM Module, DO_0 and B13 pins need to be connected to the Control inputs of the SSR.

6.2.6 AIO Connectors

Each AO (either voltage or current output) consists of 2 pins: AO_OUTp (power) and AO_OUTn (ground). Each AIO module also has the option to wire in additional power (for devices that need +/-15V) directly through the 3 pin +/-15V connector (P1).

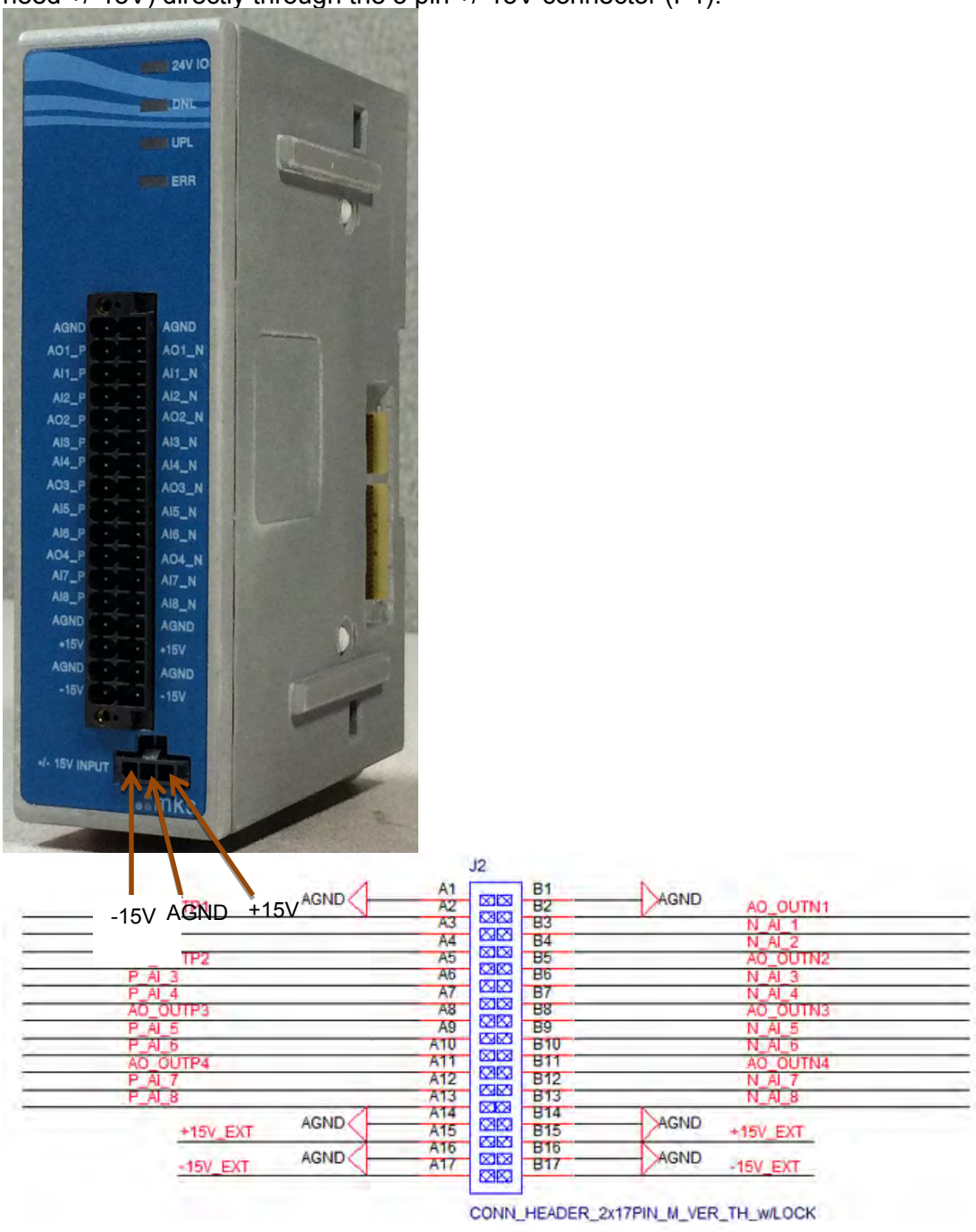


Figure 7- Connector on AIO module

The +/-15V from the 3 pin connector gets routed to pins A14, A15, A16 and A17 as well as B14, B15, B16 and B17 on the external connector. Devices that need power can be powered up using these pins on the external connector.

Note- One +/-15V power supply can power upto 2 devices that need this voltage, as long as the 2 devices pull less than 1.1A overall. Any devices or devices that pull more than 1.1A overall cannot be powered using the 3 pin connector and will require it's own dedicated power supply.

Pinout for Voltage Output:

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

Pinout for Current Output:

Pin #	Signal	Pin #	Signal
A1	AGND	B1	AGND
A2	AOC1	B2	AGND
A3	AI 0+	B3	AI 0-

A4	AI 1+	B4	AI 1-
A5	AOC2	B5	AGND
A6	AI 2+	B6	AI 2-
A7	AI 3+	B7	AI 3-
A8	AOC3	B8	AGND
A9	AI 4+	B9	AI 4-
A10	AI 5+	B10	AI 5-
A11	AOC4	B11	AGND
A12	AI 6+	B12	AI 6-
A13	AI 7+	B13	AI 7-
A14	AGND	B14	AGND
A15	+15V	B15	+15V
A16	AGND	B16	AGND
A17	-15V	B17	-15V

6.2.7 DIO Connector

The connection on J5 use a Weidmuller pluggable terminal block with a push-in type of termination. - the part number can be found in the **Error! Reference source not found.** section. The output voltage from each channel is 24V SINK or SOURCE signal.

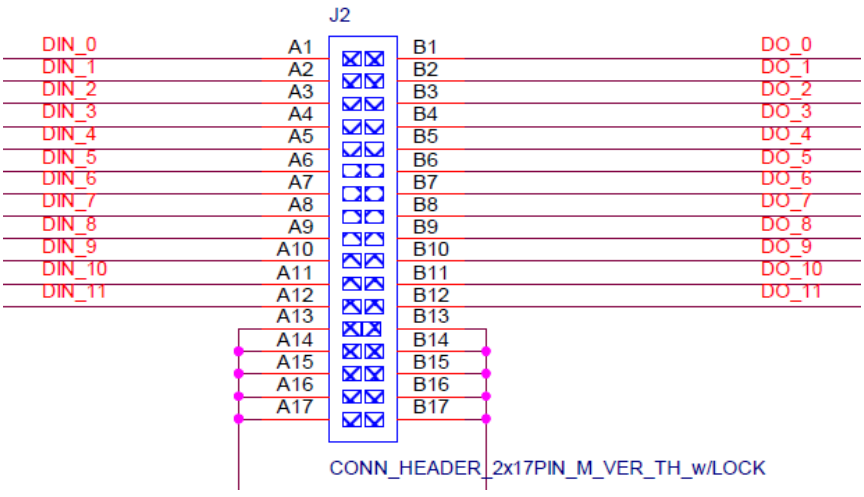


Figure 6- Connector on PWM module

Note - A13-A17 and B13-B17 provide the 24REF signals for Sink versions of the DIO module. For Source version of the DIO module, these same pins will provide the 24VCOM signals.

For example, if you need to be connected to the first Output channel on the DIO Module, DO_0 and B13 pins need to be connected to the Control inputs of the SSR.

6.2.8 MFC connector

MFC modules support either 15 or 9 pin analog mass flow controllers. The MFC Module has a direct 1:1 pin mapping of the MFC's, so connected mass flow controllers that are fully powered and controlled through the MFC slice. Each MKS MFC Module supports integrating 4 MKS mass flow controllers.

LernA MFC function	MFC controller I/O Type
Valve Test Point	AI
Flow Signal Output	AI
Valve Close	DO
Valve Open	DO
Power Supply Common	Power
No Connection	
+15 to +24 VDC Power	Power
Setpoint Input	AO
Zero Function	DI

Optional Input AI
Signal Common Signal Common
Signal Common Signal Common
No Connection
Pressure Signal Output AI
Chassis GND

MKS MFC Module function	MFC controller I/O Type
Valve Test Point	AI
Flow Signal Output	AI
Valve Close	DO
Valve Open	DO
Power Supply Common	Power
No Connection	
+15 to +24 VDC Power	Power
Setpoint Input	AO
Zero Function	DI
Optional Input	AI
Signal Common	Signal Common
Signal Common	Signal Common
No Connection	
Pressure Signal Output	AI
Chassis GND	

6.2.9 Power module connectors

MKS PWR Power Supply Modules are a compact solution for supplying additional power to the MKS Automation Platform. This is needed anytime more than 5 IO modules are connected to the PAC. Each PWR module requires a 24 VDC power supply and provides 12A current.

There are two 24V power inputs on the module-one for powering the IOs and another for powering the electronics on the module itself. The user will need to use separated and isolated 24V power supplies, one for CPU and one for I/O.

P3 (Pin1 starts at top)	DESCRIPTION
1	+24VDC
2	N/C
3	24VDC_COM

P4 (Pin1 starts at top)	DESCRIPTION
1	+24VDC
2	N/C
3	24VDC_COM

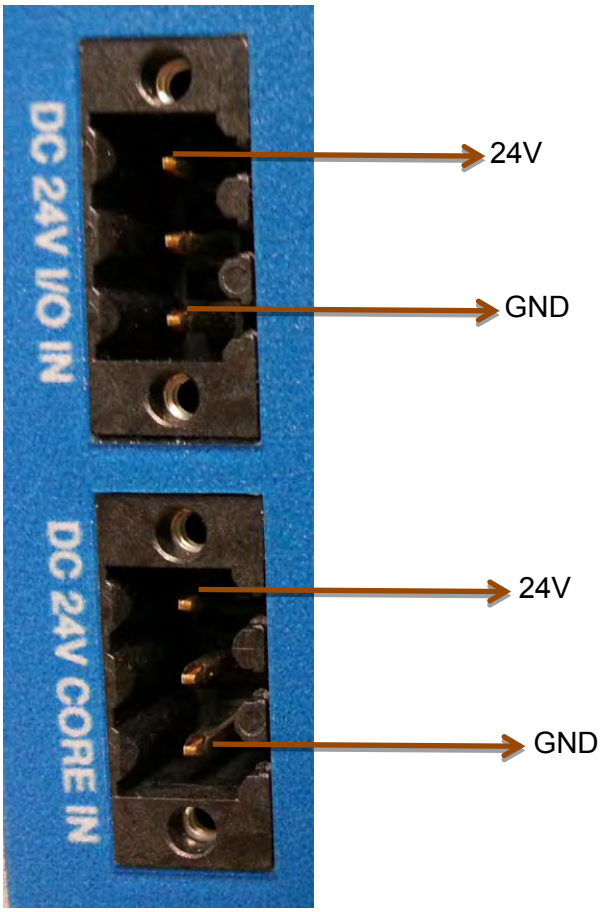


Figure 8- Power connectors on Power module

7. Programming with PAC 100

- The PAC 100 has a Modbus TCP/IP interface for programming with-
  - KW Multiprog software with IEC61131-3 compliant development environment for IEC programming capabilities
  - Controls Workbench (CWB)
  - Labview

7.1 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
Sequential Function Charts

Limitations of the programming for the MKS PAC family depends 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. Each version is discussed below. More details, refer to the software details page at https://www.phoenixcontact-software.com/en/iec-61131-control/programming-systems/multiprog-5.

Multiprog 5.5 EXPRESS support:

Nodes in the project tree	8000
Configurations/resources in Project tree	1 / 1
Program instances per resource	11
Tasks per resource	5
Program instances per task	15
Global variables/local variables per POU	5000/1500
Included libraries	32
POUs in one project	256

(incl. POUs of libraries)	
Number of supported IOs per project	128 Kbytes
I/O groups	200

MultiProg 5.5 PRO support:

Nodes in the project tree	8000
Configurations/resources in the project tree	100 / 100
Program instances per resource	1000
Tasks per resource	16
Program instances per task	500
Global variables/local variables per POU	30000/15000
Included libraries	32
POUs in one project (incl. POUs of libraries)	2000
Number of supported IOs per project	up to 128 Kbytes
I/O groups	200

Note – For details on how to program the PAC 100, refer to the Programming Manual for the PAC 100.

7.2 Controls Workbench

The Controls Workbench (CWB) supports Modbus-TCP/IP connectivity to provide data exchange and seamless integration into a Modbus network. The CWB must be installed on a PC that is on the same network as the PAC 100. The 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 User manual located in the Documents and Downloads section at http://www.mksinst.com/product/product.aspx?ProductID=1479

7.3 Labview

Virtual Instruments(VI) for the 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.

7.4 Diagnostic Telnet interface

The PAC 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 unit's power-up sequence.

The Temperature Controller has an Web server interface available through a Telnet Client like Microsoft Telnet, Teraterm, PuTTY, etc. However, this interface is intended for authorized personnel for debug, diagnostic purposes. The web server will also provide 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.

Note: This Telnet is available if the unit is setup for Modbus TCP/IP fieldbus type. If the unit has been setup for EtherCAT, the Telnet interface will not be available until the fieldbus is changed back to Modbus

Note: To change the protocol from EtherCAT to Modbus, change the Fieldbus type object (0xF503:09) to 1 (Modbus/TCP) in TwinCAT or through any other EtherCAT master.

Note: Then perform an nvsave by changing the NVSAVE (0xFBF2:01) string to ‘evas’. Power cycle the unit to restart in Modbus-TCP mode.

- ### List of commonly used commands

Once you are connected, the most commonly used commands are listed below. For more details, refer to the Appendix for the full list of commands available-

Useful shell commands	Description	Usage example	Example output
tc_rd <subcommand> <args>	Read information from the temperature controller application. The command will show all available options and usage if no subcommand or		

	arguments are given.		
tc_wr <subcommand> <args>	Write configuration to the temperature controller application.The command will show all available options and usage if no subcommand or arguments are given.		
tc_rd input_raw_temp	Show 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>	Choose the Thermocouple type for an input channel: J =1 (default) K = 0 Takes effect immediately!	tc_wr thermocouple_type 0 1	hell> 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>	Choose 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
tc_wr smp_rate <rate>	Choose 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>	Choose 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>	Assign 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>	Assign an output channel to the manip value of control loop channel.	tc_wr ctrl_ch_out 4 1	
tc_wr scaling_gain <cfgloop> <gain>	Set 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>	Set 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>	Set 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	Get all the maximum conversion value for all temperature input channels		
tc_wr max_conv <input ch> <value>	Set the maximum conversion value for the temperature input channel (NOTE: AIO Slice only supports this option)		
tc_rd min_conv	Get all the minimum conversion value for all temperature input channels		
tc_wr min_conv <input ch> <value>	Set the minimum conversion value for the temperature input channel (NOTE: AIO Slice only supports this option)		
tc_rd slice_cfg	Get 32bit slice cfg value for all slices		
tc_wr slice_cfg <slice#> <value>	Set 32bit slice cfg value for the slice (slice# starts @ 1)		

tc_rd dev_cfg	Device Configuration, now include 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	Read Sync Assignments for PowerOutput 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 POwerOutput capable slices that support sync assignment	tc_wr sync_assign 1 0x0302	
eclr_wr boot <bootmode value>	Set the bootmode for the eCLR (PLC)	eclr_wr boot 1	0 = Cold boot 1 = Warm boot 2 = Idle 3 = Exit
eclr_rd boot	Get the bootmode for the eCLR (PLC)	eclr_rd boot	
tc_wr ctrl_type <loop> <control type value>	Set 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
shm_read <type> <offset> <elements>	Read 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>	Write into PLC shared memory space	shm_write float 128 123.456	Where <type> is one of HEX (2bytes), 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

This information available through this interface is valuable when troubleshooting-with the aid of MKS applications engineering.

8. Quick Start

8.1 Network Configuration

The PAC network settings are factory configured as shown in Table 3-1:

Table 8-1 Default Ethernet setting

Parameter	Setting
IP-Address	192.168.1.3
Subnet mask	255.255.255.0
Default Gateway	None

- The following are required:
  - Laptop or PC (including TeraTerm Pro or equivalent, and Multiprog Express/Pro)
  - Ethernet cable connected directly, or over a Hub, to the PAC

- Attach the Ethernet cable between the LAN port on the unit and your computer, or use a HUB to build a small network. Your computer must be on the same subnet as the PAC.

8.2 Powering up PAC:

1. Install and wire the IO modules according to the Installation and Wiring section.
2. Power the PAC 100 by first supplying +24 volts to the 'DC CORE IN' power connector on the power supply module shown below.
3. Depending on whether IOs on the modules connected to the PAC1000 need to be powered through the PAC 1000, the 'DC I/O IN' on the power supply module may also need to be powered.

Note: Analog +/-15 volts for Analog modules and 24V for Digital IO are supplied internally. No additional power is required for the unit.

Note: A Power module also needs to be used when more than 5 slices need to be connected to the PAC 100.

8.3 Connecting to PAC100 over the Telnet interface

8.3.1 Change Fieldbus type to Modbus TCP/IP or EtherCAT

On the windows PC, open up the Telnet client and type in-

- telnet 192.168.1.3

Once you are connected, the most commonly used commands are listed below. For more details, refer to the Appendix for the full list of commands available-

- tc_rd dev_cfg will display the fieldbus protocol (Modbus TCP/IP or EtherCAT)
  1 indicates it is setup for Modbus TCP/IP
  0 indicates it is setup for EtherCAT
- tc_wr protocol 1 or 0
- nvsave

- reset (to perform a soft reset on the device. This will also close the telnet connection)

8.3.2 Change IP address

On the windows PC, open up the Telnet client and type in-

- telnet 192.168.1.3

Once you are connected, the most commonly used commands are listed below. For more details, refer to the Appendix for the full list of commands available-

- ipquery will display the IP address
  - 0.0.0.0 Will be displayed for DHCP. In this case, do a soft reset on the unit and the DHCP IP address will be displayed in the log on initial startup.
  - As an example, 192.168.1.3 will be display for a static IP address
- To assign an IP address,
  - ipsave 192.168.1.3 255.255.255.0
  - nvsave
  - reset (to perform a soft reset on the device. This will also close the telnet connection)

8.4 Programming PAC 100

- In order to connect to the PAC 100 through the IEC 61131-3 programming interface-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.

8.5 Troubleshooting Network configuration

- Make sure your PC or laptop has the same subnet as the PAC
- Ensure that all Ethernet cable connections are inserted correctly and ethernet cable is in U19 Ethernet port on PAC.
- From your PC command prompt, issue a "ping 192.168.1.3" (or to the IP address shown on the LCD screen) and see if PAC replies. If there is no reply, please check your network configuration, cable connection, PC IP address setting and whether the correct NIC card is used. Contact Applications at the MKS Automation & Control Solutions product group for further help with this.

9. WARRANTY

Please refer to MKS Website below for warranty term and legal disclaimer

http://www.mksinst.com/about/warranties.aspx

http://www.mksinst.com/about/legal.aspx

Appendix A. Modbus and EtherCAT Profile for PAC 100

- ## Control

Description	Data	Notes
Number of loops	48	
Maximum EtherCAT PDO Size	512 bytes	Need FPGA change to increase
Maximum number of Loops with PDO included	34	14 with no PDO data included still accessible via SDO No Modbus or shell restricction
CPU load per loop with PID enabled	approx 10 us	
System bus update rate	1 ms	

- ## Device Information

Fieldbus	Detail
EtherCAT Subindex	0xF500
Modbus/TCP Base	Input Reg 10000
Telnet	tc_rd dev_info

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
NVRAM Valid	BOOL	1	0	This bit will be 1 if checksum of the NVRAM was valid on boot. If the checksum was invalid, this bit will be 0 and the STAT led will amber.	**0: Error (Invalid)** **1: Valid**

Calibration Valid	BOOL	2	1	Shows the status of the temperature sensor calibration. The STAT led will red if the CRC of the calibration is invalid and all temperature sensors will show a fault.	**0: Invalid** **1: Valid**
CPU FPGA Version	WORD	6	2	FPGA revision	
PLC Status	WORD	4	3	Status of the PLC execution	**0: On** **1: Loading** **2: Starting** **3: Running** **4: Halting** **5: Halted** **6: Stopping** **7: Stopped** **8: Resetting**
PLC Last Error	WORD	5	4	Last error encountered by the PLC	**0: No Error** **1: Load Error** **2: Start Error** **3: Realtime Error** **4: Prolog Error** **5: Force List Error** **6: Out of Memory Error** **7: Runtime Error**
Sensor Error	WORD	7	5	Bit map for first 16 sensor inputs.	

Firmware Update / Reflash Status	WORD	-	6	Status after firmware has been updated. Should be 0 if no update has been done since reset.	1 : "Flash Completed Successfully!" 0 : Idle -1 : "Unsupported Record Type" -2 : "Invalid ASCII data in S19" -3 : "Invalid header state, not in expected S19 location" -4 : "Address in S19 is invalid for the targeted flash space" -5 : "Line error while parsing S19 Data record, expected end of line" -6 : "Data error while parsing S19 Data record" -7 : "Invalid record state" -8 : "Checksum error while parsing S19" -9 : "Flash erase Failed" -10 : "Flash write Failed" -11 : "Not enough memory in temporary storage for S19 data record" -12 : "Incompatible firmware, S19 is invalid for this target" -13 : "S19 data record address is not aligned to a 4 byte boundary" -14 : "S19 data record length is not a multiple of 4" -15 : "Flash erase of the application boot header

eCLR/PLC Unlocked	WORD	8	7	States whether eCLR is factory enabled/unlocked	0 = Locked 1 = UnLocked
Model Supervisor TimeStamp	DWORD	9	8-9	Displays the raw timestamp when the Model Supervisor was last processed.	
Model Supervisor Calculation Time	DWORD	10	10-11	Displays the numbers of cycles executed to perform the Model Supervisor algorithm	
Model Supervisor Time Since Last Execution	DWORD	11	12-13	Displays the time since theModel Supervisor was last performed in msec.	

- ## Manufacturing

Fieldbus	Detail
EtherCAT Subindex	0xF501
Modbus/TCP Base	Holding Reg 60000
Telnet	tc_rd mfg_info

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
Key	BYTE		0		0x4655 - Reset 0x4254 - Update Bootloader 0x4150 - Update Application 0x4F42 - Factory Reset 0x4441 - DLL Reset
Serial Number	DWORD		1-2		
Product Code	STRING		3-8		
Hardware Version String	STRING		9-11		
Ethernet MAC Address	ADDR		12-14		

Calibration Command	BYTE		15		
Calibration Channel	BYTE		16		
Calibration Status	BYTE		17		
Calibration Data	DWORD		18-19		
Switches	WORD		20		
IP Address	DWORD		21-22		0 = DHCP
IP Net Mask	DWORD		23-24		
IP Gateway	DWORD		25-26		

- ## Temperature Inputs

Fieldbus	Detail
EtherCAT Subindex	0xF502
Modbus/TCP Base	Input Reg 11000
Shell	tc_rd input_raw_temp

Display the raw temperature for all temperature inputs. Temperatures are 32-bit floating point values (TYPE = REAL), 2 modbus registers per temperature value.

- ## Device Configuration

Fieldbus	Detail
EtherCAT Subindex	0xF503
Modbus/TCP Base	Holding Reg 10000
Shell	tc_rd dev_cfg

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
PID Auto Recover	BOOL	1	1		0 = Device will always power up disabled (0% output power) 1 = Device will restore saved Control Word and Setpoint

PID Loop rate in ms (>=10 ms)	BYTE	6	3		
NVSave	BYTE	Use index 0xFBF0	6	Write a value of 1 to execute an NVSave.	
Fieldbus Type	BYTE	9	7	Change Fieldbus protocol type	0 = ECAT 1 = Modbus
PLC Boot Mode	BYTE	10	8	Choose what the PLC will do when the controller boots.	0: Cold 1: Warm 2: Idle 3: Exit
PLC Command	BYTE	11	9	Control the state of the PLC	0: No Command 1: Cold Start Boot 2: Warm Start Boot 3: Stop Boot 4: Reset 5: Cold Start 6: Warm Start 7: Hot Start 8: Stop 9: Continue

- ## Read Only Shared Memory

Fieldbus	Detail	Notes: Total RO Space = 512 bytes
EtherCAT Subindex	0xF50C	Subindexes: 1 - 128 (REAL 32bit)
Modbus/TCP Base	Input Reg 9000	Addr: 9000 - 9255
Shell	shm_read	

- ## Read/Write Shared Memory

Fieldbus	Detail	Notes: Total RW Space = 512 bytes
EtherCAT Subindex	0xF50D	Subindexes: 1 - 128 (REAL 32bit)
Modbus/TCP Base	Holding Reg 9000	Addr: 9000 - 9255
Shell	shm_write	

- ## Model User Variables

Fieldbus	Detail	Notes:
EtherCAT Subindex	0xF50E	Subindexes: 1 to m1 + m2 m1 = Model 1 number of model instances m2 = Model 2 number of model instances Max: 100 (50 per model)
Modbus/TCP Base	Holding Reg 15500	Addr: 15500 to (15500 + ((m1 + m2) * 2) - 2), m1 = Model 1 number of model instances m2 = Model 2 number of model instances Max: 15698 (50 per model) 2 registers per user variable (inverse float).
Shell		

- ## Thermocouple Types

Fieldbus	Detail
EtherCAT Subindex	0xF504
Modbus/TCP Base	Holding Reg 11000
Shell	tc_rd thermocouple_type

0: K

1: J

2: T

3: E

4. N

5: R

6: S

7: B

8: C

9: D

10: G

11-31: Reserved

 Currently only support for J, K, and N types.

- ## Power Outputs

Fieldbus	Detail
EtherCAT Subindex	0xF505
Modbus/TCP Base	Input Reg 12000
Shell	tc_rd raw_output

- ## Slice Calibration Valid Status

Fieldbus	Detail	Notes
EtherCAT Subindex	0xF506	
Modbus/TCP Base	Input Reg 13000	

Shell	tc_rd calib_valid	0 = Invalid 1 = Failed 2 = OK 255 = Unsupported NOTE: • An invalid CRC will result in a non-OK condition. Also some slices have additional restrictions on what constitutes a valid calibration status. See the appropriate slice HSID for details. • Some slices support multiple CRC values. An invalid value on ANY CRC will result in a non-OK condition.

- ## Slice Configuration

Fieldbus	Detail	Notes
EtherCAT Subindex	0xF507	
Modbus/TCP Base	Holding Reg 12000	

Shell	tc_rd slice_cfg tc_wr slice_cfg <slice_idx> <value>	slice idx starts a 0. Value is 32 bits and can be entered as hexadecimal or decimal. When writing the configuration you must include the "Slice Type" into the 32bit value (bits 31-24). See Table below for Slice Type values per slice.

Slice	Slice Type (Bits 31-24)	Slice Configuration (Bits 23-0)			
		Bits	**Function**	**Values**	**Notes**
DIO	1	2-0	Mode	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 4 = DIO Mode	(R/W) • All Modes will provide DI readings.
		3	Underload Action	0 = All outputs (12/per driver) are depending on command on/off 1 = Only the failed output (underload) is switched OFF	(R/W)
		4	Di Type	0 = Sourcing 1 = Sinking	(RO)
		5	Do Type	0 = Sourcing 1 = Sinking	(RO)
		6	Underload Mask	0 = Do not mask underload faults 1 = Mask underload faults	(R/W)
		23-7	Reserved		

		Bits	Function	Values	Notes
AIO	2	0	AI HW Cfg	0 = Voltage 1 = Current	Read only (Write ignored)
		1	AO HW Cfg	0 = Voltage 1 = Current	Read only (Write ignored)
		2	AO Signalling	0 = Single Ended 1 = Differential	
		5-3	AI Mode	0 = -10v ~ 10v 1 = 0v ~ 10v 2 = -5v ~ 5v 3 = 0v ~ 5v 4 = 0mA ~ 20mA 5 = 4mA ~ 20mA	Valid options depend upon AI HW Cfg bit.
		8-6	AO Mode	0 = -10v ~ 10v 1 = 0v ~ 10v 2 = -5v ~ 5v 3 = 0v ~ 5v 4 = 0mA ~ 20mA 5 = 4mA ~ 20mA	Valid options depend upon AO HW Cfg bit.
		9	Mode	0 = AI & Temperature In / Power Out 1 = AI & Temperature In / Generic AO	Takes effect after combined nvsave and reset
		23-10	Reserved		

AFE	3	**Bits**	**Function**	**Values** / **Notes**
		0	HW Configuration	0 = PT100 1 = PT1000 Read only (Write ignored)
		1	RTD Enable	0 = Thermocouple 1= RTD
		4-2	Sample Rate	0 = 1.67 Hz 1 = 3.30 Hz 2 = 6.51 Hz 3 = 12.66 Hz (Default) 4 = 23.81 Hz 5 = 42.92 Hz 6 = 71.43 Hz 7 = 107.53 Hz
MFC	4	**Bits**	**Function**	**Values** / **Notes**
		0	Connector Type	0 = 9-pin connector See MFC Slice (Apple Pie) for pin mapping. 1 = 15-pin DSUBconnector Software presentation of MFC slice does not change based upon this bit.

- **Slice ID**

Fieldbus	Detail
EtherCAT Subindex	0xF508
Modbus/TCP Base	Input Reg 13500

Shell	

Slice	Slice ID
AFE	0x0000AA01
DIO	0x0000AA02
AIO	0x0000AA03

- ## Slice Revision

Fieldbus	Detail
EtherCAT Subindex	0xF509
Modbus/TCP Base	Input Reg 12500
Shell	

Display the revision for each detect slice (32-bit value).

- ## Synchronous Input Assignment

Fieldbus	Detail
EtherCAT Subindex	0xF50B
Modbus/TCP Base	Input Reg 12750
Shell	

For PWM outputs on a DIDO slice, select the input that is used for synchronization.

The configuration is limited to using an input on the same slice as the output.

Slice Index (Bits 16-8)	Input Index (Bits 7-0)
(Starting at 1)	1 = DI1 2 = DI2 3 = DI3 4 = DI4 5 = DI5 6 = DI6 7 = DI7 8 = DI8 9 = DI9 10 = DI10 11 = DI11 12 = DI12 13 = NOT SYNCHRONIZED DO MODE

Temperature Transform Table

Fieldbus	Detail
EtherCAT Subindex	0xF520
Modbus/TCP Base	Holding Reg 12850
Shell	<none>

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values

Loop Index Value	WORD	1	0	Defines which Loop whose values are represented in the following Raw and Desired Temp registers	1 to MAX LOOP#
Raw Temp Entry 1	REAL	2	1-2		
Raw Temp Entry 2	REAL	3	3-4		
Raw Temp Entry 3	REAL	4	5-6		
Raw Temp Entry 4	REAL	5	7-8		
Raw Temp Entry 5	REAL	6	9-10		
Raw Temp Entry 6	REAL	7	11-12		
Raw Temp Entry 7	REAL	8	13-14		
Raw Temp Entry 8	REAL	9	15-16		
Raw Temp Entry 9	REAL	10	17-18		
Raw Temp Entry 10	REAL	11	19-20		
Desired Temp Entry 1	REAL	12	21-22		
Desired Temp Entry 2	REAL	13	23-24		
Desired Temp Entry 3	REAL	14	25-26		
Desired Temp Entry 4	REAL	15	27-28		

Desired Temp Entry 5	REAL	16	29-30		
Desired Temp Entry 6	REAL	17	31-32		
Desired Temp Entry 7	REAL	18	33-34		
Desired Temp Entry 8	REAL	19	35-36		
Desired Temp Entry 9	REAL	20	37-38		
Desired Temp Entry 10	REAL	21	39-40		

- **Temperature MinMax Scale**

Fieldbus	Detail
EtherCAT Subindex	0xF50A
Modbus/TCP Base	Holding Reg 15000
Shell	tc_rd max_conv tc_rd min_conv tc_wr max_conv <inputch#> <value> tc_wr min_conv <inputch#> <value>

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
Chnl 1 TC Scale Min	REAL	2	0-1		
Chnl 1 TC Scale Max	REAL	1	2-3		
Chnl 2 TC Scale Min	REAL	4	4-5		
Chnl 2 TC Scale Max	REAL	3	5-6		
...	...	...	...		
...	...	...	...		

Channel Objects

MKS Channel Info

Fieldbus	Detail
EtherCAT Subindex	0x2NN0
Modbus/TCP Base	Input Register 2NN00
Shell	tc_rd chnl_info

Object	Type	EtherCAT Subindex	Modbus Offset	Description
Control Temperature Raw (No Bias)	REAL	1	0-1	Indicates the Raw Temperature value of the control input before the temperature bias is applied and fed to the controlling loop
Limit Temperature	REAL	2	2-3	Indicates the processed limit input temperature.
Limit Temperature Raw (No Bias)	REAL	3	4-5	Indicates the limit input temperature before the limit bias is applied.
Timestamp	DWORD	4	6-7	Displays the raw timestamp when the loop was last processed.
Calculation Time	DWORD	5	8-9	Displays the numbers of cycles executed to perform the control algorithm for this zone.
Time Since Last Execution	DWORD	6	10-11	Displays the time since the control algorithm was last performed in msec.
Model Supported	BOOL	7	12	Indicates whether or not the unit is configured to include model-based control.

MKS Channel Configuration

Fieldbus	Detail
EtherCAT Subindex	0x4NN0
Modbus/TCP Base	Holding Register 2NN00
Shell	tc_rd chnl_dev_cfg

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
CT Alarm Max	REAL	17	0-1		
CT Alarm Min	REAL	18	2-3		
Control Type	WORD	19	4		0 =PID 1 = MPC Ctrl 1st 2 = MPC Ctrl 2nd 3 = Model Master 4 = Model Slave
Control Channel Input	BYTE	20	5		
Limit Channel Input	BYTE	21	6		
Limit Clear Alarms	WORD	22	7		
Limit Alarm 1 Enable	BYTE	23	8		
Limit Alarm 2 Enable	BYTE	24	9		
Limit Alarm 1 High Action	BYTE	25	10		
Limit Alarm 1 Low Action	BYTE	26	11		
Limit Alarm 2 High Action	BYTE	27	12		
Limit Alarm 2 Low Action	BYTE	28	13		
Limit Temperature Bias	REAL	29	14-15		
Limit Alarm 1 SP High	REAL	30	16-17		
Limit Alarm 1 SP Low	REAL	31	18-19		
Limit Alarm 1 SP MAX	REAL	32	20-21		
Limit Alarm 1 SP MIN	REAL	33	22-23		
Limit Alarm 2 SP High	REAL	34	24-25		
Limit Alarm 2 SP Low	REAL	35	26-27		

Limit Alarm 2 SP MAX	REAL	36	28-29		
Limit Alarm 2 SP MIN	REAL	37	30-31		
Input Filter Coefficient	REAL	38	32-33		
Derivative Filter 1 Coefficient	REAL	39	34-35		
Setpoint Filter Coefficient	REAL	41	36-37		
Power Offset	REAL	42	38-39		
Control Channel Output	BYTE	43	40		
Scaling Gain	REAL	44	41-42		
Scaling Offset	REAL	45	43-44		
Setpoint Source Cfg	UDINT	46	45-46		
Enable\Disable Temperature Transform Table Offsets	BYTE	47	47		

Channel Inputs

As defined by ETG.5003.2060.

Fieldbus	Detail
EtherCAT Subindex	0x6NN0
Modbus/TCP Base	Input Register 3NN00
Shell	tc_rd chnl_inputs

Click here to expand...

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
Control Status	WORD		0		
Process Value	REAL		1-2		
Manipulated Value (Control Output)	REAL		3-4		
Current Transformer reading	REAL		5-6		
Controlling Set Point	REAL		7-8		

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
Alarm Condition	WORD		9		
Limit Condition	WORD		10		

Channel Outputs

As defined by ETG.5003.2060.

Fieldbus	Detail
EtherCAT Subindex	0x7NN0
Modbus/TCP Base	Holding Register 3NN00
Shell	tc_rd chnl_outputs

Click here to expand...

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
Control Word	WORD		0		
Target Set Point	REAL		1-2		
Forced MV	REAL		3-4		
Clear Alarms	WORD		5		

Channel Configuration

As defined by ETG.5003.2060.

Fieldbus	Detail
EtherCAT Subindex	0x8NN0
Modbus/TCP Base	Holding Register 4NN00
Shell	tc_rd chnl_cfg

Object	Type	EtherCAT Subindex	Modbus Offset	Description	Values
Sensor Type	BYTE		0		

TC Type	BYTE		1		
Units of Measure	BYTE		2		
Alarm 1 Enable	BYTE		3		
Alarm 2 Enable	BYTE		4		
Safe State Action	BYTE		5		
Output 1 Cycle Time	REAL		6-7		
Standby Set Point	REAL		8-9		
SP High Limit	REAL		10-11		
SP Low Limit	REAL		12-13		
PV Bias (offset)	REAL		14-15		
MV High Limit	REAL		16-17		
MV Low Limit	REAL		18-19		
Propband 1	REAL		20-21		
Integral 1	REAL		22-23		
Derivative 1	REAL		24-25		
Alarm 1 SP High	REAL		26-27		
Alarm 1 SP Low	REAL		28-29		
Alarm 1 SP Limit High	REAL		30-31		
Alarm 1 SP Limit Low	REAL		32-33		
Alarm 2 SP High	REAL		34-35		
Alarm 2 SP Low	REAL		36-37		

MFC

Analog Inputs

Description	Channels	Register Address	Type	RO/RW	Shell access
Indicates the active state of the input TXPDO mappable	MFC Analog Input 1	EtherCAT Index: 0xF510 Subindex: 1 Modbus Input Register: 14000	INT	RO	mfcrd ai

Range is +/- 14.2 V	MFC Analog Input 2	EtherCAT Index: 0xF510 Subindex: 2 Modbus Input Register: 14001	INT	RO	
	…	…			
	MFC Analog Input N	EtherCAT Index: 0xF510 Subindex: N Modbus Input Register: 140NN	INT	RO	

- ## Channel Numbering

AI	9 pin	15 pin	Function
1	CH1 Pin 9	CH1 Pin 1	Valve Test Point
2	CH1 Pin 2	CH1 Pin 2	Flow
3	CH2 Pin 9	CH2 Pin 1	Valve Test Point
4	CH2 Pin 2	CH2 Pin 2	Flow
5	CH3 Pin 9	CH3 Pin 1	Valve Test Point
6	CH3 Pin 2	CH3 Pin 2	Flow
7	CH4 Pin 9	CH4 Pin 1	Valve Test Point
8	CH4 Pin 2	CH4 Pin 2	Flow

	9 pin	15 pin	Function
9	N/A	CH1 Pin 10	Optional Input
10	N/A	CH1 Pin 14	Pressure
11	N/A	CH2 Pin 10	Optional Input
12	N/A	CH2 Pin 14	Pressure

13 N/A CH3 Pin 10 Optional Input

14 N/A CH3 Pin 14 Pressure

15 N/A CH4 Pin 10 Optional Input

16 N/A CH4 Pin 14 Pressure

Analog Outputs

Description	Channels	Register Address	Type	RO/RW	Shell access
Sets the active state of the output PDO mappable Range is 0-10 V	MFC Analog Output 1	EtherCAT Index: 0xF511 Subindex: 1 Modbus Holding Register: 14000	UINT	RW	mfcrd ao mfcwr ao <ch 1-N> <val 0-65535 or 0x0000-0xffff>
	MFC Analog Output 2	EtherCAT Index: 0xF511 Subindex: 2 Modbus Holding Register: 14001	UINT	RW	
	…	…			
	MFC Analog Output N	EtherCAT Index: 0xF511 Subindex: N Modbus Holding Register: 140NN	UINT	RW	

Digital Outputs

Description	Channels	Register Address	Type	RO/RW	Shell access

Sets the active state of the output ECAT PDO mappable Active = 1 Inactive = 0	MFC Digital Outputs 1-16	EtherCAT Index: 0xF512 Subindex: 1,2 Modbus Holding Register: 14100	BYTE/WORD	RW	mfcrd do mfcwr do <ch 1-N> <0 or 1>
	MFC Digital Outputs 17-32	EtherCAT Index: 0xF512 Subindex: 3,4 Modbus Holding Register: 14101	BYTE/WORD	RW	
	…	…			
	MFC Digital Outputs N	EtherCAT Index: 0xF512 Subindex: N-1,N Modbus Holding Register: 141NN	BYTE/WORD	RW	

Digital Output Configuration

Description	Channels	Register Address	Type	RO/RW	Shell access
Configures the behavior of the output Bit 0 - Invert output • 0 = Active 5V, Inactive 0V	MFC Digital Output 1 Configuration	EtherCAT Index: 0xF513 Subindex: 1 Modbus Holding Register: 14200	BYTE	RW	mfcrd docfg mfcwr docfg <ch 1-N> <0-3>

• 1 = Active 0V, Inactive 5V		EtherCAT Index: 0xF513	
Bit 1 - Drive inactive value • 0 = Inactive buffer is tri-stated • 1 = Inactive buffer is driven.	MFC Digital Output 2 Configuration … MFC Digital Output N Configuration	Subindex: 2 Modbus Holding Register: 14201 … EtherCAT Index: 0xF513 Subindex: N Modbus Holding Register: 142NN	BYTE RW BYTE RW

Digital

Digital Inputs

Description	Channels	Register Address	Type	RO/RW	Shell access
Indicates the active state of the input TXPDO mappable	Digital Input 1 - 16	EtherCAT Index: 0xF514 Subindex: 1,2 Modbus Input Register: 14300	WORD	RO	cord di
	Digital Input 17-32	EtherCAT Index: 0xF514 Subindex: 3,4 Modbus Input Register: 14301	WORD	RO	

	…	…			
	Digital Input N	EtherCAT Index: 0xF514 Subindex: N-1, N Modbus Input Register: 143NN	WORD	RO	

Digital Outputs

Description	Channels	Register Address	Type	RO/RW	Shell access
Sets the active state of the output ECAT PDO mappable Active = 1 Inactive = 0	Digital Outputs 1-16	EtherCAT Index: 0xF515 Subindex: 1,2 Modbus Holding Register: 14300	BYTE/WORD	RW	cord do cowr do <ch 1-N> <0 or 1>
	Digital Outputs 17-32	EtherCAT Index: 0xF515 Subindex: 3,4 Modbus Holding Register: 14301	BYTE/WORD	RW	
	…	…			
	Digital Outputs N	EtherCAT Index: 0xF515 Subindex: N-1,N Modbus Holding Register: 143NN	BYTE/WORD	RW	

Digital Outputs HW Status

Description	Channels	Register Address	Type	RO/RW	Shell access
Indicates the error state of the output Error = 1 OK = 0	Digital Outputs 1-16 HW Status	EtherCAT Index: 0xF516 Subindex: 1,2 Modbus Holding Register: 14400	BYTE/WORD	RO	costs do
	Digital Outputs 17-32 HW Status	EtherCAT Index: 0xF516 Subindex: 3,4 Modbus Holding Register: 14401	BYTE/WORD	RO	
	…	…			
	Digital Outputs N HW Status	EtherCAT Index: 0xF516 Subindex: N-1,N Modbus Holding Register: 144NN	BYTE/WORD	RO	

Digital Outputs Thermal Warning Status

Description	Channels	Register Address	Type	RO/RW	Shell access
Indicates the error state of the output Error = 1 OK = 0	Digital Outputs 1-16 Thermal Warning Status	EtherCAT Index: 0xF517 Subindex: 1,2 Modbus Holding Register: 14500	BYTE/WORD	RO	costs do

	Digital Outputs 17-32 Thermal Warning Status	EtherCAT Index: 0xF517 Subindex: 3,4 Modbus Holding Register: 14501	BYTE/WORD	RO	
	…	…			
	Digital Outputs N Thermal Warning Status	EtherCAT Index: 0xF517 Subindex: N-1,N Modbus Holding Register: 145NN	BYTE/WORD	RO	

Digital Outputs Overload Status

Description	Channels	Register Address	Type	RO/RW	Shell access
Indicates the error state of the output Error = 1 OK = 0	Digital Outputs 1-16 Overload Status	EtherCAT Index: 0xF518 Subindex: 1,2 Modbus Holding Register: 14600	BYTE/WORD	RO	costs do
	Digital Outputs 17-32 Overload Status	EtherCAT Index: 0xF518 Subindex: 3,4 Modbus Holding Register: 14601	BYTE/WORD	RO	
	…	…			

	Digital Outputs N Overload Status	EtherCAT Index: 0xF518 Subindex: N-1,N Modbus Holding Register: 146NN	BYTE/WORD	RO	

Digital Outputs Underload Status

Description	Channels	Register Address	Type	RO/RW	Shell access
Indicates the error state of the output Error = 1 OK = 0	Digital Outputs 1-16 Underload Status	EtherCAT Index: 0xF519 Subindex: 1,2 Modbus Holding Register: 14700	BYTE/WORD	RO	costs do
	Digital Outputs 17-32 Underload Status	EtherCAT Index: 0xF519 Subindex: 3,4 Modbus Holding Register: 14701	BYTE/WORD	RO	
	…	…			
	Digital Outputs N Underload Status	EtherCAT Index: 0xF519 Subindex: N-1,N Modbus Holding Register: 147NN	BYTE/WORD	RO	

Digital Outputs Power Supply Status

Description	Channels	Register Address	Type	RO/RW	Shell access

Indicates the error state of the output Error = 1 OK = 0	Digital Outputs 1-16 Power Supply Status	EtherCAT Index: 0xF51A Subindex: 1,2 Modbus Holding Register: 14800	BYTE/WORD	RO	costs do
	Digital Outputs 17-32 Power Supply Status	EtherCAT Index: 0xF51A Subindex: 3,4 Modbus Holding Register: 14801	BYTE/WORD	RO	
	…	…			
	Digital Outputs N Power Supply Status	EtherCAT Index: 0xF51A Subindex: N-1,N Modbus Holding Register: 148NN	BYTE/WORD	RO	

Analog

AnalogInputs

Description	Channels	Register Address	Type	RO/RW	Shell access
Indicates the active state of the input TXPDO mappable	Analog Input 1	EtherCAT Index: 0xF51B Subindex: 1 Modbus Input Register: 5000	INT/UINT	RO	cord ai

	Analog Input 2	EtherCAT Index: 0xF51B Subindex: 2 Modbus Input Register: 5001	INT/UINT	RO	
	…	…			
	Analog Input N	EtherCAT Index: 0xF51B Subindex: N Modbus Input Register: 50NN	INT/UINT	RO	

Analog Outputs

Description	Channels	Register Address	Type	RO/RW	Shell access
Sets the active state of the output ECAT PDO mappable	Analog Output 1	EtherCAT Index: 0xF51C Subindex: 1 Modbus Holding Register: 5000	INT/UINT	RW	cord ao cowr ao <ch N> <val>
	Analog Output 2	EtherCAT Index: 0xF51C Subindex: 2 Modbus Holding Register: 5001	INT/UINT	RW	
	…	…			

	Analog Output N	EtherCAT Index: 0xF51C Subindex: N Modbus Holding Register: 50NN	INT/UINT	RW	

Analog Inputs Status

Description	Channels	Register Address	Type	RO/RW	Shell access
Indicates the error state of the output Error = 1 OK = 0	Analog Inputs Status 1-16	EtherCAT Index: 0xF51D Subindex: 1,2 Modbus Holding Register: 5100	BYTE/WORD	RO	costs ai
	Analog Inputs Status 17-32	EtherCAT Index: 0xF51D Subindex: 3,4 Modbus Holding Register: 5101	BYTE/WORD	RO	
	…	…			
	Analog Inputs Status N	EtherCAT Index: 0xF51D Subindex: N-1,N Modbus Holding Register: 51NN	BYTE/WORD	RO	

Analog Outputs Status

Description	Channels	Register Address	Type	RO/RW	Shell access

Indicates the error state of the output Error = 1 OK = 0	Analog Outputs Status 1-16	EtherCAT Index: 0xF51E Subindex: 1,2 Modbus Holding Register: 5200	BYTE/WORD	RO	costs ao
	Analog Outputs 17-32 Status	EtherCAT Index: 0xF51E Subindex: 3,4 Modbus Holding Register: 5201	BYTE/WORD	RO	
	…	…			
	Analog Outputs N Status	EtherCAT Index: 0xF51E Subindex: N-1,N Modbus Holding Register: 52NN	BYTE/WORD	RO	

Appendix B: Available Telnet Commands

• reset :
- This command will force a soft reset on the unit
Usage: “reset”

• nvdata :
- This command is used to read the contents of NVRAM
Usage: “nvdata”

• nvsave :
- This command causes the current state of NVRAM to be saved
Usage: “nvsave”

• netstat :
- This command is used to display network statistics
Usage: “netstat”

• ipsave :
- This command is used to modify 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 Teraterm log during startup.

• ipquery :
- This command is used to display the stored IP address used on boot
Usage: “ipquery”

• Help :
- Displays information about all shell commands mentioned in this section
Usage: “help <command>”

- **Reading Data**

Data and information can be read using the following command:
“tc_rd <subcommand> <channel number>”

The subcommands will be explained below within each section of the device profile.

1.3 Reading All Channel Data
All channel information and data for a single channel can be read at once using the following command: “tc_rd all <channel number>” where channel number starts from 1.

The information will be displayed in a table as follows:

Reading All Channel information and data:

shell> tc_rd all 1
Reading All Channel information and data:

Read Device Info:
CPU Version : 6
NVRAM Valid : 1
Sensor Error: 0

Read Manufacturer Info:
key : 0
ser num : 10033910
hw ver : 1.0.0
mac address: 0:B:17:10:12:AA
product code: ASXXXXXG-YY
cal command: 0
cal channel: 0
cal status : 0
mfg data : 0

Read Min Conv Values:
Chnl 00 Min: 0.000000
Chnl 01 Min: 0.000000
Chnl 02 Min: -10.000000
Chnl 03 Min: -10.000000
Chnl 04 Min: -10.000000
Chnl 05 Min: -10.000000
Chnl 06 Min: -10.000000
Chnl 07 Min: -10.000000

Read Max Conv Values:
Chnl 00 Max: 10.000000
Chnl 01 Max: 10.000000
Chnl 02 Max: 10.000000
Chnl 03 Max: 10.000000
Chnl 04 Max: 10.000000
Chnl 05 Max: 10.000000
Chnl 06 Max: 10.000000
Chnl 07 Max: 10.000000

32-bit Slice Cfg:
Slice 01: 0x02000044 (33554500)
Slice 02: 0x0100000B (16777227)

Read Input Raw Temperature:
Chnl 01 Raw Temperature: 5.000038
Chnl 02 Raw Temperature: 5.000153
Chnl 03 Raw Temperature: 0.000076

Chnl 04 Raw Temperature: -0.000229
Chnl 05 Raw Temperature: -0.000381
Chnl 06 Raw Temperature: 0.000610
Chnl 07 Raw Temperature: 0.000153
Chnl 08 Raw Temperature: 0.000305

Read Inputs for module: 0:
Raw TMP Val: 5.000
Limit TMP Val: 5.000
Raw Limit TMP Val: 5.000
Timestamp: 496900000
Processing Time: 0
Time Since Last: 100
Model Supported: 0

Read Device Configuration:
Ilk enable: 0
CT enable: 0
loop time: 100
protocol: 1

Read Input Chnl TC Type Configuration:
Chnl 01 TC Type: 11()
Chnl 02 TC Type: 11()
Chnl 03 TC Type: 11()
Chnl 04 TC Type: 11()
Chnl 05 TC Type: 11()
Chnl 06 TC Type: 11()
Chnl 07 TC Type: 11()
Chnl 08 TC Type: 11()
Chnl 09 TC Type: 11()
Chnl 10 TC Type: 11()
Chnl 11 TC Type: 11()
Chnl 12 TC Type: 11()
Chnl 13 TC Type: 11()
Chnl 14 TC Type: 11()
Chnl 15 TC Type: 11()
Chnl 16 TC Type: 11()
Chnl 17 TC Type: 11()
Chnl 18 TC Type: 11()
Chnl 19 TC Type: 11()
Chnl 20 TC Type: 11()
Chnl 21 TC Type: 11()
Chnl 22 TC Type: 11()
Chnl 23 TC Type: 11()
Chnl 24 TC Type: 11()
Chnl 25 TC Type: 11()
Chnl 26 TC Type: 11()

Chnl 27 TC Type: 11()
Chnl 28 TC Type: 11()
Chnl 29 TC Type: 11()
Chnl 30 TC Type: 11()
Chnl 31 TC Type: 11()
Chnl 32 TC Type: 11()
Chnl 33 TC Type: 11()
Chnl 34 TC Type: 11()
Chnl 35 TC Type: 11()
Chnl 36 TC Type: 11()
Chnl 37 TC Type: 11()
Chnl 38 TC Type: 11()
Chnl 39 TC Type: 11()
Chnl 40 TC Type: 11()
Chnl 41 TC Type: 11()
Chnl 42 TC Type: 11()
Chnl 43 TC Type: 11()
Chnl 44 TC Type: 11()
Chnl 45 TC Type: 11()
Chnl 46 TC Type: 11()
Chnl 47 TC Type: 11()
Chnl 48 TC Type: 11()

Read Raw Power Output:
Chnl 1 Power Output: 0.000000
Chnl 2 Power Output: 0.000000
Chnl 3 Power Output: 0.000000
Chnl 4 Power Output: 0.000000
Chnl 5 Power Output: 0.000000
Chnl 6 Power Output: 0.000000
Chnl 7 Power Output: 0.000000
Chnl 8 Power Output: 0.000000
Chnl 9 Power Output: 0.000000
Chnl 10 Power Output: 0.000000
Chnl 11 Power Output: 0.000000
Chnl 12 Power Output: 0.000000
Chnl 13 Power Output: 0.000000
Chnl 14 Power Output: 0.000000
Chnl 15 Power Output: 0.000000
Chnl 16 Power Output: 0.000000

Read Slice Calibration Valid Status:
Slice 1 Calibration Status: 0
Slice 2 Calibration Status: 255

Zone Config for module: 1:
alarm max: 350.000
alarm min: 0.000

ctrl type: 0
ctrl channel in: 1
limit channel in: 1
limit clear alarms: 0
limit alarm1 enable: 0
limit alarm2 enable: 0
limit alarm1 SP high action: 0
limit alarm1 SP low action: 0
limit alarm2 SP high action: 0
limit alarm2 SP low action: 0
limit temp bias: 0.000
limit alarm1 SP high: 0.000
limit alarm1 SP low: 0.000
limit alarm1 SP max: 350.000
limit alarm1 SP min: 0.000
limit alarm2 SP high: 0.000
limit alarm2 SP low: 0.000
limit alarm2 SP max: 350.000
limit alarm2 SP min: 0.000
input filter sample num: 0.000
Derivative tau: 1.000
Setpoint tau: 0.000
power offset: 0.000
ctrl channel out: 1
scaling gain: 1.000
scaling offset: 0.000
setpoint source: 0

Semi inputs for module: 1:
control state : 0
ctrl loop mod : 0
sensor err   : 0
tune occuring : 0
process   val: 5.000
    manip val: 0.000
Heat manip val: 0.000
tranformer val: 0.000
ctrl setpoint : 0.000
alarm status : 0x0
limit status : 0x0

Semi outputs for module: 1:
control state: 0
control mode : 0
setpoint   : 0.000
forced manual: 0.000
clear alarms : 0x0

Semi config for module: 1:
sensor type : 0
tc type : 0
measure unit: 0
alrm1 enable: 0
alrm2 enable: 0
safe state act : 0
out1 cycl time : 50.000
stndby setpoint: 0.000
setpoint HI lim: 350.000
setpoint LO lim: 0.000
pv Bias : 0.000
mvHigh Limit : 100.000
mv Low Limit : 0.000
propband 1 : 5.000
integral 1 : 20.000
derivative 1 : 0.000
alrm1 setPnt HI: 350.000
alrm1 setPnt LO: 0.000
alrm1 SP lim HI: 350.000
alrm1 SP lim LO: 0.000
alrm2 setPnt HI: 350.000
alrm2 setPnt LO: 0.000
alrm2 SP lim HI: 350.000
alrm2 SP lim LO: 0.000

- **Writing Data**

Data and information can be written using the following command:
tc_wr <subcommand> <channel number> <value>

The subcommands will be explained below within each section of the device profile.