EtherCAT® Supplemental Manual

SLA58xx and SLAMf Series
Mass Flow Controllers & Meters

BROOKS® INSTRUMENT

Beyond Measure

Essential Instructions

Read this page before proceeding!

Brooks Instrument designs, manufactures and tests its products to meet many national and international standards. Because these instruments are sophisticated technical products, you must properly install, use and maintain them to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, using and maintaining Brooks Products.

- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, please see back cover for local sales office contact information. Save this instruction manual for future reference.
- If you do not understand any of the instructions, contact your Brooks Instrument representative for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation and maintenance of the product.
- Install your equipment as specified in the installation instructions of the appropriate instruction manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, use qualified personnel to install, operate, update, program and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by Brooks Instrument.
- Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look-alike substitutions may result in fire, electrical hazards or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent electrical shock and personal injury.

ESD (Electrostatic Discharge)

⚠ CAUTION

This instrument contains electronic components that are susceptible to damage by electricity. Proper handling procedures must be observed during the removal, installation, or other handling of internal circuit boards or devices.

Handling Procedure:

1. Power to the unit must be removed.

2. Personnel must be grounded, via a wrist strap or other safe, suitable means before any printed circuit card or other internal device is installed, removed or adjusted.

3. Printed circuit cards must be transported in a conductive container. Boards must not be removed from protective enclosure until immediately before installation. Removed boards must immediately be placed in protective container for transport, storage or return to factory.

Comments:

This instrument is not unique in its content of ESD (electrostatic discharge) sensitive components. Most modern electronic designs contain components that utilize metal oxide technology (NMOS, SMOS, etc.). Experience has proven that even small amounts of static electricity can damage or destroy these devices. Damaged components, even though they appear to function properly, exhibit early failure.

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Introduction

Many applications of Flow Controllers/Meters are moving to increase the use of automation. Automation comes in many forms: PLC's (Programmable Logic Controllers, such as the Siemens S7 300/4000), DCS's (Distributed Control Systems, such as Emerson's Digital V), PC based solutions (National Instruments Labview TM), and Ethernet based field buses. Digital communications from these varied systems and the devices they measure and control, are a very effective means of not onlyaccomplishing more effective and rapid system integration, but also providing greatly improved system diagnostics and maintainability. EtherCAT is an Ethernet based communication system and is known for its high cycle time and cost efficient cabling and master application solutions. Brooks Instrument now introduces the EtherCAT interface on its SLA Enhanced Series platform.

Definition of Terms

Abbreviation	Description
Byte	A Byte refers to 8 consecutive bits.
CoE	CANOpen over EtherCAT
CRC	Checksum
Cycle	A cycle is defined as the process of sending a command, waiting for a response, and processing it in order to be ready to send a new command.
EEPROM	Electrically Erasable Programmable Read-Only Memory.
ESC	EtherCAT Slave Controller
ESI	EtherCAT Slave Information file. (Device description in XML format)
EtherCAT	Ethernet for Control and Automation Technology
Frame	The transportation unit in a network, also known as a packet. (Contains a Header followed by the data to be sent).
Header	The Header is part of the Frame and contains all protocol defined constructs for addressing, size, etc.
LSB	Least Significant Bit
MAC	Media Access Control is responsible for address checking and is most often done in the hardware of a NIC.
Master	A Master is a unit which controls the Slaves, feeding them commands and receiving status reports in exchange.
MFC/MFM	Mass Flow Controller / Mass Flow Meter
MSB	Most Significant Bit
MTU	Maximum Transmission Unit. The maximum payload that a standard Ethernet Frame can hold. The MTU is set at 1500 bytes (Not considering theHeader and Checksum).
NIC	Network Interface Controller. A hardware component that connects a computer to a network.
OSI Model	A standardized representation for how a communication system can be organized. (e.g., a protocol stack) The model is divided into layers, each responsible for a part of the communication.
PDO	Process Data Object
PDU	Protocol Data Unit. A Slave command
RO	Read Only
RT	Real-time. A system that adheres to strict timing demands.
RW	Read / Write
SDO	Service Data Object
SII	Slave Information Interface. Data stored on an EEPROM in the Slave, containing information about it and its operation.
Slave	A Slave is a unit (node) on the EtherCAT network (e.g., an MFC). The Slave is connected to a Master.
Stack	A synonym for the implementation of the layers of a protocol. (e.g., a Master)
Topology	The way a network (Master & Slaves) is connected. The overall layout. (e.g., Star, Tree, Line Topology)
WO	Write Only

Background & Assumptions

This manual is a supplement to the Brooks SLA Enhanced Series installation and operation manual.
It is assumed that the owner of this EtherCAT MFC/MFM is thoroughly familiar with the theory and
operation of this device. If not, it is recommended that the owner read the installation and operation manual first before continuing with this supplement.

This manual assumes basic knowledge and understanding of EtherCAT (its topology and its method of logically accessing the data or parameters within this device). This manual is not intended to be a
replacement to the EtherCAT specifications. It is recommended but not required, for the purposes of this manual, that the user obtains a copy of the EtherCAT specifications (www.ethercat.org).

This manual does not make any assumptions about any particular manufacturer of equipment or custom software used by the user to communicate with the Brooks device, but assumes that the user has
thorough understanding of such equipment and any configuration software.
Application Notes and FAQ's are available at the Brooks Instrument web site (www.BrooksInstrument.com).

Numbers

Numeric values used throughout this manual will be clearly denoted as to the base numeric system it represents. All hexadecimal numbers (base 16) will be prefixed with a 0x, like "0xA4". All binary
numbers (base 2) will be suffixed with a b, like "1001b". All other numbers not annotated this way will be assumed decimal (base 10).

Quick Start

This section assumes that the owner of the Digital Series device has a fully operational and trouble-free communications network with appropriate power supplies. This section also assumes that an EtherCAT master application is connected to the network capable of PDO and mailbox data communication. Both types of data communication modes are supported by the Brooks SLA 5800 ‘E’ Series EtherCAT device

Master Hardware

Various companies provide EtherCAT master applications, e.g. TwinCAT from Beckoff, or offer EtherCAT master stacks to develop a master application, e.g. Acontis. A P.C. can be used to run most EtherCAT master applications but needs dedicated EtherCAT hardware to support the high cycle times and kernel mode operations of the master applications, see www.beckoff.com. Screen dumps of master applications used in this manual are taken from the EtherCAT Configurator tool or TwinCAT 3® applications from Beckoff Inc.

Physical Interfaces

The available physical interfaces on the EtherCAT device are listed below:

- 5 pin M8 threaded male connector for power and Analog I/O, indicated by pwr.
- In and Out ports with RJ-45 connectors.
- 2.5mm female jack for RS485 diagnostic port indicated by ‘DIAG’, refer to the SLA 5800 Series installation and operation manual for more details.

Power Supply and Analog I/O

Power needs to be supplied via the M8 connector. This connector also provides access to analog I/O signals, see Table 4-1. M8 mating cables can be purchased as a second line item, details given below.

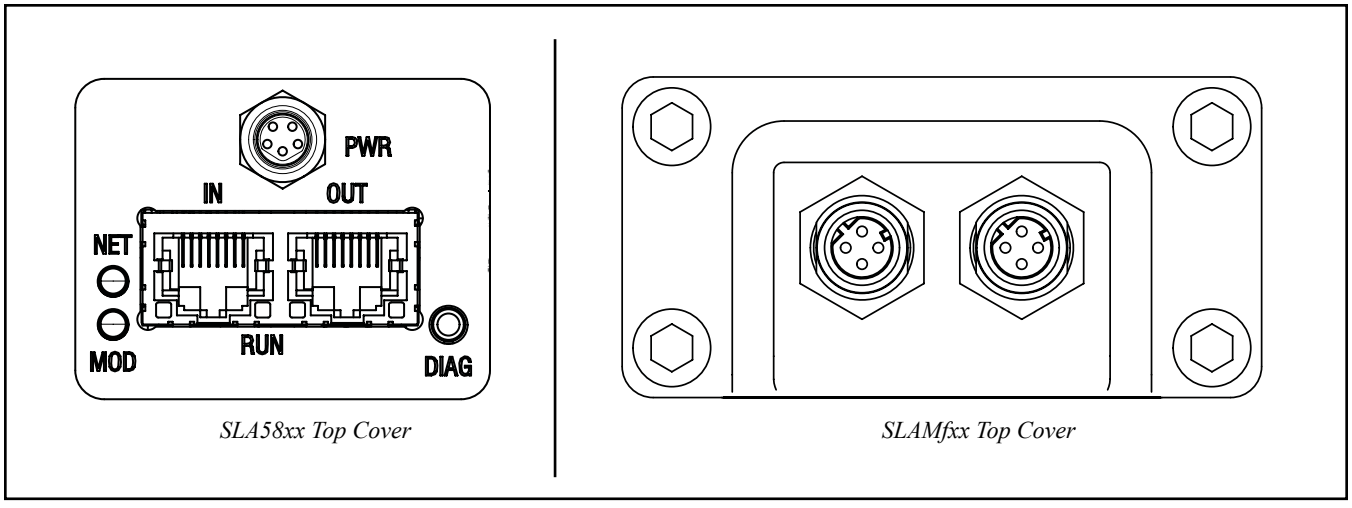


Figure 4-1 EtherCAT Top Cover

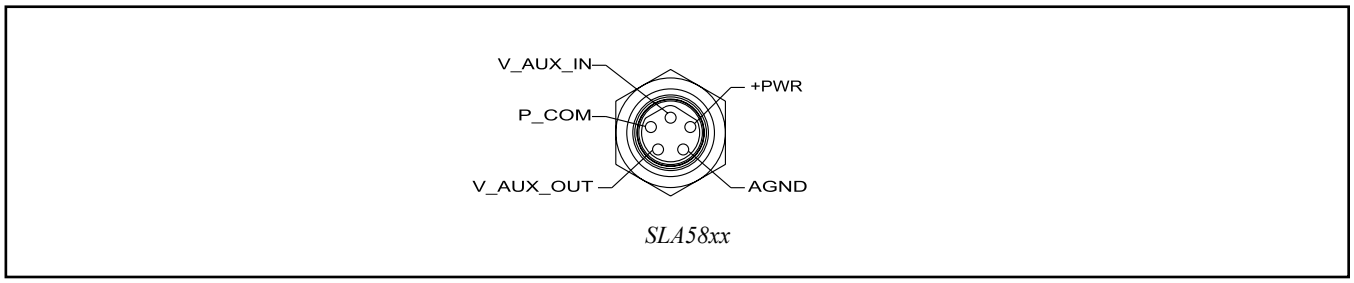


Figure 4-2 M8 Male Device Connector Pin Layout, Pin Side View

Table 4-1 Pin Labeling of M8 Male Device and Female Mating Cable Connector

Pin Label	Function at Remote Connector
P_COM	Power Supply Common
+VPWR	Positive Power Supply Voltage
V_AUX_OUT	Flow Output 0-5V
AGND	Analog I/O Common
V_AUX_IN	Auxiliary Input 0-5/10V for Future Use

RUN and MOD LED's

The MOD LED indicates that the device is supplied sufficiently with power.
The MOD LED will indicate the following:

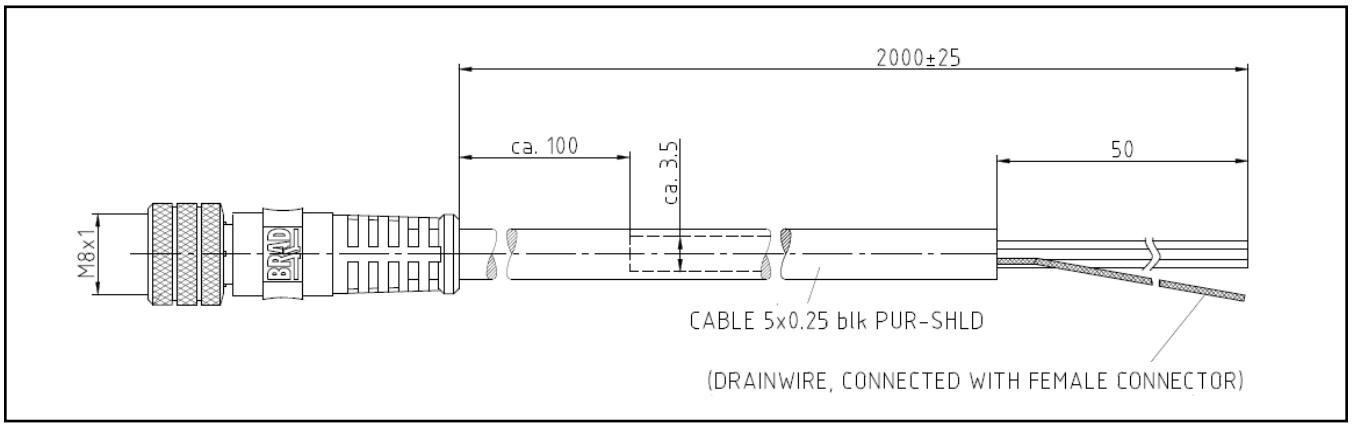


Figure 4-3 M8 Female Mating Cable

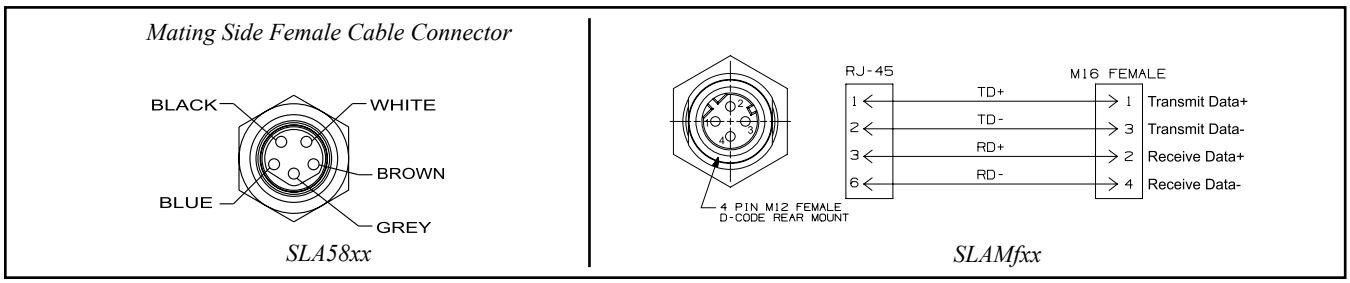


Figure 4-4 Female Mating Cable Connector Pin Layout

Table 4-2 Wire Labeling of M8 Female Mating Cable Connector

Wire Color	Wire Label	Function at Remote Connector
Blue	P_COM	Power Supply Common
Brown	+VPWR	Positive Power Supply Voltage
Black	V_AUX_OUT	Flow Output 0-5V
White	AGND	Analog I/O Common
Grey	V_AUX_IN	Auxiliary Input 0-5/10V for Future Use

Table 4-3 M8 Female Mating Cable Part Numbers

Supplier	Part Number	Description
Brooks Instrument	124X049AAA	M8 Mating Cable 2m
	124X050AAA	M8 Mating Cable 5m
	124Z170AAA	ECAT to DB15 Male

EtherCAT MFC Slave Hardware

The main parts of the EtherCAT MFC are:

Table 4-4 MOD LED Specification

Flash Code	Description
Flashing Red/Green	The device is in the Self-Test mode.
Solid Green	All Self-Tests have passed. No faults have been detected.
Solid Red	An unrecoverable fault has occured.

Table 4-5 RUN LED Specification

Flash Code	Description
Off	The device is in state INIT.
Rapid Flashing	About 3 times per second.
Slow Flashing	About once per second.
On	The device is in state OPERATIONAL.
Flickering	The device is booting and has not yet entered the INIT state.

- Standard Ethernet Physical Layer Components
- EtherCAT Slave Controller (ESC) and EEPROM (ESC configuration data and application specific data)
- For intelligent slaves with an application controller: Host controller

EtherCAT Theory

Ethernet for Control and Automation Technology

• Uses standard Ethernet hardware, Cat 5 cabling, and Network Interface Cards (NIC).
• Streamlines Ethernet communication at the hardware level.
• Data processing on Slave devices is handled “on-the-fly” via FPGA or ASIC, minimizing latency.
• Initial setup and configuration is required.

Frames (EtherCAT vs Ethernet)

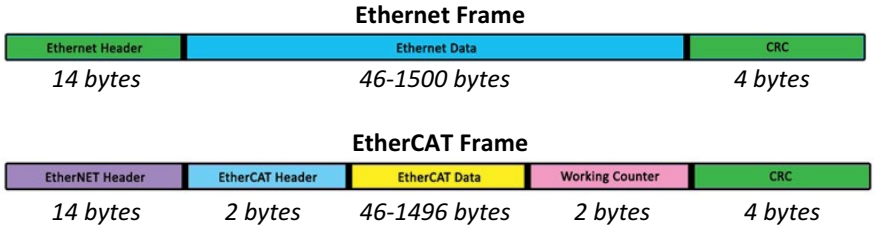
Ethernet Header:
• Ether type 0x08A4 specifies EtherCAT

EtherCAT Header:
• Data Length: 11bits
• Reserved: 1bit
• Protocol type: 4bits (0x01 indicates CoE/Can over EtherCAT)

EtherCAT Data:
• 46 – 1496 bytes

Working Counter:
• 2 Bytes

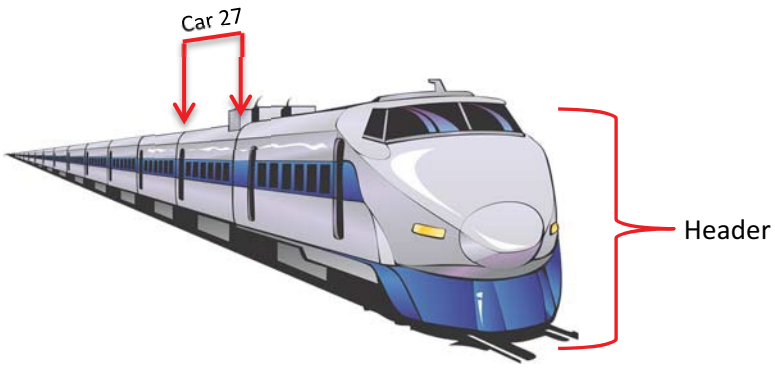
CRC (Checksum):
• 4 Bytes



Speed

• The EtherCAT protocol reduces the addressing overhead by letting a Master communicate with all
Slaves using a single frame, instead of one frame per device.
• This One Frame holds messages to any or all slaves on the network.

EtherCAT Examples



Analogy: Fast Train.

• "Train" (EtherCAT Frame) does not stop.

• Even when watching "Train" through narrow window one sees the entire "Train"

• "Car 27" (Sub-Telegram) has variable length. (46-1496 bytes)

• One can "extract" or "insert" single "persons" (Bits) or entire "groups" (Bytes) – even multiple groups per train… This is done without the train ever having to stop!

• An EtherCAT Master initially maps out the location and addresses of all of the slaves.

• The single EtherCAT Frame (the train) has instructions loaded on-board for some or all of the slaves.

• Only the instructions that are specifically addressed to a specific slave are delivered to that slave.

• So, for example, if there is a specific instruction on-board the EtherCAT Frame for a slave (node) with the Station ID, then only that slave with that address, will receive that specific instruction. The slave (node) will ignore all instructions on the EtherCAT frame Except for those instructions that are specifically addressed to it.

Another Example of the EtherCAT process...

• Each cubicle is an EtherCAT slave containing an engineer (a SLA58xx).

• Each engineer is told where to sit by its hardware address (Station ID).

• The Engineer is assigned specific tasks (by SDO's).

• The Boss (Master) identifies each engineer by first and last name, what they look like, and where exactly they are sitting.

• The Boss is the EtherCAT Master, sending instructions (PDO's) out to the engineers each morning and picking up their work at the end of the day.

EtherCAT Explained

1. EtherCAT Communication

• Each slave on the network has a unique address, set by hardware.
• Master/Slave configuration with the EtherCAT Master sending and requesting data from the Slave.
• Data not addressed to a particular slave are forwarded along to the network.
• Minimal processing time can provide cycle update rates of up to 32kHz.
• Network physical layout is limited only by the allowable lengths of CAT5 Ethernet cable, up to 100m.
• Increased noise immunity due to reliance on Ethernet physical components.

2. SDO's and PDO's

Data is moved along an EtherCAT network using two protocols: SDO's and PDO's

SDO: Service Data Object

• SDO's can be sent at any time… before, after or during real time operation of the network but require
additional communication overhead.
• As a result, SDO usage is typically only used for **Network Setup Commands.**

PDO: Process Data Object

• PDO's contain the raw operational data with minimal overhead and thus are used for real time
processes, like motion and I/O control.
• PDO's can only be used once they have been mapped using SDO's.
• Mapping sets up which byte in each PDO goes to which memory address on the slave.

3. EtherCAT Master

• Can be software and or hardware configured to assemble, send and receive EtherCAT datagrams.
• Requires only standard Ethernet physical layer components for communication.
• Facilitates coordination between EtherCAT slaves, writing and receiving data from each slave in an EtherCAT frame.
• In motion control applications, the relevant data sent to the drives are profiling data.
• The data requested are position and input status.

4. EtherCAT Slave

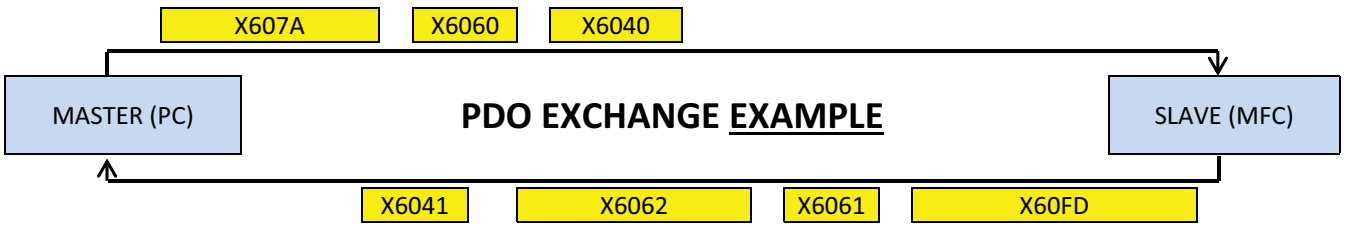
• Reads and processes profiling data.
• Can be configured for multiple modes of operation.
• All slaves contain specific spaces in memory where data can be written
• These spaces are called Objects… The entire memory space is called the Object Dictionary.
• Each Object has its own address, specified as an index/sub index.

5. SDO vs PDO Summary

SDO	PDO
Transfer Confirmation	No Transfer Confirmation
Client/Server Model	Peer-to-peer Model
Device Configuration, PDO Mapping	High priority transfer of small amounts of Data.
Can be sent at any time	Can only be used after configuration using SDO's
Significant communication overhead	No additional protocol overhead.

6. The EtherCAT Slave State Machine

STATE	Allowed Communication
INIT	No User Communication
Pre-OP	SDO Communication Only
Safe-OP	SDO, PDO Communication Allowed Output PDO Info ignored
OP	SDO & PDO Communication Allowed



Incoming PDO	
Location	**Function**
X607A	Target Setpoint
X6060	Mode of Operation
X6040	Control Word

Outgoing PDO	
Location	**Function**
X6041	Status word
X6062	Setpoint Demand Value
X6061	Mode of Operation
X6064	Setpoint Actual Value
X60FD	Digital Input Status

Introduction

Based on the information provided by the EtherCAT Slave Information File (ESI, device description in XML format) and/or the EEPROM, master applications are able to configure the EtherCAT network.
For the EtherCAT network configuration of the SLA 5800 Series devices, the following ESI file is
provided on the Brooks Instrument website. (www.BrooksInstrument.com):
• 'Brooks SLA Enh.xml' – SLA5800 Series Mass Flow Controller/Meter

Outputs (Master Side)

The request message, sent from master to slave, consists of the fields indicated in Figure 5-1, these fields will be described in the sections below.

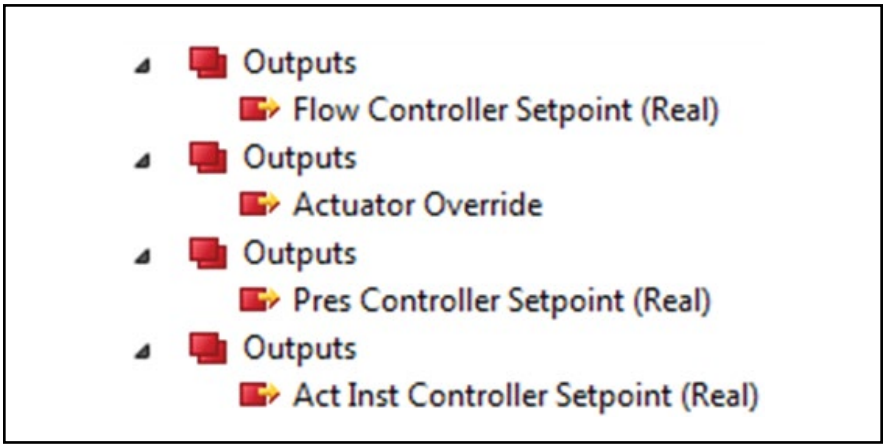


Figure 5-1 Output PDOs

PDO Entry Index	Output PDO	Data Units	Descriptions
0x7030:01	Flow Controller Setpoint(Real) 0x1600	Setpoint by Setpoint Controller Data Units	Setpoint specified in the seleced Data Units
0x7040:02	Actuator Override 0x1601	**vdOverride** Table 5□1 Valve Override Values **(vdOverride)**	Valve Override
0x7050:01	Pressure Controller Setpoint(Real) 0x1602	Specified by Setpoint Controller Data Units	Setpoint specified in the selected Data Units
0x7060:01	Act Inst Controller Setpoint(Real) 0x1603	TBD	TBD

Inputs (Master Side)

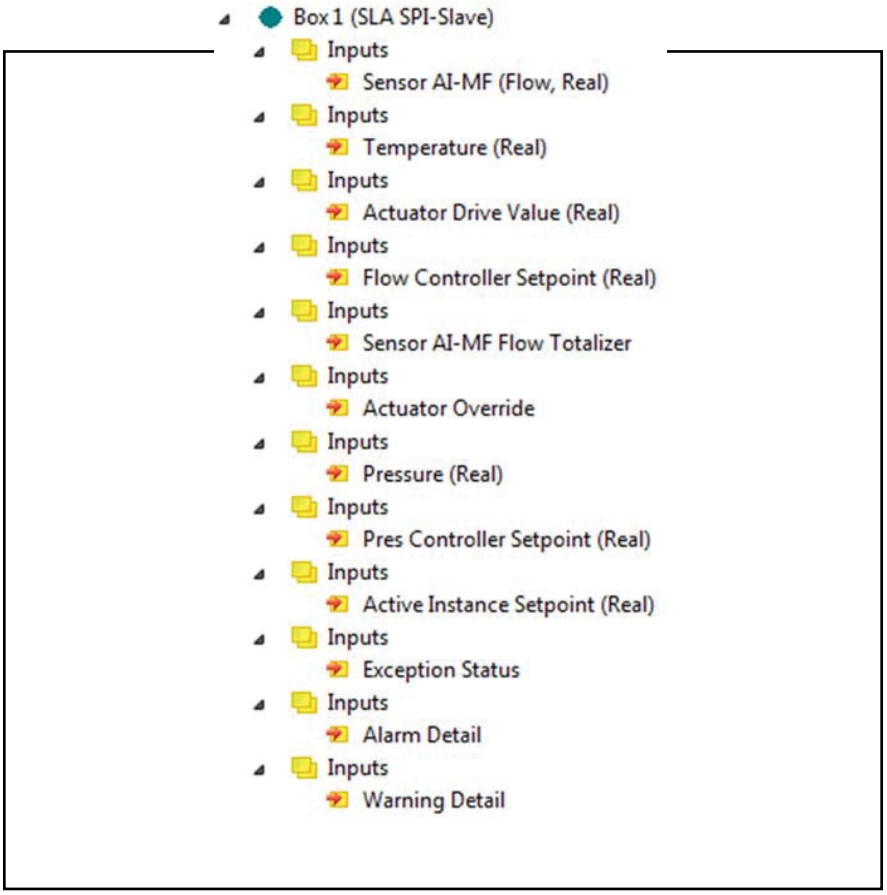


Figure 5-2 Input PDOs

PDO Entry Index	Input PDO	Data Units	Descriptions
0x6000:01	Sensor AI□MF (Flow, Real) 0x1A00	Specified by Flow Sensor Data Units	Flow specified in Flow Sensor Data Units
0x6020:01	Temperature (Real) 0x1A01	Specified by Temperature Sensor Data Units	Temperature specified in Temperature Sensor Data Units
0x6040:01	Actuator Drive Value (Real) 0x1A02	%	Valve drive value
0x6030:01	Flow Controller Setpoint (Real) 0x1A05	Specified by Setpoint Controller Data Units	Setpoint specified in Setpoint Controller Data Units
0x6000:02	Sensor AI□MF Flow Totalizer 0x1A04	cm^3	Flow totalizer value
0x6040:02	Actuator Override 0x1A05	**vdOverride** Table 5□1 Valve Override Values **(vdOverride)**	Valve Override
0x6010:01	Pressure (Real) 0x1A06	Specified by Pressure Sensor Data Units	Pressure specified in Pressure Sensor Data Units
0x6050:01	Pres Controller Setpoint (Real) 0x1A07	Specified by Pressure Controller Data Units	Pressure specified in Pressure Controller Data Units

PDO Entry Index	Input PDO	Data Units	Descriptions
0x6060:01	Active Instance Setpoint (Real) 0x1A08	TBD	TBD
0xF800:03	Exception Status 0x1A09	Bit Mask	Summary of Alarm and Warning deatil
0x6F00:02	Alarm Detail 0x1A0A	Bit Mask	Alarms
0x6F00:03	Warning Detail 0x1A0B	Bit Mask	Warnings

COE Online Attributes

Device Attributes

Index	Name	Access	Example Values
1000	Device type	RO	> 2 <
1001	Error register	RO	0x00 (0)
1008	Device name	RO	SLA
1009	Hardware version	RO	10
100A	Software version	RO	1.20
1018:0	Identity	RO	>4<
1018:01	Vendor ID	RO	0x00000602 (1538)
1018:02	Product code	RO	0x0000000A (10)
1018:03	Revision	RO	0x00000001 (1)
1018:04	Serial number	RO	0x0608B787 (101234567)
10F1:01	Error setting	RO	>2<
1600:0	1st Rx PDO-Map	RO	>1<
1601:0	2nd Rx PDO-Map	RO	>1<
1602:0	3rd Rx PDO-Map	RO	>1<
1603:0	4th Rx PDO-Map	RO	>1<
1A00:0	1st Tx PDO-Map	RO	>1<
F010:0	Application object	RO	>6<
F100:0	Device status object	RO	>1<
F301	Exception Detail Alarm(Dm13)	RO	0x1000000000002
F401	Exception Detail Warning(Dm14)	RO	0x1000002000002
F800:0	Exception Status and Settings	RO	>6<
F801:0	Reset Service Object	RO	>1<
F880:0	Calibration Object	RO	>5<
F880:01	Last Calibration Date(SacA1)	RO	
F880:02	Next Calibration Date(SacA2)	RO	
F880:05	Run Hours(SacA5)	RO	0x00000000 (0)
F901	Device Type(DmA1)	RO	MFC-RT
F902	Standard Revision Level(DmA2)	RO	
F903	Device Manuf. Indentifier(DmA3)	RO	Brooks Instrument
F904	Manufacturer Model Num(DmA4)	RO	SLA584X
F907	Serial Number(DmA7)	RO	10SLM12345678
F920	Device COnfiguration(DmA8)	RO	SLA8540S1AAB1B2A1W3HBAB

Figure 5-3 Device Attributes

Flow Sensor

Index	Name	Access	Example Values
8000:0	AI-MF Error Settings	RO	> 2 <
8000:01	AlarmEnable	RW	FALSE
8000:02	WarningEnable	RW	FALSE
8004:0	AI-MF Settings	RO	> 37 <
8004:03	Safe State	RO	0x0000 (0)
8004:08	Alarm Trip Point High	RW	0.000000 (-0.000000e+000)
8004:09	Alarm Trip Point Low	RW	0.000000 (-0.000000e+000)
8004:0B	Warning Trip Point High	RW	-0.000000 (-0.000000e+000)
8004:0C	Warning Trip Point Low	RW	-0.000000 (-0.000000e+000)
8004:21	Data Type	RO	0x00CA (202)
8004:22	Data Units	RW	0x1007 (4103)
8004:23	Alarm Setting Time	RW	0x0000 (0)
8004:24	Warning Setting Time	RW	0x0000 (0)
8004:25	Rest Flow Totalizer	RW	0x0

Figure 5-4 Flow Sensor Attributes

Flow Sensor Attributes	Data Type	Description
AlarmEnable	Enable (1) Disable (0)	Enable/disable the high and low flow alarm
WarningEnable 8000:02	Enable (1) Disable (0)	Enable/disable the high and low flow warning
Alarm Trip Point High	To be specified in selected flow data units	Flow alarm high limit
Alarm Trip Point Low	To be specified in selected flow data units	Flow alarm low limit
Warning Trip Point High	To be specified in selected flow data units	Flow warning high limit
Warning Trip Point Low	To be specified in selected flow data units	Flow warning low limit
Data Type	Real (202)	Data type is fixed to Real
Data Units	fmDataUnits Table 5-2 Flow Data Units (fmDataUnits)	Flow data units
Alarm Setting Time	Time:ms	Time in milliseconds that the alarm condition needs to be present before the alarm is raised
Warning Setting Time	Time:ms	Time in milliseconds that the alarm condition needs to be present before the warning is raised
Rest Flow Totalizer	0	Writing the value 0 to this attribute will reset the flow totalizer

Flow Sensor Zero Adjust

Index	Name	Access	Example Values
B000:0	Service transfer	RO	> 8 <
B000:01	Perform Zero	WO	

Figure 5-5 Flow Sensor Zero Adjust Attribute

Service Transfer Attribute	Data Type	Description
Perform Zero B000:01	1	The flow sensor can be zero adjusted by writing a 1 to this attribute. Refer to the isntruction manual for proper instructions.

Flow Sensor Status

Index	Name	Access	Example Values
A000:0	AI-MF Status	RO	> 33 <
A000:01	Status	RO	0x0000 (0)
A000:21	Zeroing Status	RO	0x0000 (0)

Figure 5-6 Flow Sensor Status Attributes

Flow Sensor Status Attribute	Data Units	Description
Status A000:01	 b00000001 (0x01) b00000010 (0x02) b00000100 (0x04) b00001000 (0x08)	Flow sensor status bit mask indication high and low flow alarms and warning High flow alarm Low flow alarm High flow warning Low flow warning
Zeroing Status A000:21	0 1	0 = idle 1 = zero adjust in progress

Temperature Sensor

Index	Name	Access	Example Values
8020:0	Temperature Error Settings	RO	> 2 <
8020:01	sasAlarmEnable	RW	FALSE
8020:02	sasWarningEnable	RW	FALSE
8024:0	Sensor Temperature Settings	RO	> 36 <
8024:08	Alarm Trip Point High	RW	0.000000 (0.000000e+000)
8024:09	Alarm Trip Point Low	RW	0.000000 (0.000000e+000)
8024:0B	Warning Trip Point High	RW	0.000000 (0.000000e+000)
8024:0C	Warning Trip Point Low	RW	0.000000 (0.000000e+000)
8024:21	Data Type	RO	0x00CA (202)
8024:22	Data Units	RW	0x1201 (4609)
8024:23	Alarm Setting Time	RW	0x00C9 (201)
8024:24	Warning Setting Time	RW	0x0065 (101)

Figure 5-7 Temperature Sensor Attributes

Flow Sensor Attributes	Data Units	Description
Temperature AlarmEnable	Enable (1) Disable (0)	Enable/disable the high and low temperature alarm
Temperature WarningEnable	Enable (1) Disable (0)	Enable/disable the high and low temperature warning
Alarm Trip Point High	To be specified in selected Temperature data units	Temperature alarm high limit
Alarm Trip Point Low	To be specified in selected Temperature data units	Temperature alarm low limit
Warning Trip Point High	To be specified in selected Temperature data units	Temperature warning high limit
Warning Trip Point Low	To be specified in selected Temperature data units	Temperature warning low limit
Data Type	Real (202)	Data tupe is fixed to Real
Data Units	Table 5-3 Temperature Data Units (tmUnits)	Temperature data units
Alarm Setting Time	Time:ms	Time in milliseconds that the alam condition needs to be present before the alarm is raised
Warning Setting Time	Time:ms	Time in milliseconds that the wawrning condition needs to be present before the alarm is raised

Temperature Sensor Status

Index	Name	Access	Example Values
A020:0	Temperature Status	RO	> 1 <
A020:01	Status	RW	0x0000 (0)

Figure 5-8 Temperature Sensor Status Attrivbute

Temperature Sensor Status Attributes	Data Units	Description
Status A020:01	 b00000001 (0x01) b00000010 (0x02) b00000100 (0x04) b00001000 (0x08)	Temperature sensor status bit mask indicating high and low flow alarms and warnings High temperature alarm Low temperature alarm High temperature warning Low temperature warning

Setpoint Controller

Index	Name	Access	Example Values
8030:0	Flow Controller Error Settings	RO	> 2 <
8030:01	AlarmEnable	RW	FALSE
8030:02	WarningEnable	RW	FALSE
8033:0	FlowController Settings	RO	> 36 <
8033:01	Alarm Settle Time	RW	0x0000 (0)
8033:02	Alarm Error Band	RW	1.000000 (1.000000e+000)
8033:03	Warning Settle Time	RW	0x0000 (0)
8033:04	Warning Error Band	RW	1.000000 (1.000000e+000)
8033:21	Data Type	RO	0x00CA (202)
8033:22	Data Units	RW	0x1007 (4103)
8033:23	Control Mode	RW	0x0000 (0)
8033:24	Ramp Time	RW	0x00000000 (0)

Figure 5-9 Setpoint Controller Attributes

Setpoint Controller Attribute	Data Units	Description
AlarmEnable	Enable (1) Disable (0)	Enable/disable the setpoint error band alarm
sasWarningEnable	Enable (1) Disable (0)	Enable/disable the setpoint error band warning
Alarm Settling Time	Time:ms	Time in milliseconds that the alarm condition needs to be present before the alarm is raised
Alarm Error Band	To be specified in selected data units	Error band in fmUnits where an alarms condition needs to be present before the warning is raised
Warning Settling Time	Time:ms	Time in milliseconds that the warning condition needs to be present before the warning is raised
Warning Error Band	To be specified in selected data units	Error band in fmUnits where an alarms condition needs to be present before the warning is raised
Data Type	Real (202)	Data type is fixed to Real
Data Units	fcDataUnits Table 5-6 Flow Data Units (fcDataUnits)	Setpoint controller data units
Control Mode	fcControlMode Table 5-4 Setpoint Control Mode (fcControlMode)	The setpoint control is fixed to the digital EtherCAT interface (future enhancement: analog setpoint source)
Ramp Time	Time:ms	Time in milliseconds to reach a newly configured setpoint

Setpoint Controller Status

Index	Name	Access	Example Value
A030:0	Controller Status	RO	> 1 <
A030:01	Status	RW	0x0000 (0)

Figure 5-10 Setpoint Controller Status Attribute

Setpoint Controller Status Attributes	Data Units	Description
Status A030:01	 b00000001 (0x01) b00000010 (0x02)	Setpoint controller staus bit mask Setpoint error band alarm Setpoint error band warning

Valve Actuator Attributes

Index	Name	Access	Example Values
8040:0	Actuator Error Settings	RO	> 2 <
8040:01	AlarmEnable	RW	FALSE
8040:02	WarningEnable	RW	FALSE
8044:0	Actuator Settings	RO	> 40 <
8044:21	Data Type	RO	0x00CA (202)
8044:22	Data Units	RW	0x1007 (4103)
8044:23	Alarm Trip Point High	RW	9.900000 (9.900000e+000)
8044:24	Alarm Trip Point Low	RW	0.000000 (0.000000e+000)
8044:26	WarningTrip Point High	RW	0.000000 (0.000000e+000)
8044:27	Warning Trip Point Low	RW	0.000000 (0.000000e+000)

Figure 5-11 Valve Actuator Attributes

Valve Actuator Attribute	Data Units	Description
AlarmEnable	Enable (1) Disable (0)	Enable/disable the high and low valve drive alarm
WarningEnable	Enable (1) Disable (0)	Enable/disable the high and low valve drive warning
Data Type	Real (202)	Data type is fixed to Real
Data Units	vdDataUnits Table 5-5 Valve Drive Data Units (vdDataUnits)	Valve drive data units, fixed to percent
Alarm Trip Point high	To be specified in selected valve drive data units (percent)	Valve drive alarm high limit
Alarm Trip Point low	To be specified in selected valve drive data units (percent)	Valve drive alarm low limit
Warning Trip Point High	To be specified in selected valve drive data units (percent)	Valve drive warning high limit
Warning Trip Point Low	To be specified in selected valve drive data units (percent)	Valve drive warning low limit

Index	Name	Access	Example Value
A040:0	Actuator Status	RO	> 1 <
A040:01	Status	RW	0x0000 (0)

Figure 5-12 Valve Actuator Status Attributes

Service Transfer Attributes	Data Units	Description
Status A040:01	 b00000001 (0x01) b00000010 (0x02) b00000100 (0x04) b00001000 (0x08)	Valve acuator status bit mask indication high and low valve drive alarms and warnings High valve drive alarm Low valve drive alarm High valve drive warning Low valve drive warning

Service Transfer Attributes

Index	Name	Access	Example Values
B000:0	Service transfer	RO	> 8 <
B000:01	Perform Zero	WO	
B000:03	Select Gas Table	RW	0x0006 (6)
B000:04	Full Scale Range	RO	1000000.000000 (1.000000e+006)
B000:05	Full Scale Range Units	RO	0x1400 (5120)
B000:06	Select Pressure Application	RW	0x0000 (0)
B000:06	Pressure Full Scale Range	RO	
B000:07	Pressure Full Scale Range Units	RO	

Figure 5-13 Service Transfer Attributes

Service Transfer Attribute	Data Units	Description
Perform Zero	1	Refer to Section 5.3.2.1 Flow Sensor Zero Adjust
Select Gas Table	1..6	Selected process gas page
Full Scale Range	Real	Full scale range being the flow at 100%
Full Scale Range Units	Table 5-2 Flow Data Units (fmDataUnits)	Data unit of the full scale range

Calibration Object Attributes

Index	Name	Access	Example Description
F880:0	Calibration Object	RO	> 5 <
F880:01	Last Caslibration Date (SacA1)	RO	
F880:02	Next Calibration Due Date (SacA2)	RO	
F880:05	Run Hours (SacA5)	RO	0x00000000 (0)

Figure 5-14 Calibration Object Attributes

Calibration Object Attributes	Data Units	Description
Lat Calibration Date	Date	Date at which the device was calibrated
Next Calibration Due Date	Date	Date at which the device needed tpo be calibrated
Run Hours	Time:hours	Time that the device has observed flow in the range of 0-100%

Exceptions

Alarm- and Warning Details

The device, flow, temperature, setpoint controller and valve actuator related exceptions are collected in the alarm and warning detail byte sequences.

The Bitmasks are shown below:

	Byte Number	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	TwinCat hex values
Common Exception Detail Size	0	0	0	0	0	0	0	1	0	02
Common Exception Detail 1st byte	1	0	0	0	0	EEPROM Excepetion	0	0	Internal Diagnostic Exception	00, 0, 09
Common Exception Detail 2nd byte	2	0	0	0	0	0	0	0	0	00
Device Exception Detail Size	3	0	0	0	0	0	0	1	0	02
Common Exception Detail 1st byte	4	0	0	Valve alarm/ warning high	Valve alarm/ warning low	Flow control alarm/ warning	Flow alarm/ warning high	Flow alarm/ warning low	Flow sensor reading not valid	00 to 3F
Manuf. Exception Detail Size	5	0	0	0	0	Pressure control alarm/ warning	Pres-sure alarm/ warning high	Pressure alarm/ warning low	Pressure sensor reading not valid	00 to 0F
Manuf. Exception Detail 1st byte	6	0	0	0	0	0	0	0	0	01
Manuf. Exception Detail 2nd byte	7	0	0	0	0	Temp alarm/ warning high	Temp alarm / warning low	0	0	00,08,00

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Exception Status F800:03 (1 byte)	0	Manuf. specific warning	Device specific warning	Common exception warning	0	Manuf. specific alarm	Device specific alarm	Common exception alarm

Exception Status

The device, flow, temperature, setpoint controller, and valve actuator related exceptions are collected in the alarm and warning detail byte sequences.

The Bitmasks are shown below:

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Exception Status	0	Manuf specific warning	Device specific warning	Common exception warning	0	Manuf specific alarm	Device specific alarm	Common exception alarm

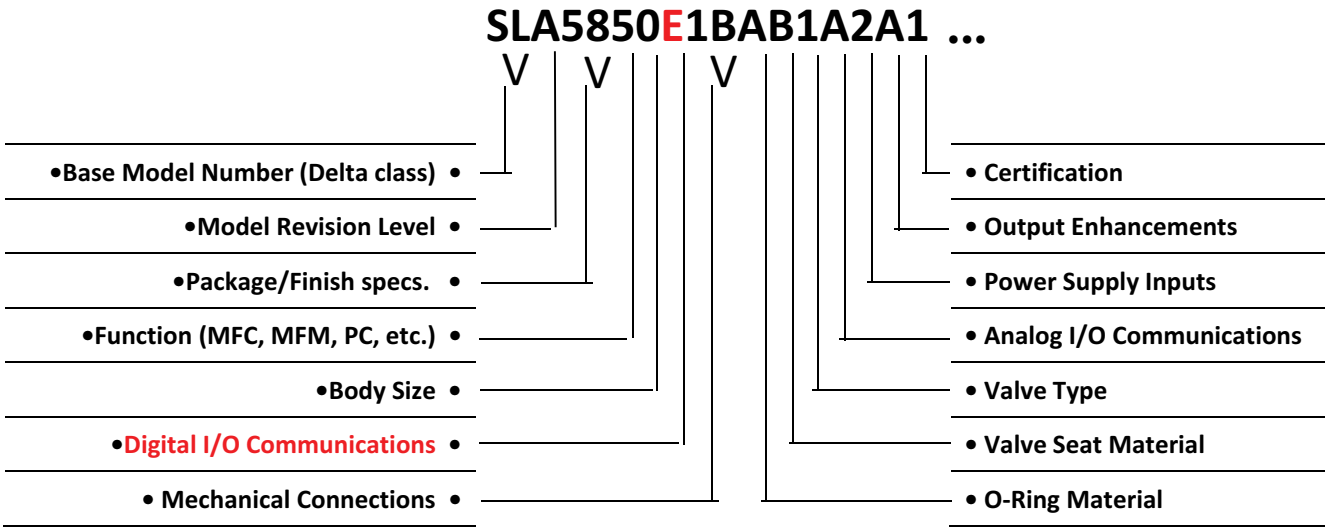
(Product Description Code): I/O and Model Code

Communications I/O:

EtherCAT	DeviceNET*	RS-485	Profibus*	Foundation Fieldbus*	None
E	D, J, K, L, V	S	P,R,T	F, M, N, Q	A

**I/O letter designation is dependent on the type of connector*

Example Model Code(PDC):



Please see the SLA 5800 Series Instruction/Operators manual for a complete and comprehensive breakdown of the Product Description Code.

Tables

Value	Description
0	Normal
1	Off
2	Purge

Table 5-1 Valve Override Values (vdOverride)

Value	Description
4103	Percent
5120	SCCM
5121	SLM

Table 5-2 Flow Data Units (fmDataUnits)

Value	Description
4608	Celsius
4609	Fahrenheit
4610	Kelvin
4611	Rankine

Table 5-3 Temperature Data Units (tmDataUnits)

Value	Description
0	Digital
128	Analog (future)

Table 5-4 Setpoint Control Mode (fcControlMode)

Value	Description
4103	Percent

Table 5-5 Valve Drive Data Units (vdDataUnits)

Value	Description

Table 5-6 Flow Controller Data Units (fcDataUnits)

Beckhoff Automation: TwinCAT® *(A PC Master Option)*

Establishing a PC Ethernet Master (TwinCAT)

AUTO SETUP - PC Ethernet Master (TwinCAT)

- In the Solution Explorer, Right-click on “Devices”, under the I/O Icon.
- From the drop-down menu select ”Scan” to automatically scan your PC for EtherCAT compatible Ethernet Adapters.
- A pop-up box appears reminding the user that “Not all devices can be found automatically”. Select “OK”.

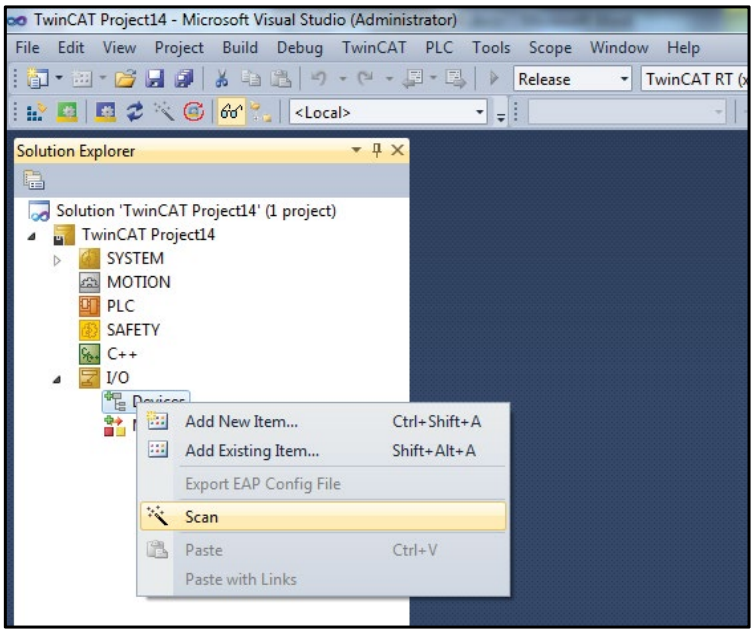


Figure 6-1 AUTO SETUP - PC Ethernet Master, Scanning for Compatible Devices

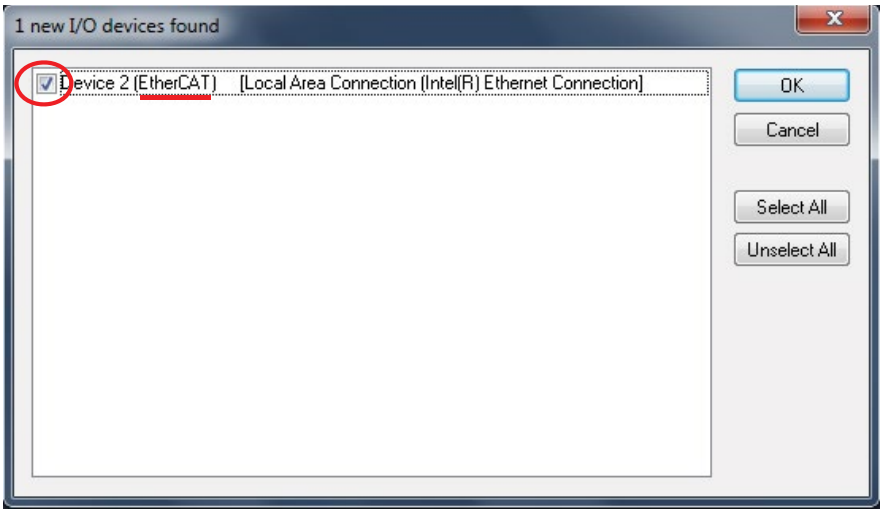


Figure 6-2 AUTO SETUP - PC Ethernet Master, I/O Devices Found

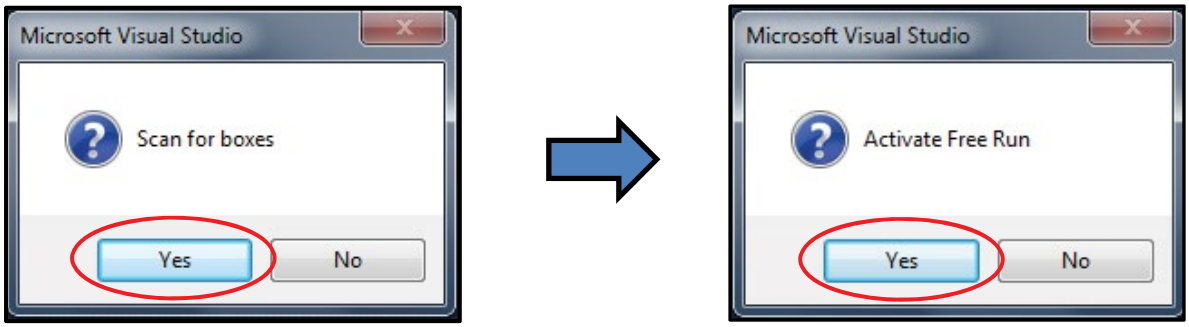


Figure 6-3 AUTO SETUP - Pop-Up Screens

- In the TwinCAT Solution Explorer display to the right, **"Device 2"** represents the EtherCAT Master.

- "**Box 1 (GF04x SPI-Slave)"** represents the Slave device. (In this example the slave is a single GF-40 device) .

Inputs: Attribute(s) reported from the Slave device to the Master. (e.g. **"Sensor Flow AI-MF"**)

Outputs: An explicit attribute change sent from the Master to the Slave device. (e.g. **"Controller Setpoint"**)

Add to Watch: Puts the data stream into a separate window which provides the user with real-time monitoring capability.

Figure 6-4 AUTO SETUP - Proper Communications: Master and Slave (Beckhoff Automation: TwinCAT)

MANUAL SETUP - PC Ethernet Master (TwinCAT)

- Sometimes when you Right-click on “Devices” and select “Scan”, you may receive a response of: “No New I/O Devices Found”.
- If you receive this reply from TwinCAT, you must set up the Ethernet connection **manually** by installing it.
- From the ‘TwinCAT’ drop-down tab located in the main toolbar, select **“Show Realtime Ethernet Compatible Devices”.**

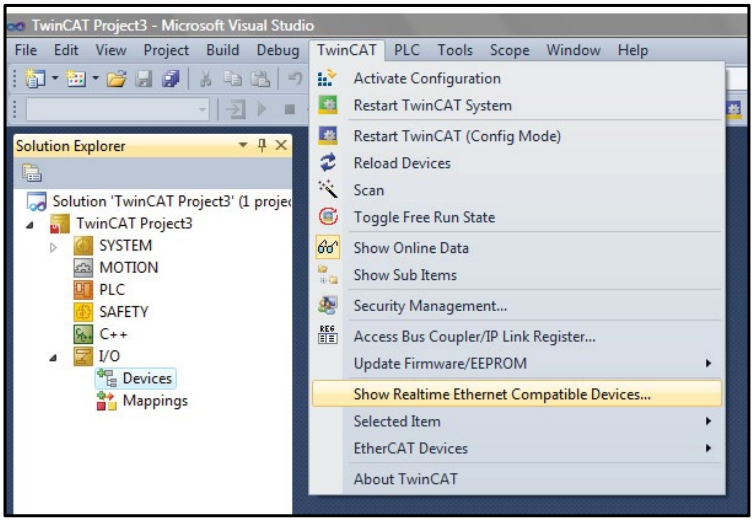


Figure 6-5 MANUAL SETUP - PC Ethernet Master, Scanning for Compatible Devices

- A pop-out screen appears (similar to this one) that displays all of the Ethernet Adapters that were found by TwinCAT on your PC.
- Some of the adapters are listed under “Compatible” and others may be listed under “Incompatible. The difference is the current status of the Ethernet Device Driver.
- Click on the Ethernet Adapter that represents a LAN connection for your PC. Then click on the “Install” button and follow on-screen instructions.
- Note: EtherCAT operates on an available LAN connection and is not currently suitable for wireless internet operation. Selecting the Wireless Ethernet Adapter would not work in this case.

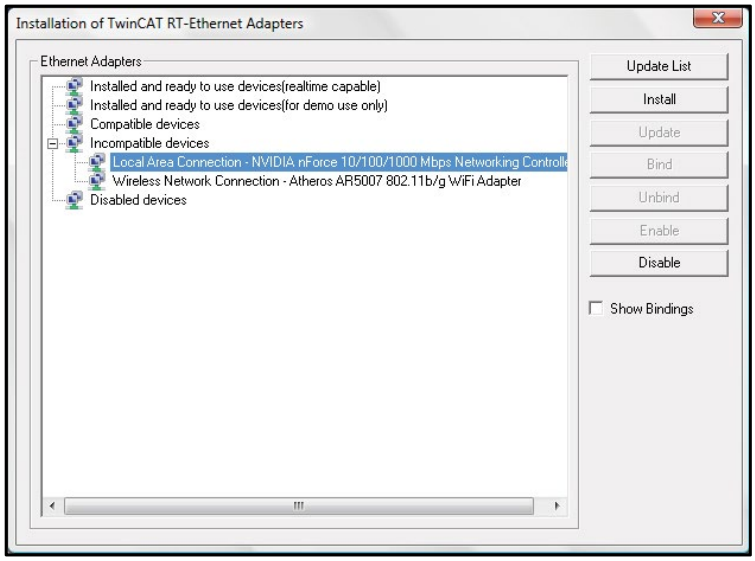


Figure 6-6 MANUAL SETUP - Pop-Up Screen

CoE Online Attributes - Making Changes (Beckhoff Automation: TwinCAT)

- Assuming that you are already connected to the device using either TwinCAT or EtherCAT configurator, click once on the gf-40 box so that there is a display screen on the right with menu tabs (General, EtherCAT, Process Data, Startup, CoE-Online, Online).
- The tab we are interested in is “CoE-Online”…. Please click on that tab.
- You are presented with a table that lists all of the device attributes with a title header of: “Index”, “Name”, “Flags”, and “Value”.

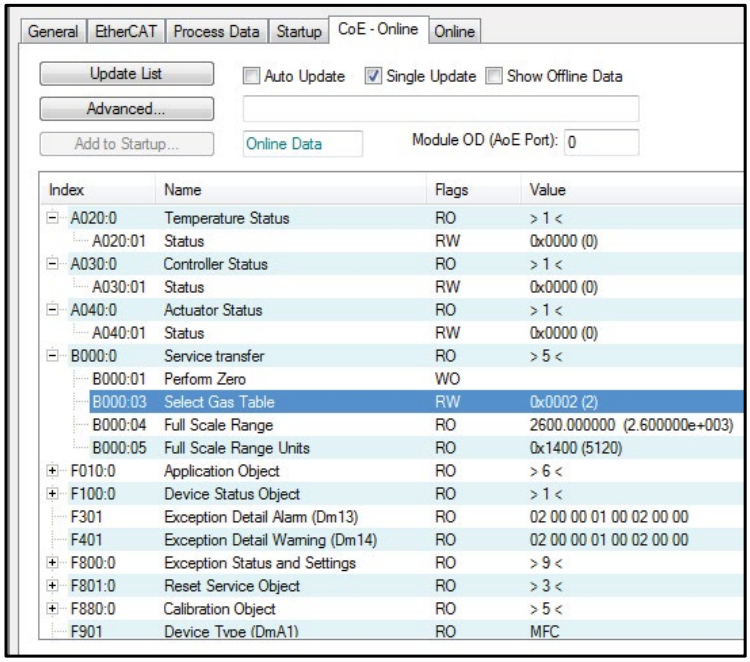


Figure 6-7 CoE Online: Changing the Active Gas Page (and other device attributes)

- You will notice that under the “Flags” title: RW is Read/Write. RO is Read Only. Only those attributes with an **RW** flag can be changed.
- <u>You change the attribute ‘Value’ by double-clicking on the attribute</u>. You will get a pop-up window to enter the new information. After you click ‘OK’, verify that the attribute did indeed change.
- **The attribute for gas page is Index: B000:03 “Select Gas Table”(with Bechhoff “EtherCAT Configurator”)**
- Just enter in the new gas page number here and click ‘OK’.

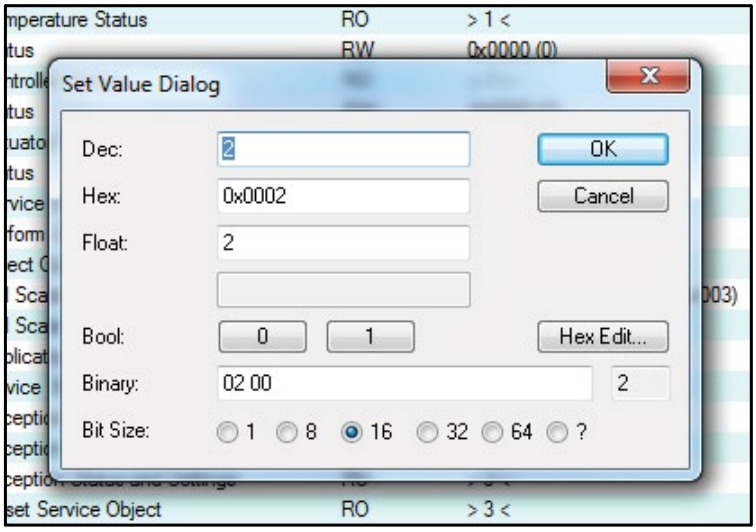


Figure 6-8 CoE Attributes - Pop-Up Screen

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X-DPT-EtherCAT-SLA58xx-SLAMFxx-Series-RevB-MFC-eng/541B208AAG/2022-04

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